STUDIES ON ACARINE PREDATORS OF NORTH KERALA

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CERTIFICATE

This is to certify that this thesis is an authentic record of the work carried out by Mrs. MARY ANITHALATHA SADANANDAN M.Sc., M.Ed. under my supervision and guidance in partial fulfilment of the requirements of the Degree of Doctor of Philosophy in Zoology, under the Faculty of Science of the University of Calicut. No part of this thesis has been presented before for any other degree. I also certify that Mrs. Mary Anithalatha Sadanandan has passed the Ph.D. qualifying examination held in May 2001.

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DECLARATION

I hereby declare that this thesis is an authentic record of the work carried out by me under the supervision and guidance of Dr. N. Ramani, Reader, Division of Acarology, Department of Zoology, University of Calicut and no part of this has been published previously or submitted for the award of any degree or diploma.

Calicut University,
10.05.2002.

Mary Anithalatha Sadanandan

Dedicated to

My Beloved Father

Late Sri. Adolf Sadanandan

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Mary Anithalatha Sadanandan

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INTRODUCTION

INTRODUCTION

Mites constitute an important group of organisms belonging to the class Arachnida of the phylum Arthropoda. Acarology, the study of mites and ticks has gained adequate recognition recently, leading to its ramification along diverse lines and enabling to shed light on several new avenues. Acquisition of knowledge on this branch of science has helped the scientific community to evaluate the impact of mites and ticks on man and his environment. Ticks, unlike mites have already attracted public attention owing to their veterinary and medical importance. Mites because of their microscopic size and cryptic behaviour, are generally overlooked and the damage symptoms induced by them are assessed on the basis of their feeding response. Mites are gaining importance throughout the world on account of their role either in the beneficial or injurious levels. A good quantum of mites has been recognized as serious pests of agricultural crops, medicinal plants, stored products, live stock and so on and cause diseases even to man. They possess a supreme adaptability to survive in totally diverse ecological situations like benthic zones of oceans, hostile conditions of caves, freezing temperatures of artics and warm waters of thermal springs. In terms of habits, mites represent a marvellously heterogeneous group enjoying phytophagous, parasitic, predatory, scavenging and commensalistic mode of life.

The major phytophagous groups of mites recognized so far generally belong to the families Tetranychidae, Eriophyidae, Tenuipalpidae and Tarsonemidae which are considered to be of great economic importance by virtue of the various types of injuries caused by them leading to heavy yield loss.

Apart from their pest status on agricultural crops, mites have also attracted much human attention, especially from the scientific sector on account of the damages induced by them in stored ecosystems. All types of food grains, bakery items, fishery products, cattle and poultry feeds, leather goods, wool, etc. have become favourable food items to mites especially to the acarid mites. They decline both the quality and quantity of stored products through their feeding and other life activities. The excretory products and exuviae of these mites cause various types of health hazards to the persons who handle or consume the infested items. Such effects have raised them to the status of serious pests of stored products causing considerable financial loss and health hazards to public life.

Besides the pest status, mites are also noted for their eminent parasitic role. Mites attacking animals cause a great concern to man by producing a variety of diseases. Both ecto and endoparasitism by mites are reported in almost all groups of animals including man. Mites are responsible for the sarcoptic mange and psoroptic mange in cattle and other domestic animals, characterized by intense itching and weeping lesions. Dust mites of the genus *Dermatophagoides* produce severe respiratory problems in man through out the world leading to chronic asthma and other bronchial disorders. Some mites also act as vectors of pathogenic agents like bacteria, rickettssiae, viruses and pathogenic protozoa. Ecto and endoparasitic mites affecting honey bees cause serious problems to apiculture.

The points discussed so far comprise the adverse effects projecting the notoreity of mites thereby leading to consider them as a taboo for man and his environment. However, increasing knowledge acquired through recent findings provided adequate evidence to alter the existing concept on this group and also to attribute them, several beneficial roles. An understanding of the positive role of mites in the maintenance of soil fertility, biological control of pests and weeds and bioindication of environmental conditions marked a turning point in the development of this discipline.

More than any other habitat, the soil litter stratum is the province of mites. It is estimated that nearly 70-80% of the soil fauna consists of mites. In the soil, mites contribute significantly to speed up the process of decomposition and subsequent nutrient cycling by comminuting litter and other organic matter, feeding and disseminating microbial colonies and vectorising microbial propagules. Potential of mites in the maintenance of soil fertility is of much significance in an agricultural country like India. In this regard oribatid mites deserve special mention as they constitute one of the largest components of the soil mesofauna on account of their species diversity, numerical abundance and diverse feeding trends. Through their differential feeding strategies within the soil ecosystem, these mites facilitate the routine process of decomposition and humification. Extreme sensitivity of mites to the microclimatic changes in their immediate surroundings has helped to consider them as biological tools for evaluating the physico-chemical characteristics of the soil ecosystem.

Mites are also reported to play a prominent role in subsiding the vast populations of various terrestrial and aquatic weeds. An exquisite example is the control of the notorious aquatic weed *Eichhornia crassipes* by the release of a phytophagous galumnoid mite, *Orthogalumna terrebrantis* in various countries including India.

The incidence of phytophagous mites has become more severe especially after the use of broad spectrum pesticides in 1940's and 50's. Control of these mites has become much more difficult because of the fact that several species of tetranychids have developed many fold resistance to a number of common pesticides and acaricides. Such resistant mite populations usually require frequent acaricidal treatments, leading to heavy cost of production and residual problems in the ultimate food products.

Man's interference in nature by destroying the forests, raising crops in monoculture and the indiscriminate use of broad spectrum pesticides and synthetic pyrethroids upset the natural balance of pests and their predators. As a result heavy population explosion of pest mites occur through secondary outbreak. One concrete example is the sudden outbreak of the coconut eriophyid mite *Aceria guerreronis* in Kerala since 1996 and its subsequent spread to the southern states of India viz., Tamil Nadu, Karnataka and Andhra Pradesh. Most of the developed countries have given much emphasis to minimise the pesticidal applications in order to reduce environmental hazards and pest resurgence problems. In this context, much stress is being laid to promote implementation of biological control with predatory mites for developing Integrated Pest Management Programme.

Predatory mites constitute a highly significant beneficial group on account of their vital role in the maintenance of pest population below the economic injury level. There is enough evidence that the members of the mite families like Phytoseiidae, Cheyletidae, Cunaxidae, Stigmaeidae, Bdellidae, Tydeidae, Ascidae, Anystidae, Erythraeidae and some Tarsonemidae etc. are potential predators which can suppress the mite pests on various crops substantially, if judiciously utilised as natural enemies of insect pests and one species has been mass reared and tried against the cotton boll weevil *Anthonomus grandis*.

Predatory mites of the family Hemisarcoptidae are the best known acarine natural enemies of the armoured scale insects. Water mites are known to parasitise/ predate the larvae of several dipteran families of medical or veterinary importance. Excellent examples are the mites *Piona nodata* and *Thyas barbigera* whose nymphs and adults voraciously feed on mosquito larvae. Members of several mite families attack grasshoppers and locusts and the families Podapolipidae and

Trombidiidae deserve special mention in this regard. Mites belonging to various suborders feed on nematode pests thereby exerting an effective check on their population density. These include the members of Astigmata, Cryptostigmata and Mesostigmata.

Among the predatory mites, species of Phytoseiidae are potentially important as a biotic factor in the control of phytophagous mites of the families Tetranychidae, Tenuipalpidae, Eriophyidae and Tarsonemidae. The functional response of phytoseiid mites to the density of tetranychid mites and aspects of their numerical response are also evaluated by several workers.

Because of the microscopic size and fragile nature of mites only less than 5% of existing species has been described taxonomically. Despite this, the predatory behaviour of mites on the phytophagous mites/insects represents a well explored field in various countries including India. However, most of the work on this aspect has been carried out in India using the imported and exotic predatory species which often fail to thrive well in the field conditions. With a view to offset this bottleneck and to identify the predatory mite species which are able to thrive well in our climatic conditions, a systematic study on the native predatory mites in their preferred habitat becomes imperative. The present study has been undertaken with an intention to provide information on the predatory mites of Kerala. Kerala being an agricultural land, more attention has been given to study the predatory mites affecting the phytophagous mites of agricultural crops and stored products.

The study includes a detailed survey on the predatory mites inhabiting various crops and stored items from various districts of northern Kerala, their systematic aspects and also the feeding and breeding aspects of two representative species.

REVIEW OF LITERATURE

PART I

GENERAL SURVEY ON PREDATORY MITES

CHAPTER 1

REVIEW OF LITERATURE

Taxonomic studies of predatory mites have attained considerable progress with the addition of hundreds of new taxa from far and wide regions of the world. A complete and upto date review of literature though appears to be required, attempt has been made during the present work to make the review concised with in the limit of time and space. Therefore only the important and relevant findings on the predatory groups of mites which were studied during the present investigation have been cited in the following part.

1.1. Family PHYTOSEIIDAE Berlese, 1952

The earliest phytoseiid mite was described in 1839 by C.L. Koch (Chant, 1985). The systematics of phytoseiidae had a tumultuous and confused history due to a notable lack of agreement among the major authors on the higher classification of the family. However, some groups with in the family have been recognised as morphologically distinct by many taxonomists. These groups were either monotypic or relatively small in size and may have phylogenetic and evolutionary significance. Inorder to foster the establishment of stable systematics for the family it might be constructive initially to under take phylogenetic studies of these groups.

Taxonomists differ in their opinion about the generic and suprageneric concept of Phytoseiidae. Berlese (1916) proposed the superfamily Phytoseiinae under the family Laelaptidae including the genera *Podocinum, Ameroseius, Epicroseiopsis, Amblyseius* and *Iphidizercon*. Vitzthum (1941) also recognised Phytoseiidae as a subfamily of Laelaptidae and included 7 genera viz. *Typhlodromus, Seiulus, Phytoseius, Amblyseius, Iphidulus, Seiopsis* and *Kleemania* under the taxon, but none of them provided the diagnosis of the family which was later provided by Garman (1948) on the basis of the type, number, distribution of setae on dorsal shield and by the shape and size of the anal plate of the female mite, he included 9 genera in this subfamily. Nesbitt (1951) made the first critical review of this subfamily and recognised the genera *Amblyseius, Typhlodromus, Blattisocius, Kleemania, Phytoseius, Kampimodromus* and *Garmania* under it. Baker and Wharton (1952) after giving the group the family status divided it in to 2 subfamilies viz., Phytoseiinae including 12 genera and Podocinae comprising 10 genera. Inspite of the fact that family status was given, Womersley (1954) considered it as the subfamily Phytoseiinae under the family Laelaptidae. Chant *et al*., (1959) proposed a new subfamily Macroseiinae to accomodate one typical genus *Macroseius*.

Chant (1959a) made a conservative approach in classifying Phytoseiidae and recognised two subfamilies, viz., Macroseiinae with one genus *Macroseius* and

Phytoseiinae with 8 genera, viz., *Typhlodromus, Phytoseius, Phytoseiulus, Iphiseius, Asperoseius, Proprioseius, Seiulus* and *Typhloseiopsis*.

Additional genera were proposed by Athias - Henriot (1960) and Swirski and Shechter (1961). Muma (1961) after making extensive studies reevaluated the subfamilies, genera and species on the basis of dorsal scutal form, dorsal setal pattern, scapular setae, sternal setation and leg IV macrosetae. He recognised 4 subfamilies and 48 genera of which 29 genera and 2 subfamilies were proposed as new. Additional genera were proposed by Gonzalez and Schuster (1962). Hirschman (1962) proposed a very conservative systems of classification and put all the species presently considered in Phytoseiidae under one genus which was included in the family Gamasidae. Pritchard and Baker (1962) followed a somewhat conservative system of classification recognising 6 tribes, each consisting of a genus, of which one was proposed as new and included 16 subgenera of which 2 were new. Wainstein (1962) apparently being unaware of the work of Muma (1961) and Karg (1961) divided the family into 2 subfamilies, 3 tribes, 7 genera, 22 subgenera and 20 sections. However majority of them were synonyms. Schuster and Pritchard (1963) divided the family into 6 tribes with 17 genera under it. Lindquist and Chant (1964) transferred *Aceodromus* to the subfamily Blattisociinae under Aceosejinae. Chant (1965) made an attempt to stabilise the generic concept of Phytoseiidae by making radical changes. He brought 4 genera of otopheidomenid mites as a subfamily Otopheidomeninae under the family Phytoseiidae, while his other subfamily Phytoseiinae comprised of 9 known genera and one new genus. He synonymised 4 of the genera proposed by Chant (1959b) and 35 of the genera proposed by Muma (1961). Addition and reallocation of genera were proposed by Muma (1963) and De Leon (1966). Denmark and Muma (1966) revised the genera *Galendromus, Phytoseius* and *Poprioseius.* Muma and Denmark (1968) criticized Chant (1965) for the generic concept proposed by him and deleniated 5 new genera and synonymised 4 genera. The same authors (1970) further criticized Chant's generic concept as he included otopheidomenid mites under Phytoseiidae. They recognised 3 subfamilies viz., Amblyseiinae, Phytoseiinae and Macroseiinae with a total of 28 genera under these subfamilies from Florida. They excluded otopheidomenid mites altogether from Phytoseiidae. Even after that work, a big question baffled taxonomists whether to include otopheidomenid mites under Phytoseiidae or treat it as a separate family.

Later Prasad (1970), Wainstein (1972), Ramsy (1973) and Treat (1975) studied the systematics of this group and most of them gave a separate family status to the otopheidomenid mites and the remainder as a subfamily Treatinae under the family Phytoseiidae. Inorder to shed further light on this subject Chant *et al.* (1978) made critical study of this family using numerical taxonomy and a new classification was proposed which recognised two subfamilies viz., Otopheidomeninae having 4 genera under it, namely *Otopheidomenis*, *Treatia*, *Hemipteroseius* and *Entomoseius* and Phytoseiinae having 5 tribes as Phytoseiini, Typhlodromini, Amblyseiini, Macroseiini and Chantini.

Subsequently the number of new species described under Phytoseiidae increased day by day from different parts of the world. Chaudhri *et al* (1979) reported several new species in addition to erecting a few genera viz., *Denmarkia*, *Amathia*, *Ansaria*, *Kashmerius* and a new subfamily Gnoriminae under Phytoseiidae from Pakistan. Yousef (1981) described a new species *Typhlodromus africanus* from Egypt. Denmark (1982) revised the genus *Galendromus*, erected a new subgenus *Ennoseius*, the subgenus *Mugidromus* was synonymized with *Leonodronus*, *Galendromus deleoni* was synonymized with *G. pomi*, *G. loculus* was synonymized with *G. flumensis*, *G. ruralis* and *G. delicatus* were synonymized with *G. herbertae*; while *G. tuttle*, *G. negundinis*, *G. bromus* and *G. bakeri* were described. A neotype was designated for *G. mexicanus*. Denmark and Schicha (1983) revised the genus *Phytoseiulus fragariae* and redescribed *P. persimilis* and *P. macropilis* from Australia. Congdon and Mc Murtry (1985) described a new species under the genus *Euseius* viz., *E. tularensis* from California. Ueckermann and Loots (1985) erected *Trochoseius*, a new subgenus of *Amblyseius* from South Africa. Taxonomical and biological aspects of phytoseiid mites from Egypt were published by Abou-Awad and El-Banhawy (1986). A new subfamily Chantiinae was proposed by Chant and Yoshida Shaul (1986a) under the family Phytoseiidae governing the two genera *Chantia* and *Chantieus*. The same author (1986b) erected a subfamily Cydnodromellinae under the family Phytoseiidae. Karg (1986) reported a new species under the genus *Amblyseius* viz., *A. caviphilus* from Vienna. Gupta (1987) reported 8 new species from North East India viz., *A.* (*Asperoseius*) *hyauliangensis, A. (Typhlodromalus) ficusi, Indoseius eharai, Iphiseius (I.) hapoli, Okiseius yazuliensis, Phytoseius (Pennaseius) namdaphaensis, Typhlodromus (Amblydromella) arunachalensis, T. (Typhlodromus) sijiensis.* Wang and Xu (1987) reported a new species under the genus *Amblyseius* viz., *A. castaneae* from China. Moraes *et al.* (1988) added a new species under the genus *Amblyseius, A. neoaurescens* from Paraguay. Mc Murtry and Bounfour (1989) conducted a survey on phytoseiid mites on citrus and various other plants in Morocco and reported 17 species, 2 of which were new. They also reported the occurrence of the genera *Kuzinellus, Typhloctonus* and *Typhlodromus* from Morocco. The new genus *Chelaseius* erected by Muma and Denmark under Amblyseiinae had been revised by Denmark and Kolodochka (1990) and 10 species were described under this genus. El-Banhawy and Abou - Awad (1990) reported many species under the genus *Amblyseius*. Papadoulis and Emmanouel (1991) described several new species of phytoseiid mites under the genus *Amblyseius*. El-Banhawy and Abou - Awad (1991) reported 3 species viz., *T. asticus, T. totifolianensis* and *T. devesalaani* from Tanzania. Meshkov (1991) described a new species *E.*

amissibilis under the genus *Euseius* from Tajikistan. Moraeus *et al.* (1991) reported the occurrence of 55 phytoseiid mites from Latin America under the genera *Amblyseius, Cydnodromella, Ricoseius, Euseius, Phytoseiulus, Proprioseius, Phytoseius, Typhlodromus* and *Typhloseiopsis.*

The tribe Phytoseiini was completely revised by Chant and Yoshida Shaul (1992b) with a world review of the *Pursegloiei* species group in the genus *Phytoseius.* According to them the number of described species has increased to over 1614. A new genus *Indoseiulus* proposed by Ehara was revised by Denmark and Kolodochka (1993) with 6 species. Takahashi and Chant (1993 a, b, c) studied in detail the phylogenetic relationship of the genus *Phytoseiulus* and its adaptive strategies. Ryu (1993) reviewed the family Phytoseiidae of Korea and reported 27 species under 2 subfamilies, 3 genera and 5 subgenera from the Republic of Korea. Chant and Mc Murtry (1994) reviewed the subfamilies Phytoseiinae and Typhlodrominae with 142 and 452 known species respectively with keys to subfamilies, genera and species. Chiara and Tsolakis (1994) revised the genus *Kampimodromus* and described a new species viz. *K. ericinus* from Italy. Aponte and Mc Murtry (1995) revised the genus *Iphiseiodes* and redescribed 5 species.

A new species of the genus *Amblyseius* viz., *A.. verginensis* was reported by Papadoulis (1995) from Greece. Ryu (1995) reported 2 new species under the genus *Amblyseius* viz., *A. (A.) mountus* and *A. (A.) sorakensis* from Korea. From eastern India addition of a new species under the genus *Typhlodromus* viz., *T. malviyai* on egg plant was made by Singh and Singh (1996). A new species *Euseius obispensis* was reported from avacado in California by Aponte and Mc Murtry (1997). Evans and Edland (1998) identified a new species *Anthoseius parinopinatus* from Norway. Karg (1998) added 5 new species from Germany, *A. crassicaudalis, A. similicaudalis, A. filicinae* under the genus *Amblyseius* and *P. latocavi* and *P. vitreus* under the genus *Proprioseiopsis*. According to Gupta and Arun Gupta (1999) Phytoseiidae contain 168 known species under 12 genera. Moraes and Denmark (1999) identified 2 new species under the genus *Proprioseius* viz., *P. aculeatus* from Brinjal. Wu and Ou (1999) added two new species under the genus *Amblyseius* from China viz., *A. dicircellatus* and *A. guizhouensis*.

Basha and Yousef (2000) identified two new species from Egypt viz., *Proprioseiopsis sharkiensis* and *Phytoseius kassasini* from grape wine and *Vitis vinifera*. Lofego *et al.* (2000) described 3 new species from Brazil viz., *A. neochiapensis* from *Manihot* species, *A. bahiensis* from unidentified plant and *Typhlodromatus feresi* from Mabea. From Pakistan Muhammed *et al.* (2000) identified two new species under the genus *Phytoseius* viz., *P. ferax* and *P. mancus* from grapes and peach respectively from Pakistan. Moraes *et al.* (2000) had reported 50 phytoseiids from French Caribbean islands, of which 3 of them were new to science viz., *N. martinicensis, Typhlodromips neoarcus* and *Metaseiulus*

(*Metaseiulus*) *neoflumenis*. Ragusa (2000) described a new species under the genus *Cydnodromus* viz., *C. picanus* on citrus from northern Chilean desert. Five new species under the genera *Amblyseius* viz., *A. apocynae, A.pseudorientalis, A. rubiae, A. apocynaevagrans* and *A. keralensis* were described by Chinniah and Mohanasundaram (2001) from Kerala.

1.2. Family CHEYTETIDAE Leach, 1815

The family Cheyletidae Leach (1815) represents one of the important families of Trombidiform mites and comprises about 218 species and 54 genera (Fain, 1979a). The cheyletid mites were identified based on their prominent thumb claw complex. The palp tarsus carries sickle and comb like setae and they lack prodorsal sensilla.

The genus *Cheyletomorpha* was erected by Oudemans (1904) with *Acarus lepidopterorum* as type species. Baker (1949) assigned 19 genera to the family Cheyletidae including *Acaropsis, Chelacaropsis, Cheletoides, Cheletogenes, Cheletominrus, Cheletomorpha, Cheletonella, Cheletophanes, Cheletophyes, Chelonotus, Cheletopsis, Cheletosoma, Cheyletus, Cheyletia, Cheyletiella, Eucheyla, Eucheyletia, Eutogenes* and *Neocheyletia*. Cunliffe (1955) placed 4 families in the superfamily Cheletoidea on the basis of number of dorsal shields. Dubinin (1957) made new classification of mites of the superfamilies Cheyletoidea and Demodicoidea. Volgin (1961) divided the family Cheyletidae on the basis of presence of 1 or 2 comb like setae on palp tarsus. The genera lacking comb like setae on palp tarsus were included in the second subfamily Cheletiellinae. Four new species under the genus *Ker* was erected by Zaheer and Soliman (1967) from Egypt. El-Badry (1969) reported two new species viz., *Acaropsis tyrophagus* and *Cheyletus egypticus* from milled wheat from Egypt. Volgin (1969) continued his contribution by mentioning 54 genera of the family Cheyletidae and assigned them into 10 new tribes. While reviewing the family Cheyletidae Smiley (1970) raised the subfamily Cheyletiellinae to the family status, providing a comprehensive review and taxonomic information on the misidentified species. He added 9 new species also under this family.

Subsequently, Smiley and Moser (1970) included 3 new species to this family. Summers and Price (1970) agreed with many of Volgin's opinion but on the basis of new information collected by them from type specimens, they made some changes in the systematics of the family Cheyletidae and accordingly, the family Cheyletidae included 186 species in 51 genera. Corpuz - Raros (1972) erected two new genera viz., *Philippicheyla* and *Tutacheyla* and described and illustrated 8 new species viz., *Hemicheyletia makilingensis, H. scitula, H. transversa, H. uichancoi, Hoffmannita rimandoi, Neocaropsis levis, P. filipina* and *T. robusta* from Philippines. Smiley and Williams (1972) erected a new genus *Neochelacheles* with a single species. A new genus *Chelacaropsis* was erected from stored food by

Attiah (1973) from Egypt. A new species under the genus *Hemicheyletia* viz., *H. reticulata* was reported from Scotland by Jeffrey and Campbell (1975). Summers (1976) erected a new genus *Acaropsellina* with *Acaropsis sollers* as type species, transfers *A. docta* to the new genus and described a new species viz., *A. anarsia* from California. A new genus under *Pavlovskicheyla* viz., *P. platydernae* was described by Thewke and Enns (1976) from Missouri. Qayyum and Chaudhri (1977) described 3 new species under the genus *Cheletomorpha* viz., *C. obrustus, C. tenerum* and *C. opacus* from Pakistan. Smiley (1977) through another publication divided the family into 5 subfamilies viz., Ornithocheyletiinae, Teinocheyletinae, Criokerontinae, Neheliianae and Cheyletiellinae based on differences in habitat, host preference and morphological features. According to him the subfamily Cheyletiellinae contains the genera *Eucheyletiella* and *Cheyletiella*. Soliman (1977) added 3 new species with a key from Egypt. A new genus *Apodicheles* and 3 new species under this genus were erected by Fain (1979a) thereby raising the number of genera to 54 and number of known species to 218. The same author (1979 b) had erected another new genus *Galagocheles* with *Cheyletiella lemuricola* as type species and also reported a new species viz., *Nehelia cynictis* from Afrotropical primates, carnivores and rodents. The same author (1979 c) through another publication reported 3 new species under the genera *Cheletoides* and *Metacheletoides* viz., *M. crinifer, M. gisagarensis* and *C. chirunduensis*. Qayyum and Chaudhri (1979) described 16 new species from

Pakistan under the genus *Hemicheyletia*. Vaivanijkul (1979) recorded a new genus *Polycheyletus* and species *P. boonkongae* from Thailand. Zdarkova (1979) reported the cheyletid fauna associated with stored products in Czechoslovakia.

Fain *et al.* (1980) reported a new species, *Cheyletus tenuipilis*, a house dust mite in Western Europe and Israel. Mathur and Mathur (1981) reported a new species *Hemicheyletia hissariensis* from samples of wheat straw collected from Hissar. Smiley and Whitaker (1981) erected a new genus *Cominocheyletus* with 4 new species. Fain (1984) again added a new species, *Samsinakia gonocephalum* from *Gonocephalum simplex* beetle. Smiley (1984a) described 2 new species under the genus *Ornithocheyletia* from Australia, enhancing the number of nominated species to 24.

Diaz and Goff (1985) added two new speices viz., *Bak elongatus* and *Cheletomimus citrosinensis* and new records of Cheyletidae from Hawaii with a key to the 21 known species. Fain and Lukoschus (1985) had reported a new species under the genus Criokeron viz., *C. thailandicus* from Thailand. Gupta (1985) reported the occurrence of this mites from India and Andamans, the reported species were *Chelacaropsis moorei, Cheletogenes ornatus* and *Cheyletus fortis* collected from aerial parts of various species of plants. Lekprayoon and Smiley (1986) redescribed *Chelacaropsis moorei* along with illustrations of polymorphic males. This mite was collected from garlic field and in storage and was found distributed in Thailand, India, Japan and Egypt. Akbar *et al.* (1988) reported 3 new species viz., *Acaropsis shorkotiensis, Cheletogenes dissitus* and *Cheyletus barides* from Pakistan. Corpuz - Raros (1988) described 4 new species including *Acaropsella filipina* from Philippines stored soyabeans. Putatunda and Kapil (1988) described 7 new species of *Cheletophyes* associated with carpenter bees from India. In 1989 Oliver and Theron had outlined the characteristics of the genus *Microcheyla* and reported 2 new species under this genus viz., *M. paraparvula* and *M. squamosa*.

Two new species under the genus *Acaropsis, A. vitrus* and *A. platessa* were described by Aheer *et al.* (1991) raising the number of nominated species to 12 in the world, out of which 7 were described from Pakistan alone. A new species under the genus *Bak* viz., *B. furcatus* was collected and described by Gerson and Fain (1991) from the hives of *Apis cerana* from Thailand, thus enhancing the number of described species to 9 under this genus. Gupta (1991) described a new species, viz., *Hemicheyletia indica* from North East India. Aheer *et al.* (1992) added 3 new species under the genus *Cheletogenes* viz., *C. sagacis, C. iconis* and *C. carinatus* from Pakistan collected from economically important plants. Two new species under the genus *Cheyletus* viz., *C. ayyazi, C. infensus* were reported from the summer vegetables in Pakistan by Shamshad *et al.* (1993). Again Aheer *et al.* (1994) described 3 new species under the genus *Cheletomimus* viz., *C. cambio, C.*

zamia and *C. larme* from Pakistan. The Chinese fauna of the genus *Cheletogenes* was enriched by Lin and Liu (1994) by reporting a new species of *C. meihuashanense* from bamboos. Gerson (1994) added 2 new species description viz., *C. waitei* and *Philippicheyla notelaeae* from Australia. Lucza *et al.* (1996) added 9 species belonging to 6 genera from ornamental trees and shrubs from Hungary. Further addition to the Pakistan fauna of predatory mites were made by Aheer *et al.* (1997) by reporting descriptions of new species under the genera *Cheletomorpha* and *Ker.* The species described were *C. dolosus* and *K. acidalia.* Lin *et al.* (1997) described *Chelacheles michalskii* and *Chelatacarus raptor* from China. Zdarkova and Pavel Horak (1997) studied the bionomics of *Eucheyletia taurica*, a species new to central Europe.

Aheer *et al.* (1998) again added two new species under the genera *Cheletomimus, C. trema* and *C. flecto* from Pakistan. He also published the phenetic affinities of the species. Corpuz-Raros (1998) described 12 new species from Philippines namely *Alliea prasadi, Chelacheles robustus, Cheletomimus daltoniensis, Eutogenes bakeri, E. cornutus, E. makilingiensis, Hemicheyletia lanceolata, K. mercedesae, K. pintoriensis, Neoeucheyla dua, N. maysa* and *P. philippicana.* He also published a key for 27 genera and 49 species from Philippines as well as a key to world species in 7 genera. From South India Bochkov and Mironov (1998) identified a new species *Samsinakia trilobitus* from a tenebrionid. Shamshad *et al.* (1999) had reported 2 new species under the genus *Acaropsis* viz., *A. venustus* and *A. subitus* from Pakistan on mango and cotton respectively. Ramaraju and Mohanasundaram (1999) described 2 new species of cheyletid mites from Tamil Nadu which included *Cheletophyes xylocopae* and *Samsinakia carabae*. Xia Bin *et al* (1999) identified a new species of the genus *Cheletonella* viz., *C. judlandis* from China. He also published a key to the known species of *Cheletonella* of the world. Corpuz - Raros (2000) reported two new species and a new record of *Bak* from Philippines viz., *B. faini* and *B. gersoni*. Fain and Ardeshir (2000) reported a new species under the genus *Neoeucheyla* from Iran viz., *N. iranica*. In 2000, Farooq *et al.* reported two new species under the genus *Cheyletus*, *C. mianiensis* and *C. rafiquiensis* from Pakistan.

1.3. Family CUNAXIDAE Thor, 1902

Thor (1902) erected the family Cunaxidae to include mites having 4 palpal segments which were previously placed in the family Bdellidae. Hermann (1804) erected the genus *Scirus* and described *S. setirostris* as the first species to this family. Von Heyden (1826) erected the genus *Cunaxa* for *S. setirostris* based on the presence of 4 palpal segments and that character was used as the generic character for *Cunaxa*. There after the actual cunaxid species described were assigned to *Scirus* by Koch (1839), Kramer (1881) and Berlese (1910).

Thor (1902) created the family Cunaxidae to hold the two species described by Koch earlier, under the family Bdellidae viz., *Eupalus vitellinus* and *E. croceus* and one genus *Scirula* and two species *Coleoscirus curtipalpis* and *Cunaxa capreolus* described by Berlese and one of Kramer's species, *Armascirus taurus*. However neither Koch (1839), Thor (1902) nor Thor and Willmann (1941) realized that the name *Eupalus* was preoccupied. Berlese (1910) continued to use the name *Scirus* for two undescribed cunaxids. Thor and Willmann (1941) made the first comprehensive study of the family, recognising 7 genera and 30 species. During the study of Baker and Hoffmann (1948) on the family Cunaxidae, only 3 genera (*Cunaxa, Bonzia* and *Scirula*) were existing and they proposed replacement names *Cunaxoides* and *Eupalus*. After their monographic study, most of the work on this family was done by American acarologists for several decades.

Later Radford (1950) proposed the names *Haleupalus* and *Eupalus*. These names were not valid since they were preoccupied. Atyeo (1958) described the first cunaxid taxon that showed a definite relationship to the family Bdellidae and provided positive taxonomic features to include Cunaxidae under superfamily Bdelloidea. Meyer and Ryke (1959) also reported several cunaxids occuring on plants in South Africa.

Schruft (1971) erected a new species under the genus *Haleupalus* viz., *H. oliveri* on grape vine from Germany. Den Heyer (1975) erected a new genus

Cunabdella from the Ethiopian region. Smiley (1975) revised the generic classification and established 4 new genera, viz., *Parabonzia, Pseudobonzia, Neocunaxoides* and *Pseudocunaxa* (*Coleoscirus*). Again Den Heyer (1976) added another new genus *Scutascirus* from South Africa. Six new species of *Pseudobonzia* were described from South Africa by Den Heyer (1977). He also redescribed the generic characters of *Pseudobonzia* and supplemented a key to the South African species. The same author (1978 a) erected the subfamily Bonziinae. Four new species under a new genus *Armascirus* were described from the Ethiopian region by the same author (1978 b). Chaudhri (1979) reported many new species from Pakistan. Den Heyer (1979a) continued his contribution by adding the description of a new genus *Rubroscirus* and 3 new species from the Ethiopian region viz., *R. africanus, R. vestus* and *R. rarus*. The same author through another publication (1979b) erected 4 new species under the new genus *Armascirus*. He again (1979c) erected a new subfamily Coleoscirinae and described 2 new South African species of *Coleoscirus*. Again the same author (1980 a) described 3 new Afrotropical *Neocunaxoides* viz., *N. lajumensis, N. rykei* and *N. zuluensis*. Further he (1980 b) reported 6 new species under the subfamily Coleoscirinae from the Republic of South Africa viz., *Coleoscirus buartsus, C. breslauensis, C. coatesi, Scutascirus braziliensis, Pseudobonzia smileyi, Neoscirula delareyi* and also synonymized *Coleoscirus magdalenae* with *C. simplex*. Through another publication the same author (1980 c) reported a new genus *Scutopalpus* and two new species viz., *S. latisetosus* and *S. arboreus* from Ethiopian region. Again the same author (1980d) erected a new genus *Pulaeus*. Most of the taxa published by him were known from the African region only. Gupta and Ghosh (1980) reported 4 new species under the genus *Cunaxoides* viz., *C. nicobarensis, C. myabunderensis, C. cynodonae* and *C. bambusae* from Andaman and Nicobar islands. The same authors described a new species viz., *Neocunexoides pradhani* and a new genus *Indocunaxa* with *I. smileyi* as type species. Den Heyer (1981) erected 8 new Afrotropical species under the genus *Cunaxoides*. El-Bishlawy and Rakha (1983) described a new *Pulaeus* species from Egypt viz., *P. zaherii*. From China, Liang (1983) published new taxa under the genera *Pseudobonzia* and *Pulaeus* and gave notes on 4 species.

During the period (1969-1984) the Cunaxidae received considerable attention from acarologists around the world. The important papers included works on the biology, taxonomy, systematics and classification. A list of such works were compiled by Sepasgosarian (1984), which dealt with 124 species belonging to 4 subfamilies, 6 tribes and 17 genera. Liang (1985) described new taxa under the genera *Pseudobonzia* and *Pulaeus* and reported 2 African species viz., *P. themedae* and *Cunaxa africanus* from China. Bu and Li (1987) published two new taxa belonging to genus *Pulaeus* and erected the subfamily Orangescirulinae.

Inayatullah and Shahid (1989) made further addition to the family by reporting two new species under *Neocunaxoides* viz., *N. dilato* and *N. kalamiensis* from Pakistan.

Again Gupta (1991) reported 3 new species viz., *Cunaxa crista, C. curassavica* and *Neocunaxoides cerasoides* from North East India. Muhammad and Chaudhri (1992) made further addition to the family by publishing two new species under the genus *Coleoscirus* viz., *C. carnus* from pear and *C. disparis* from rice from Pakistan. Smiley (1992) provided a comprehensive treatment of the family Cunaxidae with a new classification and proposed 3 new subfamilies thereby dividing the family into 9 subfamilies viz., Bonziinae, Coleoscirinae, Cunaxiinae, Cunaxoidinae, Denheyernaxoidinae, Neobonzinae, Orangescirulinae, Paracunaxoidinae and Scirulinae. Thirtynine new species and 127 nominal species under 17 genera were reported, of these 3 were new viz., *Denheyernaxoides, Neobonzia* and *Paracunaxoides.*

Three new species of the genus *Pseudocunaxa* viz., *P. kifayati, P. mardi* and *P. carex* were described from Pakistan by Inayatulla and Shahid (1993) from banana, rice and rotten leaves respectively. In addition, a key to the species of *Coleoscirus* in Pakistan, a table comparing their characteristics, a similarity matrix and phenogram were presented. Corpuz Raros (1996) studied the Philippine Cunaxidae and reported 7 species under the genus *Pulaeus.* Two species under the genus *Pseudobonzia* and 3 species under the genus *Scutascirus* were taxonomically treated by Corpuz-Raros and Garcia (1996) from Philippines, of these 3 were new to science.

1.4. Family BDELLIDAE Duges', 1834

Family Bdellidae Duges' (1834) constitutes a large family of active, red, reddish brown or green mites preying upon small arthropods or their eggs. Ewing and Webster (1912) reported 4 species of *Bdella* and *Cyta* feeding on *Lepidosaphus ulmi*. Baker and Balock (1944) reported several new species of Bdellidae from Western hemisphere besides erecting the new genus *Monotrichobdella*. The reported species were *M. maxosburni, Biscirus lapidarius, B. chaupultepecensis, B. riolermensis, B. cronini, B. virgata, B. distincta, B. oblonga, B. mexicana* and *B. willisi* collected mostly from lichens, mosses and other economically important plants. Atyeo (1960) revised the family Bdellidae from North and Central America. Soliman and Zaher (1975) described 8 species out of which 3 were new to science, key to the species was also presented. Tseng (1978) identified 14 species under 5 genera of which 6 were new to science and 7 were new records from Taiwan. Chaudhri *et al.* (1979) reported the occurrence of 3 species of bdellids from Pakistan namely, *B. muscorum, Spinibdella depressa* and *B. arenarius* collected from banana and plant debris. Gupta and Ghosh (1980) reported a species under the genus *Bdellodes* from Andaman Islands on black berry viz., *B. (Haploscirus) procincta*. Sorensen *et al.* (1983) made biological observation on *B. longicornis* from California. Kuznetsov (1984) described 2 new species of bdellids from Crimea and central Asia viz., *Neomolgus longipalus* and *Spinibdella tadjikistanica*. Gupta (1985) reported the occurrence of only one species, *Bdellodes* (*Haploscirus*) *affinis* collected from *Areca catechu* from India. Swift and Goff (1987) identified 6 new species from Hawaiian Islands viz., *Bdella nihoaensis, Bdellodes hygrotes, Bdella haramotoi, Cyta kauaiensis, Spinibdella bioculata* and *S. howarthi*. *Bdella captiosa, Bdella mexicana, Bdellodes meridonalis, S. depressa* and *S. thori* were new records from the Island. The same authors (1989) reported a total of 14 species of bdellid mites from Hawaiian Islands of which 5 were new records. Gupta (1991) identified 3 new species from North East India under the genus *Bdella* viz., *B. khasyana, B. atro* and *B. angustifolius* and 2 species under the genus *Bdellodes* viz., *B. manipurensis* and *B. grandiflora*.

1.5. Family STIGMAEIDAE Oudemans, 1931

The family Stigmaeidae was erected by Oudemans (1931) with *Stigmaeus* as its type genus. Nearly 35 years later Gonzalez (1965) prepared a comprehensive key including 13 genera belonging to this family. Summers (1966) provided a key to 14 genera of the family along with characters of each genus. Later Gonzalez (1967) and Meyer (1969) added one genus each to the family from Australia and New Zealand, while Wood (1971) erected 3 genera from South Africa. This raised the number of genera to 19 under the family. So far, more than 200 species were described under the superfamily Raphignathoidea, of which more than 60% belong to the family Stigmaeidae.

Andre (1977) further expanded the family by describing a new species under the genus *Mediolata* viz., *M. mariaefraneae* from Belgium and reviewed the literature on the systematics, ecology and distribution of species described in the above genus. Kuznetsov (1977) erected a new genus *Postumius* with *P. tectus* as type species and also described a new species under the genus *Mediolata* viz., *M. conserva* from U.S.S.R. Other new additions included *S. corticeus* under the genus *Stigmaeus* and *A. gratus* and *A. herbarius* under the genus *Apostigmaeus* from Soviet Union by Kuznetsov and Vainshtein (1977). While revising the species of the genus *Stigmaeus*, Kuznetsov (1978) recognised 112 species from U.S.S.R., of which 7 were new from that country.

Chaudhri *et al.* (1979) recorded 7 species under 3 genera, viz., *Apostigmaeus, Mediolata* and *Cheylostigmaeus* from various crop plants, of which 6 were new to science. Another major work on the systematics of this family was that of Tseng (1982) who published 25 species from Taiwan, including 15 new species and one new genus. He transferred *Agistemus terminalis, A. exsertus* and *A. fleschneri* to the genus *Zetzellia* and provided a key to the world genera. Ehara and Oomen (1983) described 5 new species from tea plants, belonging to *Zetzellia* and *Agistemus* from Indonesia. Bolland and Ueckermann (1984) reported a new species, *A. camerounensis* from Cameroun, Africa and provided a key to the females of the African species of *Agistemus*. Ehara and Wongsiri (1984) described 4 new species of stigmaeid mites from Thailand, viz., *Eringiopus yusumatsui* under the genus *Eringiopus, A. thaianus, A. giganteus* and *A. siamensis* under the genus *Agistemus* and also recorded *A. terminalis* for the first time from that country. Rakha and Mc Coy (1984) described a new species *Eryngiopus citri* from the foliage of citrus from Florida. Gupta (1985) reported the occurrence of the stigmaeid mites in India belonging to the genus *Indostigmaeus* viz., *I. rangatensis* and species like *A. industani* and *A. fleschneri* under the genus *Agistemus* collected from economically important plants. Swift *et al.* (1985) reported a new species *Eustigmaeus kauaiensis* from *Hibiscus tiliaceus* from Hawaiin Islands. Liang and Hu (1987) described 3 new species of the genus *Stigmaeus* viz., *S. macroposbus, S. longisetosus* and *S. pseudoluteus* from China. A new species *S. sinai* was reported from Phlebotomine flies under the genus *Stigmaeus* by Swift (1987). Vacante and Gerson (1987) raised 3 new species under the genus *Eryngiopus* viz., *E. siculus, E. summersi* and *E. bifidus* from Italy. Bolland (1988) described *A. tranatalensis* and *Eupalopseiulus brevipilus* for the first time from Kenya and also reported a new species *Exothorhis kenyae*.

Gupta and David (1990) reported a new species of *Eryngiopus, E. coimbatorensis* from Tamil Nadu, India. Gupta (1991) extended his studies to

North East India and reported 9 new species under the genus *Agistemus* viz., *A. aramatai, A. obscura, A. lakoocha, A. heterophylla, A. hystrix, A. exsertus, A. gavanicum, A. edulis* and *A. gamblei*. Akbar *et al.* (1993) described a new species under the genus *Agistemus* from Pakistan viz., *A. nagrii* from *Momordica charantia*. Flechtman (1995) erected a new species *A. tariloby* from bamboo leaves from Brazil. Zhang and Gerson (1995) described a new species *Eustigmaeus johnstoni* which was parasitic on Phlebotomine sand flies. Hu (1996) described a new species under the genus *Zetzellia* viz., *Z. huaxiensis* from Pomegranates in China. Two new species under the genus *Agistemus* was described by Fan *et al.* (1997) from China. Fan and Yan (1997) further described new species under the genus *Storchia* viz., *S. cuneata*. Hu *et al.* (1997) described a new species under the genus *Agistemus* viz., *A. pinus* from *Pinus* sp. from China. Fan and Liu (1999) historically reviewed the genera *Ledermuelleriopsis* and *Pseudostigmaeus* and described 2 new species viz., *L. verricula* under the bark of *Pinus massoniana* and *P. ueckermanii* from the foliage of *Cryptomeria fortunei* from China. Kapaxidi and Papadoulis (1999) reported 5 species of stigmaeid mites from Greece, of which *Eustigmaeus ioanninensis* as new to science.

MATERIALS AND METHODS

Mary Anithalatha Sadanandan "Studies on acarine predators of North Kerala "
Thesis. Department of Zoology , University of Calicut, 2002

CHAPTER 2
MATERIALS AND METHODS

The predatory mite fauna harbouring various species of economically important plants and stored items were collected by making extensive surveys covering different localities in 6 districts of Northern Kerala.

2.1. Sampling Localitis

The fauna of predatory mites included in the present study were collected from various species of economically important plants cultivated in 6 districts of Northern Kerala (Plate 1). The districts covered during the period of survey included Kasaragod, Kannur, Wayanad, Kozhikode, Malappuram and Palakkad. In Kasaragod district (Plate 2; Fig. 1 and 2), Nileswaram and Uduma were the two sites. The study area in Kannur district (Plate 2; Fig. 3 and 4) were Payyannur, Dharmadam, Thalassery and Anjarakandy. Wayanad district (Plate 2; Fig. 5, 6 and 7), one of the very attractive districts of Kerala specially known for the occurrence of virgin forest ecosystem, 4 localities viz., Agricultural Research station Ambalavayal, Mananthavady, Vythiri and Kalpetta were surveyed for the occurrence of predatory mites. In Kozhikode district (Plate 3; Figs. 1, 2, 3 and 4) Madappally, Vatakara, Puthuppanam, Kuttiadi, Coconut Nursery Thikkodi, Quilandy, Agricultural Farm Koothali, Indian Institute of Spices Research

PLATE 1

MAP OF KERALA SHOWING COLLECTION SITES

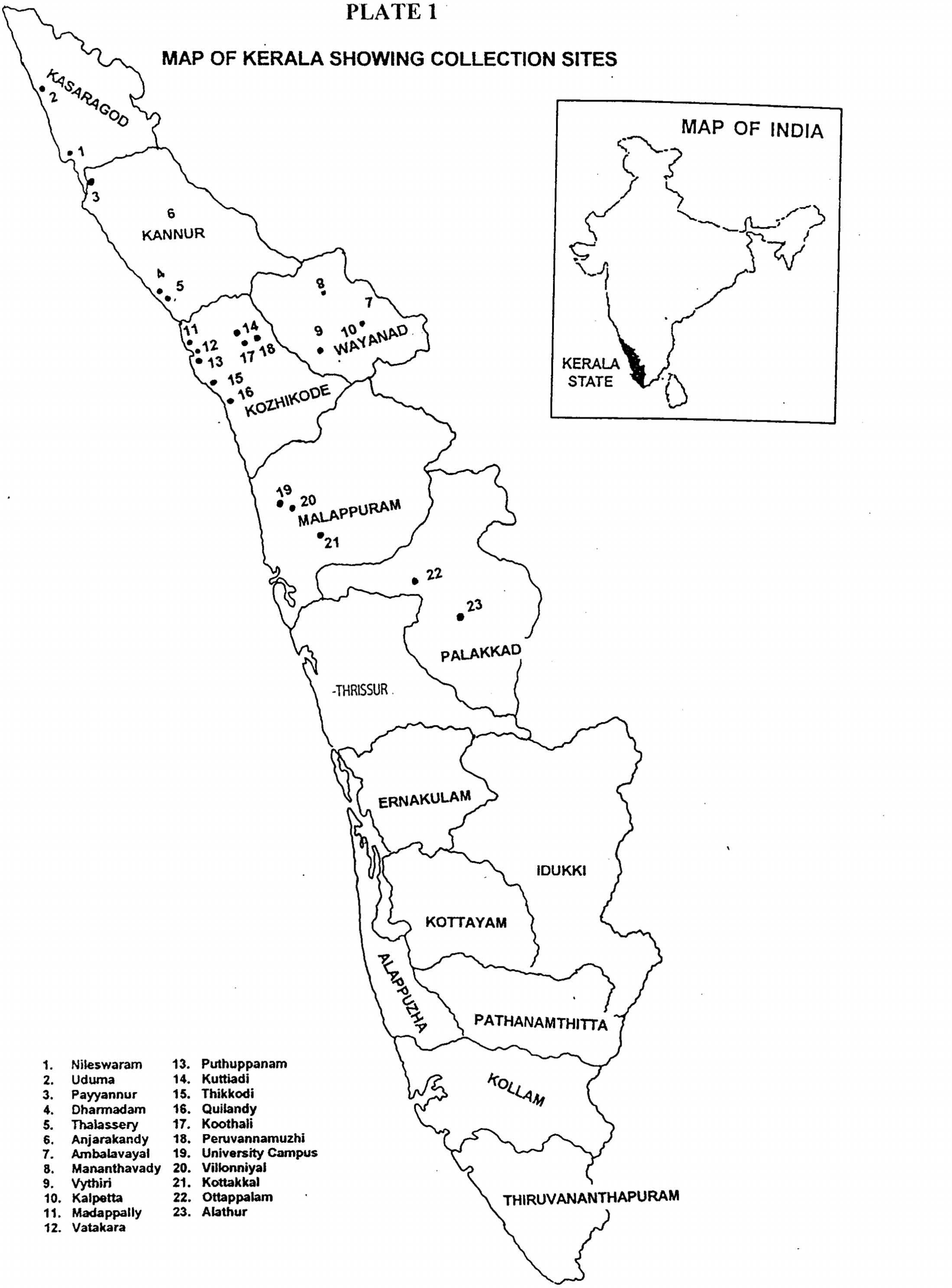

PLATE 2

Figs. 1-7. Collection sites at Kasaragod, Kannur and Wayanad districts

Fig. 1. Nileswaram – Kasaragod

2. Uduma – Kasaragod
3. Anjarakandy – Kannur
4. Payyannur – Kannur
5. Vythiri – Wayanad
6. Kalpetta – Wayanad
7. Mananthavady – Wayanad

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PLATE 3

Figs. 1-10. Collection sites at Kozhikode, Malappuram and Palakkad districts

Fig. 1. Koothali – Kozhikode

2. Puthuppanam – Kozhikode
3. Vatakara – Kozhikode
4. Kuttiadi – Kozhikode
5. Villonniyal field – Malappuram
6. C.U. Campus – Malappuram
7. Villoonniyal field – Malappuram
8. C.U. Campus – Malappuram
9. Alathur – Palakkad
10. Ottappalam – Palakkad.

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PLATE 3

Experimental Garden Peruvannamuzhi etc. were the collection sites. Calicut University Campus, the centre of the present investigation was one of the major collection sites in Malappuram district (Plate 3; Figs. 5, 6, 7 and 8). The other localities were agricultural and vegetable fields of large scale cultivation situated at Villonniyal, Ayurvedic Herbal Garden of Kottakkal Arya Vaidya Sala, Kottakkal etc. In Palakkad district (Plate 3; Figs. 9 and 10), Ottappalam and Alathur were the two sampling sites.

A detailed survey was conducted to find out the association of predatory mites with various stored items in Kozhikode and Wayanad districts. In Kozhikode district, Government and Private warehouses, grocery shops, godowns, houses in urban and rural areas, dry fish godowns etc. were surveyed. In Wayanad district, godowns situated in Vythiri and Mananthavady were the major collection sites.

2.2. Plants surveyed

The range of flora from which the predatory mites were collected included small herbs, bushes, creepers, tall trees, field crops and horticultural crops of all stature and different phenology cultivated in varied agroecosystems. Table 1 provides information on the various species of plants surveyed in different districts of Kerala during the period of study. A total of 55 species belonging to 50 genera and 35 families were surveyed. They comprised fruit crops, vegetables, tuber crops, medicinal plants, beverages, spices, condiments and resins, oil yielding plants, flowers and masticatories.

2.3. Stored items surveyed

Table 2 provides information on the various species of stored items surveyed during the present study for the presence of predatory mites. They included stored grains, spices, beverages, masticatory items, tuber crop, oil seeds and stored dry fish etc.

2.4. Methods of Collection

Samples containing leaves, twigs, petioles, flowers etc. were randomly collected with the aid of scissors or blade from different heights of the plants. Sampling was usually done during morning hours. The number of plant parts examined from individual plant varied according to their nature and texture. Twenty to thirty leaves were usually collected from each plant, but when the leaves were remarkably large their numbers were reduced accordingly. The plant materials thus collected were taken in clean polyethylene bags with proper labelling and screened in the laboratory under a stereozoom binocular microscope. Utmost care was taken while handling the samples during collection and transportation.

Mites from stored products recovered by collecting representative samples of stored commodities for further extraction/isolation in the laboratory. Random samples of 100 - 200 gms. of various stored items as well as sweepings from storage godowns were collected in polyethylene bags and brought to the laboratory for extraction of mites.

TABLE 1

List of plants surveyed for the collection of predatory mites

Economic Category	Scientific name	Family
Fruit crops	*Achras sapota* L.	Sapotaceae
	Anacardium occidentale L.	Anacardiaceae
	Annona squamosa L.	Annonaceae
	Artocarpus incisa L.	Moraceae
	Artocarpus integrifolia L.	Moraceae
	Carica papaya L.	Caricaceae
	Citrus limon L.	Rutaceae
	Cucumis melo L.	Cucurbitaceae
	Mangifera indica L.	Anacardiaceae
	Morus alba L.	Moraceae
	Musa paradisiaca L.	Musaceae
	Psidium guajava L.	Myrtaceae
	Syzygium jambos (L.) Alston	Myrtaceae
	Syzygium malaccense L.	Myrtaceae
Vegetables	*Abelmoschus esculentus* L.	Malvaceae
	Amaranthus viridis L.	Amarantaceae
	Canavalia ensiformis Duchesne	Papilionaceae
	Cucurbita maxima Duchesne	Cucurbitaceae
	Dolichos lablab L.	Leguminaceae
	Ipomoea muricata L.	Convolvulaceae
	Luffa acutangula L.	Cucurbitaceae
	Momordica charantia L.	Cucurbitaceae
	Phaseolus vulgaris L.	Leguminaceae
	Pisum sativum L.	Papilionaceae
	Solanum melongena L.	Solanaceae
	Trichosanthes anguina L.	Cucurbitaceae
Medicinal plants	*Adhatoda beddomei* Clarke	Acanthaceae

	Citrus medica Willd.	Rutaceae
	Ficus racemosa L.	Moraceae
	Piper longum L.	Piperaceae
	Saraca asoca (Roxb.) De Wilde	Caesalpiniaceae
	Scaevola taccada L.	Goodeniaceae
	Tinospora cordifolia Miers	Menispermaceae
Condiments and Spices	*Capsicum annum* L.	Solanaceae
	Cinnamomum zeylanicum Breyn	Lauraceae
	Elettaria cardamomum Maton	Zingiberaceae
	Murraya koenigii (L.) Spreng.	Rutaceae
	Myristica fragrans Houth	Myristicaceae
	Piper nigrum L.	Piperaceae
	Syzygium aromaticum (L.) Alston	Myrtaceae
	Vanilla planifolia Andr.	Orchidaceae
	Zingiber officinale Roxb.	Zingiberaceae
Tuber crops	*Amorphophallus companulatus* Blume.	Araceae
	Colocasia esculenta Schott	Araceae
	Dioscorea alata L.	Dioscoreaceae
	Manihot esculenta Crantz	Euphorbiaceae
	Maranta arundinaceae L.	Marantaceae
Beverages	*Coffea arabica* L.	Rubiaceae
	Theobroma cocoa L.	Sterculiaceae
Flowers	*Jasminum gradiflorum* L.	Oleaceae
	Rosa indica Hook.	Rosaceae
Oil yielding plants	*Cocos nucifera* L.	Palmae
	Ricinus communis L.	Euphorbiaceae
Masticatories	*Areca catechu* L.	Palmae
Resins	*Vathria indica* L.	Dipterocarpaceae

TABLE 2

List of stored items surveyed for the collection of predatory mites

Sl. No.	Common names	Scientific names
1.	Black gram	*Phaseolus mungo* L.
2.	Green gram	*Phaseolus aureus* Roxb.
3.	Horse gram	*Dolichos biflorus* L.
4.	Red gram	*Cajanus cajan* Druce
5.	Rice	*Oryza sativa* L.
6.	Wheat	*Triticum aestivum* L.
7.	Garlic	*Allium sativum* L.
8.	Arecanut	*Areca catechu* L.
9.	Cassava	*Manihot esculenta* Crantz
10.	Ginger	*Zingiber officinale* Roxb.
11.	Copra	*Cocos nucifera* L.
12.	Coffee berries	*Coffea arabica* L.
13.	Dry fish	*Ophiocephalus* sp.

2.4.1. Hand picking

Hand picking of mites directly from the habitats with the help of a fine moistened camel hair brush was the most common method adopted during the study. This method was followed in the case of fairly big sized, fast moving and bright coloured mites of the families Cheyletidae, Cunaxidae, Bdellidae and Stigmaeidae. The mites of these families were often isolated by the collection of plant materials/stored products which were screened in the laboratory. This was found to be not only rapid but also more effective as there was no chance to miss the predatory mites. Occassionally when the samples could not be processed immediately, those were stored in a refrigerator at a temperature of 5-15°C for 7 to 10 days.

2.4.2. Beating

Beating method was generally adopted for the collection of predatory mites directly from the field. The mite infested plant parts were beaten over a dark coloured rexin sheet and the mites thus dislodged were picked up with a moistened camel hair brush. The mites picked up were placed in 70% alcohol containing a few drops of lactic acid and glycerine.

2.4.3. Extraction

The samples of stored items were placed in modified Berlese funnels constructed locally for the purpose and subjected to extraction for 24 hours under 40 watts electric bulbs. The mites thus got extracted out of the samples through the funnels were collected in 70 percent ethyl alcohol.

2.5. Clearing and mounting of mites

For taxonomic studies, the mites preserved in 70 percent alcohol were upgraded through alcohol series. When the mites were completely dehydrated, they were transferred from absolute alcohol to the clearing medium prepared by mixing lactic acid and alcohol in 1:1 ratio. In the case of hard bodied mites and those with undigestable internal contents, were processed in lactophenol, having the following composition:

Lactic acid	-	2 parts
Phenol crystals	-	1 part
Distilled water	-	1 part

The specimens were placed in lactophenol for 48-78 hours to digest and clear the internal contents. After the treatment with lactophenol, the specimens were thoroughly washed 3 or 4 times with distilled water until the cloudy interference of lactophenol disappeared.

2.5.1. Preparation of mounting medium

Hoyer's medium

Hoyer's medium was prepared by careful and proper mixing of the following ingredients in the order given below. It was then filtered through cotton wool.

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

2.5.2. Preparation of permanent slides

Predatory mites either from a preservative or live were mounted in this mounting medium with out any pre-treatment, since the mites were found cleared directly in the medium itself. Usually two to five specimens were mounted on each slide. The specimens were pressed to the bottom of the slide and legs spread to the lateral positions. The specimens were mounted in the dorsal and ventral positions on the same slide. In the case of phystoseiid mites the specimens were mounted laterally also to ensure a better view of the spermatheca which was important for generic and specific determination. Some large sized mites required a small body puncture to eliminate gut contents for quicker clearing.

After mounting, the slides were kept in an oven at 45-50°C or under a table lamp for atleast 24 hours which hastened the clearing process and subsequent drying of the slides. The slides were then labelled and numbered serially for identification. Data on host, locality, collector's name, date of collection and slide number were given on the label apart from the name of the species. To avoid damage to the specimens due to excessive moisture or drying, the edges of the cover glass were sealed with nail polish.

2.6. Identification of mites

Identification of the slide mounted specimens was made under a Meopta Research Microscope as well as Carl Zeiss Research Microscope. The dorsum, ventrum, shields, chelicera, spermatheca in females, spermatophoral process in males, peritreme, legs etc. were studied and figures were drawn using Wild Leitz GMBH camera lucida attached to the microscope. The measurements of all structures with systematic importance were made with an ocular micrometer. Microphotographs of some of the important characters were taken using phase contrast system of a Meopta Research Microscope. Systematic position of individual species was assessed following. Gupta (1986, 1987), Smiley (1992) and recent literature and also seeking opinion from experts. The setal nomenclature suggested by Rowel *et al.* (1978), Chant and Yoshida-Shaul (1989, 1991 and

1992a) as well as the leg chaetotaxy of Evans (1963) was followed in this study. All measurements were given in microns.

The following abbreviations were used in the figures showing morphological and taxonomical features to denote the various structures and parts.

C_f	-	Chelicera of female
C_m	-	Chelicera of male
DD	-	Dorsal view of deutonymph
DF	-	Dorsal view of female
DL	-	Dorsal view of larva
DM	-	Dorsal view of male
DP	-	Dorsal view of protonymph
DS	-	Dorsal body seta
DG	-	Dorsal view of gnathosoma
L1 to L IV	-	Leg 1 to IV showing setation
Mp	-	Metapodal plate
Sp	-	Spermatheca
Tt	-	Tarsal tip of Leg I
VD	-	Ventral view of deutonymph
VF	-	Ventral view of female
VL	-	Ventral view of larva
VM	-	Ventral view of male

VP - Ventral view of protonymph

VG - Ventral view of gnathosoma.

The slides of all type specimens have been deposited in the Division of Acarology, Department of Zoology, University of Calicut, Kerala, India.

OBSERVATION

CHAPTER 3
OBSERVATION

During the present study predatory mites harbouring 55 species of plants belonging to 50 genera and 35 families (Table 1) were collected and examined for studying their taxonomic characters. Apart from this, different types of stored items (Table 2) collected from various godowns were also examined for the presence of associated predatory mites. Table 3 supplements the details of the plants surveyed from various localities of North Kerala and the different species of predatory mites collected from individual plant species. As illustrated in table 3, a total of 45 species belonging to 9 genera, 7 subgenera and 5 families were collected under 2 suborders viz. Mesostigmata and Prostigmata. Of these, 20 species belonging to 5 genera and 5 subgenera appeared to be new to science. The predatory families recorded during the study were Phytoseiidae, Cheyletidae, Cunaxidae, Bdellidae and Stigmaeidae (Plate 4 and 5). As shown in Plate 4 and 5 Phytoseiidae included 32 species (72%), Cheyletidae – 6 (13%), Cunaxidae – 3 (7%), Bdellidae - 2 (4%) and Stigmaeidae – 2 (4%).

The mesostigmatid mites recovered during the study could be categorized under a single family Phytoseiidae, which was found exhibiting the maximum diversity with respect to genera, subgenera and species. This was quite evidenced by the recovery of 32 species out of the 45 collected of which 12 species appeared to be new taxa. Eleven out of the 12 new species were collected from various plants as mentioned in table 3, while the remaining one species, *A.(A.) coffeae* was collected from coffee berries stored for 2 years.

The 32 species mentioned above could be categorised under 3 subfamilies viz. Amblyseiinae, Cydnodromellinae and Phytoseiinae under the family Phytoseiidae. As presented in Table 3 the above 3 subfamilies included 3 genera and 7 subgenera. The genus *Amblyseius* belonging to the subfamily Amblyseiinae was the dominant one represented by 6 subgenera and 30 species (Plate 6) thereby forming the most abundant genus of predatory mites surveyed during the study. The other genera recorded under Phytoseiidae were *Platyseiella* and *Typhlodromus* belonging to subfamilies Cydnodromellinae and Phytoseiinae respectively. The subgenera (Plate 7) recorded under the genus *Amblyseius* were *Amblyseius, Euseius, Neoseiulus, Paraphytoseius, Typhlodromalus* and *Typhlodromips* represented by 15, 7, 3, 2, 1 and 2 species respectively. The subfamilies Cydnodromellinae and Platyseiinae were represented by a single species each. *Platyseiella mumai* and *Typhlodromus (Amblydromella) bambusicolus* were the respective species recovered under the above two subfamilies.

The suborder Prostigmata was found represented by members of 4 families viz., Cheyletidae, Cunaxidae, Bdellidae and Stigmaeidae. However species and generic diversity under each of the above families were comparatively very low than that of Phytoseiidae. The family Cheyletidae formed the second with respect to species diversity accommodating 6 species (Plate 4 and 6) under a single genus, *Cheyletus*, of which 4 appeared to be new. The new species collected were *C. arecae, C. calicunsis, C. ichthyus* and *C. rosensis*. Of the 6 species of cheyletid mites encountered during the present study 5 were collected from the various stored items surveyed, whereas *C. rosensis* sp. nov. could be collected from two plants viz. *R. indica* and *C. nucifera*. This species was found in association with white flies on both of the host plants. The cheyletid mites collected from stored items were seen associated with acarid mites, beetles and weevils commonly present in stored ecosystems.

The family Cunaxidae (Plate 4 and 6) was found represented by 3 species categorised under 2 genera viz. *Cunaxa* and *Dactyloscirus* comprising 2 and 1 species respectively, under a single subfamily Cunaxiinae. The study enabled to recognize 2 species under the genus *Bdella* of the family Bdellide (Plate 4 and 6). Two species of mites belonging to Stigmaeidae were also collected during the period of study, one each under the genera *Agistemus* and *Apostigmaeus* (Plate 4 and 6). Both the species were recognized as new taxa, on detailed taxonomic study.

The predatory mites studied during the present investigation were found exhibiting a general preference to the lower surface of the leaves. This was particularly true for members of Phytoseiidae, Cunaxidae, Bdellidae and

Stigmaeidae. Cunaxid mites could be collected from both surfaces of leaves. Phytoseiids were found occupying the upper surface of the leaves very rarely. The preference to lower surface was seen as a general trend irrespective of variations in leaf texture of host plants. However the occurrence and population density of these mites on their respective host plants showed variations with respect to the age of the plant examined, time of cultivation (particularly in the case of vegetables) and the season of the year. The relative distribution pattern and species diversity of predatory mites on individual host plant often showed considerable variation. However, these mites were not found exhibiting any host specificity. This was true for both the plants and stored items examined during the current study.

Generally the distribution of predatory mites was found influenced by the distribution pattern of the prey mites, irrespective of the supporting ecosystem ie. plants/stored items. *A. (N.) longispinosus* was recognized as the species with maximum diversity in distribution by colonising 8 species of plants (Table 3). The second species in this category was *A. (A.) indirae* followed by *A. (E.) finlandicus*. A similar diversity was often noted in the case of plants also, where the maximum species complexity of predatory mites was seen on coconut palm which supported 7 species. All the remaining species possessed comparatiely lesser degree of host selection. Twenty out of the 45 species examined were found confined only to a single species of host plants/stored items.

A. (N.) longispinosus was recognized as the species with wide distribution pattern and maximum population density on *M. esculenta* and *C. nucifera*. The different life stages of this mites were found distributed on the above plants under field conditions. All stages appeared very active in the field as well as in the laboratory. Evidence of feeding was observed in the case of adult and nymphal stages when *T. neocaledonicus* were offered as prey in the laboratory. Females of this species oviposited on the leaf surface, mainly near the mid rib and veins. Similarly, results of field sampling in most instances revealed the abundance of *A. (N.) longispinosus* and *A. (E.) finlandicus* on the tuber crop *M. esculenta* though these species were collected from other plants also. In most sampling occassions, a good number of eggs, immatures and adults of these species could be collected from the leaves of the above plant. A single mite infested cassava leaf collected from the field often revealed the presence of 20-25 life stages of these predatory mites.

The predatory mites examined during the present study were found associated with other mites, particularly the tetranychids, tenuipalpids, tarsonemids, eriophyids and so on. Besides, several insect associates also were evidenced in field condition like the staphylinid beetles, coccinellids, aphids, coccids etc. The cheyletid mite *C. ichthyus* sp. nov. was found feeding on the eggs of *Necrobium* species. The stigmaeid species, *A. chelavurensis* sp. nov. was found predating on tenuipalpid mites on *M. alba*.

TABLE 3

Distribution of predatory mites with respect to host plants and stored products in various localities of North Kerala

	Species	Host plant / stored item	Location of collection	District
	Family : PHYTOSEIIDAE Berlese, 1952			
	Subfamily : Amblyseiinae Muma, 1961			
1.	*Amblyseius (Amblyseius) adhatodae* Muma, 1967	*Vanilla planifolia*	I.I.S.R. Exp.Garden, Peruvannamuzhi Vythiri	Kozhikode Wayanad
2.	*A. (A.) aerialis* (Muma), 1955	*Citrus limon*	Anjarakandy	Kannur
		Citrus medica	Ottappalam	Palakkad
3.	*A. (A.) amorphalae* sp. nov.	*Amorphophallus companulatus*	Dharmadam	Kannur
4.	*A. (A.) bhadrakshae* sp. nov.	*Scaevola taccada*	Ayurv. H.G.K.A.V.S., Kottakkal	Malappuram
5.	*A. (A.) channabasavannai* Gupta and Daniel, 1978	*Cocos nucifera*	C.U. Campus All the districts surveyed	Malappuram
6.	*A. (A.) coffeae* sp. nov.	*Coffea arabica* (stored)	Mananthavady Vythiri	Wayanad Wayanad
7.	*A. (A.) indirae* Gupta, 1985	*Cucurbita maxima,*	Dharmadam	Kannur
		Z. jambos, Z. malaccense, Cucumis melo, Cocos nucifera, Piper longum, Anacardium occidentale	All the districts surveyed	
8.	*A. (A.) koothaliensis* sp. nov.	*Carica papaya*	Agri. Farm, Koothali	Kozhikode
9.	*A. (A.) kundurukkae* sp. nov.	*Vathria indica*	Ayurv. H.G.K.A.V.S., Kottakkal	Malappuram

10.	*A. (A.) largoensis* (Muma), 1955	*Mangifera indica*	Nileswaram	Kasaragod
		Piper nigrum	Kalpetta	Wayanad
11.	*A. (A.) malabarensis* sp. nov.	*Areca catechu*	Madappally	Kozhikode
		Ficus recemosa, Saraca asoca	All the district surveyed	
12.	*A. (A.) mohanasundarami* sp. nov.	*Dioscorea alata*	West Hill	Kozhikode
13.	*A. (A.) muraleedharani* Gupta, 1981	*Tinospora cordifolia*	Ayurv. H.G.K.A.V.S. Kottakkal	Malappuram
14.	*A. (A.) orientalis* Ehara, 1957	*Capsicum annum*	I.I.S.R. Exp. Garden, Peruvannamuzhi	Kozhikode
		Murraya koenigii	Ayurv. H.G.K.A.V.S. Kottakkal	Malappuram
15.	*A. (A.) paraaerialis* Muma, 1967	*Psidium guajava*	Agri. R. Station Ambalavayal	Wayanad
		Artocarpus hirsuta *A. companulatus*	Vythiri Uduma	Wayanad Kasaragod
16.	*A. (Euseius) alstoniae* Gupta, 1975	*Maranta arundinaceae*	Kuttiadi	Kozhikode
		Jasminum gradiflorum	Agri. R. Station, Ambalavayal	Wayanad
17.	*A. (E.) coccineae* Gupta, 1975	*Dolichos lablab*	C.U. Campus	Malappuram
		Annona squamosa	Ottappalam	Palakkad
18.	*A. (E.) delhiensis* Narayanan and Kaur, 1960	*Maranta arundinaceae* *Luffa acutangula, Canavalia ensiformis*	Uduma All the districts surveyed	Kasaragod
19.	*A. (E.) finlandicus* (Oudemans), 1915	*Manihot esculenta*	Thalassery	Kannur
		Anacardium occidentale, Amaranthus viridis, Musa paradisiaca, M. esculenta	All the districts surveyed	
20.	*A. (E.) papayensis* sp. nov.	*Carica papaya*	Dharmadam	Kannur

21.	*A. (E.) rhododendronis* Gupta, 1970	*Zingiber officinale*	I.I.S.R. Exp. Garden, Peruvannamuzhi	Kozhikode
		Luffa acutangula	Agri. R. station Ambalavayal	Wayanad
		Momordica charantia and *Musa paradisiaca*	All the districts surveyed	
22.	*A. (E.) sacchari* Ghai and Menon, 1967	*Ricinus communis*	Ayurv. H.G.K.A.V.S. Kottakkal	Malappuram
		Achras sapota	Quilandy	Kozhikode
23.	*A. (Neoseiulus) longispinosus* (Evans), 1952.	*Manihot esculenta*	Vatakara	Kozhikode
		M. esculenta, Phaseolus vulgaris, Trichosanthes anguina, Ipomoea muricata Cocos nucifera, Solanum melongena, Rosa indica, Abelmoschus esculentus	All the districts surveyed	
24.	*A. (N.) mulberricus* sp. nov.	*Morus alba*	I.I..S.R. Exp. Garden, Peruvannamuzhi	Kozhikode
25.	*A. (N.) Villoonniyensis* sp. nov.	*Pisum sativum*	Villonniyal field	Malappuram
		Abelmoschus esculentus	Ottappalam	Palakkad
26.	*A. (Paraphytoseius) arjunae* sp. nov.	*Ipomoea muricata*	Alathur	Palakkad
27.	*A. (Paraphytoseius) multidentatus* (Swirski and Shechter), 1961	*Abelmoschus esculentus*	Payyannur	Kannur
		Momordica charantia	Quilandy	Kozhikode
28.	*A. (Typhlodromalus) sativae* sp. nov.	*Pisum sativum*	Puthuppanam C.U. Campus Payyannur	Kozhikode, Malappuram, Kannur

29.	*A. (Typhlodromips) eujaniae* gupta, 1977	*Morus alba*	I.I.S.R. Exp. Garden, Peruvannamuzhi	Kozhikode
		Musa paradisiaca	Kuttiadi	Kozhikode
30.	*A. (T.) sapienticola* Gupta, 1977	*Colocasia esculentus*	Kuttiadi	Kozhikode
	Subfamily : Cydnodromellinae Chant and Yoshida Shaul, 1986			
31.	*Platyseiella mumai* Ray and Gupta, 1981	*Elettaria cardamomum, Cinnamomum zeylanicum*	Vythiri	Wayanad
	Subfamily : Phytoseiinae Berlese, 1916			
32.	*Typhlodromus (Amblydromella) bambusicolus* Gupta, 1977	*Theobroma cocoa*	Agri. R. Station, Ambalavayal	Wayanad
		Coffea arabica	Vythiri	Wayanad
	Family CHEYLETIDAE Leach, 1815			
33.	*Cheyletus arecae* sp. nov.	*Araca catechu* (stored) *Cocos nucifera*	Kalpetta Big Bazar	Wayanad Kozhikode
34.	*C. calicunsis* sp. nov.	*Manihot esculenta, Oryzae sativa, Triticum aestivum*	Big Bazar	Kozhikode
35.	*C. eruditus* Schrank, 1781	*Phaseolus mungo, Allium sativum, Zingiber officinale, Cajanus cajan*	Big Bazar	Kozhikode
36.	*C. ichthyus* sp. nov.	Dry fish (stored)	Puthiyappa	Kozhikode
37.	*C. malaccensis* Oudemans, 1903	*Phaseolus mungo, P. aureus, Dolichos biflorus, Cajanus cajan*	Big Bazar	Kozhikode
38.	*C. rosensis* sp. nov.	*Rosa indica*	Agri. R. Station, Ambalavayal	Wynad
		Cocos nucifera	Coconut Nursery, Thikkodi	Kozhikode

	Family CUNAXIDAE Thor, 1902			
	Subfamily : Cunaxiinae Oudemans, 1902			
39.	*Cunaxa bambusae* Gupta and Ghosh, 1980	*Anacardium occidentale*	Ottappalam	Palakkad
40.	*C. setirostris* (Hermann), 1804	*Vathria indica*	Ayurv. H.G.K.A.V.S., Kottakkal	Malappuram
41.	*Dactyloscirus bakeri* Lindquist, 1970	*Cocos nucifera*	Coconut Nursery, Thikkodi	Kozhikode
	Family : BDELLIDAE Duges, 1834			
	Subfamily : Bdellinae Grandjean			
42.	*Bdella kottakkalensis* sp. nov.	*Cinnamomum zeylanidium*	Ayurv. H.G.K.A.V.S., Kottakkal	Malappuram
43.	*B. thikkodiensis* sp. nov.	*Cocos nucifera*	Coconut Nursery, Thikkodi	Kozhikode
	Family STIGMAEDAE			
44.	*Apostigmaeus chelavurensis* sp. nov.	*Morus alba, Myristica fragrans*	I.I.S.R. Exp. Garden, Peruvannamuzhi	Kozhikode
45.	*Agistemus udumae* sp. nov.	*Anacardium occidentale*	Uduma	Kasargod

PLATE 4
Family diversity of predatory mites

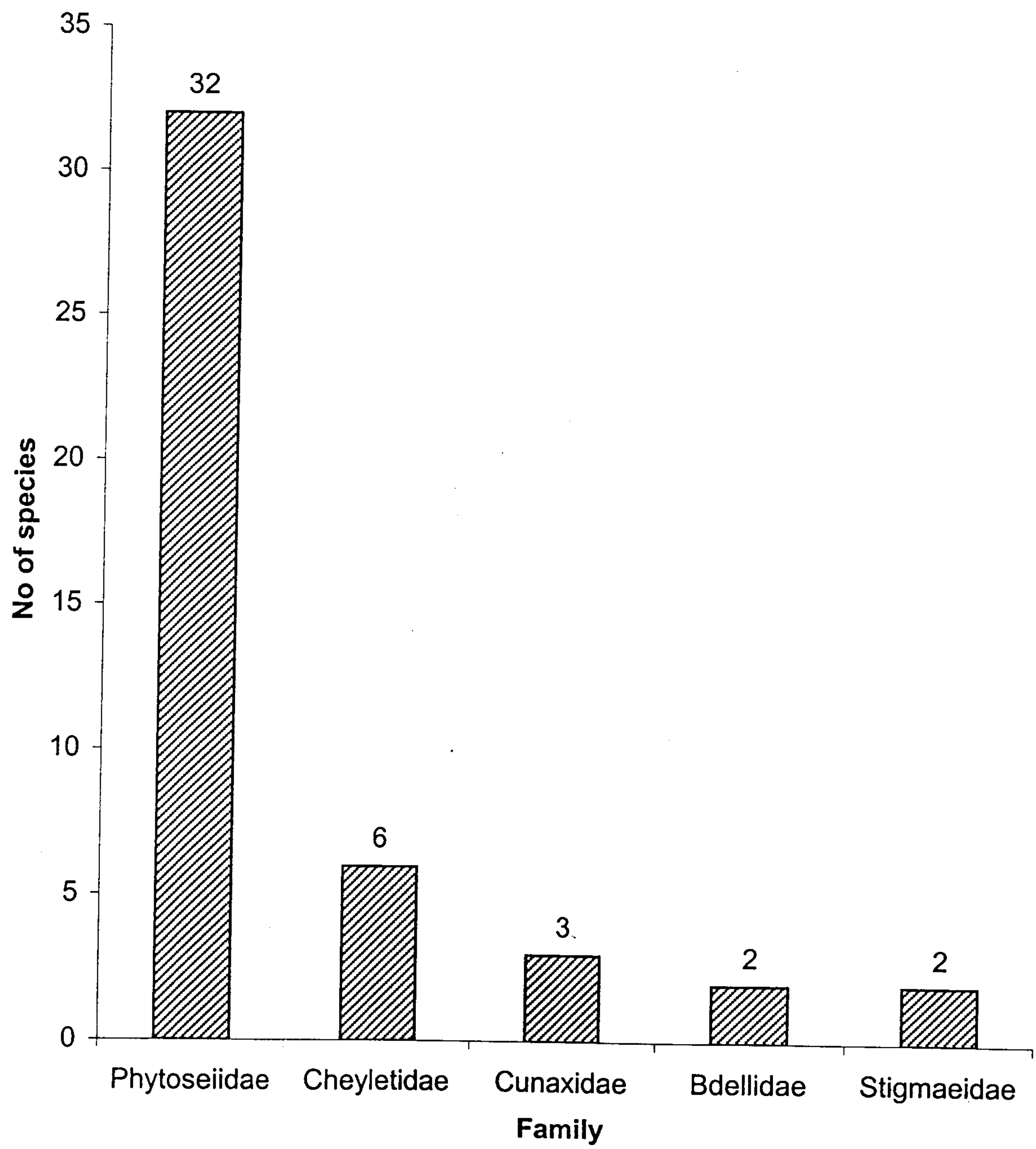


PLATE 5

Percentage distribution of various families of predatory mites

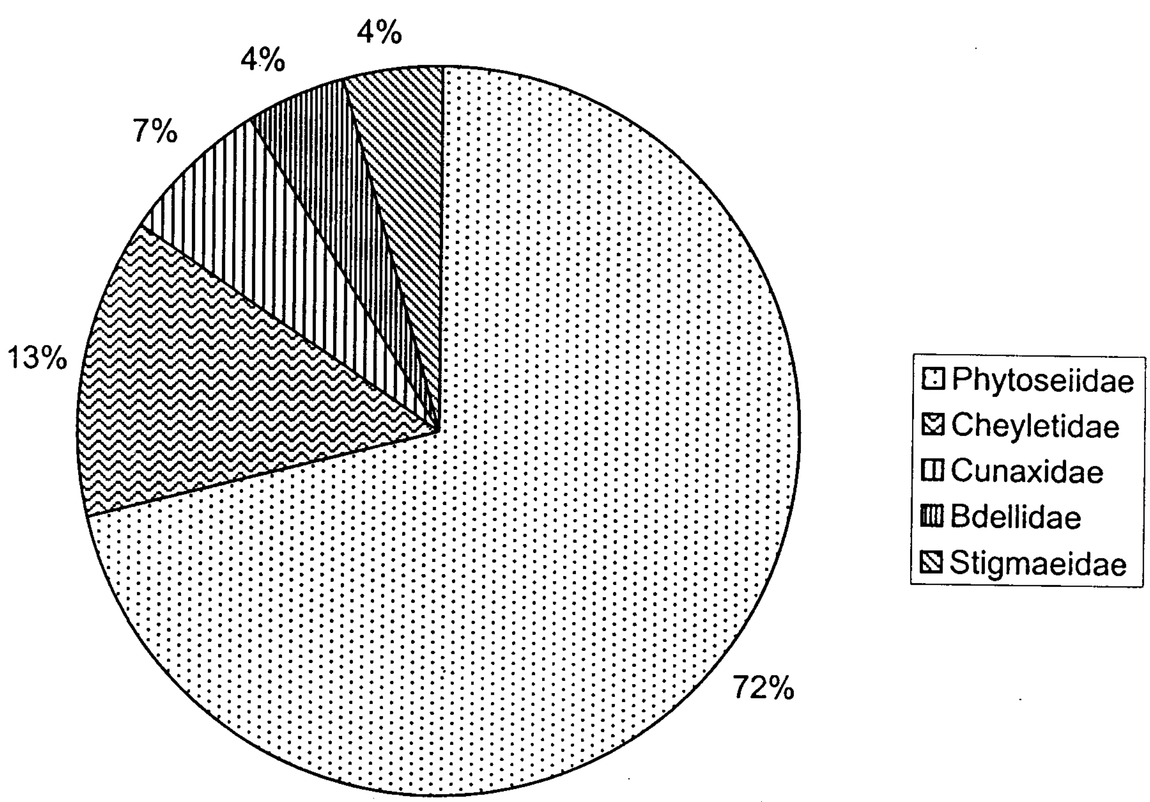


PLATE 6
Generic diversity of various families of predatory mites

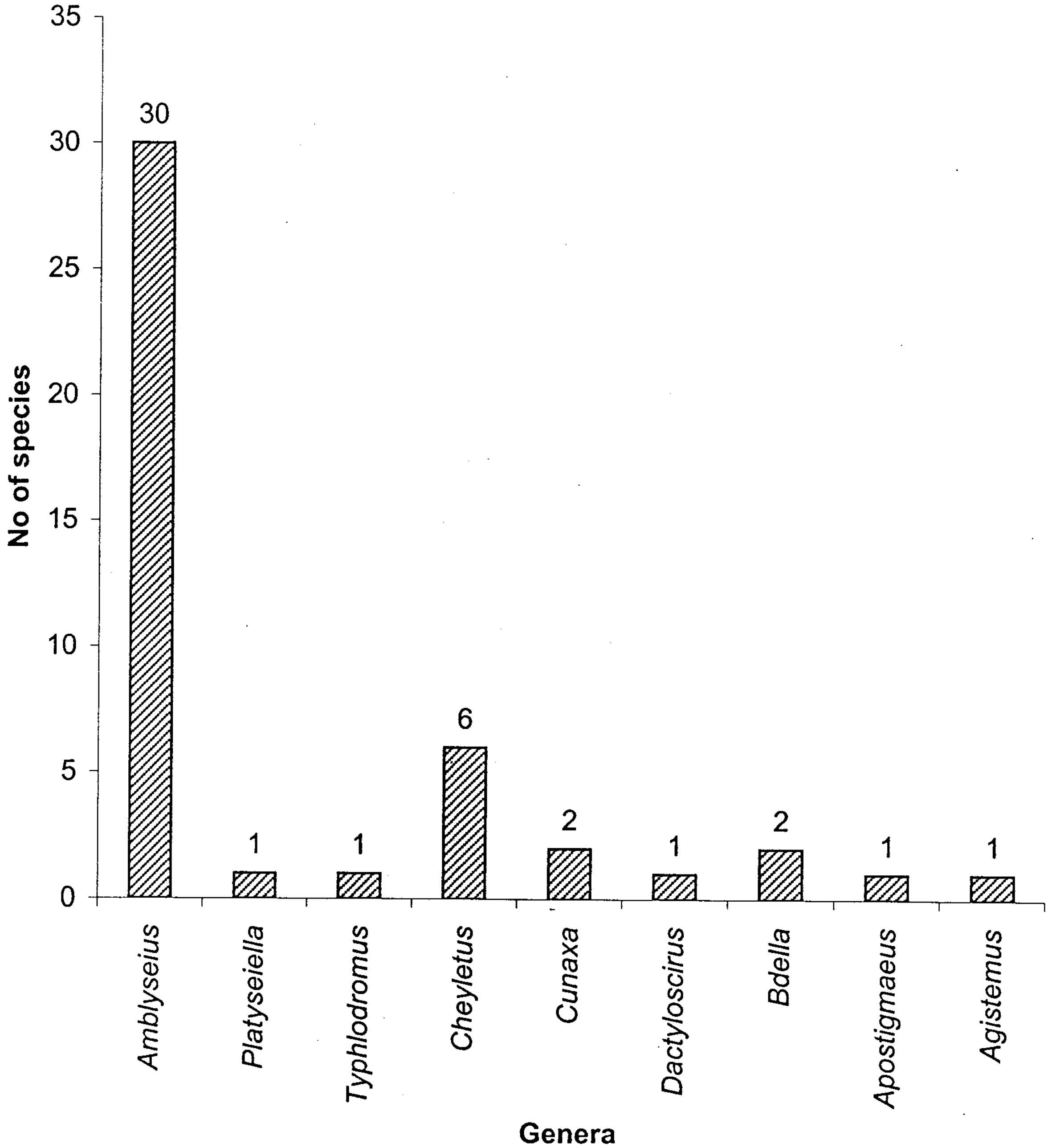
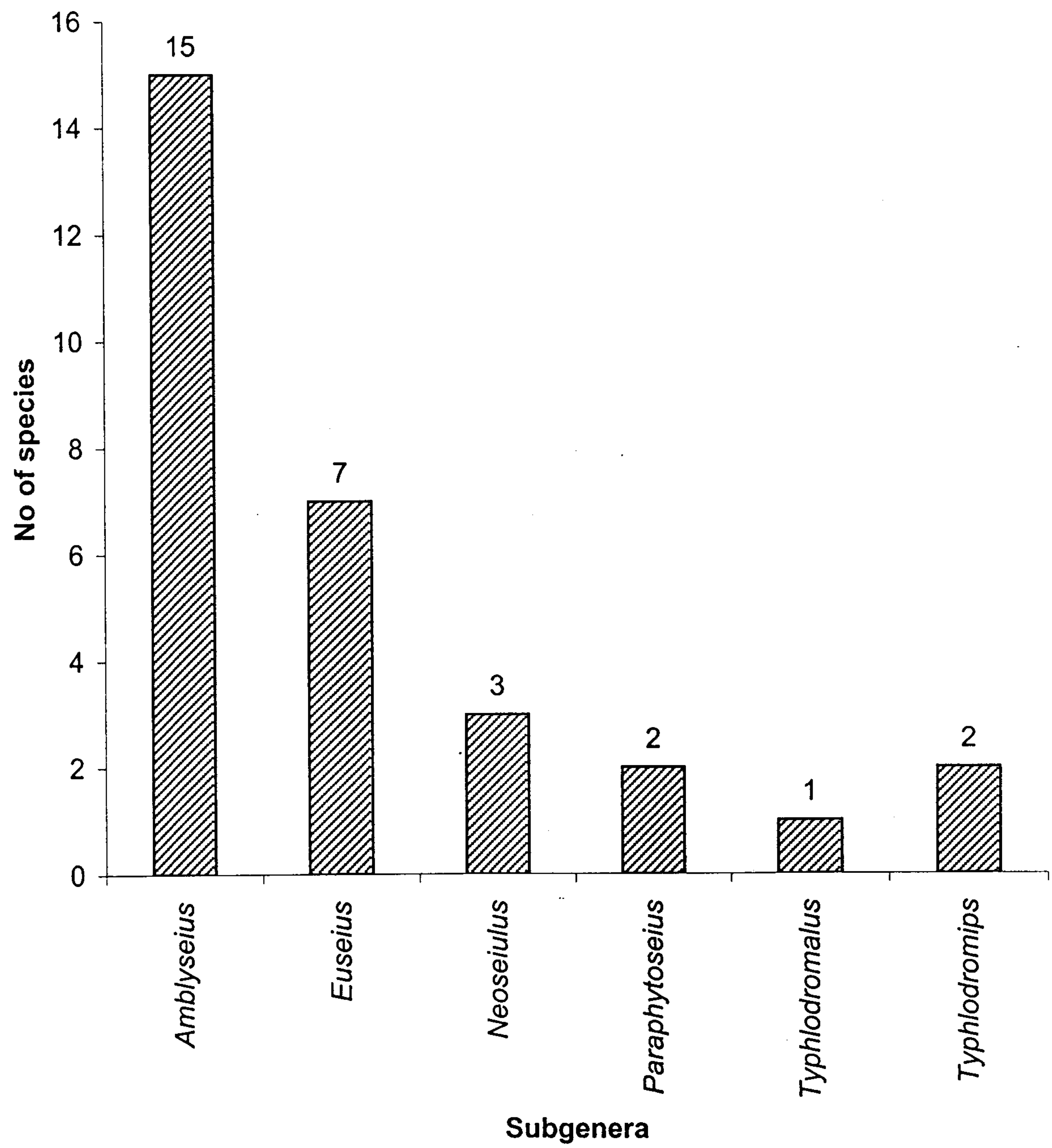


PLATE 7
Subgeneric diversity of the genus *Amblyseius*



SYSTEMATIC POSITION OF THE SPECIES STUDIED

PART II

TAXONOMY OF PREDATORY MITES

CHAPTER 4

SYSTEMATIC POSITION OF THE SPECIES STUDIED

ORDER : PARASITIFORMES

Suborder : MESOSTIGMATA

Family : I. **PHYTOSEIIDAE** Berlese, 1952

Subfamily : A. **AMBLYSEIINAE** Muma, 1961

Genus : a. *Amblyseius* Berlese,1915

Subgenus : 1. ***Amblyseius*** Berlese, 1914

Species 1. *Amblyseius (Amblyseius) adhatodae* Muma, 1967

2. *A. (A.) aerialis* (Muma), 1955

3. *A. (A.) amorphalae* sp. nov.

4. *A. (A.) bhadrakshae* sp. nov.

5. *A. (A.) channabasavannai* Gupta and Daniel, 1978

6. *A. (A.) coffeae* sp. nov.

7. *A. (A.) indirae* Gupta, 1985

8. *A. (A.) koothaliensis* sp. nov.

9. *A. (A.) kundurukkae* sp. nov.

10. *A. (A.) largoensis* (Muma), 1955

11. *A. (A.) malabarensis* sp. nov.

12. *A. (A.) mohanasundarami* sp. nov.

13. *A. (A.) muraleedharani* Gupta, 1981

14. *A. (A.) orientalis* Ehara, 1957

15. *A. (A.) paraaerialis* Muma, 1967

Subgenus : 2. ***Euseius*** Wainstein, 1962

Species 1. *Amblyseius (Euseius) alstoniae* Gupta, 1975

2. *A. (E.) coccineae* Gupta, 1975

3. *A. (E.) delhiensis* Narayanan and Kaur 1960

4. *A. (E.) finlandicus* (Oudemans), 1915

5. *A. (E.) papayensis* sp. nov.

6. *A. (E.) rhododendronis* Gupta, 1970

7. *A. (E.) sacchari* Ghai and Menon, 1967

Subgenus : 3. ***Neoseiulus*** Hughes, 1948

Species 1. *Amblyseius (Neoseiulus) longispinosus* (Evans), 1952

2. *A. (N.) mulberricus* sp. nov.

3. *A. (N.) villoonniyensis* sp. nov.

Subgenus : 4. ***Paraphytoseius*** Swirski and Shechter, 1961

Species 1. *Amblyseius (Paraphytoseius) arjunae* sp. nov.

2. *A. (P.) multidentatus* Swirski and Shechter, 1981

Subgenus : 5. ***Typhlodromalus*** Muma, 1961

Species 1. *Amblyseius (Typhlodromalus) sativae* sp. nov.

Subgenus : 6. ***Typhlodromips*** De Leon, 1965

Species 1. *Amblyseius (Typhlodromips) eujaniae* Gupta, 1977

2. *A. (T.) sapienticola* Gupta, 1977

Subfamily : B. **CYDNODROMELLINAE** Chant and Yoshida Shaul, 1986

Genus : b. *Platyseiella* Muma, 1961

Species 1. *Platyseiella mumai* Ray and Gupta, 1981

Subfamily : C. **PHYTOSEIINAE** Berlese, 1916

Genus : c. *Typhlodromus* Scheuten, 1857.

Subgenus : 7 ***Amblydromella*** Muma, 1961

Species 1. *Typhlodromus (Amblydromella) bambusicolus* Gupta, 1977

ORDER : ACARIFORMES

Suborder : PROSTIGMATA

Superfamily : Cheyletoidea

Family : II. **CHEYLETIDAE** Leach, 1815

Genus : d. *Cheyletus* Latreille, 1796

Species 1. *Cheyletus arecae* sp. nov.

2. *C. calicunsis* sp. nov.

3. *C. eruditus* Schrank, 1781

4. *C. ichthyus* sp. nov.

5. *C. malaccensis* Oudemans, 1903

6. *C. rosensis* sp. nov.

Superfamily : Bdelloidea

Family : III. **CUNAXIDAE** Thor, 1902

Subfamily : CUNAXIINAE Oudemans, 1902

Genus : e. *Cunaxa* Von Heydon, 1826

Species 1. *Cunaxa bambusae* Gupta and Ghosh, 1980

2. *C. setirostris* (Hermann) 1805

Genus : f. *Dactyloscirus* Berlese, 1916

Species 1. *Dactyloscirus bakeri* Lindquist, 1970

Family : IV. **BDELLIDAE** Duges, 1834

Subfamily : BDELLINAE Grandjean

Genus : g. *Bdella* Latreille

Species 1. *Bdella kottàkkalensis* sp. nov.

2. *B. thikkodiensis* sp. nov.

Superfamily : Raphignathoidea

Family : V. **STIGMAEIDAE** Oudemans, 1931

Genus : h. *Apostigmaeus* Grandjean

Species 1. *Apostigmaeus chelavurensis* sp. nov.

Genus : i. *Agistemus* Summers, 1960

Species 1. *Agistemus udumae* sp. nov.

DESCRIPTION OF SPECIES

CHAPTER 5

DESCRIPTION OF SPECIES

5.1. Family PHYTOSEIIDAE Berlese, 1952

1952. Phytoseiidae : Baker and Wharton, *An Introduction to Acarology*, 465pp.

1959. Phytoseiidae : Chant, *Canadian Entomol.*, **91** (Suppl. 12) : 48.

1961. Phytoseiidae : Muma, *Bull. Fla. St. Mus.*, **5**(7): 270.

1962. Phytoseiidae : Pritchard and Baker, *Hilgardia*, **33:** 207.

1963. Phytoseiidae : Schuster and Pritchard, *Hilgardia*, **34**: 199.

1965. Phytoseiidae : Chant, *Canadian Entomol.*, **97**: 353.

1966. Phytoseiidae : Ehara, *Mushi*, **39**: 16.

1970. Phytoseiidae : Muma and Denmark, *Arthropods of Florida*, **6**: 11.

1973. Phytoseiidae : Tuttle and Muma, *Tech. Bull. Agr. Exp. Sta. Univ. Arizona*, **208**: 5.

1974. Phytoseiidae : Chaudhri, *Univ. Agri. Lyallpur*, p. 204.

1978. Phytoseiidae : Chant *et al.*, *Canadian J. Zool.*, **50**(6): 1330.

1986. Phytoseiidae : Gupta., *Fauna of India (Acari: Mesostigmata) Family Phytoseiidae*, 350 pp.

Diagnosis **:** Dorsal shield is entire or transversely divided, with less than 25 pairs of setae. Sublateral setae 1 to 3 pairs. Peritreme extends anteriorly from the mesolateral stigmata; palpal apotele 2 tined. Fixed digit of chelicera well developed with variable number of teeth, movable digit with or without teeth. Epistome (tectum) smooth or indistinctly serrate, sternal shield with 2 to 3 pairs of lateral setae and 1 to 2 pairs of lateral pores. Female genital pore protected by an anterior membrane of the genital shield, more or less truncate posteriorly with a pair of lateral setae. Ventrianal shield having various shapes with 1 to 4 pairs of setae, in addition to the paraanal and postanal setae; ventrolateral setae 1 to 5 pairs and a pair of caudal setae. A pair of spermathecae open between the coxae III and IV. Males with spermatophoral process on the movable digit of chelicera, genital aperture placed anteriorly on the sternitigenital shield.

Type genus : ***Phytoseius*** Ribage, 1904.

5.1.1. Morphology and Terminology

The various terminologies used in the taxonomic part of Phytoseiidae of the present study are briefly summarised for better understanding of the morphology of the mites concerned. Similar to other members of Acarina the body of a typical phytoseiid mite is also divided into Gnathosoma and Idiosoma.

5.1.1.1. Gnathosoma

The gnathosoma bears the mouth parts, a pair of chelicerae and a pair of pedipalp. The mouth is hidden by the palpi and chelicerae. Dorsally the gnathosoma is usually covered in part by a thin shield of varying shape called the tectum or epistome.

a. ***Chelicerae:*** Chelicerae (Plate 9) of the phytoseiid mites are 2 in number and are of chelate type. Each chelicera terminates in a chela which is provided with 2 digits, a dorsal fixed digit and a ventral movable digit. The digits are provided with varying numbers of teeth. The fixed digit also bears a *pilus dentilis.* In males (Plate 9) the movable digit of each chela bears a process called the spermatophoral process.

b. ***Pedipalpi*** : Palpi are 2 in number, coxae of palpi fuse together to form a basal shield known as *basis capituli.* The segments of each palpus are named as that of legs, viz., coxa, trochanter, femur, genu, tibia and tarsus.

5.1.1.2. Idiosoma

Idiosoma (Plate 8) is covered with a dorsal shield which may be entire or divided transversely. It is furnished with the following sets of setae.

a. ***Vertical setae*** (j1) : One pair of setae, anterior in position on the dorsal shield.

b. ***Clunal setae*** (J5) : One pair of setae, posterior in position on the dorsal shield.

c. ***Dorsocentral setae*** (j-J) : There is a central row of paired setae known as dorsocentral setae. Generally 3 pairs are present, usually 4th pair is also present, 5th pair is rarely present.

d. ***Mediolateral setae* (z-Z) :** First pair of median setae is always present and is at level mid way between j5 and j6. Second pair of median setae is usually present, may be absent in most of the mites, when present is on the proscutum of the shield. One pair of median setae is always present posteriorly.

e. ***Dorsolateral setae*** (s-S) : The mites of the family Phytoseiidae contain variable number of lateral setae. Maximum number of setae is known to be 12 on one side.

f. ***Sublateral setae*** (r_3 and R_1) : Generally 2 pairs of sublateral setae are present on the membrane lateral to the dorsal shield.

5.1.1.3. Venter

The ventral side of a phytoseiid mite (Plate 8) posesess the following shields and structures.

a. ***Sternal shield*** (SS) : Sternal shield (Plate 8) is variously shaped with 2 or 3 pairs of sternal setae (ST). If 2 pairs, these setae are present on the shield proper, the third pair is present on the membrane, otherwise all the 3 pairs of setae are on the sternal shield. In males (Plate 9) the sternal and genital shields are fused together to form sternitigenital shield bearing 5 pairs of setae.

b. ***Metasternal plates*** (Msp) : One pair of small metasternal plates (Plate 8) are present, each plate bearing setae.

c. ***Genital shield*** (GS) : Genital shield (Plate 8) is truncated posteriorly with a pair of setae (G).

d. ***Ventrianal shield*** (VAS) : Ventrianal shield (Plate 8) is variously shaped with 1 to 4 pairs of setae known as preanal setae. A pair of anal and postanal setae are also present. In some, a pair of preanal pore may be present, while in others, they are wanting. Unlike the female, the ventrianal shield of male shows little variation between species and thus, they are of little taxonomic importance. The ventrianal shields of all males (Plate 9) are of the same shape and possess 4-5 pairs of setae, either entire or fragmented, sometimes fused lightly with sternitigenital shield but the line of fusion is clear.

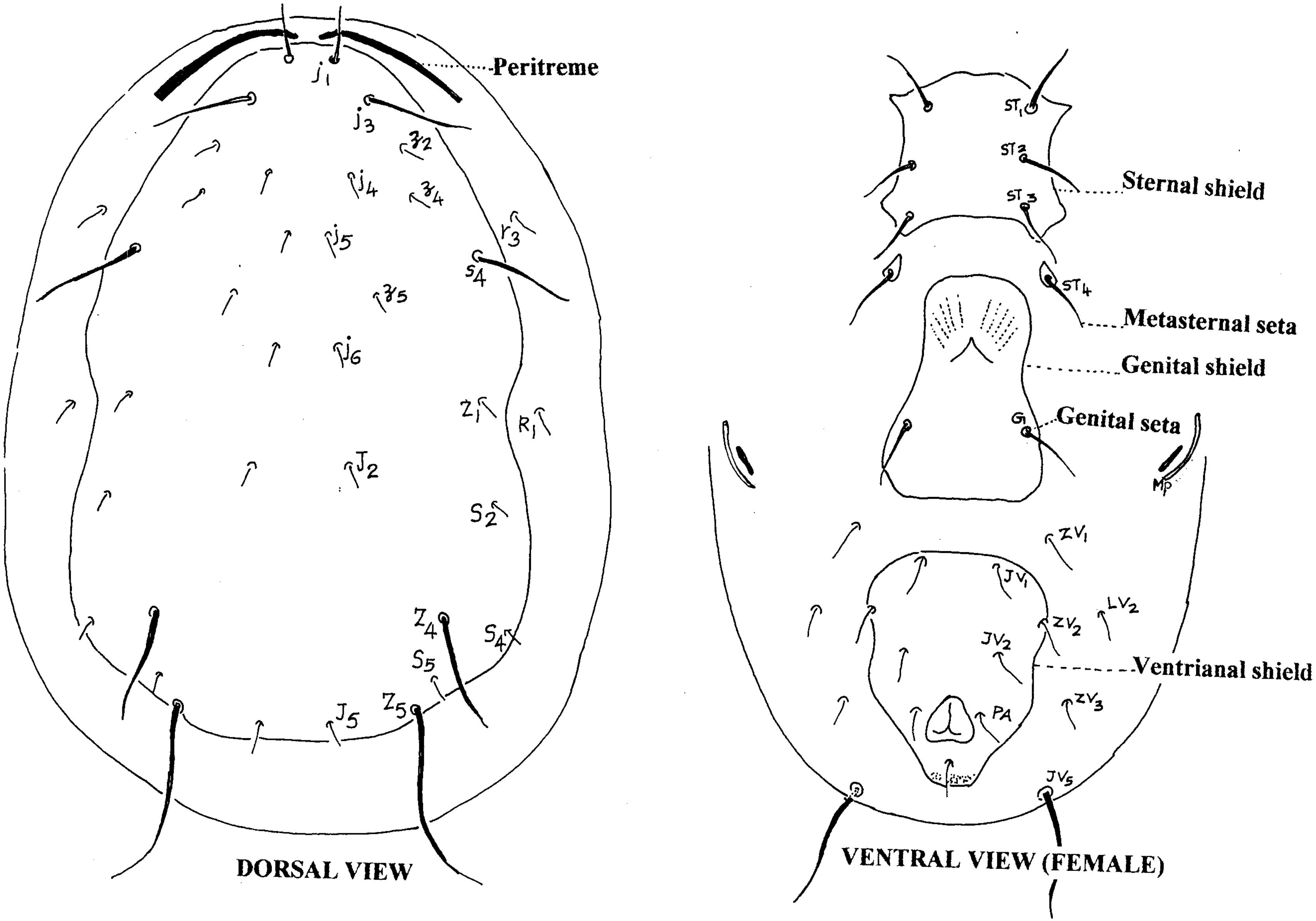
e. ***Metapodal plates*** (Mp): Just behind the coxae IV are present one or two pairs of metapodal plates (Plate 8), which may be round, oval, triangular, etc. and serve as important characters for recognition of genera and species. In *Paraamblyseius*, the metapodal plates are massive. In addition to metapodal plates, small platelets are often present between the genital and ventrianal shields and also on the membrane around ventrianal shield.

f. ***Setae on membrane*** : Posteriorly, a variable number of setae and pores are present on the membrane surrounding ventrianal shield. One pair of caudal setae (JV_5) is always present. In addition to seta JV_5, 1 to 5 pairs of setae and a variable number of pores are present (Plate 8).

g. ***Spermatheca*** (Sp) : A pair of spermathecae (Plate 9) always present in Phytoseiidae in contrast to Blattisocidae where it is not always present. The actual function of this organ is the reception of spermatophores and is of great importance in the separation of species. Very often species with identical characters are separated based on the structural difference of spermatheca alone. Each spermatheca has its external orifice on the venter between coxae III and IV.

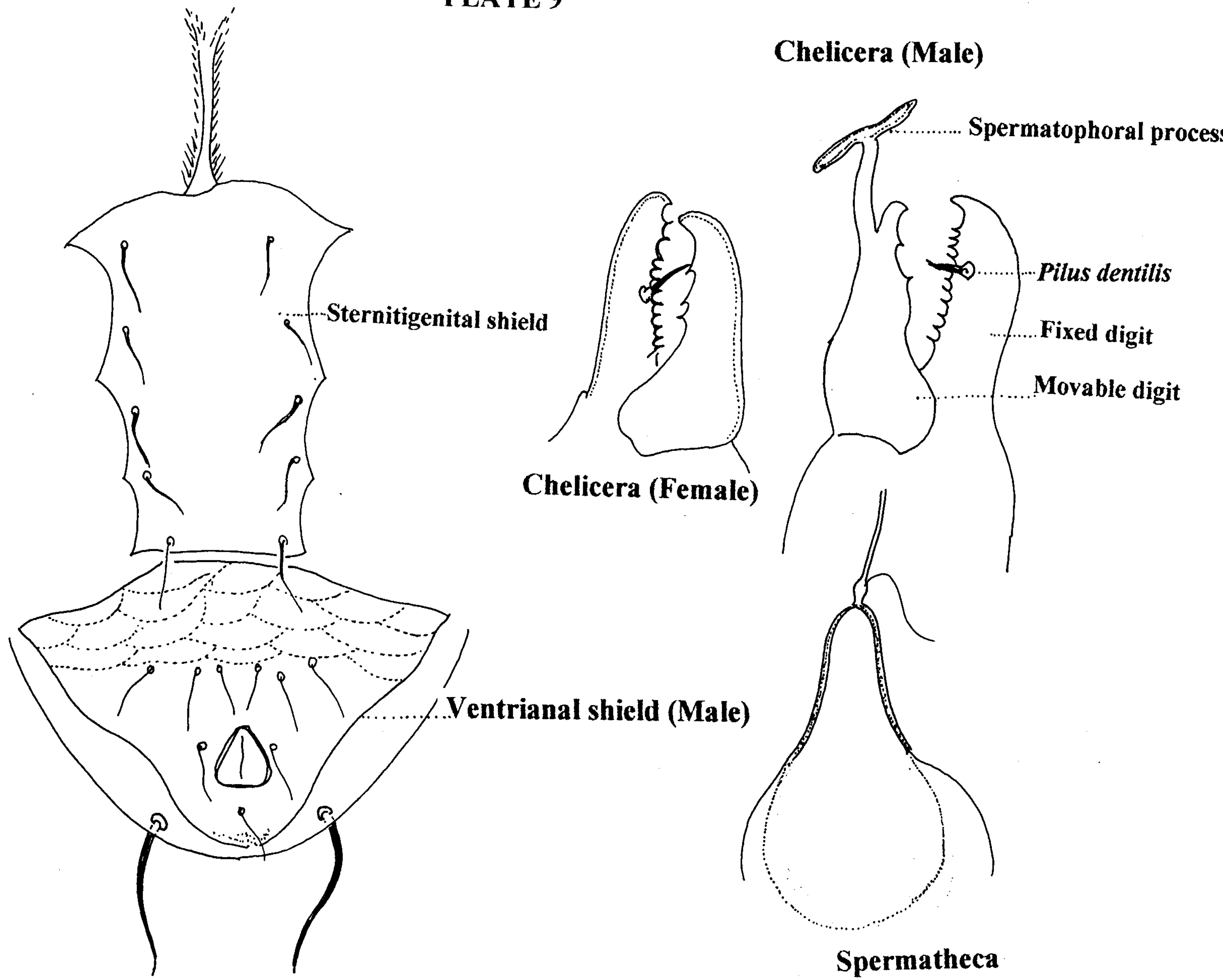
h) ***Peritreme*** (P): The stigmata and peritreme are on peritremal shield; length of peritreme (Plate 8) has recently been looked upon as of great taxonomic value. Often the peritremal shield may be fused anteriorly with dorsal shield as in *Phytoseius, Gigagnathus, Paraamblyseius Macroseius* etc. and posteriorly curves around coxae IV.

PLATE 8



Morphological and Taxonomical characters of the family Phytoseiidae- I

PLATE 9



VENTRAL VIEW (MALE)

Morphological and Taxonomical characters of the family Phytoseiidae II

5.1.1.4. Legs

There are 4 pairs of legs and the chaetotaxy of legs is of great value for generic and specific determination. Evans (1963) in his pioneering work has showed that all phytoseiids have standard chaetotaxy of leg II and III. In *Macroseius* 8 setae on genu II, 7 setae on genu III; in *Typhlodromus* 7 or 8 setae on genu II and 7 setae on genu III; in *Chantia* 7 setae on each of genu II and III and tibia II and III; in *Platyseiella* and *Phytoseius* 7-6-7 setae on genu II, III and IV respectively, but genu III of *Phytoseius* also possesses 7 setae in some of the species. *Iphiseius* and *Amblyseius* possess 7-7-7 setae on genu II, III and IV respectively and 6-7 and 6-7 and 6 setae on tibia II, III and IV respectively. *Paraamblyseius* has 7 setae on genu II and 6 setae on genu III, *Phytoseiulus* has 7, 8 or 9 setae on genu II and 7 setae on genu III, *Okiseius* has 6 setae on genu II, 7 setae each on genu III and IV. The leg chaetotaxy especially of genu II and III and tibia II and III are represented by leg chaetotactic formula as:

$$\text{genu, } 2\ \frac{2}{0}\ \frac{2}{0}\ 1 \quad \text{or} \quad 2al\ \frac{2ad}{0av}\ \frac{2pd}{0pv}\ 1pl$$

where, al - anterolateral, ad - anterodorsal, av - anteroventral, pd - posterodorsal, pv - posteroventral and pl - posterolateral.

Generally genu, tibia, and basitrsus of leg IV and in some cases the genu and tibia of leg II and III bear macrosetae, the relative length of which are of taxonomic value for separation of species; macrosetae may be simple, knobbed, spatulate or with some other shape.

Key to the subfamilies of PHYTOSEIIDAE

1. Dorsal shield divided .... Macroseiinae

– Dorsal shield undivided 2

2. Sublateral seta R_1 present 3

- Sublateral seta R_1 absent .... Cydnodromellinae

3. Dorsal shield with 12 pairs of lateral setae; sublateral setae 3 pairs, preanal setae on ventrianal shield 6 pairs .... Gnoriminae

- Dorsal shield with 8-11 pairs of lateral setae; sublaterals setae 2 pairs, preanal setae 2-4 pairs 4

4. Prolateral setae 4 pairs .... Amblyseiinae

- prolateral setae 5-6 pairs .... Phytoseiinae

Subfamily AMBLYSEIINAE Muma, 1961

1961. Amblyseiinae Muma, *Bull. Fla. St. Mus.*, **5**(7): 273.

1963. Amblyseiini : Schuster and Pritchard, *Hilgardia*, **34**(7): 225.

1965. Phytoseiinae : Chant, *Canadian Entomol.*, **97**(4): 359.

1970. Amblyseiinae : Muma and Denmark, *Arthropods of Florida*, **6**: 22.

1973. Amblyseiinae : Tuttle and Muma, *Tech. Bull. Agr. Exp. Sta. Univ. Arizona,* **208**: 6.

1978. Phytoseiinae : Chant *et al.*, *Canadian J. Zool.*, **56**(6): 1344.

***Diagnosis*:** Dorsal shield undivided, with 4-6 pairs of setae on dorsocentral series, 1-2 pairs of median setae, 6-9 pairs of lateral setae (4 of these are prolateral), 1-2 pairs of sublateral setae; 1-3 pairs of preanal setae on ventrianal shield; 1-3 macrosetae on leg IV; males with fragmented or entire ventrianal shield with 3-4 pairs of preanal setae, 2 pairs of sublateral setae, both placed on dorsal shield.

Type genus : ***Amblyseius*** Berlese, 1915

Key to the genera of AMBLYSEIINAE

1. Ventrianal shield absent or indistinctly demarcated, only preanal setae distinctly present .... ***Indoseiulus***

– Ventrianal shield distinctly present 2

2. R_1 on dorsal shield .... ***Okiseius***

– R_1 on lateral integument 3

3. Lateral integument sclerotized so that r_3 and R_1 though on usual lateral position appear to be on lateroventral extension of dorsal shield .... ***Iphiseius***

– Lateral integument not sclerotized as above 4

4. Metapodal plates large, single paired, triangular, genital shield very broad and punctate, ventrianal shield massive, genu III with 6 setae.. ***Paraamblyseius***

– Metapodal plates 2 pairs, slender, elongate, genital and ventrianal shields usually narrow, genu III with 7 setae .... ***Amblyseius***

Genus *Amblyseius* Berlese, 1915

1915. *Amblyseius* Berlese, *Redia*, **10**: 143.

1923. *Amblyseius* (*Seiopsis*): Berlese, *Redia*, **15**: 255.

1948. *Amblyseius (Amblyseiopsis)*: Garman, *Bull. Conn. Agr. Exp. Stn.*, **520**: 17.

1951. *Kampimodromus :* Nesbitt, *Zool. Verh.*, **12**: 52.

1955. *Amblyseiella* : Muma, *Ann. Entomol. Soc. Amer.*, **48**: 266.

1957. *Proprioseius* : Chant, *Canadian Entomol.*, **89**: 357-358.

1957. *Asperoseius :* Chant, *Canadian Entomol.*, **89**: 360-362.

1957. *Typhlodromus* (*Amblyseius*) : Chant, *Canadian Entomol.*, **89**: 528-532.

1959. *Phyllodromus* : De Leon, *Entomol. News*, **70**: 260.

1961. *Phytoscutus :* Muma, *Bull. Fla. St. Mus.*, **5**(7): 275.

1962. *Amblyseius* (*Ptenoseius*) : Pritchard and Baker, *Hilgardia*, **33**: 295.

1966. *Euseius* : De Leon, In: S*tudies on the fauna of suriname and other Guyanas*, **8**: 93.

1970. *Fundiseius :* Muma and Denmark, *Arthropods of Florida*, **6**: 71.

1970. *Neoseiulus* : Muma and Denmark, *Arthropods of Florida*, **6**: 100.

1982. *Quadromalus* : Moraes *et al.*, *Internat. J. Acarol.*, **8**(1): 15-17 (new synonymy).

1986. *Amblyseius* : Gupta, *Fauna of India (Acari : Mesostigmata) family Phytoseiidae*, 350pp.

Diagnosis : Dorsal shield with 13-17 pairs of setae of which 4 pairs always present on prolateral series; setae of diverse length; sublateral setae (r_3, R_1) on lateral integument. Sternal shield with 3 pairs of sternal setae, 4th pair either on integument or on metasternal plates. Genital shield truncate posteriorly with a pair of setae. Ventrianal shield entire or fragmented, and of variable shape, with 3 pairs of preanal setae; 4 pairs of setae present on the membrane around ventrianal shield; 1-2 pairs of elongate metapodal plates may present. Peritremal plate fused anteriorly with dorsal shield. Chelicera uni-bi or multidentate. Tritosternum present.

Type species : ***Zercon obtusus*** Koch, 1839.

Key to the subgenera of ***Amblyseius*** Berlese

1. Dorsal shield with 5 pairs of postlateral setae 4
– Dorsal shield with less than 5 pairs of postlateral setae 2
2. Seta Z_1 present 3

– Seta Z_1 absent .... ***Proprioseius***

3. Seta S_2 present .... ***Asperoseius***

- Seta S_2 absent.. ***Paraphytoseius***

4. Ventrianal shield massive covering major portion of posteroventral region 5

– Ventrianal shield not as above 6

5. Setae J_5 present .... ***Proprioseiopsis***

– Setae J_5 absent .... ***Phytosutella***

6. Seta s_4, Z_5 and Z_4 long and whip like, longer than distance between their bases; leg IV with macrosetae on genu, and erect seta on tarsus.................... .... ***Amblyseius***

– Setae Z_5 shorter, at most as long as distance between their bases; leg 1 with no macroseta or only one on genu, no erect seta on trsus 7

7. Sternal shield distinct and straight or concave posteriorly, ventianal shield approximately shield shaped or pentagonal 8

– Sternal shield indistinct, may be trilobate posteriorly, ventrianal shield elongate, vase shaped or concave laterally 9

8. Z_5 and Z_4 distinctly serrate, ventrianal shield as wide as or wider than long, macroseta may be present on genu 1 genu II and III .... ***Typlodromips***

– Z_5 and Z_4 mostly smooth, sternal shield longer than wide, genu I, II and III without macrosetae .... ***Neoseiulus***

9. Peritreme extends anteriorly upto j_3; anterior pair of preanal setae adjacent to anterior margin of ventrianal shield .... ***Typhlodromalus***

– Peritreme not extends upto j_3; anterior pair of preanal setae removed from anterior margin of ventrianal shield .... ***Euseius***

Subgenus : *Amblyseius* Berlese, 1914

1914. *Amblyseius* Berlese, *Redia*, **10**:143.

1961. *Amblyseius* (*Amblyseius*) : Muma, *Bull. Fla. St. Mus.*, **5**(7): 287.

1967. *Amblyseius* : Denmark and Muma, *Fla. Entomol.*, **50**(3): 169.

1970. *Amblyseius*: Muma and Denmark, *Arthropods of Florida*, **6**: 62.

1972. *Amblyseius* : Denmark and Muma, *Fla. Entomol.*, **55**(1): 19.

1974. *Amblyseius* : Denmark, *Fla. Entomol.*, **57**(2): 146.

1978. *Amblyseius*: Knisley and Denmark, *Fla. Entomol.*, **61**(1): 8.

1981. *Amblyseius* : Denmark and Andrews, *Fla. Entomol.*, **64**(1): 148.

1982. *Amblyseius* : Deneshwar and Denmark, *Internat. J. Acarol.*, **8**(1): 5.

1986. *Amblyseius*: Gupta, *Fauna of India, (Acari: Mesostigmata) Family Phytoseiidae*, 350 pp.

Diagnosis :Dorsal shield smooth, well sclerotized with 17 pairs of setae, of which 6 pairs of dorsocentral, 2 pairs of median and 9 pairs of laterals. Setae s_4, Z_5, and Z_4 being long and whip like and may be serrate minutely; setae j_1 and j_3 may also be long. Sternal shield smooth, as wide as or wider than long with 3 pairs of sternal setae. Ventrianal shield pentagonal or vase shaped with 3 pairs of preanal setae. Peritreme extends anteriorly upto j_1, fixed digit of chelicerae multidentate with a strong *pilus dentilis*, movable digit with 1-4 teeth. Genu of leg I, II, III and also tibia II, III often possess macrosetae, leg IV with macrosetae on genu, tibia and basitarsus and that on genu IV being longest.

Amblyseius (Amblyseius) adhatodae Muma, 1967

PLATE 10

1967. *Amblyseius adhatodae* Muma, *Fla. Entomol.*, **50**: 268-270.

1967. *Amblyseius ipomoeae*: Ghai and Menon, *Oriental Ins.*, **1**: 71-72.

1974. *Amblyseius ipomoeae*: Prasad, *A catalogue of mites of India*, p.166.

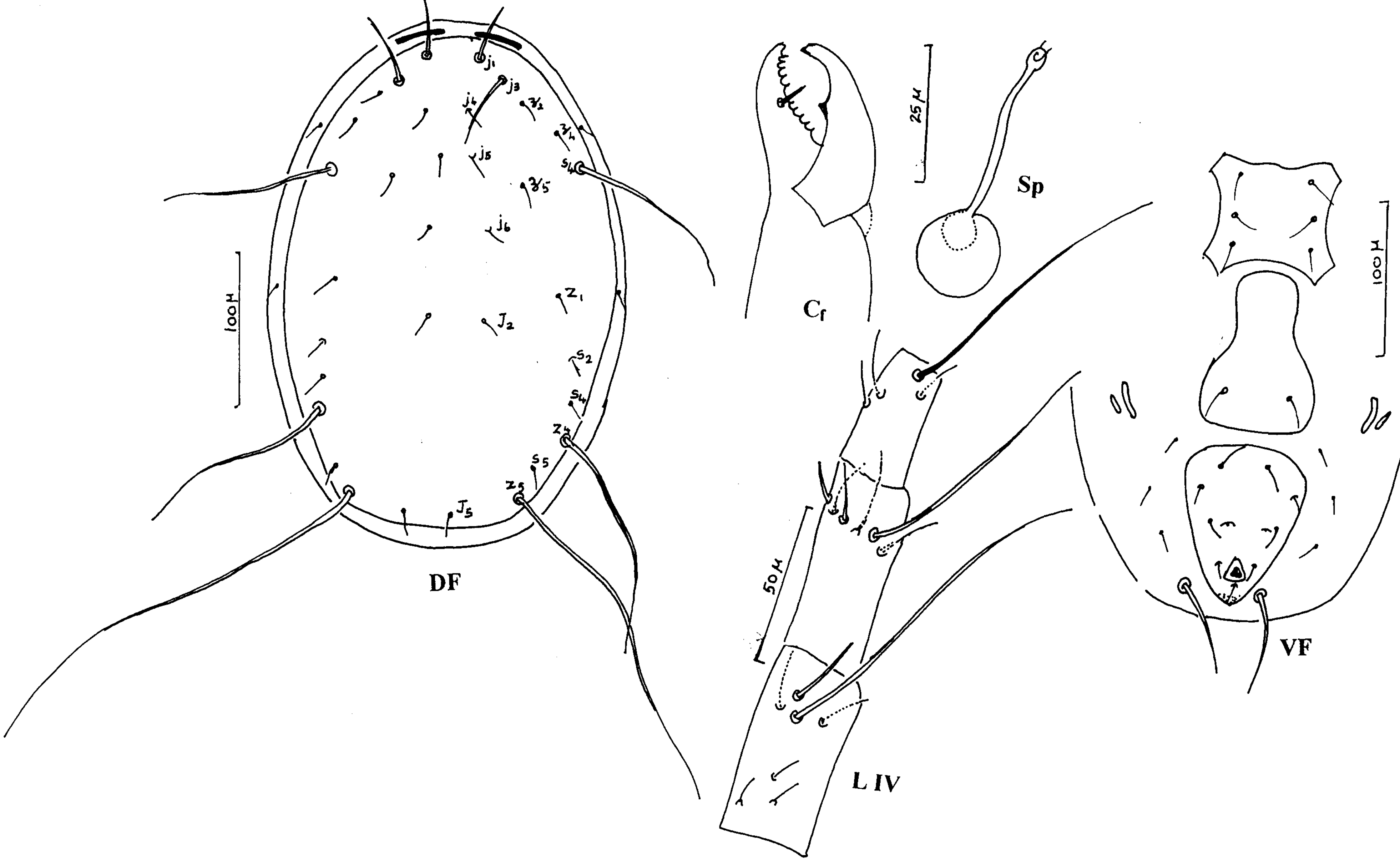
1975. *Amblyseius adhatodae*: Gupta, *Internat. J. Acarol.*, **1**(2): 31.

1975. *Amblyseius ipomoeae*: Gupta, *Internat. J. Acarol.* **1**(2): 37.

1986. *Amblyseius (Amblyseius) adhatodae* Gupta, *Fauna of India (Acari: Mesostigmata) Family Phytoseiidae*, p.37.

Female: Dorsal shield 325 long and 230 wide with 17 pairs of setae, lightly sclerotized with indistinct dark, less sclerotized areas. Setae j_1, j_3, s_4, Z_4 and Z_5 long and latter two whip like. Measurements of setae: j_1 - 40, j_3 - 52, s_4 - 120, Z_4 - 143 and z_5 - 300; all other setae minute. Sternal shield 66 long 72 wide, laterally concave with 3 pairs of setae measuring 26 each. Genital shield 78 wide with a pair

PLATE 10



Amblyseius (Amblyseius) adhatodae Muma, 1967 of genital setae (26). Ventrianal shield 103 long and 70 wide, with 3 pairs of preanal setae (16 each) and a pair of elliptical pores; 4 pairs of setae present on the membrane around ventrianal shield. Setae JV_5 smooth, 68 long. Two pairs of metapodal plates present, primary one 20 long and accessory one 8 long. Fixed digit of chelicera with 10 teeth, movable digit with 1 tooth. Spermatheca with slender, elongate tubular cervix. Peritreme extends anteriorly beyond j_1. Macroseta present on Leg IV: genu - 96, tibia - 70 and basitarsus - 82.

Leg chaetotaxy : genu II $2\,\frac{2}{0}\,\frac{2}{0}\,1$, genu III $1\,\frac{2}{1}\,\frac{2}{0}\,1$.

Male : Not studied.

Habitat : *Vanilla planifolia.*

Known habitat: *Adhatoda vasica* and *Ipomoea* sp.

Material examined: Female marked on the slide along with other 3 ♀♀, INDIA: KERALA: Indian Institute of Spices Research Experimental Garden, Peruvannamuzhi (Kozhikode district), 12 - xi – 2000, ex. *Vanilla planifolia*, coll. Mary Anitha (No. A 36/1). Three ♀♀ collected from Vythiri (Wayanad district), 24.i.2000, from the same habitat, coll. Mary Anitha (No. A 36/3).

Distribution: INDIA: Kerala, Maharashtra; OUTSIDE INDIA : Pakistan.

Remarks: The specimen studied closely resembles *A. (A.) adhatodae* Muma in the structure of spermatheca, chelicera, setal measurements etc. and hence fixed as *A. (A.) adhatodae* Muma.

Amblyseius (Amblyseius) aerialis (Muma), 1955

PLATE 11

1955. *Amblyseiopsis aerialis* Muma, *Ann. Entomol. Soc. Amer.*, **48**: 264-266.

1957. *Amblyseius aerialis :* Athias - Henriot, *Bull. Soc. Hist. Nat. Afr. Nord.*, **48**: 338 - 339.

1958. *Amblyseius aerialis*: Garman, *Ann. Entomol. Soc. Amer.*, **51**: 75.

1958. *Amblyseius aerialis*: Athias - Henriot, *Bull. Soc. Hist. Nat. Afr. Nord.*, **49**: 34.

1964. *Amblyseius aerialis* : Rao and Rao, *Comm. Inst. Biol. Contr. Tech. Bull.*, **4**: 38 - 39.

1974. *Amblyseius aerialis*: Prasad, *A catalogue of mites of India*, p.160-161.

1975. *Amblyseius aerialis*: Gupta, *Internat. J. Acarol.*, **1**(2): 31.

1981. *Amblyseius aerialis*: Gupta and Nahar, In *Contrib. to Acarol. in India*, p.9.

1986. *Amblyseius (Amblyseius) aerialis :* Gupta, *Fauna of India (Acari: Mesostigmata) Family Phytoseiidae*, p.39.

Female: Dorsal shield 340 long 252 wide with 17 pairs of setae. Setae j_1, j_3, s_4, Z_4 and Z_5 long and Z_5 the longest among dorsal setae and whip like; z_2 longer than z_4, all other setae small and almost equal in size. Measurements of setae: j_1 - 36, j_3 - 62, s_4 - 102, z_2 – 10, z_4 – 6, Z_4 - 148, Z_5 - 270 and remaining setae 10 long. Sublateral setae r_3 and R_1 present on the interscutal membrane. Sternal shield 80 long, 75 wide, smooth with 3 pairs of sternal setae (20 long). Genital shield 80 wide with a pair of setae (24 long). Ventrianal shield longer (125) than wide (80) with 3 pairs of preanal setae (22) and a pair of elliptical preanal pores just below the 3rd pair of preanal setae, 4 pairs of setae present around the ventianal shield, JV_5 smooth, 71 long; 2 pairs of metapodal plates present, primary one 22 long and accessory one 10. Fixed digit of chelicera multidentate with *pilus dentilis*, movable digit with 4 teeth. Peritreme extends anteriorly beyond j_1. Spermatheca with tubular cervix. Macrosetae on Leg IV: genu - 130, tibia - 104 and basitarsus – 72. Genu 1 - III and tibia III also with macroseta.

Leg chaetotaxy: genu II $2 \frac{2}{0} \frac{2}{0} 1$, tibia II $1 \frac{1}{1} \frac{2}{1} 1$.,

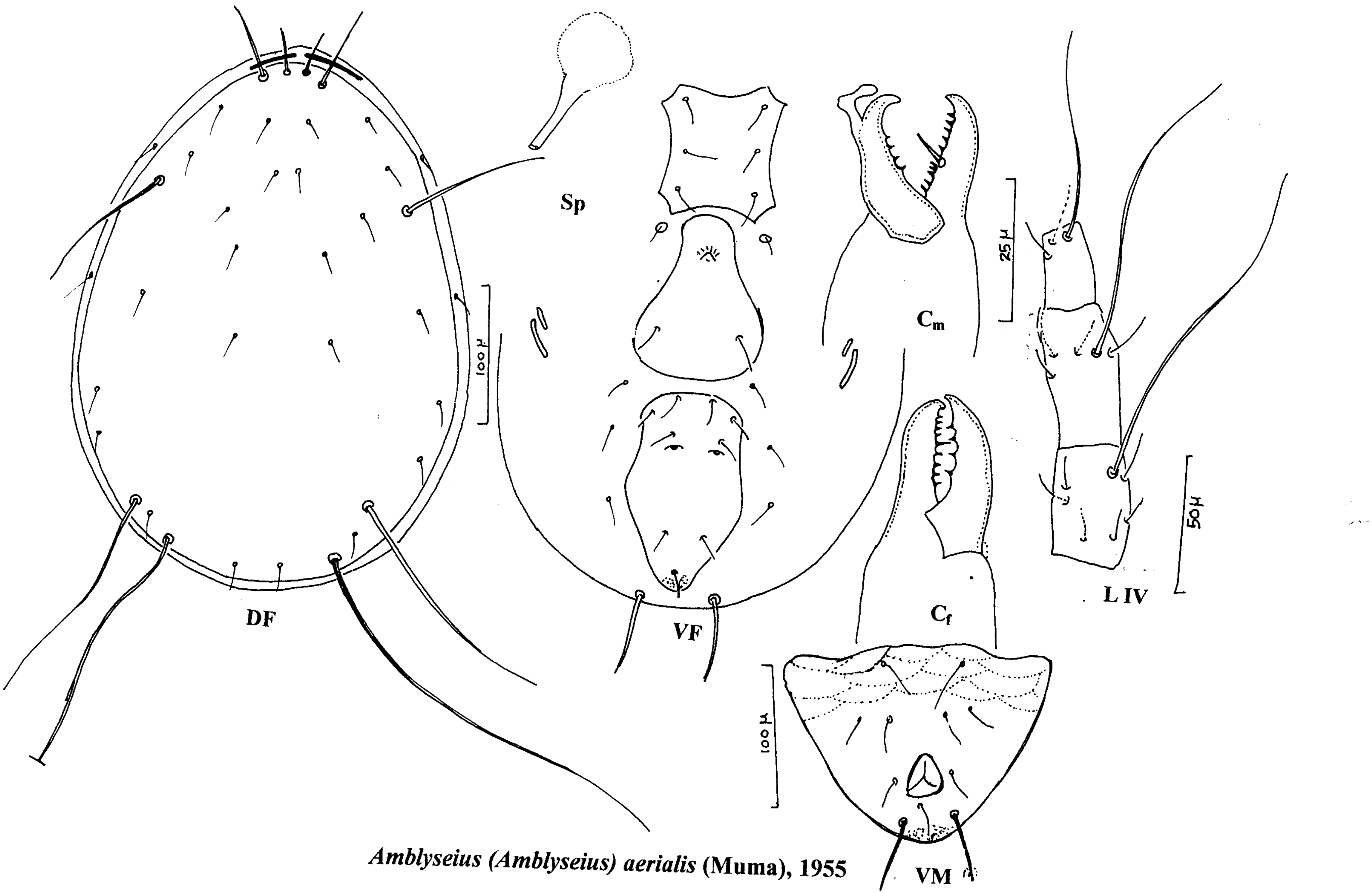
genu III $1 \frac{2}{1} \frac{2}{0} 1$, tibia III $1 \frac{2}{1} \frac{1}{1} 1$.

Male : Spermatophoral process and ventrianal shield as figured.

Habitat: *Citrus limon* and *Citrus medica*.

Known habitat: Citrus.

PLATE 11



Amblyseius (Amblyseius) aerialis (Muma), 1955

Material examined: Female marked on the slide along with other 4 ♀♀, INDIA: KERALA: Anjarakandy (Kannur district), 20 - x – 2001, ex. *Citrus limon*, coll. Mary Anitha (No. A 12/1). Two ♀♀ and 2 larva, Ottappalam (Palakkad district), 18.iii.2000, ex. *Citrus medica*, coll. Mary Anitha (No. A 44/1).

Distribution: INDIA: Kerala, Karnataka and Bihar; OUTSIDE INDIA: Mexico, U.S.A. Bermuda, Galapagos Island, Jamaica, Puerto Rico and Brazil.

Remarks: The specimen examined agrees with almost all the features of *A. (A.) aerialis* (Muma), hence fixed as *A. (A.) aerialis* (Muma).

***Amblyseius (Amblyseius) amorphalae* sp. nov.**

PLATE 12

Female: Dorsal shield 403 long, 278 wide with 17 pairs of setae and 2 pairs of small pores. Setae j_1, j_3, s_4, Z_4, Z_5 long. Measurements of setae: j_1 - 33, j_3 - 42, s_4 - 90, z_4 - 90, Z_5 – 225, all other setae between 6 and 8; $r_3 = R_1 = 8$ each, both on lateral integument. Sternal shield 90 long, 105 wide with 3 pairs of sternal setae (21), metasternal plate with setae distinct. Genital shield 92 wide with a pair of setae (28). A clear band present between genital and ventrianal shield. Ventrianal shield 120 long, 75 wide, vase shaped with concave lateral margins, 3 pairs of preanal setae (15) and a pair of semilunar pores. Four pairs of setae present around ventrianal shield; JV_5 - 45 long, smooth. Two pairs of metapodal plates present, primary one 24 and accessory one 16 long. Fixed digit of chelicera with 4 teeth anterior to *pilus dentilis* and 3 teeth posterior to it; movable digit with 3 teeth. Peritreme extends anteriorly beyond j_1. Spermatheca with short cervix and a bulged rounded capitulum. Macrosetae on Leg IV: genu - III, tibia - 75, basitarsus - 60.

Leg chaetotaxy : genu II $2\,\frac{2\ \ 2}{0\ \ 0}\,1$, tibia II $1\,\frac{1\ \ 2}{1\ \ 1}\,1$;

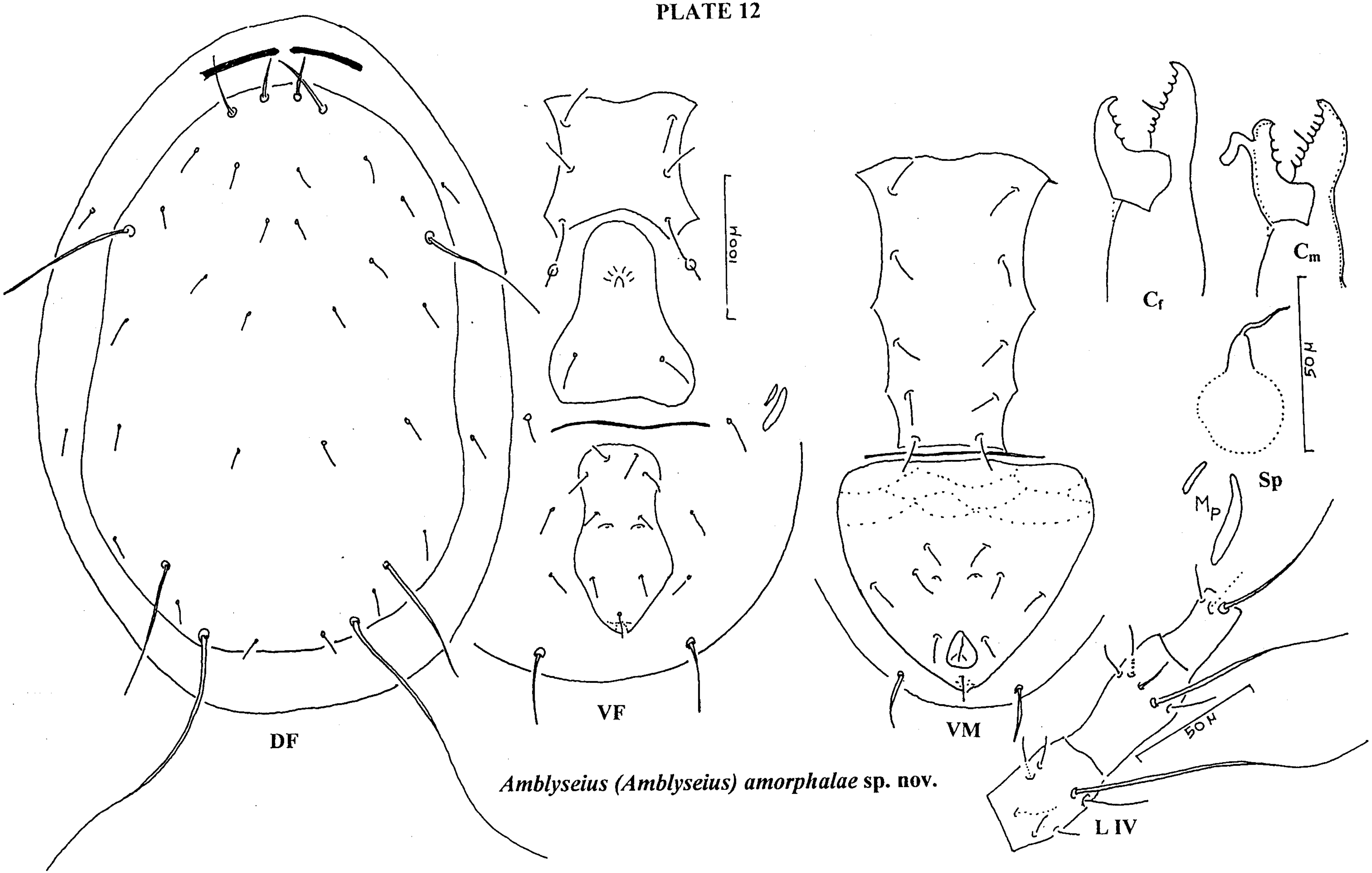
genu III $1\,\frac{2\ \ 2}{1\ \ 0}\,1$, tibia III $1\,\frac{1\ \ 2}{1\ \ 1}\,1$

Male: Dorsal chaetotaxy similar to that of ♀. Spermatophoral process, ventrianal shield and sternitigenital shield as illustrated.

Habitat: *Amorphophallus companulatus.*

Material examined: Holotype ♀ marked on the slide along with other 4 ♀♀ and a ♂, INDIA: KERALA: Dharmadam (Kannur district), 30.ix.2000, ex. *Amorphophallus companulatus*, coll. Mary Anitha (No.A 2/7), two paratype slides with 10 ♀♀, collection details same as holotype (No. A 2/2, 2/4).

PLATE 12



Amblyseius (Amblyseius) amorphalae sp. nov.

Remarks: The specimen examined resembles *A. (A.) largoensis* (Muma) in the dorsal chaetotaxy, shape of ventrianal shield but can be differentiated from it by the following characters:

1. A clear band present between ventrianal shield and genital shield which is absent in *A. (A.) largoensis* (Muma).
2. Spermatheca with short cervix instead of the long one in *A. (A.) largoensis* (Muma).
3. Macrosetae on basitarsus of Leg IV longer in the new species.
4. Movable digit of the chelicera with 3 teeth instead of 2 in *A. (A.) largoensis* (Muma).

Amblyseius (Amblyseius) bhadrakshae sp. nov.

PLATE 13

Female; Dorsal shield 372 long, 240 wide with 17 pairs of setae, j_1, j_3, s_4, Z_4 and Z_5 long, all others small. Measurements of setae: j_1 - 36, j_3 - 42, j_4, j_6, j_2, J_5 - 5 each, z_2 - 8, z_4 - 12, z_5 - 6, s_4 - 125, Z_1, 10, S_2 - 12, S_4 - 12, S_5 - 11, Z_4 - 108, Z_5 - 225. Sublateral setae r_3 - 10, R_1 - 8, both on the lateral integument. Sternal shield 76 long, 98 wide with 3 pairs of sternal setae (20 long), metasternal plate with setae distinct. Genital shield 90 wide with a pair of genital setae (24 long). A clear fold seen between genital shield and ventrianal shield. Ventrianal shield 120 long, 75 wide as figured with 3 pairs of preanal setae, a pair of preanal pores located little below the level of 3rd pair of preanal setae; 4 pairs of setae present around ventrianal shield; setae JV_5 - 60 long. Two pairs of metapodal plates present, primary one - 20 long, accessory one 12 long. Fixed digit of chelicera with 5 teeth posterior to *pilus dentilis* and 4 teeth anterior to it; movable digit with 3 teeth. Peritreme extends anterior to j_1. Spermatheca with short cervix. Macrosetae on Leg IV: genu - 128, tibia – 90 and basitarsus – 75.

Leg Chaetotaxy: genu II $2\,\dfrac{2}{0}\,\dfrac{2}{0}\,1$, tibia II $1\,\dfrac{1}{1}\,\dfrac{2}{1}\,1$,

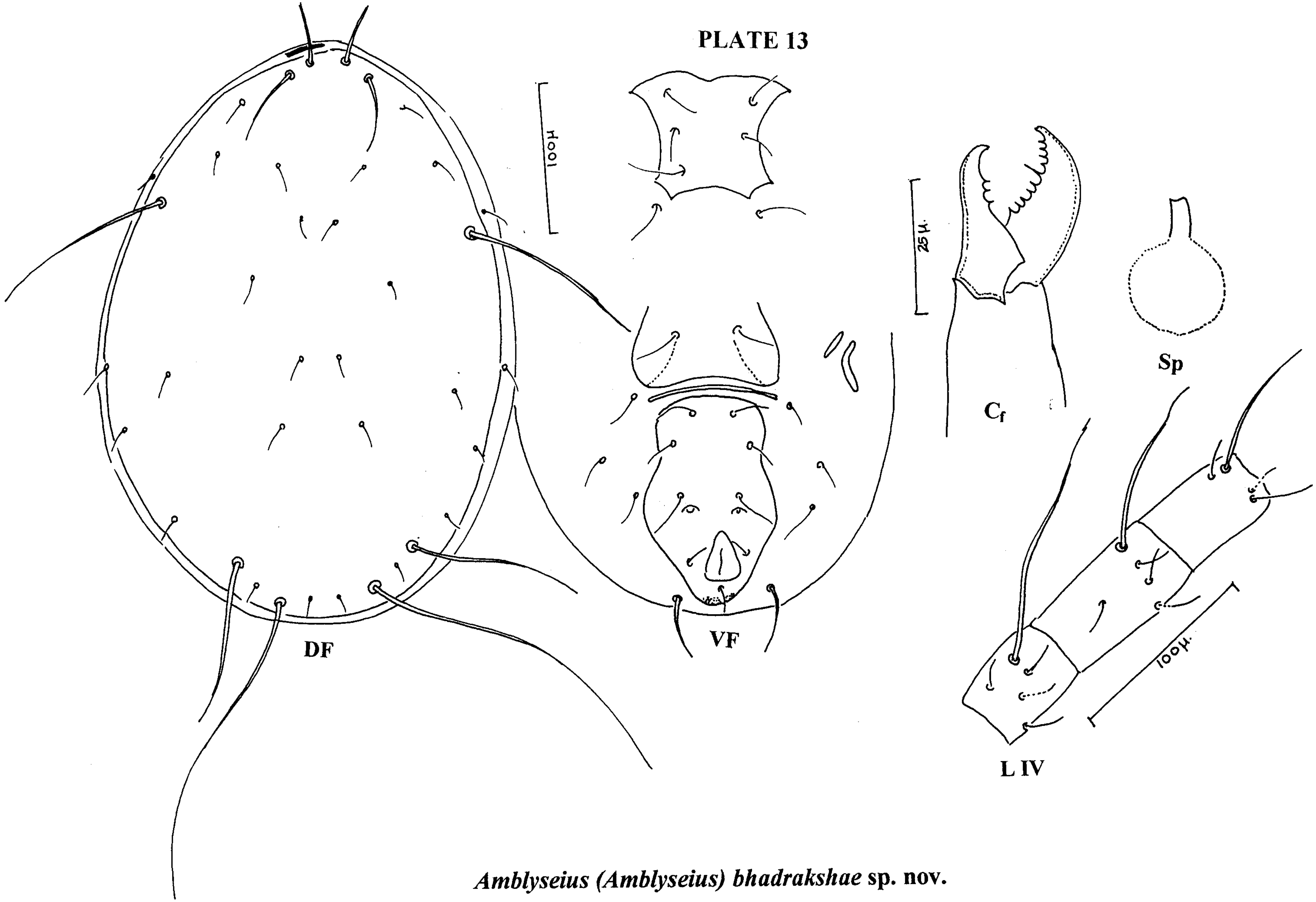
genu III $1\,\dfrac{2}{0}\,\dfrac{2}{1}\,1$, tibia III $1\,\dfrac{1}{1}\,\dfrac{2}{1}\,1$,

Male: Unknown.

Habitat: *Scaevola taccada*.

Material studied: Holotype ♀marked on the slide along with 3 ♀♀ and a larva, INDIA: KERALA: Ayurvedic Herbal Garden of Kottakkal Arya Vaidya Sala, Kottakkal (Malappuram district), 17.iv.2001, ex. *Scaevola taccada*, coll. Mary Anitha (No.A 37/1). One paratype slide with 6 ♀♀, collection details same as that of holotype (No. A 37/2).

PLATE 13



Amblyseius (Amblyseius) bhadrakshae **sp. nov.**

Remarks: This new species resembles *A. (A.) herbicolus* (Chant), but differs from it by the following characters:

1. In the new species a clear fold is seen between genital and ventrianal shield.
2. Shape of spermatheca is different from *A. (A.) herbicolus* (Chant).
3. Fixed digit of chelicera with 5 teeth posterior to *pilus dentilis* and 4 teeth anterior to it, unlike that of *A. (A.) herbicolus* (Chant).
4. Dorsal shield is longer in the new species.
5. Setae j_1 is longer (36) instead of 25 in *A. (A.) herbicolus* (Chant).

Amblyseius (Amblyseius) channabasavannai Gupta and Daniel, 1978

PLATE 14

1978. *Amblyseius channabasavanni* Gupta and Daniel, *Oriental Ins.*, **12**: 328-329.

1979. *Amblyseius channabasavanni*: Daniel, *First All India Symp. Acarol.*, p.49.

1981. *Amblyseius channabasavanni*: Daniel, In *Contrib. to Acarol. in India*, p.167.

1986. *A. (A.) channabasavannai* : Gupta, *Fauna of India (Acari: Mesostigmata) Family Phytoseiidae*, p.41.

Female: Dorsal shield smooth anteriorly, rugose posteriorly, 340 long, 230 wide, with 17 pairs of setae; j_1, j_3, s_4, Z_4 and Z_5 long, Z_5 being the longest. Measurements of setae: j_1 - 28, j_3 - 44, s_4 - 80, Z_4 - 100, Z_5 - 252 all other setae minute. Sternal shield weakly sclerotized, 80 long, 76 wide with 3 pairs of sternal setae, 4th pair lie on the metasternal plates. Genital shield 80 wide, with a pair of setae. Ventrianal shield 110 long, 90 wide with 3 pairs of preanal setae, and a pair of semicircular pores; 4 pairs of setae present around ventrianal shield; setae JV_5 smooth, 70 long. Two pairs of metapodal plates present, primary one 20 long, accessory one 9. Spermatheca with long cervix and swollen atrium. Fixed digit of chelicera multidentate, with a strong *pilus dentilis*, movable digit with 3 teeth. Peritreme extends anteriorly beyond j_1 and curves down. Macrosetae on leg IV: genu - 90, tibia - 66, basitarsus - 60.

Leg Chaetotaxy: genu II $2\ \frac{2}{0}\ \frac{2}{0}\ 1$, tibia II $1\ \frac{1}{1}\ \frac{2}{1}\ 1$,

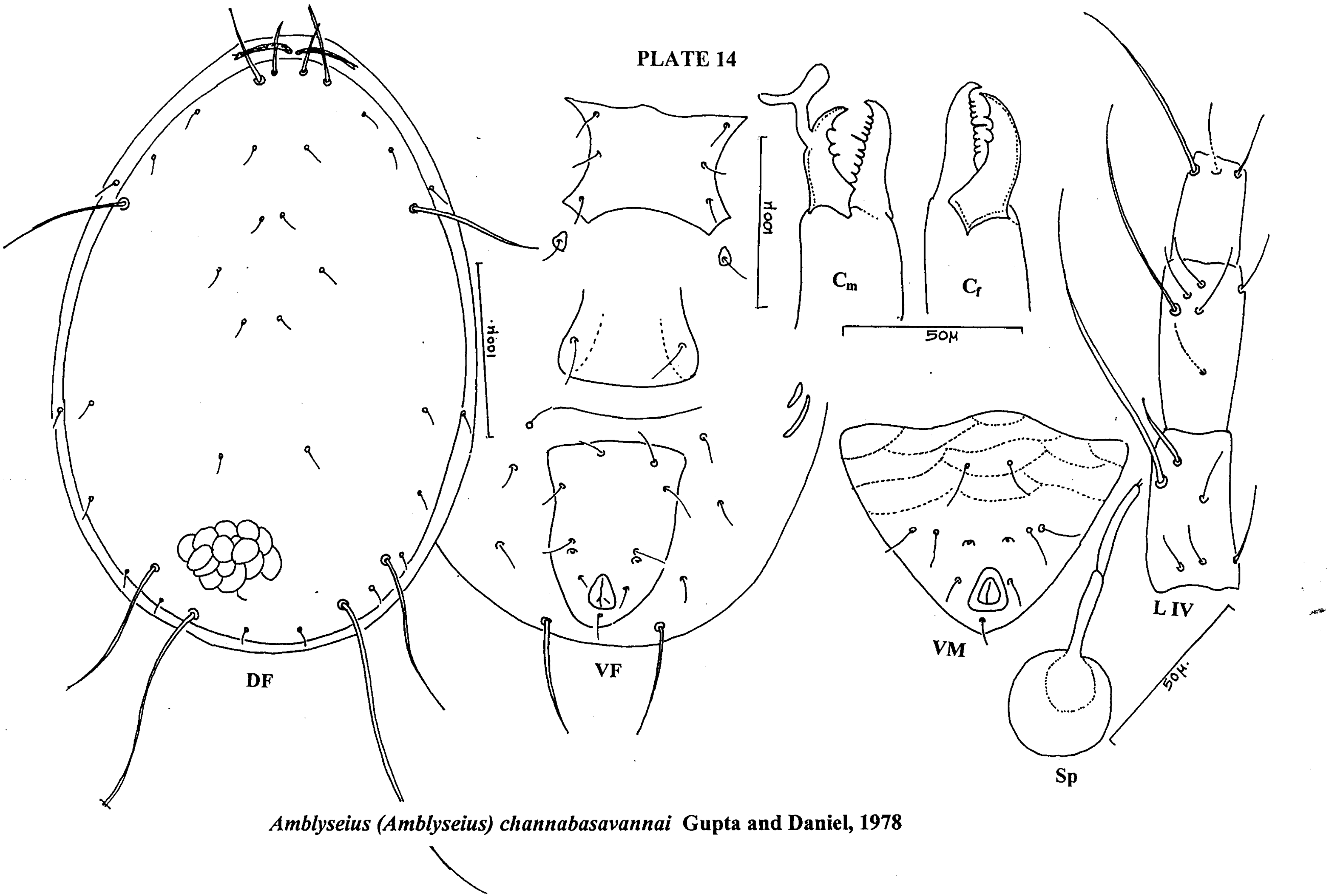
genu III $1\ \frac{2}{1}\ \frac{2}{0}\ 1$, tibia III $1\ \frac{1}{1}\ \frac{2}{1}\ 1$.

Male: Dorsal chaetotaxy similar to that of female. Spermatophoral process and ventrianal shield as figured.

Habitat: *Cocos nucifera.*

Known habitat: Chrysanthimum, dahlia, palm.

PLATE 14



Amblyseius (Amblyseius) channabasavannai Gupta and Daniel, 1978

Material examined: Female marked on the slide along with other 5 ♀♀, INDIA: KERALA: Calicut University Campus (Malappuram district), 4.iii.2001, ex. *Cocos nucifera,* coll. Mary Anitha (No.A 4/8). Many ♀♀ and ♂♂ were collected from the same habitat from different districts surveyed.

Distribution: INDIA: Kerala, Tamil Nadu, Arunachal Pradesh.

Remarks: The specimen studied resembles almost all characters of *A. (A.) Channabasavannai* Gupta and Daniel except the presence of 3 teeth on the movable digit of chelicera, hence fixed so. This predatory mite was seen along with tenuipalpid and tetranychid populations in the field.

Amblyseius (Amblyseius) coffeae **sp. nov.**

PLATE 15

Female: Dorsal shield smooth, 440 long and 307 wide with 17 pairs of setae, j_1, j_3, s_4, Z_4 and Z_5 long and the latter two being whip like, Z_5 the longest among the dorsal setae. $s_4 > Z_4$, $j_3 > j_1$. Measurements of the setae: j_1 - 37, j_3 - 47, s_4 - 109, Z_4 - 99 and Z_5 - 244, z_2, z_4 - 8 each, Z_1, S_2, S_5 - 7 each. r_3, R_1 - 8 each, both on the lateral integument, all other setae minute. Sternal shield longer (90) than broad (75) with 3 pairs of setae (30); metasternal plates with setae distinct. Genital shield 86 wide with a pair of setae (28). Ventrianal shield longer (109) than wide (49), vase-shaped, lateral margins concave with 3 pairs of preanal setae (22) and a pair of semilunar pores, little posterior to 3rd pair of preanal setae; 4 pairs of setae present on the membrane around ventrianal shield. Setae JV_5 - 62 long, smooth; 2 pairs of metapodal plates present, primary one 26 long, accessory one 8 long. Fixed digit of chelicera multidentate with *pilus dentilis*, movable digit with 3 sharp teeth. Spermatheca with short tubular cervix. Peritreme extends anteriorly beyond j_1 and curves down a little. Macrosetae on leg IV: genu - 105, tibia - 78, basitarsus - 68.

Leg Chaetotaxy: genu II $2\,\frac{2}{0}\,\frac{2}{0}\,1$, tibia II $1\,\frac{1}{1}\,\frac{2}{1}\,1$;

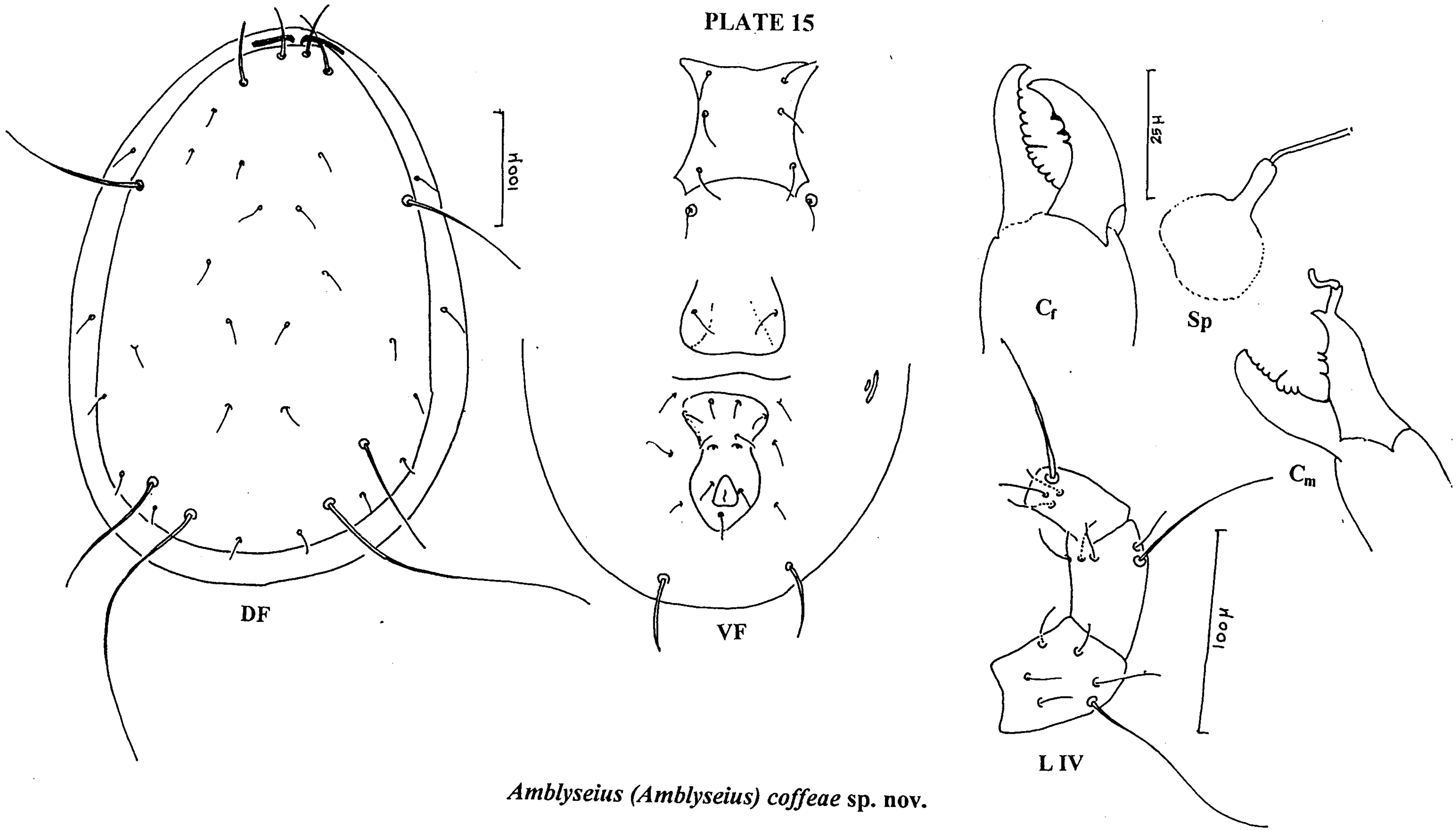
genu III $1\,\frac{2}{1}\,\frac{2}{0}\,1$, tibia III $1\,\frac{1}{1}\,\frac{2}{1}\,1$.

Male: Dorsal chaetotaxy similar to that of female. Spermatophoral process as illustrated. Macrosetae on Leg IV: genu - 90, tibia - 65, basitarsus - 60.

Habitat: *Coffea arabica* (Stored)

Material examined: Holotype ♀ marked on the slide along with other 3 ♀♀, INDIA: KERALA: Mananthavady (Wayanad district), 8.ix.2000, ex. *Coffea arabica* (stored), coll: Mary Anitha (No. AS 24/1). One paratype slide with 4 ♀♀ and a ♂, collection details same as that of holotype (No. AS 24/2).

PLATE 15



Amblyseius (Amblyseius) coffeae sp. nov.

Remarks: This new species resembles *A. (A.) largoensis* (Muma) in the shape of ventrianal shield and shape of spermatophoral process of male, but differs from it by the following characters:

1. The more elongated nature of the dorsal shield.

2. The length of s_4 (109) in the new species exeeds that of Z_4 (99) while in *A. (A.) largoensis* (Muma) Z_4 is longer than s_4.

3. Number of teeth on the movable digit of chelicera is 3 in the new species instead of 2 in *A. (A.) largoensis* (Muma).

4. Cervix of the spermatheca is short in the new species while it is long in *A. (A.) largoensis* (Muma).

Amblyseius (Amblyseius) indirae Gupta, 1985

PLATE 16

1985. *Amblyseius (Amblyseius) indirae* Gupta, *Entomon*, **10**(3): 209-211.

1987. *Amblyseius (Amblyseius) indirae:* Gupta, *Rec. Zool. Surv. India*, p.16.

Female: Dorsal shield 340 long, 210 wide, with 17 pairs of setae, all setae small except, j_1, j_3, s_4, Z_5, Z_4. j_1 slightly shorter than j_3, $z_2 = z_4$, $s_4 > Z_4$. Measurements of setae: j_1 - 30, j_3 - 36, j_4 - j_6, J_2, J_5 very small, z_2, z_4, z_5 -6 each, s_4 - 105, Z_1, S_2, S_5 -

6 each, Z_5 - 238, Z_4 – 102, r_3, R_1-10 each. Sternal shield 90 wide with 3 pairs of setae, metasternal plates conspicuous with a pair of setae. Genital shield 70 wide, with a pair of setae. Ventrianal shield 105 long, 70 wide, lateral margin concave with 3 pairs of preanal setae; a pair of crescent shaped preanal pores slightly below the level of 3rd pair of preanal setae; 4 pairs of setae present around the ventrianal shield. Setae JV_5 - 60 long; 2 pairs of metapodal plates present, primary one 24 long and accessory one 10 long. Spermatheca as figured with a long tubular duct. Fixed digit of chelicera multidentate with 5 teeth anterior to *pilus dentilis,* 4 teeth posterior to it, movable digit toothless. Peritreme extends anteriorly up to j_1. Macrosetae present on leg IV: genu - 120, tibia - 98, basitarsus 74.

Leg chaetotaxy: genu II $2\ \dfrac{2}{0}\ \dfrac{2}{0}\ 1$, tibia II $1\ \dfrac{1}{1}\ \dfrac{2}{1}\ 1$,

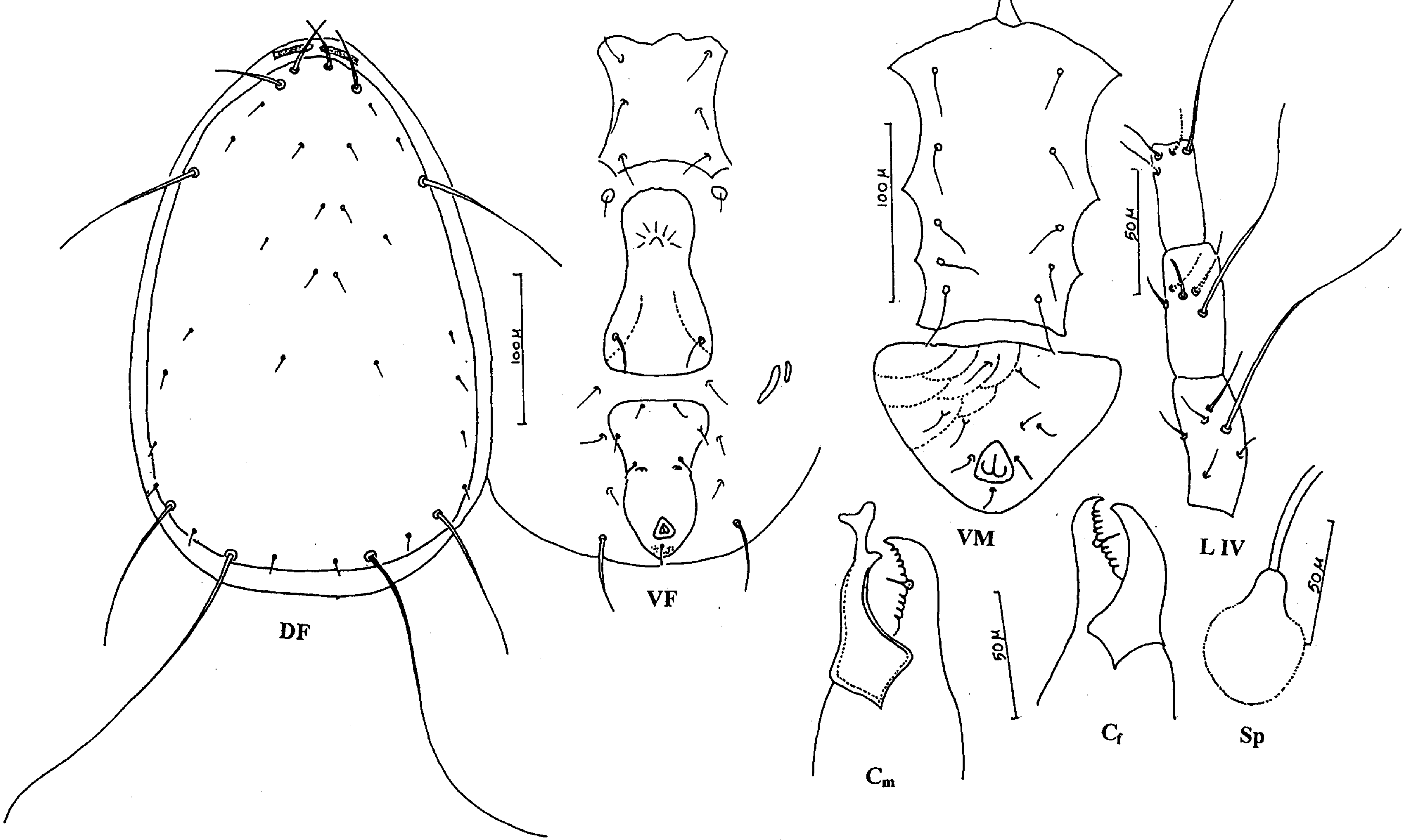
genu III $1\ \dfrac{2}{1}\ \dfrac{2}{0}\ 1$, tibia III $1\ \dfrac{1}{1}\ \dfrac{2}{1}\ 1$.

Male: Dorsal chaetotaxy similar to that of female. Spermatophoral process, ventrianal shield and sternitigenital shield as figured.

Habitat: *Cucurbita maxima, Syzygium jambos, Syzygium malaccense, Cucumis melo, Cocos nucifera, Piper longum, Anacardium occidentale.*

Known habitat: Undetermined plant.

PLATE 16



Amblyseius (Amblyseius) indirae Gupta, 1985

Material examined: Female and a ♂ marked on the slide along with 4 ♀♀, INDIA: KERALA: Dharmadam (Kannur district), 4.x.2000, ex. *Cucurbita maxima*, coll. Mary Anitha (No.A 49/4). Many ♀♀ and ♂♂ from the habitats mentioned above from different districts surveyed (A 23/3, 43/4, 46/3, 4/5, 52/2).

Distribution: INDIA: Kerala, Karnataka.

Remarks: The specimen studied agrees with *A. (A.) indirae* Gupta in almost all characters and hence fixed so. It was seen associated with tenuipalpids as well as tetranychids.

Amblyseius (Amblyseius) koothaliensis sp. nov.

PLATE 17

Female: Dorsal shield 360 long, 295 wide with 17 pairs of setae, j_1, j_3, s_4, Z_4 and Z_5 long and Z_5, the longest. Measurements of setae ; j_1 - 35, j_3 - 75, s_4 - 210, Z_4 - 115 and Z_5 - 528. Two pairs of sublateral setae present, $r_3 = R_1 = 18$, on the lateral integument. All other body setae measures 15 - 24 in length. Broad reticulate pattern seen on the dorsum. Sternal shield 78 long 86 wide with 3 pairs of sternal setae (30 long), and 4th pair present on the faintly visible metasternal plates. Genital shield 90 wide with a pair of setae (20 long). The shape of ventrianal shield as figured measuring 120 long and 105 wide with 3 pairs of preanal setae (28 long) and a pair of crescent shaped preanal pores; 4 pairs of ventrolateral setae present on the membrane around the ventrianal shield. Setae JV_5 smooth, 70 long. Spermatheca as figured with round bulged capitulum and short tubular cervix. Chelicera 100 long and proportionate to the body size. The fixed digit of the chelicera with a distinct *pilus dentilis,* 5 teeth present anterior to *pilus dentilis* and 5 posterior to it. Movable digit tridentate; all the teeth prominent and pointed. Peritreme extends anteriorly beyond j_1, peritremal shield joined with dorsal shield anteriorly. Macrosetae present on leg I, III and IV; genu IV - 264, tibia IV – 201, basitarsus - 160; Genu III - 148, tibia III -- 86, basitarsus III - 115; Genu I - 93, tibia I - 150, basitarsus I - 120. Separation between basitarsus and tarsus weak, tarsal tips of the legs end with pinsor like claws.

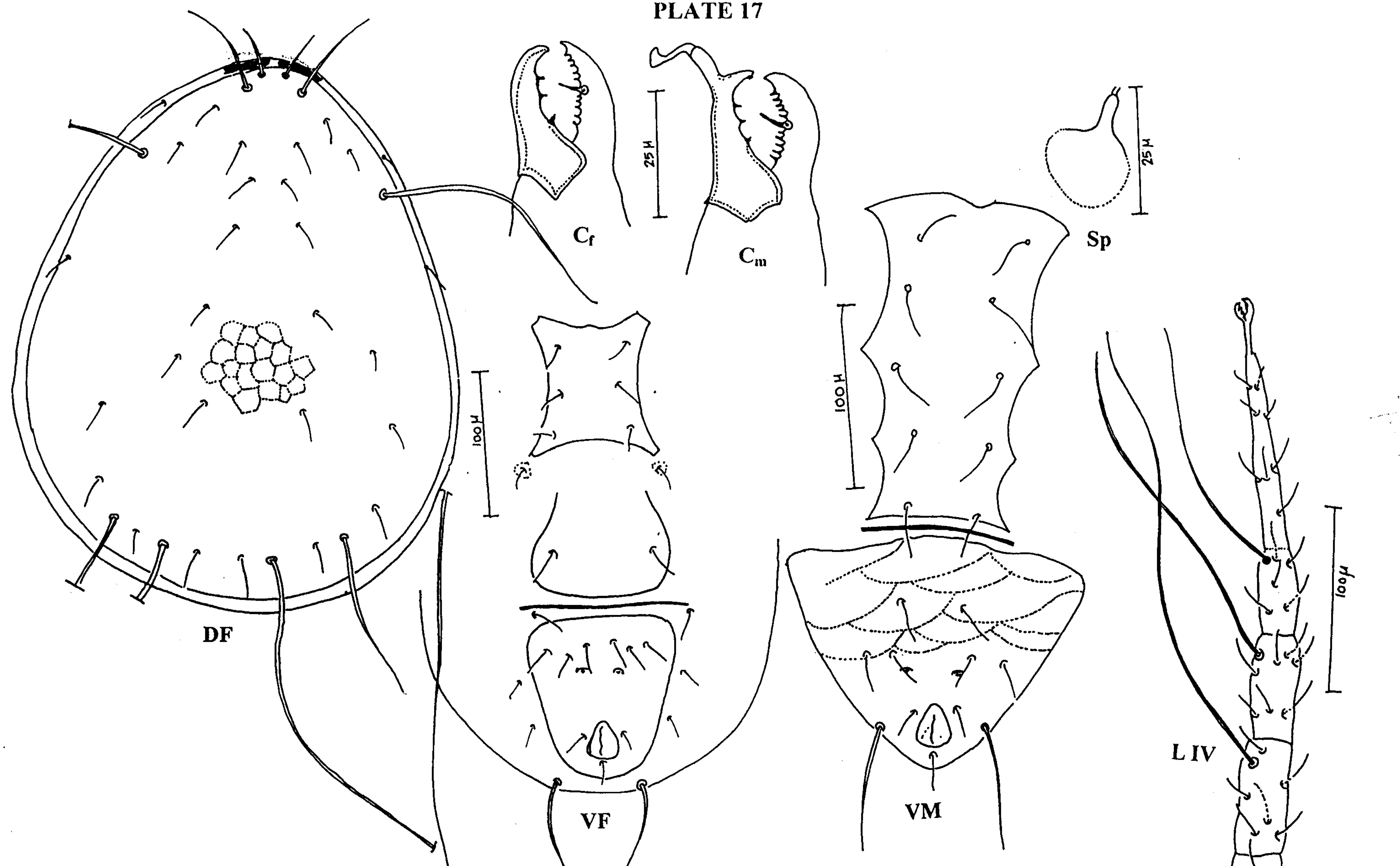
Leg chaetotaxy: genu II $2\,\frac{2}{0}\,\frac{2}{0}\,1$, tibia II $1\,\frac{1}{1}\,\frac{2}{1}\,1$, and genu III $1\,\frac{2}{0}\,\frac{2}{1}\,1$.

Male: Dorsal chaetotaxy similar to that of female. Spermatophoral process, ventrianal shield and sternitigenital shield as figured.

Habitat: *Carica papaya.*

Material examined: Holotype♀, marked on the slide along with other 3♀♀, INDIA: KERALA: Agricultural Farm, Koothali (Kozhikode district), 19.iv.2001, ex. *Carica papaya,* coll. Mary Anitha (No.A 14/1). Paratype slides with 14 ♀♀ and 2 ♂♂, collection details same as holotype (No. A 14/2, 14/3 and 14/4).

PLATE 17



Amblyseius (Amblyseius) koothaliensis sp. nov.

Remarks: This new species can be differentiated from all other known species by the possession of the following characters:

1. Pinsor like claws on tarsal tips of the legs.
2. Macrosetae on Leg I, III and IV.
3. Very long nature of the seta Z_5 when compared to all the other species studied.
4. Broad reticulate pattern of the dorsum.
5. Weak separation between basitarsus and tarsus.

Amblyseius (Amblyseius) kundurukkae **sp. nov.**

PLATE 18

Female: Dorsal shield with characteristic design, 360 long, 250 wide with 17 pairs of setae, j_1, j_3, s_4, Z_4 and Z_5 long and the latter two whip like. Measurements of setae : j_1 - 38, j_3 - 58, s_4 – 107; j_4, j_6, J_2, J_5 extremely small; z_2, z_4 - 7 each; Z_1, S_2, S_5 - 6 each Z_4 - 98, Z_5 - 250. Sublateral setae r_3, R_1 - 10 each on the lateral integument. Sternal shield 116 long, 88 wide with 3 pairs of setae. Genital shield 85 wide, genital and sternal shield overlapping. Ventrianal shield 106 long, 70 wide with characteristic shape, with 3 pairs of preanal setae, semilunar pores absent; 4 pairs of ventrolateral setae present on the membrane around ventrianal shield. Genital and ventrianal shields wide apart (50); setae JV_5 - 58 long, smooth. Metapodal plates 2 pairs, primary one 30 and accessory one 10 long. Fixed digit of chelicera with 5 teeth anterior to ***pilus dentilis*** and 2 teeth posterior to it; movable digit toothless. Peritreme extends between j_1 and j_3. Spermatheca with short cervix. Macrosetae on leg IV: genu - 126, tibia - 78, basitarsus - 60.

Leg chaetotaxy: genu II $2\,\frac{2}{0}\,\frac{2}{0}\,1$, tibia II $1\,\frac{1}{1}\,\frac{2}{1}\,1$;

genu III $1\,\frac{2}{1}\,\frac{2}{0}\,1$, tibia III $1\,\frac{1}{1}\,\frac{2}{1}\,1$.

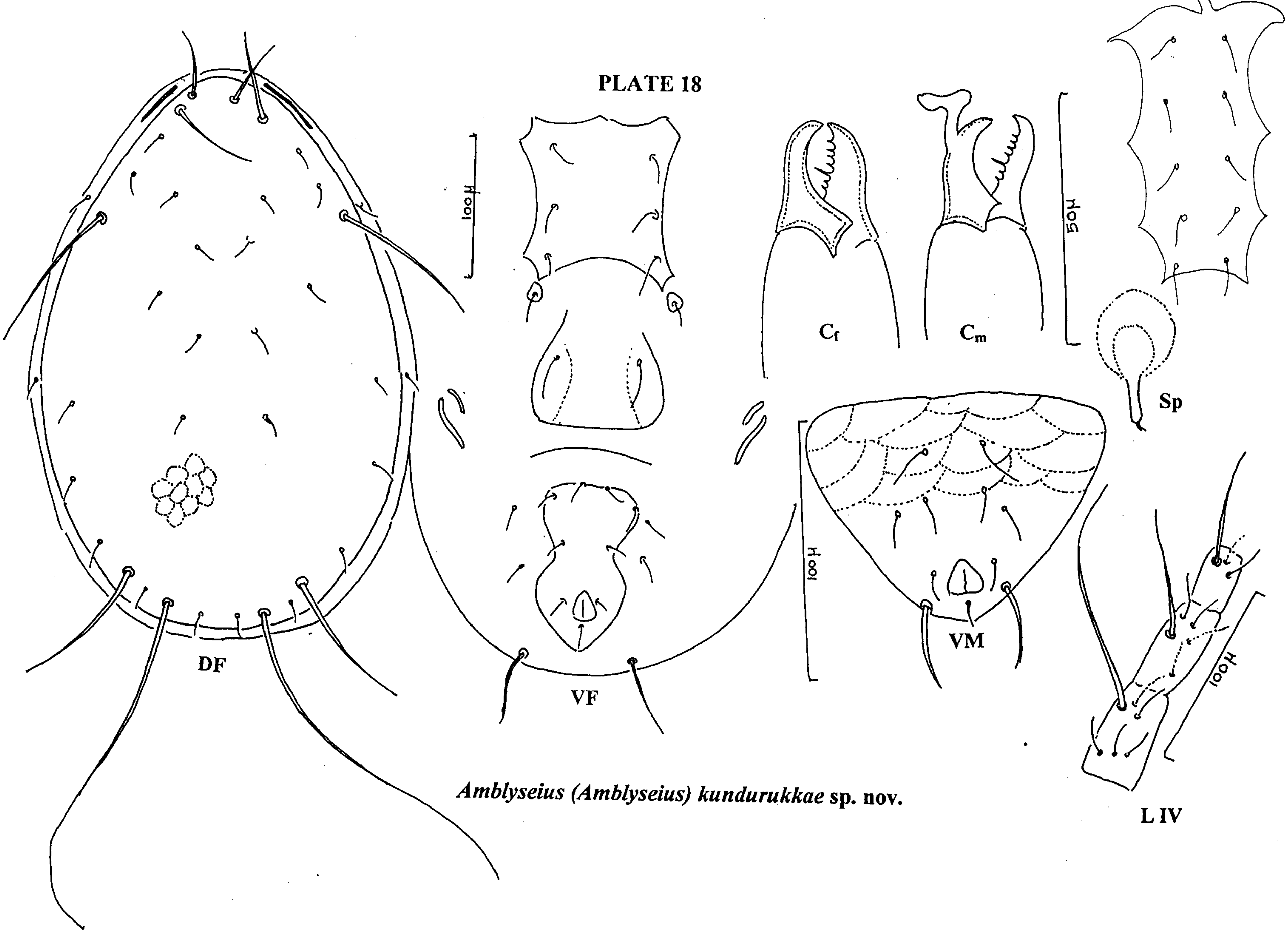
Male: Dorsal chaetotaxy similar to that of female. Spermatophoral process, ventrianal shield and sternitigenital shield as figured.

Habitat: *Vathria indica.*

Materials examined: Holotype ♀ marked on the slide along with other 4 ♀♀, INDIA: KERALA: Ayurvedic Herbal Garden of Kottakkal Arya Vaidya Sala , Kottakkal, (Malappuram district), 16.iii.2001, ex. *Vathria indica*, coll. Mary Anitha (No.A 40/1). Two paratype slides with 10 ♀♀, collection details same as that of holotype (No. A 40/2, 40/3).

Remarks: This new species resembles *A. (A.) indirae* Gupta, but differs from it in the following characters:

PLATE 18



Amblyseius (Amblyseius) kundurukkae sp. nov.

1. Overlapping of sternal and genital shields in the new species.

2. Difference in the structure of spermatheca.

3. Ventrianal shield and genital shield placed wide apart (50).

4. Presence of a clear fold between genital and ventrianal shields.

5. Longer nature of j_3 (58) in the new species when compared to *A. (A.) indirae* Gupta (36).

6. Characteristic design on the dorsal shield of the new species.

7. Extended nature of the peritreme between j_1 and j_3 in the new species.

Amblyseius (Amblyseius) largoensis (Muma), 1955

PLATE 19

1955. *Amblyseius largoensis* Muma, *Ann. Entomol. Soc. Amer.*, **48**: 266.

1959. *Amblyseius largoensis* : Ehara, *Acarologia*, **1**: 293-294.

1964. *Amblyseius largoensis* : Rao and Rao, *Comm. Inst. Biol. Contri. Tech. Bull.*, **4**: 38-39.

1969. *Amblyseius amitai* : Bhattacharyya, *J. Bomb. Nat. Hist. Soc.*, **65**(3): 677-679. (New synonymy).

1970. *Amblyseius largoensis* : Gupta, *Sci. and Cult.*, **36**: 298.

1971. *Amblyseius largoensis* : Gupta *et al.*, *Sci. and Cult.*, **37**: 98.

1974. *Amblyseius largoensis* : Prasad, *A catalogue of mites of India*, p.166-167.

1974. *Amblyseius largoensis* : Gupta, *Entomol. Rec.*, **86**: 143.

1975. *Amblyseius largoensis* : Gupta, *Internat. J. Acarol.*, **1**(2): 38.

1977. *Amblyseius largoensis* : Gupta, *Indian J. Acarol.*, **1**: 33.

1977. *Amblyseius amtalaensis* : Gupta, *Entomologist's Mon. Mag.*, **112**: 53 (New Synonymy).

1977. *Amblyseius largoensis* : Gupta, *Oriental Ins.*, **11**: 629-631.

1978. *Amblyseius largoensis* : Gupta, *Indian J. Acarol.*, **2**(2): 65-66.

1979. *Amblyseius largoensis* : Gupta and Nahar, *First All India Symp. Acarol. (Abstract)*, p.3.

1981. *Amblyseius largoensis* : Gupta and Nahar, In: *Contrib. to Acarol. in India*, p.9.

1982. *Amblyseius largoensis* : Gupta, *Indian J. Acarol.*, **6**: 25.

1986. *Amblyseius (Amblyseius) largoensis* : Gupta, *Fauna of India (Acari : Mesostigmata) Family Phytoseiidae*, p.51.

Female: Dorsal shield 348 long 253 wide with 17 pairs of setae and three pairs of pores. Setae j_1, j_3, s_4, Z_4 and Z_5 long and the latter two whip like $s_4 < Z_4$, $j_3 > j_1$, j_1 - 31, j_3 - 47, j_4, j_5, j_6 - J_2 5 each, Z_4 - 105, Z_5 - 250 z_2, z_4 - 7 each, s_4 - 99, r_3 and R_1 - 8 each, both on the lateral integument. Sternal shield longer (94) than broad (84) with 3 pairs of sternal setae (24 long), metasternal plates with setae (26) distinct. Genital shield 84 wide with a pair of setae (26). Ventrianal shield 105 long, 75 wide, vase shaped with concave lateral margins, 3 pairs of preanal setae and a pair of semilunar pores; 4 pairs of setae present on the membrane around ventrianal shield. Setae JV_5 smooth, 60 long; 2 pairs of metapodal plates present, primary one 26 long and accessory one 18. Fixed digit of chelicera with 4 teeth anterior to *pilus dentilis* and 3 teeth posterior to it, movable digit with 2 sharp teeth. Peritreme extends anteriorly beyond j_1. Spermatheca with tubular cervix and parallel walls. Macrosetae on leg IV : genu 98, tibia 70, basitarsus 48; genu 11 - 34, genu III - 36 and tibia III - 44.

Leg Chaetotaxy : genu II $2\,\frac{2}{0}\,\frac{2}{0}\,1$, tibia II $1\,\frac{1}{1}\,\frac{2}{1}\,1$;

genu III $1\,\frac{2}{1}\,\frac{2}{1}\,1$, tibia III $1\,\frac{1}{1}\,\frac{2}{1}\,1$.

Male: Dorsal chaetotaxy similar to that of female. Spermatophoral process, ventrianal shield and sternitigenital shield as figured.

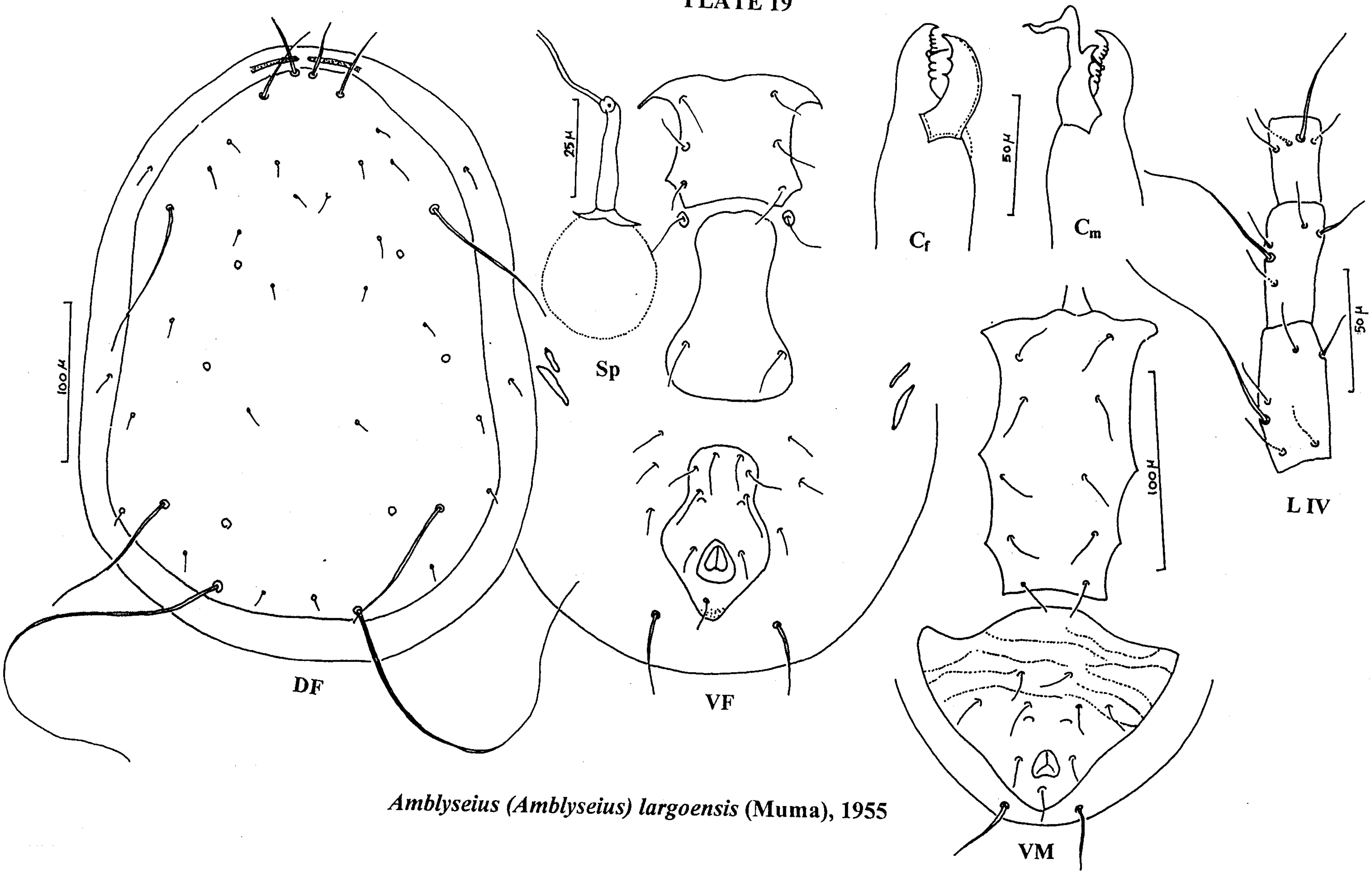
Known habitat: Mango, *Callophyllum inophyllum, Musanda corymbosa, Tabernaemontam coronria,* Castor, banana, citrus, coconut pomegranate, Dalbergia, eucalyptus, *Tectoma grandis,* black berry, sugarcane, rose, cassia, cashewnut, bamboo, arecanut, Eugenia, fig, guava, pepper, Nerium, litchi, plum, *Manglietia insignis*, chilli, shorea sp., papaya, *Musa, Bauhinia acuminata*, poppy, pine cone, grass, dahlia, "Kanku," peach, *Cassia fistula* and *Citrus medica*.

Material examined : Female marked on the slide along with other 3 ♀ ♀, INDIA: KERALA: Nileswaram (Kasaragod district), 8.viii.2000, ex. *Mangifera indica,* coll. Mary Anitha (No. A 13/1). 8 ♀, Kalpetta (Wayanad district), 3. X. 2000, ex. *Piper nigrum* , coll. Mary Anitha (No. A 24/2).

Distribution: INDIA: Kerala, West Bengal, Bihar, Manipur, Tripura, Nagaland, Arunachal Pradesh, Assam, Meghalaya, Orissa, Andra Pradesh, Karnataka, Tamil Nadu, Pondicherry Utter Pradesh, Punjab, Himachal Pradesh, Gujarat, Andaman Nicobar Islands. **OUTSIDE INDIA**: Japan, Guatemala, Honduras, Puerto Rico, Brazil, Costa Rica, New Zealand, Mexico, Jamaica, Trinidad, S. Africa, Kenya, California, Florida, Hawaii, Israel, Western and Northern Iran, Hong Kong, Philippines, Taiwan and Thailand.

Remarks : The material examined agrees with *A. (A.) largoensis* (Muma) in almost all characters, hence fixed so.

PLATE 19



Amblyseius (Amblyseius) largoensis (Muma), 1955

***Amblyseius (Amblyseius) malabarensis* sp. nov.**

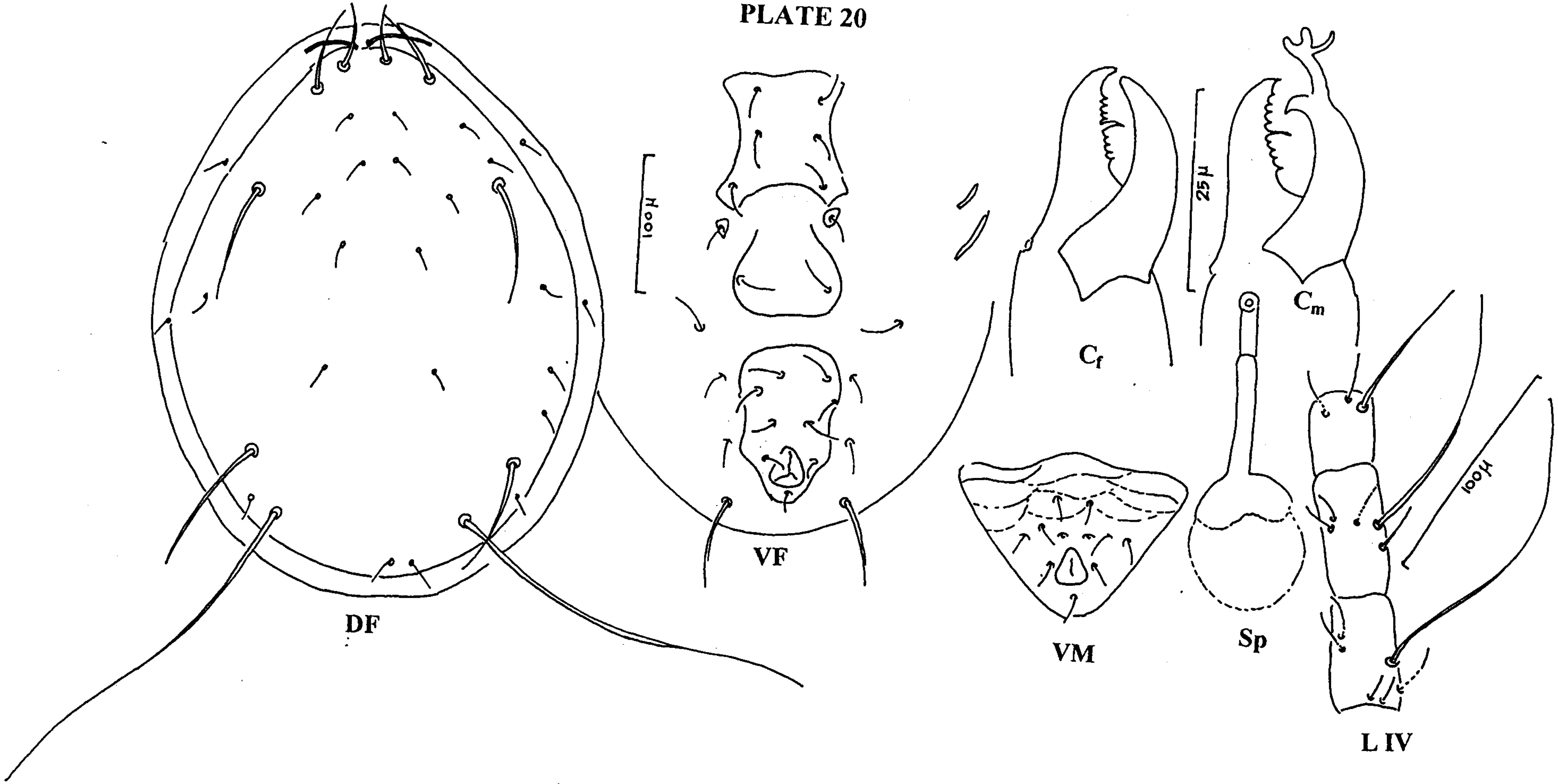
PLATE 20

***Female*:** Dorsal shield smooth anteriorly, 398 long and 315 wide with 17 pairs of setae. j_1, j_3, s_4, Z_4 and Z_5 long, the latter the longest, all other setae minute. Measurements of setae: j_1 - 38, j_3 - 52, s_4 - 90, Z_4 - 105, Z_5 - 285, j_4, j_6, J_2, J_5 - 10 each, z_3 - 12, z_4, z_5 - 8, Z_1 = 12, S_2 - 6, S_5 - 10. Sternal shield lobate posteriorly, 94 long, 80 wide with 3 pairs of sternal setae, 4th pair lie on the metasternal plates. Genital shield 80 wide with a pair of setae (26 long). Ventrianal shield 105 long, 90 wide with 3 pairs of preanal setae (28 long) and a pair of elliptical pores; 4 pairs of setae present around the ventrianal shield. Metapodal plates 2 pairs, primary one 24 long and accessory one 12 long. Setae JV_5 smooth, 56 long. Fixed digit of chelicera multidentate with a strong *pilus dentilis*, movable digit toothless. Spermatheca with a long tubular cervix and bulged capitulum. Peritreme extends anteriorly upto j_1 and slightly curves downwards. Peritremal shield joins with dorsal shield anteriorly. Macroseta present on leg IV: genu - 135, tibia - 120, basitarsus - 60.

Leg chaetotaxy: genu II $2 \, \frac{3}{0} \, \frac{1}{0} \, 1$, tibia II $1 \, \frac{2}{1} \, \frac{1}{1} \, 1$;

genu III $1 \, \frac{2}{2} \, \frac{1}{0} \, 1$, tibia III $1 \, \frac{2}{1} \, \frac{1}{1} \, 1$.

PLATE 20



Amblyseius (Amblyseius) malabarensis sp. nov.

Male: Spermatophoral process as illustrated.

Habitat: *Areca catechu, Ficus racemosa* and *Saraca asoca*

Material examined: Holotype ♀ marked on the slide, INDIA: KERALA: Madappally (Kozhikode district), 16.ix.2000, ex. *Areca catechu,* coll. Mary Anitha (A.27/1). Paratypes 12 ♀♀ and 6 ♂♂ from the habitats mentioned above from all the districts surveyed (A 27/5, A 33/6, A 32/7).

Remarks: This new species resembles *A. (A.) indirae* Gupta, but can be differentiated from it based on the following characters:

1. Dorsal shield larger than that of *A. (A.) indirae* Gupta.
2. Sternal shield lobate posteriorly.
3. Shape of spermatophoral process different from that of *A. (A.) indirae* Gupta.
4. Peritreme extends anteriorly upto j_1 and curves downwards.
5. Difference in the length of macrosetae on genu and tibia for the new species (135, 120 instead of 117, 94) of *A. (A.) indirae* Gupta.
6. Shape of spermatheca different.

***Amblyseius (Amblyseius) mohanasundarami* sp. nov.**

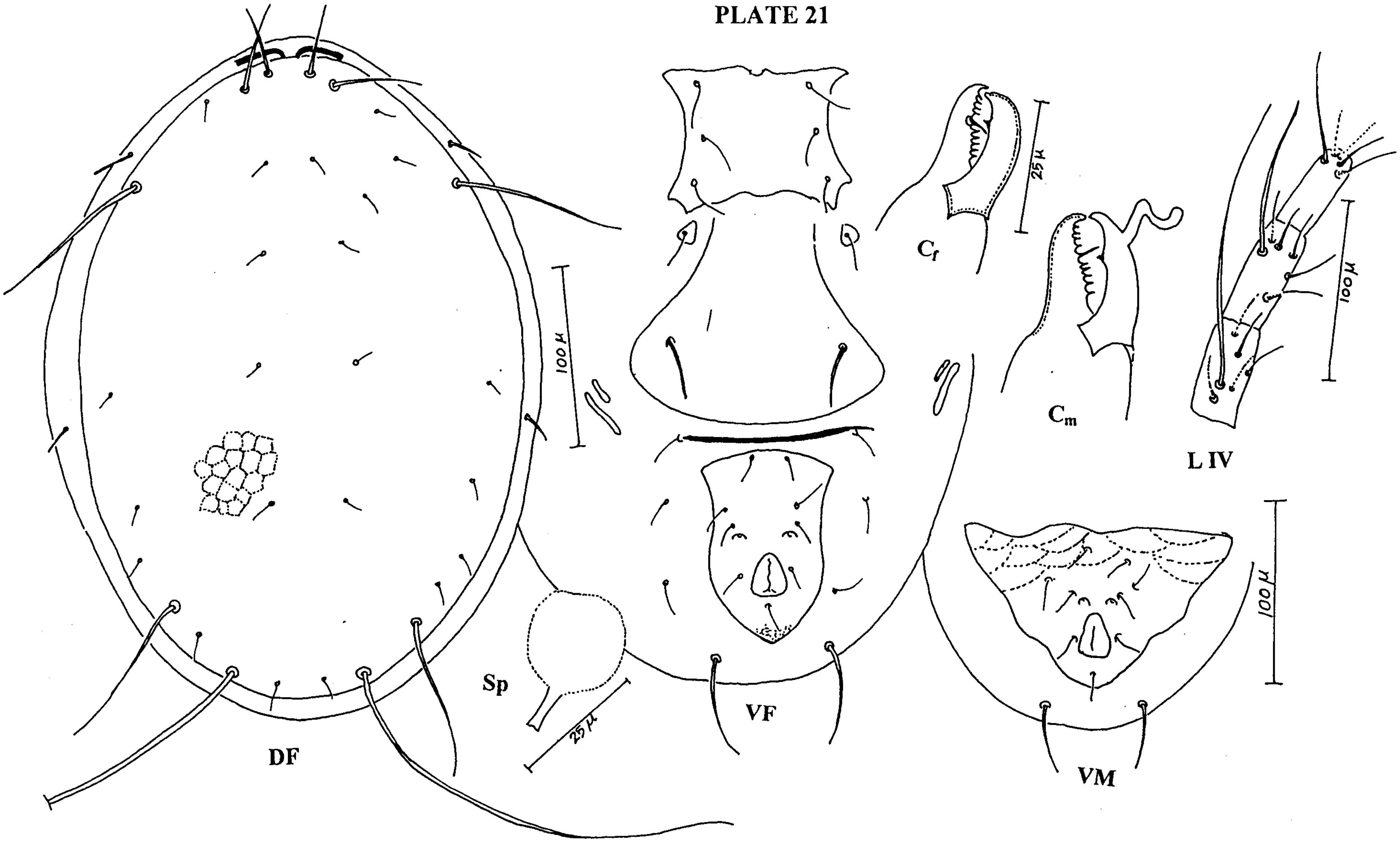
PLATE 21

Female: Dorsal shield 365 long, 248 wide, smooth anteriorly and rugose posteriorly with 17 pairs of setae. j_1, j_3, s_4, Z_4, Z_5 long, Z_5 the longest; all other setae minute. Measurements of setae: j_1 - 33, j_3 - 48, s_4 - 99, Z_4 - 90, Z_5 - 252. Sternal shield 75 long, 90 wide with 3 pairs of sternal setae, 4th pair placed on the metasternal plates. Genital shield 146 wide with a pair of genital setae (18 long). A band present between genital and ventrianal shield. Ventrianal shield 100 long and 78 wide with 3 pairs of preanal setae and a pair of semicircular preanal pores; 4 pairs of setae present around ventrianal shield. Setae JV_5 - 65 long; 2 pairs of metapodal plates present, primary one 24 long and accessory one 10 long. Fixed digit of chelicera multidentate with a strong *pilus dentilis*, movable digit with one tooth. Peritreme extends beyond j_1 and curves inwards. Spermatheca with short cervix and swollen atrium. Macrosetae present on leg IV: genu - 140, tibia - 90, basitarsus - 60; genu 1 - 38, genu II - 48, genu III - 48.

Leg chaetotaxy: genu II $2\,\frac{2}{0}\,\frac{2}{0}\,1$, tibia II $1\,\frac{1}{1}\,\frac{2}{1}\,1$;

genu III $1\,\frac{2}{1}\,\frac{2}{0}\,1$, tibia III $1\,\frac{1}{1}\,\frac{2}{1}\,1$.

PLATE 21



Amblyseius (Amblyseius) mohanasundarami sp. nov.

Male: Dorsal chaetotaxy similar to that of ♀. Spermatophoral process as illustrated.

Habitat: *Dioscorea alata.*

Material examined: Holotype ♀ marked on the slide along with other 3 ♀ ♀ and a ♂, INDIA: KERALA: West Hill (Kozhikode district), 20.iv.2000, ex. *Dioscorea alata*, coll. Mary Anitha (No.A. 58/1). Two paratype slides with 12 ♀ ♀, collection details as that of the holotype (No.A58/2, 58/3).

Remarks: This new species resembles *A. (A.) channabasavannai* Gupta and Daniel in the dorsal chaetotaxy, peritreme structure, body design etc. but can be clearly differentiated from it by the possession of the following characters:

1. Movable digit of the chelicera possesses only a single tooth instead 4 in *A. (A.) channabasavannai* Gupta and Daniel.

2. Shape of spermatheca different.

3. Larger size of genital shield (167 wide), where as it is 76 - 80 in *A. (A.) channabasavannai* Gupta and Daniel.

4. Longer nature of macrosetae on leg IV genu and tibia; genu 140 (80 - 95); tibia 90 (60-64).

This species is named for Dr. M. Mohanasundaram, Retired professor of Entomology, Tamil Nadu Agricultural University, Coimbatore for his rich contribution to the advancement of Acarology.

Amblyseius (Amblyseius) muraleedharani Gupta, 1981

PLATE 22

1981. *Amblyseius rhabdus*: Muraleedharan and Chandrasekharan, *Pestology*, **5**: 13.

1983. *Amblyseius (Amblyseius) rhabdus*: Ray and Gupta, *Rec. Zool. Surv. India*, **80**: 304-305.

1986. *Amblyseius (Amblyseius) muraleedharani* : Gupta, *Env. and Ecol.*, **3**(3): 434.

Female: Dorsal shield smooth with 17 pairs of setae, 400 long; 250 wide. Setae j_1, j_3, s_4, Z_4 and Z_5 long and whip like measuring 28, 46, 106, 322 and 160 respectively; all other setae small (6-8). Sternal shield 80 long, 118 wide with 3 pairs of sternal setae (30 long), 4th pair lie on oval shaped metasternal plates. Genital fold 110 wide with a pair of genital setae (20 long). A clear integumental shield present between genital and ventrianal shield. Ventrianal shield pentagonal 140 long 129 wide, reticulate, with 3 pairs of preanal setae; 4 pairs of setae present around ventrianal shield. Two pairs of metapodal plates present, primary one 20 and triangular shaped, accessory one 16 long. Fixed digit of chelicera multidentate, movable digit unidentate. Spermatheca as figured. Peritreme extend anteriorly up to j_1. Macrosetae on Leg IV: genu - 110, tibia - 98, basitarsus 72; genus III - 62, genu II - 44; genu I - 40, tibia III - 58.

Leg chaetotoxy : genu II $2\,\frac{2}{0}\,\frac{2}{0}\,1$, tibia II $1\,\frac{1}{1}\,\frac{2}{1}\,1$, and genu III $1\,\frac{2}{0}\,\frac{2}{1}\,1$.

Male: Unknown.

Habitat: *Tinospora cordifolia*

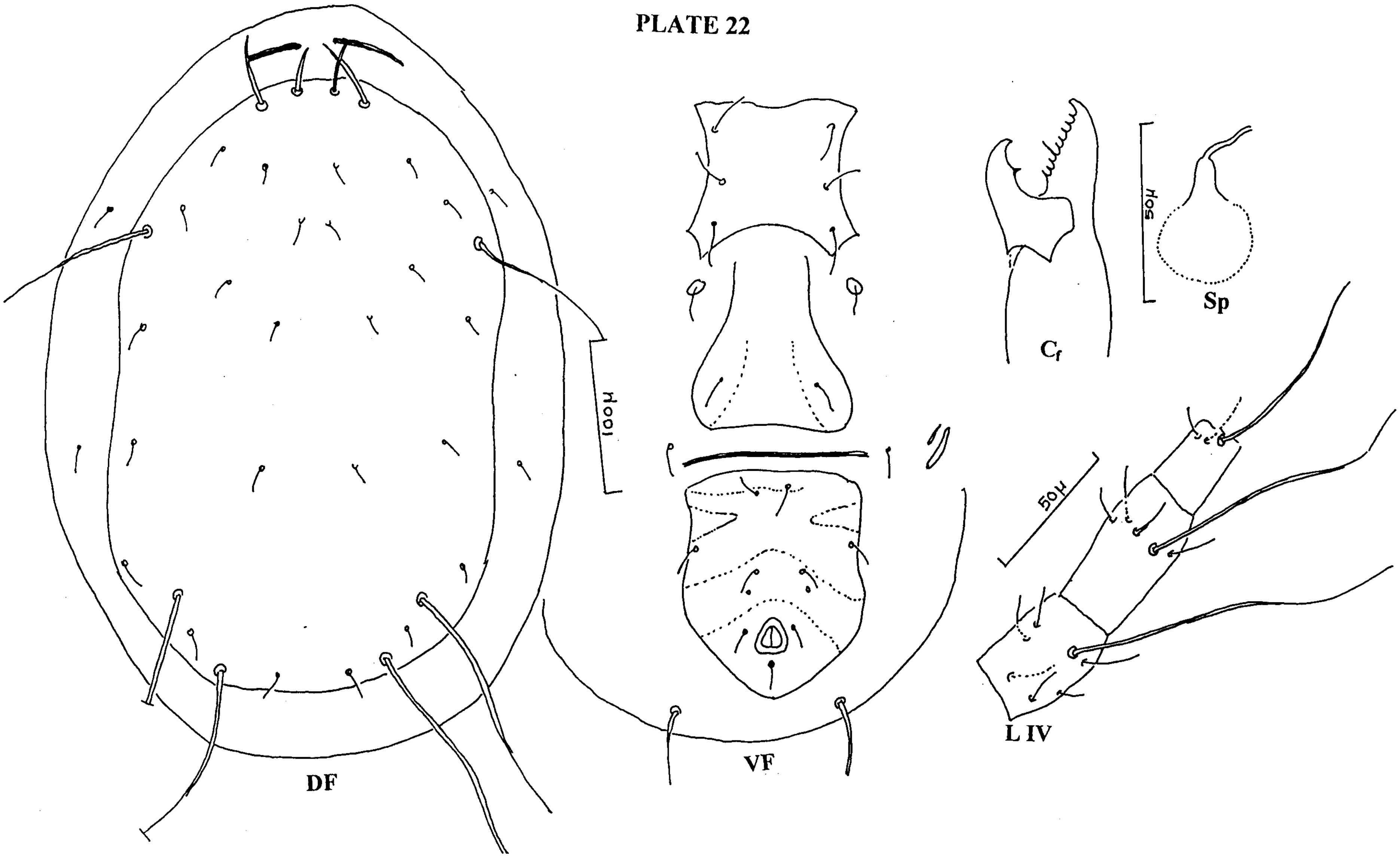
Known habitat: Tea

Material examined: One female marked on the slide along with other 4 ♀♀, INDIA: KERALA: Ayurvedic Herbal Garden of Kottakkal Arya Vaidya Sala, Kottakkal, 17.iv. 2001, ex. *Tinospora cordifolia*, coll. Mary Anitha (No. A 47/1). Two paratype slides with 8 ♀♀, 1 larva, collection details same (No.A 47/2, 47/3).

Distribution: INDIA: Kerala, Tamil Nadu.

Remarks: The specimen studied closely resembles *A.(A.) muraleedharani* Gupta in almost all characters, hence fixed so.

PLATE 22



Amblyseius (Amblyseius) muraleedharani **Gupta, 1981**

***Amblyseius (Amblyseius) orientalis* Ehara, 1957**

PLATE 23

1957. *Amblyseius* sp. Ehara, *Annotes Zool, Jap.*, **31**(1): 55.

1959. *Amblyseius orientalis* Ehara, *Acarologia*, **1**: 291-293.

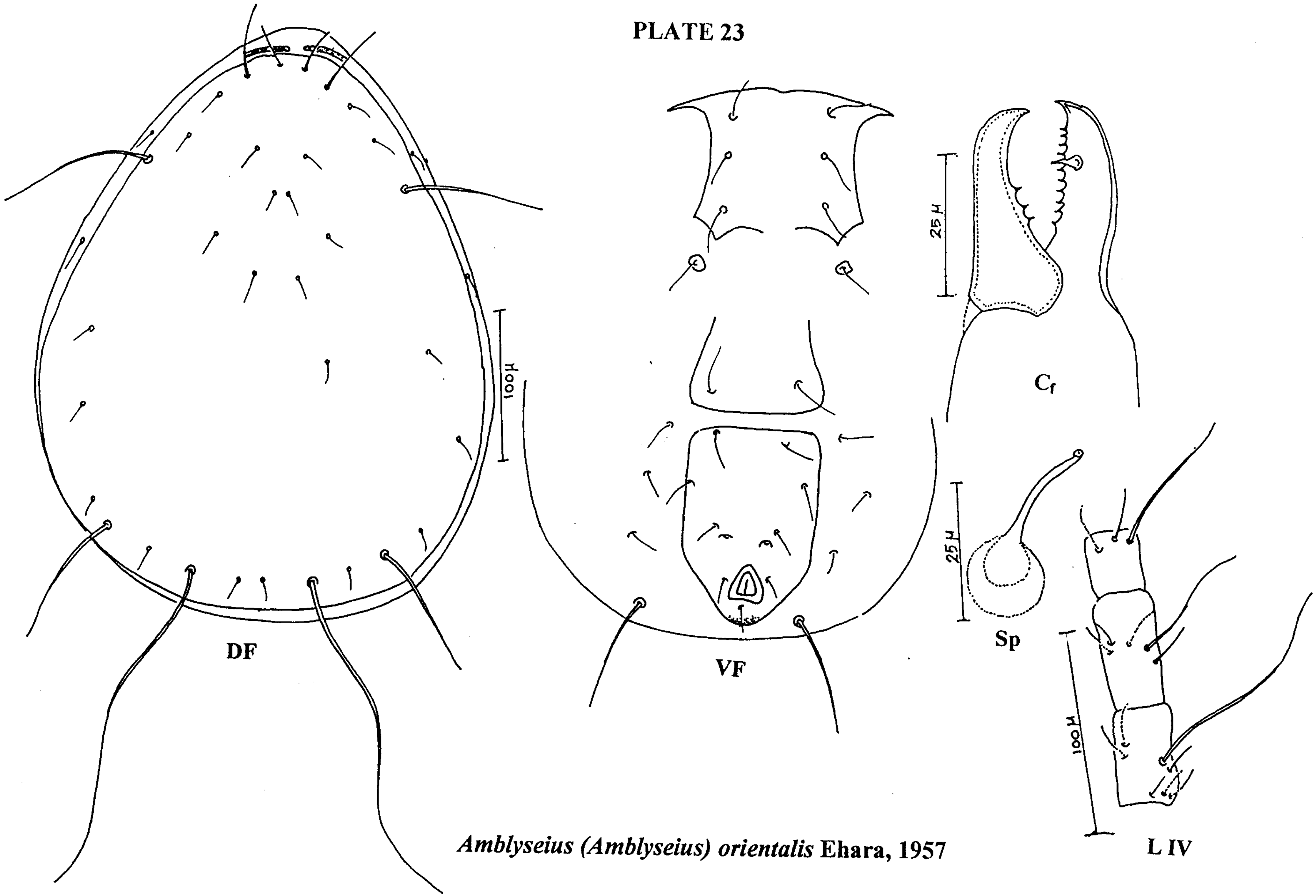
1978. *Amblyseius orientalis* : Gupta, *Indian J. Acarol.*, **2**(2): 69-71.

1986. *Amblyseius* (*Amblyseius*) *orientalis*: Gupta, *Fauna of India (Acari : Mesostigmata) Family Phytoseiidae*, p.61.

Female : Dorsal shield 364 long, 297 wide, with 17 pairs of setae, of those j_1, j_3, s_4, Z_5, Z_4 and Z_5 long while others are minute. Seta $j_3 > j_1$, $Z_4 = s_4$. Measurements of setae: j_1 - 22, j_3 - 44, s_4 - 90, Z_4 - 90, Z_5 - 240, $r_3 = R_1 = 14$ on lateral integument; all other setae small. Sternal shield wider (105) than long (95) with 3 pairs of sternal setae. Ventrianal shield 128 long, 90 wide almost wide as genital shield, with 3 pairs of preanal setae and a pair of elliptical preanal pores, little posterior to 3rd pair of preanal setae, 4 pairs of setae present on the membrane around ventrianal shield. Setae JV_5 - 80 long, smooth. Fixed digit of chelicera multidentate with *pilus dentilis*, movable digit with 3 teeth. Peritreme extends anteriorly beyond j_1. Spermatheca with tubular cervix. Macrosetae on leg IV: genu - 110, tibia - 68 and basitarsus - 74.

Male: Not studied.

PLATE 23



Amblyseius (Amblyseius) orientalis Ehara, 1957

***Habitat*:** *Capsicum annum, Murraya koenigii*

***Known habitat*:** Undetermined plant.

***Material examined*:** Female marked on the slide along with 4 ♀ ♀. INDIA: KERALA: Indian Institute of Spices Research Experimental Garden, Peruvannamuzhi (Kozhikode district), 12-xi-2000. ex. *Capsicum annum*, coll. Mary Anitha (No.A17/1). Five ♀♀ and a larva, Ayurvedic Herbal Garden of Kottakkal Arya Vaidya Sala, Kottakkal (Malappuram district), 17.iv.2001, ex. *Murraya koenigii*, coll. Mary Anitha (No.A5/1).

Distribution : INDIA: Kerala and Assam. **OUTSIDE INDIA***:* Japan.

Remarks: The specimen examined closely resembles *A. (A.) orientalis* Ehara in size and shape of dorsal shield, measurements of setae, all characters of ventrum, leg chaetotaxy and structure of spermatheca etc., hence fixed as *A. (A.) orientalis* Ehara.

***Amblyseius (Amblyseius) paraaerialis* Muma, 1967**

PLATE 24

1967. *Amblyseius paraaerialis* Muma, *Fla. Entomol.*, **50**: 270-271.

1974. *Amblyseius paraaerialis* : Prasad, *A catalogue of mites of India*, p.168-169.

1975. *Amblyseius paraaerialis* : Gupta, *Internat. J. Acarol.*, **1**(2): 40.

1978. *Amblyseius paraaerialis* : Gupta, *Indian J. Acarol.*, **2**(2): 71-72.

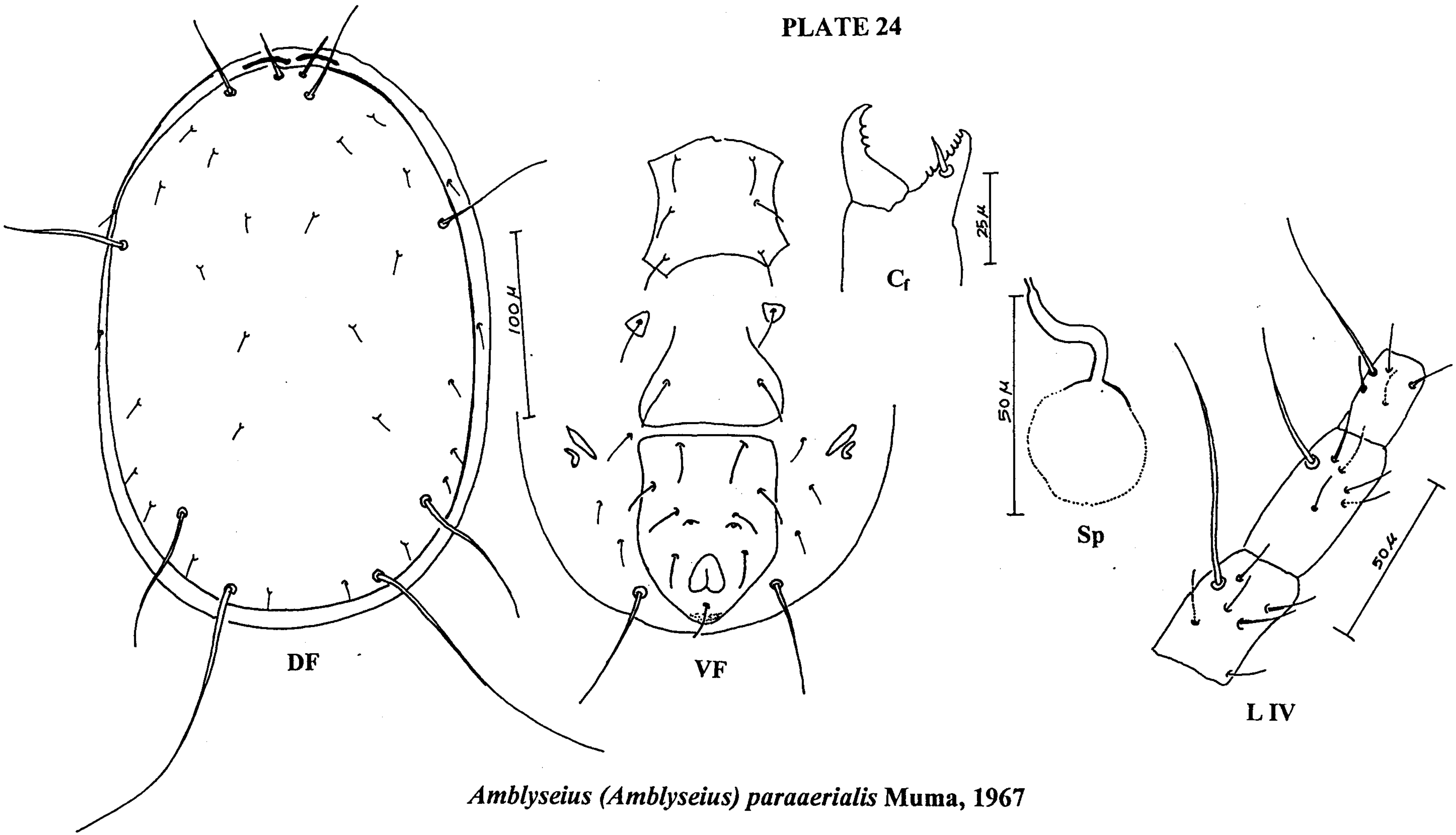
1986. *Amblyseius (Amblyseius) paraaerialis* Muma, *Fauna of India* (*Acari : Mesostigmata) Family Phytoseiidae*, p.63-65.

Female: Dorsal shield 310 long, 208 wide, smooth with 17 pairs of setae, mostly small except j_1, j_3, s_4, Z_4 and Z_5. Measurements of setae: j_1 - 25, j_3 - 46, j_4, j_6, J_2, J_5 - 6 each, z_2, z_4 - 9 each z_5 - 7, s_4 - 68, $Z_1 = S_2 = S_5$ - 8 each, Z_4 - 80, Z_5 - 158 r_3 - 15, R_1 = 8 on lateral integument. Sternal shield 75 long, 80 wide smooth with 3 pairs of sternal setae measuring 8 each, 4th pair of setae 20 long and inserted on a pair of conspicuous triangular metasternal plates. Genital shield 88 wide with a pair of 26 long genital setae. Ventrianal shield pentagonal, smooth, straight anteriorly, concave laterally, 110 long, 85 wide with 3 pairs of preanal setae measuring 18 each and a pair of large elliptical preanal pores little below the level of 3rd pair of preanal setae. Four pairs of setae on membrane surrounding ventrianal shield. Setae JV_5 smooth, 65 long. Two pairs of large conspicuous metapodal plates present. Fixed digit of chelicera with 4 teeth anterior to *pilus dentilis*, 2 teeth posterior to it; movable digit with 3 teeth. Peritreme extends anteriorly up to j_1. Spermatheca with tubular looped cervix. Macrosetae on leg IV: genu - 70, tibia - 44, basitarsus - 52; genu III - 38, genu II - 32, genu I - 32.

Leg chaetotoxy: genu II $2\,\frac{2}{0}\,\frac{2}{0}\,1$, tibia II $1\,\frac{1}{1}\,\frac{2}{1}\,1$, and genu III $1\,\frac{2}{0}\,\frac{2}{1}\,1$.

Male: Not studied.

PLATE 24



Amblyseius (Amblyseius) paraaerialis **Muma, 1967**

Habitat: *Psidium guajava,Artocarpus hirsuta* and *Amorphophallus companulatus.*

Known habitat: Egg fruit, citrus and one undetermined plant.

Material examined: Female marked on the slide along with 4 other ♀♀ INDIA: KERALA: Agricultural Research Station, Ambalavayal (Wayanad district), 24.vi.2001. ex. *Psidium guajava,* coll: Mary Anitha (No. A 10/3). Four ♀♀ collected from Vythiri (Wayanad district), 24.vi.2001, ex. *Artocarpus hirsuta,* coll. Mary Anitha (No.A 50/1 and A. 50/3). Two ♀♀ from Uduma (Kasaragod district), 18.xii.2001. ex. *Amorphophallus companulatus*, coll. Mary Anitha (No. A 2/1).

Remarks: The specimen studied agrees with *A. (A.) paraaerialis* in almost all characters and hence fixed as *A. (A.) paraaerialis* Muma, 1967.

Subgenus *Euseius* Waintein, 1962

1962. *Amblyseius* (*Amblyseius)* Section *Euseius* Wainstein, *Acarologia*, **4**: 15.

1967. *Euseius*: De Leon, *Allen Press Inc. Kansas*, U.S.A., p.18.

1970. *Euseius*: Muma and Denmark, *Arthropods of Florida*, **6**: 92.

1972. *Euseius:* Denmark and Muma, *Fla. Entomol.*, **55**(1): 20.

1973. *Euseius:* Denmark and Muma, *Rev. Brazil. Biol.*, **33**(2): 260.

1975. *Euseius* : Denmark and Muma. *J. Agr. Univ. Puerto Rico.*, **59**: 203.

1978. *Euseius:* Denmark and Muma, *Internal. J. Acrol.,* **4**(1): 11.

1981. *Euseius:* Mathysse and Denmark, *Fla. Entomol.,* **64:**(2): 348.

1981. *Euseius*: Denmark and Andrews, *Fla. Entomol.*, **64**(1): 151.

1982. *Euseius*: Moraes *et al.*, *Internat. J. Acarol.*, **8**(1): 18.

1986. *Euseius:* Gupta, *Fauna of India (Acari: Mesostigmata) Family Phytoseiidae,* 350pp.

Diagnosis: Dorsal shield with 6 pairs of dorsocentral setae, 9 pairs of laterals and 2 pairs of median setae; Z_5 longest. Chelicera small, fixed digit with 0-2 teeth distal to the medially located *pilus dentilis.* Sternal shield longer than wide, may be indistinctly lobate posteriorly. Peritreme extends anteriorly upto j_1. Ventrianal shield elongate, frequently vase shaped, preanal setae more or less arranged in two transverse curved rows. Macrosetae may sometimes occur on genu of legs II and III; genu, tibia and basitarsus of leg IV always with macrosetae, with the latter usually longest.

Type species: *Seiulus finlandicus* (Oudemans), 1915 (by designation), Wainstein, 1962.

Amblyseius(Euseius) alstoniae Gupta, 1975

PLATE 25

1975. *Amblyseius alstoniae* Gupta, *Internat. J. Acarol.*, **1**(2): 31-32.

1977. *Amblyseius alstoniae*: Gupta, *Indian J. Acarol.*, **1**: 29.

1978. *Euseius alstoniae*: Gupta, *Oriental Ins.*, **12**(3): 327.

1978. *Amblyseius alstoniae*: Gupta, *Indian J. Acarol.*, **2**(2): 61.

1980. *Amblyseius alstoniae*: Dhooria, *Acarol. News L.*, **10**: 5.

1981. *Amblyseius alstoniae*: Gupta and Nahar, In: *Contrib. to Acarol. in India*, p.9.

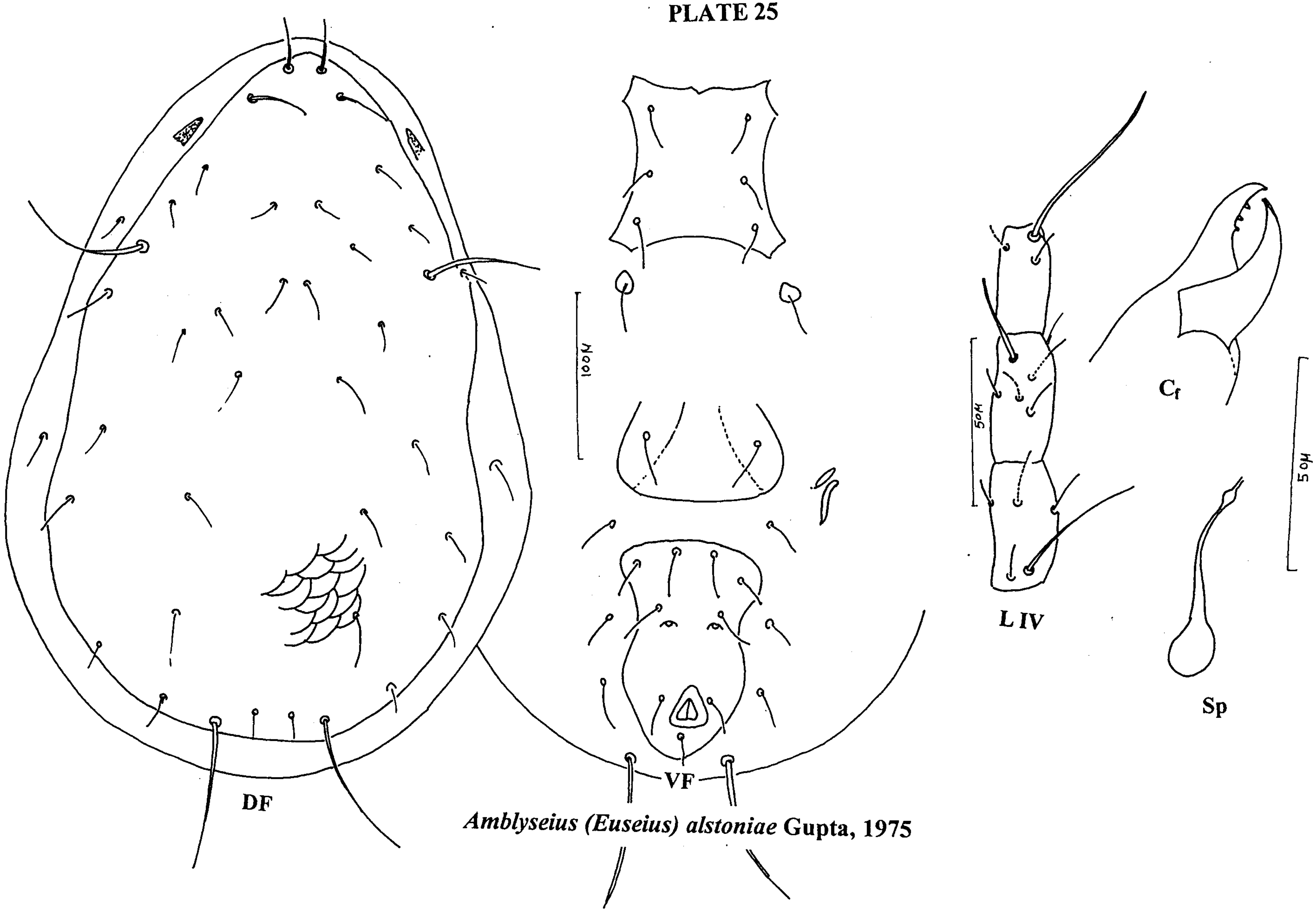
1982. *Amblyseius alstoniae*: Gupta, *Indian J. Acarol.*, **5**(1-2): 47.

1982. *Amblyseius alstoniae* : Gupta, *Rec. Zool. Surv. India*, **79** (3-4): 369-370.

1986. *Amblyseius (Euseius) alstoniae:* Gupta, *Fauna of India (Acari: Mesostigmata) Family Phytoseiidae*, p.74-76.

Female: Dorsal shield smooth anteriorly, rugose posteriorly, 313 long, 207 wide with 17 pairs of simple setae. Measurements of setae: j_1 - 20, j_3 - 25, j_4 - 11, j_5 - 12, j_6 - 28, J_2 - 24, z_4 - 34, s_4 - 58, Z_5 - 65, $r_3 = R_1$ =20 on lateral integument. Sternal shield 99 long, 86 wide with 3 pairs of sternal setae, 4th pair lie on the triangular metasternal plates. Genital shield 85 wide with a pair of setae. Ventrianal shield vase shaped, 92 long, 80 wide with 3 pairs of preanal setae; 4 pairs of setae present around ventrianal shield. Setae JV_5 smooth, 37 long. Two pairs of metapodal plates present, primary one 16 and accessory one 9 long. Spermatheca with long tubular cervix and rounded capitulum. Peritreme extends between z_2 and j_3. Chelicera with 3 small teeth on fixed digit; movable digit toothless. Macrosetae on leg IV: genu - 43, tibia - 31, basitarsus - 60.

PLATE 25



Amblyseius (Euseius) alstoniae Gupta, 1975

Leg chaetotaxy: genu II $2\,\dfrac{2}{0}\,\dfrac{2}{0}\,1$, tibia II $1\,\dfrac{1}{1}\,\dfrac{2}{1}\,1$ and genu III $1\,\dfrac{2}{1}\,\dfrac{2}{0}\,1$.

Male: Not studied.

***Habitat*:** *Maranta arundinaceae*, *Jasminum gradiflorum*.

Known habitat: *Alstonia scholaris, Zinia* sp., sapota, chilli, cotton, acacia, date palm, *Nerium indicum*, cucurbits, pomegranate, *Tabernaemontana coronaria*, palm, maize, pear, sugarcane, *Dalbergia sissoo, Butea monosperma,* grass, rose, *Nyctanthes arbortristris,* guava, Ficus, citrus, ornamental plant, vines, beans, mulberry, sunflower.

***Material examined*:** Female marked on the slide along with other 4♀♀, INDIA: KERALA: Kuttiadi (Kozhikode district), 10.iv.2001, ex. *Maranta arundinaceae*, coll. Mary Anitha (No. A 51/3). Five ♀♀, Agricultural Research Station, Ambalavayal (Wayanad district), 24.vi.2001, ex. *Jasminum gradiflorum*, coll. Mary Anitha (No. A 33/1).

Distribution: INDIA: Kerala, West Bengal, Orissa, Bihar, Tamil Nadu, Rajasthan, Gujarat, Punjab, Utter Pradesh, Madhya Pradesh, Jammu and Kashmir.

***Remarks*:** The specimen studied agrees with *A.* (*E.*) *alstoniae* Gupta in almost all characters, hence fixed so.

Amblyseius (Euseius) coccineae Gupta, 1975

PLATE 26

1975. *Amblyseius coccineae* Gupta, *Internat. J. Acarol.*, **1**(2): 31-32.

1977. *Amblyseius coccineae:* Gupta, *Indian J. Acarol.*, **1**: 30.

1978. *Amblyseius coccineae*: Gupta, *Oriental Ins.*, **12**: 329.

1978. *Amblyseius coccineae*: Gupta, *Indian J. Acarol.*, **5**(1-2): 46.

1981. *Amblyseius coccineae*: Ray and Gupta, *Bull. Zool. Surv. India,* **4**(3): 279.

1982. *Amblyseius coccineae*: Gupta, *Rec. Zool. Surv. India,* **79**(3-4): 370.

1982. *Amblyseius coccineae*: Gupta, *Indian J. Acarol.*, **6**: 26.

1986. *Amblyseius (Euseius) coccineae:* Gupta, *Fauna of India (Acari: Mesostigmata) Family Phytoseiidae*, p.78.

Female: Dorsal shield reticulate, 322 long, 217 wide, with 17 pairs of setae. Measurements of setae: j_1 - 26, j_3 - 27, j_4, j_5, J_2, z_5 - 10 each, z_2, z_4 - 21 each s_4 – 36, Z_1 - 12, S_2, S_4, S_5 - 22 each, Z_4 - 15, Z_5 - 58. Sublateral setae r_3, R_1 - 14 each, both on the lateral integument. Sternal shield 70 long 72 wide with 3 pairs of sternal setae, 4th pair lie on interscutal membrane. Genital shield 82 wide with a pair of genital setae. Ventrianal shield as figured, 85 long, 76 wide with 3 pairs of preanal setae and a pair of semilunar preanal pores; 4 pairs of setae present on the membrane around ventrianal shield. Metapodal plates single pair (20 long), faintly seen. Setae JV_5 - 34 long, smooth. Fixed digit of chelicera with 2 teeth; none on movable digit. Spermatheca as figured. Macrosetae present on leg IV : genu - 48, tibia - 38, basitarsus - 60, all with slightly knobbed tips.

Leg chaetotaxy: genu II $2\ \frac{2}{0}\ \frac{2}{0}\ 1$, tibia II $1\ \frac{1}{1}\ \frac{2}{1}\ 1$;

genu III $1\ \frac{2}{1}\ \frac{2}{0}\ 1$, tibia III $1\ \frac{1}{1}\ \frac{2}{1}\ 1$.

Male: Not studied.

Habitat: *Dolichos lablab, Annona squamosa.*

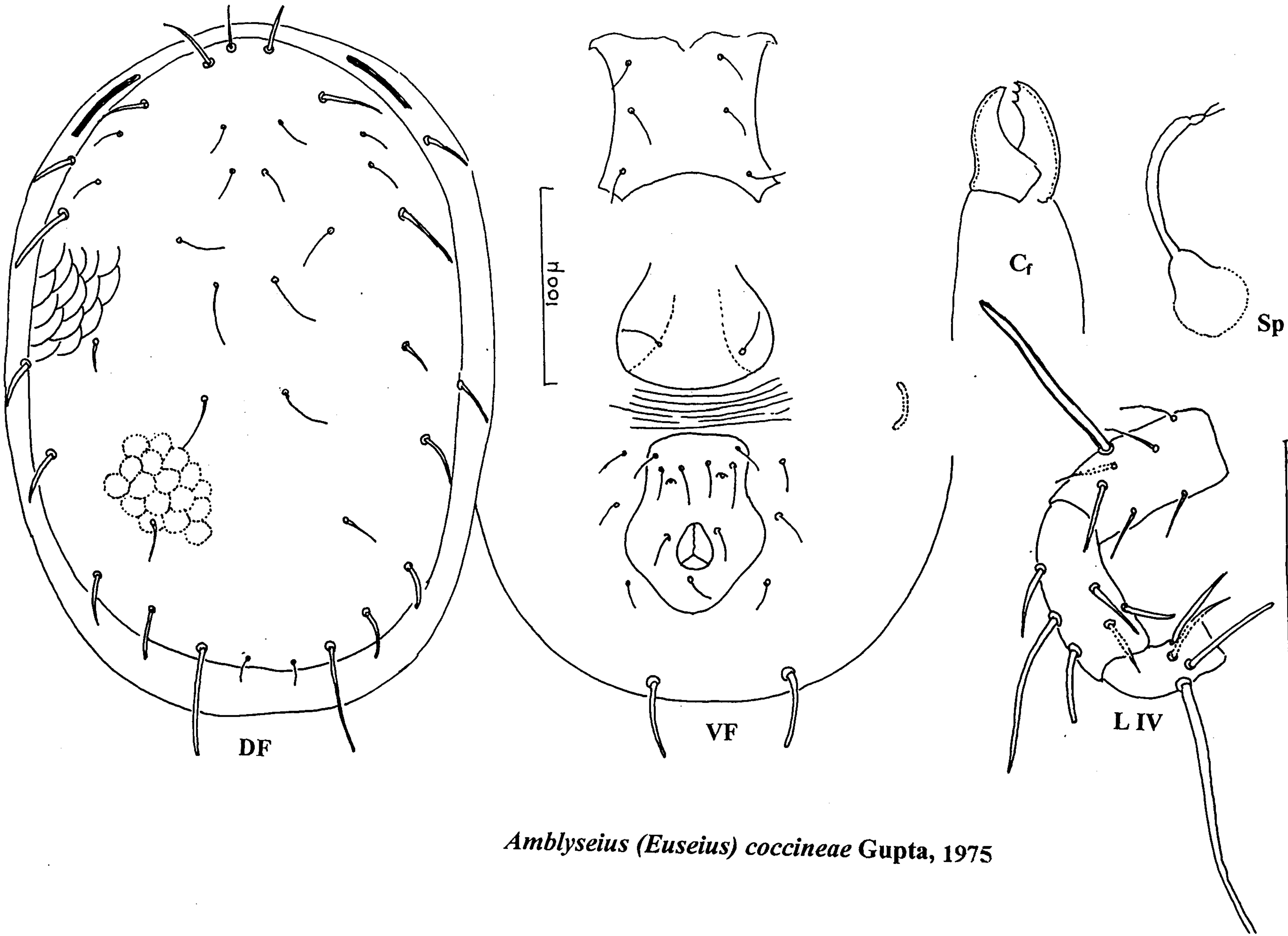
Known habitat: Mango, papaya, guava, *Alstonia scholaris*.

Material examined: Female, along with other 3 ♀♀marked on the slide, INDIA: KERALA: Calicut University Campus (Malappuram district), 18.iii.2000, ex. *Dolichos lablab*, coll. Mary Anitha (No. A 22/2). Four♀♀, Ottappalam (Palakkad district), 6.iii.2000, ex. *Annona squamosa* (No. A 9/2).

Distribution: INDIA: Kerala, Karnataka, Pondicherry, Tamil Nadu, Andra Pradesh, Gujarat, West Bengal. U.P., Orissa, Meghalaya, Bihar, Tripura and Madhya Pradesh.

Remarks: Material studied closely resembles *A. (E.) coccineae* Gupta in almost all characters, hence fixed so.

PLATE 26



Amblyseius (Euseius) coccineae Gupta, 1975

Amblyseius (Euseius) delhiensis Narayanan and Kaur, 1960

PLATE 27

1960. *Typhlodromus (Amblyseius) delhiensis* Narayanan and Kaur, *Proc. Indian Acad. Sci.*, **51**: 5-7.

1970. *Amblyseius delhiensis*: Gupta, *Sci. and Cut.*, **36**: 98.

1971. *Amblyseius delhiensis*: Gupta *et al.*, *Sci. and Cult.*, **37**: 298.

1971. *Amblyseius delhiensis*: Gupta *et al.*, *Sci. and Cult.*, 37: 484.

1972. *Amblyseius delhiensis*: Gupta and Dhooria, *Cur. Sci.*, **41**: 824-825.

1973. *Amblyseius delhiensis*: Sandhu *et al.*, *Sci. and Cult.*, **39**: 226-227.

1974. *Amblyseius delhiensis*: Prasad, *A catalogue of mites of India*, p. 162-163.

1975. *Amblyseius delhiensis*: Gupta, *Internat. J. Acarol.*, **1**(2): 36.

1977. *Amblyseius delhiensis*: Gupta, *Indian J. Acarol.*, **1**: 30.

1978. *Amblyseius delhiensis*: Gupta, *Indian J. Acarol.*, **2**(2): 62.

1979. *Amblyseius delhiensis*: Somchoudhury, *First All India Symp. Acarol.*, p.50-51.

1981. *Amblyseius delhiensis*: Somchoudhury, In: *Contrib. to Acarol. in India*, p.179.

1982. *Amblyseius delhiensis*: Gupta, *Indian J. Acarol.*, 6: 27.

1986. *Amblyseius (Euseius) delhiensis*: Gupta, *Fauna of India (Acari: Mesostigmata) Family Phytoseiidae*, p. 82-84.

Female: Dorsal shield 290 long 185 wide with 17 pairs of setae. Setae $j_1 = j_6 = J_2$, $j_4 = j_5$, $j_3 > j_1$, $z_4 > z_2$, $s_4 > j_3$. Measurements of setae: j_1 - 34, j_3 - 42, j_4, j_5 - 20 each, j_6, J_2 - 34 each, J_5 - 12, Z_2 - 36, z_4 - 48, z_5 - 20, s_4 - 68, S_2 - 34, S_4 - 30, S_5 - 40, Z_4 - 34, Z_5 - 70. Sublateral setae, r_3 - 22, R_1 - 16 on lateral integument. Sternal shield 75 long and 80 wide with 3 pairs of setae, 4th pair lie on interscutal membrane. Genital shield 82 wide with a pair of setae. Ventrianal shield 95 long, 54 wide with 3 pairs of preanal setae and a pair of crescent shaped preanal pores; 4 pairs of setae present around the ventrianal shield. Setae JV_5 - 38 long. Single pair of metapodal plates present, 26 long. Fixed digit of chelicera with 3 apical teeth, movable digit with one tooth. Spermatheca as figured. Peritreme terminate anteriorly between z_2 and z_4. Macrosetae on leg IV: genu-41, tibia - 30, basitarsus - 64.

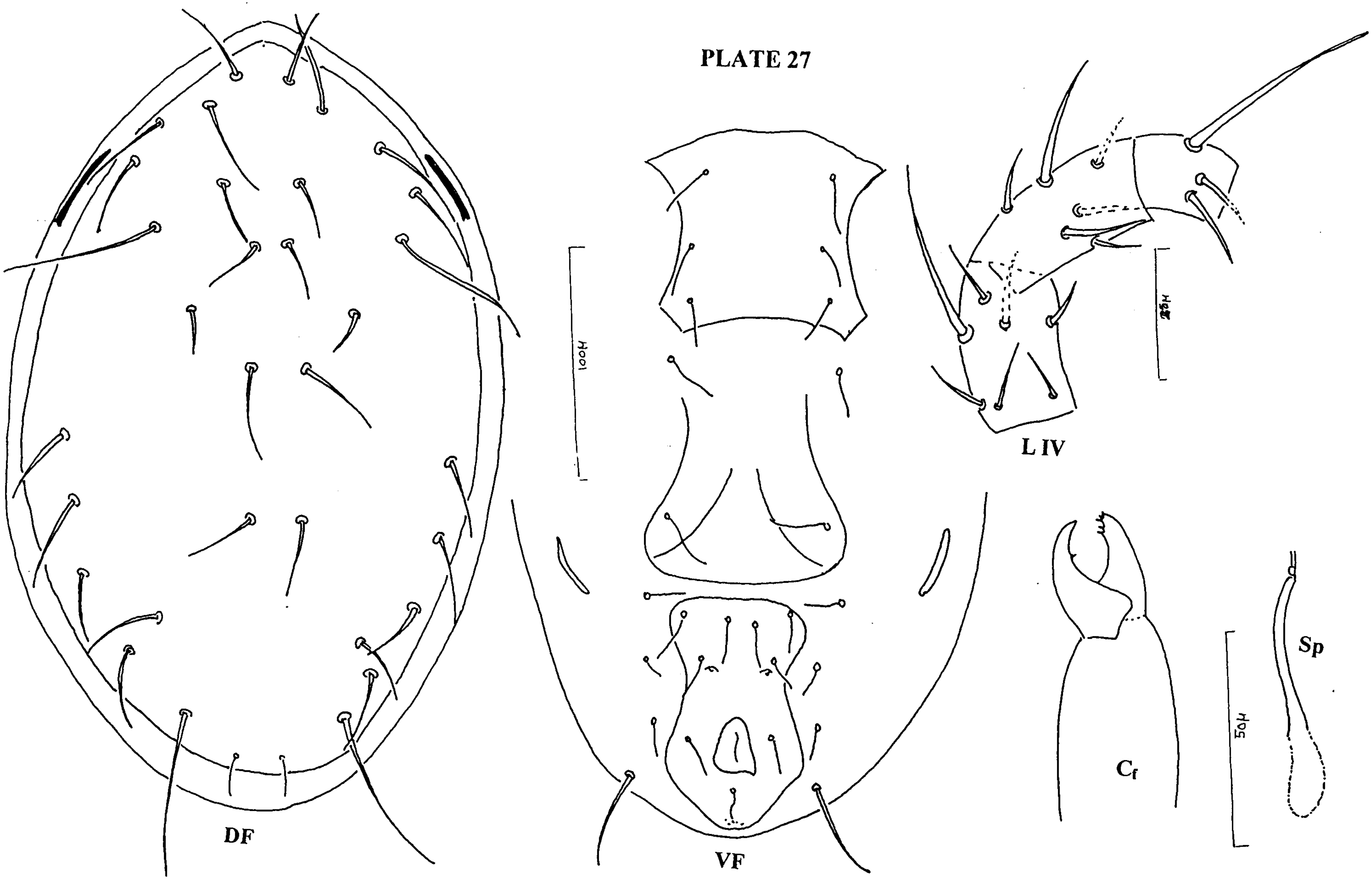
Leg chaetotaxy: genu II $2\ \frac{2}{0}\ \frac{2}{0}\ 1$, tibia II $1\ \frac{1}{1}\ \frac{2}{1}\ 1$;

genu III $1\ \frac{2}{1}\ \frac{2}{0}\ 1$, tibia III $1\ \frac{1}{1}\ \frac{2}{1}\ 1$.

Male: Unknown.

Habitat: *Maranta arundinaceae, Luffa acutangula and Canavalia ensiformis.*

PLATE 27



Amblyseius (Euseius) delhiensis Narayanan and Kaur 1960

Known habitat: *Hibiscus esculentus, Gossypium* sp. *Hibiscus rosasinensis,* grapevine, guava, maize, *Syzygium javanicum*, citrus, maize, Bougainvilla sp. and beans.

Material examined: Female marked on the slide along with other 5♀♀, INDIA: KERALA: Uduma (Kasaragod district), 10.xi.2001, ex. *Maranta arundinaceae,* coll. Mary Anitha (No. A 51/3). Several ♀♀from the habitat mentioned above from different districts surveyed.

Distribution: INDIA: Kerala, Delhi, U.P., West Bengal.

Remarks: The species studied closely resembles *A. (E.) delhiensis* Narayanan and Kaur in almost all characters, hence fixed so.

Amblyseius (Euseius) finlandicus **(Oudemans), 1915**

PLATE 28

1915. *Seius finlandicus* Oudemans, *Entomol. Ber.*, **4**:183

1958. *Amblyseius finlandicus:* Athias-Henriot, *Bull. Soc. Hist. Nat. Afr. N.*, **49**: 34-36.

1967. *Amblyseius finlandicus*: Ghai and Menon, *Oriental Ins.*,**1**: 70.

1971. *Amblyseius finlandicus*: Gupta *et al.*, *Sci. and Cult.*, **37**: 298.

1973. *Amblyseius finlandicus*: Sandhu, Koushal and Gupta:*Sci. and Cult.*, **39**: 226-227.

1975. *Amblyseius finlandicus*: Gupta, *Internat. J. Acarol.*, **1** (2):36

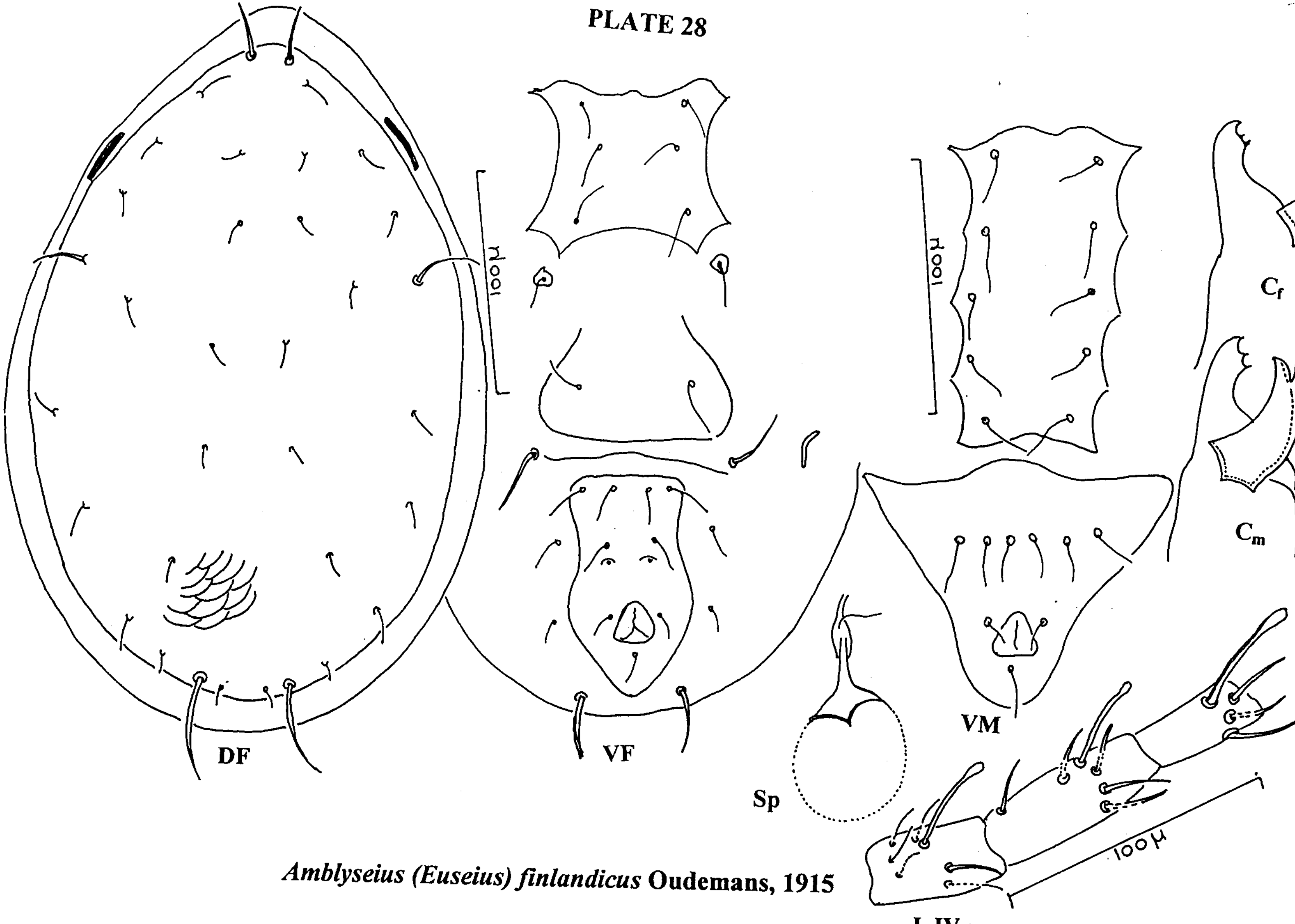
1986. *Amblyseius (Euseius) finlandicus*: Gupta, *Fauna of India (Acari: Mesostigmata) Family Phytoseiidae*, p. 86.

Female: Dorsal shield oval, 295 long 192 wide reticulate with 17 pairs of setae. Measurements of setae: j_1 - 28, j_3 - 20, j_4 - j_6, J_2, 10 each, z_2 - 18, z_4 - 16, s_4 - 28, Z_1 - 14, S_2 - 20, S_4 - 28, Z_4 - 18 and Z_5 - 48 all setae simple. Sternal shield 71 long 90 wide with 3 pairs of sternal setae, 4th pair lie on the metasternal plates. Genital shield 78 wide with a pair of genital setae. Ventrianal shield vase shaped 980 long, 61 wide with 3 pairs of preanal setae and a pair of crescent shaped preanal pores, much below the level of 3rd pair of preanal setae; 4 pairs of setae present around the ventrianal shield. Setae JV_5 smooth, 22 long. Metapodal plates single paired, 12 long. Chelicera with 2 teeth on the fixed digit, movable digit toothless. Spermatheca as illustrated. Peritreme extends anteriorly up to coxae II. Macroseta on leg IV: genu 34, tibia - 31, basitarsus – 46, all with dilated tips.

Leg chaetotaxy: genu II $2\,\frac{2}{0}\,\frac{2}{0}\,1$, tibia II $1\,\frac{1}{1}\,\frac{2}{1}\,1$;

genu III $1\,\frac{1}{1}\,\frac{2}{1}\,1$, tibia III $1\,\frac{2}{1}\,\frac{1}{1}\,1$.

PLATE 28



Amblyseius (Euseius) finlandicus Oudemans, 1915

Male: Dorsal chaetotaxy similar to that of female. Spermatophoral process and ventrianal shield as illustrated.

Habitat: *Manihot esculenta, Anacardium occidentale, Amaranthus viridis.*

Known habitat: Hedge plant, guava, *Pyrus communis,* maize, chiner, grapevine, tea, peach, pine, cucurbitaceous plant, dahlia, chrysanthimum, citrus, apple, wood apple, castor, bamboo, *Nerium indicum*, cotton.

Material examined: Female marked on the slide along with other 4 ♀♀, INDIA: KERALA: West Hill (Kozhikode district), 4.iv.2000. ex. *Manihot esculenta*, coll. Mary Anitha (No. A 1/13). Three ♀♀ and 2 ♂♂, Thalassery (Kannur district), 2.ii.2000. ex. *Anacardium occidentale* (No. A 48/2). Many ♀♀and ♂♂ from the habitats mentioned above from all the districts surveyed.

Distribution: INDIA: Kerala, West Bengal, Bihar, Punjab, Jammu and Kashmir, Himachal Pradesh, Utter Pradesh. OUTSIDE INDIA: Pakistan, Europe, Canada, Mexico, Hawaii, Japan, U.S.S.R., Africa, North America, South Africa.

Remarks: The material studied agrees with almost all the characters of *A. (E.) finlandicus* (Oudemans) and hence fixed so.

***Amblyseius (Euseius) papayensis* sp. nov.**

PLATE 29

Female: Dorsal shield elongate, oval with flat posterior margin, faintly reticulate, 290 long, 200 wide with 17 pairs of setae. Measurements of setae: j_1 - 31, j_3 - 16, j_6 - 14, $z_2 = z_3 = 16$, $z_4 = z_5 = 12$., $Z_1 = S_2 = S_1 = 16$, Z_4 - 12, $Z_5 = 46$, all body setae smooth. Sublateral setae arise from the lateral margins of dorsal shield (18 long). Sternal shield 87 long, 56 wide with 3 pairs of sternal setae (28), 4th pair of setae present on faintly visible metasternal plates. Genital shield 80 wide with a pair of setae measuring 26 in length. Space between genital and ventrianal shield very narrow (8) with a thick folding in the interspace. The shape of ventrianal shield as figured, measuring 81 long, 56 wide with 3 pairs of 24 long preanal setae and a pair of crescent shaped preanal pores. Four pairs of ventrolateral setae present on the membrane around the ventrianal shield. Setae JV_5 - 27 long and smooth. A pair of weakly sclerotized metapodal plates present (22). Shape of spermatheca as shown in the figure with a round capitulum and a long tubular cervix. Fixed digit of chelicera with 3 fine apical teeth, movale digit devoid of teeth. Peritreme terminates anteriorly just before z_2. Macrosetae present on leg IV : genu-31, tibia - 28 and basitarsus - 49.

Leg chaetotaxy: genu II $2\,\frac{2}{0}\,\frac{2}{0}\,1$, tibia II $1\,\frac{2}{1}\,\frac{1}{1}\,1$;

$$\text{genu III} \quad 1\frac{2}{0}\frac{2}{1}1, \qquad \text{tibia III} \quad 1\frac{2}{1}\frac{1}{1}1.$$

Male: Dorsal chaetotaxy similar to that of female, spermatophoral process as figured.

Habitat: *Carica papaya*

Material examined: Holotype ♀ marked on the slide along with 2 ♀♀ and 2 ♂♂, INDIA: KERALA: Dharmadam (Kannur district), 23.ix.2001, ex. *Carica papaya,* coll. Mary Anitha (No. A 14/3). Four paratype slides with 14 ♀♀, collection details same as holotype (No A 14/2, 14/4, 14/5).

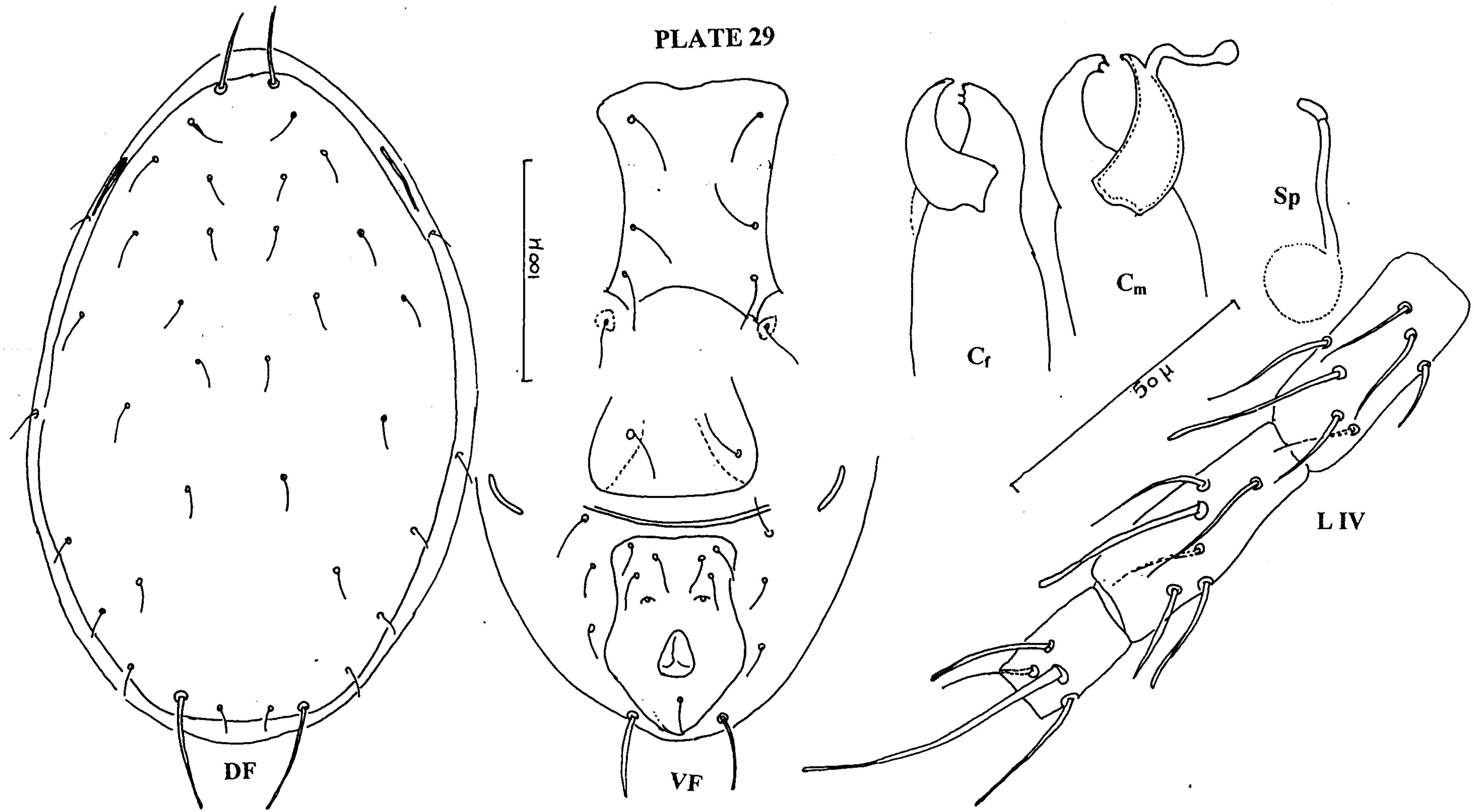
Remarks: This new species resembles *A.* (*E.*) *sacchari* Ghai and Menon (1967) in dorsal chaetotaxy, shape of ventrianal shield, shape of spermatheca etc., but clearly differentiated on the basis of the following characters:

1. The size is smaller than that of *A. (E.) sacchari* and the shape also shows variation.

2. Ventrianal shield, genital shield and sternal shield smaller in size in the new species.

3. All the dorsal setae longer especially j_3 is twice longer in the new species when compared to that of *A. (E.) sacchari* (8).

PLATE 29



Amblyseius (Euseius) papayensis sp. nov.

4. The space between genital and ventrianal shield is smaller with a thick folding in the interspace which is absent in *A. (E.) sacchari*.

5. The spermatophoral process of the male is more elongated and ends with a swollen tip, where as in *A. (E.) sacchari* there is no such modification.

Amblyseius (Euseius) rhododendronis **Gupta, 1970**

PLATE 30

1970. *Amblyseius rhododendronis*: Gupta, *Oriental Ins.*, **4**: 187-188.

1974. *Amblyseius rhododendronis*: Prasad, *A catalogue of mites of India*, p.169.

1976. *Amblyseius rhododendronis*: Gupta, *Internat. J. Acarol.*, **1**(2): 43.

1978. *Euseius kodaikanalensis*: Gupta, *Oriental Ins.*, **12**: 331-333 (new synonymy).

1981. *Amblyseius rhododendronis*: Ray and Gupta, *Bull. Zool. Surv. India*, **4**(3): 280.

1986. *Amblyseius (Euseius) rhododendronis*, Gupta, *Fauna of India (Acari: Mesostigmata) Family Phytoseiidae*, p.96.

Female: Dorsal shield 360 long, 270 wide, some what oval in shape with posterior margin flat, faintly reticulate with 17 pairs of setae and 5 pairs of prominent pores. All the setae small except j_1 and z_5, which are longer and thicker, $s_4 > S_2 = S_5$, $z_5 >$

j_1. Measurements of setae: j_1 - 28, j_3 - 18, $j_4 = j_5 = 9$, $j_6 = 6$, s_4 - 18, S_2 - 10, S_4 - 16, S_5 - 10, $z_2 = z_4 = 12$, z_5 - 8, Z_1 - 16, Z_4 - 8, Z_5 - 68. Sublateral setae r_3 and R_1 arise from the lateral margins of the dorsal shield, $r_3 = R_1 = 10$. Sternal shield 60 long 86 wide with 3 pairs of sternal setae, 4th pair lie on metasternal plates. Genital shield 68 wide with a pair of setae. Ventrianal shield 100 long 76 wide with 3 pairs of preanal setae and a pair of crescent shaped preanal pores, 4 pairs of setae present around ventrianal shield. Setae JV_5 smooth, 42 long. Fixed digit of the chelicera with 3 teeth, movable digit toothless. Peritreme terminates anteriorly at the base of j_3. Shape of spermatheca as figured with elongated tubular cervix. Macrosetae on leg IV: genu - 38, tibia - 26, basitarsus - 40, all with swollen tips.

Leg chaetotaxy : genu II $2\,\frac{2}{0}\,\frac{2}{0}\,1$, tibia II $1\,\frac{2}{1}\,\frac{2}{0}\,1$;

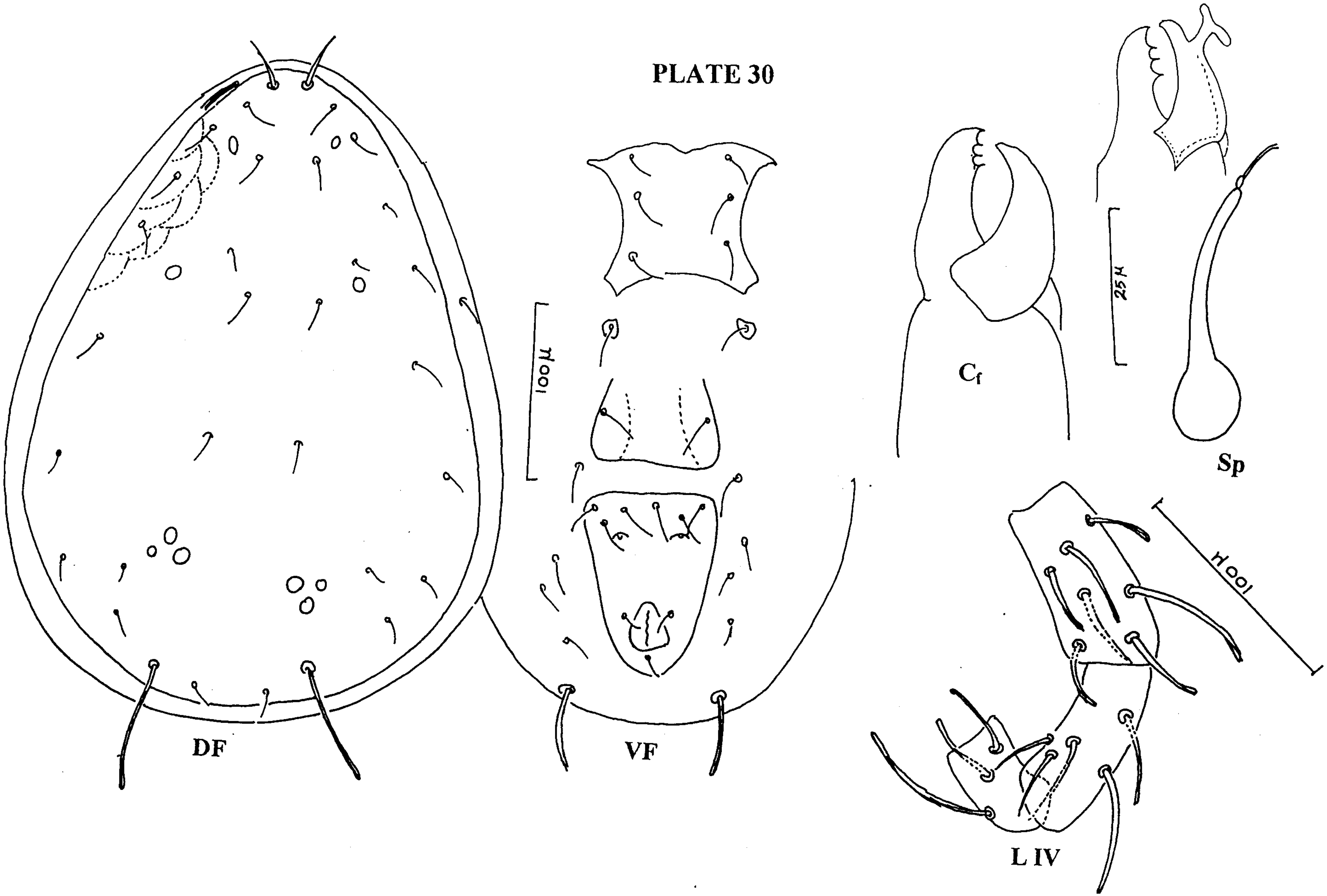
genu III $1\,\frac{1}{1}\,\frac{2}{1}\,1$, tibia III $1\,\frac{1}{1}\,\frac{2}{1}\,1$.

Male: Dorsal chaetotaxy similar to that of female. Spermatophoral process as figured.

Habitat: *Zingiber officinale, Luffa acutangula, Momordica charantia, Musa paradisiaca and Trichosanthes anguina*

Known habitats: *Rhododendron* sp., *Shorea robusta*, lichi.

PLATE 30



Amblyseius (Euseius) rhododendronis Gupta, 1970

Material examined: Female marked on the slide along with 3 other ♀♀ and a ♂♂, INDIA: KERALA: Indian Institute of Spices Research Experimental Garden, Peruvannamuzhi (Kozhikode district), 8.iii.2001, ex. *Zingiber officinale*, coll. Mary Anitha (No. A 30/4). 4 ♀♀, Agricultural Research Station, Ambalavayal (Wayanad district), 4.vi.2001, ex. *Luffa acutangula* (No. A 19/3). Many ♀♀from the habitats mentioned above from all the districts surveyed.

Distribution: INDIA: Kerala, West Bengal and Tripura.

Remarks: The specimen studied agrees with *A. (E.) rhododendronis* Gupta in almost all the characters except the presence of 3 teeth on the fixed digit of chelicera instead of 2 described by Gupta (1986). Hence the present specimen is fixed as *A. (E.) rhododendronis* Gupta.

Amblyseius (Euseius) sacchari **Ghai and Menon, 1967**

PLATE 31

1967. *Amblyseius sacchari* Ghai and Menon, *Oriental Ins.*, **1**: 75-76.

1970. *Amblyseius sacchari*: Gupta, *Sci. and Cult.*, **36**: 98.

1974. *Amblyseius sacchari*: Prasad, *A catalogue of mites of India*, p.169.

1974. *Amblyseius sacchari*: Gupta and Dhooria, *Proc. Indian Sci. Cong.*, 1974: 69.

1975. *Amblyseius sacchari*: Gupta, *Internat. J. Acarol.*, **1**(2): 43.

1977. *Amblyseius sacchari*: Gupta, *Indian J. Acarol.*, **1**: 33 - 34.

1978. *Euseius sacchari*: Gupta, *Oriental Ins.*, **12**; 337.

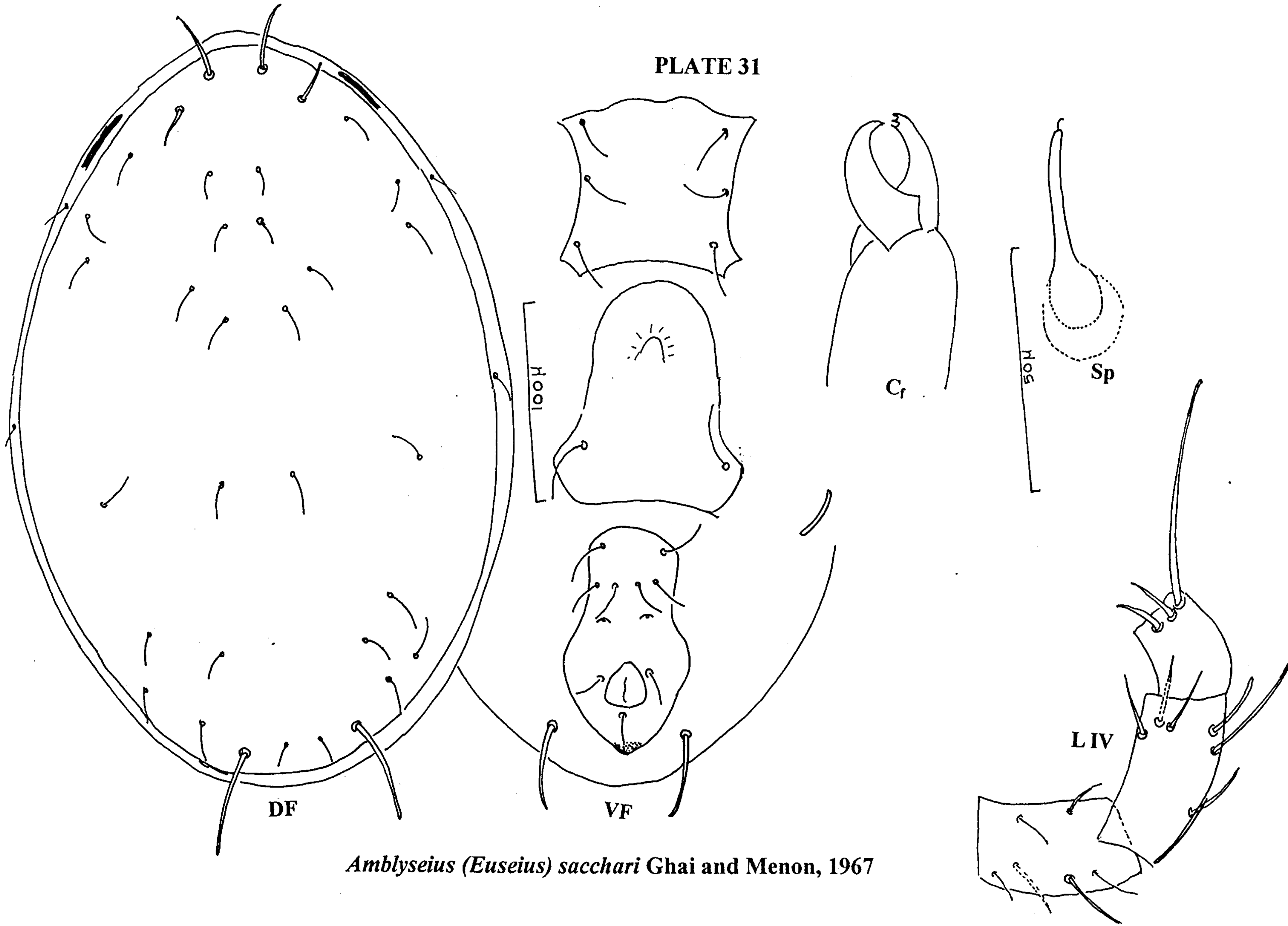
1981. *Amblyseius sacchari*: Gupta and Nahar, In *Contrib. to Acarol. in India*, p.9.

1986. *Amblyseius (E.) sacchari*: Gupta, *Fauna of India (Acari: Mesostigmata) Family Phytoseiidae*, p.98.

1987. *Amblyseius (Euseius) sacchari*: Gupta, *Rec. Zool. Surv. India*, p.29.

Female: Dorsal shield 362 long, 246 wide with 17 pairs of setae. Measurements of setae: j_1 - 33, j_3 - 15, j_4 - j_5 - 6 each, j_6 J_2 - 12 each, J_5 - 5, z_2, z_4 - 10 each, S_4 - 15, Z_1 - 10, S_2 - 15, S_4 - 16, S_5 - 18, Z_4 - 10, Z_5 - 42. All setae smooth except Z_5, the latter slightly serrate. Sublateral setae r_3, R_1 - 10 each on the lateral integument. Sternal shield 98 long, 80 wide with 3 pairs of sternal setae (30 long), 4th pair lie on metasternal plates. Genital shield 98 wide with a pair of setae (30 long). Ventrianal shield 112 long, 74 wide with 3 pairs of preanal setae (30 long) and a pair of crescent shaped preanal pores, below the level of 3rd pair of preanal setae; 4 pairs of setae present around the ventrianal shield. Setae JV_5 smooth 34 long. A single pair of metapodal plates present, 16 long. Chelicera with 2 teeth on the fixed digit and none on the movable digit. Peritreme terminates anteriorly between j_3 and z_2. Spermatheca with elongated cervix as figured. Macrosetae on leg IV: genu - 36, tibia 32, basitarsus - 45, all with swollen tips.

PLATE 31



Amblyseius (Euseius) sacchari Ghai and Menon, 1967

Leg chaetotaxy : genu II $2\,\frac{2}{0}\,\frac{2}{0}\,1,$ tibia II $1\,\frac{1}{1}\,\frac{2}{0}\,1;$

genu III $1\,\frac{1}{1}\,\frac{2}{1}\,1,$ tibia III $1\,\frac{1}{1}\,\frac{2}{1}\,1.$

Male: Not studied.

***Habitat*:** *Ricinus communis, Achras sapota.*

***Known habitat*:** Sugar cane.

***Material examined*:** Female marked on the slide along with other 4 ♀♀, INDIA: KERALA: Ayurvedic Herbal Garden of Kottakkal Arya Vaidya Sala, Kottakkal (Malappuram district), 17.iv.2001, ex. *Ricinus communis,* coll. Mary Anitha (No.A 3/1). Five ♀♀, 2 larva,Quilandy (Kozhikode district), 4.x.2001, ex. *Achras sapota* (No. A 13/2).

***Distribution*:** INDIA: Kerala, Karnataka, West bengal, Punjab, Himachal Pradesh, Gujarat, Tamil Nadu.

***Remarks*:** The specimen examined agrees with most of the characters of *A. (E.) sacchari* Ghai and Menon and hence fixed so. It is seen associated with eriophyid mites.

Subgenus *Neoseiulus* Hughes, 1948

1948. *Neoseiulus* Hughes, *Min. Agr. Fish. London,* p.141.

1959. *Typhlodromus* (*Typhlodromopsis*) :De Leon, *Entomol. News*, **70**: 133.

1965. *Neoseiulus* : De Leon, *Proc. Entomol. Soc. Wash.*, **67**(1): 23.

1970. *Neoseiulus* : Muma and Denmark, *Arthropods of Florida,* **6**: 100.

1978. *Neoseiulus:* Denmark and Muma, *Internat. J. Acarol.,* **4**(1): 12.

1982. *Neoseiulus:* Moraes *et al.*, *Internat. J. Acarol.*, **8**(1): 19.

1986. *Neoseiulus :* Gupta, *Fauna of India (Acari: Mesostigmata) Family Phytoseiidae,* 350 pp.

Diagnosis: Dorsal shield well sclerotized, smooth or reticulate with 17 pairs of setae (6 pairs of dorsocentral, 2 pairs of median, 9 pairs of lateral). Chelicera with 4-8 teeth on fixed digit. Sternal shield as long as or longer than wide with straight or concave posterior margin with 3 pairs of sternal setae. Peritreme extends anteriorly up to j_1. Ventrianal shield elongate, pentagonal, shield shaped or nearly quadrate with 3 pairs of preanal setae. No distinguishable macrosetae on leg I, II, III but it is always present on basitarsus IV in some species, it is also present on genu IV and tibia IV.

Type : *Neoseiulus barkeri* Hughes, 1948, by designation.

Amblyseius (Neoseiulus) longispinosus (Evans), 1952.

PLATE 32

1952. *Typhlodromus longispinosus* Evans, *Ann. Mag. Nat. Hist.*, **5**(12): 413-416.

1953. *Typhlodromus longispinosus*: Evans, *Ann. Mag. Nat. Hist.*, **12**(6): 449.

1970. *Amblyseius longispinosus*: Gupta, *Sci. and Cult.*, **36**: 98.

1974. *Amblyseius longispinosus*: Prasad, *A. catalogue of mites of India*, p.167.

1975. *Amblyseius longispinosus*: Gupta, *Internat. J. Acarol.*, **1**(2): 38.

1977. *Amblyseius longispinosus*: Gupta, *Oriental Ins.*, **11**: 631.

1978. *Neoseius longispinosus*: Gupta, *Oriental Ins.*, **12**: 334-335.

1978. *Amblyseius longispinosus*: Gupta, *Indian J. Acarol.*, **2**(2): 66.

1979. *Amblyseius longispinosus*: Gupta, In: *First All India Symp. Acarol.*, p.6.

1981. *Amblyseius longispinosus*: Gupta and Nahar, In: *Contrib. to Acarol. in India*, p.9.

1982. *Amblyseius longispinosus*: Gupta, *Indian.J. Acarol.*, **6** :25.

1986. *Amblyseius (Neoseiulus) longispinosus*: Gupta, *Fauna of India (Acari: Mesostigmata) Family Phytoseiidae*, p.116-118.

***Female*:** Dorsal shield 292 long, 162 wide, smooth with 17 pairs of setae mostly long except j_1, J_5 and S_5. Measurements of setae: j_1 - 16, j_4 - 53, j_5 - 68, j_6 - 65, J_2 - 68, J_5 - 9, j_3 - 59, z_2 - 62, z_4 65, z_5 - 34, s_4 - 78, S_2 - 65, S_4 - 60, S_5 - 16, Z_5 - 74, Z_1 - 68, Z_4 - 65, r_3 - 59, R_1 - 68. Sternal shield 78 long and 68 wide with 3 pairs of sternal setae, slightly concave posteriorly, 4th pair of setae present on metasternal plate. Genital shield 65 wide with a pair of long setae. Ventrianal shield some what triangular, 99 long and 83 wide reticulate with 3 pairs of preanal setae and a pair of semilunar preanal pore. Four pairs of setae present around the ventrianal shield, JV_5 - 65 long. Two pairs of metapodal plates present, primary one 22 long and accessory one 9 long. Small platelets present around ventrianal shield. Structure of spermatheca as illustrated in figure. Fixed digit of chelicera with 3 teeth anterior to *pilus dentilis,* movable digit with two sharp teeth. Peritreme extends anteriorly upto j_1. Macrosetae (64 long) present on the basitarsus of leg IV.

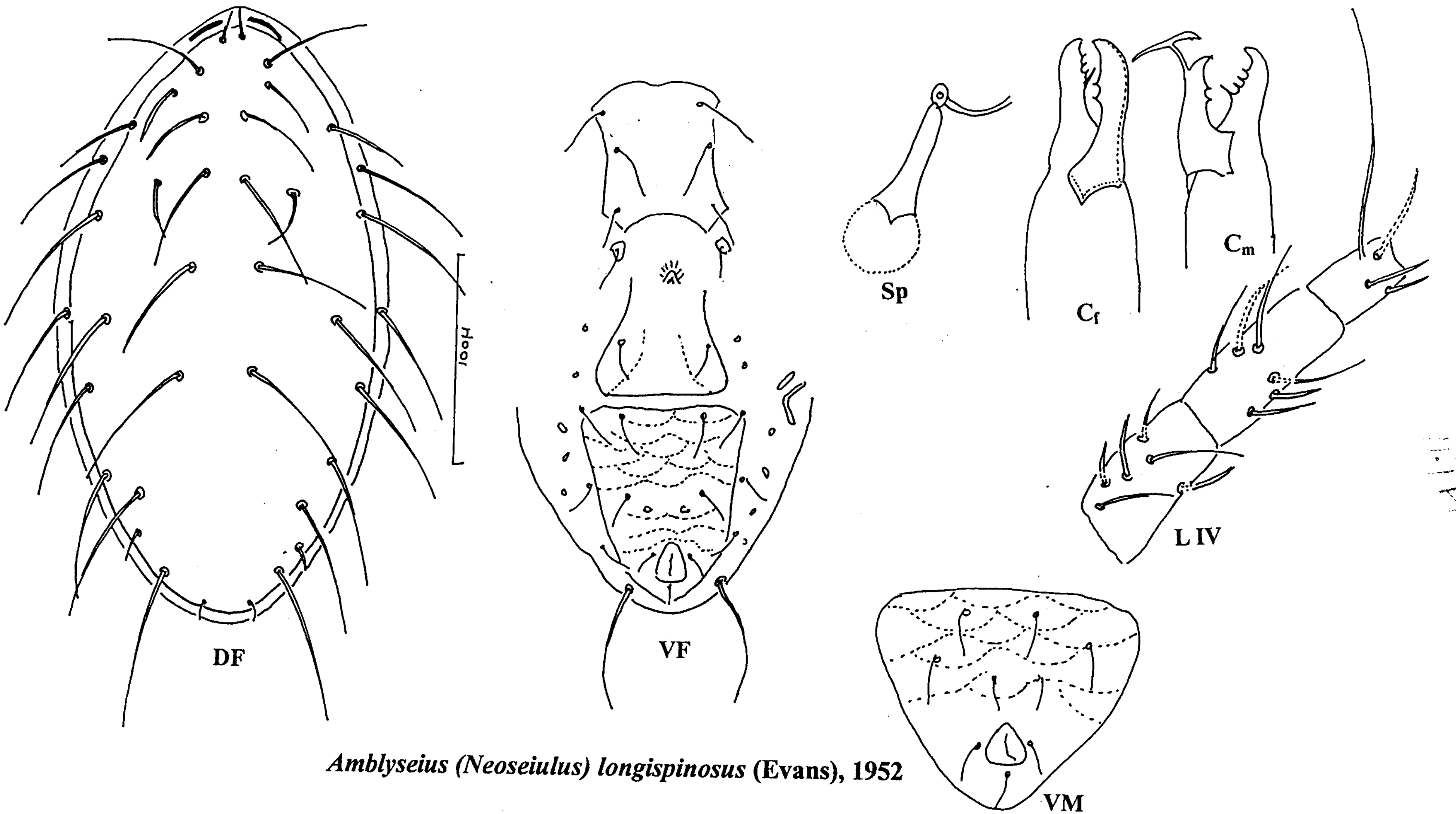
Leg chaetotaxy: genu II $2\ \frac{2}{0}\ \frac{2}{0}\ 1$, tibia II $1\ \frac{2}{1}\ \frac{1}{1}\ 1$;

genu III $1\ \frac{2}{1}\ \frac{2}{0}\ 1$, tibia III $1\ \frac{1}{1}\ \frac{2}{1}\ 1$.

Male: Dorsal chaetotaxy similar to that of female. Spermatophoral process as figured. Macroseta on basitarsus IV- 58.

Habitat: *Abelmoschus esculentus, Cocos nucifera, Manihot esculenta, Solanum melongena.*

PLATE 32



Amblyseius (Neoseiulus) longispinosus (Evans), 1952

Known habitat: *Datura* sp., *Tabernaemontana coronaria, Bauhinia purpuria,* castor, *Zinia* sp., paddy, guava, rose, *Datura metal.*

***Material examined*:** Female marked on the slide along with other 4♀♀, INDIA: KERALA: Vatakara (Kozhikode district), 8.iv.2000, ex. *Manihot esculenta,* coll. Mary Anitha (No.A 1/1). 28 ♀♀ and 4 ♂♂ on different habitats mentioned above from all the districts surveyed (No. A 18/5, 4/10, 1/9, 16/4).

***Distribution*:** INDIA: Kerala, West Bengal, Orissa, Bihar, Tamil Nadu, Pondicherry, Andaman Nicobar Ist., Utter Pradesh. OUTSIDE INDIA: Philippines, Taiwan, Indonesia, South Africa, Tasmania, Japan, Honkong, Malaya, Hawaii, New Zealand, Jamaica.

***Remarks*:** The specimen studied, very closely resembles *A. (N.) longispinosus* (Evans) in all characters. All the setal measurements, structure of spermatheca etc. are very similar to *A. (N.) longispinosus* (Evans) and hence fixed so. This predatory mite was found actively feeding on tetranychids on *M. esculenta.* Often, fully fed female assumes reddish colour.

Amblyseius (Neoseiuous) mulberricus **sp. nov.**

PLATE 33

***Female*:** Dorsal shield 352 long, 204 wide with 17 pairs of setae, mostly short, except j_3, s_4, Z_4, Z_5. Measurements of setae: j_1 - 26, j_3 - 44, j_4 - j_6, J_2 - 8 each, z_2 - z_4

- 18 each S_4 - 90, Z_1, S_5, S_4 - 14 each, S_2 - 20, Z_5 = 90 Z_4 - 76. Sublateral setae r_3, R_1 - 20 each on the lateral integument. Sternal shield 90 long 94 wide with 3 pairs of sternal setae; 4th pair lie on the metasternal plates. Genital shield 78 wide with a pair of setae. Ventrianal shield 104 long, 94 wide with 3 pairs of preanal setae, a pair of round preanal pores present almost at the level of 3rd pair of preanal setae, 4 pairs of setae present around the ventrianal shield. A band formed of 3-4 folds present between genital and ventrianal shield. Setae JV_5 - 44 long; 2 pairs of metapodal plates present, primary one 20 long accessory one 10 long. Fixed digit of the chelicera multidentate with a strong *pilus dentilis*, movable digit with 3 teeth. Perireme extends anteriorly beyond j_1. Spermatheca as figured. Measurements of macrosetae on leg IV: genu - 53, tibia - 31, basitarsus – 77.

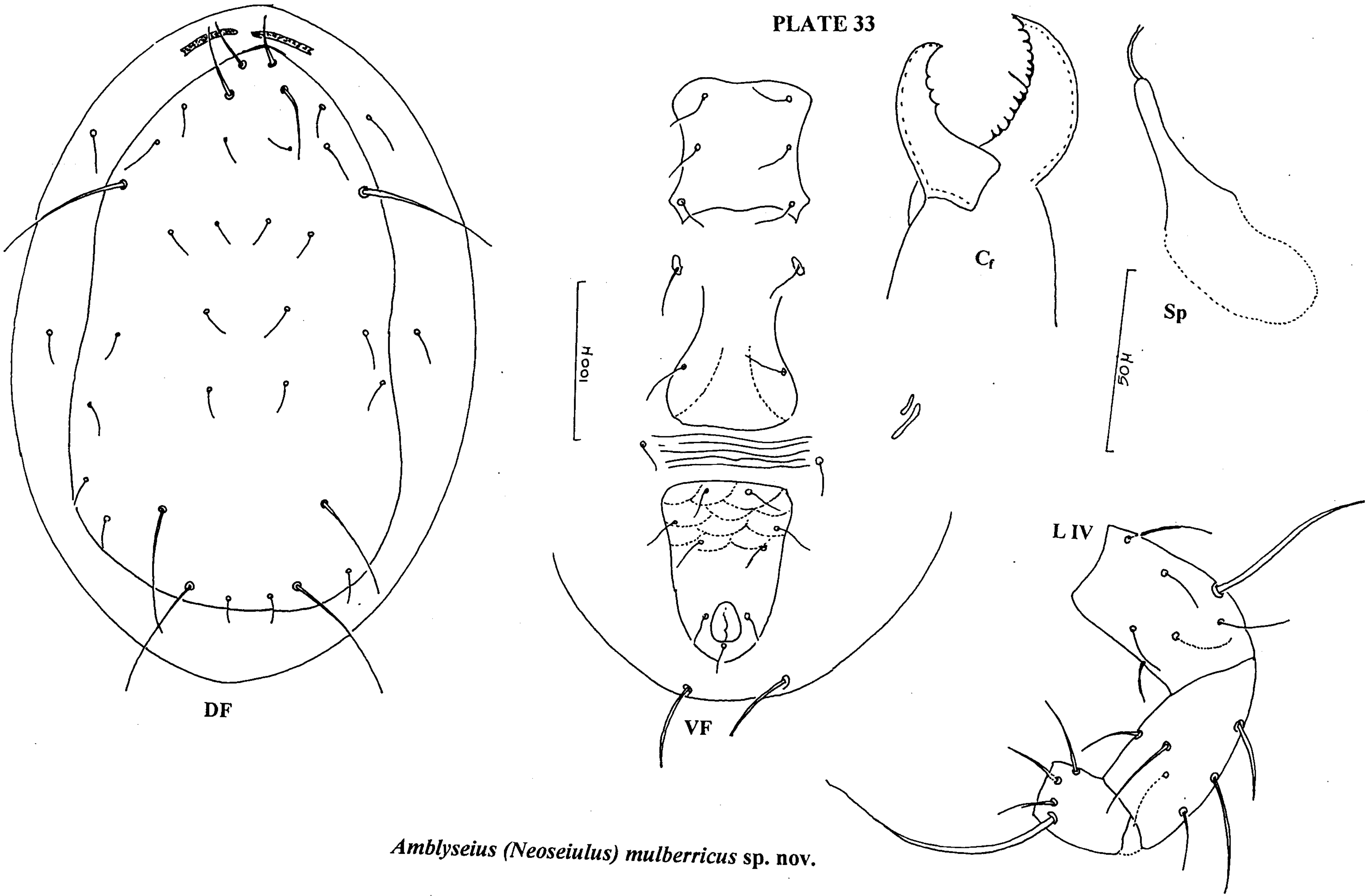
Leg chaetotaxy : genu II $2\,\frac{2}{0}\,\frac{2}{0}\,1$, tibia II $1\,\frac{2}{1}\,\frac{1}{1}\,1$;

genu III $1\,\frac{2}{1}\,\frac{2}{0}\,1$, tibia III $1\,\frac{1}{1}\,\frac{2}{1}\,1$.

Male Unknown.

Material examined: Holotype ♀ marked on the slide along with other 4 ♀♀, INDIA: KERALA : Indian Institute of Spices Research Experimental Garden, Peruvannamuzhi (Kozhikode district), 17.vi.2000, ex. *Morus alba*, coll. Mary

PLATE 33



Amblyseius (Neoseiulus) mulberricus sp. nov.

Anitha (No. A 34/1). Two paratype slides with 12 ♀♀, collection details same as that of the holotype (No. A 34/2, 34/3).

Remarks: This new species resembles *A. (N.) rangatensis* Gupta, 1977 in dorsal chaetotaxy, shape of ventrianal shield etc. but it can be clearly differentiated by the possession of the following characters:

1. Variations in the measurements of the dorsal shield and dorsal chaetotaxy.
2. Spermathecal structure different in the new species.
3. Presence of macrosetae on the tibia of leg IV (31 long) of the new species, where as it is absent in the tibia IV of *A. (N.) rangatensis* Gupta.
4. Fixed digit of the chelicera multidentate with a strong *pilus dentilis* and movable digit with 3 teeth in the new species instead of 2 teeth on fixed digit and 1 tooth on movable digit of *A. (N.) rangatensis* Gupta.

***Amblyseius (Neoseiulus) villoonniyensis* sp. nov.**

PLATE 34

Female: Dorsal shield 325 long, 202 wide, smooth with 17 pairs of setae mostly long except j_1, J_5 and S_5 which are smaller. Measurements of setae: j_1 - 9, j_3- 59, j_4 - 60, j_5 - 70, j_6 - 82, J_2 - 80, J_5 - 10, $z_2 = z_4 = 80$, z_3 - 70, z_5 -46, Z_1 - 74, Z_4 - 72, Z_5 - 70, S_4 - 82, S_2 - 56, S_5 - 14. Two pairs of sublateral setae (r_1, R_3 - 68 long) arise from the edges of the dorsal shield. Dorsal shield with more than 4 pairs of pores. Sternal shield 74 long, 72 wide with 3 pairs of setae (36), lateral and posterior margins concave, 4th pair of sternal setae lie on large metasternal plates. Genital shield 102 long, 65 wide with a pair of genital setae (34), genital and ventrianal shield 10 apart with a thick integumental fold between them. Ventrianal shield almost triangular, 118 long, 78 wide, reticulate with 3 pairs of preanal setae (24), and a pair of crescent shaped preanal pores; 4 pairs of setae present on the membrane around the ventrianal shield; setae JV_5 - 68 long. Two pairs of metapodal plates present, primary one 32 long, accessory one 21 long. Spermatheca as figured. Fixed digit of chelicera with 3 teeth anterior to *pilus dentilis*, movable digit unidentate. Peritreme extends anteriorly up to j_1. Macrosetae present only on basitarsus of leg IV, 76 long.

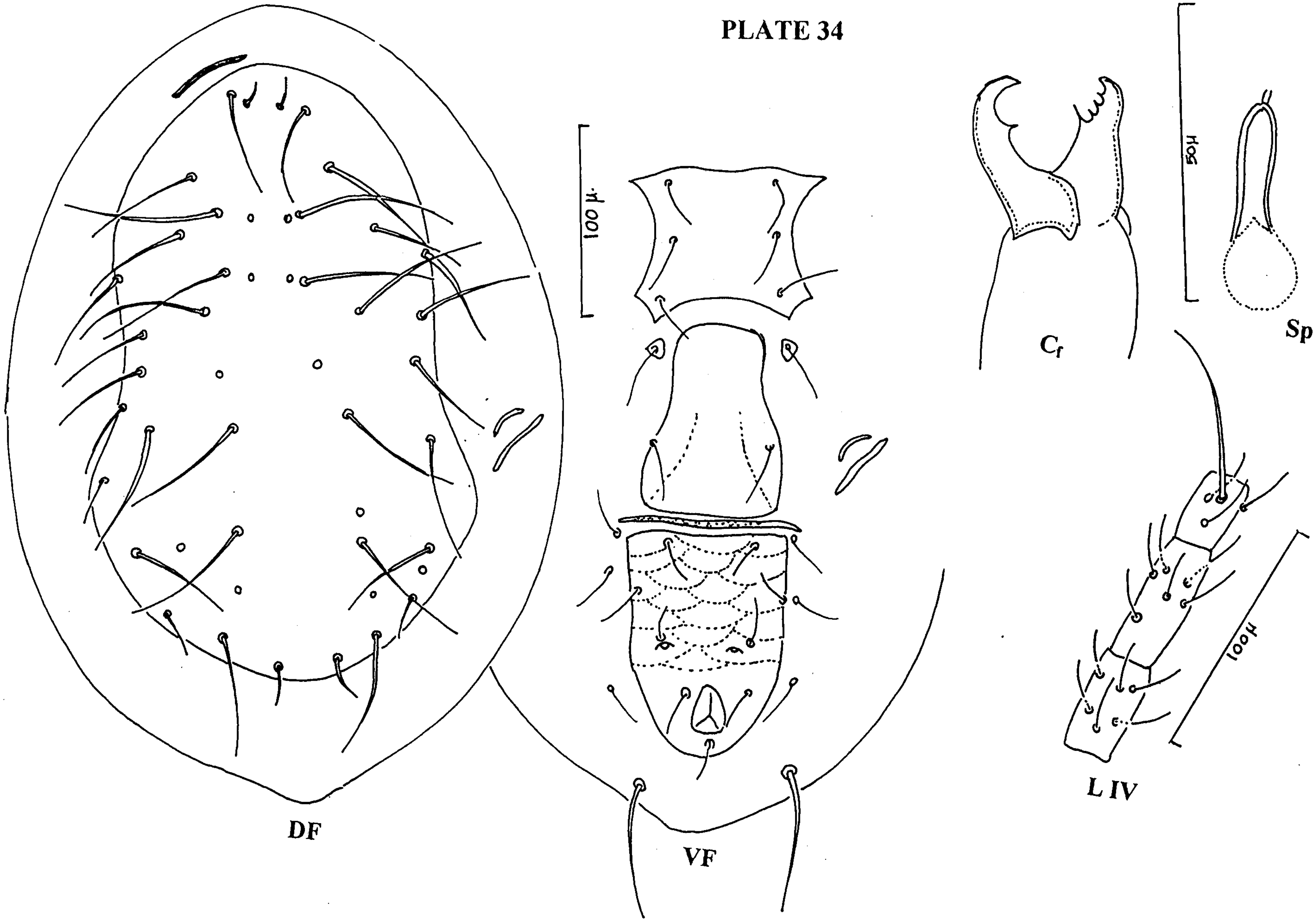
Leg chaetotaxy: genu II $2\,\frac{2}{0}\,\frac{2}{0}\,1$, tibia II $1\,\frac{2}{1}\,\frac{1}{1}\,1$;

genu III $1\,\frac{2}{2}\,\frac{1}{0}\,1$, tibia III $1\,\frac{2}{1}\,\frac{1}{1}\,1$.

Male: Unknown.

Habitat: *Pisum sativum, Abelmoschus esculentus.*

PLATE 34



Amblyseius (Neoseiulus) villoonniyensis **sp. nov.**

Materials examined: Holotype ♀ marked on the slide along with 4 ♀♀ INDIA: KERALA: Villoonniyal field (Malappuram district), 12.iv.2000, ex. *Pisum sativum*, coll. Mary Anitha (No. A 45/8). Paratype 4 ♀♀, Ottappalam (Palakkad district), 6.iii.2000, ex. *Abelmoschus esculentus* (No. A 18/2). Several paratypes from the habitats mentioned above from different districts surveyed.

Remarks: This new species closely resembles *A.* (*N.*) *longispinosus* (Evans) in dorsal chaetotaxy, shape of ventrianal shield, structure of spermatheca etc., but differs from it by the possession of the following features:

1. Dorsal shield longer and broader in the new species apart from the variations in the measurements of dorsal chaetotaxy.

2. Presence of a thick integumental fold between genital and ventrianal shield in this new species which is absent in *A. (N.) longispinosus* (Evans).

3. In the new species there is only a single tooth on the movable digit instead of 2 in *A. (N.) longispinosus* (Evans).

4. Size of metapodal plates show variations in the new species, 30 and 21 instead of 22 and 9 of *A. (N.) longispinosus* (Evans).

Subgenus *Paraphytoseius* Swirski and Shechter

1961. *Paraphytoseius* Swirski and Shechter, *Israel J. Agri. Res.*, **11**: 113.

1962. *Amblyseius (Ptenoseius):* Pritchard and Baker, *Hilgardia*, **33**: 295.

1963. *Ptenoseius*: Schuster and Pritchard, *Hilgardia,* **34**(7): 198.

1965. *Paraphytoseius* : De Leon, *Fla. Entomol.*, **48**(2): 130.

1966. *Ptenoseius*: Corpuz and Rimando, *Philip. Agr.,* **50**: 115.

1975. *Paraphytoseius*: Denmark and Muma, *J. Agr. Univ. Puerto Rico.*, **59**(4): 283.

1976. *Paraphytoseius*: Blommers, *Bijdragen Tot de Dierkunde*, **46**(1): 87.

1977. *Amblyseius* (*Paraphytoseius*): Ehara and Bhandhufalck, *J. Fac. ed. Tottori. Univ.*, **27**(2): 78.

1981. *Paraphytoseius*: Mathysse and Denmark, *Fla Entomol.*, **64**(2): 342.

1986. *Paraphytoseius*: Gupta, *Fauna of India* (*Acari: Mesostigmata*) *Family Phytoseiidae*, 350 pp.

Diagnosis: Dorsal shield smooth, moderately sclerotized with 5 pairs of setae on dorsocentral series; 2 pairs of median and 6-7 pairs of lateral and 2 pairs of sublateral setae present on lateral integument. Setae j_1, j_3, s_4, Z_5, Z_4, r_3 and R_1 long, thick and serrate. Sternal shield with 3 pairs of sternal setae. Ventrianal shield with 3 pairs of preanal setae. Leg IV with macrosetae on genu, tibia and basitarsus, mostly spatulate and knobbed.

Type: *Paraphytoseius multidentatus* Swirski and Shechter, 1961 (by designation).

***Amblyseius (Paraphytoseius) arjunae* sp. nov.**

PLATE 35

Female: Dorsal shield 308 long, 165 wide, elongate, incised at the level of s_4 with 13 pairs of setae. The setae j_1, j_3, s_4, Z_4, Z_5, r_3 and R_1 long, thick and serrate, measuring 38, 90, 140, 100, 80, 50 and 34 respectively, while all other setae relatively small, measuring j_4, j_5 – 4 each, j_6 - 8, J_5 – 4, z_5, - 4, z_2 - 6, z_3 – 10, setae r_3 and R_1 on the lateral integument. Sternal shield 80 long, 72 wide with almost flat lateral and posterior margin, postlateral angulation absent, three pairs of sternal setae (30 long) are present and the 3 rd pair of setae on the edge or a little moved from the posterior margin of the sternal shield. A pair of well sclerotized, triangular metasternal plates present with a pair of setae (30 long) and a pair of prominent pores. Genital shield 74 wide, truncate posteriorly with a pair of long (36 long) setae. The genital and ventrianal shield 34 apart with a thin fold in the interspace. The ventrianal shield 104 long, 60 wide, narrow, the lateral margins slightly concave with 3 pairs of preanal setae, shaped as figured; 4 pairs of setae present on the membrane around the ventrianal shield. The setae JV_5 - 68 long, thick and serrate. Metapodal plates are not clearly visible. The fixed digit of chelicera with 8 teeth, 4 above the *pilus dentilis* and 4 posterior to it. The movable digit tridentate. The structure of spermatheca as figured, with very long, tubular cervix. Peritreme extends anteriorly upto j_1. Macrosetae on leg IV: genu- 25, tibia – 38,basitarsus – 52, distitarsus - 38 all with bulged tips. The femur of leg IV also has a blunt erect setae (20 long).

Leg chaetotaxy: genu II $1\,\frac{2}{2}\,\frac{1}{0}\,1$, tibia II $1\,\frac{1}{2}\,\frac{1}{1}\,1$;

genu III $1\,\frac{2}{2}\,\frac{1}{0}\,1$, tibia III $1\,\frac{1}{2}\,\frac{2}{0}\,1$.

Male: Un known.

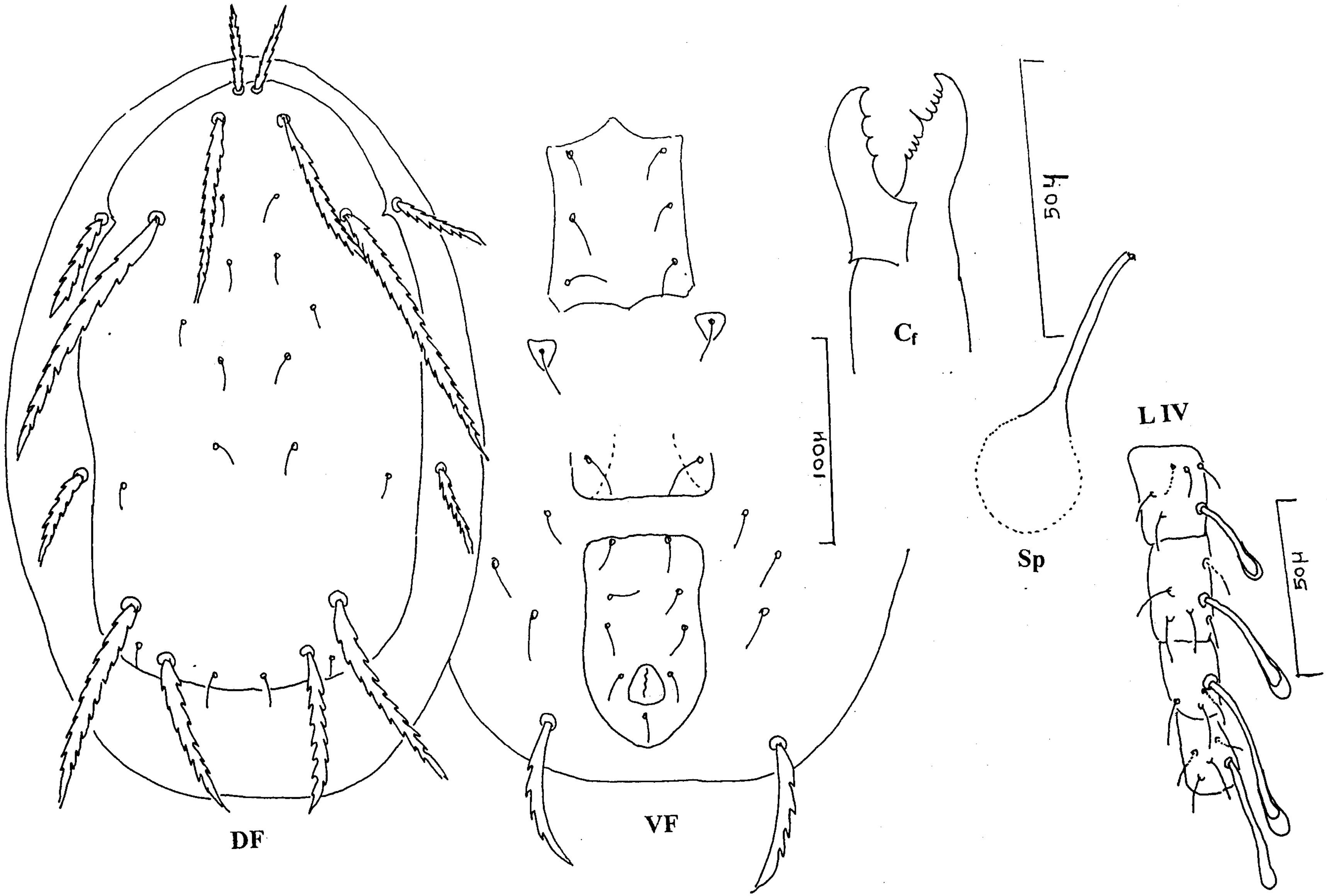
Habitat: *Ipomoea muricata.*

Material examined : Holotype ♀ marked on the slide along with other 4 ♀♀ INDIA : KERALA : Alathur (Palakkad district), 19.ivi.2001, ex. *Ipomoea muricata*, coll. Mary Anitha (No. A 55/2). Several paratype ♀♀ collected from the same locality on the above habitat.

Remarks: The new species resembles *Amblyseius (Paraphytoseius) multidentatus* Swirski and Shechter in its dorsal shield, shape, chaetotaxy, presence of knobbed macrosetae on leg IV, but it can be very well differentiated by the following characters:

1. Peritreme extends up to j_1 in the new species.

PLATE 35



Amblyseius (Paraphytoseius) arjunae **sp. nov.**

2. There is a clear variation in the structure of spermatheca (with long cervix).

3. The length of macrosetae on leg IV and the leg chaetotaxy also varying.

4. The lateral margins of ventrianal shield, more concave.

5. Movable digit of chelicera tridentate instead of two teeth.

6. The length of the dorsal shield more, the measurements of all body setae more.

7. Metapodal plates not clearly visible in the new species.

These predatory mites were found actively feeding on tenuipalpids and tarsonemids.

Amblyseius (Paraphytoseius) multidentatus (Swirski and Shechter), 1961

PLATE 36

1961. *Paraphytoseius multidentatus* swirski and shechter, *Israel J. Agri. Res.*, **11**(2): 114-116.

1967. *Amblyseius (Paraphytoseius) narayanani* Ehara and Ghai, *Mushi*, **40**(6): 77.

1970. *Amblyseius horrifer* : Gupta, *Sci. and Cult.*, **36**: 98.

1974. *Amblyseius narayani:* Prasad, *A Catalogue of mites of Inida* : p. 165.

1975. *Amblyseius narayani :* Gupta, *Internat. J. Acarol.*, **1** (2) : 39.

1978. *Amblyseius bhadrakaliensis :* Gupta, *Indian J. Acarol.*, **2** (2) : 61.

1979. *Paraphytoseius multidentatus* : Gupta, *Bull. Zool. Surv. India*, **2** (1): 80

1981. *Amblyseius (Paraphytoseius) multidentatus* : Gupta and Ray, *Bull. Zool. Surv. India*, **4**(3) : 43-44.

1986. *Amblyseius(Paraphytoseius) multidentatus* : Gupta, *Fauna of India (Acari: Mesostigmata) Family Phytoseiidae*, p. 123-126.

Female: Dorsal shield elongate 286 long and 164 wide, rugose with 13 pairs of setae. j_1, j_3, s_4, Z_4, Z_5 long, thick and serrate measuring j_1 - 31, j_3 - 87, s_4 - 115, Z_4 - 69 and Z_5 - 87. Sublateral setae r_3(45), R_1 (42) present on the lateral integument. Sternal shield 92 long, 80 wide with 3 pairs of sternal setae (28 long), 4th pair (30 long), placed on metasternal plates. Genital shield 86 wide with a pair of setae. Ventrianal shield 87 long, 57 wide with 3 pairs of preanal setae (20 long). Lateral margin of ventrianal shield almost straight. Three pairs of setae present on the membrane arround the shield. A pair of large metapodal plates (20 long) present. Setae JV_5 - 72 long, thick and serrate. Fixed digit of chelicera multidentate, movable digit bidentate. Spermatheca as figured. Peritreme extends anteriorly up to j_3. Macrosetae present on leg IV : genu - 28, tibia - 31, basitarsus - 40 and distitarsus - 38, all thick with knobbed tips.

Leg chaetotaxy: genu II $2\ \frac{2}{0}\ \frac{2}{0}\ 1$, tibia II $1\ \frac{1}{1}\ \frac{2}{1}\ 1.$,

$$\text{genu III}\quad 1\ \frac{2\quad 2}{1\quad 0}\ 1, \qquad\qquad \text{tibia III}\quad 1\ \frac{1\quad 2}{1\quad 1}\ 1.$$

Male: Dorsal chaetotaxy similar to that of female. Spermatophoral process as figured. Macrosetae on leg : IV, genu - 22, tibia - 21, basitarus and distitarsus - 24 each.

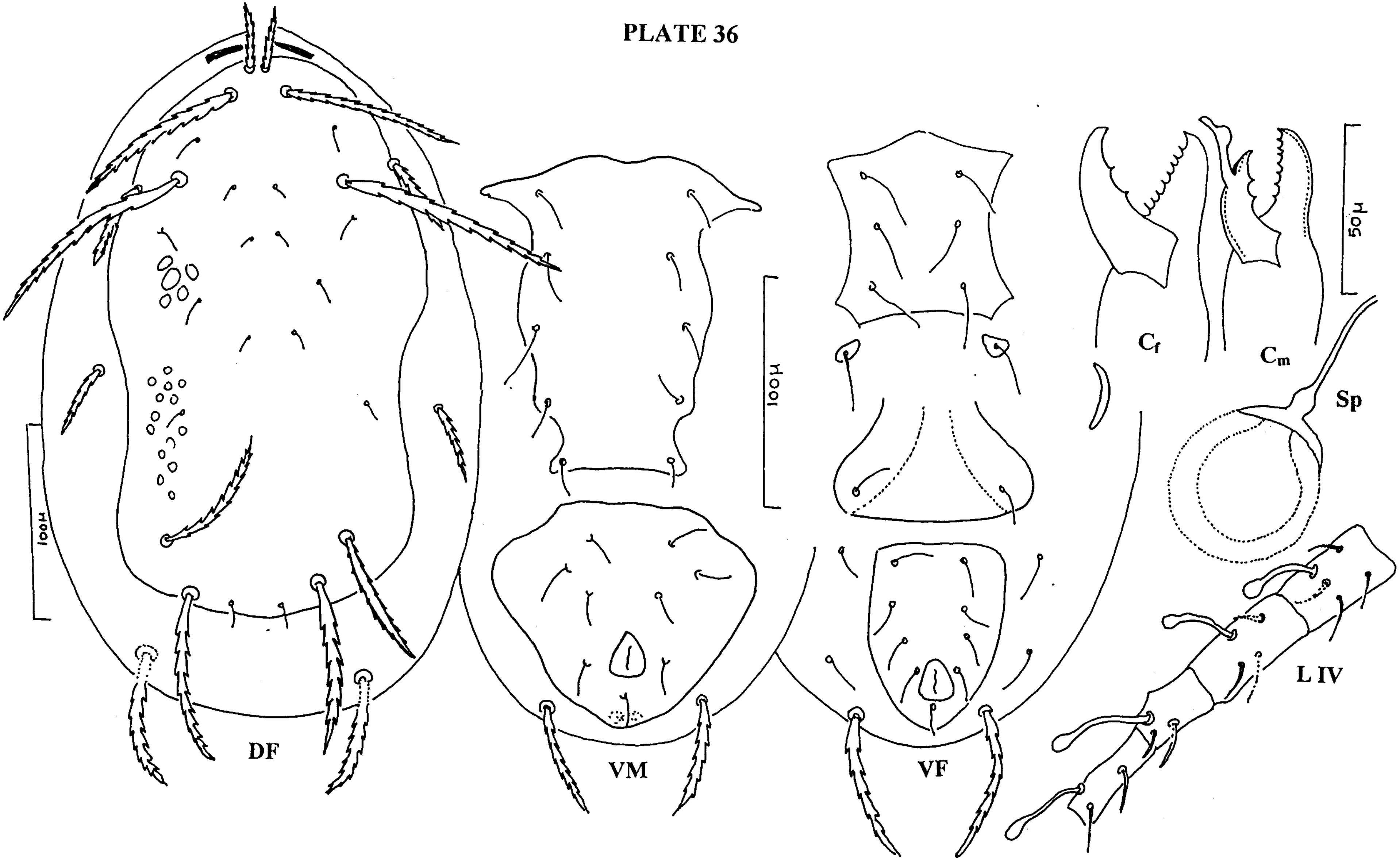
Habitat: *Momordica charantia, Abelmoschus esculentus.*

Known habitat: *Datura metal,* Paddy, *Cajanus cajan, Rubs* sp., brinjal, banana, pear, beans, rose, tea, eucalyptus, sunflower, cashew, fern, *Shorea robusta, Albizzia lucida, Ipomoea,* cotton, *Chromolaena odorata, Polygonium* sp. *Hibiscus mutabilis.*

Material examined: Female marked on the slide, INDIA: KERALA: Payyannur (Kannur district), 12.iii.2000, ex. *Abelmoschus esculentus*, coll. Mary Anitha (No. A 18/1). Three ♀♀ and 2 ♂♂, Quilandy (Kozhikode district), 8.v.2001, ex. *Momordica charantia*, coll. Mary Anitha (No. A 20/1).

Distribution: INDIA: Kerala, Tripura, Maharashtra, West Bengal, Andaman and Nicobar Islands, Bihar, Meghalaya, Assam, Tamil Nadu, Karnataka, Andra Pradesh, Utter Pradesh. OUTSIDE INDIA: Hong Kong, Thailand, Nigeria and Medagascar.

PLATE 36



Amblyseius (Paraphytoseius) multidentatus Swirski and Shechter, 1981

Remarks: The specimen studied, closely resembles *A. (P.) multidentatus* Swirski and Shechter in almost all characters, hence fixed so.

Subgenus *Typhlodromalus* Muma

1961. *Amblyseius* (*Typhlodromalus*) Muma, *Bull. Flat. St. Mus.* **5**(7): 288.

1964. *Amblyseius* (*Typhlodromalus*) : Merwe and Ryke, *J. Entomol. Soc. S. Afr.*, **26**(2): 263.

1967. *Typhlodromalus*: De Leon; Allen Press Inc., *Kansas*, p.21.

1970. *Typhlodromalus*: Muma and Denmark, *Arthropods of Florida*, **6**: 86.

1981. *Typhlodromalus* : Denmark and Andrews, *Fla. Entomol.*, **64**(1): 153.

1982. *Typhlodromalus*: Moraes *et al.*, *Internat. J. Acarol.*, **8**: 18.

1986. *Typhlodromalus*: Gupta, *Fauna of India (Acari: Mesostigmata) Family Phytoseiidae*, p.140.

Diagnosis: Dorsal shield with 6 pairs of dorsocentrals, 3 pairs of median and 8-9 pairs of laterals, of these Z_5 being longest. Fixed digit of chelicera multidentate, half of which proximal to *pilus dentilis*. Sternal shield longer than wide, mostly lobate posteriorly. Peritreme extends anteriorly upto j_1. Ventrianal shield elongate, mostly vase shaped with 3 pairs of preanal setae, anterior pair mostly adjacent to anterior margin of the shield. Macrosetae usually present on genu I, II and III and also present on genu, tibia and basitarsus of leg IV, that on basitarsus being longest.

Type: *Typhlodromalus peregrinus* Muma, 1955 by designation Muma (1961).

Amblyseius (Typhlodromalus) sativae sp. nov.

PLATE 37

Female: Body elongated and oval. Dorsal shield 336 long, 250 wide, reticulate with 17 pairs of setae. Measurements of setae : j_1 - 10, j_3 - 20, s_4 - 32, Z_4 - 30, Z_5 - 65, the latter weakly serrate; all other setae small. Sublateral setae r_3, R_1 - 22 each present on the lateral integument. Sternal shield 68 long with 3 pairs of sternal setae (22), metasternal plate with distinct seta. Genital shield 80 wide with a pair of setae (22) . An integumental fold between genital and ventrianal shield. Ventrianal shield 99 long, 72 wide, constricted at the level of preanal pores, latter crescent shaped; 3 pair of preanal setae (16) present, 4 pairs of setae present around ventrianal shield. Setae JV_5 - 34 long and smooth. Two pairs of metapodal plates present, primary one 19 and accessory one 10 long. Spermatheca as figured. Fixed digit of chelicera multidentate with *pilus dentilis*, movable digit with 3 teeth. Peritreme terminates anteriorly near j_1. Length of macrosetae on leg IV: genu - 50, tibia - 32, basitarsus size 53.

Leg chaetotaxy: genu II $2\ \frac{2}{0}\ \frac{2}{0}\ 1$, tibia II $1\ \frac{1}{1}\ \frac{2}{1}\ 1$.,

$$\text{genu III} \quad 1\,\dfrac{2\quad 2}{0\quad 1}\,1, \qquad\qquad \text{tibia III} \quad 1\,\dfrac{1\quad 2}{1\quad 1}\,1.$$

Male: Dorsal chaetotaxy similar to that of female. Spermatophoral process and ventral plates as illustrated.

Habitat: *Pisum sativum*.

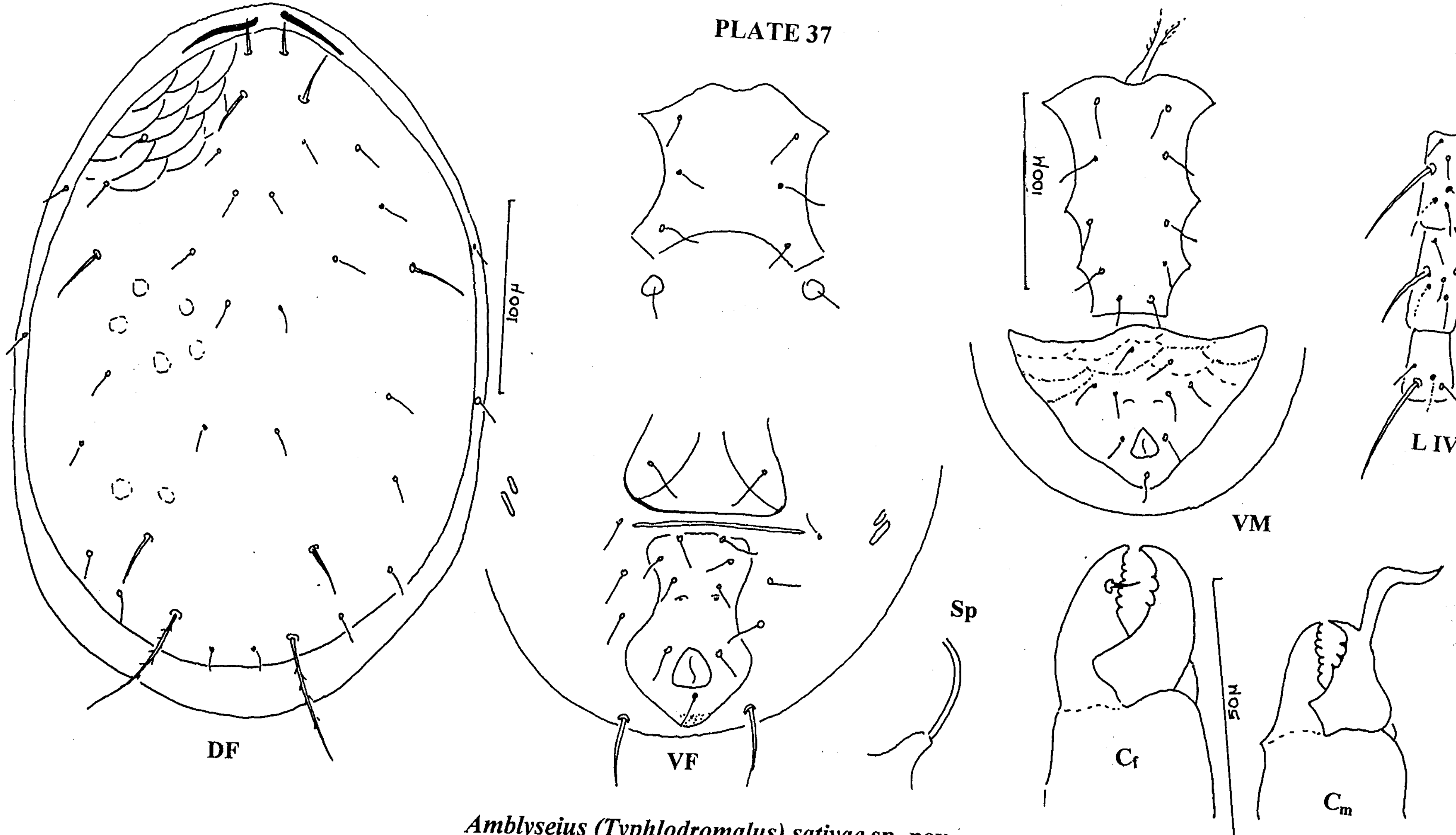
Material examined: Holotype ♀ marked on the slide along with other 3 ♀♀, INDIA: KERALA: Puthuppanam (Kozhikode district), 24.ii.2001, ex. *Pisum sativum*, coll. Mary Anitha (No. A 45/3). Paratypes 4 ♀♀, 1 ♂, Calicut University Campus (Malappuram district), 20.viii.2001, from the same host plant (No. A 45/4). Five ♀♀, 1 ♂, Payyannur (Kannur district), 12.iii.2000, from the same host plant (No. A 45/6).

Remarks: This new species closely resembles *A. (T.) eucalypticus* (Gupta) but differs from it based on the following characters:

1. Movable digit of the chelicera with 3 teeth in the new species instead of 2 in *A. (T.) eucalypticus* Gupta.

2. Presence of a clear integumental fold between ventrianal shield and genital shield in the new species.

PLATE 37



Amblyseius (Typhlodromalus) sativae sp. nov.

3. The length of j_1 is 10 in the new species where as it is 24 in *A. (T.) eucalypticus* Gupta.

4. Setae Z_5 is slightly serrate in the new species.

5. Characteristic design on the dorsal shield of the new species is absent in *A. (T.) eucalypticus* Gupta.

Subgenus *Typhlodromips* De Leon, 1965

1959. *Typhlodromopsis*: De Leon, *Entomol. News*, **70**: 133.

1965. *Typhlodromips*: Muma, *Fla. Entomol.*, **48**(4): 250.

1967. *Typhlodromips*: Denmark and Muma. *Flat. Entomol.*, **50**(3): 171.

1981. *Typhlodromips*: Matthysse and Denmark, *Fla. Entomol.*, **64**(2): 346.

1982. *Typhlodromips*: Moraes *et al.*, *Internat. J. Acarol.*, **8**(1): 5.

1986. *Typhlodromips*: Gupta, *Fauna of India (Acari : Mesostigmata) Family Phytoseiidae*, p.159.

Diagnosis: Females with 6 pairs of dorsocentral, 2 pairs of median and 9 pairs of lateral setae,Z_5 and Z_4 serrate or plumose. Chelicerae normal in size in proportion to the body, fixed digit multidentate with *pilus dentilis.* Peritreme long, extending forward upto j_1. Ventrianal shield pentagonal or shield shaped. Macrosetae usually present on genu and occassionally on tibia and basitarsus of leg IV, macrosetae on tarsus being the longest.

Type: *Typhlodromopsis simplicissimus* De Leon, 1965, by original designation.

Amblyseius (Typhlodromips) eujeniae **Gupta, 1977**

PLATE 38

1977. *Amblyseius eujeniae* Gupta, *Oriental Ins.*, **11:** 627-629.

1986. *Amblyseius (Typhlodromips) eujeniae*: Gupta, *Fauna of India (Acari: Mesostigmata) Family Phytoseiidae*, p. 164-165.

1987. *Amblyseius* (*Typhlodromips*) *eujeniae* : Gupta, *Rec. Zool. Surv. India*, p.60.

Female: Dorsal shield 306 long, 206 wide, smooth with 17 pairs of setae. j_1, j_3, s_4, Z_4 and Z_5 long, the latter two weakly serrate, others small, smooth and pointed. Meaurements of setae: j_1 - 20, j_4 - j_6 - 5 each, J_2 - 10, J_5 - 6 J_3 - 36, s_4 - 64, Z_4 - 64, Z_5 - 90, z_2, z_4 z_5, Z_1, S_2 S_5 - 8 each. Sternal shield 84 wide with 3 pairs of sternal setae, 4th pair lie on metasternal plates. Genital shield 80 wide with a pair of setae. Ventrianal shield 108 long, 76 wide, lateral margins straight, with 3 pairs of preanal setae; 4 pairs of setae present on the membrane around ventrianal shield. JV_5 - 24 long, metapodal plates 2 paired, primary one 19 long, accessory one 10 long. Spermatheca as figured. Fixed digit of chelicera with 2 teeth anterior to *pilus* *dentilis*, 5 teeth posterior to it; movable digit with 3 teeth. Peritreme extends anteriorly upto j_1. Macrosetae on leg IV: genu size 56, tibia - 28, basitarsus - 71.

Leg chaetotaxy: genu II $2\,\frac{2}{0}\,\frac{2}{0}\,1$, tibia II $1\,\frac{1}{1}\,\frac{2}{1}\,1$.,

genu III $1\,\frac{2}{1}\,\frac{2}{0}\,1$, tibia III $1\,\frac{1}{1}\,\frac{2}{1}\,1$.

Male: Unknown.

Habitat: *Morus alba, Musa paradisiaca.*

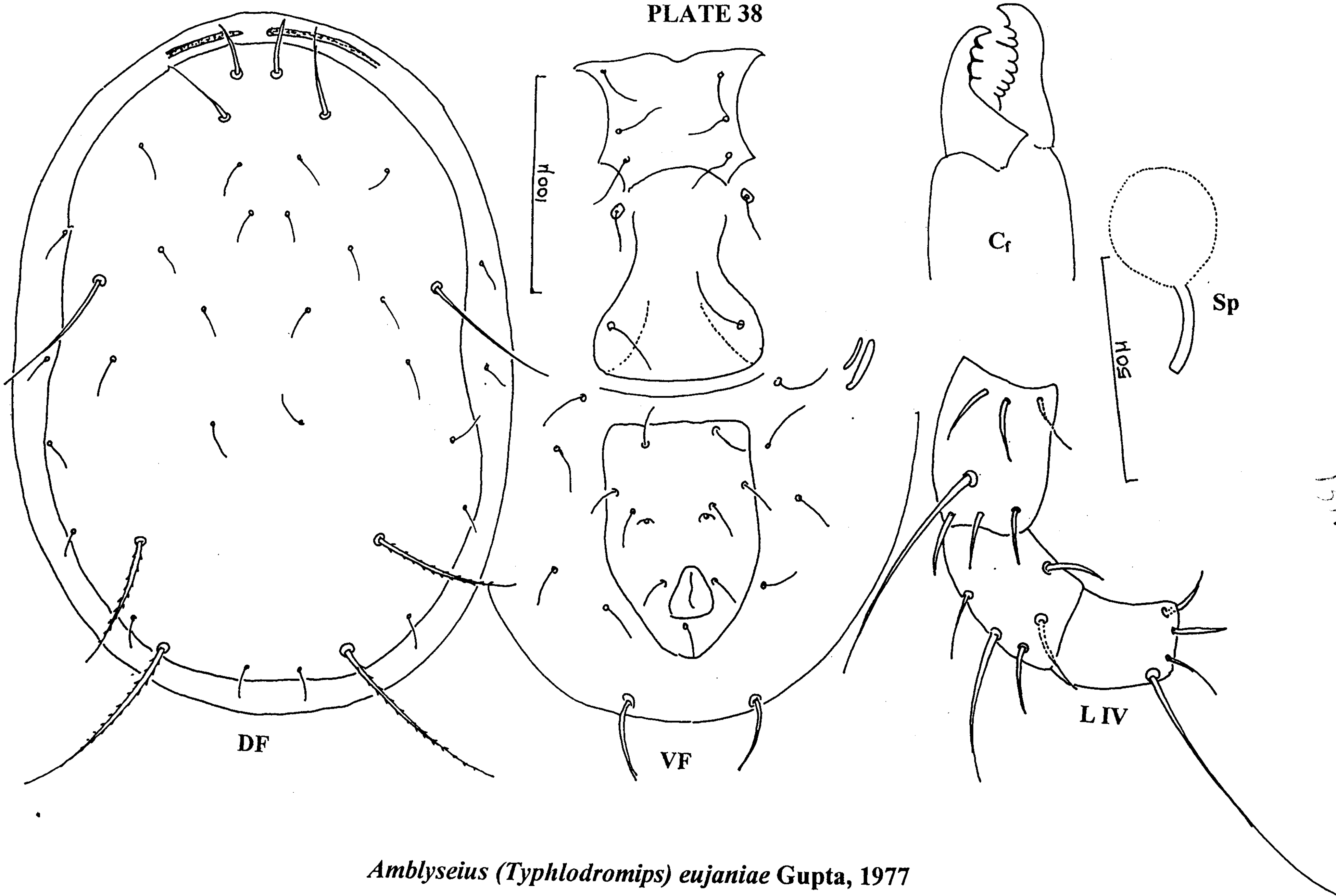
Known habitat: *Eujenia jambolana,* banana.

Material examined: Female marked on the slide along with 3 ♀♀, 1 larva, INDIA: KERALA: Indian Institute of Spices Research Experimental Garden, Peruvannamuzhi (Kozhikode district), 12.xi.2000, ex. *Morus alba,* coll. Mary Anitha (No. A 36/1). Five ♀♀, Kuttiadi (Kozhikode district), 10.iv.2001, ex. *Musa paradisiaca* (No. A 6/2).

Distribution: INDIA: Kerala, Andaman Islands.

Remarks: The specimens studied agrees with *A. (T.) eujeniae* Gupta in almost all characters and hence fixed so.

PLATE 38



Amblyseius (Typhlodromips) eujaniae Gupta, 1977

Amblyseius(Typhlodromips) sapienticola **Gupta, 1977**

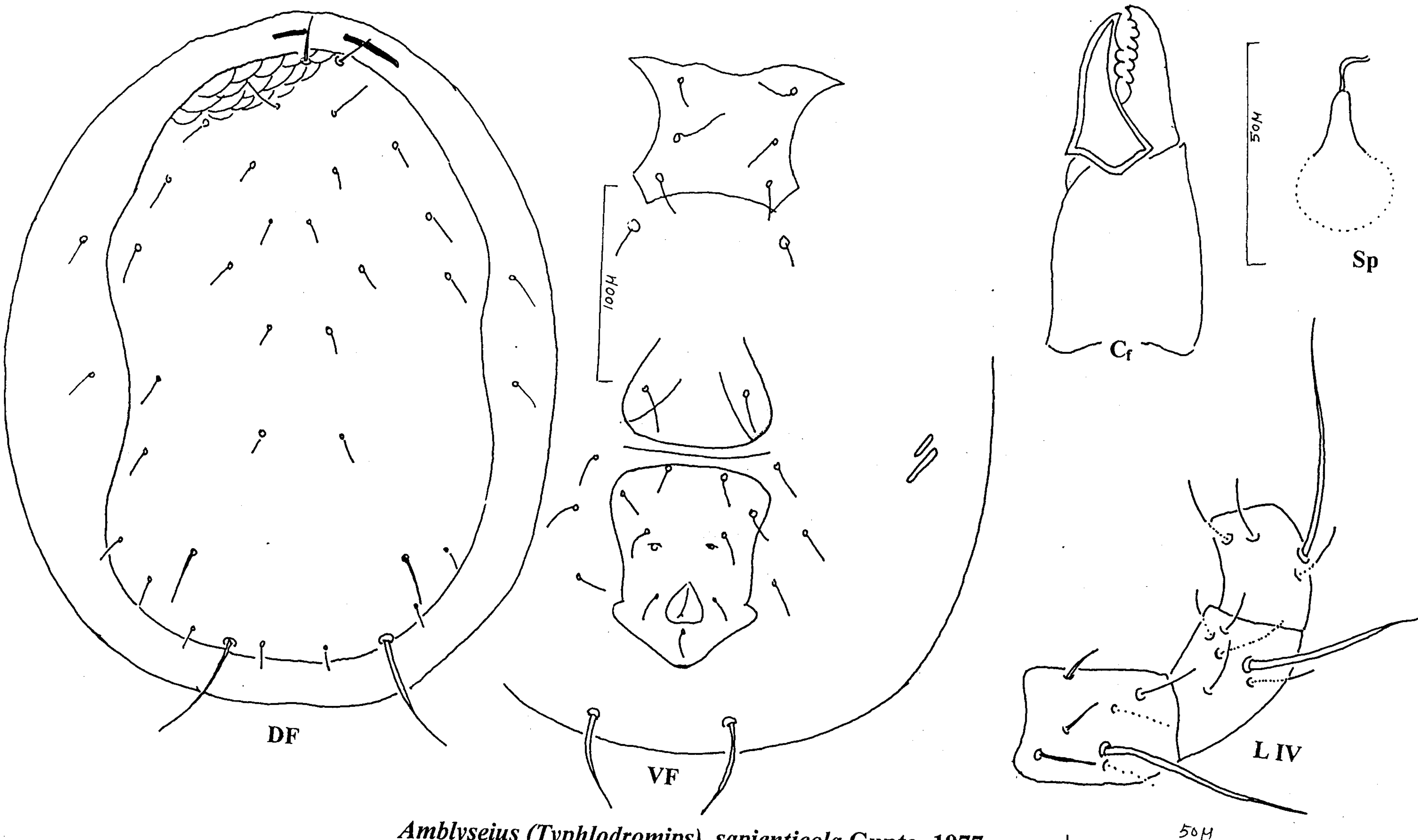
PLATE 39

1977. *Amblyseius sapienticola* : Gupta, *Oriental Ins.*, **11**: 633 - 635.

1986. *Amblyseius (Typhlodromips) sapienticola* : Gupta, *Fauna of India (Acari: Mesostigmata) Family Phytoseiidae,* p. 182-193.

***Female*:** Dorsal shield 320 long 200 wide, reticulate, well sclerotized with 17 pairs of setae, all being smooth. Almost all the setae small except Z_5 and Z_4, which are longer and the former thicker than the latter. Measurements of setae: j_1 - 4, j_3 - 12, j_4, j_6, J_2, J_5 - 8 each; z_2, z_4 - 8 each; s_4 - 16; Z_1, z_5, S_4, S_5 - 8 each; S_2 - 10, Z_4 - 26, Z_5 - 68. Sternal shield smooth 65 long, 75 wide with 3 pairs of sternal setae, 4th pair of setae on triangular metasternal plates. Genital shield 74 wide with a pair of setae. Ventrianal shield 105 long, 80 wide, with lateral margin slightly concave, notched below the level of 3rd pair of preanal setae. A pair of small round preanal pores present, 4 pairs of setae present around the ventrianal shield; setae JV_5 - 50 long. A thin cuticular fold present in between genital and ventrianal shield. Two pairs of metapodal plates present, primary one 20 long, accessory on 10 long. Fixed digit of chelicera multidentate with *pilus dentilis* movable digit tridentate. Peritreme extends anteriorly upto j_1. Spermatheca as figured. Macrosetae on leg IV: genu - 50, tibia - 40, basitarsus - 50; genu 1 - 30, genu III - 34.

PLATE 39



Amblyseius (Typhlodromips) sapienticola Gupta, 1977

Leg chaetotaxy : genu II $2 \, \frac{2}{0} \, \frac{2}{0} \, 1$, tibia II $1 \, \frac{1}{1} \, \frac{2}{1} \, 1$.,

genu III $1 \, \frac{2}{1} \, \frac{2}{0} \, 1$, tibia III $1 \, \frac{2}{0} \, \frac{2}{1} \, 1$.

Male: Unknown.

Habitat: *Colocasia esculentus*

Known habitat: Banana.

Materials examined: Female marked on the slide along with other 5 ♀♀, INDIA: KERALA: Kuttiadi (Kozhikode district), 10.iv.2001, ex. *Colocasia esculentus*, coll. Mary Anitha (No. A 56/1). Ten ♀♀ from the habitat mentioned above with same collection details (No. A 56/2 and A 56/3).

Remarks: The specimen examined closely resembles *A. (T.) sapienticola* in the general appearence, the dorsal and ventral chaetotaxy and hence fixed so.

Subfamily CYDNODROMELLINAE Chant and Yoshida - Shaul, 1986

1986. Cydnodromellinae: Chant and Yoshida – Shaul, *Canadian J. Zool.* **64** (12): 2881 – 2823.

Diagnosis: The subfamily cydnodromellinae diagnosed by the presence of 5 pairs of marginal setae on the podoscutum of the dorsal shield viz., j_3, z_2, z_4 and s_4. Setae z_3 is absent.

Type genus : *Cydnodromella* Muma, 1961.

Key to the genera of Cydnodromellinae

1. Opisthoscutum of dorsal shield with 3 – 4 pairs of setae; genu III with 6 setae; most marginal setae of dorsal shield markedly thickned and serrated .... ***Platyseiella***

- Opisthoscutum with 5 – 8 pairs of setae ; genu III with 7 setae; some dorsal setae thick and serrated but not as strong as above ....***Cydnodromella***

Genus *Platyseiella* Muma, 1961

1961. *Platyseiella* Muma, *Bull. Fla. St. Mus.*, **5**(7): 280.

1965. *Platyseiella*: Chant, *Canadian Entomol.*, **97**(4): 370.

1970. *Platyseiella* : Muma and Denmark, *Arthropods of Florida*, **6**: 56.

1978. *Platyseiella* : Chant *et al.*, *Canadian J. Zool.*, 56(6): 1344.

1981. *Platyseiella* : Ray and Gupta, *Bull. Zool. Surv. India*, **4**(3); 277.

Diagnosis: Dorsal shield rugose, lightly sclerotized with 5 pairs of dorsocentral, 2 pairs of median and 6 pairs of lateral setae; r_3 lies on dorsal shield, R_1 absent. Sternal shield smooth, as long as wide, with 3 pairs of sternal setae. Ventrianal shield smooth, elongate, vase shaped, with 2-3 pairs of preanal setae. peritreme extends anteriorly up to j_1. Macrosetae present on genu, tibia and basitarsus of leg IV, may be spatulate or knobbed at the tip.

Type: *Phytoseius platypilis* Chant, 1959 by designation (Muma, 1961).

Platyseiella mumai **Ray and Gupta, 1981**

PLATE 40

1981. *Platyseiella mumai* Ray and Gupta, *Bull. Zool. Surv. India*, **4**(3): 277-279.

1986. *Platyseiella mumai* Gupta, *Fauna of India* (*Acari: Mesostigmata*) *Family Phytoseiidae*, p.208-210.

1987. *Platyseiella mumai* Gupta, *Rec. Zool. Surv. India*, **95**: 75-76.

Female: Dorsal shield 294 long, 146 wide with 14 pairs of setae, rugose patches and reticulations anteriorly. Setae j_4, j_5, j_6, J_2, j_5 and z_5 small and simple, the remaining setae long thick and serrate. Measurements of setae : j_1 - 18, j_3 - 24, j_4 -7, j_5 - 6, j_6, J_2, J_5 - 5 each, z_2 - 11, z_4 - 9, z_5 - 5, s_4 - 106, s_6 - 70, Z_5 - 74, Z_4 - 72. Sublateral setae r_3 - 32, R_1 absent. Sternal shield 80 long 86 wide with 3 pairs of sternal setae. Posterior margin of the sternal shield with lateral lobes, 4th pair of setae present on the metasternal plates. Genital shield 80 wide with a pair of setae. Ventrianal shield as figured, 100 long, 68 wide. Metapodal plates present, primary one 28 long. Setae JV_5 60 long, thick and serrated. Fixed digit of chelicera multidentate with *pilus dentilis*, movable digit with 2 teeth. Peritreme extends anteriorly upto j_3. Measurements of setae on leg IV: genu, 28, tibia - 30, basitarsus - 34, all knobbed distally.

Male: Spermatophoral process as figured.

Habitat: *Eletteria cardamomum, Cinnamomum zeylanicum.*

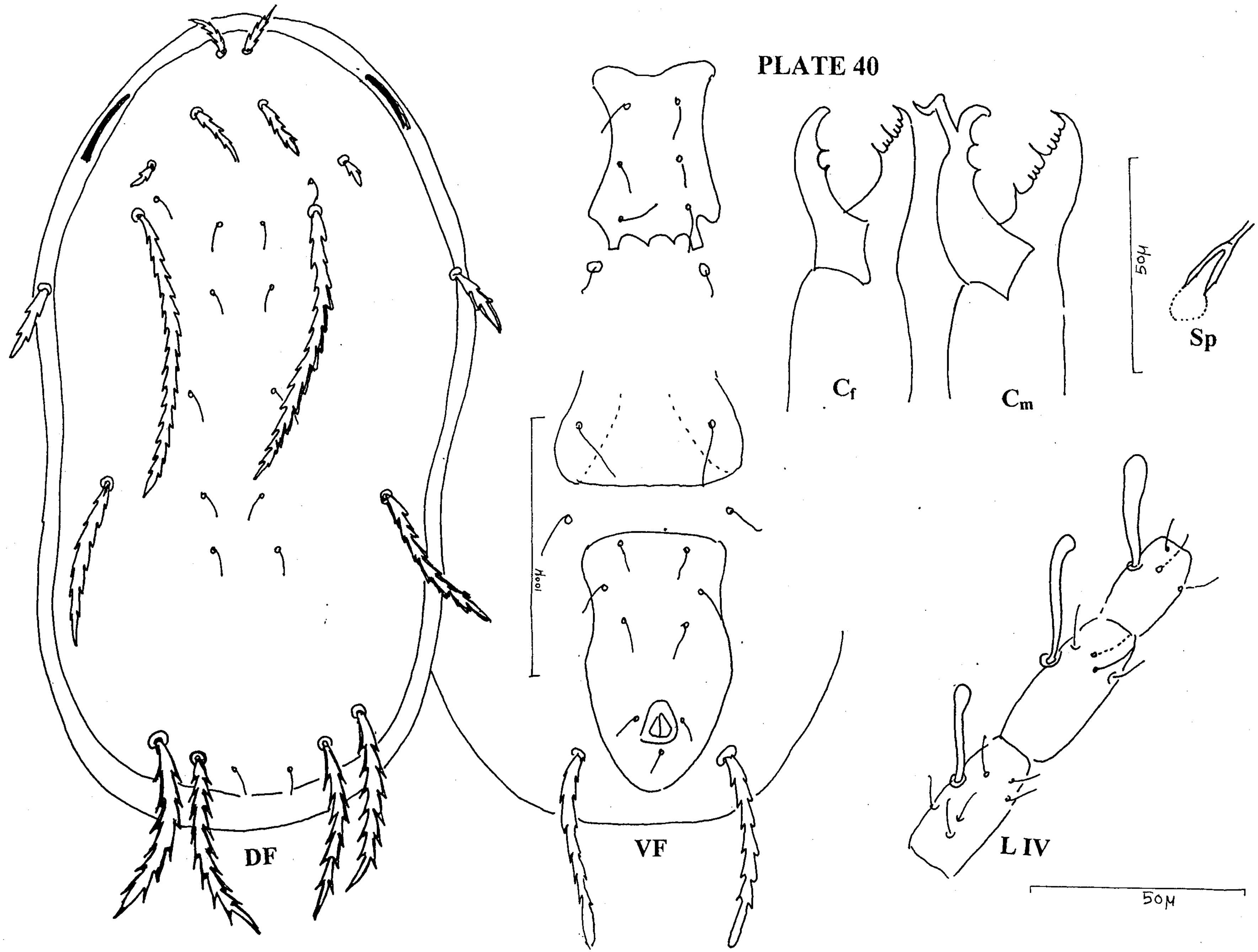
Known habitat: Undertermined plant.

Material examined: Female marked on the slide along with a ♂, Vythiri (Wayanad district), 24.i.2000, ex. *Elettaria cardamomum* (No. A 28/1). 2 ♀♀, Vythiri (Wayanad district), 24.i.2000, ex.*Cinnamomum zeylanicum* (No. A 39/1).

Distribution: INDIA: Kerala, Tripura.

Remarks: The specimen studied agrees in almost all characters with *P. mumai* Ray and Gupta, hence fixed so.

PLATE 40



Platysiella mumai Ray and Gupta, 1981

Subfamily PHYTOSEIINAE Berlese, 1916

1916. Phytoseiinae Berlese, *Redia*, **12**:11.

1961. Phytoseiinae : Muma, *Bull. Fla. St. Mus.*, **5** (7): 292.

1965. Phytoseiinae : Chant, *Canadian Entomol.*, **97** : 353.

1970. Phytoseiinae : Muma and Denmark, *Arthropods of Florida*, **6** : 115.

1973. Phytoseiinae : Tuttle and Muma, *Tech. Bull. Agr. Exp. Sta. Univ. Arizona*, **208** : 27.

1978. Phytoseiinae : Chant *et al.*, *Canadian J. Zool.*, **56** (6) : 1344.

1986. Phytoseiinae : Gupta, *Fauna of India (Acari : Mesotigmata) Family phytoseiidae*, p. 216 – 217.

Diagnosis: Dorsal shield undivided , 5-6 pairs of dorsocentral setae, 2 – 3 pairs of median setae and 7 – 11 pairs of lateral setae, of these 5 pairs of prolateral, 1- 2 pairs of sublateral setae either on lateral integument or on dorsal shield. Ventrianal shield with 1 – 4 pairs of preanal setae; 0 – 3 macrosetae on leg IV.

Type genus *:* *Phytoseius* Ribaga, 1904.

Key to the genera of Phytoseiinae

1. Both setae r_3 and R_1 on dorsal shield .... *Indodromus*

\- r_3 may be on dorsal shield, R_1 it present, always on lateral integument 2

2. r_3 on dorsal shield, genu II with 7 setae, genu III with 6 setae .... *Phytoseius*

- r_3 on lateral integument, genu II with 7 or 8 seate; genu III with 6 or 7 setae .... *Typhlodromus*

Genus *Typhlodromus* Scheuten

1857. *Typhlodromus* Scheuten, *Arch. Naturges.* **23**: 111.

1887. *Seius (Seiulus)*: Berlese, *Acari Myriapoda et Scorpionides,* Fasc., **41**(3): 3.

1957. *Typhlodromus* (*Typhlodromus*): Chant, *Canadian Entomol.*, **89**: 529.

1961. Cydno*dromella* : Muma, *Bull. Fla. St. Mus.*, **5**(7): 286.

1967. *Cydnoseius* : Muma, *Flat. Entomol.*, **50**: 274-276.

1982. *Typhlodromus :* Daneshwar and Denmark, *Internat. J. Acarol.*, **8**(1): 6.

1986. *Typhlodromus* : Gupta, *Fauna of India* (*Acari* : *Mesostigmata*) *Family Phytoseiidae*, p.262.

Diagnosis: Dorsal shield entire with 16-20 pairs of setae, of those, 5-6 pairs of prolateral series. Setae short or long, smooth or serrate; dorsocentral setae 5-6 pairs and median setae 2-3 pairs, lateral setae 8-12 pairs, sublateral setae on lateral integument. Female with sternal and genital shields and either a ventrianal or separate ventral and anal shields, with 1-4 pairs of preanal setae; 2 pairs of elongated narrow metapodal plates present. Spermatheca well developed short or long, genu II, III IV with 6-7 setae each, tibia II and III with 6-7 setae each, tibia IV with 6 setae.

Type species: *Typhlodromus pyri* Scheuten (1857) by subsequent designation (Oudemans, 1929).

Key to the subgenera of *Typhlodromus*

1. Dorsal shield with II pairs of setae .... *Typhloctonus*

- Dorsal shield with less than II pairs of setae 2

2. Dorsal shield with 10 pairs of setae 4

- Dorsal shield with less than 10 pairs of setae................................ 3

3. Sternal shield entire and distinct .... *Brethria*

- Sternal shield not entire and or slightly indistinct .... *Mataseiulus*

4. 3 pairs of median setae .... *Paraseiulus*

- 2 pairs of median setae 5

5. Ventrianal shield with 3 pairs of preanal setae .... *Anthoseius*

- Ventrial shield with 4 pairs of preanal setae 6

6. Most of the lateral setae plumose .... *Clavidromus*

- Most of the lateral setae not plumose, only a few may be serrate 7

7. Z_5 and Z_4 serrate and former knobbed .... *Amblydromella*

- Not as above 8

8. Leg IV with macrosetae on genu, tibia and basitarsus of leg IV ....
.... *Orientiseius*

- Leg IV with macrosetae on basitarsus IV only .... *Typhlodromus*

Subgenus *Amblydromella* Muma, 1961

1961. *Amblydromella* Muma, *Bull. Fla. St. Mus.*, **5**(7): 294.

1961. *Typhlodromella*: Muma, *Bull. Fla. St. Mus.*, **5**(7): 299.

1972. *Typhlodromus* (*Anthoseius*): Ehara, *Mushi*, **46**(12); 138.

1973. *Amblydromella*: Denmark and Muma, *Rev. Brazil Biol.*, **33**(2): 269.

1978. *Amblydromella* : Denmark and Muma, *Internat. J. Acarol.*, **4**(1): 18.

1982. *Amblydromella*: Daneshvar and Denmark, *Internat. J. Acarol.*, **8**(1): 7.

1986. *Amblydromella*: Gupta, *Fauna of India (Acari: Mesostigma) Family Phytoseiidae*, p.262.

Diagnosis: Dorsal shield well sclerotized, reticulate, with 18 pairs of setae, of these 10 pairs of laterals, 2 pairs of median and 6 pairs of dorsocentrals; among them Z_5 and Z_4 often thick and serrate, the former may be knobbed; 2 pairs of sublateral setae on lateral integument; sternal shield with 3 pairs of sternal setae. Ventrianal shield with a pairs of preanal setae. Macrosetae present on genu, tibia and basitarsus of leg IV, which may be simple or knobbed.

Type: *Typhlodromus fleschneri* Chant, 1960 by designation Muma, 1961.

Typhlodromus (Amblydromella) bambusicolus Gupta, 1977

PLATE 41

1977. *Typhlodromus bambusicolus* Gupta, *Indian J. Acarol.*, **2**: 2-4.

1986. *Typhlodromus* (*Amblydromella*) *bambusicolus:* Gupta, *Fauna of India (Acari : Mesostigmata) Family Phytoseiidae,* p.267.

Female: Body elongate, dorsal shield well sclerotized, 298 long, 176 wide, reticulate with 18 pairs of setae. All setae except S_2, S_4, Z_4, Z_5, r_3 and R_1 short. Setae Z_4 and Z_5 serrate and the latter gradually increases in thickness ending in a slightly knobbed tip, all other setae smooth thin and pointed. Two pairs of sublateral setae arise from the lateral integument. Measurements of setae; j_1 - 16, j_3 - 15, j_4 -12, j_5 - 10, z_2 - 14, z_3 - 12, z_4 - 16, s_4 - 16, S_2 - 22, S_4 - 22, S_5 - 14, Z_4 - 27, Z_5 - 43, r_3, R_1, 20 each. Sternal shield faintly visible 80 long and 58 wide, with 3 pairs of sternal setae, metasternal plates not visible, setae lie on the integument. Genital shield 62 wide with a pair of setae. The genital shield just 10 apart from the ventrianal shield with a thick integumental fold in the interspace. Ventrianal shield somewhat pentagonal well sclerotized, 76 long and 68 wide with 4 pairs of preanal setae and a pair of preanal pores; 4 pairs of ventrolateral setae present on the membrane around the shield. Setae JV_5 - 25 long with knobbed tip, 2 pairs metapodal plates present, both short. Peritreme extends anteriorly upto j_1 and incurved. Fixed digit of chelicera multidentate anterior to a prominent *pilus* *dentilis*, movable digit with a single tooth. Spermatheca as figured. Macrosetae on leg IV : genu - 12, tibia - 14, basitarsus - 22, all with knobbed tips.

Leg chaetotaxy: genu II $2\,\frac{2}{0}\,\frac{2}{0}\,1$, tibia II $1\,\frac{1}{1}\,\frac{1}{1}\,1$.

Male: Unknown.

Habitat: *Theobroma cocoa, Coffea arabica.*

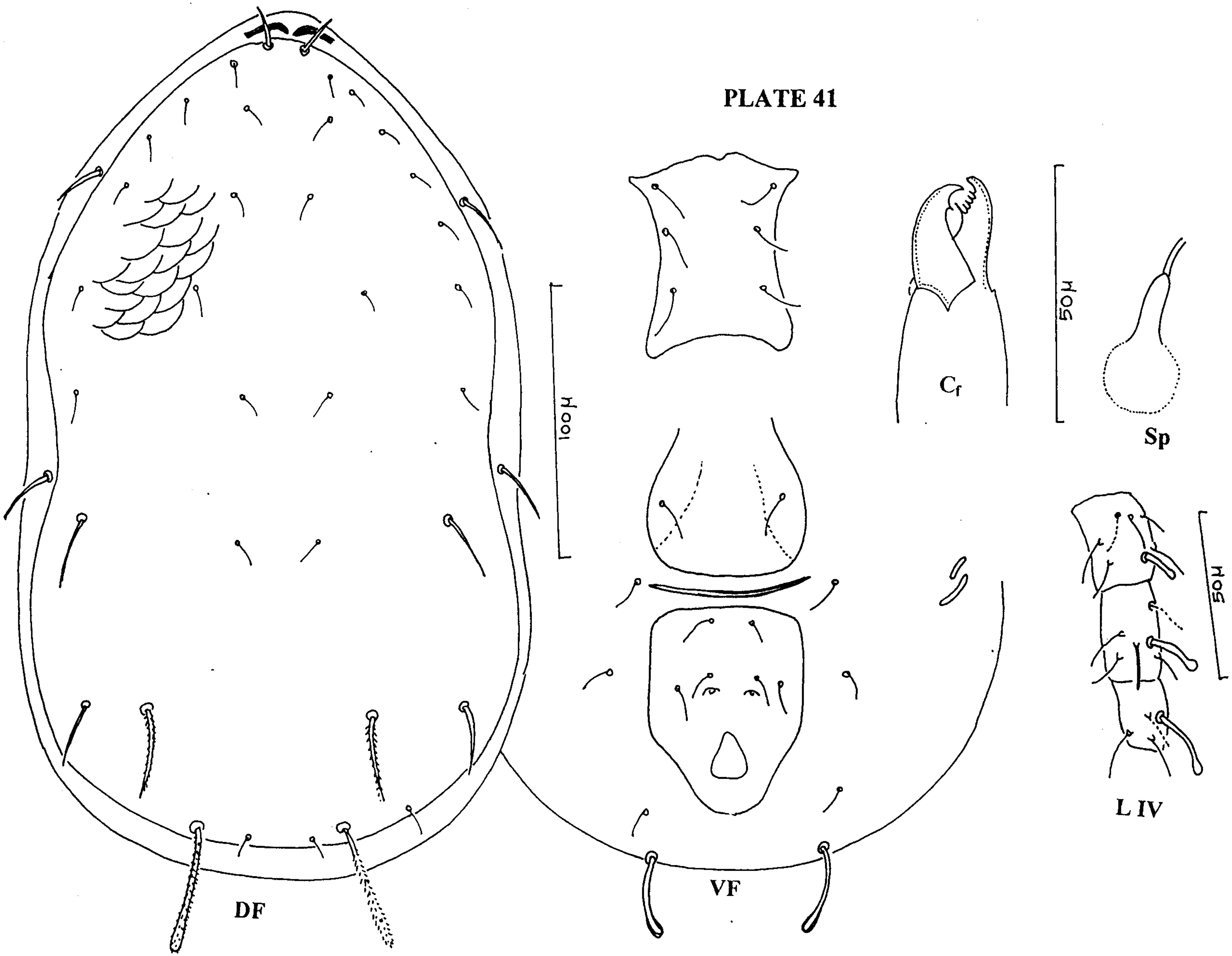
Known habitat: Bamboo, Citrus.

Material studied: One ♀ marked on the slide along with other 2 ♀♀, INDIA: KERALA: Agricultural Research Station, Ambalavayal (Wayanad district), 24.vi.2001, ex. *Theobroma cocoa*, coll. Mary Anitha (No. A 25/2). 3 ♀♀ on *Coffea arabica* from the same locality (No. A 24/3).

Distribution: INDIA: Kerala, Assam.

Remarks: The specimen examined agrees with *T. (A.) bambusicolus* Gupta in almost all characters and hence fixed so. This species was found along with a large populations of white flies in the field.

PLATE 41



Typhlodromus (Amblydromella) bambusicolus Gupta, 1977

PLATE 42

Figs. 1-6. Phytoseiid mites

Fig. 1. Male chelicera

2. Female chelicera

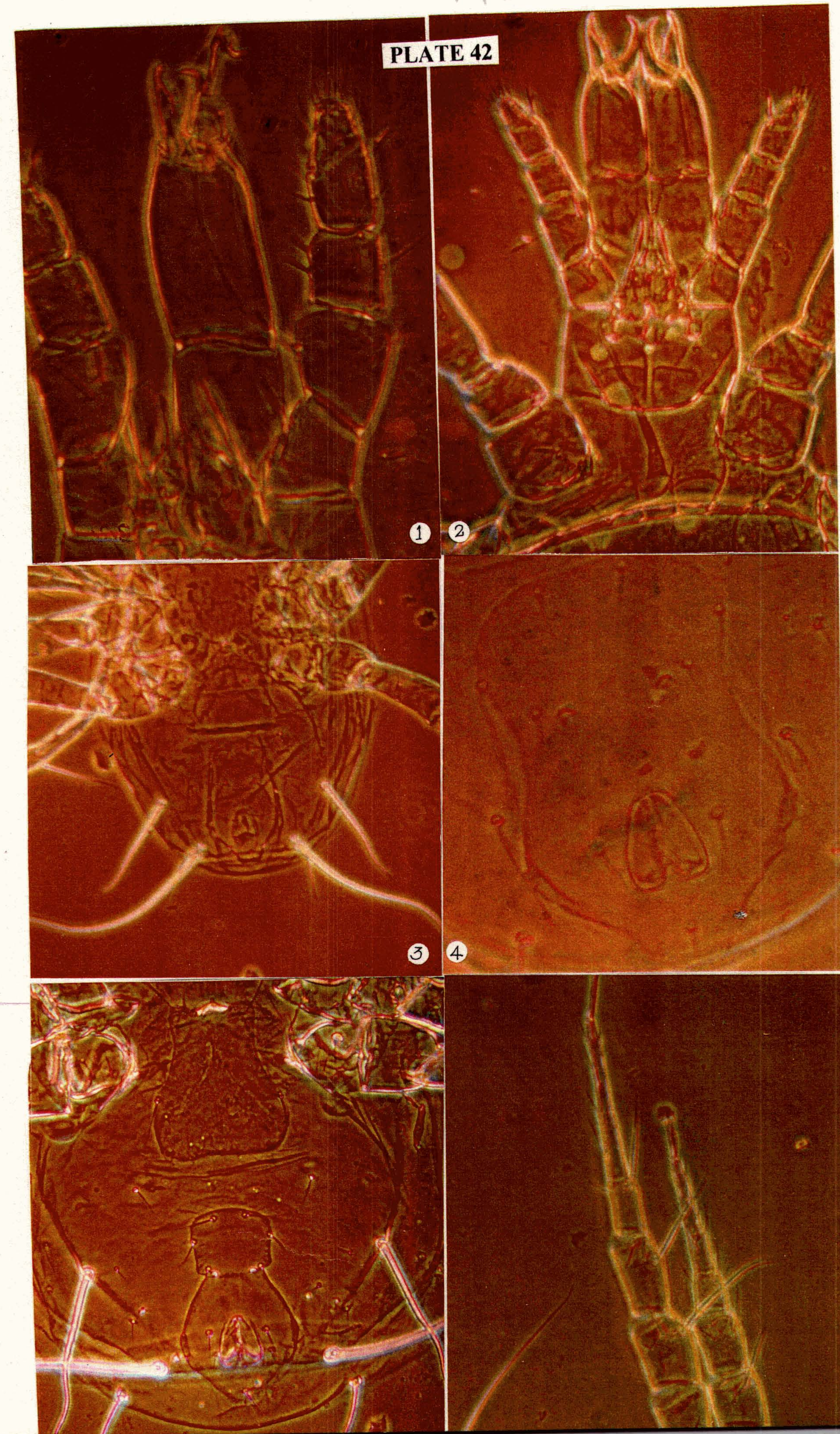
3. Hysterosoma showing Z_4 and Z_5

4. Ventrianal shield enlarged

5. Genital and ventrianal shields

6. Leg IV showing macrosetae

142C



60

ORDER : ACARIFORMES

Suborder : PROSTIGMATA

5.2. Family CHEYLETIDAE Leach, 1815

1915. Cheyletidae Leach, *Trans. Linn. Soc. Lond.*, **11**: 399.

1949. Cheyletidae Baker, *Proc. U.S. Nat. Mus.*, **99** (3238): 267-320.

1957. Cheyletidae Dubinin, *Inst. Parisit. Sbornik*, **17**: 71-136.

1969. Cheyletidae Volgin, Acarina of the family Cheyletidae, World fauna. *Operedel fauna SSR*, **101**: 1-432.

Diagnosis: Small to medium sized mites. Body (Plate 43) oval plumpy and elongate; propodosoma and hysterosoma with one or more dorsal shields. Eyes lens-like and may present or absent. Dorsal body setae simple, serrate, rod like, clavate or spatulate. Peritreme strong with varying number of links on the gnathosoma. Chelicerae short and stylet-like and used for grasping. Palp tarsus with comb like and sickle like setae; palp tibia with a strong claw having variable number of teeth. Legs ambulatory with elongate apical segments. Process on legs few but standard; not more than two setae on coxae, trochanters, femora and genua; usually four on tibiae; and seven or eight on tarsi. Tarsi usually terminate in a pair of claws. Sexual dimorphism usually well devleoped.

Genus *Cheyletus* Latreille, 1796

1904. *Cheyletus*: Oudemans, *Entomol. Ber. Nederl. Entomol Vet.* **1**(18): 160-169.

1940. *Cheyletus*: Rohdendorf, *Moscow Univ. Kchenye Zapiski, Wissensch Ber.*, **42**: 69-98.

1963. *Cheyletus*: De Leon, *Flat. Entomol.*, **45**(3): 129-137.

1977. *Cheyletus*: Qayyum and Chaudhri, *Pakistan J. Zool.*, **9**(1): 87-97.

Diagnosis : Palp tarsus with 2 sickle-like and 2 prominent comb-like setae. Palp claw with one to many basal teeth. Protegmen sub-conical. Tegmen plain or slightly serrated with prominent marks of muscle attachment. Peritreme M-shaped. Propodosomal shield covers most of the propodosoma. Eyes absent. Hysterosomal shield quadrangular, usually broadest on the front margin, about two third as wide as propodosomal shield. Dorsolateral body setae acicular, fusiform or narrowly spatulate, usually 10 pairs including one pair of humeral setae. Four pairs of setae on propodosomal shield, 2-5 pairs on hysterosomal shield. Dorso-median setae present or absent; usually very small, most species with one to three pairs. Tibiae I-IV each with one dorsal seta; much longer than the others on these segments, adoral setae tc on tarsus I rough or minutely annulated. All tarsi with paired claws and rayed empodia.

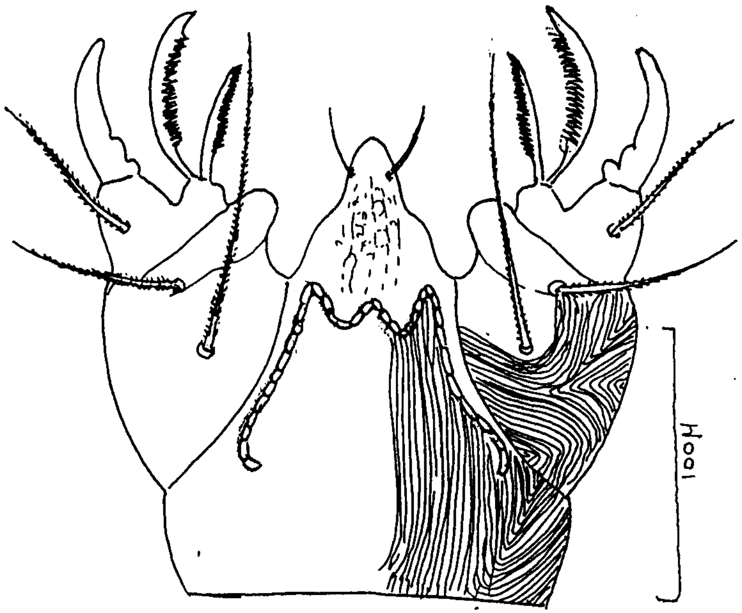
Type species: *Acarus eruditus* Schrank.

***Cheyletus arecae* sp. nov.**

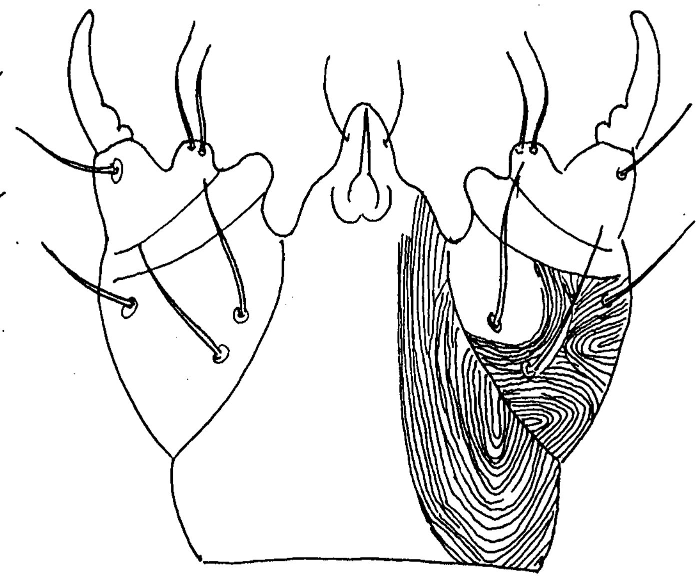
PLATE 44A and 44B

Female: Body 500 long (without gnathosoma) and 398 wide, rostrum short with lateral projections. The superior and inferior adoral setae one pair each 28, 36, long respectively. Protegmen with longitudinal broken striations and ornamentations; tegmen with longitudinal striations. Palp femur with a bulge on the inner surface, robose with striations both on dorsal and ventral surface. Palp tarsus with two comb like and two sickle like setae, outer pecten with 19 and inner with 23 processes. Peritreme as shown in figure with more than 18 links on either side. Eyes absent. Dorsum covered with two weakly sclerotized shields. Propodosomal shield wider than longer with 4 pairs of long marginal setae, rod like and barbed, unequal in size. The propodosomal shield and hystorosomal shield set apart and lumbar setae lie between it on small platelets. Three pairs of dorsal setae present on membrane below the hysterosomal shield caudally. Totally 12 pairs of dorsal setae present. The humeral setae on membrane barbed and twice longer than the others. Ventral setae three pairs, long and smooth. Paragenital setae three pairs, genital setae two pairs and anal setae three pairs, the latter finely barbed. Both dorsal and ventral surface finely striated. Legs I-IV: 428, 302, 326 and 426 long respectively. Length ratio : Leg I/Idiosoma = 0.9 and Leg I/II = 1.4.

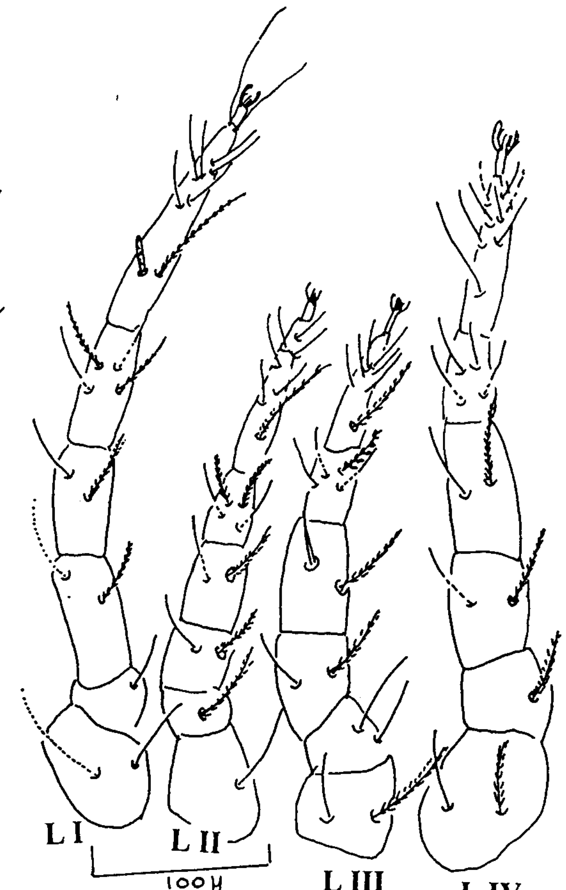
PLATE 44 A



DORSAL VIEW

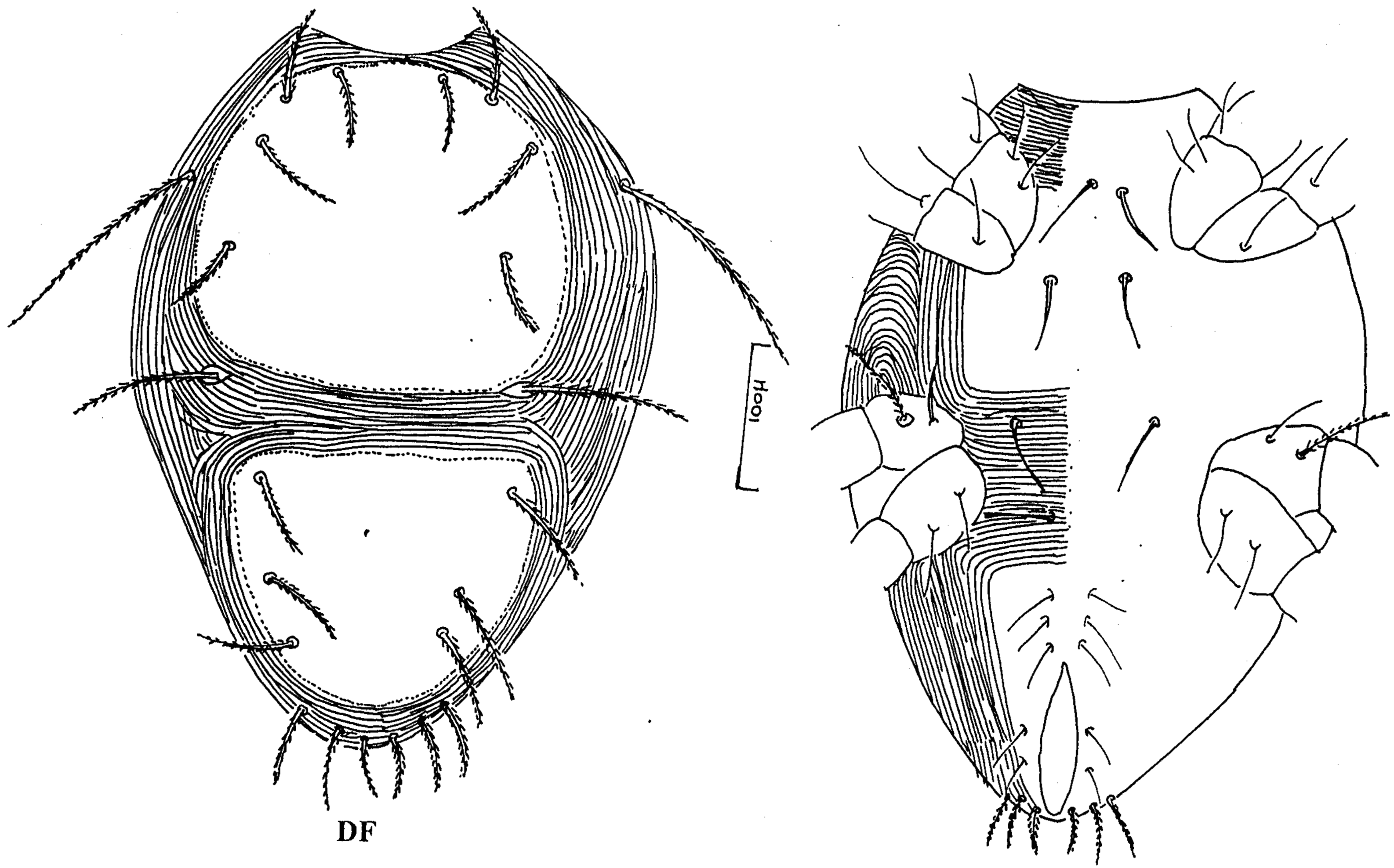


VENTRAL VIEW



Cheyletus arecae sp. nov.

PLATE 44 B



Cheyletus arecae sp. nov.

Leg chaetotaxy including solenidion: Coxae: 2-1-2-2; trochanter: 1-1-2-1; femora: 2-2-2-2; genu: 2-2-2-2; tibiae: 4-4-4-4 and tarsus: 7(1)-7-7-8. Tarsus 1 with two long adoral setae tc with a pair of claws. Solenidion present on tarsus 1 short, without a guard seta.

Male: Unknown.

Habitat: *Areca catechu, Cocos nucifera.*

Material examined: Holotype ♀ marked on the slide, INDIA: KERALA: Kalpetta (Wayanad district), 20.iv.2001, ex. stored arecanut (*Areca catechu*), coll. Mary Anitha (No. AS 27/2). Two paratype slides with 6 ♀♀, collection data similar to holotype (No. AS 27/1, 27/3). Two ♀♀, Big Bazar (Kozhikode district), 30.vi.2000. ex. Copra (*Cocos nucifera*).

Remarks: This new species resembles *C. baloghi* Volgin (1989) and *C. palmae* Chinniah (1995) in the structure of the dorsal shield, chaetotaxy and nature of setae, the number of teeth on palp claw etc. but can be distinguished by the following characters.

1) Absence of guard setae on tarsus I near the solenidion.

2) Presence of a clear bulging on the palp femur.

3) The number of teeth on the outer and inner pecten are 19 and 23 respectively.

4) More than 18 links on the peritreme, shape is also different.

***Cheyletus calicunsis* sp. nov.**

PLATE 45A and 45B

Male: Body 672 long (including gnathosoma) and 268 wide. Gnathosoma 402 long, rostrum short and obtuse with a pair of biceps like projections on its sides. Protegmen smooth and tegmen striated but striations not continuous. Palp femora elongated, slightly concave on inner side and with two pairs of pectinate setae, one on dorsal and another on ventral side; palp claw slightly curved with a single projection. Both combs on palp tarsus straight, inner pecten with 21 processes and outer pecten with 18 processes; the inner pecten shorter than the claw; ventral setae on palp tarsus sickle shaped. Propodosomal shield trapezoidal with four pairs of flat slightly broad (lanceolate), barbed, marginal setae of unequal size and two pairs of central setae of the same type. Hysterosomal shield some what triangular with six pairs of setae. Outer lumbar setae located below the posterior margin of the propodosomal shield. Humeral setae piliform, notably longer than dorsal setae. Aedeagus long and curved, on either side of it three pairs of small spines and a pair of fine setae present. Peritreme with 22 links. Both dorsal as well as ventral surface finely striated as figured. Sternal shield well developed. Ventrocentral setae five pairs including sternal setae; all ventral setae smooth. Leg I-IV: 624, 456, 460 and 480 long respectively. Leg chaetotaxy including solenidion: coxae: 2-1-2-2; trochanter: 0-1-2-1; femora: 2-2-2-1; genua: 2-2-2-2; tibiae: 6-4-4-4 and tarsi: 8-8-7-7, solenidion w_1 with out guard setae, adoral setae long exeeding the length of the tarsus.

Female: Unknown.

Habitat: *Manihot esculenta, Oryza sativa* and *Triticum aestivum*.

Material examined: Holotype ♂ marked on the slide along with other two♂♂, INDIA: KERALA : Big Bazar (Kozhikode district), 30.vi.2000. ex. *Manihot esculenta,* Coll. Mary Anitha (No. AC 3/6). Two paratype slides with 8 ♂♂ with collection data same as holotype (No. AC 3/2, 3/4). Many ♂♂ from the habitats mentioned above with same collection details.

Remarks : This new species resembles *C. malaccensis* Oudemans (1903) and *C. polymorphus* Volgin (1989) but can be differentiated by the following characters :

1. Absence of a short guard setae near w_1.
2. Presence of 18 and 21 processes on the outer and inner pecten of the palp tarsus.

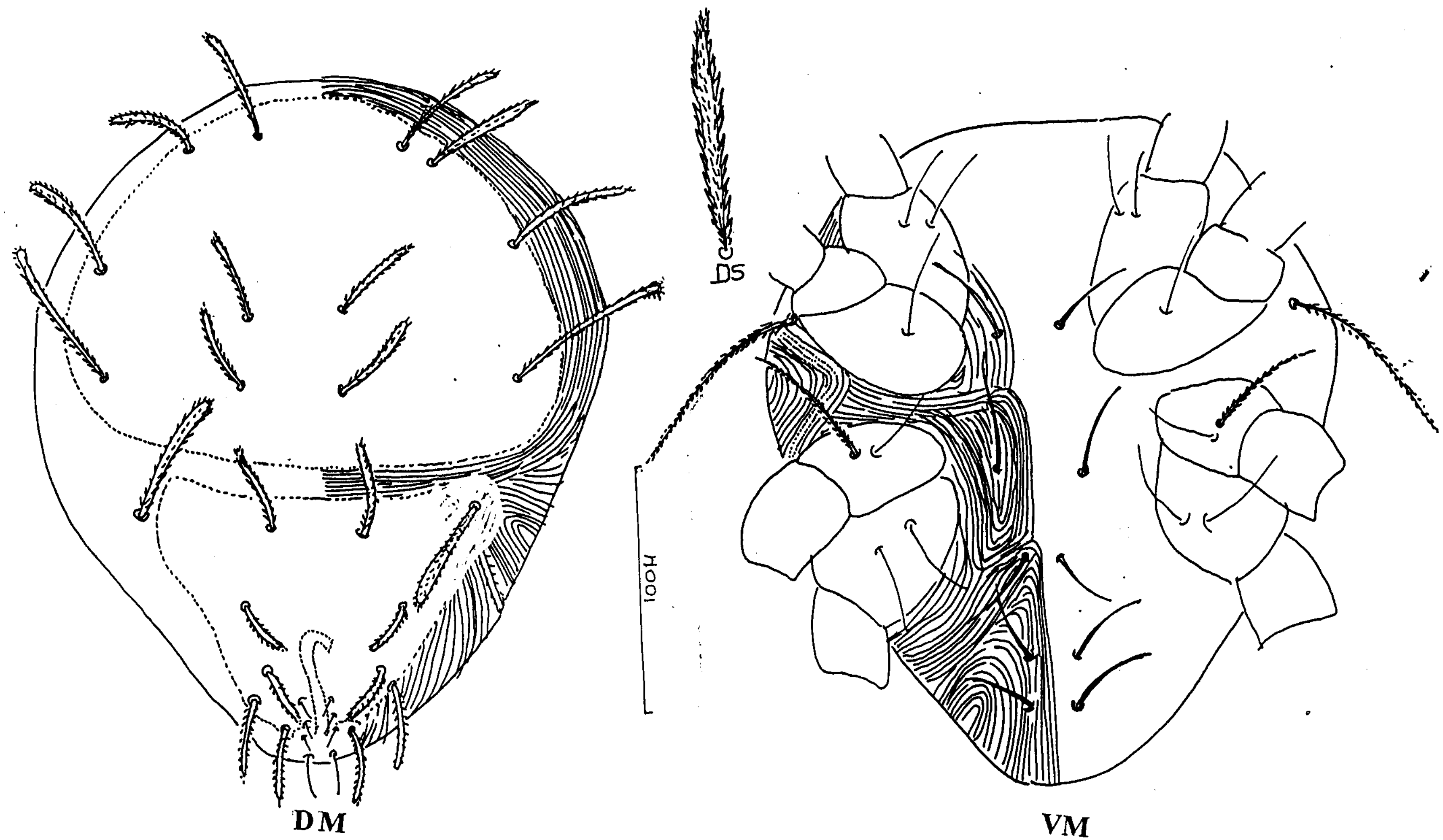
PLATE 45 A

DORSAL VIEW (MALE)

VENTRAL VIEW (MALE)

Cheyletus calicunsis sp. nov.

PLATE 45 B



Cheyletus calicunsis sp. nov.

3. Smooth protegmen in the male.

4. Presence of more number of links on the peritreme (22).

Cheyletus eruditus Schrank, 1781

PLATE 46A and 46B

1851. *Eutarsus cancriformis* Hessling.

1867. *Cheyletus eburneus* Hardy.

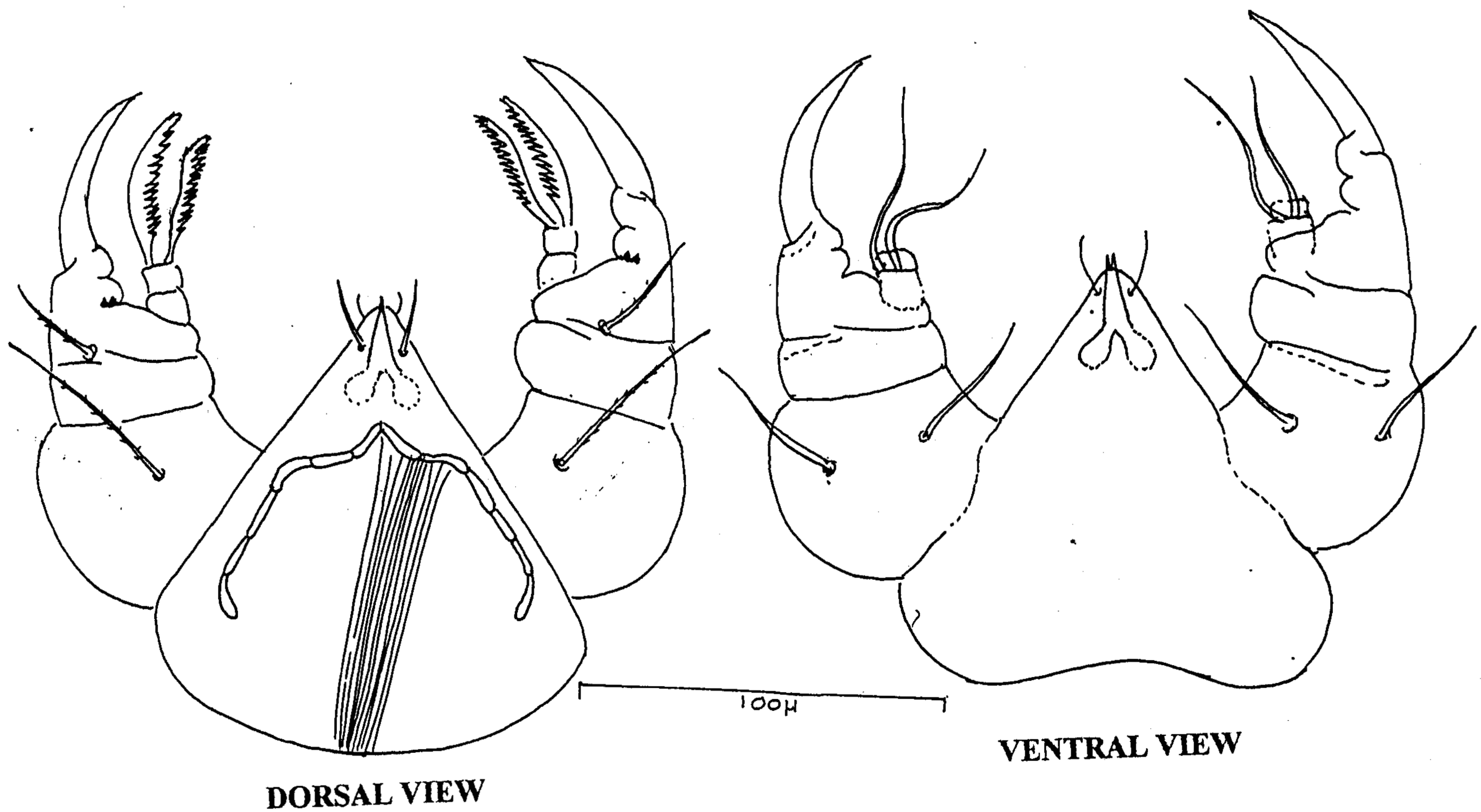
1906. *Cheyletus ferox* Banks.

1940. *Cheyletus rabiosus Rhodendorf*

1948. *Cheyletus butleri* Hughes.

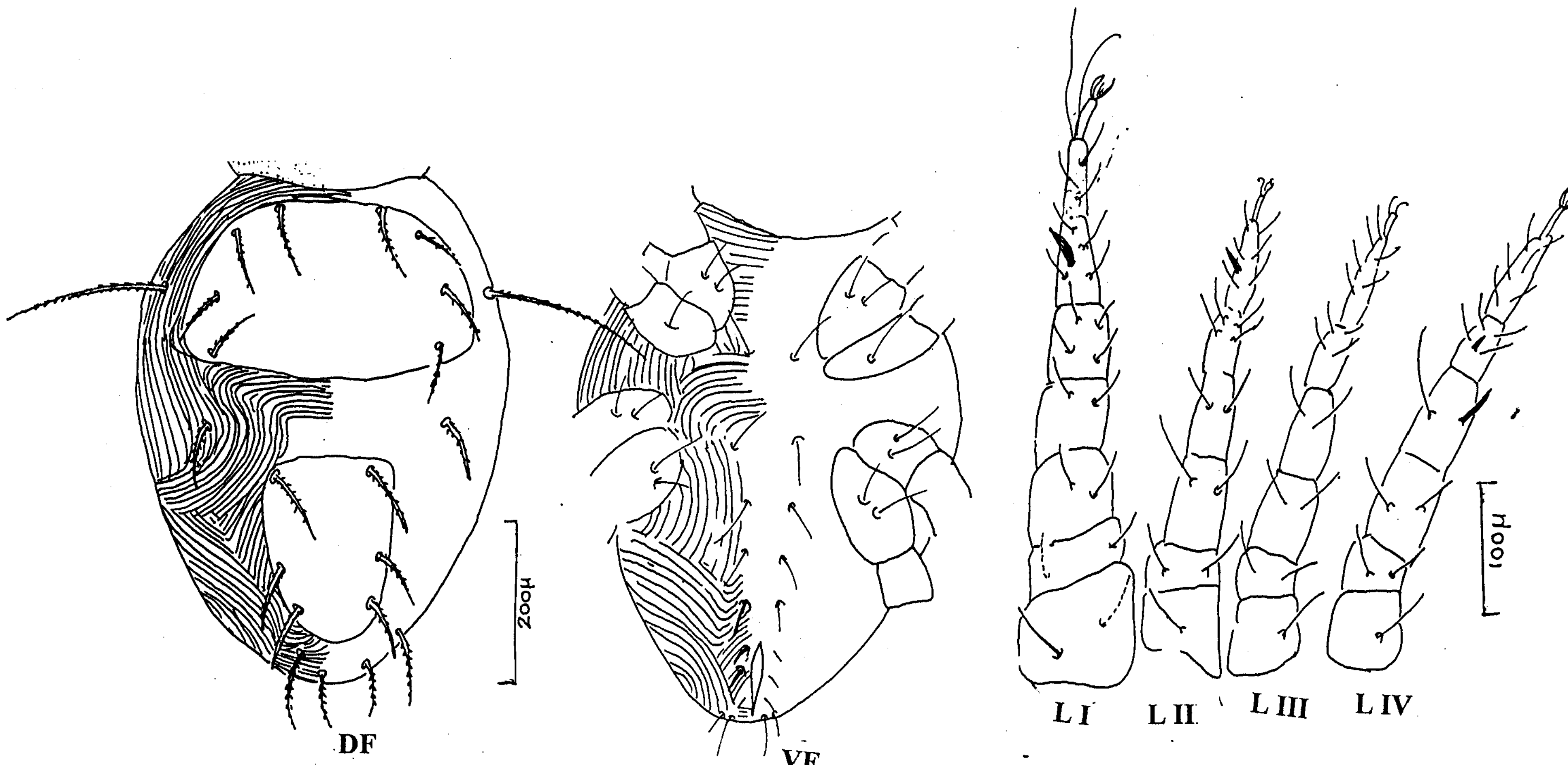
Female: Idiosoma colourless, diamond shaped, 600 long 325 wide. Gnathosoma long and narrow, tegmen ornamented with striae radiating from the base. Peritreme M shaped with 12 links. On the pedipalp of the tasus, internal comb bear 16 strong teeth which characteristically curved. External comb has 14 teeth. Tibial claw has two prominent teeth at its base. External edge of the pedipalpal femur convex. Dorsal seta on the femur long and sparsely barbed. The internal edge of the tibia has a thin flange from which arises one of the tibial setae. Propodosomal shield is having 4 pairs of pectinate marginal setae. The hysterosomal shield narrow and widely separated from the propodosomal shield with 3 pairs of setae. A pair of scapular and interscutal setae present, arising from small plates, as well as two pairs

PLATE 46 A



Cheyletus eruditus Schrank, 1781

PLATE 46 B



Cheyletus eruditus **Schrank, 1781**

of subterminal setae. Sternal shield absent. Five pairs of ventral setae present, 3 pairs of genital setae and 2 pairs of anal setae present.

Leg I-IV : 440, 355, 355, 415 long respectively.

Leg chaetotaxy : Coxae : 2-1-1-1; trochanter: 2, 2, 2, 2; femora: 2-2-2-2; genu: 2,2,2,2 (1); Tibia: 4-4-4-4(1); Tarsi: 7(1), 6(1), 6, 6.

Male: Not studied.

Habitat: *Phaseolus mungo, Allium sativum, Zingiber officinale* and *Cajanus cajan.*

Material examined: 4 ♀♀ marked on the slide, INDIA: KERALA: Big Bazar (Kozhikode district), 30.vi.2000. ex: *Phaseolus mungo*. Coll. Mary Anitha (No. AC 20/4). Many ♀♀ from the habitats mentined above with same collection details.

Remaks: The species examined agrees with *C. eruditus* in almost all characters and hence fixed so.

Cheyletus ichthyus sp. nov.

PLATE 47A and 47B

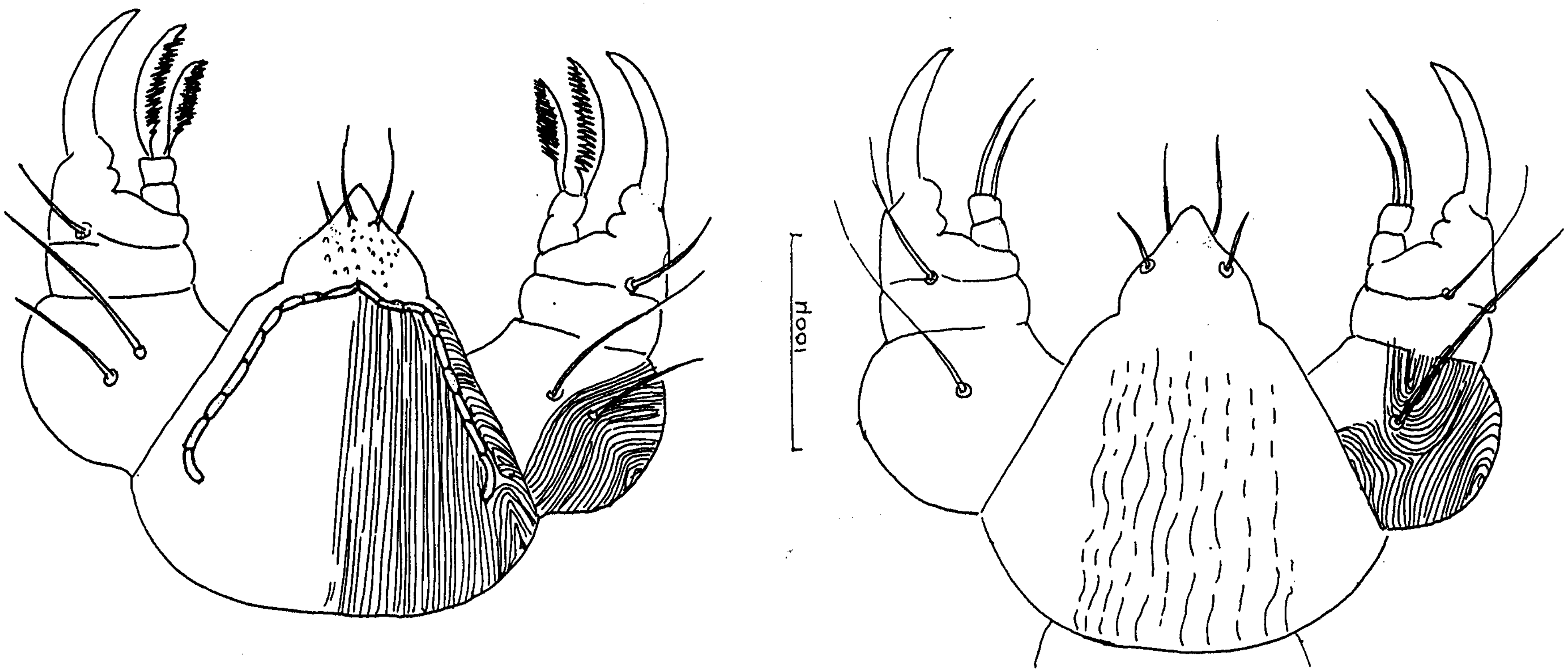
Female: Idiosoma 700 long and 500 wide; gnathosoma 200 long, large with massive palpi. Rostrum with dorsal (50) and ventral (20) adoral setae. Palp femora slightly convex on the outer surface, almost equal in length and width, striated on the dorsal surface, with two simple setae; ventral surface also striated. Palp genu without any seta. Palp tibia with one thick simple seta on the lateral aspect; palp tarsus with two comb like and two sickle shaped setae; the outer pecten as long as the claw with 18 processes and the inner pecten with 22 processes, claw with 2 basal process. Dorsum finely striated; propodosomal region with 3 pairs of thick serrate setae. Humeral setae arise on lateral end of the propodosoma. Hystersoma with 5 pairs of thick serrate setae on subdorsal position. Dorsal side of the tegmen has continuous longitudinal striations; ventral side with broken striations. Protegmen ornamented with tubercles. Peritreme as figured with 18 links. The ventral region also finely striated with 2 pairs of plain setae in the propodosomal region and 4 pairs in the hysterosomal region; genital sete 2 pairs and anal setae 3 pairs, all setae simple and moderately long. Leg 1 to IV: 550, 400, 385, 405 long respectively. The length ratio: Leg I/Idiosoma = 1.5, all legs finely striated.

Leg chaetotaxy: coxae: 2-1-2-2; trochanter: 2-2-2-1; femora: 2-2-2-1; genua: 2-2-2-2; Tibiae: 4-4-4-4; Tarsi: 6(1), 6, 6, 6. Tarsus I with two long setae tc, and ends in a pair of small claws. The solenidion w_1 on tarsus I found in the basal half of the segment, short and dagger like with out a guard seta. Tarsi of legs II to IV end in well developed curved claws, empodium rayed.

Male: Unknown.

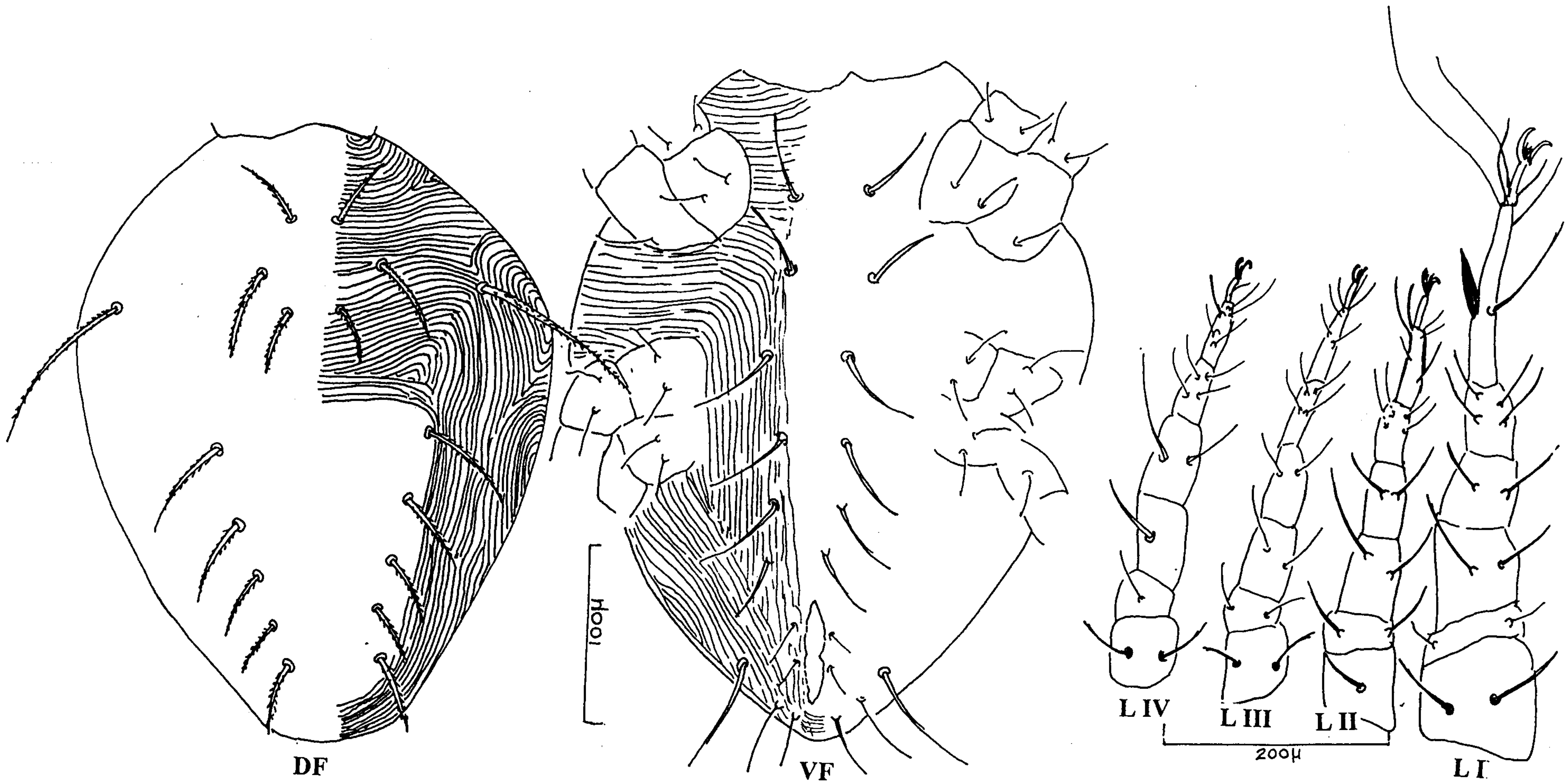
Habitat: Stored dry fish (*Ophiocephalus* sp.).

PLATE 47 A



Cheyletus ichthyes **sp. nov.**

PLATE 47 B



Cheyletus ichthyes **sp. nov.**

Material examined: Holotype ♀ marked on the slide, INDIA: KERALA: Puthiyappa (Kozhikode district), 14.ii.2001. ex. stored dry fish (*Ophiocephalus* sp.), coll. Mary Anitha (No. AF 1/3). Six paratype slides with 10 ♀♀, collection data same as type (No. F1/2, 1/4).

Remarks: This new species resembles *C. polymorphus* Volgin (1989) but differentited from it by the following characters.

1. Absence of guard setae near w_1.
2. Presence of 18 processes on the outer pecten and 22 processes on the inner pecten.
3. Dorsal and ventral striation patterns.
4. The finely serrate and thick nature of dorsal setae.

Cheyletus malaccensis Oudemans, 1903

PLATE 48A and 48B

Male: Body 705 long (including gnathosoma), 270 wide. Dorsal surface of the tegmen finely striated, the striations become indistinct infront of the peritreme. Protegmen covered with small tubercles. Rostrum expanded laterally into alae and that part overlying the palpal trochanter has two unequal teeth. Peritreme M-shaped with 12 links. Pedipalpal femur elongated with a distinct bulge on its internal surface. Both combs on the pedipalpal tarsus straight, internal with 15 and external with 11 teeth. Tibial claw has a bilobed projection. Propodosomal shield almost completely covers the front half of the body and bears 4 pairs of peripheral and 2 pairs of central setae (lanceolate and pectinate). Hysterosomal shield narrows slightly posteriorly and has 4 pairs of setae. Setae flattened and pectinate. A short sternal plate extends as far back as coxae 11 and surrounds the first pair of ventral setae. Leg I-IV: 405, 302, 336, 400 respectively.

Leg chaetotaxy including solenidia: coxae: 2, 1, 2, 2; Trochanter: 1, 1, 2, 1; femora: 2, 2, 2, 1; genua: 2, 2, 2, 2; tibia: 6, 4, 4, 4 and tarsi: 7(1), 8(1), 7, 7; solenidion with a guard seta, adoral setae long exceeding the length of the tarsus.

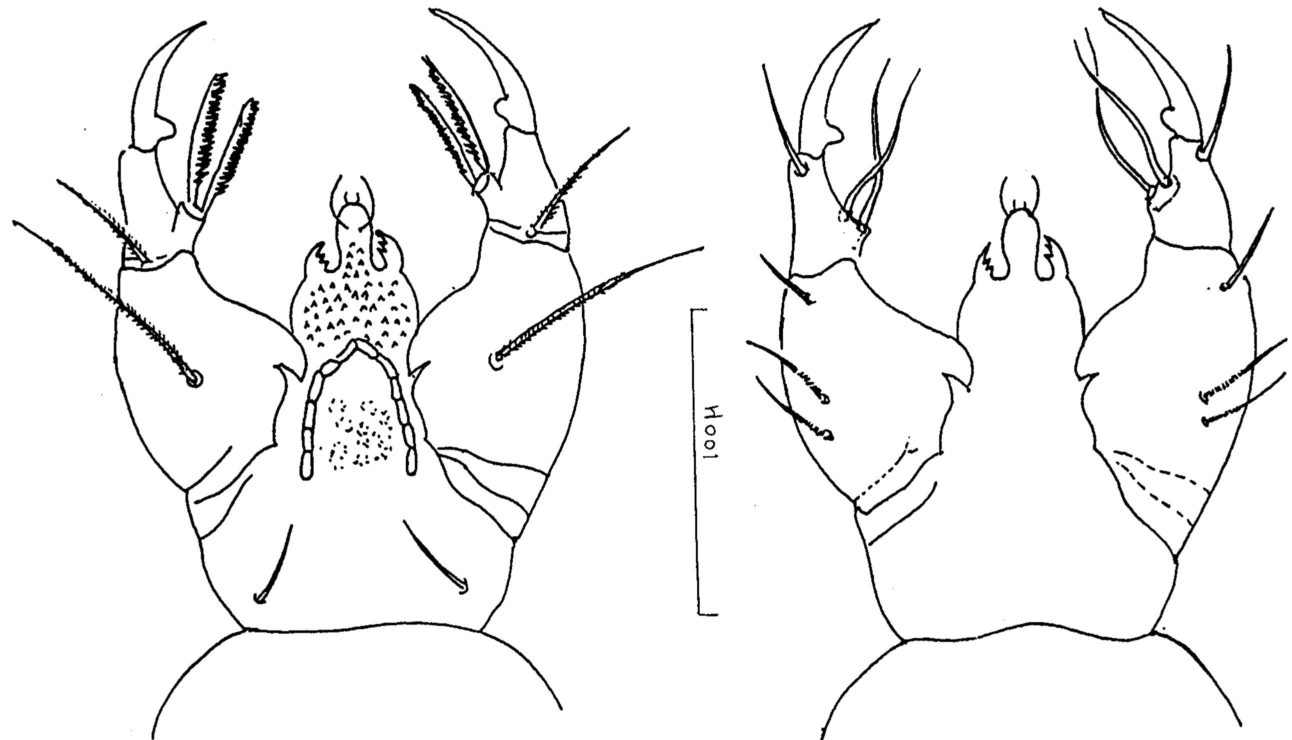
Female: Not studied.

Habitat: *Phaseolus mungo, P. aureus, Dolichos biflorus, Cajanus cajan.*

Material examined: Two ♂♂ marked on the slide, INDIA: KERALA: Big Bazar (Kozhikode district), 30.vi.2000. ex. *Phaseolus mungo*, coll. Mary Anitha (No. AC 18/3). Many paratype slides from the habitats mentioned above with same collection details.

Remarks: The specimen examined resembles *C. malaccensis* in almost all characters and hence fixed so.

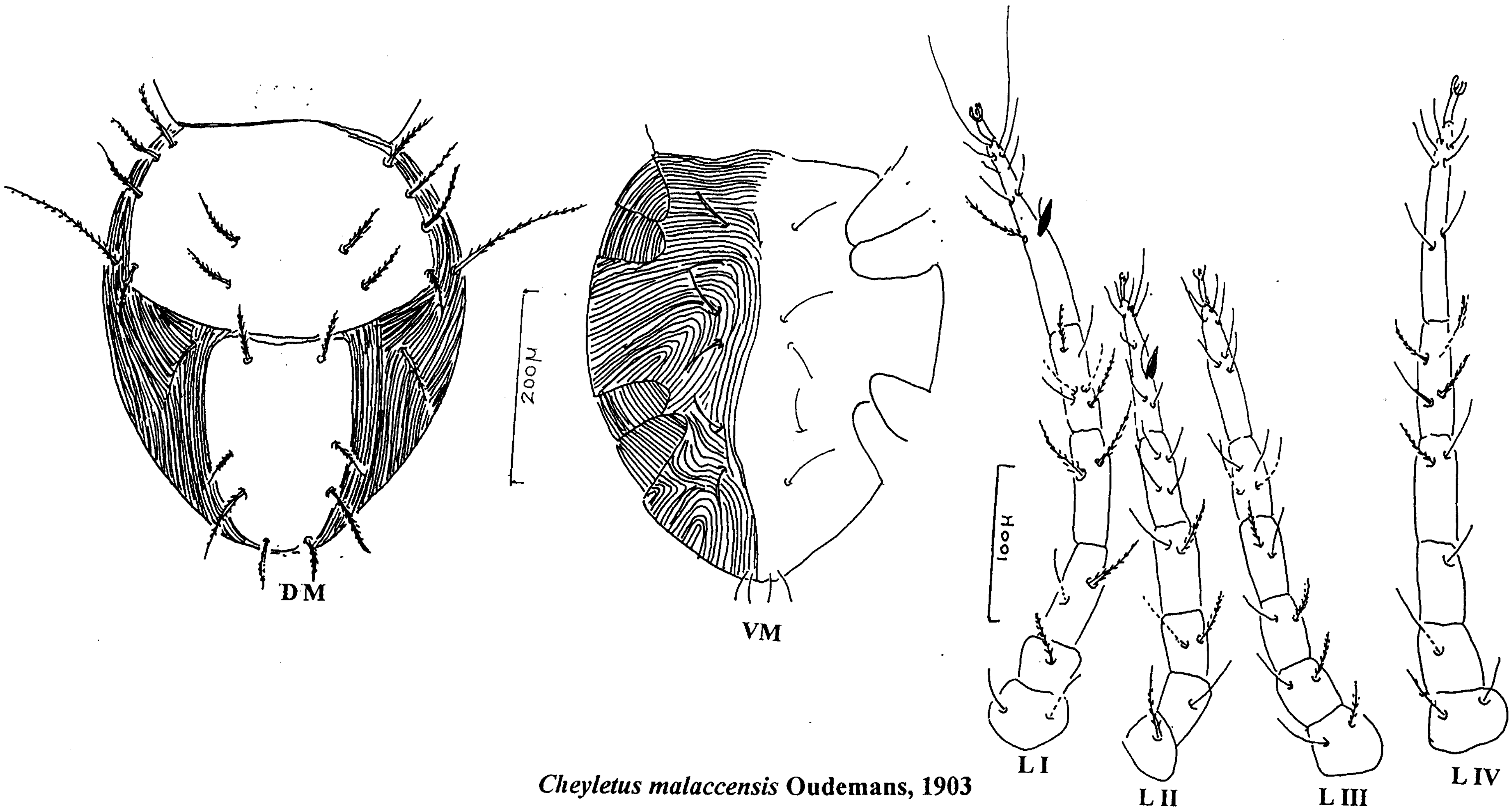
PLATE 48 A



DORSAL VIEW (MALE) **VENTRAL VIEW (MALE)**

Cheyletus malaccensis **Oudemans, 1903**

PLATE 48 B



Cheyletus malaccensis Oudemans, 1903

Cheyletus rosensis sp. nov.

PLATE 49A and 49B

Female: Idiosoma 350 long and 300 wide, gnathosoma 100 long, large with massive palpi. Rostrum with superior (10) and inferior (15) adoral setae. Protegmen smooth and tegmen with longitudinal striations and granulations. Palp femora slightly convex on outer surface, almost equal in length and width; striated and granular both on ventral and dorsal sides; setae spatulate two in number placed dorsally, one simple seta placed ventrally. Palp genu without any seta, palp tibia with one serrate, thick seta placed dorsally and one smooth seta placed ventrally; palp claw curved slightly with 7 small basal processes. Palp tarsus with two comb like and two sickle shaped setae, the outer pecten longer than the claw with 12 processes and the inner pecten with 23 processes. Peritreme M-shaped with 20 links. Dorsum without any clear shields. Propodosomal region wider (300) than long (150) with three pairs of dorsal setae, 3 pairs of subdorsal setae and a pair of lateral seta. Hysterosomal region (200) long and (250) wide with 6 pairs of dorsal setae; all dorsal setae spatulate with ribs and spines. Dorsum finely striated as shown in figure. Ventral region smooth with short simple setae; two pairs of setae in the propodosomal region, 4 pairs in the hysterosomal region, genital setae 2 pairs and anal setae 3 pairs.

Legs I-IV: 250, 175, 200 and 230, long respectively. Leg I/idiosoma = 1.4. Leg chaetotaxy: Coxae: 2-1-0-2; trochanter: 0-1-2-1; femora: 2-2-1-1; genua: 2-2-2-1; tibiae: 3-4-4-4; tarsi: 4(1) - 5(1) - 4(1) - 4(1). Tarsus I with two long adoral setae tc, and ends in a pair of small claws. The solenidion w_1 on tarsus I, short and curved without guard seta. Tarsi of legs II to IV end in well developed claws, empodium rayed.

Male: Unknown.

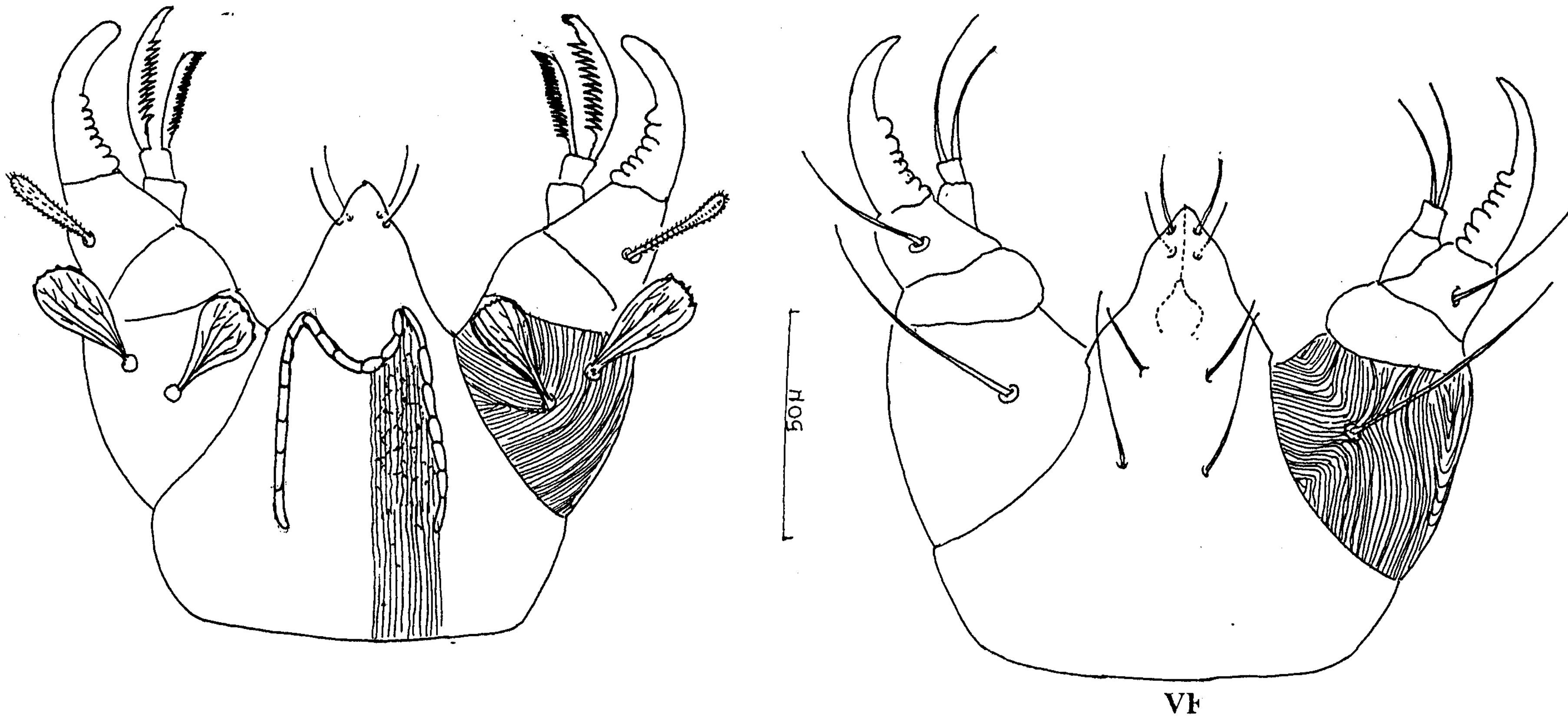
Habitat: *Rosa indica, Cocos nucifera.*

Material examined: Holotype ♀marked on the slide, INDIA: KERALA: Agricultural Research Station, Ambalavayal (Wayanad district), 24.vi.2001, ex.*Rosa indica*, coll. Mary Anitha (No. AC 35/1). One paratype slide with 3 ♀♀ from the same habitat and collection details (No. AC 35/2). 3 ♀♀, Coconut Nursery, Thikkodi (Kozhikode district), 30.iii.2001, ex. *Cocos nucifera*, coll. Mary Anitha (No. AC 2/3).

Remarks: This new species resembles *Cheyletus malaccensis* Oudemans (1903) and *C. polymorphus* Volgin (1989) but can be differentiated by the following characters:

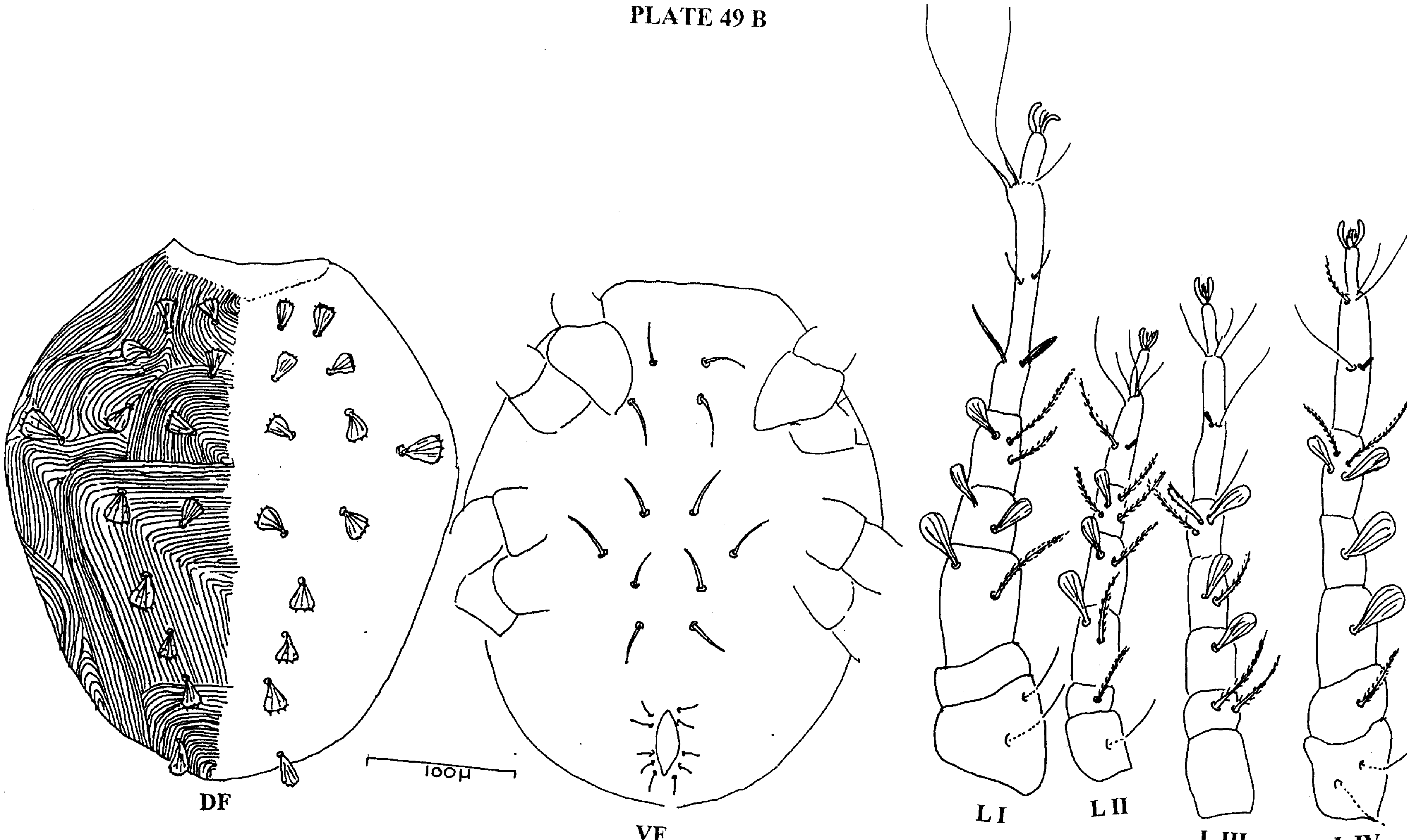
1. Absence of a short guard setae near w_1.
2. Presence of 12 short processes on the outer pecten of the palp tarsus.

PLATE 49 A



Cheyletus rosensis sp. nov.

PLATE 49 B



Cheyletus rosensis sp. nov.

PLATE 50

Figs. 1-5. *Cheyletus* species

Fig. 1. Dorsal view of *C. rosensis* sp. nov.

2. Gnathosomal palp of *C. arecae* sp. nov.

3. Gnathosoma of *C. rosensis* sp. nov.

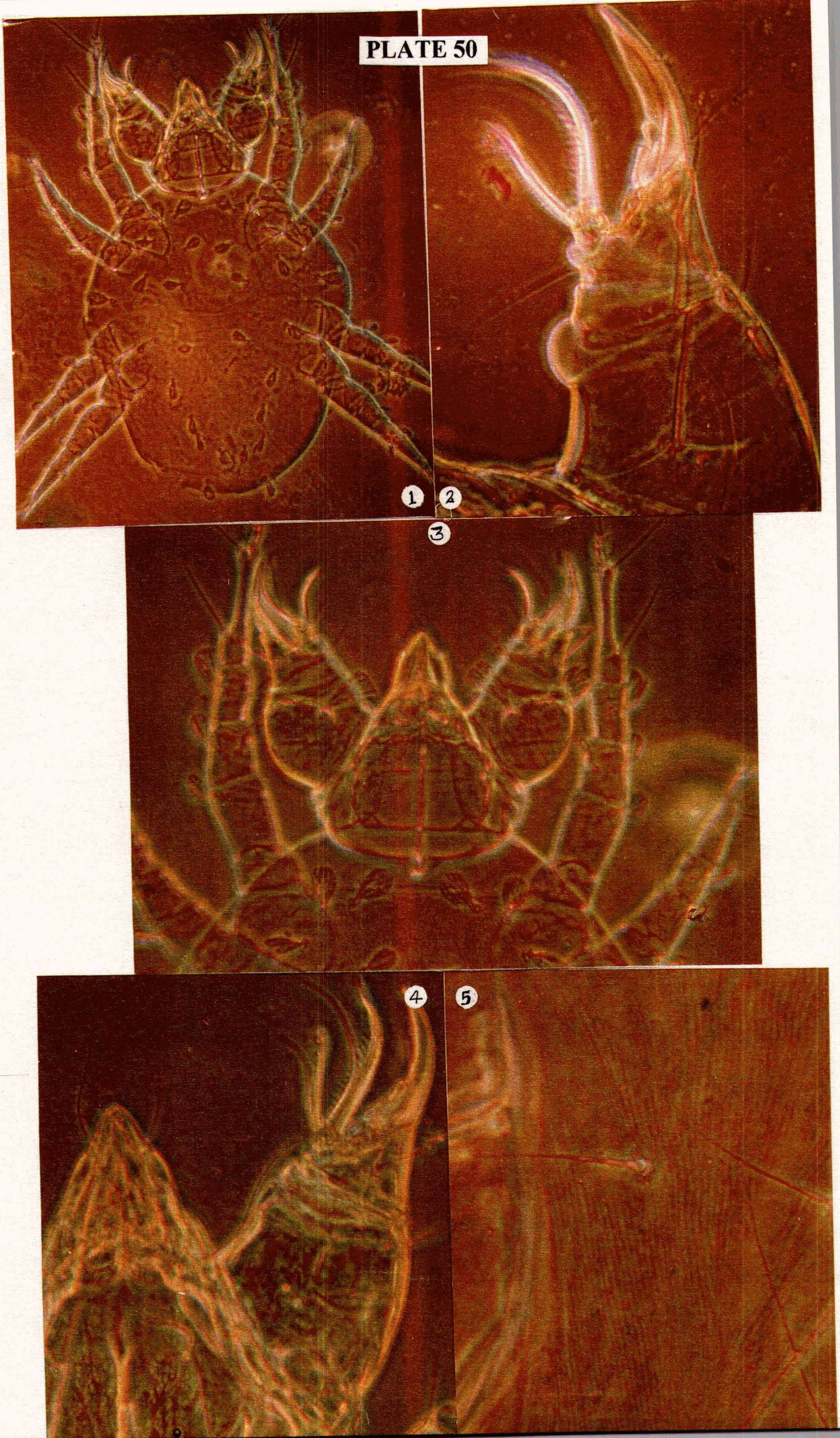
4. Gnathosomal palp of *C. ichthyus* sp. nov.

5. Dorsal body setae of *C. malaccensis*

ηι

155D

PLATE 50



75

3. Presence of spatulate dorsal setae with ribs and spines.

This new species was seen in association with white fly populations.

Superfamily BDELLOIDEA

5.3. Family CUNAXIDE Thor, 1902

Diagnosis: Soft or strongly sclerotised body with or without dorsal or ventral shields (Plate 51). Chelicerae separated and winged at base, moving laterally or scissors like over cone like gnathosoma, fixed digit vestigeal, movable digit sickle shaped. Ventral hypostome with 4-6 pairs of setae. Female genetalia without internal setae or spines (except *Parabonzia*), genital aperture with 2 or 3 pairs of acetabula. Palpal segments terminating (except *Parabonzia*) with claws; palpal solenidion when present, non setiform with strong spines and apophyses. Tarsal empodium claw like with 4 raylets; claw lack ventrolateral hairs.

The morphology (Plate 51) and terminology used herein is that of Smiley (1975), and ventral hypostomal signatures are adapted from Den Heyer (1978 b).

Setal terminology:

$D_1 - D_5$: Dorsal setae

L_1 : Lateral setae

$P_1 - P_2$: Simple propodosomal setae

ad : Adoral setae

hg : Hypostomal setae

Key to Subfamilies of CUNAXIDAE

1. Palpal tibiotarsus with an apical solenidion; ventral hypostome usually with geniculate setae (hg_1) 2

– Palpal tibiotarsus with out a solenidion; ventral hypostome never with geniculate setae 3

2. Cheliceral seta present; palpal tolofemur with spine like multibranched or forked seta .... **Bonziinae**

– Cheliceral seta absent; palpal telofemur without multibranched seta; usually spinelike seta .... **Orangescirulinae**

3. Palpus with fewer than 5 segments 4

– Palpus with 5 segments 7

4. Palpus with 4 segments .... **Scirulinae**

– Palpus with 3 segments 5

5. Setae L_4 and L_5 present, base of ventral gnathosoma with median curvature .... **Denheyernaxoidinae**

– Setae L_4 and L_5 absent, base of ventral gnathosoma without median curvature 6

6. Setae hg_1 slender and simple .... **Cunaxoidinae**

– Setae hg_1 stout and blade like .... **Paracunaxoidinae**

7. Tarsal lobes or flanges present on Leg 1-IV; setae L_4 absent ... **Cunaxiinae**

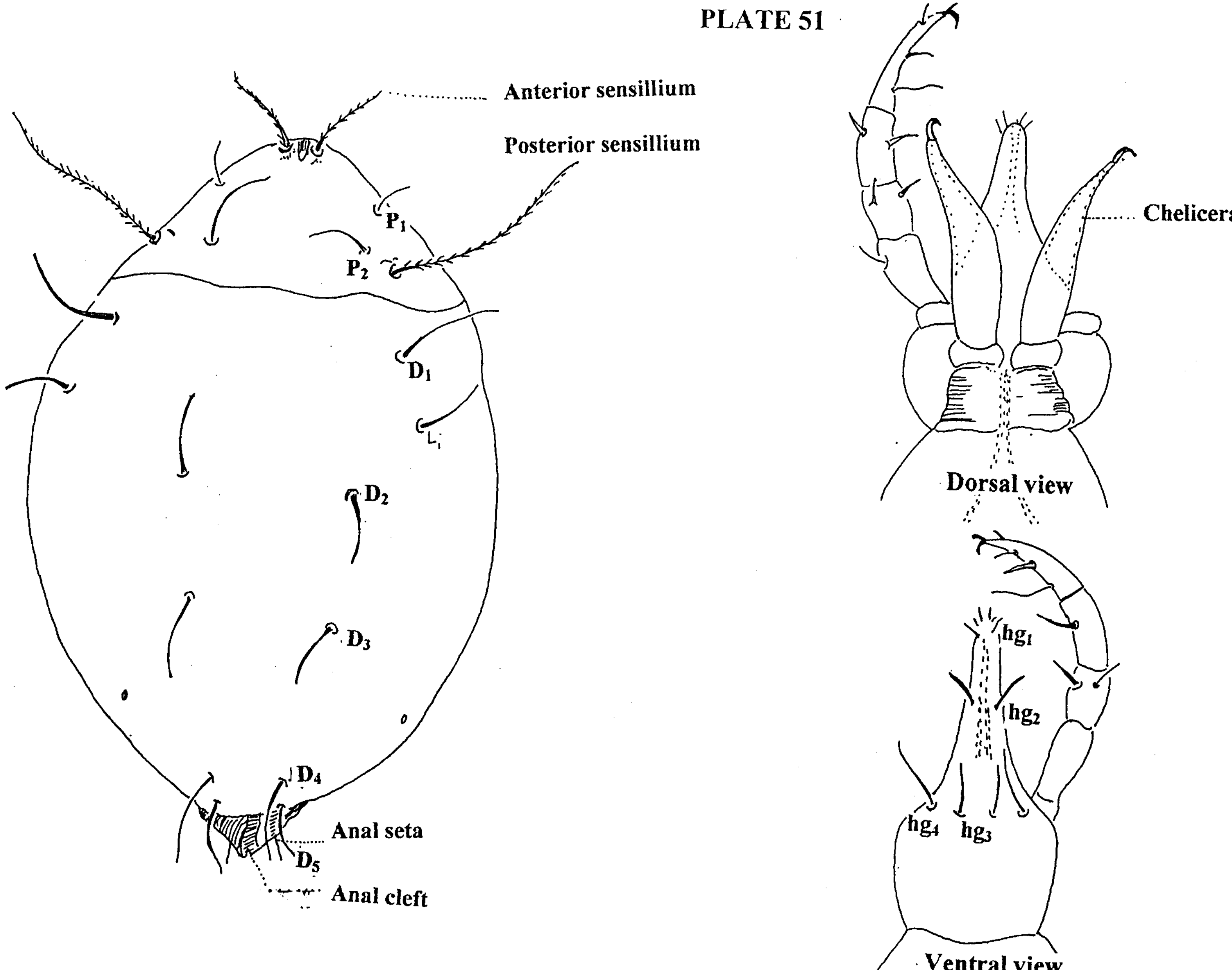
– Tarsal lobes or flanges absent on Leg 1-IV; setae L_4 present ... **Neobonzinae**

Subfamily CUNAXIINAE Oudemans, 1902

1902. Cunaxiinae : Oudemans, 58.

Diagnosis: Palp 5 segmented. Terminal segment (tibiotarsus) inner, median surface with a simple seta, or a rod like seta. Palpal telofemur with or without elongate apophysis; distal apex of tibiotarsus terminating with a small claw and simple seta. Chelicera extremely broad posteriorly and attenuate anteriorly. Dorsum of propodosoma with or without shield. Hysterosoma with or without shields, when present never more than three. Tarsi 1-IV either short and stubby or long and slender and tapering distally, with or without conspicuous lateral flange like apices. Tibia IV with a smooth trichobothridium.

PLATE 51



Morphological and Taxonomical characters of the family Cunaxidae

Key to genera of Cunaxiinae

1. Palpal genu apically without elongate apophysis, tarsi 1-IV long slender and attenuate, without conspicuous lateral, bilobed flanges terminally ... ***Cunaxa***

- Palpal genu apically with or without an elongate apophysis, tarsi 1-IV stout, short or long and terminating in conspicuous, lateral, bilobed flanges 2

2. Tarsi 1-IV short, stubby and stout, terminating in large, conspicuous, lateral, bilobed flanges, with one sensory setae having a stout, elongate base .... ***Dactyloscirus***

- Tarsi I-IV long, slender and attenuate, terminating in small but conspicuous, lateral, bilobed flanges, sensory setae without stout, elongate base .... ***Armascirus***

Genus *Cunaxa* Von Heydon, 1826

1826. *Cunaxa* : Von Heyden, In: *Isis of Oken*, **18**(6): 608-613.

1960. *Cunaxa* : Muma, *Ann. Entomol. Soc. Amer.*, **53**(3): 321-326.

1980. *Cunaxa* : Gupta and Ghosh, *Rec. Zool. Surv. India*, **77**: 189-213.

1984. *Cunaxa* : Sepagosarian, *Zeit. Ang. Zool.* **71**: 135-150.

Diagnosis: Body strongly sclerotized and may be covered with two dorsal shields. Propodosomal shield may be smooth, reticulate or striated. Striae may be with or without lobes; propodosoma and hysterosoma may be with or without a shield. Shield when present may be smooth or reticulate. The palpi are 5 segmented and may bear stout spine like setae and elongate apophysis. Tarsi 1-IV long, slender and attenuate and are without large conspicuous lateral bilobed flanges.

Type species: ***Scirus setirostris*** Hermann, 1804.

Cunaxa bambusae **Gupta and Ghosh, 1980**

PLATE 52

1980. *Cunaxa bambusae* Gupta and Ghosh, *Rec. Zool. Surv. India,* 77: 198 – 199.

Female: Length excluding gnathosoma 408 long and 285 wide. Hypostome subrectangular, cone shaped distally. Hysterosoma separated from propodosoma by striae without dot like lobes. Propodosoma without any shield, with 2 finely branched sensillae (anterior 200 and posterior 240) and 2 propodosomal simple setae, P_1 (18) and P_2 (26). Hysterosoma without any shield, with setae L_1, $D_1 - D_5$. $D_1 - D_3$, 15 long; D_4 and D_5, 28 long and L_1 – 14.

Gnathosomal palp 5 segmented, 142 long. Chaetotaxy of palp as follows; trochanter none; basifemur with one dorsomedial simple seta; telofemur with one outer lateral and one anteriomiddorsal seta; genu with two inner lateral, one outer lateral and one anteromiddorsal setae; tibiotarsus with one strong spine on inner lateral surface, anterior to it one small seta and two setae on outer lateral surface, anterior one longer and stronger. Chelicera broad at base, gradually tapering anteriorly, movable digit sharp. Five pairs of setae present ventrally between coxae II and caudal tip of body (excluding those on genital and anal region). Four pairs of seate on genital plate (Subequal simple setae). Leg 1-IV: 360, 348, 352 and 425 long respectively. Tarsi of all legs taper gradually from base to the distal end. Coxae I, II and III,IV contiguous.

Leg chaetotaxy: Coxae: 3-1-3-2; trochanter: 1-1-2-1; basifemora: 5-5-4-2; telofemora: 4-4-4-4; genu I: 4 attenuate solenidia plus 5; genue II: 2 attenuate solenidia plus 5; genu III and IV: 1 attenuate solenidia plus 5; tibia II – IV: 1 attenuate solenidia plus 5, Tibia IV with a long smooth trichobothrium; tarsus I: 5 attenuate solenidion plus 20; tarsi II-IV: 16-12-17. Each tarsus terminates in two claws and forked empodium.

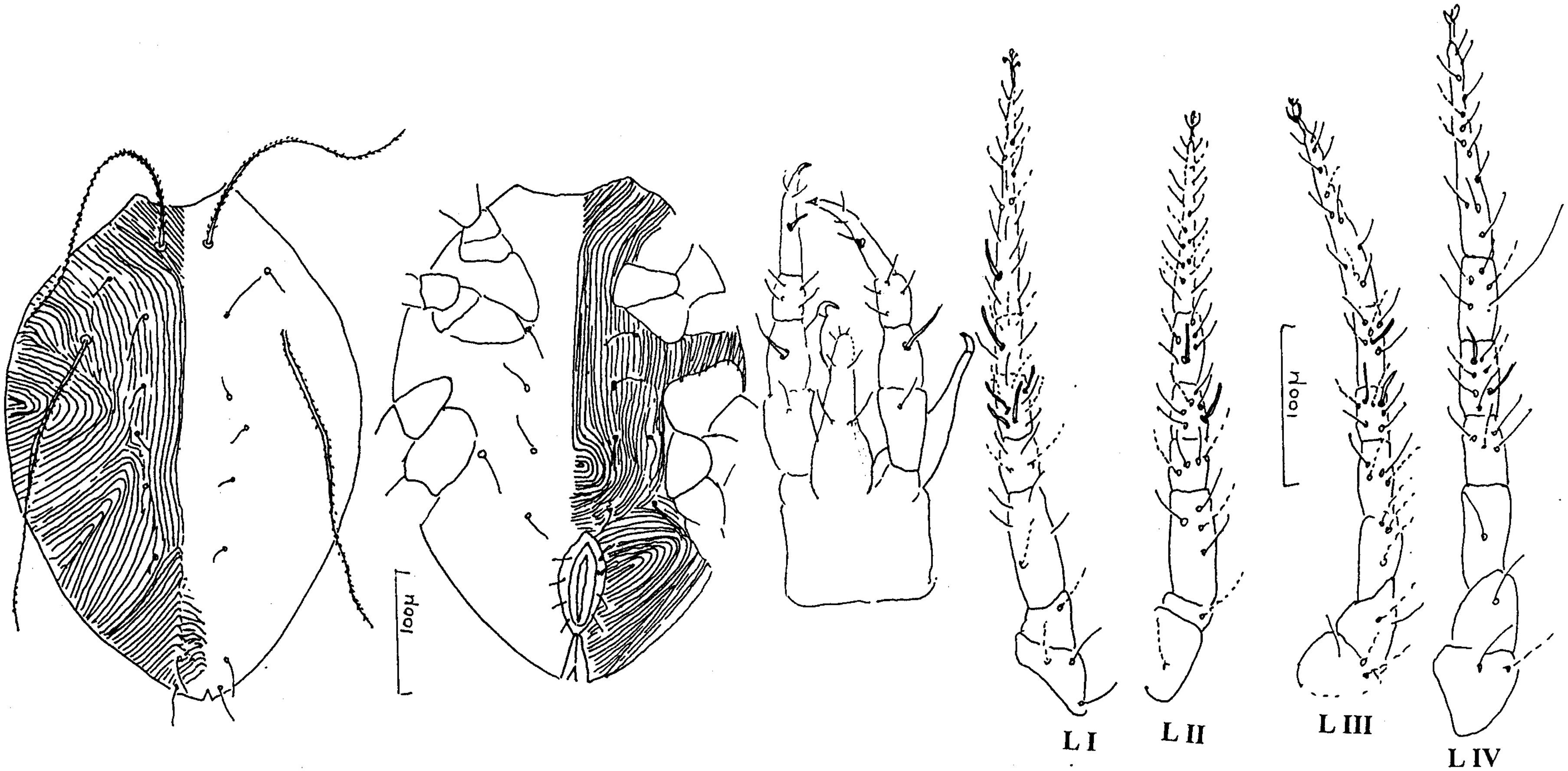
Male: Unknown.

Habitat: *Anacardium occidentale.*

Known habitat: *Bambusa arundinaceae.*

Material examined: Female marked on the slide along with other 3♀♀, INDIA: KERALA: Ottappalam (Palakkad district), 18-iv-2000, ex. *Anacardium*

PLATE 52



Cunaxa bambusae Gupta and Ghosh, 1980

occidentale, coll. Mary Anitha (No. A 8/2). Several ♀♀ from different districts surveyed.

Distribution: INDIA: Kerala, Andaman Island.

***Remarks*:** The specimen examined agrees with *C. bambusae* Gupta and Ghosh in almost all characters and hence fixed so.

Cunaxa setirostris (Hermann), 1804

PLATE 53

1804. *Scirus setirostris* Hermann, *Mem. Apteologique*, p. 60-62.

1980. *Cunaxa setirostris* (Hermann), *Rec. Zool. Surv. India*, **77:** 194-195.

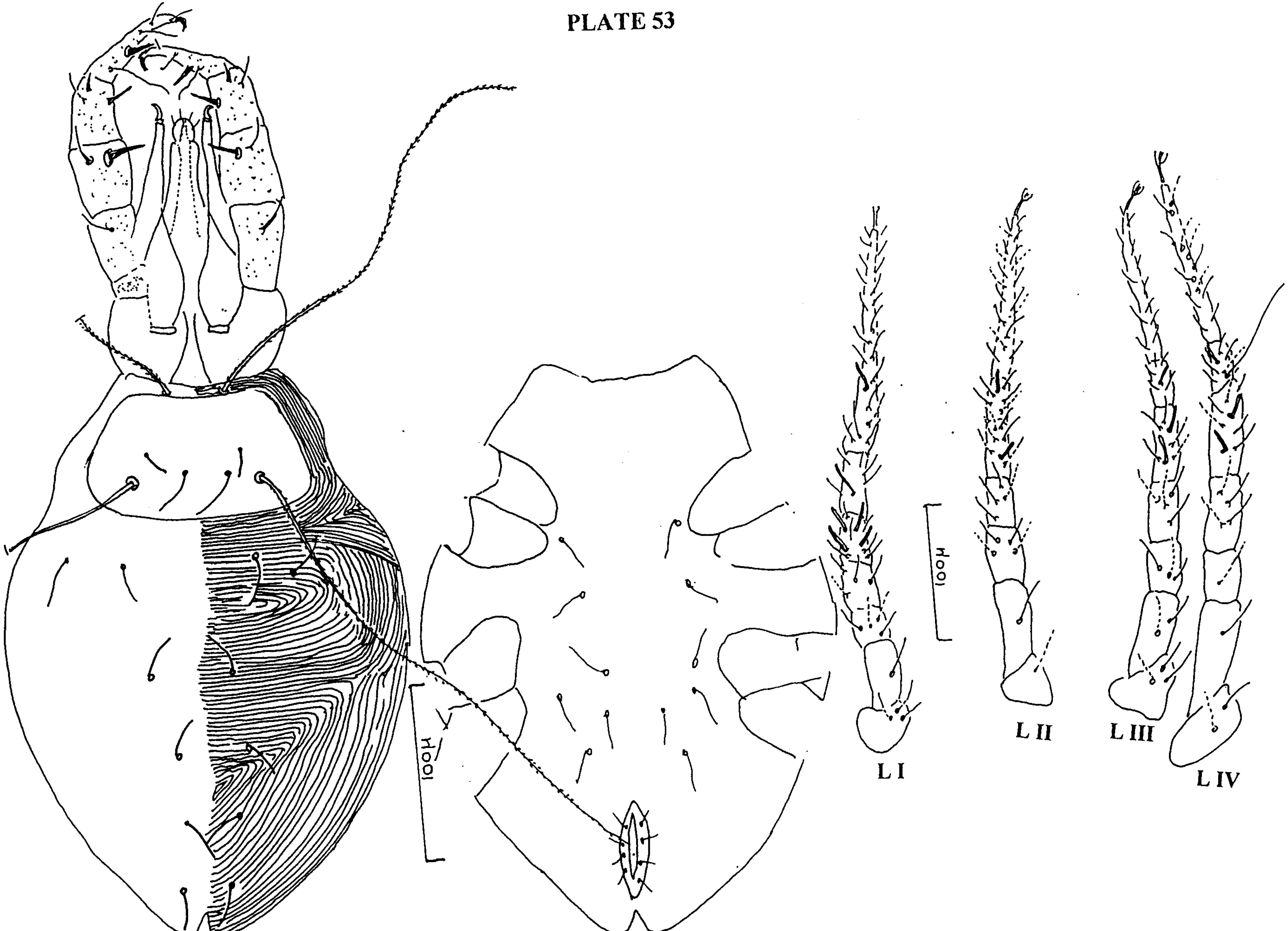
Female: Body 560 long and 312 wide. Hypostome subrectangular, cone shaped distally with 2 pairs of adoral setae and 4 pairs of hypostomal seate. Propodosoma with a smooth subrectangular shield originating behind the base of gnathosoma, extending to anterior region of hysterosoma. Shield with anterior (240) and posterior (300) sensillae and propodosomal setae P_1 (10) and P_2 (20). Hysterosomal shield separated from propodosoma by narrow transverse striae; shield smooth, subrectangular and complemented with setae L_1, D_1, D_2 and D_3. Setae D_4 and D_5 arise below the hysterosomal shield; dorsals D_1 – D_3 and lateral setae equal in length (20). Gnathosomal palpi 5 segmented, 150 long. Chaetotaxy of palp as follows: trochanter none; basifemur with one dorsomedian simple seta; tolofemur with one elongated apophysis and dorsomedial simple seta. Genu inner surface with a short spine like seta, outer surface dorsally and ventrally with simple seta; inner surface of the tibiotarsus with a long simple seta, medially with one stout spine like seta, another short simple seta arising adjacent, to the spine, outer surface with one dorsolateral simple seta, terminating with one simple seta and small claw. Idiosomal striations smooth. Venter with 6 pairs of setae between coxae II and genital region. Genitoanal region in the form of long slit with 4 pairs of anal setae. Legs 1-IV; 400, 380, 394 and 480 long respectively. Tarsi of all legs taper gradually from base to the distal end. Coxae I, II and III, IV contiguous, connected by apodemes.

Leg chaetotaxy: Coxae: 3-1-3-2; trochanter: 1-1-2-1; basifemora: 4-4-3-1; telofemora: 4-4-4-4; genu I: 4 attenuate solenidia plus 6; genu II: 1 attenuate solenidion plus 5; genu III and IV: 2 attenuate solenidia plus 5; tibia 1: one attenuate solenidion plus 5; tibia II-IV: 1 attenuate solenidia plus 5; tibia IV: 1 smooth trichobothrium plus 4; tarsus 1: 1 attenuate solenidion plus 20; tarsus II-IV: 18-12-12. Tibia IV with a long smooth trichobothrium. Each tarsus terminates in two claws and forked empodium.

Male: Not studied.

Habitat: *Vathria indica.*

PLATE 53



DF *Cunaxa setirostris* (Hermann) 1805 VF

Known habitat: Grass, Oak, Willow twig, soil, rice straw, *Punica* sp, *Lavandulus* sp., *Bulb* sp.

Material examined: Female marked on the slide along with other 2♀♀, INDIA: KERALA: Ayurvedic Herbal Garden of Kottakkal Arya Vaidya Sala, Kottakkal (Malappuram district), 20-i-2001, ex. *Vathria indica,* coll. Mary Anitha (No. A 44/2). six ♀♀, collection details same (No. A 44/3. 44/4).

Distribution: Cosmopoliton.

Remarks: The specimen examined agrees with *C. setirostris* (Hermann) in almost all characters and hence fixed so.

Genus *Dactyloscirus* Berlese, 1916

1916. *Scirus (Dactyloscirus)* Berlese, *Redia,* **12**(1): 127-177.

1941. *Dactyloscirus* : Thor and Willmann, *Das. Tierreich,* **71a**: 1-186.

1975. *Dactyloscirus*: Smiley, *Ann. Entomol. Soc. Amer.* **68**(2): 227-244.

1982. *Dactyloscirus*: Michocka, *Acarologia,* **23**: 327-332.

1987. *Dactyloscirus*: Liang, *Zootaxonomia,* 7: 79-81.

Diagnosis: Dorsal shield of propodosoma ornamented with reticulate patterns of minute granular striae. Hysterosoma without shields. Tarsal segments usually terminating with two strong lateral bilobed flanges. Palp five segemented, extending beyond apex of hypostome, with strong lateral elongated or spine like apophyses on segment II and III, and sometimes on IV. Leg 1-IV robust and not tapering to a point distally.

Type species : *Scirus (Dactyloscirus) eupaloides* Berlese.

Dactyloscirus bakeri Lindquist, 1970

PLATE 54

Female: Body including gnathosoma 890 long and 385 wide. Hypostome subrectangular, semi-cone shaped distally. Propodosoma with a reticulated subrectangular shield originating behind the base of gnathosoma, extending to anterior region of hysterosoma. Shield with anterior (380) and posterior (500) sensillae, both setose. Propodosomal setae, P_1 and P_2 equal in length. Hysterosoma separated from propodosoma by small striae bearing elongated lobes. Hysterosoma with a subrectangular reticulated shield. Setae L_1, D_1 and D_2 equal in length (20). Setae D_4 and D_5 about one fourth longer than setae L_1, D_1, D_2 and D_3. Genital plate with 4 pairs of subequal simple setae. Gnathosomal palpi 5 segmented 240 in length. Chaetotaxy of palp as follows: Trochanter none, basifemur with one slender dorsal simple seta; telofemur inner surface with elongated bulbous apophysis, apically with two dorosomedial spine like setae; genu inner surface proximally with one spine with elongate subrectangular apopohysis apically with dorsolateral simple seta; outer surface with ventral dorsolateral simple seta; tibiotarsus inner surface medially with long simple seta, above this seta, one short spine like seta, outer surface with dorsolateral simple seta, terminating with simple seta and small claw. Idiosomal striations extremely small. Coxae 1-11 contiguous, connected by small lateral apodemes; coxae III-IV contiguous, broader than coxe 1-11. Legs IV longer than others; tarsi 1-IV tapering.

Leg chaetotaxy: Coxae: 3-2-3-2; trochanter: 1-1-2-1; basifemora: 5-5-3-1, telofemora: 4-4-4-4-; genu I: 4 attenuate solenidia plus 4; genu II: 1 attenuate solenidia plus 5, genu III: 1 attenuate solenidia plus 5 and genu IV: 2 attenuate solenidia plus 5; tibia 1: 2 plus 4; tibia II: 2 plus 5; tibia III: 2 plus 4; tibia IV: 2 plus 4. Tarsus 1: 4 plus 5; tarsus II: 1 plus 6; tarsus III: 12; tarsus IV: 15.

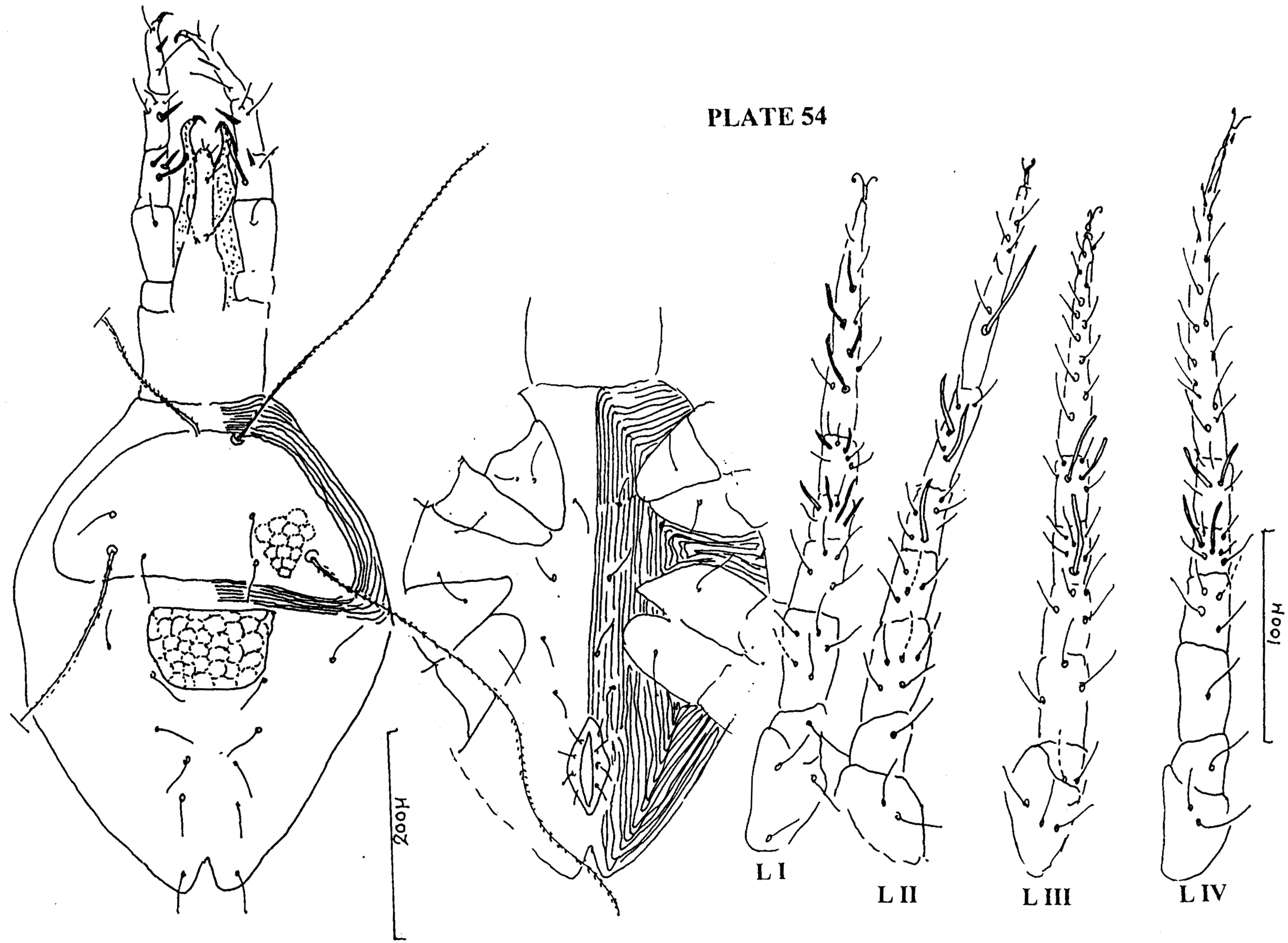
Male : Unknown

***Habitat*:** *Cocos nucifera.*

Material examined: Female marked on the slide along with other 2♀♀, INDIA: KERALA Coconut Nursery, Thikkodi (kozhikode district), 12.ii.2000, ex. *Cocos nucifera,* Coll. Mary Anitha (No. A 4/3); Four ♀♀, collection details same as above (No A 4/2. 4/1. 4/5).

Remarks : The species examined resembles *D. bakeri* in almost all characters, hence fixed so.

PLATE 54



Dactyloscirus bakeri Lindquist, 1970

PLATE 55

Figs. 1-4. Cunaxidae

Fig. 1. Dorsal view of *D. bakeri*

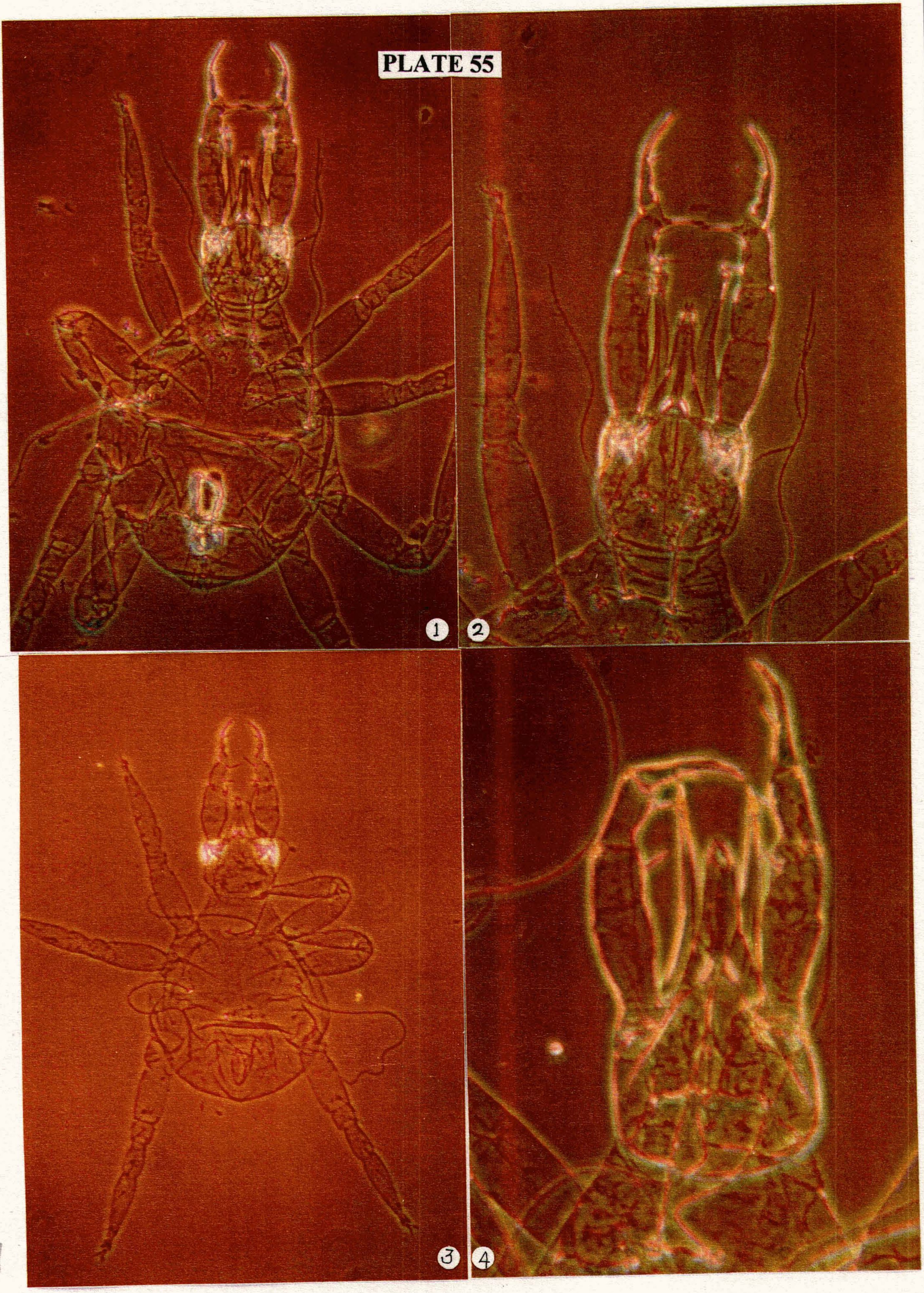
2. Gnathosoma of *D. bakeri*

3. Dorsal view of *C. setirostris*

4. Gnathosoma of *C. bambusae*

166c

PLATE 55



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5.4. Family BDELLIDAE Duges, 1834

1834. Bdellidae : Duges, *Ann. Sci. Nat. Seri. 2*, **2**: 104-106.

1938. Bdellidae : Grandjean, *Ann. Soc. Entomol. France*, **107**, 1-24.

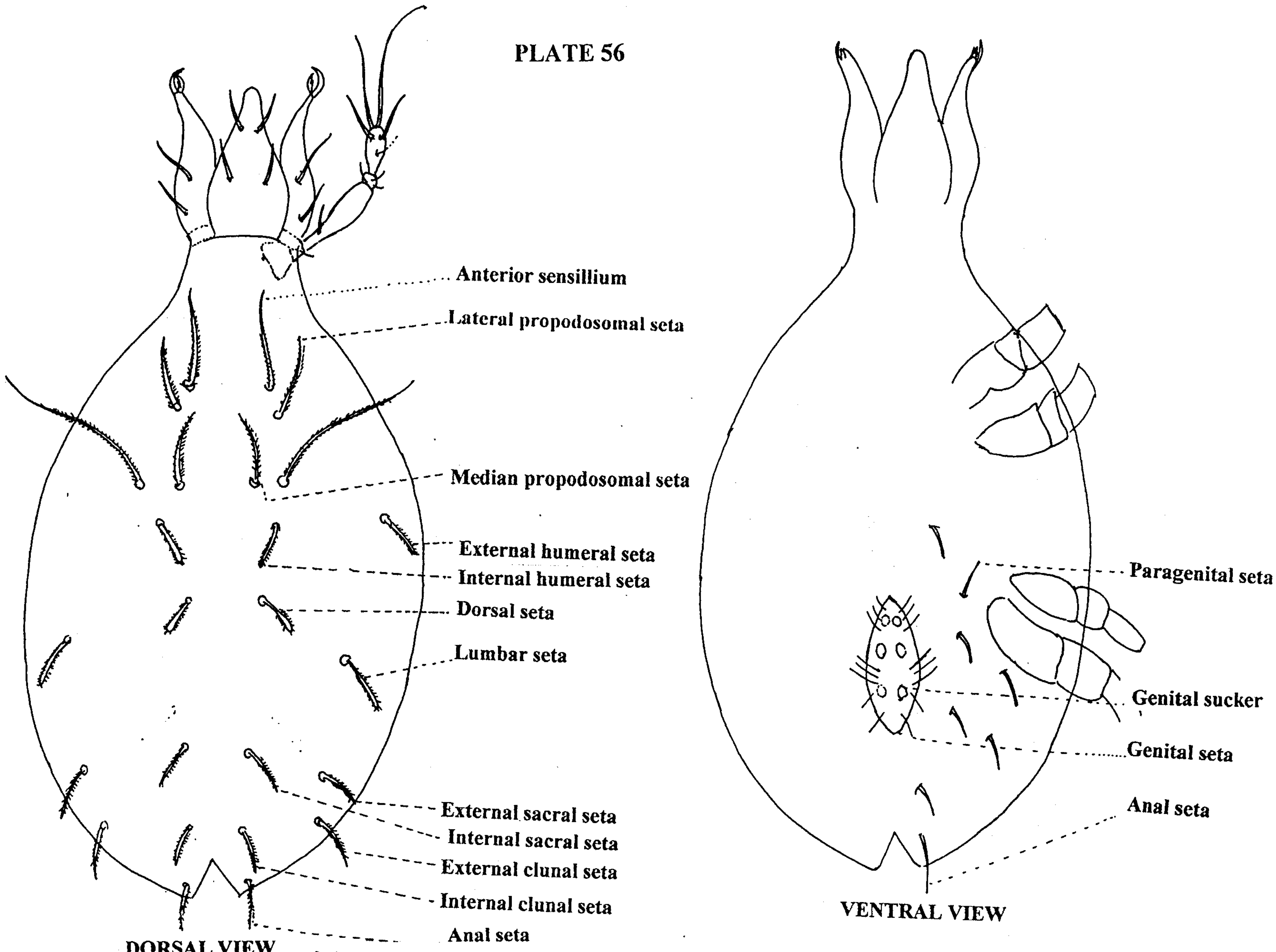
1960. Bdellidae : Atyeo, *Univ. Kansas Sci. Bull.*, **40**(8): 345-499.

Diagnosis: Medium to large sized mites, commonly known as 'snout mites'. Integument thin, striated subcutaneous shields often present on propodosoma. Gnathosoma formed by elongate chelicera and a ventral hypostome. Chelicera chelate, elongate with one or more dorsal setae. Hypostome with 2, 6 or 7 pairs of ventrolateral setae, 2 pairs of minute setae on lateral lips. Palp 5 segmented, trochanter and genu short, femur divided into short basifemur and long telofemur, tibiotarsus with various lengths having apically 2 long setae. Tracheal openings near cheliceral bases. Idiosoma divided dorsally into propodosoma and hysterosoma. Four dorsal sensilla inserted in pseudostigmatic organs. Eyes 2 or 4. Legs 8 segmented (including short pretasus); maximum of 5 pairs of trichoboths. Genital tracheae well developed. Genital suckers, 3 pairs, anal cleft terminal.

Morphology and Terminology

Gnathosoma: Consists of pedipalp and chelicera. Chelicera (Plate 56) elongated with 1 or 2 dorsal setae. Pedipalp 5 segmented, genu and tibia bent giving the palpi an elbowed appearance. Palp tarsus terminates into 2 long whip like setae.

PLATE 56



Morphological and Taxonomical characters of the family Bdellidae

Idiosoma (Plate 56): Distinguished into propodosoma and hystersoma. Body striated. Propodosoma with 2 pairs of sensory setae, hysterosoma with 9 pairs of setae.

Leg: Tarsi, tibia and genu have tactile, long sensory setae in deep sockets (trichoboths) or hollow chemosensory setae (solenidia). Genu I-IV with decreasing number of attenuate sensory setae.

Setal terminology: Terminology used in the descriptions follows Atyeo (1960) and Wallace and Mahon (1972, 1976).

Bdella kottakkalensis sp. nov.

PLATE 57A and 57B

Female: Body oval, 635 long including gnathosoma, 329 wide. Gnathosoma striated, setae Vh_1 - Vh_6 present. Vh_4 located marginally. The measurement of hypostomal setae Vh_1 - 30, Vh_2 - Vh_6 = 22-24. Chelicera normal, striated longitudinally, 106 long, smooth chela, fixed digit slightly smaller than movable digit, setae two pairs, palp with tibio - tarsus extending beyond hypostome. Palpal segment measuring I - 20, II - 10, III - 45, IV - 10, V - 25 in length, basifemur with 8 setae, telofemur with 2 setae, genu - 5, tibiotarsus 6 including ves and des measuring 80, 100 respectively. Dorsal propodosoma with broken wavy striations. Lateral and median propodosomal setae present. Eyes one pair on each side. Two pairs of sensilla present, anterior - 100 long, posterior - 122 long, anterior sensilla 68 apart, posterior sensilla - 90 apart. Propodosoma with 4 pairs of setae. Dorsal hysterosoma striated as in the figure, with 7 pairs of setae including anal setae. All setae simple. Genital shield with three pairs of suckers, 5 pairs kof genital and 6 pairs of paragenital setae. Anal region with almost semicircular parallel striations. Leg I - IV measuring 260, 258, 300, 325 respectively.

Leg chaetotaxy: Coxae : 5, 4, 4, 3; trochanter: 1-1-2-1; basifemur : 6, 6, 6, 4; Telofemur: 6-5-5-5; genu: 7-5-5-6; tibia : 7 - 7 - 6 – 6; tibia II with a solenidian tarsi: 25-16-20-20.. All tibial setae tactile, tibia I, IV and tarsi III, IV each with a trichoboth.

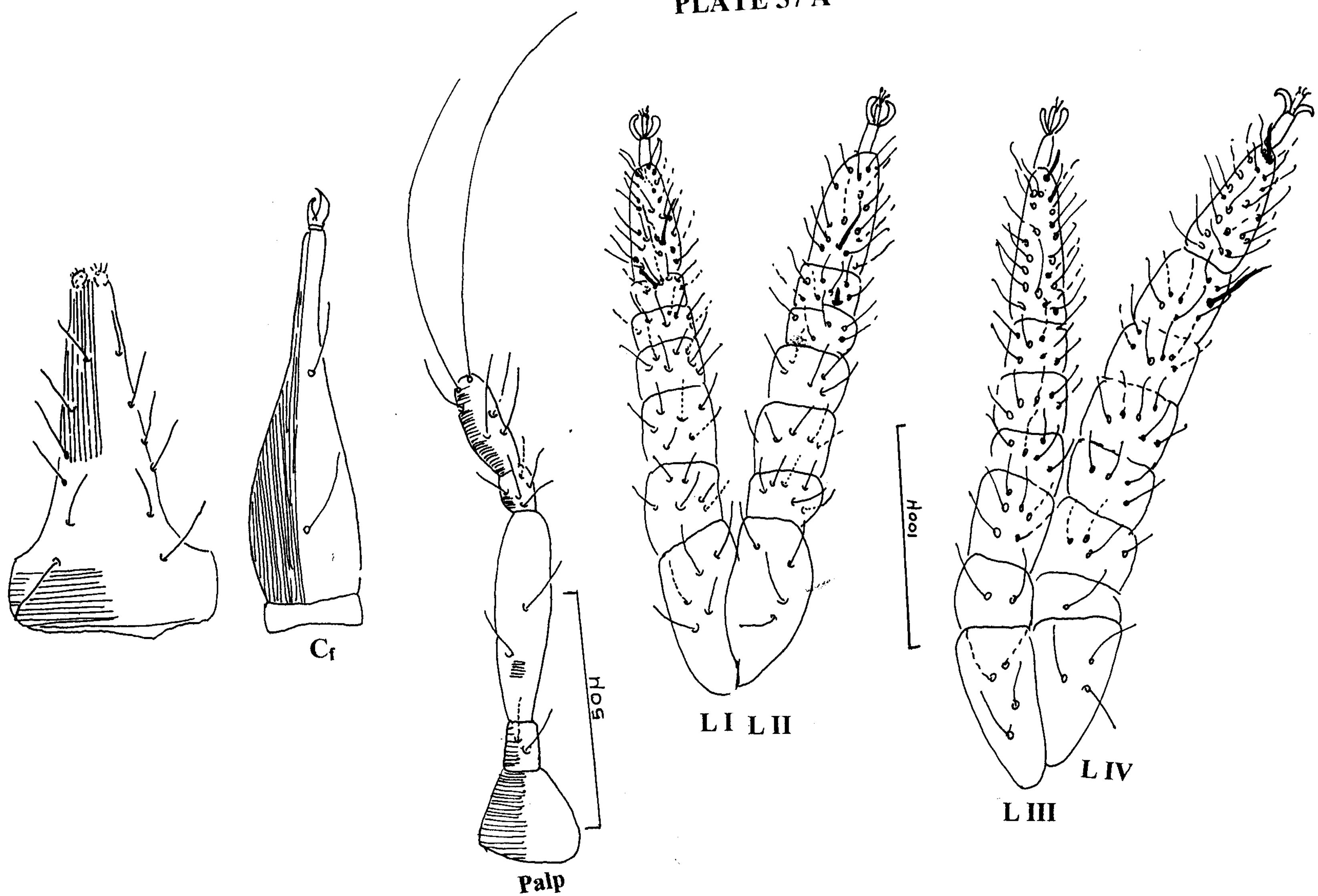
Male: Unknown.

Habitat: *Cinnamomum zeylandicum*.

Material examined: Holotype ♀, marked on the slide along with other 2 ♀♀. INDIA: KERALA: Ayurvedic Herbal Garden of Kottakkal Arya Vaidya Sala, Kottakkal (Malappuram district), 17.iv.2001, ex. *Cinnamomum zeylandicum*, coll. Mary Anitha (No.AB 32/2). Two paratype slides with 3 ♀♀, collection data same as type (No. AB 32/3 and AB 32/4).

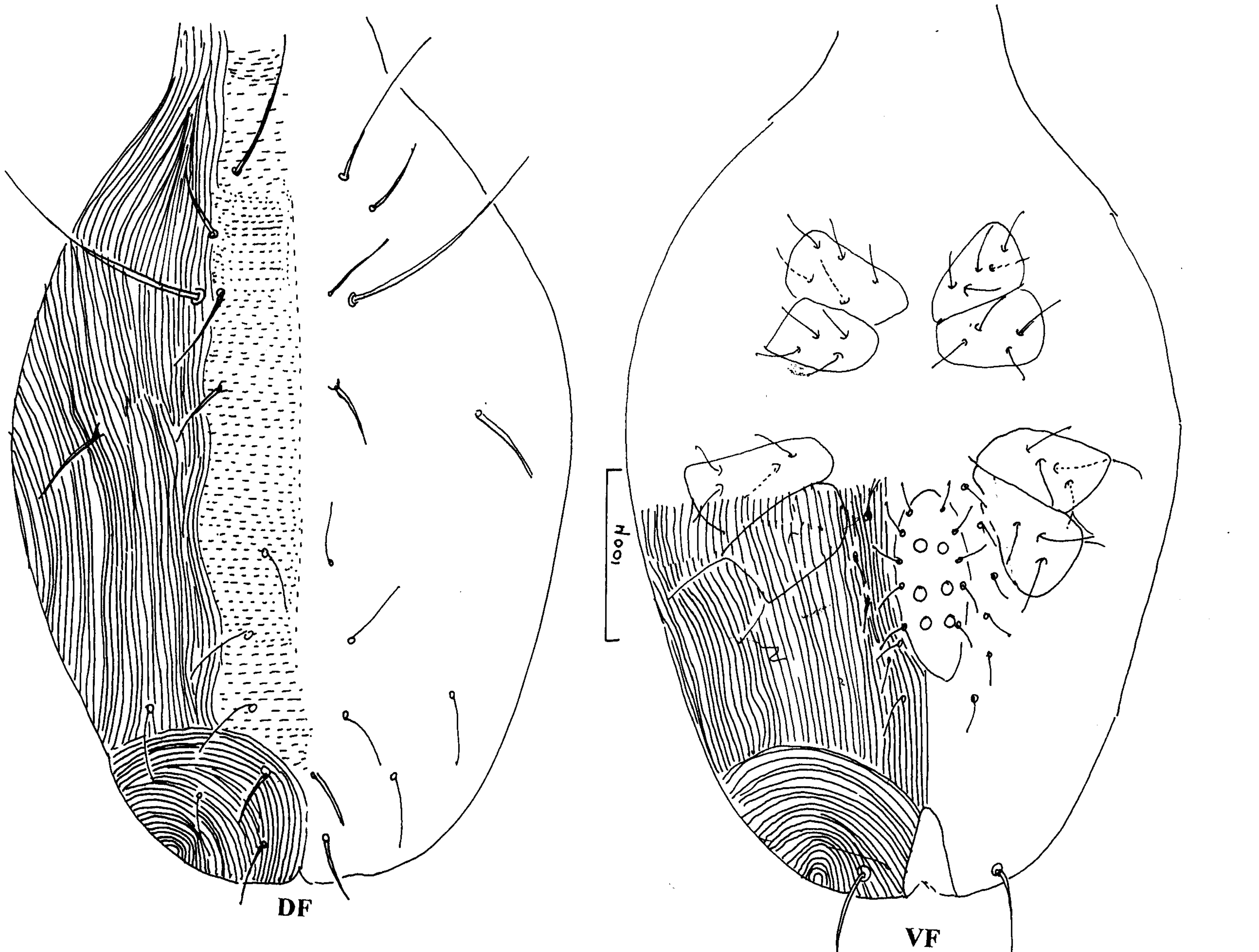
Remarks: This new species resembles *B. muscorum* Ewing (1909) in dorsum and gnathosomal characters, but distinguished by the following characters.

PLATE 57 A



***Bdella kottakkalensis* sp. nov.**

PLATE 57 B



Bdella kottakkalensis sp. nov.

1. Small size of the body.
2. Setae on the dorsum shorter in length.
3. Length of palp and chelicera shorter in the new species (double the length in *B. muscorum*).
4. A pair of eyes are closely set on each side.
5. Leg chaetotaxy varying among these two species.
6. The number of genital setae and paragenital setae are 5 and 6 in the new species, where as it is 8 and 10 respectively in *B. muscorum*.

***Bdella thikkodiensis* sp. nov.**

PLATE 58A and 58B

Female: Body oval, 325 long (excluding gnathosoma), 215 wide; gnathosoma 150 long, setae Vh_1 - Vh_4 present on hypostome in a vertical row measuring Vh_1 - 30, Vh_2 - 15, Vh_3 - 20 and Vh_4 - 20. Chelicera normal, 90 long; chela smooth, fixed digit smaller than movable digit, setae one pair on each chela, the proximal seta 15 long and distal one 30 long, located at the 2/3 of the length. Cheliceral palpus with tibiotarus extending beyond hypostome. Palpal segments measuring 1-20, 11-10, 111 - 55, IV - 12, V - 30 in length, basifemur with one seta; telofemur with one seta; genu with 3 setae and tibiotarsus with 5 setae; including ves and des measuring 80 and 60 respectively. Dorsal propodosoma with closely set striations, propodosoma with 4 pairs of setae; eyes one pair on each side separated by a distance of 6 from each other. Anterior (50) and posterior (70) sensilla present, anterior sensilla 80 apart; posterior sensilla 70 apart. Dorsal hysterosoma striated as shown in the figure. All dorsal setae serrate and blunt at tip. The measurements of setae: External humeral seta - 30, internal humeral seta - 30; dorsal seta - 30; lumbar seta - 25; internal clunal seta 30 long, external clunal seta 35; genital shield with 8 pairs of genital setae; anal cleft terminal. Paragenital setae 6 pairs. Median unpaired seta between coxae IV. Anal region with parallel striations, setae 1 pair, paraanal setae 1 pair. Legs I-IV measuring 400, 375, 500 and 500 respectively.

Leg chaetotaxy: Coxae: 4-3-4-2; trocharter: 1-1-2-1; all setae tactile; basifemora: 5-4-4-2; telofemura: 5-5-4-4; genua: 5-5-5-6; tibiae: 10-8-9-8; tarsi: 16-14-10-10; tarsi I and II with 2 solenidia each.

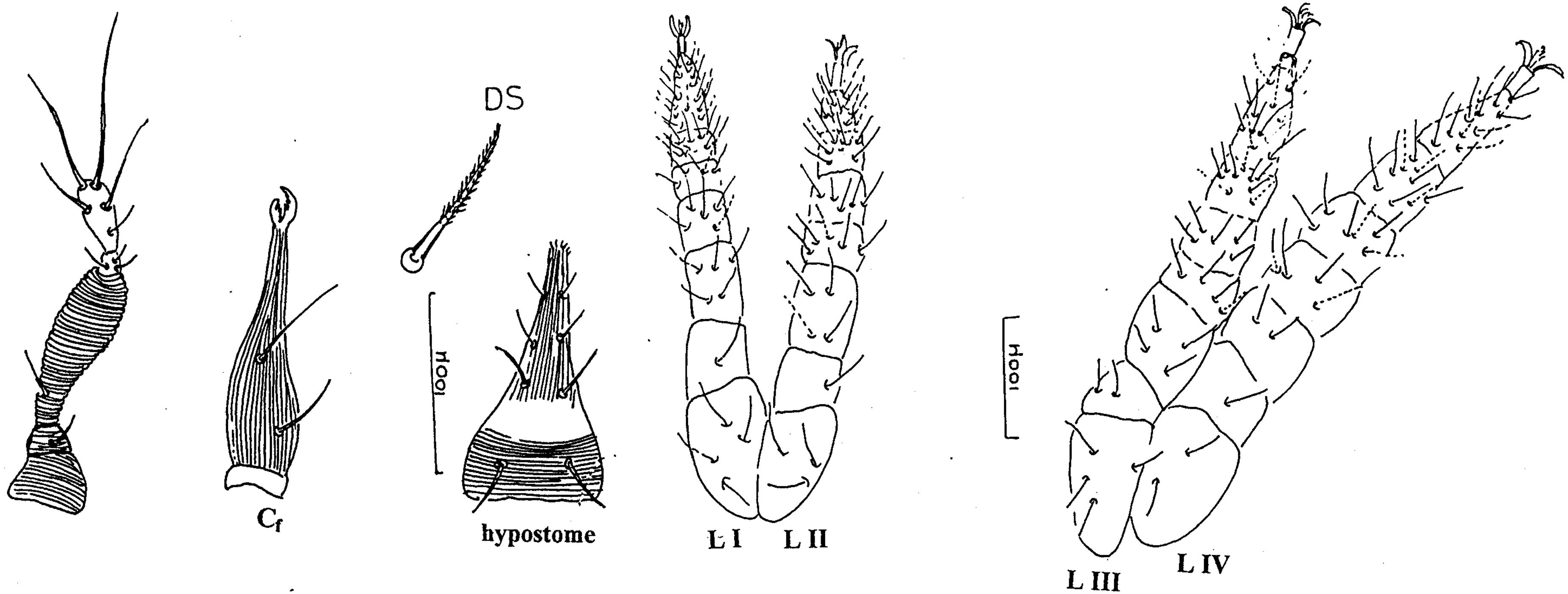
Male: Unknown.

Material examined: Holotype ♀, INDIA: KERALA: Coconut Nursery, Thikkodi (Kozhikode district), 10.i.2000, ex. *Cocos nucifera*, coll. Mary Anitha (No. AB 4/5). One paratype slide with 3 ♀ ♀, collection data same as holotype (No. AB 4/6).

Remarks: This new species resembles *B. nuciferae* Chinniah, 1995 but distinguished from it by the possession of the following characters.

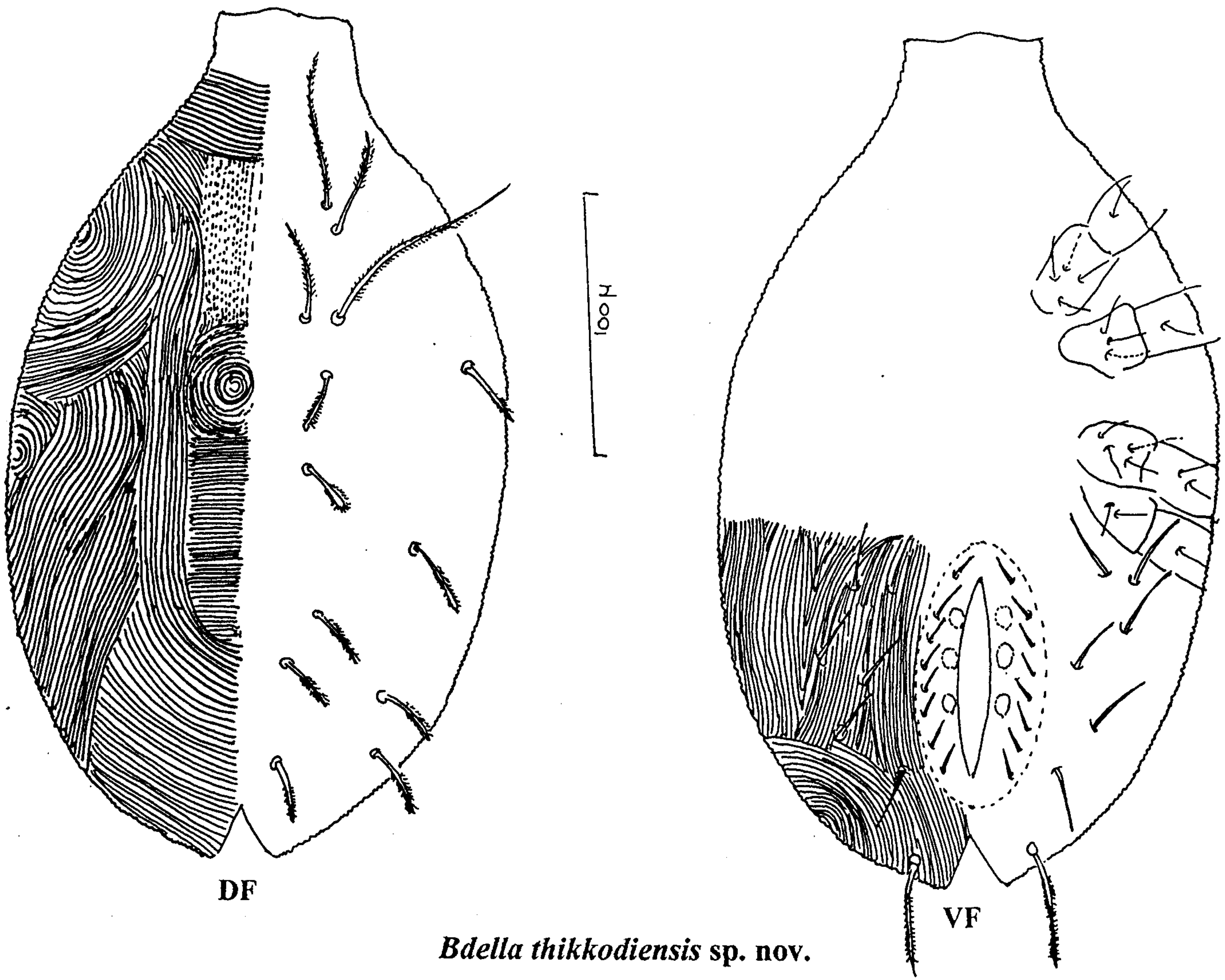
1. Larger size of the body.

PLATE 58 A



Bdella thikkodiensis sp. nov.

PLATE 58 B



Bdella thikkodiensis **sp. nov.**

PLATE 59

Figs. 1-4. *Bdella* species

Fig. 1. Dorsal body striations of *B. thikkodiensis* sp. nov.

2. Dorsal view of *B. thikkodiensis* sp. nov.

3. Ventral view of *B. kottakalensis* sp. nov.

4. Gnathosoma of *B. kottakkalensis* sp. nov.

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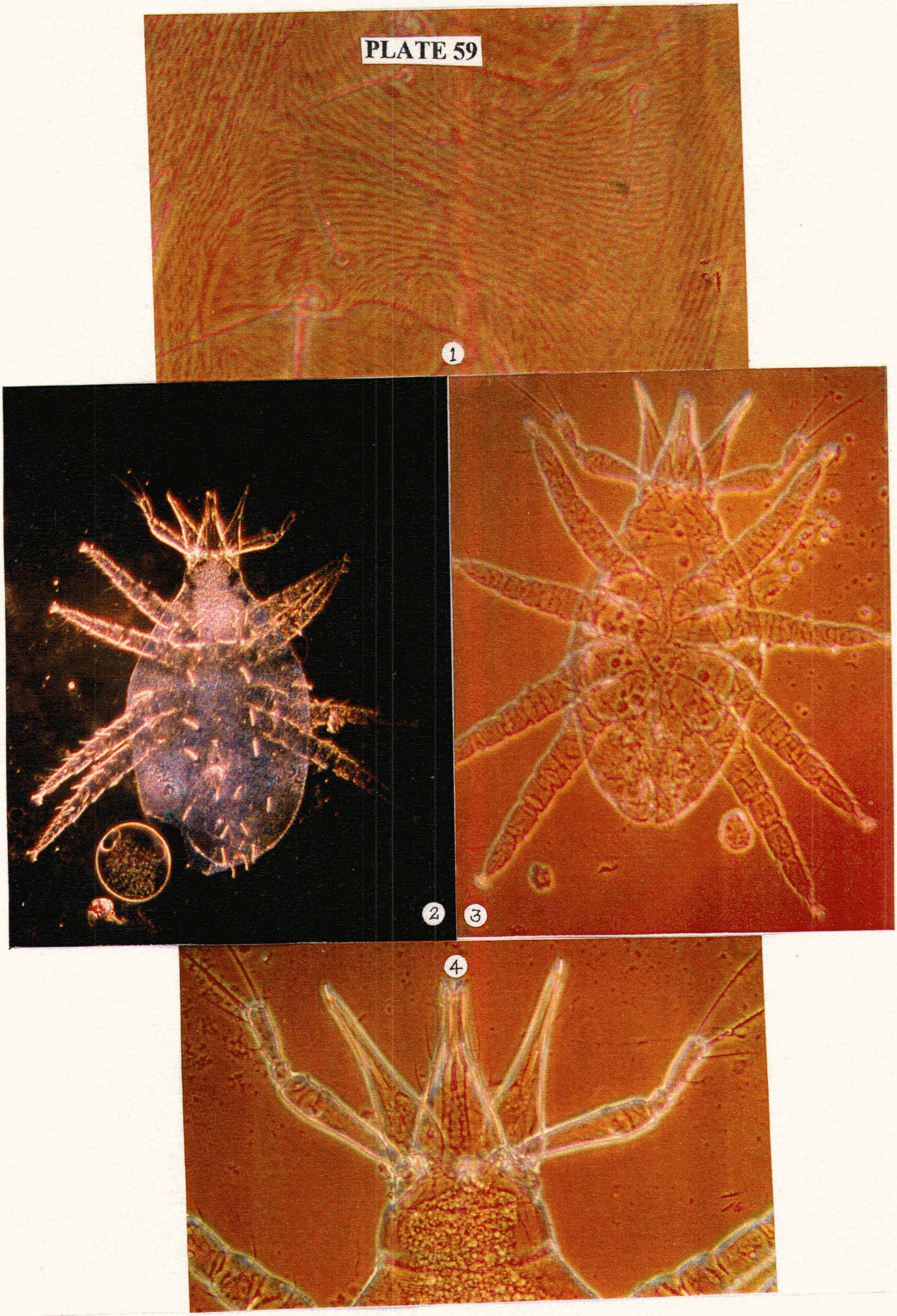
PLATE 59



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2. Distal serrate nature of dorsal seta.

3. Increased number of genital setae (8 instead of 5 in *B. nuciferae)*.

This predatory mite was found along with large population of coccids on coconut fronds.

5.5. Family STIGMAEIDAE Oudemans, 1931

1931. Stigmaeidae Oudemans, *Entomol, Ber. Nederl.*, **8** (179): 251-263.

1952. Stigmaeidae: Baker and Wharton, *An intro. Acarol.*, Mac Millar Co. New York, 465 pp.

1955. Stigmaeidae: Cunliffe, *Proc. Entomol. Wash.*, **57** (5) : 209 – 218.

1955. Stigmaeidae: Summers and Schilinger, *Hilgardia*, **34** (12) : 539 – 561.

1965. Stigmaeidae: Gonzalez, A taxonomic study of genus *Mediolata, Zetzellia* and *Agistemus* (Acarina: Stigmaeidae). *Uni. Calif. Publ. Entomol.*, **41**: 64.

1966. Stigmaeidae: Summers, *Acarologia*, **8** (2): 230 – 250.

1969: Stigmaeidae: Meyer, *Acarologia*, **11**: 227-271.

1971. Stigmaeidae: Wood, *N. Zool. J. Sc.*, **14**(1) : 54 – 61.

Diagnosis: Palptibia with a prominent claw which is sometimes with a small accessory claw. Palptarsus, a short appendage with which the main claw forms a thumb claw complex. Most of the species with 3 tined fork at the tip of palptarsus. Tracheal system orginated in the middle between basal pieces of chelicerae, having no stigmata or peritreme. Genital and anal vestibules closed externally by a single pair of genitoanal covers.

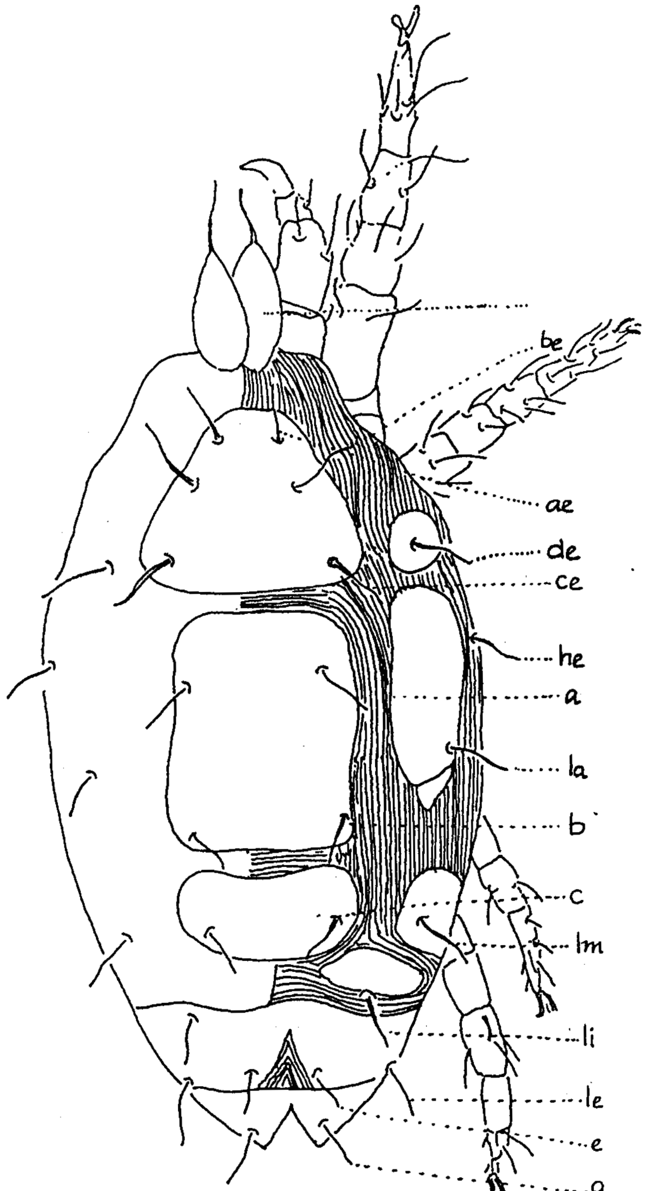
Type genus: *Stigmaeus* Koch, 1939.

Terminology: Grandjean's (1944) system of terminology with modifications and additions made by Summers (1962), Gonzalez (1965) and Meyer (1969) has been used in this description.

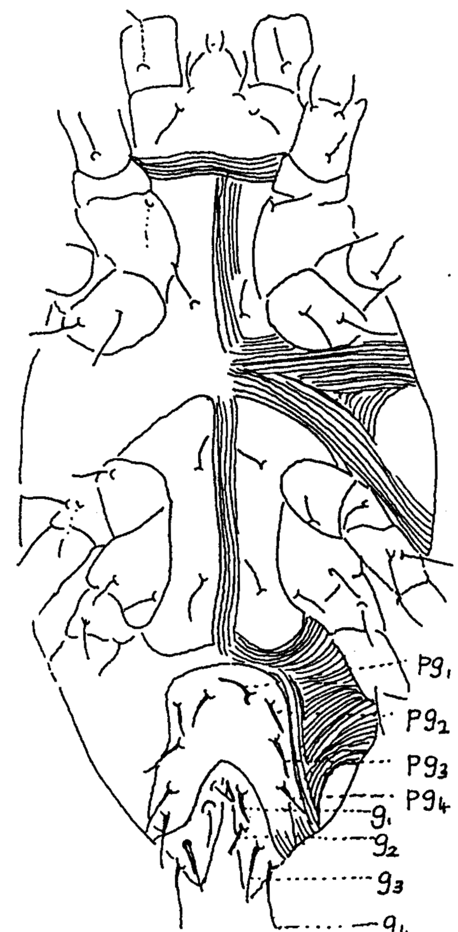
The following abbreviations are used (Plate 60):

a and b	-	dorsocentral setae
ae	-	vertical dorsal setae
be	-	preocular dorsal setae
c	-	mediozonal setae
ce -and de	-	post ocular dorsal seate
e	-	central suranal setae
he	-	humeral setae
$pg_1 - pg_4$	-	paragenital setae
la	-	dorso lateral dorsal setae
le	-	lateral suranal setae
lm	-	lateral zonal setae
w	-	tarsal solenidion
g	-	genital setae.

PLATE 60

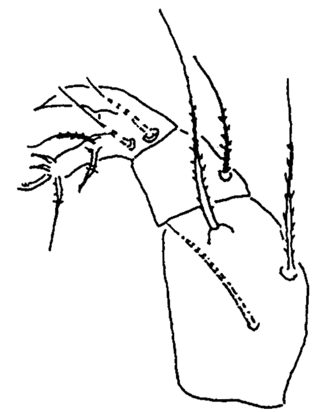


DORSAL VIEW



VENTRAL VIEW

EMPODIUM



TARSUS – I

Morphological and Taxonomical characters of the family Stigmaeidae

Genus *Apostigmaeus* Grandjean

Diagnosis: Idiosoma slender, some what spindle shaped. Chelicera move separately, not fused together. Palp tarsus bears a clusture of 4 minute sensory setae (eupathids) instead of a terminal trident. Dorsal shield very restricted and delicate. Propodosomal shield reduced, confined to mid portion of body; only two pairs of propodosomal seate ae and be, arise on this shield. Hysterosomal plating restricted to minute platelets, one platelet for each seta except suranal setae. Tip of opisthosoma partly covered by a pair of suranal plates, each plate with two setae. No obvious eyes. Dorsal setae 13 or 14 pairs, propodosoma bears 4 pairs of setae excluding humeral setae he. Four pairs of paragenital setae. Shaft of empodium project beyond the tips of claws before branching to produce three pairs of capitate raylets.

Type species : *Apostigmaeus navialla* Grandjean.

Apostigmaeus chelarurensis sp.nov

PLATE 61

Female: Body 564 long (without gnathosoma) 368 wide. Palp 5 segmented, palptarsus longer than claw with 4 simple setae and 4 eupathids; chaetotaxy of other palpal segments: tibia – 4, genu – 2, femur – 3, all setae simple. Gnathosoma ventrally with 4 pairs of setae, the posterior pair longer than others. Dorsal idiosoma with striations. Propodosoma with one shield, 148 long and reticulated. Dorsal setae 14 pairs, all lanceolate and barbed. Propodosomal shield with setae ae and be, arise in anterior region. All other setae outside the shield on separate platelets. Ventrum also striated except in coxal region. Ventral idiosoma with 3 pairs of simple setae. Paragenital setae $pg_1 - pg_4$ present and genital setae 2 pairs, (g_1 and g_2); simple. Anal setae 2 pairs (a_1 and a_2); simple. Measurements of setae : ae-30, be-42, ce-40, de-36, he – 30, le-32, la-40, a-34, b-38, c-40, e-40, lm-38, li-34, pg_1-pg_4 – 20 each, g_1, g_2 – 22 each, a_1-30, a_2-42. Legs 1-IV: 260, 198, 200 and 268 long respectively. Coxae I and II as well as III and IV contiguous.

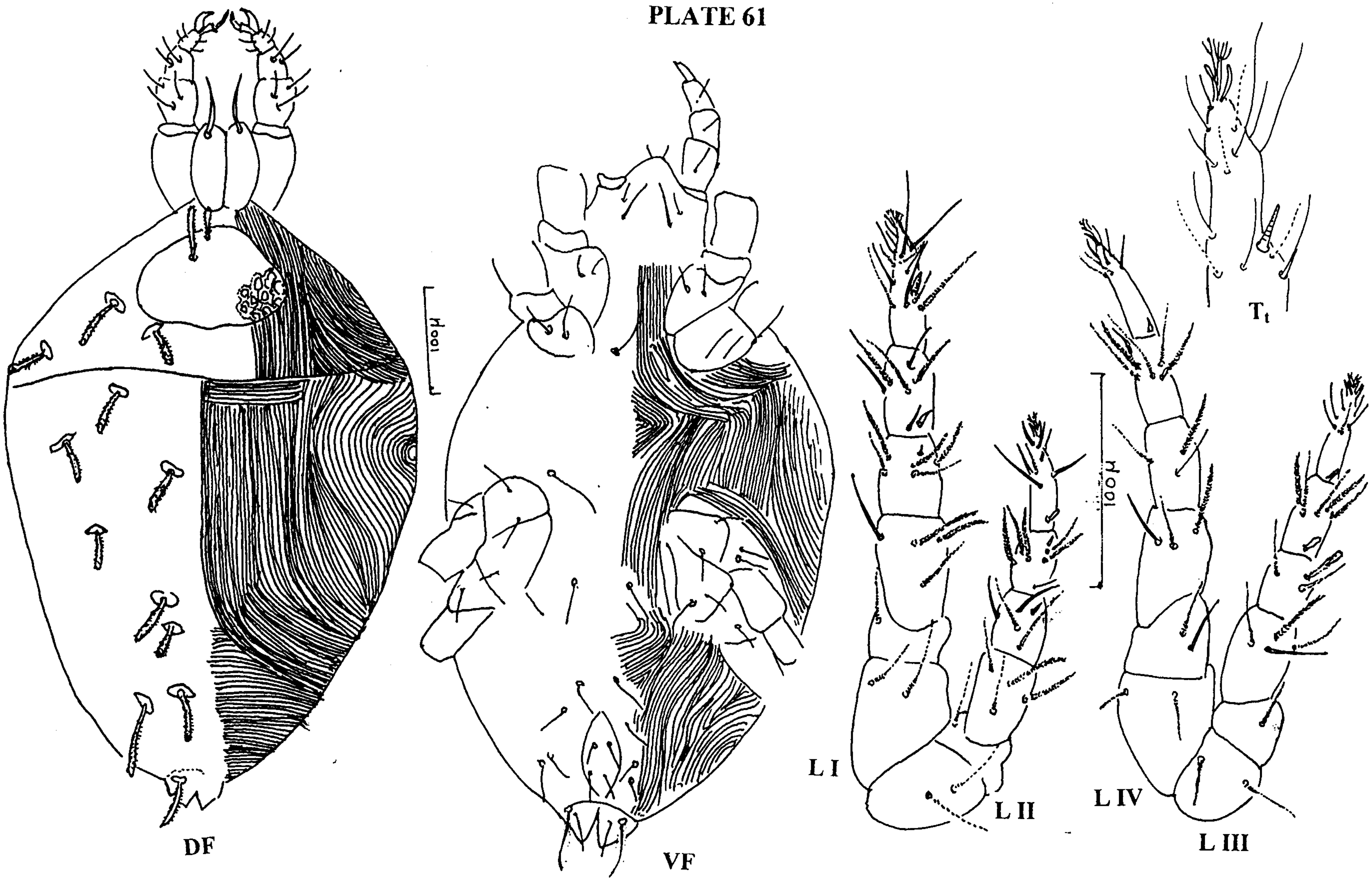
Leg chaetotaxy: Coxae: 2-2-2-2; trochanter: 1-1-1-2, femer: 4-4-4-3; genu: 5(1)-4(1)-3-3; tibia: 6(1)-5(1)-5(1)-6 and tarsus: 14(1)-7(1)-6(1)-6(1).

Male: Unknown.

Habitat: *Morus alba.*

Material examined: Holotype ♀ marked on the slide along with other 3♀♀, INDIA: KERALA: Indian Institute of Spices Research Experimental Garden Peruvannamuzhi (Kozhikode district), 14.iv.2000, ex. *Morus alba,* coll. Mary Anitha (No. A 34/2). Two paratype slides with 8 ♀♀, collection data same as that of holotype (No. A 34/3, A 34/1).

PLATE 61



Apostigmaeus chelavurensis **sp. nov.**

Remarks: This new species resembles *A. navialla* Grandjean (1944), however it differs from it by the following characters:

1. Presence of lanceolate and barbed dorsal setae.
2. Presence of two genital setae.
3. Variations in palp and leg chaetotaxy.

Genus : *Agistemus* Summers

1960. Agistemus summers, *Proc. Entomol. Soc. Wash.*, **62** : 253 – 257.

Agistemus udumae sp. nov.

PLATE 62

Female: Body 398 long (including gnathosoma), 220 wide. Palp 5 segmented. Palptibia with claw slighty shorter than tarsus. Palp femora with thickened dorsal setae which is prominently barbed. Chaetotaxy of palapl segments: femur –3, genu – 1, tibia – 4 , tarsus – 3, apically bears a terminal 3 forked seta. All dorsal plates smooth, propodosoma with one shield, propodosomal plate approximately wide as metapodal plates. Dorsal idiosomal setae, long, rough and blunt, arising from tubercles. Setae longer than the distance between its base. Ventral idiosoma with 3 pairs of simple setae. Two pairs of paragenital setae (pg_1 and pg_2) present. Genital setae (g_1 – g_4) subequal in length, g_3 and g_4 thick and barbed. Measurements of setae : ae - 50, be –80, ce – 58, de – 52, a – 62, b- 64, c – 68, la – 60, lm – 68, li –

70, le – 30, e – 44, pg_1 – 18, pg_2 – 16, $g_1 = g_2 = 14$, $g_3 = g_4 = 16$. Measurements of leg I – IV : 200, 160, 160, 180 respectively.

Leg chaetotaxy: Coxae: 2-1-2-2; trochanter: 1-1-1-1; femur: 4-4-2-2; genu: 3-1-0-0; tibia: 6-6-6-5; tarsus: 9(1) – 9(1) – 9(1) - 7.

Male: Un known.

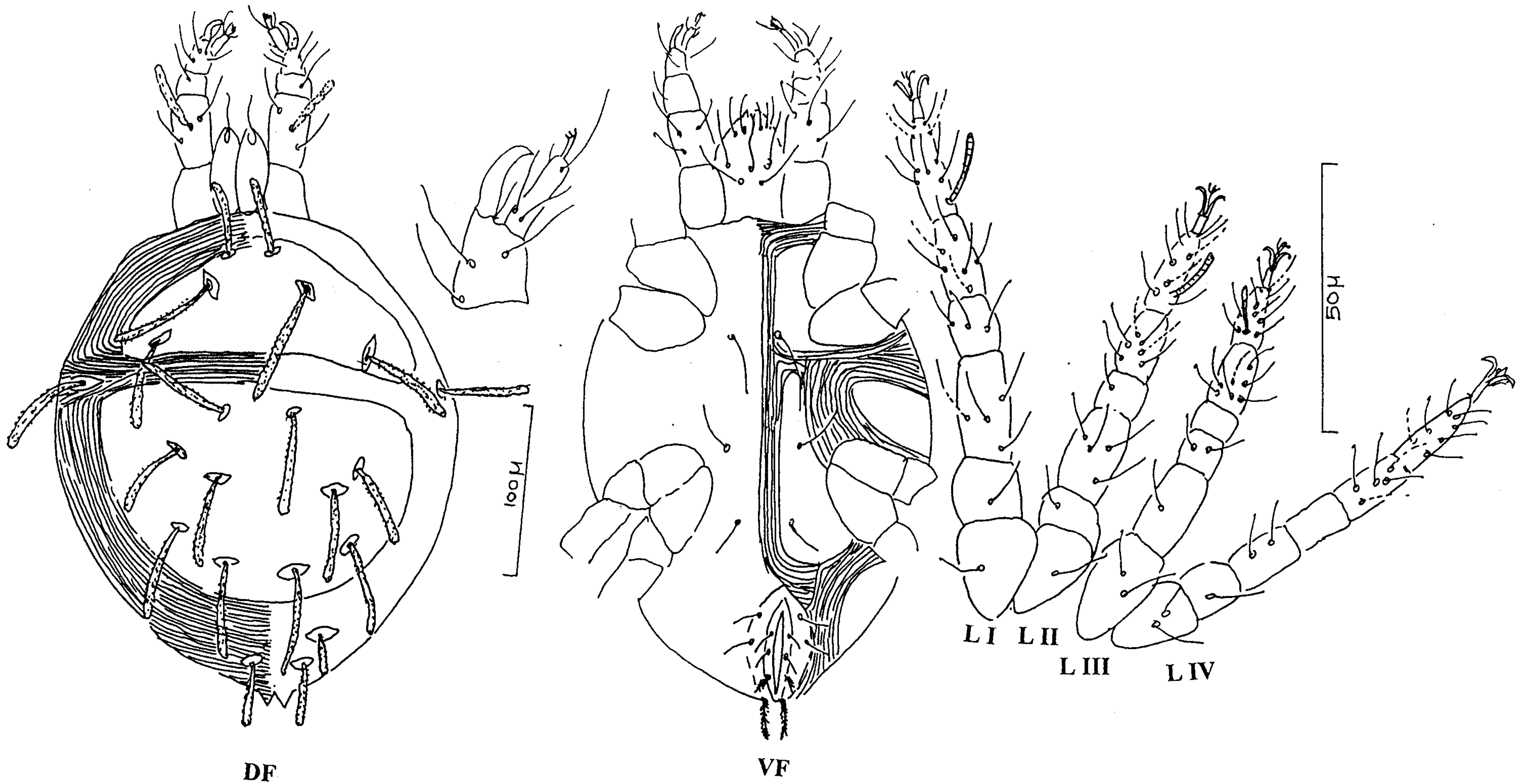
Habitat: *Anacardium occidentale.*

Material examined: Holotype ♀ marked on the slide along with other 2♀♀, INDIA: KERALA : Uduma (Kasargod district), 10.v.2000, ex. *Anacardium occidentale,* coll. Mary Anitha (No. A 8/1). Two paratype slides with 9♀♀, collection details same as that of holotype (No A 8/3, A 8/4).

Remarks: This new species is quiet close to *A. giganticus* Ehara and Wongsiri (1984) but distinguished from it by the following characters:

1. Body size smaller than that of *A. giganticus*
2. All body setae longer in the new species.
3. Leg chaetotaxy varying from that of *A. giganticus.*

PLATE 62



Agistemus udumae sp. nov.

PLATE 63

Figs. 1-4. Stigmaeidae

Fig. 1. Dorsal view of *A. chelavurensis* sp. nov.

2. Ventral view of *A. udumae* sp. nov.

3. Gnathosoma of *A. udumae* sp. nov.

4. Dorsal view of *A. udumae* sp. nov.

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PLATE 63

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PART III
FEEDING AND BREEDING BIOLOGY
INTRODUCTION

PART III

FEEDING AND BREEDING BIOLOGY

CHAPTER 6

INTRODUCTION

Predatory mites generally exhibit great diversity in feeding habits. They consume phytophagous mites like tetranychids, eriophyids, tenuipalpids, tarsonemids and even insect pests. Many of the phytoseiid predators can survive on non-prey food items like honey dew, pollen, plant sap, nectar etc. The extent of diversity exhibited by predatory mites in terms of feeding often helps them to enjoy wide distribution pattern in various habitats. Many of them exploit the foliage of higher plants while others colonise the microhabitats available in soil ecosystem, stored product ecosystem, aquatic habitat and so on. The phytoseiid mites, which have been selected for biological studies in the present work, are known to exploit the foliage habitat available on higher plants. They have world wide distribution and are important natural enemies of phytophagous mites like the spider mites, false spider mites, eriophyid mites etc.

Phytoseiids are very efficient predators since they have short life cycle than their prey, equivalent reproductive potentiality, good searching capacity, ability to survive on a low prey density and can thrive on alternate food like nectar, honey dew, plant sap etc. Several species from India have been recognised to possess high potential in biological control. *A. longispinosus, A. fallacis, A. ovalis, A.*

tetranychivorus, A. channabasavannai, A. largoensis, A. multidentatus, Indoseiulus ricini and *Typhlodromus ricker* etc. are excellent examples for this.

Predatory mites deserve special mention in an agricultural country like India, where agriculture is always under the threat of constant pest attack. Despite their importance in the suppression of pest populations in varied ecosystems, predatory mites have not acquired adequate recognition so far in India, particularly in Kerala. Considering the above lacuna, the present work has been undertaken to unravel the predatory fauna of different vegetations and stored products. The study though has been oriented in such a direction to provide information on the systematic aspects of predatory mites, also includes observations on the feeding and breeding aspects of selected species, belonging to the family Phytoseiidae, the most common predatory family encountered during the study.

Results of the general survey carried out during the present study revealed the wide occurrence of two species of phytoseiid mites viz. *A. (N.) longispinosus* and *A.(E.) finlandicus*. Hence the above two species were selected for detailed studies on their feeding and breeding aspects. Both the species were recognized as very active in the field and laboratory conditions exhibiting voracious feeding trends on various stages of tetranychid mites. In the present study, the feeding preference of the above two species of phytoseiid predators to different stages of the spider mite, *T. neocaledonicus* infesting cassava leaves were analysed. The feeding potential of both the species was analysed separately based on statistical methods to test its significance. Moreover, developmental studies of the above two species were also completed and included in the present work to know the durations of life instars, longevity of males and females and also the maximum rate of egg production etc. of individual species.

PART III
REVIEW OF LITERATURE

CHAPTER 7

REVIEW OF LITERATURE

The present review of literature includes the important works on the feeding and breeding aspects of phytoseiid mites.

It was Parrot *et al.* (1906) who first established the predatory efficiency of *Seius pomi*, upon blister mite *Eriophyes pyri*. Since then Quayle (1912), Ewing (1914), Gilliat (1935) etc. highlighted the value of phytoseiid mites in regulating the populations of plant mites especially the spider mites. Ballard (1954) pointed out that phytoseiid mites pass through 5 developmental stages viz., egg, larva, protonymph, deutonymph and adult. Dosse (1957) recorded the mean preoviposition period of females of *Typhlodromus pyri* as 1.5 days at a temperature of 25-26°C. He further (1959) reported that males used their chelicerae to place the spermatophores into the spermathecal opening between coxae III and IV of the female. He also claimed that the number of successful copulations could be determined by the number of spermatophores present in the spermatheca.

Studies were conducted by various workers like Chant (1961), Mc Murtry and Scriven (1966) on the functional response of the phytoseiid mites to the density of tetranychid mites and also on the aspects of their numerical response. Putman (1962) recorded a mean oviposition period of 9.2 and 16.3 days at 16°C and 14°C respectively for *T. caudiglans*. Hussey *et al.* (1965) observed the feeding habits of

P. rigeli and established it as a biocontrol agent of various plant feeding mites. Kamath (1968) reported that *P. persimilis* had the capacity to reduce remarkably the populations of *T. urticae* on various crops in various countries. Laing (1969) studied the morphological changes occurring at the time of egg laying in *Metaseiulus occidentalis*. Satpathy and Mania (1969) noted the morphological peculiarities of the eggs of *A. finlandicus*.

Flaherty and Huffaker (1970) found that *M. occidentalis* had the capacity to control *Eutetranychus willamette*. Smith and Newsom (1970) suspected that while shifting the eggs from their original habitats on leaves to new leaf discs by moistened camel hair brush might have reduced their viability to a greater extend. Certain phytoseiid species were known to develop only on tetranychid mites, some on combinations of tetranychids and eriophyids, some on mites and pollen and a few others on pollen alone as reported by Swirski *et al.* (1970). Gupta *et al.* (1971) reported the predatory habit of *A. finlandicus* on the tetranychid species of citrus in Punjab. Wei and Laing (1973) studied the oviposition behaviour of phytoseeid mites reported that oviposition started only after mating and frequent matings were not needed for continuous egg laying.

Mallik and ChannaBasavanna (1976) reported *A. longispinosus* as an efficient predator of spider mites and suggested the possibility of utilising this species for managing the spider mites, *T. ludeni*. Amano and Chant (1978) studied the sperm transfer behaviour of phytoseiid mites and concluded that these mites exhibited 2 types of basic pre-copulatory behavioural patterns. Puttaswamy (1978) conducted observations on the ability of *Typhlodromips tetranychivorous*, a potential native predator of tetranychid mites in India to suppress the plant feeding mites proved better results under field condition. Shih and Shieh (1979) conducted studies on the developmental biology of *A. (N.) longispinosus* and observed that the respective durations of egg, larva, protonymph and deutonymph at 24°C and 70% R.H. were 2.06, 0.80, 1.07, 1.73 days for females and 2.06, 0.82, 1.0 and 1.18 days for males.

Dover *et al.* (1979) reported the ability of *A. fallacis* to suppress the population of *Panonychus ulmi* on various economically important plants. Hoy and Smilanick (1979) reported that phytoseiid mites, as in all mesostigmatid mites were blind and lack chemosensory solenidia. Therefore they were thought to sense prey along from short distance and upon reaching the pest infested area they located their prey by the kairomones.

Hislop and Prokopy (1981) suggested that phytoseiids were able to deposit pheromones to mark the leaf area that has been searched to avoid recrossing these area. Saito and Mori (1981) studied the life history of *A. longispinosus* and noted that this species had the maximum rate of egg production on the tenth day. Mallik (1982) found that *A. longispinosus* preferred eggs and other immature stages of *T. ludeni* when compard to the adults. A study carried out by Mallik and ChannaBasavanna (1983) from Bangalore on the life history of *A. longispinosus* on a diet comprising *T. ludeni* revealed the durations of development of the egg, larva and the two nymphal stages as 44.42 hrs, 12.25 hrs, 20.53 hrs and 21.51 hrs respectively. The total time taken for development were 99.11 hrs in females and 95.30 hrs in males. Ezulike and Odebiyi (1985) traced the life history of *A. fustis*, an indigenous predator of the cassava red mite, *Oligonychus gossypi* and found that the durations of development from egg to adult of male and female was about 8 days and the longevity was about 19.2 days. Nakagawa (1985) reported that besides temperature, the quality and quantity of food available also would influence the developmental period of *A. longispinosus*, in which an increase in humidity caused a decrease in the duration of development. Neelam and Sadana (1985) observed the most suitable temperature for the development of *A. finlandicus* as 25°C and at this temperature the total developmental period was quite short with high fecundity and no mortality. Zhang and Kong (1985) studied the biology of *P. persimilis* under laboratory conditions and recorded that the duration of F_1 generation was 5.4 days. The durations of the larval and nymphal stages lasted for 0.5 and 2.4 days respectively, the preoviposition and oviposition periods were 1.3 and 2.5 days respectively.

Abou-Awad and El-Banhawy (1986) recorded a mean developmental period of about 5.7 days for *A. olivi* when fed on tetranychid mites. Gupta (1986) reported that in most of the predatory species, the maximum rate of egg production was 2.5 per day during winter temperature with abundant food. The mean total eggs laid per female depended on the species and testing conditions and egg production was maximum during the early part of the adult life and gradually declined thereafter. The rate of egg production was influenced by the prey density. Bounfour and Mc Murtry (1987) studied the biology of *E. scutalis* by offering the various life stages of *T. pacificus* and reported that the egg, larval and nymphal periods were 2.2, 0.8 and 4.3 days respectively.

Lee *et al.* (1987) conducted studies on the development, fecundity and prey consumption of *A. longispinosus* from Korean Republic and found that at constant temperature of 18, 22, 25, 28 and 30°C the duration of egg stage were 4.0, 3.3, 3.0, 1.8 and 1.7 days respectively and larval stage were 4.8, 3.6, 3.0, 2.3 and 2.6 days. The preoviposition, oviposition and post oviposition periods were 0.4, 12.1 and 16.0 days at 25°C. The average number of egg laid per female were 29, 38, 38 and 46 at 18, 22, 25 and 30°C respectively. Hariyappa and Kulkarni (1988) while studying the biology and feeding efficacy of *A. longispinosus* on *Polyphagotarsonemus latus* found that at 23-27°C and 65-70% RH, the egg, larval, protonymphal and deutonymphal stages lasted for 45.67, 14.27, 23.18, 24.41 hours in female and 46.45, 14.10, 2.78 and 22.71 hours in males respectively. Female laid an average of 27.50 eggs during an oviposition period of 16.11 days. Jose *et al.* (1989) while studying the feeding potential of *A. alstoniae* on *T. macfarlani*, found that a single predatory mite could consume a total of 191.30 eggs, 76 larvae, 82.60 nymphal stages and 46.24 adults during its life time. Labadidi (1989) studied the duration of development, life span, fecundity and sex ratio of *A. longispinosus* on a diet of *T. cinnabarinus* in Taiwan and found that at an alternate temperature of 23-30°C the developmental period of the species was 5 days for females and 4.4 days for males when compared to 4.2 and 4.1 days respectively at 20-30°C. According to Papov and Khudyakova (1989) development and reproduction could be influenced by the host plant of the prey. Zhang and Lin (1989) reported the control of *Tarsonemus fuzouensis* by *Gnorimus chaudhiri* in the paddy field in China.

Shausberger (1991) while studying the life history, life table parameters and reproductive capacity of *A. aberrans* and *A. finlandicus* feeding on *P. ulmi* reported that the duration of development of *A. aberrans* averaged 7.38 days and that of *A. finlandicus* was 7.84 days. The corresponding fecundities were 19.98 and 21.25 eggs per female, adult female life spans 40.2 and 35.1 days and sex ratio female : male is 28 : 1 and 5.8 : 1 respectively. Duso (1992) reported that *A. finlandicus* could regulate the population of *P. ulmi* on peach orchards in northern Italy. Again Shausberger (1992) observed that inspite of sufficient food supply (pollen) the rate of reproduction of *A. finlandicus* decreased with increasing numbers of the mites. Ibrahim and Palacio (1994) conducted studies on the post embryonic development of *A. longispinosus* on a prey food comprising *T. urticae* and reported that the developmental time for male egg was longer(45.2 hrs) than that of female egg (42.6 hrs). It was also noticed that larvae was non feeding and immature female consumed more eggs than male. Kim and Lee (1994) studied the foraging behaviour of *A. longispinosus* for *T. urticae* eggs and reported that when prey was abundant the predatory mite repeated a series of foraging behaviour and readily consumed the eggs which were distributed in a clump. According to Sabelis and Janssen (1994), in phytoseiid mites the rate of development per day was 10-20%. Tsunoda (1994) reported that males of phytoseiids showed several variations in the pattern of copulatory behaviour and preoviposition periods were very low (24-30 hrs).

Sathiamma (1995) found that the white spider mite *Oligonychus iseilemae* on coconut foliage was suppressed by predatory mite, *A. paraaerialis* and *A. eucalypticus*. The results of the study conducted by Momen (1996) on the predatory habit of *A. barkeri* proved that adults of the species could consume 17 and 102 individuals of *T. urticae* and *E. dioscoridia* respectively. Yue and Tsai (1996) while studying the biology of *A. largoensis* found that pollen was the most suitable food source for development of the species. Ibrahim and Rahiman (1997) conducted studies on the influence of prey density, predatory behaviour of *A. longispinosus* and reported that gravid females were more voracious feeders than young females. The highest mean number of eggs consumed in 24 hrs was 16.7 for young female and 33.3 per gravid female, an average of 17 larvae for young female and 27.8 for gravid females in 24 hours. Zhang *et al.* (1998) evaluated the potential of *A. longispinosus* as a biological control agent of *Aponychus corpuzae* on bamboo at different temperatures and found that the rate of prey consumption increased linearly with temperature, with the optimum rate of feeding at 25°C. Croft *et al.* (1999) reported the cannibalism in phytoseiid mites by observing the feeding habit of the adult females on the larvae and eggs of the same species. Ghosh *et al.* (2000) demonstrated the predatory potential of *A. tetranychivorus* against *T. urticae* under both laboratory and poly house conditions.

PART III
MATERIALS AND METHODS

Mary Anithalatha Sadanandan “Studies on acarine predators of North Kerala ”
Thesis. Department of Zoology , University of Calicut, 2002

CHAPTER 8

MATERIALS AND METHODS

During the present study, *T. neocaledonicus* infesting cassava leaves were selected as the prey food item for studying the feeding preference of two species of phytoseiid predatory mites viz. *A. (N.) longispinosus* and *A. (E.) finlandicus*. The above spider mite was recognized as a widely distributed mite pest of cassava in most of the surveyed localities. Infestation by this spider mite resulted in the formation of white spots on the leaf lamina due to chlorosis (Plate 64; Fig. 1 and 2). Heavy infestation often led to blotching and bronzing of leaves followed by premature leaf fall.

8.1. Raising of prey mite population in laboratory

Cassava seedlings were planted in earthern pots of 1 x 1 x 1 m^3 size kept near Acarology laboratory for artitificial infestation with *T. neocaledonicus*. Mite infested leaves of cassava plants cultivated in different localities were collected and brought to the laboratory. Adult stages of *T. neocaledonicus* were picked up with a moistened brush under a powerful hand lens or stereomicroscope and carefully transferred to the newly planted cassava seedlings when new leaves began to sprout.

8.2. Raising of predator mite population

The two species of predatory mites included in the present study viz. *A. (N.) longispinosus* and *A. (E.) finlandicus* were also collected from the cassava leaves infested with the prey mite. The mite infested leaves of cassava were beaten over a dark coloured rexin sheet and the dislodged predatory mites were picked up using a moistened camel hair brush. Then these mites were carefully transferred to leaf discs placed in petridishes containing water soaked absorbant cotton pad. Different stages of the prey mite in sufficient numbers were offered as food for rearing the predatory mites. Sufficient stock cultures of the predatory mites were built up in the laboratory using leaf flotation technique. For this purpose, fresh and uninfested cassava leaf bits of 2.5 x 2.5 cm^2 size were laid on water saturated cotton placed in petridishes of 10 cm diameter with their lower side up. The rim of the leaf bit was kept in contact with water for preventing the escape of the predator. Culture cells were covered with another petridish to reduce the evaporation of water from the cotton. Water was added to the cotton daily to keep it wet continuously.

Culturing was initiated from fresh and healthy male and female collected from cassava plants, where they were noticed feeding on *T. neocaledonicus*. They were provided with enough life stages of the prey mite. When depletion of prey was noticed, new ones were brushed off from the infested cassava leaf which was maintained near the laboratory. To start with the feeding efficacy tests numerous replicates of such culture cells were prepared.

8.3. Study of feeding preference

For studying the feeding preference of individual stages of the predatory mites to various stages of prey mite, different culture sets were maintained in the laboratory. Separate culture sets containing different stages of the prey were prepared and different stages of the predatory mite viz. the larva, protonymph, deutonymph and adult were released to each set for making observations on the feeding preference of individual stages. Numerous replicates were also maintained for each set of experiment. Thus there were 5 experimental sets for each stage of the prey viz., set 1. Prey egg Vs. larva of predator; set 2. Prey egg Vs. Protonymph of predator; set 3. Prey egg Vs. deutonymph of predator; set 4. Prey egg Vs. Adult female predator; set 5. Prey egg Vs. Adult male predator. Similarly different stages of the prey mites were kept in separate culture sets and different stages of predator were released to each culture set separately. Fifty numbers of each of the different life stages of the prey (25 for adults) were kept in individual sets and were exposed to a single number of different stages of the predator viz., larva/protonymph/deutonymph/adult ♀/adult♂.

Observations were made on the feeding behaviour of the various stages of the predators, the mode of feeding of individual stages of the predatory mite and the feeding potential of the two predators on various stages of the prey. Data collected on the above observations were tabulated and analysed statistically based on Scheffe test, 2 Way ANOVA etc. and presented. Comparative assessment of the feeding potential of the two species of the predatory mites were also made and the results were tabulated and presented graphically.

8.4. Developmental studies

Developmental studies of the above two phytoseiid predators viz. *A. (N.)* longispinosus and *A. (E.) finlandicus* were carried out by making stock cultures of the predators in the laboratory conditions. The postembryonic development of both the species was traced in the laboratory at a temperature of 27 $\pm$ 1°C, by adopting leaf flotation technique.

Developmental studies were initiated by releasing sufficient number of males and females of the two species in separate culture dishes and making observations on various behavioural aspects like mating, oviposition, incubation, hatching, active stages, moulting etc. Data obtained on the above were recorded and presented. As soon as the eggs were laid by the female, they were transferred to fresh leaf bits of cassava infested with various stages of *T. neocaledonicus*. Repeated observations were made per hour to gather informations on hatching process and the subsequent developmental processes like moulting, active and inactive phases of the immatures, total duration of development, longevity of the different sexes etc.

PART III
OBSERVATIONS ON FEEDING BIOLOGY

CHAPTER 9

OBSERVATIONS ON FEEDING BIOLOGY

Results of laboratory cum field studies revealed the predatory habit of both *A.(N.) longispinosus* and *A. (E.) finlandicus* on the spider mite populations colonising cassava leaves. The eggs and developing stages of the prey mite, *T. neocaledonicus* were found on the lower surface of the leaves, closely apposed to the midrib and veins. In most instances the life stages were found protected by the web constructed by the mite.

9.1. Feeding activity of the predatory mites

(Plate 64, Figs. 3-6)

The feeding pattern of the different stages of both the species of predatory mites included in the present study was more or less of similar nature. The predatory mite, irrespective of the differences in stages or species, was found moving very fast, searching the prey. The searching movement was more vigorous when the predator was starved for a day. The searching movement was found hampered by the web constructed by the prey mite. The locations of the prey was detected using the palp and first pair of legs. When the prey was located once, the predator was found slowly catching the prey with the help of palps and first legs. Simultaneously, the chelicerae were also protruded towards the prey and penetrated

PLATE 64

Figs. 1-6. Feeding Biology

Fig. 1 and 2. Highly infested cassava leaf by *T. neocaledonicus*

3. Larva of *A. (N.) longispinosus* feeding on the egg of *T. neocaledonicus*
4. Deutonymph of *A. (E.) finlandicus* feeding on larva of *T. neocaledonicus*
5. Adult female of *A. (N.) longispinosus* feeding the egg of *T. neocaledonicus*
6. Deutonymph of *A. (N.) longispinosus* feeding the larva of *T. neocaledonicus*

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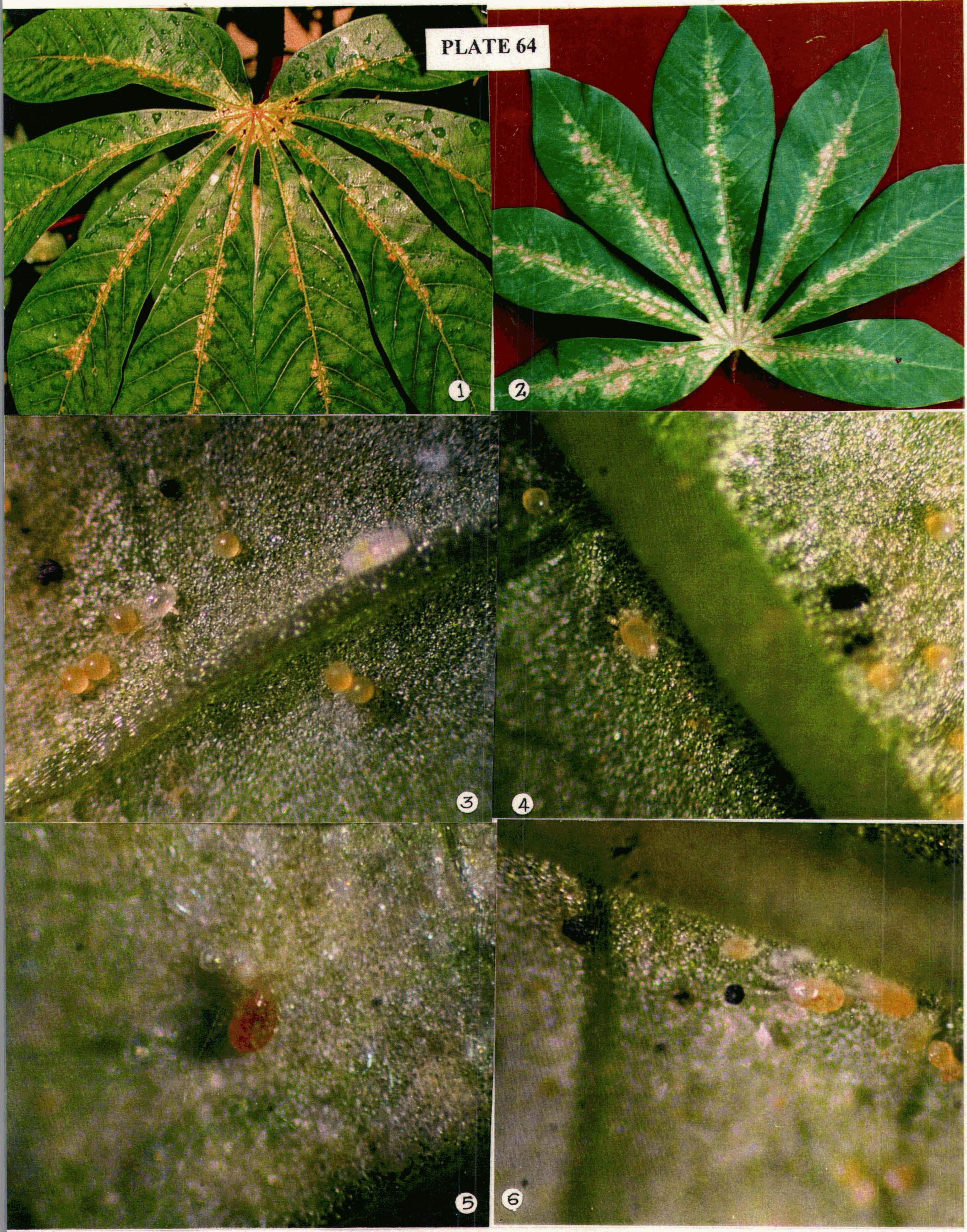
PLATE 64



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in to the body of the prey and the contents were slowly sucked. The sucking action was clearly visible while consuming the advanced stages of the prey. The coloured body fluid of the adult prey and deutonymph was more clearly visible through the transparent body of the predator.

The eggs of the prey were found rolled by the combined action of chelicerae and pedipalp at the time of feeding. Several punctures were made in the egg case and the contents were sucked in leaving behind the egg case, which appeared as a shrunken, tiny scale like structure.

The feeding potential of individual stages of the same predatory species was often found varying considerably. In both of the predatory species adult females appeared more active in capturing the prey. The average time taken by the various stages of the predatory mites for consumption of different stages of the prey was noted. It is noted that *A. (N.) longispinosus* took lesser time to suck the contents of the prey mite than *A. (E.) finlandicus*. It was observed that adult female predator of *A. (N.) longispinosus* took only one minute to suck the internal contents of the prey egg, whereas male took 2.2 minutes for sucking. While in the case of *A. (E.) finlandicus*, adult female required 1.30 minutes where as it was 3.3 minutes for adult male. The average consumption time taken by different stages of the predator increased with the progressive development of the prey.

PART III
STATISTICAL ANALYSIS

CHAPTER 10

STATISTICAL ANALYSIS

A 2 x 5 factorial experiment with five replications was conducted to assess the feeding potential of different stages of two predatory mites viz., *A. (N.) longispinosus* and *A. (E.) finlandicus* on different stages of the prey mite, *T. neocaledonicus*. A known number (50 each) of eggs, larvae, protonymph, deutonymph and adults (25 numbers) of the prey were allowed to be fed separately by five different stages of two predators.

The average number of different stages of the prey consumed by the different stages of the predators in 24 hrs. was worked out and noted that larvae of the predator *A. (N.) longispinosus* was a non feeder of the prey mite, *T. neocaledonicus* (Table 4).

The number of different stages of prey consumed by each stage of the predator was counted and the percentage of consumption was worked out (Table 5). There was a significant interaction between the predator and the life stages of the predator. Table 5 shows that females of *A. (N.) longispinosus* alone consumed 48.79 percentage of eggs of *T. neocaledonicus* which was significantly higher than any other stages of the two predators. They also consumed significantly higher number of larvae (37.8%) and protonymph (33.63%) of the prey. But consumption of deutonymph and adults of the prey was negligible by the female of the predator

TABLE 4

Average number of different stages of the prey *T. neocaledonicus* consumed by different stages of the two predators in 24 hrs

Predator	Average prey consumed in 24 hrs.					
		Egg	Larva	Proto	Deuto	Adult
A. (N.) longispinosus	Female	24.4	19.2	17	2.8	0.8
	Male	13.6	9.6	8.2	5.4	0.4
	Deuto	16.6	14	10.6	2.8	0
	Proto	9.8	11.2	5.6	1.6	1.6
	Larva	0	0	0	0	0
A. (E.) finlandicus	Female	17.8	6.8	6.4	1.8	0
	Male	4.0	2.2	2.6	0.8	0
	Deuto	3	6.4	3.0	0.4	0
	Proto	1.6	3.0	1.0	0.4	0
	Larva	3.2	0.6	0.2	0	0

TABLE 5

Percentage of predation of *T. neocaledonicus* by two species of predatory mites

Predator	Stage	Feeding percentage of *T. neocaledonicus*				
		Egg	Larva	Protonymph	Deutonymph	Adult
A. (N.) longispinosus	Female	48.79	37.80	33.63	4.26	1.02
	Male	26.94	18.21	16.26	8.74	0.39
	Deutonymph	32.70	27.82	20.81	4.37	0.00
	Protonymph	18.53	22.09	10.77	2.55	0.13
	Larva	0.00	0.00	0.00	0.00	0.00
A. (E.) finlandicus	Female	35.35	13.51	12.73	3.45	0.00
	Male	7.80	3.54	4.01	0.79	0.00
	Deutonymph	5.87	12.68	5.64	0.39	0.00
	Protonymph	2.55	5.87	1.61	0.39	0.00
	Larva	5.31	0.65	1.50	0.00	0.00

(< 5%). Deutonymph of *A. (N.) longispinosus* was the next best stage that fed well on eggs, larvae and protonymphs of the prey. The males and protonymphs also showed significant degree of predation on different stages of the prey. While in the case of the other predator, only the females of *A. (E.) finlandicus* showed remarkable feeding on the eggs of the prey (Table 5). All the other stages of this predator were very poor in consuming any stages of the prey.

Taking into consideration the consumption rates of different stages of *A. (N.) longispinosus* against different stages of *T. neocaledonicus* in 24 hours, normal plots were drawn for testing the validity of the assumption of normality. As shown in Plate 65, in all the 19 categories, the points were closed to a positively slopped straight line, hence the assumption of normality is valid.

The data obtained on the predatory habit of different stages of *A. (N.) longispinosus* on various stages of the prey mite, *T. neocaledonicus* when analysed statistically adopting Scheffe test revealed various significant combinations of predator and prey as presented in Table 6. Here the p-value < 0.01 was considered as highly significant. Accordingly, significant results were obtained on the predatory habit of *A. (N.) longispinosus* against *T. neocaledonicus*.

Plate 66 represents the mean number of life stages of *T. neocaledonicus* consumed by *A. (N.) longispinosus* in 24 hours. As indicated in the graph, female of *A. (N.) longispinosus* exhibited the maximum rate of consumption on the eggs of

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PLATE 65

Categorized Normal Plot for the rate of consumption
by different stages of *A.(N.)longispinosus* on
T.neocaledonicus in 24 hrs

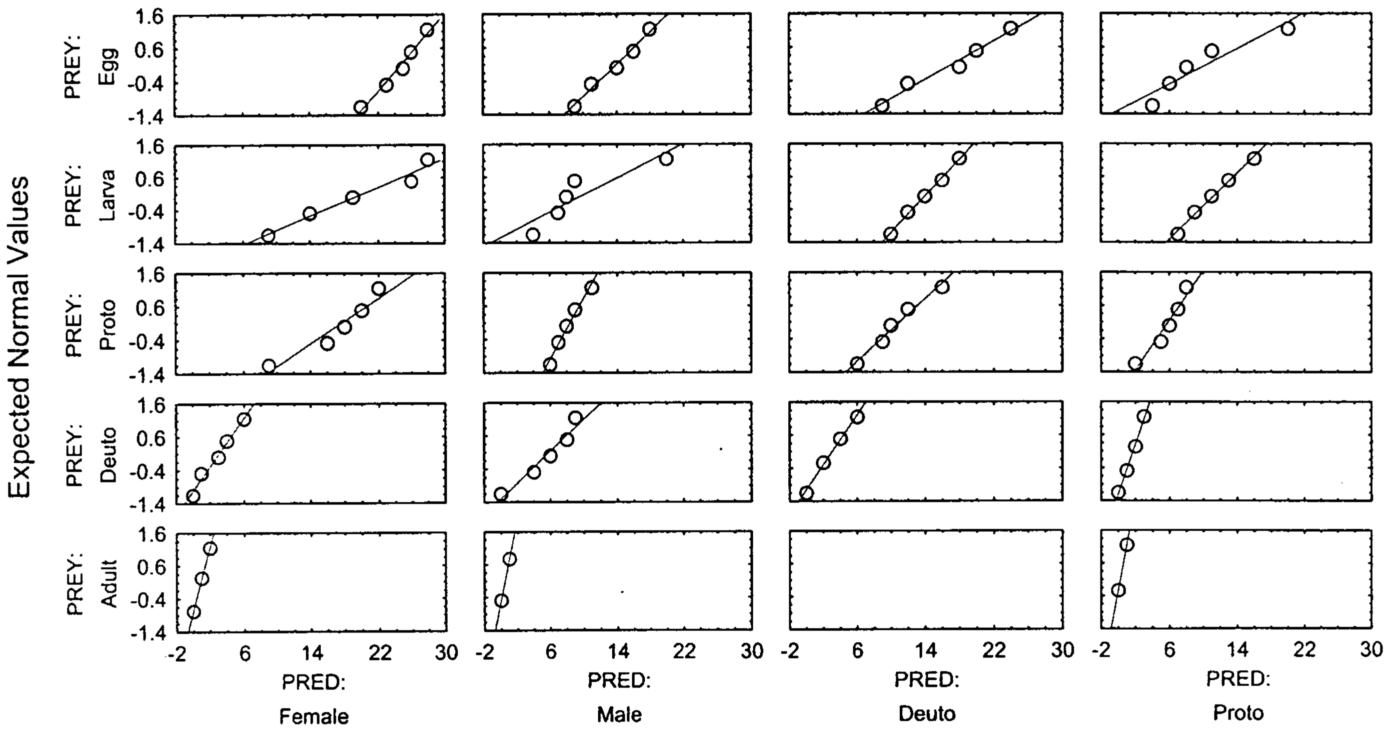


TABLE 6

Significant combinations of different stages of the predator, *A. (N.) longispinosus* against different stages of the prey mite *T. neocaledonicus* using Scheffe Test

1. Predator - Female

Prey / Prey	E	L	P	D	A
E	--	0.999	0.970	0.000*	0.000*
L	--	--	0.999	0.000*	0.001*
P	--	--	--	0.04	0.008*
D	--	--	--	--	0.999
A	--	--	--	--	--

2. Predator - Male

Prey / Prey	E	L	P	D	A
E	--	0.999	0.999	0.917	0.120
L	--	--	0.999	0.999	0.792
P	--	--	--	0.999	0.948
D	--	--	--	--	0.999
A	--	--	--	--	--

3. Predator - Deutonymph

Prey / Prey	E	L	P	D	A
E	--	0.999	0.997	0.075	--
L	--	--	0.999	0.408	--
P	--	--	--	0.948	--
D	--	--	--	--	--
A	--	--	--	--	--

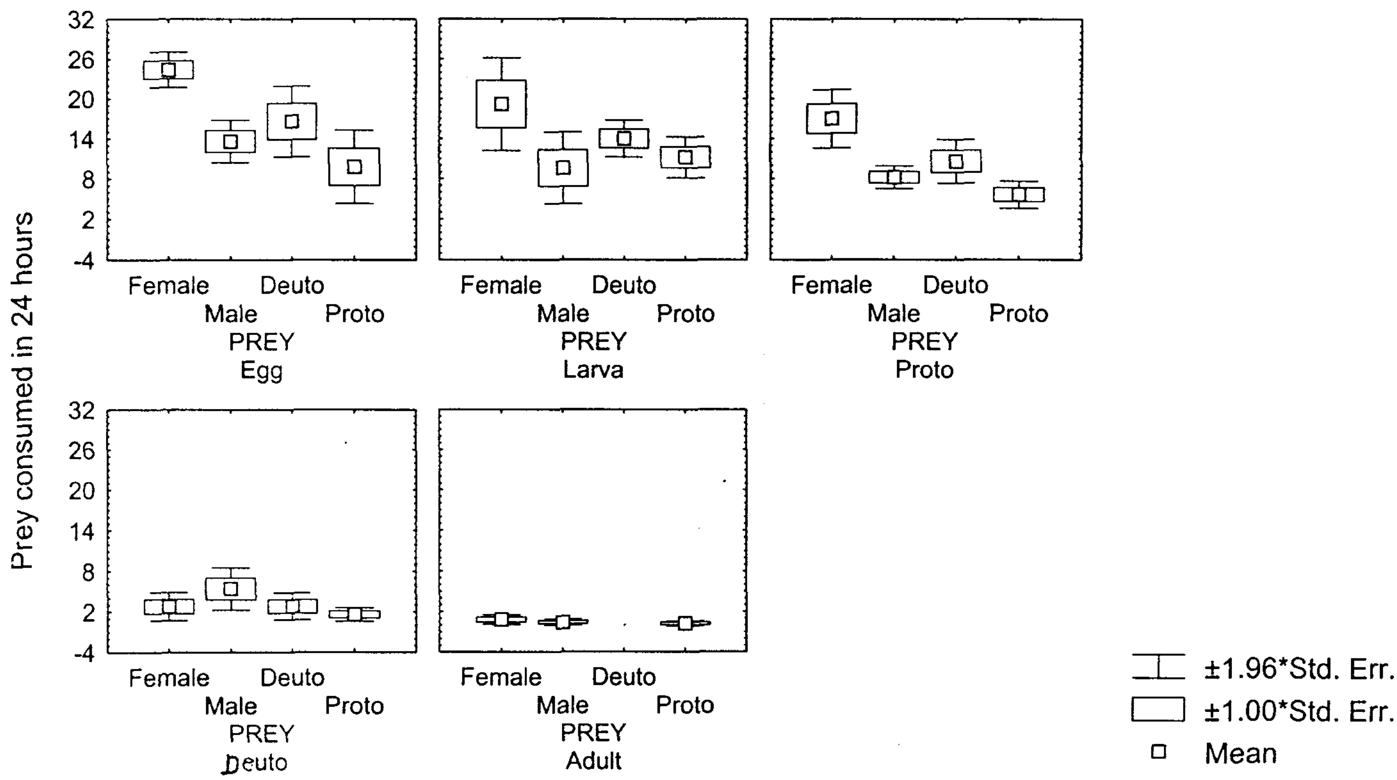
4. Predator - Deutonympy

Prey / Prey	E	L	P	D	A
E	--	0.999	0.999	0.917	0.924
L	--	--	0.999	0.724	0.447
P	--	--	--	0.999	0.999
D	--	--	--	--	0.999
A	--	--	--	--	--

Significance level at $\leq$ 0.01
* shows high significant differences.

PLATE 66

Categorized Plot for the rate of consumption by different stages of *A.(N.) longispinosus* on *T.neocaledonicus* in 24 hrs.



T. neocaledonicus. The rate of consumption was decreased in the order female > deutonymph > male > protonymph. While in the case of prey larva also the consumption rate was in the order female > deutonymph > male > protonymph. In the case of prey protonymphal stage, it was in the order female > deutonymph > male > protonymph. When the prey stage was deutonymph the consumption rate decreased in the order male > deutonymph > female > protonymph. In the case of prey adult stage the rate of consumption of *A. (N.) longispinosus* was in the order female > male > protonymph. The predator deutonymphal stage was a non feeder of adult prey. Since the predator *A. (N.) longispinosus* deutonymphal stage was a non feeding stage (missing cell) ANOVA could not be performed (Plate 65 and 66).

Taking into consideration the consumption rates of different stages of *A. (E.) finlandicus* against different stages of *T. neocalendonicus* in 24 hours, normal plots were drawn for testing the validity of the assumption of normality. As shown in Plate 67, in all the 20 categories the points were closed to a positively slopped straight line, hence the assumption of normality is valid.

The graph 68 represents the mean number of life stages of *T. neocaledonicus* consumed by *A. (E.) finlandicus* in 24 hours. As indicated in the graph, females of *A. (E.) finlandicus* exhibited the maximum rate of consumption on the eggs of *T. neocaledonicus*. The rate of consumption of the eggs of *T. neocaledonicus* by different stages of *A. (E.) finlandicus* decreased in the order male > larva > deutonymph > protonymph. In the case of prey larva, the rates of consumption

PLATE 67

Catagorised Normal Plot for the rate of consumption by different stages of *A.(E.)finlandicus* on *T.neocaledonicus* in 24 hrs.

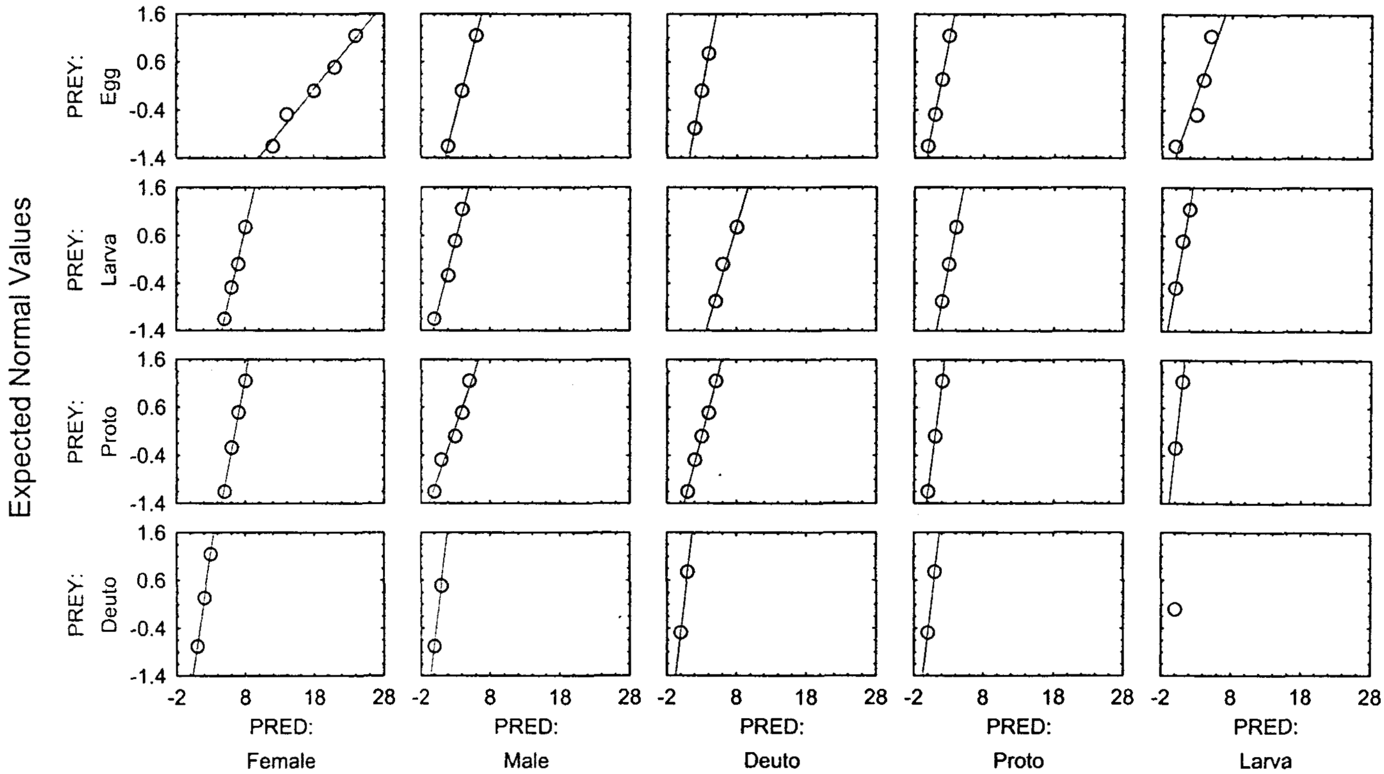
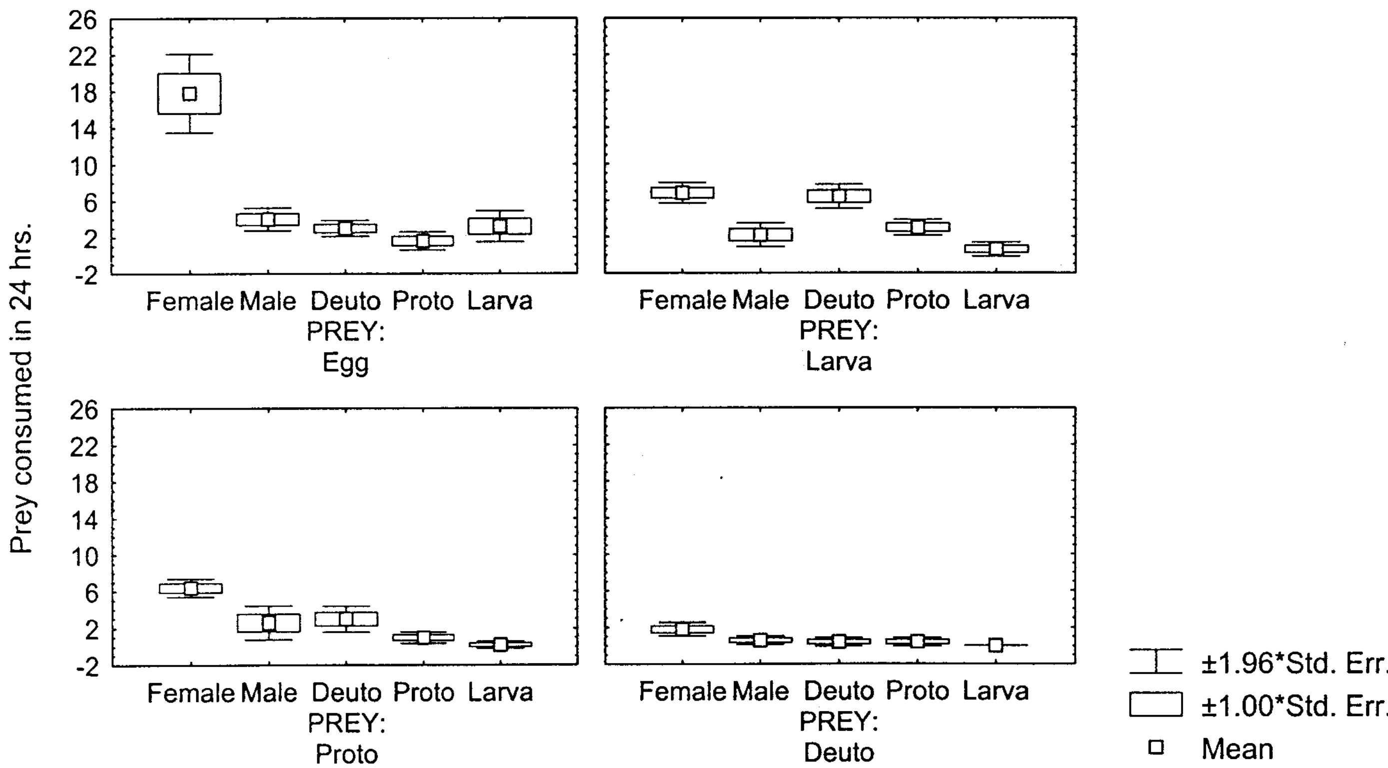


PLATE 68

Categorized Plot for the rate of consumption by different stages of *A.(E.)finlandicus* on *T.neocaledonicus* in 24 hrs.



were in the order female > deutonymph > protonymph > male > larva. In the third case, the average rates of consumption of protoymphal stages of *T. neocaledonicus* by the different stages of *A. (E.) finlandicus* were in the order of preference, female > deutonymph > male > protonymph > larva. In the case of deutonymphal stages of the prey it was in the order of preference female > male > deutonymph > protonymph > larva.

The data obtained on the predatory habit of different stages of *A. (E.) finlandicus* on various stages of the pest mite, *T. neocaledonicus* when analysed statistically adopting Scheffe test revealed various significant combinations of predators Vs. prey as presented in table 7. As shown in the table, smaller probability always indicated high significance, when the significance level at 0.01 (< 0.01) was considered to be highly significant against the interactions of the predator and prey stages.

The predatory habit of *A. (E.) finlandicus* on *T. neocaledonicus* was analysed using two way ANOVA model. Here effect of different stages of *A. (E.) finlandicus* on different stages of *T. neocaledonicus* and their interactions were tested, and found that the effects of different stages of predator were different for different stages of prey, since the p-values were less than 0.01 which showed high significance (Table 8).

TABLE 7

Significant combinations of different stages of the predator, *A. (E.) finlandicus* against different stages of the prey mite, *T. neocaledonicus* using Scheffe Test

1. Predator - Female

Pre \ Prey	Egg	Larva	Proto	Deuto
Egg	--	0.000*	0.000*	0.000*
Larva	--	--	.999	0.207
Proto	--	--	--	0.367
Deuto	--	--	--	--

2. Predator - Male

Pre \ Prey	Egg	Larva	Proto	Deuto
Egg	--	0.999	0.999	0.895
Larva	--	--	0.999	0.999
Proto	--	--	--	0.999
Deuto	--	--	--	--

3. Predator - Deutonymph

Pre \ Prey	Egg	Larva	Proto	Deuto
Egg	--	0.895	0.999	0.994
Larva	--	--	0.895	0.028
Proto	--	--	--	0.994
Deuto	--	--	--	--

4. Predator - Protonymph

Pre \ Prey	Egg	Larva	Proto	Deuto
Egg	--	0.999	0.999	0.999
Larva	--	--	0.999	0.994
Proto	--	--	--	0.999
Deuto	--	--	--	--

5. Predator - Larva

Pre \ Prey	Egg	Larva	Proto	Deuto
Egg	--	0.994	0.988	0.939
Larva	--	--	0.999	0.999
Proto	--	--	--	0.999
Deuto	--	--	--	--

* shows high significance, since the p-value < 0.01.

TABLE 8

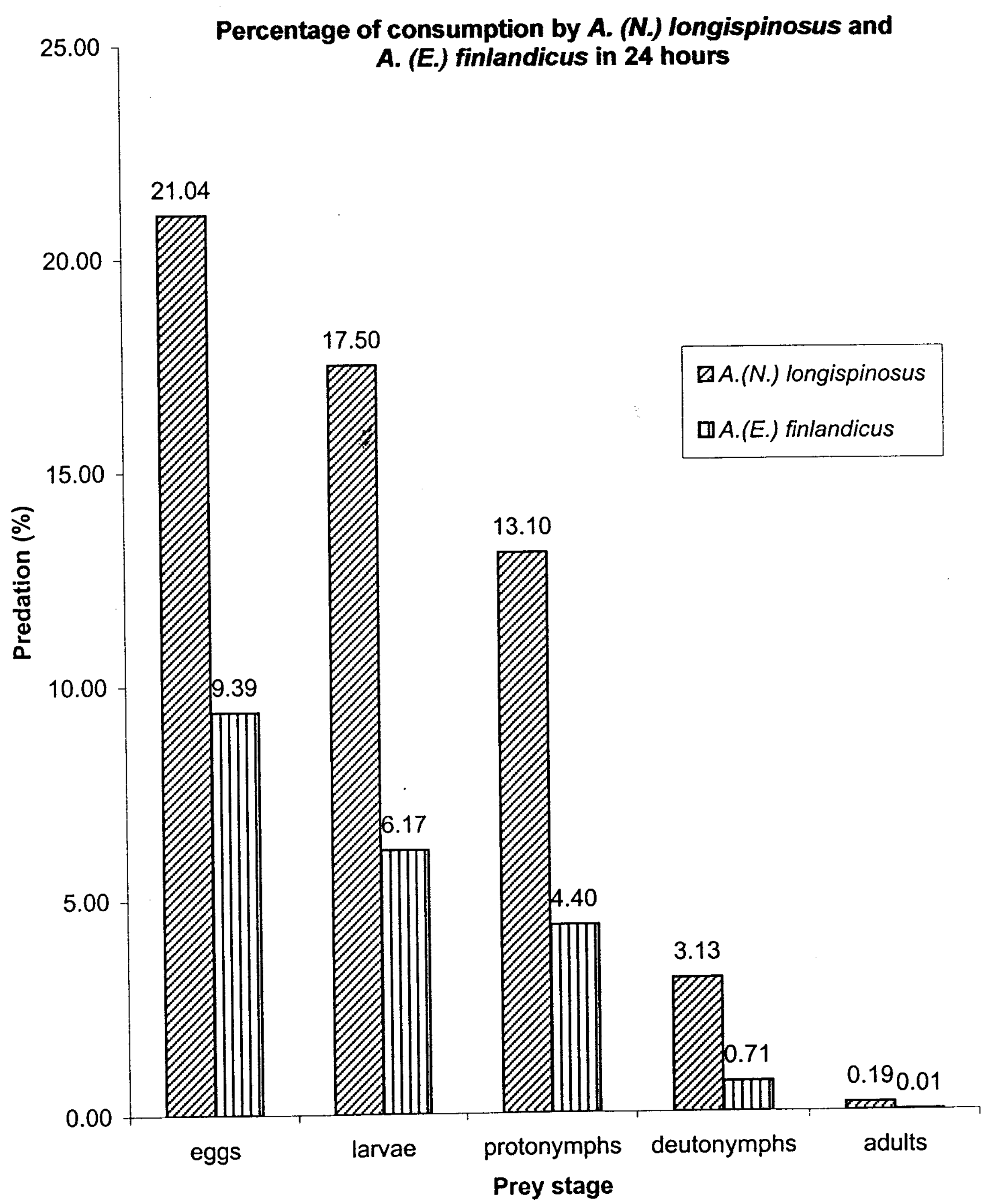
Effect of feeding of *A. (E.) finlandicus* on various stages of *T. neocaledonicus* in 24 hrs (Two-way ANOVA Model)

	df Effect	MS Effect	df Error	F	p-level
Predator	3	121.7967	2.53	48.1409	7.00847 E 18 ***
Prey	4	167.2	2.53	66.0869	1.39592 E 24***
Interaction	12	41.5133	2.53	16.4084	6.29547 E 17***

*** denotes high significance.

Among the two predators evaluated, consumption by all stages of *A. (N.) longispinosus* was significantly higher compared to the stages of *A. (E.) finlandicus* (Table 5; Plate 69 and 70). Irrespective of the predator, the eggs of *T. neocaledonicus* were more susceptible followed by larvae and protonymph (Plate 69). The adults and deutonymphs were the least preferred stages by both predator (Plate 69, 70 and 71).

PLATE 69



Percentage of consumption by *A. (N.) longispinosus* and *A. (E.) finlandicus* in 24 hours
25.00
20.00
15.00
10.00
5.00
0.00
Predation (%)
21.04
9.39
17.50
6.17
13.10
4.40
3.13
0.71
0.19
0.01
A.(N.) longispinosus
A.(E.) finlandicus
eggs
larvae
protonymphs
deutonymphs
adults
Prey stage

PLATE 70

Comparison graph of prey consumption by different stages of *A.(E.)finlandicus* and *A.(N.)longispinosus* on *T.neocaledonicus* in 24 hrs.

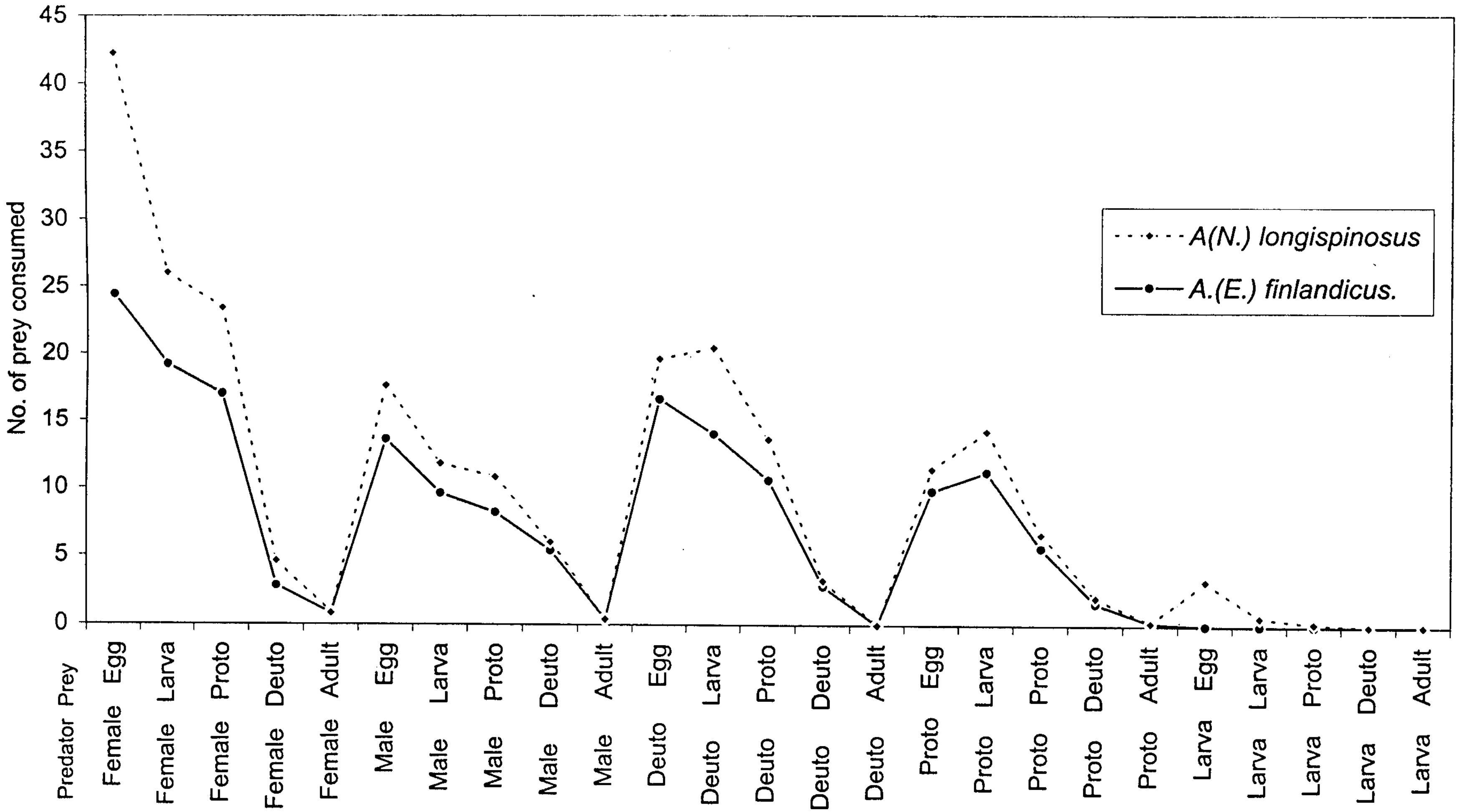
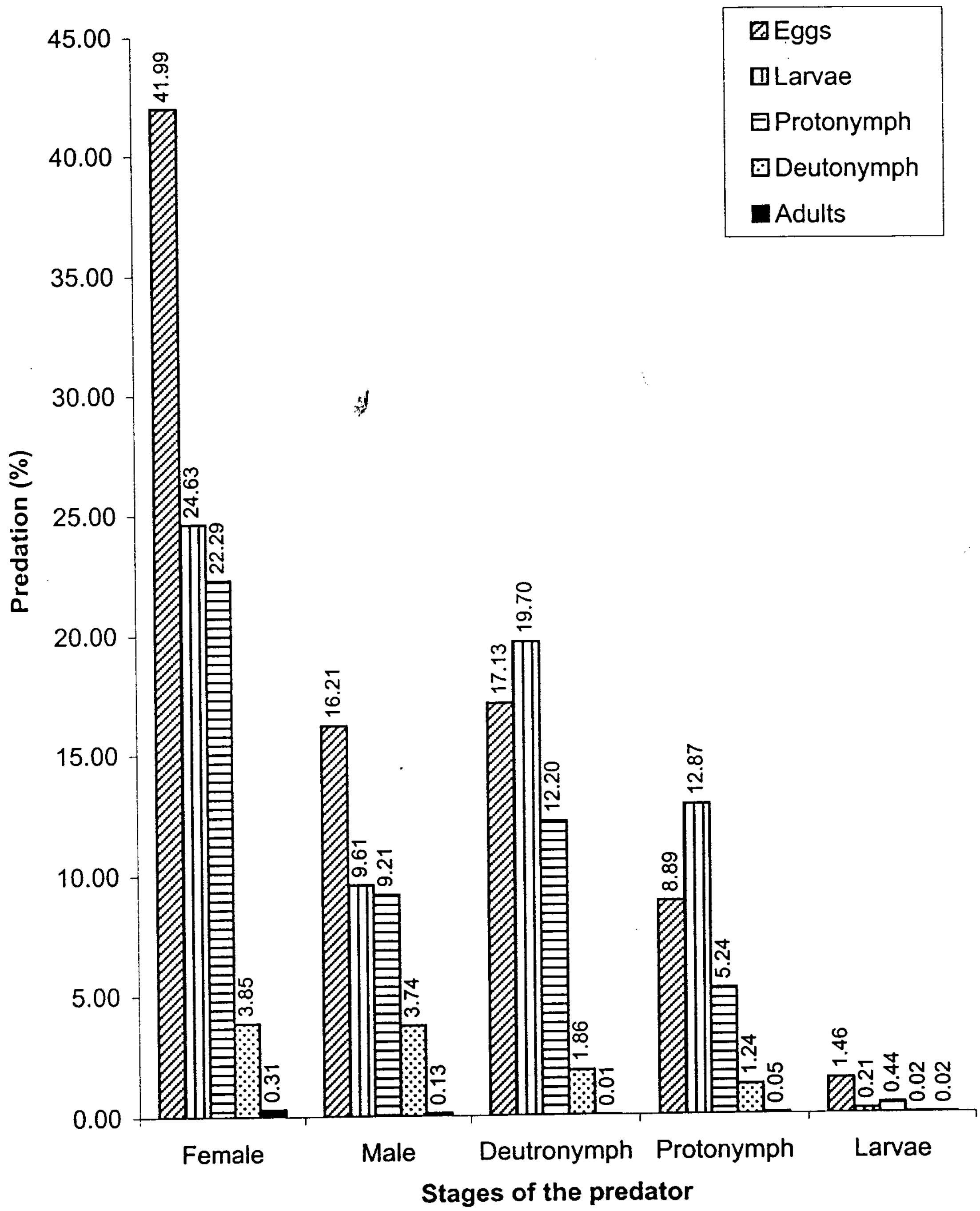


PLATE 71

Predation percentage of different stages of the predatory mites on different stages of the prey mite in 24 hrs



PART III
OBSERVATIONS ON BREEDING BIOLOGY

CHAPTER 11

OBSERVATIONS ON BREEDING BIOLOGY

II.1. DEVELOPMENTAL STUDIES OF *AMBLYSEIUS (NEOSEIULUS) LONGISPINOSUS* (EVANS)

II.1.1. Mating behaviour

The process of mating in *A. (N.) longispinosus* (Plate 74, Fig. 1) as observed during the present study was quite a prolonged process continuing for several minutes. To begin with, the male was found searching for females more vigorously than female did for males. After locating the female, in its vicinity, the male was found climbing on the back of the female so that both the mites were facing in the same direction. Such paired mites were found running about on the leaf surface. The male then turned 180° and moved posteriorly to reach under the female so that the venter of both the sexes could face each other. Then the male clasped around the female abdomen with its legs in such a way that its posterior hysterosomal margin was seen beyond that of the female. The paired sexes were found moving very fast on the leaf surface. The males' first pair of legs were stretched forward, clasping the female between the first and second pairs of legs, while the third and fourth pairs of legs were clasped around the female's hysterosoma. Then the male was found lifting the female's hysterosoma so that the latter appeared to move up and down. Then the couples turned around twice. In the next position male came down a little and changed its position. It then moved forwards and backwards and got separated from the female and moved fastly. The female remained stationary for some time and then moved and started feeding on the eggs of the prey. Female predator in paired position was found occasionally sucking the juices of the predator larva as well as the eggs thereby exhibiting a cannibalistic trend. The average time taken for mating behaviour lasted for an average of 32.45 minutes.

The same pairs sometimes copulated repeatedly even on the same day. Male often showed several variations in the pattern of copulatory behaviour.

II.1.2. Oviposition

The process of oviposition in *A. (N.) longispinosus* was initiated after mating. The average time taken for the deposition of eggs after the process of mating as observed during the study was 1.4 (1-2) days. Eggs were laid singly in horizontal position generally near the midrib or on the web or anywhere on the leaf surface, and were glued to the leaf surface by a sticky material released by the female. The number of eggs laid by a single female often showed variation and at certain instances 8-9 eggs were located on a single leaf in the field.

II.1.3. Incubation, hatching and emergence of the larva

Freshly laid eggs were transparent, white, shining (Plate 74, Fig. 3) and gradually turned dirty white (opaque). Eggs prior to hatching became half transparent and half opaque and swollen in appearance. The initiation of hatching was marked by the appearance of 4 white lines on one side more or less at the middle region of the egg. These lines then were found converging and run downwards. Subsequently a deep slit was found formed on one side at the region of the mark formation, through which the larval hysterosoma protruded out. The vigorous tilting of the legs and wriggling movements of the body then resulted in the complete extrusion of the larva from the egg case. The egg case was then seen attached to the mouth parts and first pair of legs, and the same was found removed by the wriggling movement of the second pair of legs. The process of hatching required 20-30 minutes for completion.

II.1.4. Duration of developmental stages

Larva

Laboratory studies on the biology of *A. (N.) longispinosus* showed that the eggs laid by the gravid females hatched within 37.45-47.30 hrs (Table 9). The newly emerged larva (Plate 72, 74 Fig. 3) was glittering white with 3 pairs of legs. The larva was found resting for a few minutes after emergence and then started moving about on the leaf surface. Occasionally larva was found nibbling on the leaf surface without producing any conspicuous feeding marks. The larva did not exhibit any sign of feeding, it was found wandering on the leaf surface for 1-2.30 hrs and then became inactive. This stage was recognised as the first quiescent stage. During this period the larva took rest with its first pair of legs pointing anteriorly while its mouth parts and the posterior end of the hysterosoma became squarish in appearance. The first quiescent stage lasted for 9.45-13.30 hrs (Table 9).

Protonymph

The newly emerged protonymph (Plate 74, Fig. 6) had 4 pairs of legs and was white in colour with light greenish tinch. The protonymph was found actively moving around and then initiated the feeding activity. After an average of one hour the colour was changed to light brown due to sucking the prey egg and larval stages. The active period of protonymph lasted for 8-12 hrs (Table 9) and then entered into second quiescent stage which lasted for 8-12.30 hrs (Table 9). Total protonymphal period was 19.30-22.30 hrs.

Deutonymph

After the second moulting, the deutonymph emerged (Plate 74, Fig. 4) which appeared more active and larger than the protonymph. It was similar to the adult but smaller in size. Under laboratory condition the deutonymph fed voraciously on the prey mites. After 10-12.30 hrs (Table 9) of active period it underwent quiescence. Total deutonymphal period was noted as 18.30-23 hrs (Table 9).

Quiescent stages

Quiescent mites were not totally inactive although they did not feed and remained stationary at one place. They were found moving about slightly when disturbed. On quiescence the instar assumed a characteristic posture, the first pair of legs were stretched infront along with mouth parts, the posterior legs were spread backward and the posterior end of the body was held slightly raised. Quiescent individuals made characteristic movements twisting their body side ways and these movements became frequent as the process of moulting approached.

Moulting and emergence

Just before moulting, the quiescent stage became turgid and swollen in appearance. The movements of the respective active stages could be observed clearly at this stage on higher magnification. A longitudinal slit appeared at the posterior end and it progressed further through which the hysterosoma and legs were extruded. The slit widened gradually and the constant movements of the legs and wriggling movements of the body led to the emergence of the active stage leaving behind the moulting skin. The moulting skin appeared to be entire but wrinkled. The whole process of moulting was completed within 20-30 minutes.

Thus, laboratory studies revealed that *A. (N.) longispinosus* completed its development from egg to adult within 93.15-93.30 for males and 97.30-104.30 for females (Table 9). It was noted that the longevity of the female took an average of

22 days and that of male was 18.2 days. The average number of eggs laid by the female was 44 during an oviposition period of 15 days.

II.1.5. Morphological descriptions of the developmental stages

Egg

Eggs are slightly longer than wide, being wider near one end. Freshly laid appear transparent white, gradually turning to opaque white. When examined under higher magnification, the surface of eggs appeared rough. The yolk granules are seen evenly distributed with in the egg. The eggs measures 180-195 in length and 150 in width (Table 10).

Larva

Soon after emergence the larva (Plate 72) appeared as shining and glisténing white in colour with 3 pairs of legs. Larva measures 204-268 long and 156-158 wide (Table 10) with 9 pairs of setae on the dorsum of the idiosoma. Seta Z_5 the longest and prominent j_6, J_2, Z_1, S_2, S_4, S_5, z_5, Z_4, r_3, R_1 absent. On the venter of the idiosoma 13 setae present. The second pair of sternal setae (ST_2), the preanal setae (PA_2) and all the 3 pairs of ventrolateral setae and JV_5 absent.

Protonymph

The newly moulted protonymph (Plate 72) had a shining appearance. All the 17 pairs of setae present in the adult were also present in this stage. It measures

270-282 long, 164-168 wide. Measurements of setae j_1 – 16, j_3 – 60, z_2 = 54, j_4 = 48, j_5 – 60, j_6 – 40, z_5 – 40, s_4 – 56, Z_1 – 68, s_1 – 50, S_2 – 65, J_2 – 68, S_4 – 68, Z_4 – 60, S_5 – 8, Z_5 – 90, J_5 – 10; r_3 = R_1 = 54 on lateral integument. Three pairs of sternal setae present. Metasternal plate with setae distinct. Genital setae visible. Three pairs of preanal setae present, 4 pairs of setae present around ventrianal shield. Metapodal plates not visible.

Deutonymph

Deutonymph (Plate 72) resembles the adult but little smaller in size. It measures 298-312 in long and 170-172 (Table 10) wide with 17 pairs of setae. Setae j_1 – 18, j_3 – 65, z_2 – 60, j_4 – 55, j_5 – 70, j_6 – 70, z_5 – 45, s_4 – 68, Z_1 – 75, S_1 – 58, S_2 – 76, J_2 – 70, S_4 – 74, Z_4 – 70, S_5 – 10, Z_5 – 92 and J_5 – 12. Sublateral setae r_3 and R_1 55 long, present on the lateral integument.

Female and Male

Females (Plate 74, Fig. 5) with 17 pairs of setae measuring 325-338 in length and 180-190 width (Table 10). Morphological descriptions of females are given in Chapter 5. Males (Plate 72) also with 17 pairs of setae, measuring 296-302 in length and 164-174 width (Table 10). Morphological descriptions are given in Chapter 5.

TABLE 9

Duration of development of *A. (N.) longispinosis* in hours

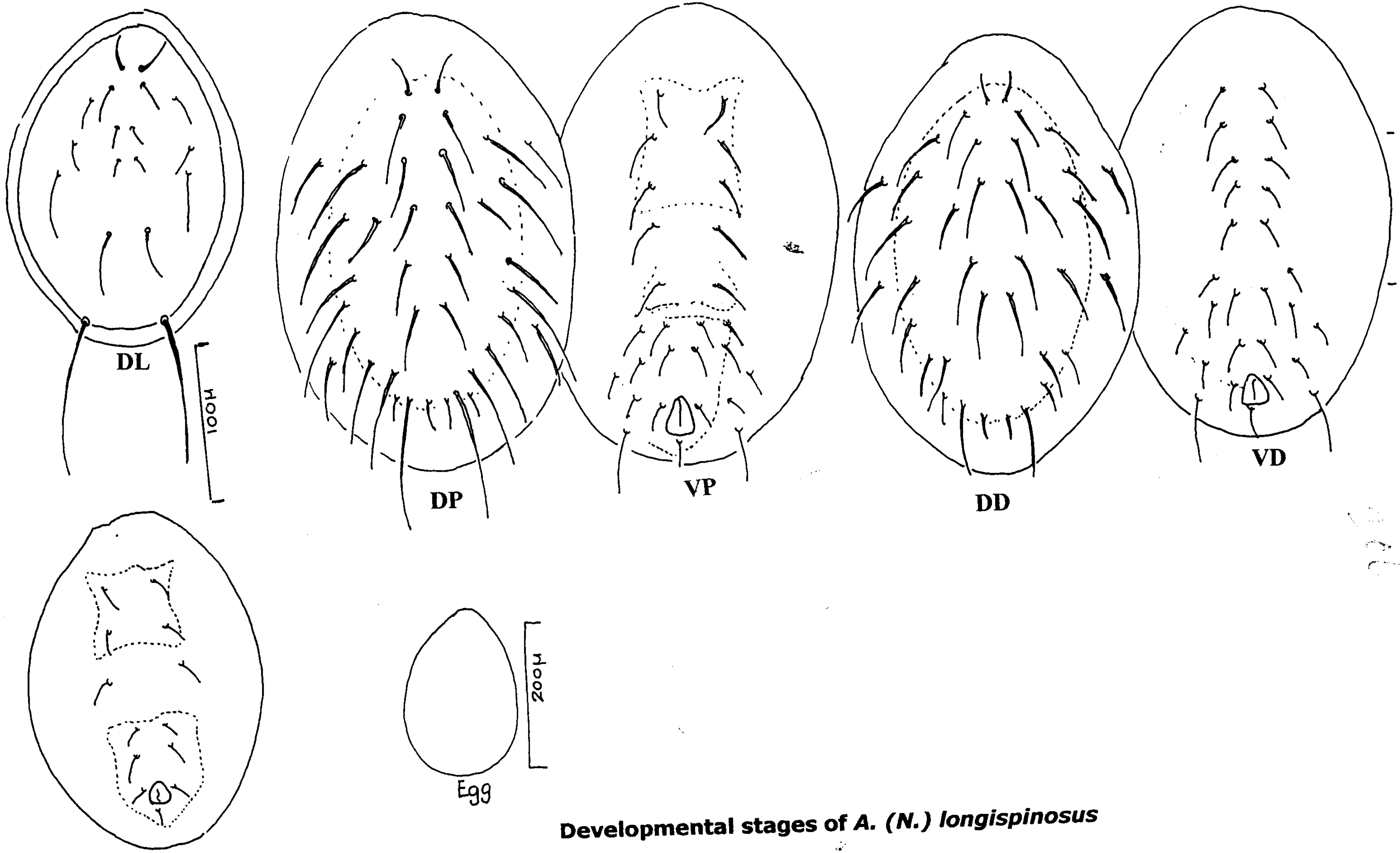
Sl. No.	Incuba-tion	Larval period		Protonymphal period		Deutonymphal period		Total
		Active	Q I	Active	Q II	Active	Q III	
1	44	2	13.30	8	12	10.30	8	98.00
2	45	1.30	11.00	8	11.30	12.30	8.30	98.00
3	43.30	1.30	10.00	9.30	11.30	12	10.30	98.30
4	47.30	2.30	12.30	12	8.00	12	10	104.30
5	37.45	2	10	10	12.30	12	9.15	93.30
6	43.30	2.30	11.00	9.30	10.30	10	10.30	97.30
7	39	1	11.30	12	8.30	11	10.15	93.15
8	40.30	2.15	9.45	12	10.30	11.30	11.30	98.00
9	43.30	2.30	11.00	9.30	10.30	10	10.30	97.30
10	39	1	11.30	12	8.30	11	10.15	93.15
Range	37.45-45	1-2.30	9.45-13.30	8-12	8-12.30	10-12.30	8-11.30	

TABLE 10

Measurements of life stages of *A. (N.) longispinosus*

Sl. No.	Egg		Larva		Protonymph		Deutonymph		Female		Male	
	L	W	L	W	L	W	L	W	L	W	L	W
1	195	150	266	156	282	164	310	172	336	188	298	170
2	180	150	262	156	278	166	312	172	328	182	296	174
3	180	150	264	158	278	166	308	170	325	180	296	174
4	195	150	268	156	276	164	306	170	330	184	298	170
5	180	150	264	158	280	168	300	170	328	180	300	174
6	180	150	268	156	274	166	298	172	328	184	300	170
7	180	150	262	157	274	164	304	170	338	190	302	170
8	195	150	264	157	282	168	304	172	332	184	298	170
9	195	150	204	157	270	168	302	170	338	182	296	168
10	180	150	268	158	278	168	300	170	336	186	296	164
Range	180-195	150	204-268	156-158	270-282	164-168	298-312	170-172.	325-338	180-190	296-302	164-174

PLATE 72



Developmental stages of *A. (N.) longispinosus*

11.2. DEVELOPMENTAL STUDIES OF *AMBLYSEIUS (EUSEIUS) FINLANDICUS* (OUDEMANAS)

11.2.1. Mating behaviour

The mating behaviour (Plate 74, Fig. 2) exhibited by *A. (E.) finlandicus* was similar to that of *A. (N.) longispinosus*. But the duration of mating was found varying. The time taken for mating lasted for an average of 42 (36-48) minutes. Often the same pairs copulated repeatedly on the same day.

11.2.2. Oviposition

The process of oviposition in *A. (E.) finlandicus* was initiated after mating. The average time taken for the deposition of eggs after copulation was 2 (1.6-2.3) days. Eggs were laid singly in horizontal position generally near the mid rib or anywhere on the leaf surface and were glued to the leaf surface by a sticky material released by the female. Females laid an average of 20.45 eggs during an oviposition period of 18 days.

II.2.3. Incubation, hatching and emergence of larva

Freshly laid eggs were glistening white in colour. As development proceeded, it became slightly opaque at its narrow end changed into cream yellow before hatching. A deep slit was found formed transversely in the middle region and the larval hysterosoma came out first followed by legs and mouth parts. The process of hatching required 20-30 minutes for completion.

11.2.4. Duration of developmental stages

Larva

In the laboratory condition the eggs laid by the females hatched with in 34.30-37 hrs (Table 11). The newly emerged larva appeared as transluscent and shining and rested for a few minutes and then started moving in search of prey.The contents in its gut could be seen through its transparent integument. After a period of 6-10 hrs of activity the larva became inactive called first quiescent stage. After a period of 4-18 hrs (Table 11) of quiescence the larva moulted into the next active stage, the protonymph.

Protonymph

Newly emerged protonymphs were yellowish and transluscent with 4 plairs of legs. After an average of 30 minutes the protonymph initiated feeding and its gut assumed the colour of the ingested food obtained from the body of the prey. The active period of the protonymph lasted for 10-14 hours (Table 11) and then entered into the second quiescent stage which lasted for 10-18 hours. The total protonymphal period was 17.30-29.00 hours.

Deutonymph

After the second moulting the deutonymph emerged which appeared more active and larger than the protonymph. After 4-8 hours (Table 11) it entered into the next quiescent stage for a period of 10-14 hours (Table 11). Deutonymph moulted into either female or male.

Thus the results of laboratory studies revealed that *A. (E.) finlandicus* completed its development from egg to adult within 90-96 hours for males and 102-108 hrs for females (Table 11).

11.1.5. Morphological descriptions of developmental stages

Egg

Freshly laid eggs appeared oval, soft, clear, transluscent and glistening white in colour, measuring 100-112 in length and 112 in width (Table 12). The yolk granules are seen evenly distributed with in the egg.

Larva

Larva measures 180-195 in length and 128-135 in width (Table 12). The larva possesses 12 pairs of setae (Plate 73). Each chelicera with 3 teeth on the fixed digit and none on the movable digit. On the dorsal side a pair of vertical setae present at the anterior end (24 long). There are 4 pairs of prolateral setae (8, 8, 14 and 60 respectively), 3 pairs of dorsocentral setae (4, 4, 12 respectively). At the posterior end a pair of whip like post lateral setae (120 long) present. Clunal setae (J_5), sublateral setae r_3, R_1, pertreme etc. absent at this stage.

On the ventral side 3 pairs of setae (6, 6 and 8 respectively) seen on the sternal shield area. Ventral shields not developed. Three pairs of preanal setae, a pair of anal setae and a post anal setae present.

Protonymph

Protonymph is transluscent and yellowish in colour, measuring 220-235 in length and 155-160 in width (Plate 73) with 4 pairs of legs. Protonymph possesses 4 pairs of dorsocentral setae (4, 6, 18, 16 long), 5 pairs of postlateral setae (14, 16, 16, 16 and 42 long), 4 pairs of prolateral setae (12, 14, 28, 40 respectively), 2 pairs of medio-lateral setae, a pair of clunal setae and 2 pairs of sublateral setae ($r_3 = R_1 = 12$ long) were present on the dorsum. Peritreme starts its appearance.

The venter possesses 3 pairs of seternal setae (18 long), 3 pairs of preanal setae, a pair of anal setae, a pair of ventrocaudal setae and a post anal setae.

Deutonymph

Deutonymph is yellowish in colour (Plate 73), measuring 250-280 in length and 168-180 width. It resembles the protonymph except in size and additional structures like the appearance of sternal shield, metasternal and genital setae. Peritreme is more pronounced. Vertical setae (j_1 – 32), prolateral setae (16, 24, 28, 52), dorsocentral setae (9, 10, 20, 20), 5 pairs of post lateral setae (18, 26, 26, 26, 60), 2 pairs of mediolateral and sublateral setae and a pair of clunal setae present. Peritreme extends upto r_3. Ventral side with 3 pairs of sternal setae (18 long), a pair of metasternal setae and a pair of genital setae (18 long).

Female and male

The morphological details of adults (Plate 74, Figs.7 and 8) were discussed in Chapter 5.

TABLE 11

Duration of development of *A. (E.) finlandicus* in hours

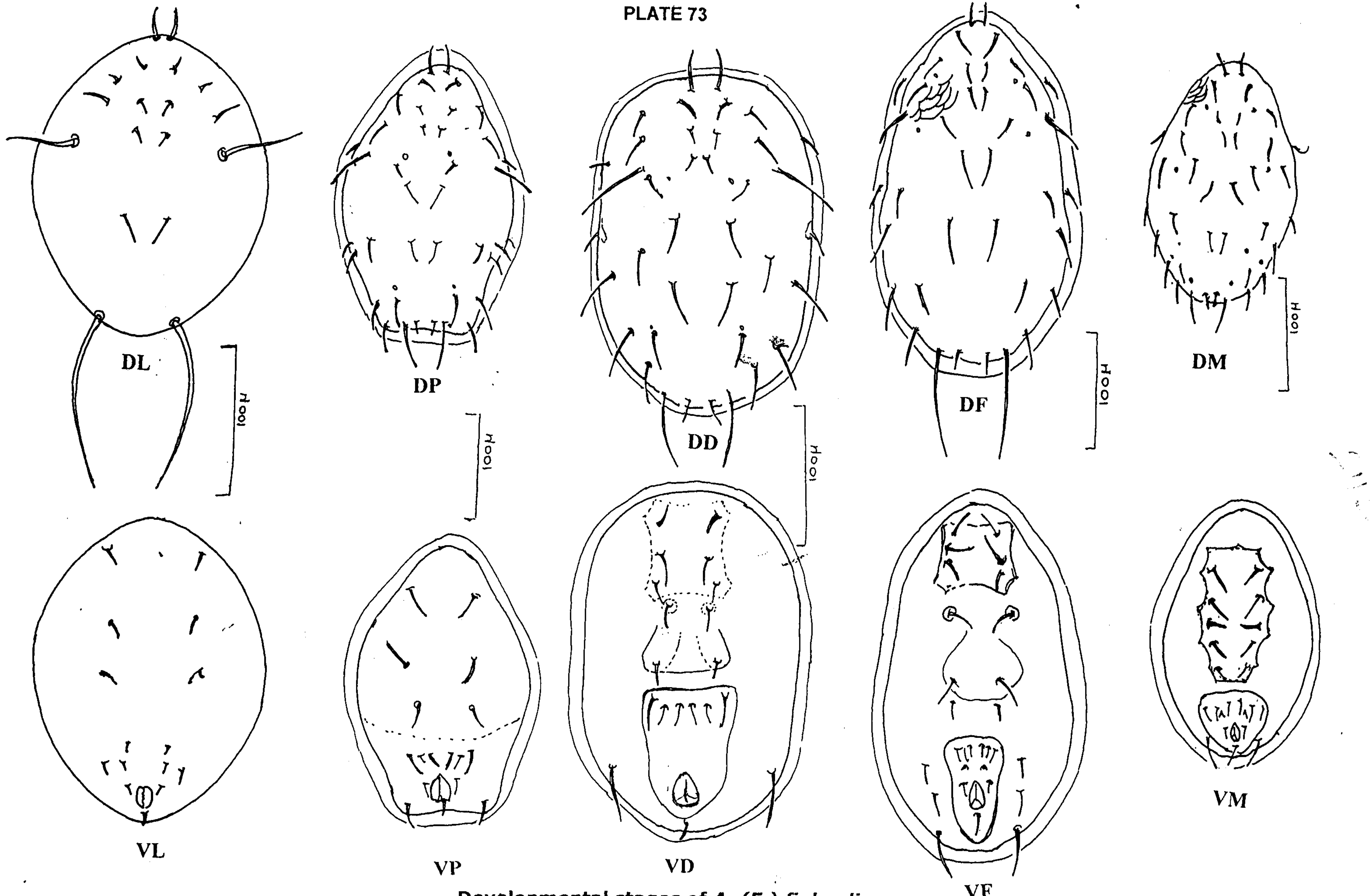
Sl. No.	Incubation	Larval period		Protonymphal period		Deutonymphal period		Total
		Active	Q I	Active	Q II	Active	Q III	
1	36.30	6.00	4.30	12.00	15.30	5.30	10.00	90.00
2	37.00	10.00	4.00	11.00	16.00	8.00	10.00	96.00
3	34.30	6.45	17.15	12.30	16.00	4.00	12.00	102.15
4	35.00	8.30	15.320	14.00	12.00	6.00	13.00	104.00
5	37.00	6.00	18.00	10.00	18.00	5.30	14.00	108.00
6	36.30	8.00	14.00	13.00	16.00	8.00	10.00	105.30
7	36.45	10.00	15.00	12.00	10.00	5.00	14.00	102.45
8	37.00	6.00	16.00	12.30	13.30	4.00	13.00	102.00
9	35.00	8.00	14.00	14.00	12.00	6.00	13.00	102.00
10	36.30	8.30	13.30	12.30	12.00	8.00	11.00	102.00
Range	34.30-37.00	6.00-10.00	4.00-.18.00	10.00-14.00	10.00-18.00	4.00-8.00	10.00-14.00	90.00-108.00

TABLE 12

Measurements of life stages of *A. (E.) finlandicus*

Sl. No.	Egg		Larva		Protonymph		Deutonymph		Female		Male	
	L	W	L	W	L	W	L	W	L	W	L	W
1	112	150	195	135	220	155	250	168	315	198	260	180
2	100	125	180	128	230	160	265	1789	330	240	225	165
3	112	150	180	128	230	160	265	178	295	192	225	165
4	112	150	195	135	230	160	265	174	295	192	240	180
5	100	150	180	128	230	160	280	174	315	255	260	180
6	112	150	195	130	220	155	265	178	300	240	225	165
7	112	150	180	135	235	165	265	18	300	240	240	180
8	100	125	195	130	235	165	280	170	300	240	240	165
9	100	125	180	135	230	160	265	168	295	192	225	165
10	112	150	195	130	220	155	280	180	330	240	260	180
Range	100-112	125-150	180-195	128-135	220-235	155-160	250-280	168-180	295-330	192-240	225-260	165-180

PLATE 73



Developmental stages of *A. (E.) finlandicus*

PLATE 74

Figs. 1-8. Breeding Biology

Fig. 1. Mating behaviour of *A. (N.) longispinosus*

2. Mating behaviour of *A. (E.) finlandicus*

3. Eggs and larva of *A. (N.) longispinosus*

4. Deutonymph of *A. (N.) longispinosus*

5. Adult female of *A. (N.) longispinosus*

6. Protonymph of *A. (N.) longispinosus*

7. Adult male of *A. (E.) finlandicus*

8. Adult female of *A. (E.) finlandicus*

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DISCUSSION

CHAPTER 12

DISCUSSION

During the period of the present work, a survey was conducted on the predatory mites infesting 55 species of economically important plants and a few items of stored products from various localities distributed in 6 districts of Northern Kerala. The results of the survey yielded a total of 45 species belonging to 9 genera, 7 subgenera and 5 families of the suborders Mesostigmata and Prostigmata. The suborder Mesostigmata was found represented by a single family Phytoseiidae while Prostigmata comprised of 4 families. However the species diversity of Mesostigmata was remarkable, as the family Phytoseiidae constituted the largest family of predatory mites comprising 32 species out of the total 45 recovered during the study. This observation clearly reveals the prevalence of phytoseiid mites on the crop plants of Kerala. The family Phytoseiidae has been reported as the largest family of Gamasida (Mesostigmata) with more than 1000 described species and are gaining importance for their role in the biological control of tetranychid mites in various agroecosystems (Mc Murtry, 1982; Mc Murtry and Rodriguez, 1989). Chant and Yoshida-Shaul (1992a) have mentioned that more than 164 species of phytoseiid have been described in the world and they further opine that this trend would keep increasing mainly under the two subfamilies Amblyseiinae and Phytoseiinae of the family Phytoseiidae. However our knowledge on the phytoseiid mites of Kerala is still in its infancy as only 168 species under 12 genera were reported so far from India (Gupta and Arun Gupta, 1999). In this context, the results of the present study appear to be quite encouraging as 32 species including 12 new species could be recovered during the study.

The present investigation not only helped to reveal the species diversity of phytoseiid mites in India but also served to add 12 new species to the family. The rich and varied agroecosystems of Kerala foster several new and interesting fauna of phytoseiid mites. Extensive studies on the feeding and breeding aspects of these new taxa may serve to open new avenues in the field of biological control for the effective management of spider mites and also insects to a certain extent. The recovery of a phytoseiid species from coffee berries stored for two years from one of the godowns at Mananthavady, Wayanad appears to be quite encouraging. The occurrence of phytoseiids in stored products is a very rare phenomenon, though isolated examples exist for the occurrence of members of *Amblyseius* and *Neoseiulus* in stored grains (Hughes, 1976; Smiley, 1984b). The species of *Amblyseius* collected from stored coffee berries could be recognized as a new taxon.

The results of the present study reveal the prevalence and species diversity of the genus *Amblyseius* belonging to the family Phytoseiidae on the various species of plants surveyed. Most of these were found in association with tetranychid mites and insects. The phytoseiid mites, especially those belonging to genera like *Amblyseius, Phytoseiulus, Typhlodromus* etc. have been considered as important as predators of tetranychids, eriophyids, tarsonemids, thrips, white flies and so on (Mc Murtry and Rodriguez, 1989). The distribution of species of *Amblyseius, Typhlodromus* and *Typhlodromalus* as observed during the study in association with spider mites and insects like coccids, white flies etc. also supports the above findings. However elaborate studies on the predatory habits of the above species are needed to confirm their predatory role on the above groups of insects and mites.

The suborder Prostigmata, though was recognized to exhibit the maximum family diversity, its species diversity was comparatively very low than the Mesostigmata. The recovered families under Prostigmata were Cheyletidae, Cunaxidae, Bdellidae and Stigmaeidae of which Cheyletidae supported the maximum number of species under a single genus *Cheyletus*. Of these, only a single species, *C. rosensis* was found inhabiting the arboreal ecosystem while the remaining 5 were recorded from various stored items. It appears quite encouraging that out of the 6 species of Cheyletid mites recovered during the study, 4 appeared to be new to science, of which one was collected from plants like *R. indica* and *C. nucifera* while the other 3 were collected from stored materials. This observation points to the fact that cheyletid mites represent a quite unstudied group in South India, particularly in Kerala and hence warrants more investigation on their taxonomic aspects. This seems to be highly essential since most of the cheyletid mites are important predators of various other groups of mites and insects (Sinha, 1968; Girish *et al.*, 1971; Mathur and Mathur, 1982; Kumar and Naqui, 1990). The predatory role of one of the new species viz., *C. ichthyus* infesting dry fish samples at Puthiyappa, Kozhikode could be well evidenced during the study. This species was found predating insect eggs readily. Out of the 60 samples collected during the course of the study 36 samples contained *C. eruditus* and 24 samples contain *C. malaccensis*. In stored ginger (*Zingiber officinale*) contained only *C. eruditus* and no other mites or insects. This indicates that in the absence of other mites and insects, it might be able to thrive on the stored grain or on its own species as they are known to exhibit cannibalistic trend (Mathur and Minocha, 1989).

During the present study 3 species of cunaxid mites categorised under 2 genera viz., *Cunaxa* and *Dactyloscirus* were recovered. The family Bdellidae was found represented by two new species under the genus *Bdella*. Two new species of family Stigmaeidae under the genera *Agistemus* and *Apostigmaeus* were also recovered. All the above families of mites still remain as relatively unstudied group in India except certain isolated examples (Gupta, 1985; 1986 and 1991), despite their significant predatory role. Further studies may reflect their potential in the field of biological control of pest.

Based on the results of the general survey, two species of phytoseiid mites viz., *A. (N.) longispinosus* and *A. (E.) finlandicus* were selected during the present study for detailed studies on their feeding and breeding aspects. Both the above species were recognized as common inhabitants on a variety of plants surveyed, irrespective of variations in habitat. For biological studies, the above two species were collected from cassava leaves, showing high infestation with the spider mite pest, *T. neocaledonicus* which served as the most favourable prey for both the species. Results of feeding studies revealed that both the species preferred the immature stages of the prey, rather than adult stage. The egg, which represented the non motile stage was the most favoured food for most of the life stages of the predatory mites and the order of preference exhibited a decreasing trend as follows: Egg > larva > protonymph > deutonymph > adult. Such an order of preference exhibited by another predatory mite, viz., *Typhlodromus occidentalis* to the life stages of the prey mite, *T. mcdanieli* was reported by Croft and McMurtry (1972), Sabelis (1985). This was true for the adults of both the predatory mites. The preference for the eggs and other immature stages of the prey mite, *T. ludeni* by the predator, *A. longispinosus* was also reported by Mallik (1982). However, a variation in the feeding trend could be observed among the life stages of the two predatory species during the present study. This was better evidenced in the case of larva of *A. (N.) longispinosus* which was proved as a non-feeding stage during the present study, showing no sign of feeding activity on any of the life stages of the prey mite. This observation was found supporting the earlier findings of Ibrahim and Palacio (1994) on *A. longispinosus*, the larva of which exhibited a non-feeding trend on *T. urticae*. This suggests that the larva of *A. longispinosus* probably may not have any role in the regulation of the pest mite in the field conditions also. Sometimes, the larva may have an alternate food choice in the field or it represents a non feeding stage. But, larva had the shortest duration, taking a mean time of 13.04 hrs, as observed during the study. Despite the above observation the larva of *A. (E.) finlandicus* was found feeding on all life stages of *T. neocaledonicus* except the adult stage. The larva of this species showed more preference to the eggs. However, the adult stage of the prey mite was not found predated by any of the life stages of the *A. (E.) finlandicus*. This suggests that *A. (N.) longispinosus* is the more efficient predator than *A. (E.) finlandicus*. The results of statistical analysis based on Scheffe test and 2 way ANOVA also support this by confirming that the consumption rates of all stages of *A. (N.) longispinosus* were significantly higher than that of *A. (E.) finlandicus*, thereby establishing it as a more efficient predator.

The rate of consumption by the individual stages of the predator on individual stages of the prey often showed considerable variations. Accordingly, the rate of consumption by the female of *A. (N.) longispinosus* was maximum on all stages of the prey mite except the deutonymphal stage of the prey. The maximum rate of consumption was observed in the case of prey eggs, reaching 48.79%, the minimum was on adults of the prey (1.02%). This was true for the males also. However, the percentage of consumption of deutonymphs by the males of *A. (N.) longispinosus* was comparatively higher than that of the female. In general, the predatory efficacy of deutonymphal stage of *A. (N.) longispinosus* was comparatively higher than that of the male. Thus the predatory efficacy of *A. (N.) longispinosus* decreased in the sequence Female > Deutonymph > Male > Protonymph. This was true for *A. (E.) finlandicus* also, though slight variations were observed often while feeding on eggs and deutonymph. In this species larva also was found feeding on the eggs, larva and protonymph of the prey. The protonymph and deutonymplh of *A. (E.) finlandicus* showed more preference to larva of the prey mite, rather than the eggs and other life stages. Thus, the results of the present study helped to establish the predatory efficacy of the females of both the predatory mites. The role of the females and deutonymphs in the control of pest mite will be more effective rather than that of the males and other developmental stages.

While conducting developmental studies of *A. (N.) longispinosus* and *A. (E.) finlandicus* in the laboratory, the males of both the species were found exhibiting varied patterns of mating. The process of mating was found initiated in both the species on the next day after emergence even though they were in association with the females in the culture cells. This seems to be quite contradictory to the earlier findings of El-Banhawy (1975), Amano and Chant (1978) and Hoy and Smilanick (1979) who could record mating immediately after moulting in *Amblyseius* species. The delay observed in *A. (N.) longispinosus* and *A. (E.) finlandicus* may be a reflection of the delay in the location of the females. It is reported that Rock *et al.* (1976), Hoy and Smilanick (1981), the males of phytoseiids get attracted to female sex pheromone at close range, which play an important role in mating behaviour. In the present study, the involvement of a sex pheromone may be suspected in the present two species also, but needs further studies for confirmation.

The time taken for mating in *A. (N.) longispinosus* and *A. (E.) finlandicus* was found varying as it was completed with an average of 32. 45 minutes in the former and 42 minutes in the latter species. The variation in time is often related to the degree of insemination in either one or both spermathecae, which in turn is related to egg production and has been reported in many species (Overmeer *et al*., 1982). Some species often require multiple matings even to complete oviposition (Amano and Chant, 1978; Eveleigh and Chant, 1981). Both the species involved in the present study also exhibited the same trend. Even the starved individuals often exhibited multiple matings. This points to the fact that starvation is not detrimental to the willingness to mate as observed earlier in *A. swirski* (Ragusa and Swirski, 1977) and *A. bibens* (Blommers and Van Arendonk, 1979). However the mated individuals were found feeding more vigorously than the unmated ones, thereby suggesting that mating process promotes feeding activity in both the species studied.

The process of oviposition was found initiated in *A. (N.) longispinosus* with an average of 1.4 days after mating. *A. (E.) finlandicus* also showed a similar trend. This time was reported to be varied in different species and the ovipositional period of individual species also showed considerable variation. Significantly longer ovipositional periods are recorded for species with multiple matings (Momen, 1993). However, even species with multiple matings also would exhibit shorter ovipositional period when exposed to different food deprivation programmes (Momen,1994). The shorter oviposition period as observed in *A. (N.) longispinosus* showed considerable variation and a single female was observed to lay a maximum of 28 eggs during its oviposition period. It is reported that (Sabelis, 1981) 60-70% of the ingested prey is utilized for egg production.

Prior to hatching, the eggs of *A. (N.) longispinosus* were found turned to opaque. Such a change in egg structure at the time of hatching was reported in the case of *Metaseiulus occidentalis* by Laing (1969). The change in colouration and texture may be due to the advancement of developmental processes taking place internally.

The rate of development and developmental duration of different species of phytoseiids were found greatly influenced by the differences in the prey and often by differences in the stage of the same prey. In the present study, the different stages of the same prey were offered as food item for both the species. *A. (N.) longispinosus* was found requiring 93.15 – 93.30 hrs for the completion of development from egg to adult in the case of males and 97.30 – 104.30 hrs in the case of females. In *A. (E.) finlandicus*, the developmental duration of male was 90-93 hrs and that of female was 99.15 – 105 hrs at a temperature of 27 $\pm$ 1°C. Thus in both the species, the time taken for male development was shorter. Longevity of females was comparatively greater in both the species. However, *A. (E.) finlandicus* was evidenced as the species with shorter developmental period and longer period of longevity.

SUMMARY

Predatory mites constitute an important group of natural enemies with well remarkable ability to suppress the insect/mite pest populations below the economic injury level. There is enough evidence that the members of the mite families like Phytoseiidae, Cheyletidae, Cunaxidae, Bdellidae, Stigmaeidae, Tydeidae, Ascidae, Anystidae etc. as potential predators of various mites/insects on various crops. Among the predatory mites, species of Phytoseiidae are potentially important as a biotic factor in the control of phytophagous mites of the families Tetranychidae, Tenuipalpidae, Eriophyidae and Tarsonemidae. In the current investigation, a general survey on the predatory mites harbouring various groups of economically important plants and stored items collected from different localities of Kerala, particularly North Kerala was undertaken. During the study period, a total of 55 species of plants belonging to 50 genera and 35 families representing fruit crops, vegetables, medicinal plants, condiments and spices, tuber crops, beverages, flowers, oil yielding plants, masticatory items and resin etc. were surveyed from different localities in 6 districts of North Kerala viz., Kasaragod, Kannur, Wayanad, Kozhikode, Malappuram and Palakkad. Apart from this, 13 stored items were also surveyed from different localities of Kozhikode and Wayanad districts.

Results of the survey enabled to recover 45 species of predatory mites belonging to 9 genera, 7 subgenera and 5 families categorised under two suborders

viz., Mesostigmata and Prostigmata. Of these, 20 species belonging to 5 genera could be recognized as new taxa. The suborder Mesostigmata included a single family Phytoseiidae. The family Phytoseiidae was distinguished as the most dominant and common taxon containing 32 species under 3 subfamilies viz., Amblyseiinae, Cydnodromellinae and Phytoseiinae. The genus *Amblyseius* belonging to the subfamily Amblyseiinae was the dominant one represented by 6 subgenera and 30 species thereby forming the most abundant genus of predatory mites surveyed during the study. The other genera recorded under Phytoseiidae were *Platyseiella* and *Typhlodromus* belonging to subfamilies Cydnodromellinae and Phytoseiinae respectively. The subgenera recorded under *Amblyseius* were *Amblyseius, Neoseiulus, Paraphytoseius, Typhlodromalus* and *Typhlodromips* represented by 15, 7, 3, 2, 1 and 2 species respectively. All the phytoseiid mites except one species could be recorded from different species of plants. *A. (A.) coffeae* sp. nov. was collected from coffee berries stored for two years.

Under the suborder Prostigmata, family Cheyletidae was found represented by 6 species under the genus *Cheyletus*, out of which 4 were new to science. Out of the 6 species encountered during the present study, 5 were collected from the various stored items surveyed, whereas *C. rosensis* sp. nov. could be collected from *R. indica* and *C. nucifera*.

The family Cunaxidae was found represented by 3 species categorised under 2 genera viz., *Cunaxa* and *Dactyloscirus* comprising 2 and 1 species respectively.

The family Bdellidae was found represented by two new species, belonging the genus *Bdella*. The recovery of 2 new species under the genera *Agistemus* and *Apostigmaeus* of the family Stigmaeidae also form the first report from Kerala. The taxonomic part of the present thesis includes the morphological descriptions of the 45 species of predatory mites recovered during the period of study, supplemented with appropriate figures.

The biology part of the present thesis includes information on the feeding and breeding aspects of two species of phytoseiid mites belonging to the genus *Amblyseius* viz., *A. (N.) longispinosus* and *A. (E.) finlandicus*. The population density of the above two species was particularly high on the leaves of the tuber crop, *M. esculenta* (Cassava) infested with *T. neocaledonicus* and hence this pest mite was selected as the prey to both of the predatory mites while conducting studies on their feeding and breeding biology.

Observations were made on the feeding behaviour of the various stages of the predators, the mode of feeding of individual stages of the predator and the feeding potential of the two predators on various stages of the prey. Data collected on the above observations were tabulated and analysed statistically based on Scheffe test, Two way ANOVA etc. and presented. Comparative assessment of the feeding potential of the two species of the predatory mites were also made and the result were tabulated and presented graphically.

The females of *A. (N.) longispinosus* alone consumed 48.79% of eggs of *T. neocaledonicus* which was significantly higher than any other stages of the predators. They also consumed significantly higher number of larvae (37.8%) and protonymph (33.63%) of the prey. But consumption of deutonymph and adults of the prey was negligible by females of the predator (< 5%). The deutonymph of *A. (N.) longispinosus* was the next best stage that fed well on eggs, larvae and protonymph of the prey. The males and protonymphs also showed significant degree of predation on different stages of the prey. While in the case of *A. (E.) finlandicus* only the female showed remarkable feeding on the eggs of the prey. All other stages of the predator were very poor in consuming any stage of the prey.

The eggs of *T. neocaledonicus* were found more favoured by both the predatory species as well as their life stages. This was followed by protonymph. The adults and deutonymphs were the least preferred stages by both the predators. It was noticed that the larvae of *A. (N.) longispinosus* was a non feeder on any of the life stages of the pest mite. Further the results of the study revealed that the adults of *T. neocaledonicus* could not be consumed by any of the life stages of the predator *A. (E.) finlandicus*. Of the two predators, *A. (N.) longispinosus* showed more promising result in controlling the pest mite.

Studies on the developmental biology of above two species of predatory mites viz., *A. (N.) longispinosus* and *A. (E.) finlandicus* were performed using *T. neocaledonicus*, as the prey mite. Accordingly it was found that the two predatory mites considered here for biological studies possessed simple life cycle with one larval and two nymphal stages. The life cycle includes 4 active stages viz., larva, protonymph, deutonymph and adults and 3 inactive stages, egg, viz., first quiescent stage and second quiescent stage. In the laboratory both the species deposited solitary eggs on the leaf surface, mainly near the mid rib and veins. A progressive increase in body size was noted during the course of development. The full setal complements appeared in the protonymphal stage, though there was conspicuous variation in the length of the setae on other stages.

No considerable differences was observed in the duration of developmental stages of the two *Amblyseius* species studied. *A. (N.) longispinsous* possessed an average of 93.22 hrs (93.15 – 93.30) to complete development from egg to adult in males whereas it was 99.35 hrs (97.30-104.30) in females. In the case of *A. (E.) finlandicus* it was 91.05 hrs (90-93) for males and 101.03 hrs (99.45 – 105.00) for females.

Observations on the laboratory studies revealed the deposition of eggs by the mated females of *A. (N.) longispinosus* was after 1.4 days where as it was 2 days for *A. (E.) finlandicus*. Rate of oviposition decreased with increase in age, maximum on the first week of development. Both the female and male adults feed immediately after moulting. Soon after mating the female showed cannibalistic behaviour on eggs and larvae of *A. (N.) longispinosus*.

To sum up, the results of the present investigation enables to confirm the predatory potential of both the species on the spider mite, *T. neocaledonicus*, both in the field and laboratory conditions.

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