STUDIES ON PREDATORY MITES INHABITING VEGETABLE CROPS OF NORTH KERALA

Thesis submitted to
the faculty of science, University of Calicut
For the Award of the Degree of

DOCTOR OF PHILOSOPHY IN ZOOLOGY

By

RAHUL. M. P

Under the guidance of

Dr. MARY ANITHALATHA SADANANDAN

PG & RESEARCH DEPARTMENT OF ZOOLOGY
MALABAR CHRISTIAN COLLEGE, CALICUT
UNIVERSITY OF CALICUT
SEPTEMBER 2018

PG & RESEARCH DEPARTMENT OF ZOOLOGY
MALABAR CHRISTIAN COLLEGE
CALICUT, KERALA

Dr. Mary Anithalatha Sadanandan
Associate Professor & Head (Rtd.)

33/4176 " Leyah"
East Malaparamba,
Malaparamba. PO, Kozhikode.09
Kerala

Phone off: 0495 2765679
Res : 0495 2370264
Mob : 09495 890076
e-mail: manithals@yahoo.co.in

Date:

CERTIFICATE

This is to certify that this thesis entitled "**STUDIES ON PREDATORY MITES INHABITING VEGETABLE CROPS OF NORTH KERALA**" is an authentic record of the work carried out by **Mr**. **Rahul. M. P,** under my supervision and guidance in partial fulfillment 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 the award of any other degree. I also certify that **Mr. Rahul. M. P**, has successfully completed the course work and passed the Ph. D qualifying examination held in December 2015.

Dr. Mary Anithalatha Sadanandan

Co-guide

DECLARATION

I, **RAHUL. M. P.,** hereby declare that this thesis entitled "**STUDIES ON PREDATORY MITES INHABITING VEGETABLE CROPS OF NORTH KERALA**" is an authentic record of the work carried out by me under the supervision and guidance of **Dr. Mary Anithalatha Sadanandan**, Associate Professor & Head (Rtd.), P G & Research Department of Zoology, Malabar Christian College, Calicut and no part of this has been published previously or submitted for the award of any degree, diploma, title or recognition before.

Malabar Christian College, **Rahul. M. P**

Date:

ACKNOWLEDGEMENT

It is a pleasure to remember all those who have contributed for the successful completion of my doctoral study. With great delight, I express my heartfelt gratitude and indebtedness to my supervising teacher Dr. Mary Anithalatha Sadanandan, Associate Professor and Head (Rtd.), P.G. and Research Department of Zoology, Malabar Christian College, Calicut for her expert guidance, creative advice, timely suggestions, constructive criticism and immense patience which formed the basis for the successful completion of my work. Mere words can never express my feeling of gratitude towards her.

I am grateful to Dr. N. Ramani, Dr. E. Pushpalatha, Department of Zoology, Dr. C. Naseema, Department of Education, University of Calicut for their timely suggestions and healthy comments at all stages of my work. I am extremely grateful to Dr. Lambert Kishore, Head of the department and Co-guide, Malabar Christian College, Calicut for his interest and whole hearted support during the course of my study.

I offer my special thanks and sincere gratitude to Dr. S.K. Gupta, Emeritus Scientist, Colleges under Calcutta University, West Bengal for confirming the identification of new species included in this study.

I am deeply indebted to Dr. Godwin Samraj, Principal, Prof. Pavamanni Mary Gladys, former Principal, Dr. Susannah Seth, H.O.D Chemistry and Mr. Jaipal Sakai, Manager, Malabar Christian College, Calicut for the facilities provided. I am also thankful to the teaching and non teaching staff of Department of Zoology, Malabar Christian College, Calicut. I am thankful to UGC for the financial assistance provided in the form of Rajiv Gandhi National Fellowship.

I record my sincere thanks to Prof. Varugese Mathew, Mr. Supran. K, Mr. Harshakumar, Mr. Sreejith. P, Dr. Ramachandran, Mr. V. T. Madhu, Dr.

Santhosh Eapen, Dr. Sachin P James, Mrs. Saigeetha Subrhamanian, Dr. Ranjini. K. D., Dr. Jasin Rahman, Dr. Anitha, Dr. Sajna Haneef, Mr. Sabu P John for their interest and whole hearted co-operation during my research work.

I wish to express my heartfelt thanks to Dr. Santhosh, P. P, Mrs. Jaisath, M. K, Ms. Shamyasree .M.S and Mr. Neeraj Martin for their for their whole hearted support, co-operation and encouragement. I also acknowledge the valuable help provided by Mr. Rajesh, Bina Villunniyal, for the technical assistance rendered and all others who helped me in various ways during the course of my study.

I feel to express my sense of gratitude, heartful respect and affection towards my parents and relatives for their encouragement and moral support.

Rahul. M. P

Dedicated to

My Beloved Father Sri. Ramakrishnan

CONTENTS

LIST OF TABLES

LIST OF PLATES

LIST OF FIGURES

CHAPTER 1
INTRODUCTION

Mites are tiny microscopic organisms belonging to the class Arachnida of the phylum Arthropoda. Mites are gaining importance throughout the world on account of their role either in the beneficial or injurious levels. They have invaded a huge range of habit and habitats including deep soil, deep sea trenches, vertebrate and invertebrate hosts, freezing trenches of polar regions and even warm waters of thermal springs. They are also seen to occupy all types of water bodies. Based on their feeding habits they are classified as parasitic, saprophytic, phytophagous, predatory, mycophagous and so on. The great diversity of known acarine species has led to the recognition of nearly 5,500 genera under 540 families (Hallan, 2005).

Phytophagous mites generally belonging to the families Tetranychidae, Eriophyidae, Tenuipalpidae and Tarsonemidae are considered to be of great economic importance due to various injuries caused by them which leads to heavy yield loss. They damage the agricultural crops, vegetables, ornamental plants and even forest trees. They suck the plant sap with the help of their cheliceral stylets, modify the developing tissues and even inject toxins inducing galls. Their feeding results in speckling, stippling, blotching or bronzing of leaves which is generally followed by yellowing and premature leaf fall. Besides this, mites are also gaining importance as pests of stored products causing considerable financial loss and health hazards to man.

Besides pest status, they are also noted for their parasitic role. Both ecto and endo parasitism by mites are reported in almost all groups of animals including man. Some parasitic mites also act as vectors of pathogenic agents like bacteria, viruses and protozoa. Dust mites of the genus *Dermatophagoides* are responsible for chronic asthma and other bronchial diseases. Species of the genus *Varroa* are seen to parasitize honey bees and cause serious problems to apiculture.

An understanding of the positive role of mites in the maintenance of soil fertility, biological control of pests, weeds and bioindication of environmental conditions marked a turning point in the development of this discipline. In the soil, many oribatid mite species through their diverse feeding strategies facilitate the routine process of decomposition and humification. Many species have distinct pH preferences and therefore, may make good indicators of acidification caused by acid rains and other air pollutants (van Straalen, 1997).

Mites play an important role in the control of vast populations of various weeds. The aquatic weed, *Eichhornia crassipes* is effectively controlled by the release of a galumnoid mite, *Orthogalumna terrebrantis* in various countries including India. Studies show that many mites under Mesostigmata are nematode feeders (Beaulieu and Walter, 2007).

The indiscriminate and excessive use of pesticides cause destruction of natural enemies of pests and other non target organisms, pesticide resistance in pests, pesticide residues in crops and health hazards to consumers (Muraleedharan, 1995; Marcic *et al.,* 2011). These issues necessitate the development of alternative pest control strategies. Biological control with natural enemies such as predators, parasites or pathogens is a viable alternative to chemical control measures. Consumers worldwide are now strongly demanding agricultural products grown with few or no chemicals. Many farmers, now a days are aware of the dangers of excessive use of chemical pesticides and are now trying to replace chemicals with natural enemies.

Predatory mites have received considerable recognition worldwide owing to their potential as biological control agents of phytophagous mites and more recently of insect pests. They are the most important biocontrol agents not only because those are voracious feeders but also because many of them are abundantly available in the fields. Studies show that the members of the predatory mite families like Phytoseiidae, Blattisociidae, Cheyletidae, Cunaxidae, Stigmaeidae, Bdellidae, Tydeidae, Ascidae, Anystidae, Erythraeidae, Hemisarcoptidae, Hydryphantidae, Acaridae, Laelapidae and some Tarsonemidae are potential predators which can suppress the mite pests on various crops. Besides helping in control of agriculturally important mite pests, some mites under the families Galumnidae, Mochlozetidae and Xylobatidae have been found in the field feeding upon insect pests, molluscan pests and plant feeding nematodes (Gupta, 2002).

Among the predatory mites, family Phytoseiidae have received maximum attention globally. Phytoseiids are predominant predators of different phytophagous mites particularly tetranychid and eriophyid mites. Mass multiplication methods have been developed to use these predators in commercial scale on a variety of crops.

Vegetables play a pivotal role to provide balanced nutritional diet and health. So vegetable cultivation gains ground in developing countries like India. Good vegetable production is a strong indicator of improved land productivity, improved economic condition of farmers as entrepreneurs, enhanced export potential and nutritional security to the people.

Vegetable cultivation in India has assumed great importance during the last decade. India is the second largest vegetable producer in the world. Vegetable crops are ravaged by several insect and non insect pests throughout the growing period. Among the non insect pests, mites are one of the important limiting factors in the production of different crops in India (Prasad and Singh, 2007). Average yield loss to vegetable crops varies from 9-100 percent due to mite infestation in different agro climatic conditions in India (Prasad *et al.,* 2007; Patil and Nandihalki, 2009).

Mite pests cause serious economic loss in many agricultural systems each year including vegetable crops. Chemical control is the primary method used for controlling the pest mites. Because of frequent applications of pesticides to confined populations and few materials to use in rotation, the potential for developing pesticide resistance or tolerant strain is very high. To avoid such situation many advanced countries either banned or are planning to ban many pesticides and are switching over towards Integrated Pest Management. In this context, much stress is being laid to promote implementation of biological control with predatory mites for developing Integrated Pest Management programme. Taxonomic studies especially those dealing with diagnosis, are thus of first importance to ensure biological control programme success. Further more knowledge of predatory mite diversity can open new insights for the control of new pests.

Despite the relevance of predatory mites, they have not acquired desired recognition in many parts of the world, especially in Kerala. Considering the above situation the present study makes an attempt to unravel the diversity of predatory mites on vegetable crops from different localities in North Kerala. Further, the study aims to explore the potential use and feasibility of *Neoseiulus sasikalae* sp.nov. and *Amblyseius dioscoreae* Rahul *et al.,* 2016 for the management of *Tetranychus urticae* and *T. neocaledonicus*. Besides this, studies on life history, life table and influence of different temperature regimes on these parameters were also included.

Objectives of the study are,

1. To conduct extensive surveys on diversity of predatory mites inhabiting vegetable crops of North Kerala.
2. To give detailed illustrations as well as descriptions of new species and new genera.
3. To provide redescription of little known taxa.
4. To record the systematics of recovered predatory mites of different families with keys.
5. To trace the feeding potential and breeding biology of some of the species under natural and experimental conditions.
6. To record observation regarding host plants and site specificity of predatory mites.

CHAPTER 2
REVIEW OF LITERATURE

2.1. FAMILY: ASCIDAE Voigts and Oudemans, 1905

Family Ascidae constitute an important group of predatory mites that live in soil, on plants, in stored products and are often closely associated with humans and animals. The mites of the family Ascidae Voigts and Oudemans, 1905 have been known to populate on various biocenoses and microhabitats.

The genus *Iphidozercon* was described hundred years ago by Berlese (1903). Family Ascidae was erected by Voigts and Oudemans (1905). They erected the subfamily Ascinae with a single genus *Asca,* without giving any diagnosis of the group. The inclusion of only the genus *Asca* in the subfamily implied that the characteristics of the subfamily corresponded to those of the genus. Some species mainly under the genera *Arctoseius, Cheiroseius, Leioseius* and *Platyseius* were described by Oudemans (1905). The family Aceosejidae was erected and established by Baker and Wharton (1952) and then Evans (1958) revised the British Aceosejinae.

Willmann (1949) and Karg (1969, 1971, 1981, 1993) contributed to the systematics, taxonomy and ecology of this mite family from Germany. Schweizer (1961) studied soil mites including Ascidae from Switzerland. The family Ascidae comprises more than 22 genera, with several hundred predatory and phytophagous mites species distributed around the world (Evans, 1992). Lindquist and Evans (1965) divided the family Ascidae into 3 subfamilies *viz.,* Arctoseiinae, Ascinae and Melicharinae. Wood (1966) described 3 new species of the genus *Asca viz., A. arboriensis, A. plumose* and *A. porosa* from New Zealand.

Tseng (1981) described and illustrated 12 species under the genus *Asca* from Taiwan including 5 new species. The genus *Asca* was reviewed by Walter *et al.,* (1993) from Australia, with descriptions of 3 new leaf inhabiting species. Halliday *et al.* (1998) revised the Australian species of Ascidae, suggested a complex family level classification based on the information on leg chaetotaxy. Masan (1998) described a new species under the genus *Zerconopsis* from Slovakian territory.

Based on spermathecal structures, Ascidae and Melicharidae were placed in the superfamily Ascoidea, while Blattisociidae was placed in the Phytoseioidea (Alberti, 2002; Alberti and Di Palma, 2002). Gwiazdowicz (2003) described a new species of the genus *Iphidozercon viz., I. poststigmatus*, with a key to Palearctic species of the genus *Iphidozercon*. Ascid species having predatory habits have been considered potentially useful as biocontrol agents of pest species (Gerson *et al*., 2003). The genus *Cheiroseius* was known to have more than 80 species in the world (Bhattacharyya and Bhattacharyya, 2004). Kaluz and Fenda (2005) recorded 35 species under the genera *Arctoseius, Asca, Cheiroseius, Iphidozercon, Lasioseius, Platyseius, Plesioseius* and *Zerconopsis* from the Slovakian territory. Three new species under the genus *Proctolaelaps viz., P. threnetes*, *P. naskreckii* and *P. chalybura* were described by Dusbabek *et al.* (2007) from Costa Rica. Until 2009, all known species described were included under the family Ascidae. Major taxonomic change was done by Lindquist *et al*. (2009). They concluded that in the existing concept, the Ascidae actually included mites of three families, namely Ascidae, Blattisociidae and Melicharidae.

Lindquist and Makarova (2012) redefined the subfamily Arctoseiinae and described a new genus, *Maxinia* based on a new species, *M. arctomontana*. They reviewed the conceptual problems with the genus

Iphidonopsis Gwiazdowicz, 2004 and a new combination *Iphidonopsis magnanalis* (Ma and Yin, 1999) was presented for *Iphidozercon magnanalis* Ma and Yin, 1999 from China. Nemati *et al.* (2012) presented a catalogue of Ascidae from Iran, according to them 5 genera and 7 species of ascid mites *viz., Arctoseius* (2 species), *Gamasellodes* (1), *Iphidozercon* (1), *Neojordensia* (1) and *Protogamasellus* (2) have been reported from Iran. In this paper they summarized the information about genera and species of ascid mites in different parts of Iran including distribution, habitat or host and new data of the occurrences. Kazemi and Rajaei (2013) published an annotated checklist of Iranian ascid species. Makarova and Lindquist (2013) described a new mite species belonging to the genus *Arctoseius viz., Arctoseius koltschaki* from Russia, and also added a key to the multidentatous species group. Mehranian (2014) described a new species of the genus *Cheiroseius viz., Cheiroseius samani* collected from Khorasan Razavi province of Iran. A revision of the biology and ecology of ascid mites were recently published by Moraes *et al.* (2015). According to that revision, about half of the species of this group were described from soil, grasses, mosses, or dead organic matter on the soil surface, with a lower proportion described from plants. A catalogue containing 372 valid species of ascid mites under 17 genera was prepared by Moraes *et al.* (2016). Britto *et al.* (2017) described a new species of the genus *Asca viz., A. mariae* sp.nov. from Northwestern Brazil.

2.2. FAMILY: PHYTOSEIIDAE Berlese, 1952

Phytoseiid mite was described by C.L. Koch in 1839 (Chant, 1985). The name Phytoseiidae was derived from the genus *Phytoseius* (Ribaga, 1904). For a long time, the taxonomy of the species of Phytoseiidae remained in a state of confusion as very few older type specimens were not available for study and the characters on which the descriptions made were insufficient and vague that it was impossible to come to any definite conclusion based on proper identification.

Family Phytoseiidae was erected by Berlese (1913) and he erected the subfamily Phytoseiinae under the family Laelaptidae in 1916. Vitzthum (1941) followed the concepts of Berlese and included 7 more genera *viz*., *Typhlodromus, Seiulus, Amblyseius, Seiopsis, Iphidulus* and *Kleemania.* Nesbitt (1951) designated *Typhlodromus elongates* Oudemans as the type of the genus *Kampimodromus*. Baker and Warton (1952) changed the status of the subfamily Phytoseiinae to the family level. Chant (1955) considered the genus *Kampimodromus* as a synonym of *Typhlodromus*. Muma (1955) listed 11 species of phytoseiid mites associated with citrus plant from Florida, of which 9 species were new to science. De Leon (1957 and 1958) described several new species of *Typhlodromus* from Southern Florida. Chant (1958) provided the first comprehensive study of immature Phytoseiidae. The same author (1959) provided a monograph for this family.

Narayanan *et al.* (1960) provided the importance of the number, the arrangement, the nature, the position and the relative length of the setae together with some anatomical characters in the classification of Phytoseiidae. Muma (1961) described a new genus namely *Paradromus* and recognized 4 subfamilies *viz*., Phytoseiinae, Amblyseiinae, Macroseiinae and Aceodrominae and he subsequently transferred the Aceodrominae to Ascidae. Wainstein (1962) kept *Kampimodromus* as a subgenus of *Amblyseius*. Again Muma (1962) described several new species and one new genus *viz*., *Amblyseiulus* in the reorganization of the supraspecific classification of the Phytoseiidae. Schuster and Pritchard (1963) divided the family into 6 tribes and placed 17 genera under it. Chant (1965) revised the family reducing Macroseiinae to generic status and proposing a new subfamily Otopheidomeninae. Ehara (1967) separated the genus *Okiseius* from related genera on the basis of position of setae R_1, mediolateral incision on dorsal shield etc. Muma and Denmark (1968) described 5 newly delineated genera *viz*., *Proprioseiulus, Neoledius, Chelaseius, Athiasia* and *Orientiseius*. At the same time they discussed and clarified the systematic problems in *Phytoseius.* Chaudhri (1968) described 6 new species of *Amblyseius* from Pakistan. Ghai and Menon (1969) identified 2 new genera *viz*., *Indoseiulus* and *Indodromus.* Denmark and Muma (1970) provided a summary of phytoseiids of South America and reported 5 new species for the first time from Paraguay; they also prepared a key for the 3 new species of *Euseius*. Muma and Denmark (1970) recognized 3 subfamilies, Phytoseiinae, Amblyseiinae and Macroseiinae. Prasad (1974) prepared a catalogue of Indian mites and reported 58 species of phytoseiid mites.

Through a series of papers Gupta (1974, 1975, 1977a, 1977b, 1977 c, 1977d, 1978 a, 1978b, 1978c, 1979, 1980a, 1980b, 1980c, 1980d, 1981a, 1981b, 1982a, 1982b, 1995, 2000) added a large number of phytoseiid mite species from different states of India with descriptions of several new species.

Denmark and Andrews (1981) conducted a survey on plant associated Phytoseiidae of El Salvador and added 21 species. The genus *Galendromus* was revised by Denmark (1982) and 18 species were redescribed. Besides this a new subgenus *Ennoseius* was described. Moraes *et al.* (1982) described a new genus *Quadromalus* and a new species *Euseius ricinus* from Colombia. Chant and Yoshida (1983) erected a new subfamily Cydnodromellinae. Later, Rather and his team through a series of papers (Rather, 1984, 1985, 1986, 1987, 1989, 1999); (Rishi and Rather, 1983, 1984); (Denmark and Rather 1984, 1996) explored phytoseiid fauna of Kashmir region with the description of several new species, which improves the knowledge of phytoseiid fauna of India. Moraes *et al.* (1986) reported 93 species of phytoseiid mites from Brazil. Moraes and Mesa (1988) reported 3 new species *viz*., *Amblyseius* *bellottii, A. calineis* and *Typhloseiopsis neopritchardi* from Colombia. McMurtry and Moraes (1989) added new records of 19 species from Peru and also added descriptions of 4 new species *viz*., *Amblyseius quichua, A. leonardi, A. lynae* and *Typhlodromalus tenuiscutum.* A revision of the genus *Amblyseius* was done by Denmark and Muma (1989). In this study illustrations and descriptions of 136 species were included. Besides this synonymy and descriptions of 10 new species were also added along with 2 new genera *viz*., *Multiseius* and *Pauciseius.*

Sadana *et al.* (1990) reported several phytoseiid mite species associated with agri-horticultural crops from Punjab. Moraes *et al.* (1991) identified a total of 55 species of phytoseiid mites from Latin America out of which 9 were new to science. Denmark and Kolodochka (1993) revised the genus *Indoseiulus* and described 6 species. Chant and McMurtry (1994) recognized 3 subfamilies *viz.,* Phytoseiinae, Amblyseiinae and Typhlodrominae. Under these subfamilies they recognized 15 tribes, 9 subtribes, 84 genera and 8 subgenera. The genus *Iphiseiodes* was revised by Aponte and McMurtry (1995) with the redescriptions of 5 species under it. Later Beard and Walter (1996) reported genera *Paraphytoseius* and *Paramblyseius* from Australia; they also provided a key to the world species of *Paraphytoseius*. According to Kostiainen and Hoy (1996) literature on the Phytoseiidae has become voluminous not only on their taxonomy but also their biology, ecology and behaviour, especially of the species that have potential for pest control. Walter and Beard (1997) revised the Australian Phytoseiidae based on a study of over 1000 slide mounted specimens. According to them only the genus *Phytoseius* is known from Australia under the subfamily Phytoseiinae. They described 11 new species and provided a key for the genus *Phytoseius.* Kreiter and Moraes (1997) reported 9 species for the first time from Guadaloupe and Martinique.

Lofego *et al.* (2000) described 3 new species *viz*., *Amblyseius neochiapensis, A. bahiensis* and *Typhlodromalus feresi* from Brazil. Gondim and Moraes (2001) conducted a survey on palm plants and reported 43 species of phytoseiid mites in areas of two states of Brazil. They described 10 new species. Mary Anitha (2002) in her Ph.D. thesis reported the occurrence of 32 species of phytoseiid mites from Kerala with several new species and records. Denmark and Welbourn (2002) listed 236 species in their world revision of the genus *Amblydromella* Muma. Ehara (2002) reported 12 species from West Sumatra and Indonesia of which 11 were new records and one new species, *viz.*, *Amblyseius (Amblyseius) sumatrensis*. During a survey on phytoseiid mites of coconut growing areas in Srilanka Moraes *et al.* (2004) reported 3 new species under 3 subfamilies. Chant and McMurtry (2005) proposed a new tribe Euseinii. Kreiter and Tixier (2006) reported a new genus *Africoseiulella* with a new species *viz*., *A. flechtmanni* from Tunisia.

Zannou *et al.,* (2007) conducted a survey to report the phytoseiid mites of the subtribe Amblyseiina Chant and McMurtry known from Africa with redescriptions of known species and descriptions of new species. They also prepared a key for the separation of the species under this subtribe. Chant and McMurtry (2007) provided an illustrated keys and diagnosis for the subfamilies, tribes, subtribes, genera and subgenera of Phytoseiidae on a worldwide basis.

Ueckermann *et al.* (2008) revised the African species of *Typhlodromus* (*Anthoseius*). Karg and Huhta (2009) reviewed the genera *Amblyseius, Proprioseiopsis* and *Typhlodromus* and reported the description of 3 new species. From Iran 19 species of phytoseiid mites were recorded by Rahmani *et al.* (2010). Afzal *et al.* (2010) reported 102 species of Amblyseiinae from Pakistan.

According to Jafari *et al.* (2011) the subgenus *Typhlodromus (Anthoseius)* comprised of 322 valid species. El-Banhawy and Knapp (2011) reported a total of 107 species of phytoseiid mites from 4 different geographical zones of Kenya. Faraji *et al.* (2011) prepared a checklist and a key for the 62 species of Phytoseiidae of Turkey. They consider removing *Phytoseius finitimus* Ribaga from synonymy with *P. plumifer* by accepting the previous conclusion on the species concept of *P. finitimus*. Prasad (2012) prepared a checklist of Phytoseiidae of the world with 2,962 species including their synonyms. Four phytoseiid species *viz*., *Amblyseius obtuses, Neoseiulus marginatus*, *N. sugonjaevi* and *N. zwoelferi* were redescried by Fayaz and Khanjani (2013) from Western Iran.

Karmaker and Gupta (2014) described 4 new species from West Bengal, 2 under *Euseius* and one each under *Neoseiulus* and *Amblyseius*. Gupta and Karmaker (2015) prepared a checklist of Indian Phytoseiidae, listed 211 species under 21 genera, 3 subfamilies. Sajna (2015) in her Ph. D thesis on phytoseiid mites of North Kerala described a total of 37 species under 10 genera with 15 new species. Demite *et al.* (2015) prepared a database on phytoseiid mites reported a total of 2479 valid species belonging to 90 genera.

From Kerala significant contributions were made by Chinniah and Mohanasundaram (2001), Mary Anitha (2005, 2006a, 2006b, 2006c, 2006d), Mary Anitha and Ramani (2006, 2007), Sajna and Mary Anitha (2013, 2015), Santhosh and Mary Anitha (2016), Rahul and Mary Anitha (2016a, 2016b, 2017) and Rahul *et al.,* (2016).

Doker *et al.* (2017) described 3 new species of Phytoseiidae *viz., Eharius deniziensis* sp.nov., *Typhlodromus (Anthoseius) kerainsaliensis* sp.nov. and *T. (Typhlodromus) papadoulisi* sp.nov. from Turkey. Again

Doker (2018) described a new species of the genus *Neoseiulella viz., N. kazaki* sp. nov. from Turkey.

2.3. FAMILY: BLATTISOCIIDAE Garman, 1948

Family Blattisociidae is a diverse group of predatory mites that has adapted to live on a broad spectrum of terrestrial, arboreal and subaquatic habitats. Some of them have potential usefulness as biological indicators of ecosystem in soil or water habitats (Lindquist *et al*., 2009). Blattisociids are now receiving attention in the field of biological control on agricultural pests (Mohamed, 2013).

Taxonomy of Blattisociidae is scattered over hundreds of publications and the concepts of genera have been revised many times based on the morphological features. Baker and Wharton (1952) erected the family Aceosejidae with *Aceosejus* Sellnick as the type genus. Later Evans (1957) placed the genus *Blattisocius* in the family Aceosejidae. Evans and Hyatt (1960) modified the family Aceosejidae and divided it into 2 subfamilies *viz.,* Blattisociinae and Platyseiinae. Chant (1963) studied the genera and species of the subfamily Blattisociinae and added the descriptions of many new species from North America. According to him *Blattisocius dentriticus* (Berlese) found in important food materials are associated with acarid mites and mites of family Blattisociidae seems very similar in its biology to those of Phytoseiidae. A new genus *Orolaelaps* was erected by De Leon (1963) from Mexico and Southeast United States. Lindquist and Chant (1964) redescribed the genus *Aceodromus* and they removed the subfamily Aceodrominae from Phytoseiidae and synonymized under the subfamily Blattisociinae of family Blattisociidae.

Until 2009, the family Blattisociidae was included in the family Ascidae because of their many external morphological similarities (Lindquist and Chant, 1964). Walter and Lindquist (1997) reviewed the Australian members of the *porulosus* groups, they described 5 new species of *Lasioseius* and presented a key to the species of *Lasioseius* that inhabit on rainforest leaves. Through a series of papers, Bhattacharyya (1968, 1969, 1972 and 1978), Bhattacharyya *et al.* (2000), Bhattacharyya and Bhattacharyya (2001), Bhattacharyya and Sanyal (2002) added more information to the knowledge of Blattisociidae from India.

Some *Blattisocius* species found in stored foods have been studied to determine their potential as predators of arthropod pests (Halliday *et al*., 1998, Haines, 1981, Thind and Ford, 2006). Mites of the genus *Platyseius* Berlese were mentioned as possible predators of mosquitoes, as they were found on adult mosquitoes and flies (Reisen and Mullen 1978; Smith 1983; Halliday *et al*., 1998). Lindquist (2003) divided the genus *Platyseius* into two species groups, the *subglaber* and the *italicus* species group. Lindquist *et al.* (2009) made a major change in the suprageneric level of the family Ascidae and proposed 3 separate families *viz.,* Ascidae, Blattisociidae and Melicharidae under the superfamily Phytoseioidea and Ascoidea based on the spermathecal structures (Alberti 2002) as well as external morphology. According to them family Blattisociidae included the following genera *viz., Aceodromus* Muma, *Adhaerenseius* Loots and Theron, *Arrhenoseius* Walter and Lindquist, *Blattisocius* Keegan, *Cheiroseiulus* Evans and Baker, *Cheiroseius* Berlese, *Discoseius* Lindquist and Moraza, *Fungiseius* Moraza and Lindquist, *Hoploseius* Berlese, *Krantzoseius* Seeman, *Lasioseius* Berlese, *Opilioseius* Lindquist and Moraza, *Platyseius* Berlese and *Zercoseius* Berlese.

In the subfamily Blattisociinae alone, nearly 60 species of the genus *Lasioseius* have been identified (Lindquist and Moraza, 2010). They had revised the family Blattisociidae and provided an updated key to the genera, subfamilies and also added description of a new genus *viz., Opilioseius* from

Costa Rica. Thomas *et al*. (2011) noted that *Blattisocius keegani* Fox as the predator of coleopteran species. Again Lindquist and Moraza (2012) described a new genus *viz., Discoseius* from Costa Rica. They provided an updated key to the world genera of the subfamily Blattisociinae.

Nemati *et al.* (2012) prepared a catalogue of blattisociid mites from Iran, a total of 29 species of blattisocid mites were recorded under 6 genera *viz., Blattisocius* Keegan, *Cheiroseius* Berlese, *Zercoseius* Berlese, *Hoploseius* Berlese, *Platyseius* Berlese and *Lasioseius* Berlese. Eliaderani *et al.* (2013) reported 2 new species of *Lasioseius viz., L. sugawarai* and *L. youcefi* from Iran. Mahjoori *et al.* (2015) prepared a checklist and a key for blattisociid mites from Iran and reported 4 species under 2 genera *viz., Lasioseius* and *Cheiroseius*. Lindquist and Moraza (2016) described a new genus *Calyptoseius* under the subfamily Platyseiinae from Costa Rica. A worldwide catalogue of Blattisociidae was prepared by Moraes *et al.* (2016) in which 367 species was arranged under 14 genera. Masan and Halliday (2016) described a new species of *Hoploseius viz., H. oblongus* associated with fungus from Slovakia. Horn *et al.* (2016) recovered a species of Blattisociidae *viz., Blattisocius keegani* from commercial poultry from Brazil.

Lasioseius Berlese is the most diverse genus of Blattisociidae (Karg, 1980; Christian and Karg, 2006; Moraes *et al*., 2016) which contains almost 200 species, described especially from tropical regions. Santhos (2017) in his doctoral thesis studied the taxonomy of blattisociid mites and reported 10 species associated with medicinal plants. Nasr *et al.,* (2017) described two new species under the genus *Platyseius viz., P. aegypticus* and *P. girgaensis* from Egypt.

2.4. FAMILY: BDELLIDAE Duges, 1834

Mites of the family Bdellidae are predators of insects and mites, known to occur on all continents. They are readily recognized by an elongated, snout like gnathosoma with elbowed pedipalps having long terminal setae.

Bdellids were the first mites ever described by Linnaeus (1758). He had described 31 species of mites under a single genus *Acarus* among these, 2 species *viz., Bdella longicornis* and *Neomolgus littoralis* were later included with in the family Bdellidae. Latreille (1795) erected the genus *Bdella* and the same author (1796) designated *Bdella longicornis* as the type species.

Duges (1834) erected the family Bdellidae. The taxonomy of Bdellidae was vague and obscure until the work of Thor (1902). Important contributions to the taxonomy and systematics of Bdellidae were made by Thor (1931), Oudemans (1926 a, b), Grandjean (1938), Wallace (1974) and Atyeo (1960, 1963). Baker and Balock (1944) erected a genus *Monotrichobdella*. Atyeo (1960) in his revision of the mite family Bdellidae from North and Central America added notes on the bionomics, morphology and intraspecific variations of 32 species. In this study he recognized 11 genera of which one was new *viz., Octobdellodes* and 2 synonymized. The synonymized genera were *Cacnobdella* Oudemans, 1937 to *Cyta*, *Hoploscirus* Thor, 1937 to *Bdellodes*. Out of the 32 species included in this revision, 16 were new to science, 4 were moved to other genera and 13 were synonymized.

Wallace and Mahon (1972) studied the taxonomy and biology of the subfamilies Bdellinae, Spinibdellinae and Cytinae of Australia and also added 5 new species. Soliman and Zaher (1975) added 8 species, out of which 3 were new to science. Wallace and Mahon (1976) synonymized *Odontoscirus* Thor, 1913 with *Bdellodes* Oudemans, 1937 but unfortunately choose to validate the junior name. From Taiwan, Tseng (1978) reported 14 species under 5 genera, of which 6 were new to science and 7 were new records. Gupta and Ghosh (1980) added a new species under the genus *Bdellodes* from Andaman Islands *viz., B. (Haploscirus) procincta.*

From *Areca catechu,* Gupta (1985) identified a new species *viz., Bdellodes (Haploscirus) affinis* from India. Swift and Goff (1987) described 6 new species and 5 new records from Hawaiian Islands and also provided a key to the species known from Hawaiian Islands. Goff (1987) listed 15 species from Hawaiian Islands, of which 6 were new to science.

Gupta (1991) added 5 new species under the genera *Bdella* and *Bdellodes* from North East India. van Der Schyff *et al.* (2004) described 5 new species under the new genus *Hexabdella* from Southern Africa. The same authors (2005) discribed 7 new species from Southern Africa with redescription of *Bdella neograndjeani*. Hernandes and co-workers through a series of papers (Hernandes and Feres (2006), Hernandes *et al.* (2007 and 2008), Hernandes *et al.* (2011) and Hernandes (2013) explored bdellid fauna of South Africa and Brazil with descriptions of several new genera and species. Paktinat *et al.* (2014) described first species of the genus *Hexabdella viz., H. persiaensis* from Asia. He presented an updated key to all species of the genus *Hexabdella.* Hernandes *et al.* (2016) presented a catalogue listing 278 valid species with genus *Rigibdella* Tseng, 1978 as junior synonym of *Cyta* Von Heyden and *Bdelloides* Oudemans as junior synonym of *Odontoscirus*. They also provided keys for the identification of subfamilies, genera and species. Ziad and Ueckermann (2017) described two new species *viz., Cyta kreiteri* sp.nov. and *Odontoscirus tixieri* sp.nov. from Syria. Eghballan *et al.* (2017) described two new species of the family *viz., Spinibdella pourmiza* and *Odontoscirus denheyeri* from Western Iran.

2.5. FAMILY: CUNAXIDAE Thor, 1902

They are free living predaceous mites found in a variety of habitats. They predates on armoured scale insects, spring tails, other small arthropods, eriophyids and tetranychids. They are cosmopolitan in distribution.

Family Cunaxidae was erected by Thor (1902) to include mites having 4 palpal segments which were previously placed in the family Bdellidae. Before that Hennmann (1804) erected the genus *Scirus* and described *S. setirostris* as the first species to this family. Von Heydon (1826) erected the genus *Cunaxa* instead of *Scirus*. Thereafter Berlese (1916) erected the new genus *Coleoscirus* and described 2 species *viz*., *C. halacaroides* and *C. corniculatus*. He proposed the subgenus *Dactyloscirus* in the genus *Scirus* to accommodate a new species *viz., Scirus (Dactyloscirus) eupaloides*. Ewing (1917) added a new species *viz., Scirus simplex* from USA.

Thor and Willmann (1941) elevated the subgenus *Dactyloscirus* to generic level. The same authors made the first comprehensive study of the family, recognizing 7 genera and 30 species. Baker and Hoffmann (1948) considered *Dactyloscirus* as the senior synonym of *Cunaxa*.

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 the superfamily Bdelloidea. Meyer and Ryke (1959) reported several cunaxid mites on plants from South Africa.

Generic classification of the family was revised by Smiley (1975) and added 9 genera of which, 4 were newly erected *viz., Neocunaxoides, Pseudobonzia, Parabonzia* and *Pseudocunaxa*.

Through a series of papers Den Heyer (1975, 1976, 1977, 1978 a, 1978 b, 1979 a, 1979 b, 1979 c, 1980 a, 1980 b and 1981) erected many new subfamilies, new genera and new species under the family Cunaxidae. Most of the taxa published by him were known from the African region only.

Gupta and Ghosh (1980) added 4 new species under the genus *Cunaxoides viz., C. nicobarensis, C. myabunderensis, C. cynodonae* and *C. bambusae* from Andaman and Nicobar islands and also erected a new genus *Indocunaxa* with *I. smileyi* as type species. A new genus *Lapicunaxa* was erected by Tseng (1980) with *L. horidula* as the type species. Sepasgosarian (1984) compiled a list of works on cunaxid biology, taxonomy, systematics and classification and reported 124 species belonging to 4 subfamilies, 6 tribes and 17 genera. Bu and Li (1987) added new taxa belonging to the genus *Pulaeus* and erected the subfamily Orangescirulinae. From Pakistan Inayatullah and Shahid (1989) made further addition by reporting 2 new species under *Neocunaxoides viz., N. dilata* and *N. kalamiensis.*

Gupta (1991) added 3 new species *Cunaxa crista, C. curassavica* and *Neocunaxoides cerasoides* from India. Muhammad and Chaudhri (1991) published 2 new species of the genus *Armascirus viz., A. mactator* and *A. pluri*. The same authors (1992) again added 2 new species under the genus *Coleoscirus viz., C. carnus* and *C. disparis* from Pakistan. Smiley (1992) made a comprehensive treatment of the family Cunaxidae with a new classification and added 3 new subfamilies thereby dividing the family into 9 subfamilies *viz.,* Bonzinae, Orangescirulinae, Paracunaxoidinae, Coleoscirulinae, Cunaxiinae, Cunaxoidinae, Denheyernaxoidinae, Neobonzinae and Scirulinae. Again Inayatullah and Shahid (1993) described 3 new species of the genus *Pseudocunaxa viz., P. kifayati, P. mardi* and *P. carex*. Besides this, a key to the species of *Coleoscirus* in Pakistan, a table comparing their characteristics, a similarity matrix and phenogram were provided. Corpus-Raros (1996) reported 2 new species under the genus *Pulaeus* from Philippines. Corpus-Raros and Garcia (1996) reported 2 species under the genus *Pseudobonzia* and 3 species under the genus *Scutascirus,* of which 3 were new to science.

Mary Anitha (2002) in her Ph. D thesis described 3 species of cunaxid mites from North Kerala. Sionti and Papadoulis (2003 a) added 2 new species under the genus *Neocunaxoides viz., N. abiesae* and *N. smolikensis* from Greece. The same authors (2003 b) again reported 14 species from Greece, of which 2 were new to science *viz., Cunaxoides paracroceus* and *Cunaxa thessalica.* Bashir *et al.* (2005) added a new cunaxid mite, *Cunaxa reticulates* from Pakistan. Sergeyenko (2006) described a new species of the genus *Rubroscirus* from Ukraine. Bashir *et al.* (2007) identified a new species under the genus *Cunaxoides viz., C. sargodhaensis* from Pakistan. Den Heyer and Castro (2009) added 4 new genera under the subfamily Cunaxoidinae *viz., Bunaxella, Dunaxeus, Funaxopsis* and *Qunaxella* from South Africa. Lin and Zhang (2010) provided a detailed historical review of Cunaxidae from China.

Den Heyer (2011) prepared a database with information on 329 species of this family. Den Heyer *et al.* (2013) studied the subfamily Cunaxoidinae and described 8 species, of which 5 were new to science *viz., Cunaxoides decastroae, Cunaxoides lootsi, Pulaeus razanensis, Lupaeus iranensis* and *Lupaeus sativae.* They also provided a key to the Iranian Cunaxoidinae. Bashir *et al.* (2014a) summarized the subfamily Coleoscirinae and provided keys for the identification of genera and species from Pakistan. According to Skvarla *et al.* (2014) the genus *Cunaxoides* includes a total of 22 species from different continents. Rocha *et al.* (2015) reported 3 new species *viz., Neocunaxoides promatae, Bonzia flechtmanni* and *Dactyloscirus multiscutus* from Brazil. They provided comprehensive keys to the subfamilies, genera and species of cunaxids from the world. A new species of *Cunaxoides viz., C. shahriari* was described by Bagheri *et al.* (2016). They also provided a key to the *Cunaxoides* species of Iran. Rahul *et al.* (2017) described a new species *viz., Cunaxa soansi* from Kerala. Kaluz and Josef (2018) described two new species *viz., Armascirus skvarlai* sp.nov. and *Cunaxa corpuzrarosae* sp.nov. from Madagascar. Chen *et al.* (2018) described a new species with illustrations under the genus *Neobonzia viz., N. neomalookensis* sp.nov. from China. They also prepared a key to the species of *Neobonzia* of China.

2.6. Family: ACARIDAE Latreille, 1802.

Family Acaridae was erected by Latreille (1802). The mites included in this family are whitish, large sized, mostly fungal feeders but some of them feed on the eggs of insects and pest mites. It is a large cosmopolitan group of mites with more than 90 genera and about 400 described species (Fan and Zhang 2007). Acarid mites are one of the most abundant and diversified group of arthropods which not only prevail in agroecosystem but also occupy storage structures and greenhouses.

Berlese (1923) first described the genus *Caloglyphus* and marked *Caloglyphus berlesei* Michael, 1903 as its type species. Later many authors, Zachvatkin (1941), Nesbitt (1944, 1949), Samsinak (1966, 1988), Mahunka (1973, 1974, 1978, 1979), Channabasavanna *et al*. (1981), Rao (1982), Ashfaq and Chaudhri (1984), Zou and Wang (1989), Sher *et al*. (1991), Sevastyanov and Rady (1991), added many species to this group.

Oudemans (1923) reported *Aphelenia medanensis* from Sumatra but later (1924) he synonymized it with the genus *Suidasia.* The genus *Tyrophagus* was erected by Oudemans (1924) with type species *Acarus putrescentiae* Schrank, 1781. Genus *Acotyledon* is the most dominating member of the family Acaridae which was erected in 1903 by Oudemans with description of *A. paradoxa*. This genus was then synonymized with *Eberhardia*, *Cosmoglyphus* and *Myrmoglyphus* by Zachvatkin (1941). Based on comparative morphological studies Nesbitt (1945) again revised the family Acaridae.

Prasad (1965) and Gupta (1970) reported species of this family occurring on plants from India. Jhonston and Bruce (1965) described a new species of *Tyrophagus viz., T. neiswanderi* from Ohio. Wadhi *et al.* (1971) reported *Rhizoglyphus* on plant from India. Hughes (1976) prepared an excellent accumulation of knowledge to the genus *Caloglyphus*. Tseng and Hsieh (1976) re-described *Caloglyphus mycophagus* from Taiwan. Samsinak (1980) erected a new tribe Caloglyphini and re established the genus *Caloglyphus*. Ashfaq and Chaudhri (1984) reported two new species of acarid mites belonging to the genus *Forcellinia* from Pakistan. Ferguson (1985) described a new species under a new genus *viz., Comerinia chuetolamina* from Mexico. He also indicated the position of the new genus in a commonly used key to the family of Acaridae.

Bu and Li (1998) prepared taxonomic descriptions and key to all known species under the genus *Rhizoglyphus* from China. Klimov (1999) reported a new genus *viz., Umakefeq* from Russian Far East and Japan. Ashfaq and Sarwar (1999) described a new species of the genus *Lackerbaueria* from Pakistan. Diaz *et al*. (2000) reported that mites of the genus *Rhizoglyphus* are cosmopolitan and can cause damage to crops and ornamental plants, both in greenhouses and in the field. Klimov (2000) revised acarid mites of tribe Caloglyphini and synonymized *Caloglyphus* with *Sancassania* and described a new genus and species *viz., Mycetosancassania grifolapholiotae* from Siberia and Russian Far East.

Klimov and Oconnor (2003) published the phylogeny, historical ecology and systematics of some mashroom associated acarid mites with key and also added biological information of the genus *Sancassania*. Fan and Zhang (2004) revised the genus *Rhizoglyphus* of Australia. Sarwar and

Ashfaq (2004, 2006, 2010 a, b) and Sarwar *et al*. (2005, 2009) reported 9 species of *Caloglyphus* from different localities of Pakistan. Mold mites, *Tyrophagus putrescentiae*, are well known and treated as one of the most common, cosmopolitan and polyphagous mites of agricultural and medical importance (Chmielewski, 1999; Klimov and Oconnor, 2009). Fan and Zhang (2007) described 5 new species belonging to the genus *Tyrophagus* from New Zealand and reported that there are more than 90 genera and about 400 described species under this family. According to Bahrami *et al.* (2007) *Tyrophagus putrescentiae* is a good predator of some nematodes like *Aphelenchus avenae* Basin and *Meloidogyne javanica* (Treub). According to Darvishzadeh and Kamali (2009) almost 400 species of stored grain mites have been reported all over the world from the family Acaridae.

Two new *Acotyledon* species have been identified from Pakistan (Bashir *et al*., 2012). Originally, Berlese in 1923 described *Caloglyphus* as a subgenus of *Tyroglyphus*. He designated *Tyroglyphus mycophagus* Mégnin, (1874) as the type species of genus *Caloglyphus* for a single species, afterward several species of genus *Caloglyphus* have been referred from numerous expanses of the world (Sarwar and Ashfaq, 2012). Sarwar *et al.* (2013) added two new species of the genus *Caloglyphus viz. C. pejowaliensis* and *C. aurangensis* from Pakistan and also prepared key to all the known species of this genus. According to Bashir *et al.* (2014 b) 35 species of the genus *Tyrophagus* have been reported worldwide. Maslov (2014) redescribed *Pontoppidania pontica* and provided the key to the species of genus *Pontoppidania*. Sarwar *et al.* (2015) described two new acarid species of the genus *Acotyledon viz., A. augokiensis* and *A. haroonabadensis* from Pakistan. They also added a key to the species. Rahul and Mary Anitha (2016 b) conducted a survey on predatory mites inhabiting vegetable crops from Kerala, reported 2 species under 2 genera *viz., Acarus* and *Tyrophagus*.

CHAPTER 3

MATERIALS AND METHODS

An extensive survey was carried out in detail for ascertaining the association of predatory mites with different species of vegetable crops. Predatory mites were collected by performing extensive surveys covering 6 districts of North Kerala from May 2015 to December 2017.

3.1. Study area

North Kerala was considered as the study area (Plate 1), as the excellent environmental flora contributes to the acarine faunal habitat round the year. Kerala state experiences the humid equatorial tropic climatic condition. The districts in North Kerala selected for the study were Palakkad, Malappuram, Kozhikode, Wayanad, Kannur and Kasaragod. The sampling localities in Palakkad district were Pattambi, Chittur, Nenmaara, Mannarkad and Ottapalam (Plate 3). From Malappuram district Thenjipalam, Mongam, Chelari, Manjeri, Parappanagadi and Perinthalmanna were the sites (Plate 4). The collection sites in Kozhikode district were Kakkur, Chaliyam, Kavumvattam, Kadalundi, Malaparamba, Kakkodi, Mankav, Kunduparamba, Ashokapuram, Koorachund, Vadakara, Balussery, Ummalathoor, Feroke, Kootalida, Kurumpoyil, Pazhoor, Payyoli, Vengeri, Kollam, Kanayamkode, Cheliya and Ramanattukara (Plate 4). In Wayanad district 4 sites *viz*., Ambalavayal, Thekkumthara, Kalpetta and Sulthan Batheri were surveyed (Plate 3). The places surveyed in Kannur district were Pariyaram, Thaliparamba, Edakkad and Pazhayangadi (Plate 2). In Kasaragod district Nileswaram, Kanhangad, Bekkal, Vellachal and Takkekad were the collection sites (Plate 2).

3.2. Plants surveyed

Predatory mites were recovered as a result of thorough and rapid surveys carried out on a wide range of vegetable plants from various localities of 6 districts of North Kerala. A total of 32 species of vegetable crops belonging to 27 genera and 16 families were surveyed. Table 1 provides the details of the various species of vegetable crops surveyed in different districts of North Kerala during the period of study.

TABLE 1

List of vegetable plants surveyed for the collection of predatory mites

Sl. No	Scientific Name	Family
1	*Abelmoschus esculentus* L.	Malvaceae
2	*Amaranthus dubius* Mart. ex Thell.	Amarantaceae
3	*Amaranthus viridis* L.	Amarantaceae
4	*Amorphophallus paeoniifolius* (Dennst.) Nicolson	Araceae
5	*Artocarpus heterophyllus* Lam.	Moraceae
6	*Benincasa hispida* (Thunb.) Cogn.	Cucurbitacaea
7	*Brassica oleracea* L.	Brassicaceae
8	*Canavalia ensiformis* (L) DC.	Fabaceae
9	*Canavalia gladiata (*Jacq.) DC.	Fabaceae
10	*Capsicum annuum* L.	Solanaceae
11	*Capsicum frutescens* L.	Solanaceae
12	*Carica papaya* L.	Caricaceae
13	*Coccinia grandis* (L.) Voigt	Cucurbitaceae
14	*Colocasia esculenta* (L.) Schott	Araceae
15	*Cucumis sativus* L.	Cucurbitaceae
16	*Cucurbita maxima* Duchesne	Cucurbitaceae
17	*Cucurbita pepo* L.	Cucurbitaceae
18	*Dioscorea alata* L.	Dioscoreaceae
19	*Dolichos lablab* L.	Fabaceae

Sl. No	Scientific Name	Family
20	*Ipomoea batatas* (L.) Lam	Convolvulaceae
21	*Manihot esculenta* Crantz	Euphorbiaceae
22	*Momordica charantia*	Cucurbitaceae
23	*Moringa oleifera* Lam.	Moringaceae
24	*Murraya koenigii* Sprengel.	Rutaceae
25	*Musa acuminate* Colla.	Musaceae
26	*Phaseolus vulgaris* L.	Fabaceae
27	*Pisum sativum* L.	Fabaceae
28	*Plectranthus rotundifolius* Spreng.	Lamiaceae
29	*Solanum melongena* L.	Solanaceae
30	*Solanum lycopersicum* L.	Solanaceae
31	*Spinacia oleracea* L.	Amaranthaceae
32	*Trichosanthes cucumerina* L.	Cucurbitaceae

3.3. Methods of collection

Mites were collected from leaves, petioles, buds, flowers, twigs and axils of leaves. Collection of samples were usually done during morning hours. Leaves showing infestation symptoms such as bronzing, speckling and discoloured patches were randomly collected with the aid of blade or scissors. The number of leaves collected depended on the size of the leaf. The collected leaves were taken in clean, labeled polythene bags. The mouths of the bags were tied with rubber bands to prevent the escape of mites. They were then screened in the laboratory under a stereozoom binocular microscope.

Identification of host plants were done with the help of experts and in some cases herbarium was prepared for confirming the plant species. The various methods employed for recovering the mites from collected samples were:

3.3.1. Hand picking

Fast moving mites were collected directly from the field using a soft brush. Mites were also picked up from the affected plant parts after screening under a stereo microscope.

3.3.2. Beating

The collections of mites from the field were done using beating method. The infected leaves were beaten over a black coloured rexin sheet and the mites were collected and stored in 70% alcohol. Pest mites associated with predatory mites were also preserved for identification.

3.3.3. Aspirator

Predatory mites along with pest mites can be sucked into an aspirator. Aspirator consists of a glass vial, fitted with a two holed cork into which two thin transparent rubber tubes were inserted. Of these, one is used as a sucking tube and other as an entry tube. While sucking, the vaccum created inside the vial drew the desired mites into it through the entry tube. Collected mites were stored in 70% alcohol.

3.4. Clearing and mounting of mites

The samples preserved in 70% alcohol were upgraded in alcohol series for dehydration. Thereafter, the samples were treated with clearing medium prepared by mixing equal volumes of lactic acid and alcohol, if required. The hard bodied mites and those with undigested internal contents were treated with lactophenol. The mites were treated in this medium for 2 days to digest the internal contents. Then the specimens were thoroughly washed 2-3 times with distilled water until it cleared.

3.4.1. Preparation of mounting medium

Hoyer's medium

Hoyer's medium was prepared by proper mixing of the following ingredients in the following order it was then filtered through cotton wool.

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

3.4.2. Preparation of permanent slides

Mites were mounted in this medium without any pretreatment, since the mites were found cleared directly in the medium itself. A drop of mounting medium was placed centrally on the microscopic slide. Usually 2-3 mites were mounted on each slide. After putting a cover slip, the slides were dried in an oven at a temperature of 45^{o} C for 24 hrs or under a table lamp having 60 Watt electric bulb for at least 48 hours. The slides were labeled and numbered serially for identification. Data like name of the species, host plant, locality, name of the collector, collection date and number were marked on the label. The edges of the cover slips were then sealed with transparent nail polish to avoid damage to the specimens due to excessive moisture or drying.

3.5. Identification of mites

The slide mounted specimens were observed and identified using Olympus CX 31 microscope. Details of the dorsum, ventrum, peritreme, chelicera, shields, spermatheca in females, spermatophoral process in males, hypognathum, gnathosoma, setal pattern, striations, pedipalp, leg IV setation etc. were studied and figures were drawn using Camera lucida. Measurements of body structures with systematic importance were recorded using Ocular micrometer in microns. Microphotographs of some of the important morphological characters were taken using DM 740 model Phase contrast microscope with camera. Dichotomus keys were also prepared for the separation of subfamilies, tribes, subtribes, genera and species included in the present study.

The abbreviations used in the illustrations to denote the morphological and taxonomical characters of the various structures of the predatory mites were as follows:

Cf	-	Chelicera of female
Cm	-	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
L I to L IV	-	Legs I to IV showing setation
Mp	-	Metapodal plate
Sp	-	Spermatheca
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
P	-	Pedipalp
Hd	-	Hypognathum dorsal
Hv	-	Hypognathum venter
T	-	Tectum

All the specimens have been deposited in the Post graduate and Research Department of Zoology, Malabar Christian College, Calicut, Kerala and eventually will be transferred to any of the recognized mite depositories.

The abbreviations and symbols used in the text are as follows:

^{o}C	-	Degree Celsius
L	-	Length
RH	-	Relative Humidity
W	-	Width
♀	-	Female
♂	-	Male

CHAPTER 4
OBSERVATION

During the present study a total of 62 species of predatory mites inhabiting 32 species of vegetable crops belonging to 27 genera, 16 families were examined. Table 1 supplements the details of the vegetable crops that were selected for the study. Table 2 provides the details of the species of predatory mites recovered from their respective host plants that were located in 47 different localities in 6 districts of North Kerala. As illustrated in Table 2, a total of 62 species belonging to 20 genera, one sub genera and 6 families were collected under 3 suborders *viz*., Monogynaspida, Prostigmata and Oribatida. Out of the 62 species identified 23 species belonging to 11 genera appeared to be new to science. The different families recovered were Ascidae, Phytoseiidae, Blattisociidae, Bdellidae, Cunaxidae and Acaridae (Figure 1). Figure 2 supplements the details of the percentage of species recovered under different families *viz*., Ascidae- single species (1.6%), Phytoseiidae- 42 species (67.7%), Blattisociidae – 9 species (14.5%), Bdellidae- 3 species (4.8%), Cunaxidae- 5 species (8.1%) and Acaridae- 2 species (3.2%).

The monogynaspid mites identified during the present study could be categorized under 3 families *viz*., Ascidae, Phytoseiidae and Blattisociidae. Family Ascidae was represented by a single species under the subfamily Asciinae. A new species under the genus *Asca* was recovered from the subfamily Asciinae *viz., Asca babithae* sp.nov.

Phytoseiidae was found exhibiting the maximum diversity with respect to genera and species (Figure 4). This was evidenced by the recovery of 42 species out of the 62 species collected, of which 12 species appeared as new to science (Figure 1, Table 2). The identified 42 species of phytoseiid mites could be categorized under 3 subfamilies *viz*., Amblyseiinae, Phytoseiinae and Typhlodrominae. Under the subfamily Amblyseiinae a total of 8 genera were recovered. Genus *Amblyseius* of subfamily Amblyseiinae was the dominant one with 19 species (Figure 3), out of which 6 were new to science. Under the genus *Euseius* 11 species were identified of which 4 were new to science. This was followed by 2 species each under genera *Neoseiulus, Paraphytoseius, Scapulaseius* and *Proprioseiopsis*. The other genus recorded was *Transeius* represented by a single species (Figure 4). Under the subfamily Phytoseiinae only a single species under the genus *Phytoseius* was recovered, whereas under the subfamily Typhlodrominae only a single genus, *Typhlodromus* under the subgenus *Anthoseius* was recovered (Figure 3).

Family Blattisociidae was represented by 9 species of which 5 were new to science (Figure 1). This could be categorized under two subfamilies *viz*. Platyseiinae and Blattisociinae. The subfamily Platyseiinae was represented by a single species which was new to science under the genus *Cheiroseius viz., C. kozhikodensis* sp.nov. Under the subfamily Blattisociinae a total of 8 species were identified under the genus *Lasioseius*, of which 4 were new to science (Figure 3).

The suborder Prostigmata was found represented by 2 families *viz*., Bdellidae and Cunaxidae. However species and generic diversity under the above families were comparatively very low than Phytoseiidae. Family Bdellidae was represented by 3 species (Figure 1), 2 were new to science. These 3 species were coming under 2 subfamilies Bdellinae and Cytinae. Under Bdellinae a single genus *Bdella* and under Cytinae a single genus *Cyta* were recovered during the present study (Figure 5). The family Cunaxidae represented with 2 subfamilies *viz.,* Cunaxinae and Cunaxoidinae and the family formed the third with respect to species diversity accommodating 5 species (Figure 1). Under the subfamily Cunaxinae a total of 2 genera were recovered *viz., Cunaxa* and *Dactyloscirus* represented by 3 and 1 species respectively. Under the subfamily Cunaxoidinae only a single species under the genus *Neocunaxoides* was recovered (Figure 5). Under the family Cunaxidae 3 species were identified as new taxa, *viz., Cunaxa pushpae* sp.nov, *C. soansi* Rahul *et al.,* 2017 and *Dactyloscirus esculentae* sp.nov.

The suborder Oribatida, was found represented by a single family Acaridae. The two species recovered were already known species coming under the subfamily Acarinae (Figure 1). Under the subfamily Acarinae two genera were identified *viz., Tyrophagus* and *Acarus*.

Almost all the predatory mites were mostly noted to occupy the under surface of leaf and many of them showed no specific habitat preference. As noted in the study, affected plants showed more number of predatory mites and dry and hot weather conditions could give rich population of both prey mites and predatory mites.

New host plants were recorded to support the existence of already described 33 species of mites that were recovered during the present study (Table 2). *Amblyseius herbicolous* was a species found on 5 different host plants and was seen feeding on different species of tetranychid mites as well as tenuipalpid mites. *Amblyseius dioscoreae* sp.nov. (Published as *A. dioscoreae* Rahul *et al.* 2016) was recovered from 4 different vegetable plants. *Pisum sativum, Capsicum annuum* and *Amaranthus dubius* were the 3 plant species that harboured more than 10 species of predatory mites. Sixteen species of host plants examined out of the 32 were noticed to host only a single species of predatory mite (Table 2).

Maximum numbers of predatory mites were collected from localities in Kozhikode district followed by Malappuram, Palakkad, Kasaragod, Kannur and Wayanad districts. *Amblyseius channabasavanai* and *N. longispinosus* were recovered from all the districts surveyed (Table 2).

Amblyseius cinctus was a new record from India on a new host plant, *C. annuum*. Under the family Blattisociidae, 3 new records from India were reported (Table 2). *Bdella distincta* was a new record from India from a new host palnt, *C. annuum.*

Most of the predatory mites were observed in association with other pest mites like tetranychids, tenuipalpids, tarsonemids, eriophyids and so on. Some of them were also found in association with small insects like thrips, coccids and scale insects.

CHAPTER 5

SYSTEMATIC ACCOUNT OF THE SPECIES STUDIED

SYSTEMATIC POSITION

SUPERORDER: I. PARASITIFORMES
SUBORDER: MONOGYNASPIDA
ORDER: MESOSTIGMATA

Superfamily: Ascoidea Voigts and Oudemans, 1905

Family : **I. ASCIDAE Voigts and Oudemans, 1905**

Subfamily : **Ascinae Voigts and Oudemans, 1905**

Genus : **1**. ***Asca*** Von Heyden, 1826

Species 1. *A. babithae* sp. nov.

Superfamily: Phytoseioidea Berlese, 1916

Family : **II. PHYTOSEIIDAE** Berlese, 1916.

Subfamily : **Amblyseiinae** Muma, 1961.

Tribe : Neoseiulini Chant and McMurtry, 2003.

Genus : **2**. ***Neoseiulus*** Hughes, 1948.

Species 1. *N. longispinosus* (Evans), 1952.

2. *N. sasikalae* sp. nov.

Tribe : Kampimodromini Kolodochka, 1998.

Subtribe : Paraphytoseiina Chant and McMurtry, 2003.

Genus : **3**. ***Paraphytoseius*** Swirski and Schechter, 1961.

Species 1. *P. bhadrakaliensis* Gupta, 1969.

2. *P. orientalis* Narayanan, *et al.*, 1960.

Tribe : Typhlodromipsini Chant and McMurtry, 2005.

Genus : **4. *Typhlodromips*** De Leon, 1965.

Species 1. *T. syzigii* Gupta, 1975.

Genus : **5. *Scapulaseius*** Karg and Oomen - Kalsbeek, 1987.

Species 1. *S. meghalayensis* Gupta, 1978

2. *S. suknaensis* Gupta, 1970.

Tribe : Amblyseiini Muma, 1961.

Subtribe : a. Amblyseiina Muma, 1961.

Genus : **6**. ***Transeius*** Chant and McMurtry, 2004

Species 1. *T. tetranychivorous* (Gupta), 1978.

Genus : **7. *Amblyseius*** Berlese, 1914.

Species 1. *A. aerialis* (Muma), 1955

2. *A. amithae* Rahul and Mary Anitha, 2017

3. *A. channabasavannai* Gupta and Daniel, 1978

4. *A. cinctus* Corpuz and Rimando, 1966

5. *A. cucurbitae* Rather, 1985

6. *A. dioscoreae* Rahul *et al.,* 2016

7. *A. herbicolus* (Chant), 1959

8. *A. indirae* Gupta, 1985

9. *A. kulini* Gupta, 1978

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

11. *A. manasi* Rahul and Mary Anitha, 2016

12. *A. muraleedharani* Gupta, 1981

13. *A. orientalis* Ehara, 1957

14. *A. paraarealis* Muma,1967

15. *A. ramani* sp. nov.

16. *A. sachini* Rahul and Mary Anitha, 2017

17. *A. santhoshi* sp. nov.

18. *A. sijiensis* Gupta, 1986

19. *A. velayudhani* Santhosh and Mary Anitha 2016

Subtribe : Proprioseiopsina Chant and McMurtry, 2004.

Genus : **8**. ***Proprioseiopsis*** Muma, 1961.

Species 1. *P. narayani* sp. nov.

2. *P. peltatus* Van der Merwe, 1968.

Tribe : Euseiini Chant and McMurtry, 2005.

Subtribe : Euseiina Chant and McMurtry, 2005.

Genus : **9. *Euseius*** Wainstein, 1962.

Species 1. *E. alstoniae* Gupta, 1975.

2. *E. bambusae* Ghai and Menon, 1967

3. *E. coccineae* Gupta, 1975

4. *E. delhiensis* (Narayanan and Kaur), 1960

5. *E. finlandicus* (Oudemans), 1915

6. *E. kadalundiensis* sp. nov.

7. *E. malabarensis* sp. nov.

8. *E. ovalis* (Evans), 1970

9. *E. rhododendronis* Gupta, 1970

10. *E. sativae* sp.nov.

11. *E. ummalathoorensi*s sp. nov

Subfamily : **Phytoseiinae** Berlese, 1913.

Genus	:	**10**. ***Phytoseius*** Ribaga, 1904.
Species	1.	*P. intermedius*, Evans and Macfarlane, 1962
Subfamily	:	**Typhlodrominae** Wainstein, 1962.
Tribe	:	Typhlodromini Wainstein, 1962.
Genus	:	**11**. ***Typhlodromus*** Wainstein, 1962.
Subgenus	:	**1. *Anthoseius*** De Leon, 1959.
Species	1.	*T.* (*A.*) *bambusicolus* Gupta, 1977.
Family	:	**III. BLATTISOCIIDAE Garman, 1948**
Subfamily	:	**Platyseiinae Evans and Hyatt, 1960**
Genus	:	**12**. ***Cheiroseius*** Berlese, 1916
Species	1.	*C. kozhikodensis* sp. nov.
Subfamily	:	**BLATTISOCIINAE Garman, 1948**.
Genus	:	**13**. ***Lasioseius*** Berlese, 1923
Species	1.	*L. arjuni* sp. nov.
	2.	*L. furcisetus* Athias-Henriot, 1959
	3.	*L. glomerulus* Karg, 1979
	4.	*L. kurumpoyilensis* sp. nov.
	5.	*L. phytoseioides* Chant, 1963
	6.	*L. quadrisetosus* Chant, 1960
	7.	*L. seethae* sp. nov.
	8.	*L. vengeriensis* sp. nov.

SUPERORDER: ACARIFORMES
ORDER: I. TROMBIDIFORMES
SUBORDER: PROSTIGMATA

Superfamily: Bdelloidea Duges, 1834

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

Subfamily : **Bdellinae Grandjean, 1938**

Genus : **14**. ***Bdella*** Latreille, 1795

Species 1. *B. distincta* Baker and Balock, 1944

2. *B. hispidae* sp. nov.

Subfamily : **Cytinae Grandjean, 1938**

Genus : **15**. ***Cyta*** Von Heyden, 1826

Species 1. *C. bharathani* sp. nov.

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

Subfamily : **Cunaxinae Oudemans, 1902**

Genus : **16**. ***Cunaxa*** Von Heydon, 1826

Species 1. *C. pushpae* sp. nov.

2. *C. soansi* Rahul *et al.,* 2017

3. *C. womersleyi* Baker and Hoffmann, 1948

Genus : **17**. ***Dactyloscirus*** Berlese, 1916

Species 1. *D. esculentae* sp. nov

Subfamily : **Cunaxoidinae Den Heyer, 1979**

Genus : **18**. ***Neocunaxoides*** Smiley, 1975

Species 1. *N. andrei* (Baker and Hoffmann), 1975

ORDER: II. SARCOPTIFORMES
SUBORDER: ORIBATIDA

Superfamily: Acaroidea Latreille, 1802

Family : VI. **ACARIDAE Ewing and Nesbitt, 1959**

Subfamily : **Acarinae Latreille, 1802**

Genus : **19**. ***Acarus*** Linnaeus, 1758

Species 1. *A. gracilis* Hughes, 1957

Genus : **20**. ***Tyrophagus*** Oudemans, 1924

Species 1. *T. putrescentiae* Schrank, 1781

CHAPTER 6

DESCRIPTIONS OF SPECIES

SUPERFAMILY: ASCOIDEA Voigts and Oudemans, 1905.

1905. Ascoidea Voigts and Oudemans, *Abh. herausg. Naturwiss. Ver. Bremen.,* **18**: 199-253.

2007. Ascoidea Affandi, *J. Hort*., **17**(1):81-87.

2009. Ascoidea Krantz and Walter, *A manual of Acarology, Texas Tech University press,* p. 148.

2013. Ascoidea Kazemi and Rajaei, *Persian J. Acarol*., **2**(1): 63–158.

2014. Ascoidea Lindquist and Moraza, *J. Nat. His.,* **48**(27-28): 1611-1651.

2016. Ascoidea Lam and Zhang, *Syst. Appl. Acarol.,* **21**(12): 1693–1709.

Diagnosis: Dorsal shield entire, or with lateral incisions, or divided; sternal shield usually with 3 pairs of setae, but with 2 pairs or rarely 1 pair of setae; ventrianal shield rarely divided into ventral and anal shields; sperm induction pores on sternal region between bases of coxae III and IV; spermatodactyl on movable cheliceral digit usually simple and finger like, sometimes elongated.

Type Genus: ***Asca*** von Heyden, 1826

6.1. Family: ASCIDAE Voigts and Oudemans, 1905.

1905. Ascidae Voigts and Oudemans, *Abh. herausg. Naturwiss. Ver. Bremen.,* **18**: 199-253.

1958. Ascidae Evans, *Proc. Zool. Soc. Lond.*, **131**: 177.

1960. Ascidae Evans and Hyatt, *Bull. Brit. Mus. (Nat. Hist.) Zool*., **6**(2): 25.

1963. Ascidae Hurlbutt, *Acarologia*, **5**: 481.

1965. Ascidae Lindquist and Evans, *Mem. Entomo. Soc. Can.*, **47**: 1-64.

1968. Ascidae Bhattacharyya, *Acarologia*, **10**: 528.

1970. Ascidae Dusbabek and Cerny, *Acarologia*, **XII**: 269-281.

1976. Ascidae Hughes, *Min. Agri. Fish Food Lond. Tech. Bull*., **9**: 313.

1977. Ascidae Fain *et al*., *Acta zool. path. antverp*., **69**: 99-154.

1978. Ascidae Hyland *et al*., *J. New York Entomol. Soc.*, **86**: 260-267.

1979. Ascidae Domrow, *Rec. West. Aust. Mus.,* **8**(1): 97-116.

1985. Ascidae Zamudio, *Folia Entomol. Mex*., **64:** 81-91.

1990. Ascidae Dobkin, *Behavioral Ecology*, **1**(2): 131-139.

1993. Ascidae Walter *et al., Invert. Taxonomy*, **7**: 1327.

1994. Ascidae Ostovan and Kamali, *J. Entomol. Soc. Iran*, **14**: 9-18.

1996. Ascidae Karg, *Mitt. Zool. Mus. Berl*., **72**: 157.

1998. Ascidae Halliday *et al*., *Invert. Taxonomy.***12:** 1-54.

2005. Ascidae Kaluz and Fenda, *Slovak Academy of Sciences, Bratislava*, 148 pp.

2006. Ascidae Chelav *et al*., *17th Iranian Plant Protection Congress*. p. 184.

2007. Ascidae Dusbabek *et al*., *Zootaxa,* **1484**: 51-67.

2008. Ascidae Atamehr *et al*., *J. Entomol. Soc. Iran*, **27**(2): 1-2.

2009. Ascidae Fenda and Kaluz, *In: Tajovsky K, Schlaghamersky J, Pizi V. (eds.) Contribution to Soil Zoology in Central Europe III*. pp: 33-40.

2011. Ascidae Rajaei *et al*., *First Persian Congress of Acarol*., p. 48.

2012. Ascidae Nemati *et al*., *Internat. J. Agri. Crop Sci*., **4** (14): 1005-1011.

2013. Ascidae Eliaderani *et al., J. Crop Prot*., **2** (2): 127-138.

2014. Ascidae Fenda and Lukas, *Folia faunistica Slovaca*, **19** (2): 171-175.

2015. Ascidae Britto *et al*., *Exp. Appl. Acarol*., **66**(2): 203-217.

2016. Ascidae Moraes *et al*., *Zootaxa*, **4112**(1):1-299.

Diagnosis: Adults with distinct podonotal or opisthonotal shields, which are fused or not. More than 21 pairs of setae on dorsal shield (usually 23 - 26 pairs), setae mostly nude or slightly hairy, sometimes indented, seldom broadened. Third pair of sternal setae mostly on posterolateral corners of sternal shield; Seta ST_4 usually on unsclerotised cuticle. Genital shield truncate to convex posteriorly. Ventrianal shield rarely with circumanal setae, or bearing additionally up to 7 pairs of setae. Peritrematic shield broadly connected to exopodal shield beside coxa IV. Fixed cheliceral digit multidentate with strong *pilus dentilis* and movable digit usually bidentate. 1 - 2 pairs of metapodal plates present. Chaetotaxy of trochanter, femur and genu 2-5-6 respectively.

Type Genus: ***Asca*** von Heyden, 1826

Morphology and terminology

Dorsal shield with more than 21 pairs of setae (usually 23 - 26 pairs), setae mostly nude or slightly hairy, sometimes indented, seldom broadened. Dorsal shield with solid margins or with distinct shallow incisions. Sternal shield with 3 pairs of sternal setae. If metasternal plate present, they are small, oval, rhomboid or triangular, with a single pair of setae. Genital shield usually reaches behind coxae IV. Lateral margins of genital shield parallel, caudally broadened, with caudal margin. One pair of genital setae on the shield or closed to lateral margins. Ventrianal shield enlarged, wearing several pairs of ventrianal setae. In some species anal shield can be visible only with 3 anal setae.

Chelicera normal, fixed digit of chelicerae with several teeth or with the row of denticles, movable digit mostly with two teeth. Metapodal shields small, oval (1-2 pairs). In females 1- 2 pairs of endopodal shields are present. Peritremes and peritremal shields narrow or wide. Peritremes sometimes exceed both stigmae and coxae IV. Tectum with various shapes; gnathosomal setae usually equal and nude, however rostral setae sometimes whip-shaped (prolonged), corniculi horn like, strongly sclerotized acuminated terminally.

Stable-forked seta on tarsus of pedipalp two-folded; setae on palp-trochanter equal or inner setae long, whip-shaped. Legs with short claws; leg I sometimes without claws, medial part of pulvillae on pretarsi wide and rounded or narrow and sharp. Tarsi IV in several species with two long and apically curved dorso-medial setae. Chaetotaxy of trochanter, femur and genu 2-5-6 respectively. Males usually have two shields on ventral side.

Notations for dorsal idiosoma and ventral setation follows Lindquist and Evans (1965) and Lindquist (1994) respectively. Leg setal notation and chaetotactic formulae were based on Evans (1963). The dorsal and ventral shield furnished with the following sets of setae (Plate 5A)

Dorsal setae

i) Dorsocentral setae (j-J): Paired setae present on central region of dorsal shield.

$j_1 – j_6$ - Vertical setae

$J_1 – J_5$ – Clunal setae

ii) Dorsolateral setae (s-S): Present between mediolateral and sublateral setae.

$s_1 – s_6$ – Propodosomal dorsolateral setae

$S_{1} – S_5$ – Opisthosomal dorsolateral setae

iii) Mediolateral setae (z-Z): Present between dorsocentral and dorsolateral setae.

$z_1 – z_6$ – Propodosomal mediolateral setae

$Z_1 – Z_5$ – Opisthosomal mediolateral setae

iv) Marginal setae (r and R series): Present on the lateral integument of the dorsal shield.

$r_1 - r_6$ – Propodosomal marginal setae

$R_1 - R_6$ – Opisthosomal marginal setae.

Ventral setae

$ST_1 - ST_3$	- Sternal setae
ST_4	- Metasternal setae
ST_5	- Genital setae
$ZV_1 - ZV_5$ and $JV_1 - JV_5$	- Preanal setae
$a_1 - a_3$	- Anal setae
JV_5	- Caudal setae

SUBFAMILY: ASCINAE Voigts and Oudemans, 1905

1905. Ascinae Voigts and Oudemans, *Abh. herausg. Naturwiss. Ver. Bremen.,* **18**: 199-253.

1939. Ascinae Oudemans, *Neu Funde auf gebiete der Systematik. Nomen. Acari. III. Zool. ANzeiger,* **126** (1-2): 20-24.

1952. Ascinae Baker and Wharton, *An Intro. Acarol.*, p.465.

1965. Ascinae Lindquist and Evans, *Mem. Ent. Soc. Can.,* **47**: 1-67.

1995. Ascinae Fain *et al*., *Internat. J. Acarol.,* **21**(2): 107-122.

2009. Ascinae Krantz and Walter, *A Manual of Acarology* 3rd ed. *Texas Tech University Press*, pp. 124-232.

2016. Ascinae Huhta, *Memoranda Soc. Fauna Flora Fennica*, **92**: 129-148.

Diagonosis: Dorsal shield completely divided without transverse lines extending across surface. Peritremal shield broad and truncate posteriorly. Usually sternal shield with 3 pairs of setae. Holodorsal shield with R- series, which are on soft cuticle. Fixed digit of chelicerae with 4-6 teeth, movable digit with 2 teeth in addition to an apical tooth.

Genus: *Asca* Von Heydon, 1826

1826. *Asca* Von Heydon, *Isis Oken*, **19**: 610.

1959. *Asca* Halaskova, *ActaUniversitatis Carolinae-Biologica*, **1**: 17-21.

1963. *Asca* Hurlbutt, *Acarologia,* **5:** 480-518.

1967. *Asca* DeLeon, *Lawrence (Kansas): Allen Press, Inc*., p. 47-66.

1969. *Asca* Genis *et al*., *Museu do Dundo-Subsidios para o Estudo da Biologia na Lunda, Diamang Publ. Cult.*, **81**: 83-105.

1972. *Asca* Lindquist, *Can. Entomol*., **104**: 1543-1550.

1979. *Asca* Karg, *Mitt. Zool. Mus. Berlin*, **55**: 251-267.

1992. *Asca* Bai and Gu, *Acta Zootaxonomica Sinica*, **17**: 314-316.

1993. *Asca* Walter *et al., Invert. Taxonomy*, **7**: 1327-1347.

1997. *Asca* Bhattacharyya *et al., Ann. Entomol.*, **15** (2): 11-15.

2002. *Asca* Bhattacharyya and Sanyal, *Acarina*, **10**: 167-173.

2004. *Asca* Facundo and Corpuz-Raros, *The Philippine Agricultural Scientist*, **87**: 196-228.

2005. *Asca* Facundo, *Asia Life Sciences*, **14**: 111-131.

2011. *Asca* Beard *et al*., *Syst. Appl. Acarol*., **16**: 7-20.

2017. *Asca* Britto *et al*., *Internat. J. Acarol.,* **43**(4): 286-290.

Diagnosis: Dorsal shield completely divided; opisthonotal shield bears 15 pairs of setae. Opiosthonotal shield with setae Z_4 and S_5 inserted together on a pair of posterolateral tubercles; podonotal shield without setae z_1; setae j_2 well behind the level of j_1. Peritremal shield broad and truncate posteriorly. Leg chaetotaxy of genu I-IV: 12, 11, 8, 9; tibia I-IV: 13 or 12, 10, 8,10 or 9. Pretarsi present on all legs.

Asca babithae sp. nov.

PLATE 6

Female: Dorsal shield 200 long, 113 wide with 33 pairs of setae, 18 pairs on anterior shield and 15 pairs on posterior shield. All setae moderately long, acicular, bilaterally plumose except J_4 and Z_4 which are plumose. Anteriodorsal shield with web like pattern of ornamentation. Posteriodorsal shield without any ornamentation. On anteriodorsal side, series j and s with 6 pairs of setae, z series with 5 pairs of setae. Setae j_1 – 10, j_2 – 13, j_3 – 10, j_4 – 15, j_5 – 12 and j_6– 13 long. Setae z_1 absent, z_2 – 10, z_3 and z_4 – 14 each, z_5 – 15 and z_6 – 14 long. Setae s_1 – 13, s_2 – 15, s_3 and s_4 – 13 each, s_5 and s_6 – 18 each. Posteriodorsal side, setae J_1 – 17, J_2 and J_3 – 19 each, J_4 – 31 and J_5 – very short and plumose. Setae Z_1 – 18, Z_2 – 25, Z_3 – 20, Z_4 – 31 and Z_5 – 23 long. Setae S_1 – 13, S_2 – 18, S_3 – 15, S_4 – 17 and S_5 – 20 long. Sternal shield smooth, ventrally 60 long and 40 wide with 3 pairs of setae, ST_1, ST_2 – 18 and ST_3 – 20 long. Metasternal shield with setae ST_4 – 18 long. Anterior margin of sternal shield centrally grooved, posterior margin straight and lateral margins are deeply concave. Genital shield 40 wide with setae ST_5 – 17 long. A clear skin fold is present in between genital and ventrianal shield; ventrainal shield massive, semicircular, reticulated anteriorly, 75 long and 102 wide with 5 pairs of setae which are simple and slender, not enlarged or situated on tubercles, and similar to other ventrianal setae. Metapodal plates are inconspicuous. Peritreme extends anteriorly up to setae j_1. Fixed digit of chelicerae with 5 teeth, movable digit with 2 sharp teeth. Spermatheca with fundibular cervix. Macrosetae on leg IV; basitarsus – 16 long and tarsus 20 long.

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

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

Male: Sternogenital shield 112 long, 56 wide with setae ST_1, ST_2, ST_3, ST_4 and ST_5. Ventrianal shield 100 long and 156 wide, semicircular with 5 pairs of setae in addition to anal setae. Spermatophoral process as illustrated.

Habitat: *Capsicum annuum* L.

Material Examined: Holotype ♀ marked on the slide INDIA: KERALA: Kadalundi (Kozhikode district), 2.xi.2015, ex. *Capsicum annuum*, coll. Rahul (No. A 193/1). Four paratype slides with 3 ♀♀ and two ♂♂, collection details same as above (No. A 193/2, 193/3, 193/4, 193/5).

Remarks: This new species closely resembles *Asca plumosa* Wood, 1966 in general appearance but it can be differentiated by the following characters.

1. Anteriodorsal shield of the new species bears 18 pairs of setae, whereas *A. plumosa* have only 17 pairs of setae.
2. Posteriodorsal shield without any ornamentation pattern in the new species but *A. plumosa* with unusual ornamentation pattern.
3. Metapodal plates are inconspicuous in the new species but in *A. plumosa* 2 pairs of metapodal plates present.
4. In the new species 5 pairs of setae were present on the ventrianal shield whereas in *A. plumosa* 6 pairs were present in addition to anal setae.
5. S_5 of *A. plumosa* sickle shaped where as in the new species it is not like that.

SUPERFAMILY: PHYTOSEIOIDEA Berlese, 1916

1916. Phytoseioidea Berlese, *Redia,* 3.

1965. Phytoseioidea Karg, *Zool. Jb. Syst. Bd*., **103**: 505-546.

1989. Phytoseioidea Karg, *Zool. Jb. Syst*., **116**: 31-46.

2009. Phytoseioidea Krantz and Walter, *A Manual of Acarology*. Third Edition. Texas Tech University Press; Lubbock, Texas, 807 pp.

2011. Phytoseioidea Vargas *et al., Subterranean Biology*, **9**: 113-126.

2016. Phytoseioidea Lam and Zhang, *Syst. Appli. Acarol.,* **21**(12): 1693-1709.

2017. Phytoseioidea Fahad *et al., Acarologia,* **57**(2): 275-294.

Diagnosis**:** Peritremes may be long (over many coxae) or short. Male movable digit of chelicera with spermatodactyl, male genital opening at the front edge of ventral shield, males may have spurs or tubercles on legs II or IV. Sternal shield entire with 2 - 4 pairs of setae. May lack claws on tarsus I.

Key to the families of Superfamily Phytoseioidea included in the present study

1. Corniculi with pointed tips, generally well separated from each other and subparallel; podonotal region with15-25 pairs of setae and opisthonotal region with 8-16 pairs of setae............................... Blattisociidae Garman

\- Corniculi deeply separated, slender, proximal, parallel and bladder like; a maximum of 14 pairs of setae on the podonotum and opisthonotum region……………………………………….……..Phytoseiidae Berlese

6.2. Family I: PHYTOSEIIDAE Berlese, 1916

1916. Phytoseiini Berlese, *Redia,* 3.

1941. Phytoseiinae Vizthum, *Akadem. Verlag,* 768.

1952. Phytoseiidae Baker and Wharton, *An Intro. Acarol.*, p.87.

1959. Phytoseiidae Chant, *Can. 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, *Can. Entomol*., **97**: 353.

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

1973. Phytoseiidae Tuttle and Muma, *Tech. Bull. Agr. Exp. Sta. Univ. Arizona*, **208**: 1-55.

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

1978. Phytoseiidae Chant *et al*., *Can. J. Zool*., **56**(6): 1330.

1982. Phytoseiidae Karg, *Zool. Jb. Syst. Bd.,* **103**: 507.

1986. Phytoseiidae Chant and Yoshida- Shaul, *Can. J. Zool.,* **65:** 1770.

1986. Phytoseiidae Gupta, *Fauna of India (Acari: Mesostigmata) Family Phytoseiidae*, Zool. Surv. India, Culcutta, p. 350.

1987. Phytoseiidae Gupta, *Rec. Zool. Surv. India. Occ. Pap*., **95**: 3.

1990. Phytoseiidae Denmark and Kolodochka, *Internat.J. Acarol.,* **16**(4):219.

1991. Phytoseiidae Gupta, *Rec. Zool. Surv. India. Occ. Pap*., **81**: 3.

1992. Phytoseiidae Chant and Yoshida-Shaul, *Internat. J. Acarol.,* **18**(3): 177-193.

1993. Phytoseiidae Takahashi and Chant, *Internat. J. Acarol*., **19**: 15–22.

1995. Phytoseiidae Yoshida- Shaul and Chant, *Acarologia,* **36**(1): 3-19.

1997. Phytoseiidae Gupta and Chatterjee, In: *State Fauna Ser. 6, Fauna of Delhi,* p.523-527.

2003. Phytoseiidae Gupta, In: *A monograph on plant inhabiting predatory mites of India. Part II: Order: Mesostigmata. Mem. Zool. Surv. India.,* **20**(1): 1-185.

2007. Phytoseiidae Chant and McMurtry, In: *Illustrated keys and diagnoses for the genera and subgenera of the Phytoseiidae of the world (Acari: Mesostigmata)*, p.219.

2008. Phytoseiidae Tixier *et al., Biological J. Linn. Soc.,* **93**: 845-885.

2009. Phytoseiidae Abad-Moyano *et al., Exp. Appli. Acarol.*, **47**: 121-132.

2010. Phytoseiidae Tsolakis and Ragusa, *Acarologia*, **50**: 415-429

2013. Phytoseiidae Barbar, *Acarologia,* **53**: 247-261.

2014. Phytoseiidae Demite *et al., Zootaxa*, **3795**: 571-577.

2015. Phytoseiidae Tsolaki and Ragusa, *Zootaxa*, **3926** (2): 229-243.

Diagnosis: Dorsal shield entire or divided transversely with 23 or fewer pairs of setae (including setae r_3 and R_1), 1- 3 pairs of sublateral setae. The colour of live phytoseiids varies from colourless or pale yellow to darker shades of brown. Palpal claw with 2 tined apotele, tectum is smooth or slightly denticulate. Fixed digit of chelicera with variable number of teeth, movable digit, with or without teeth. Peritreme extends anteriorly from mesolateral stigmata, anus ventral, legs with pretarsus and ambulacra. Genital shield truncate posteriorly with a pair of seta, a pair of spermatheca open between coxae III and IV; ventrianal shield elongate, square type or pentagonal with 1 to 7 pairs of of preanal setae in addition to para and postanals. Movable digit of male chelicerae with spermatophoral process; genital aperture of male placed anteriorly on the sternigenital shield. Ventrianal shield with 2 to 7 pairs of preanal setae and a pair of caudal setae.

Type Genus: *Phytoseius* Ribaga, 1904.

Morphology and Terminology

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

Gnathosoma

The gnathosoma bears the mouthparts, a pair of chelicerae and a pair of pedipalpi. 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 8 A) are 2 in number and are of chelate type. Each chelicera terminates in a chela, which provided with 2 digits, a dorsal fixed digit and a ventral movable digit. The digits are provided with variable number of teeth. The fixed digit also bears *pilus dentilis*. In males (Plate 8 B) the movable digit of each chela bears a copulatory organ called the spermatophoral process or spermatodactyl.

b) ***Pedipalpi*****:** Palpi are 2 in number, coxae of palpi fused 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.

Idiosoma

Idiosoma (Plate 8 A) 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*** (j_1): A pair of setae, anterior in position on the dorsal shield.

b) ***Clunal setae*** (J_5): A 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): Between j_5 and j_6 always lies the first pair of median setae. The second pair or median setae if present lies on the proscutum of the shield and the posterior region is always provided with one pair of median setae.

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

f) ***Sublateral setae*** (r_3 and R_1): Sublateral setae are generally 2 pairs and are located on the sublateral integument or lateral integument of the dorsal shield. In males r_3 lies on the dorsal shield.

Venter

The ventral side of phytoseiid mites posess the following structures (Plate 8 A).

a) ***Sternal shield***: Posterior to the tritosternum lies the sternal shield which is formed by the fusion of coxal plates. It may be smooth, reticulate and variously sclerotized in different genera. Normally 3 pairs of sternal setae (ST) are present on the shield, but in some cases there are only 2 pairs on the sternal setae and 3rd pair lies on the interscutal membrane. The sternal and genital shield in males fused to form sternitigenital shield bearing 5 pairs of setae.

b) ***Metasternal plate***: A pair of metasternal plates is present which may be small or massive and usually bear a pair of sternal setae (ST_4).

c) ***Genital shield***: Genital shield lies posterior to the sternal shield. This shield guards the female genital pore and is normally truncated in the posterior region and has a pair of setae (ST_5).

d) ***Ventrianal shield***: Ventrianal shield (Plate 8 A) lies posterior to genital shield and shows extreme variation in size and shape with 1 - 4 pairs of preanal setae, a pair of anal and post-anal setae are also present. The ventrianal shield often bears a pair of conspicous preanal pores, but sometimes they may be absent. In males the ventrianal shield shows little variation among species and is of less taxonomic value. Ventrianal shield of all males are of same shape and is equipped with 4 - 5 pairs of setae. The ventrianal shield is entire, fragmented or sometimes fused with sternitigenital shield.

e) ***Metapodal plates***: One or two pairs of metapodal plates (Plate 8 A) are present just behind coxae IV, which may be round, oval or triangular in shape. In addition to metapodal plates, small platelets are often present between the genital and ventrianal shield.

f) ***Setae on membrane***: The membrane surrounding the ventrianal shield is provided with variable number of setae and pores. A single pair of caudal setae, JV_5 is always present which may be smooth, serrated or barbed.

g) ***Spermatheca***: A pair of spermathecae (Plate 8 B) is always present in Phytoseiidae for the reception of spermatophores and is of great importance in the separation of species. The spermatophores are collected in a membraneous vesicle with a sclerotized portion called cervix which leads into a chamber called atrium. A minor and major duct arises from the atrium. Between the coxae III and IV on the venter lies the external opening of the spermatheca.

h) ***Peritreme***: The peritreme and stigmata lies on the peritremal shield and is of great taxonomic importance. In some species they are anteriorly fused with the dorsal shield and are posteriorly curved around coxae IV. Peritreme and stigmata serves the respiratory function of the organism.

Legs

Phytoseiids have 4 pairs of legs and the chaetotaxy of legs are of immense taxonomic value in generic and species identification. According to Evans (1963) all phytoseiids possess standard chaetotaxy of legs II and III. Setal number of leg II and III varies in different species. Genus *Typhlodromus* bears 7 or 8 setae on genu II and 7 on genu III. Genus *Macroseius* has 8 setae on genu II and 7 on genu III. Seven setae are present on each of genu II and III, tibia II and III of genus *Chantia.* Genu II, III and IV of genus *Platyseiella* and *Phytoseius* bears 7-6-7 setae, but some species of genus *Phytoseius* has 7 setae on genu III. Genus *Amblyseiu*s and *Iphiseius* have genu II, III and IV with 7-7-7 setae respectively. Genu II has 7 setae and genu III has 6 setae in genus *Paraamblyseius*. Genu II of *Phytoseiulus* has 7, 8 or 9 setae and 7 on genu III. The leg chaetotactic formula of genu II and genu III and tibia II and III can be represented as:

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

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

Macrosetae are present on genu, tibia and basitarsus of leg IV and in some cases they are also seen on genu and tibia of leg II and leg III. The length and shape of the macrosetae are of much taxonomic relevance as they help in separation of species. Macrosetae may be knobbed, spatulated, simple or with some other shapes.

Systematic position of all the species have been described in detail and was made following Gupta (1987, 2003), Chant and McMurtry (2007) and also based on recent literatures and expert opinion. Setal nomenclature followed is of Rowel *et al.* (1978), Chant and Yoshida-Shaul (1989, 1991 and 1992). Leg chaetotactic pattern used in the study was of Evans (1963).

Key to the subfamilies of family Phytoseiidae included in the present study

1. Setae z_3 and s_6 absent...... ……………………………Amblyseiinae Muma

- Either or both setae small, z_3 and s_6 present..2

2. Setae Z_1, S_2, S_4 and S_5 absent..................................Phytoseiinae* Berlese

* Seta z_3 present .... …………………………….Genus: *Phytoseius* Ribaga

- At least one of Z_1, S_2, S_4, or S_5 present…........ .Typhlodrominae* Wainstein

* Most species with S_4 and JV_4 present...Tribe: Typhlodromini** Wainstein

** Seta Z_1 absent…………………………….……Genus: *Typhlodromus* Scheuten

SUBFAMILY: AMBLYSEIINAE Muma, 1961

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

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

1965. Phytoseiinae Chant, *Can. Entomol.*, **97**(4): 359 (in part).

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.*, *Can. J. Zool.*, **56** (6): 1344.

1978. Amblyseiinae Gupta, *Handbk. Plant mites of India.* p.333.

1986. Amblyseiinae Gupta, *Fauna of India (Acari: Mesostigmata) Family Phytoseiidae,* p.32.

1987. Amblyseiinae Gupta *Rec. zool. Surv. India, Occ. Pap.,* **95**: 4.

1989. Amblyseiinae Cobanoglue, *Turk. Entomol. derg.,* **13**(3): 169.

1989. Amblyseiinae Gupta, In: *Progress in Acarology,* **1:** 404.

1990. Amblyseiinae El-Banhawy and Abou-Awad, *Insect Sci. Appl*., **11**: 899 - 901.

1992. Amblyseiinae Gupta, In: *State Fauna Ser. 3, Fauna of West Bengal Part 3,* p.150.

1993. Amblyseiinae Schicha and O'Dowd, *J. Aust. Ent. Soc. Indiroopilly*, **32**: 297-305.

1995. Amblyseiinae Amitai, *Entomol. Hell*., **10**: 19-20.

2003. Amblyseiinae Chant and McMurtry, *Internat. J. Acarol.*, **29** (1): 3-46.

2004. Amblyseiinae Ehara and Amano, *J. Acarol. Soc. Japan*, **13**(1): 1-30.

2005. Amblyseiinae Chant and McMurtry, *Internat. J. Acarol.,* **31**(4): 315-340.

2007. Amblyseiinae Chant and McMurtry, In: *Illustrated keys and diagnoses for the genera and subgenera of the Phytoseiidae of the world (Acari: Mesostigmata)*, p.13.

2008. Amblyseiinae, Guanilo *et al., Zootaxa*, **1880**: 1-47

Diagnosis**:** The key character of the subfamily Amblyseiinae is the number and position of the dorsal seate. The dorsal shield is undivided, 2 - 5 pairs of dorsal setae, 1 - 3 pairs of median setae, 3 or 4 pairs of lateral setae well anterior to s_4, normally it is 7 or 8 total; females with 1 - 3 pairs of sublateral setae; 1 - 3 pairs of preanal ventrianal setae and 1 - 3 macrosetae on leg IV. Males with fragmented or entire ventrianal shield; 3 or 4 pairs of ventrianal setae and usually with 2 pairs of sublateral setae both on the dorsal shield.

Type Genus: ***Amblyseius*** Berlese, 1914.

Key to the Tribes/ Subtribe / Genera in the Subfamily Amblyseiinae included in the present study

1. Sternal shield with median posterior projection; deutosternal groove wider (>5 μ in width), with forward migration of preanal setae (JV_2 and ZV_2); preanal setae in male usually arranged in tangential row rather than in triangular pattern................................Tribe: Euseinii Chant and McMurtry

- Sternal shield without posterior projection; deutosternal groove narrower (< 5μ in width); setae JV_2 and ZV_2 not forwardly migrated; preanal setae of male usually arranged in triangular pattern rather than in a tangential row 2

2. Seta S_4 present...3

- Seta S4 absent……………………Tribe: Kampimodromini* Kolodochka

* Some dorsal setae thickened serrated arising from tubercles with distinctive notch or incision in lateral margin of dorsal shield at level of s_4...................................Subtribe: Paraphytoseiina* Chant and McMurtry

* Setae S_2 and J_2 absent, seta S_5 present or absent............................... …..Genus: *Paraphytoseius* Swirski and Schester.

3. Ratio of setae s_4:Z_1< 3:1, Setae s_4, Z_4 and Z_5 not usually longer than other dorsal setae; usually lightly sclerotized, never with wide sternal shield; seta J_2 always present...........……………………………………………..4

– Ratio of setae s_4: Z_1> 3:1, setae s_4, Z_4, Z_5 markedly longer than other dorsal setae, J_2 may be present or absent…........Tribe: Amblyseiini Muma

4. Macroseta on genu II absent, on genu III is rarely present, fixed digit of chelicera usually with fewer than 6 teeth, rarely multidendate, never with

these two characters present together...
....Tribe: Neoseiulini* Chant and McMurtry

* Female ventrianal shield not wider at level of anus without prominent waist not as long as width, chelicera with teeth not confined to apical region, primary metapodal plate normal……….Genus: *Neoseiulus* Hughes

\- Macroseta on genu II and III rarely present, fixed digit of chelicerae with more than 6 teeth, most species with both these characters..........................
.......……...............................Tribe: Typholdrompsini Chant and McMurty

Tribe: NEOSEIULINI Chant and McMurtry, 2003

2003. Neoseiulini Chant and McMurtry, *Internat. J. Acarol.,* **20**(4): 2007.

2007. Neoseiulini In: Chant and McMurtry. *Illust. Keys and Diag. for the Genera and Subgenera of the Phytoseiidae of the World (Acari: Mesostigmata)*. p.13.

Diagnosis: Dorsal shield usually is moderately sclerotized and much longer than wide; increasing in the lengths of certain dorsal setae; setae Z_4 and Z_5 are usually slender, setiform; dorsolateral setae approximately equal in length; chelicerae of normal size and shape, with fixed digit usually having 5 or fewer teeth; posterior margin of sternal shield straight or concave; sternal and genital shields are usually longer than wide; ventrianal shield is usually without a marked waist, and is wider at the level of setae ZV_2 than at the level of the anus; peritremal shield narrow, fused anteriorly with the dorsal shield.

Type Genus: ***Neoseiulus*** Hughes, 1948.

Genus *Neoseiulus* Hughes, 1948

1948. *Neoseiulus* Hughes, *Min. Agric. Fish.* p.141.

1951. *Typhlodromus* (*Neoseiulus*) Nesbitt, *Zool. Verhandl.,* **12**: 34.

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

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

1965. *Typhlodromopsis* Muma, *Fla. Entomol.,* **48**: 245.

1978. *Dictyonotus* Athias-Henriot, *Entomophaga*, **23**: 189-194.

1979. *Dictydionotus* Athias-Henriot, *Rev. Suisse. Zool.*, **86**(3): 673-677.

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

1983. *Amblyseius* (*Neoseiulus*) Karg, *Mitt. Zool. Mus. Berlin*. **59**(2): 313.

1986. *Neoseiulus* Gupta, *Fauna of India. Phytoseiidae.* p.100.

1987. *Neoseiulus* Daneshvar. *Ent. Phyt. Appl.,* **54**(1-2): 13.

1992. *Neoseiulus* Gupta, In: *State Fauna Ser. 3, Fauna of West Bengal, part 3,* p.161.

2003. *Amblyseius (Neoseiulus)* Gupta, In: *A monograph on plant inhabiting predatory mites of India. Part II: Order: Mesostigmata. Mem. Zool. Surv. India,* **20**(1): 1–185.

2007. *Neoseiulus* Chant and McMurtry, In: *Illustrated keys and diagnoses for the genera and subgenera of the Phytoseiidae of the world (Acari: Mesostigmata)*, p.22.

2014. *Neoseiulus* Kolodochka and Gwiazdowicz, *Zootaxa,* **3793**(4): 441-452.

2012. *Neoseiulus* Tsolakis *et al., Zool. J. Linn. Soc.,* **165**: 253-273.

2017. *Neoseiulus* Zheng *et al., Syst. Appl. Acarol.,* **22**(7): 1059-1068.

2018. *Neoseiulus* Syromyatnikov *et al., Zootaxa,* **4394**(2): 270-278.

Diagnosis: Female with 4 pairs of dorsocentral setae, 3 pairs of median setae, 8 pairs of lateral setae and 2 pairs of sublateral setae, on the interscutal membrane; sternal and ventrianal shields with 3 pairs of setae. Chelicerae small in proportion to body size with 3-4 teeth on fixed digit but there are exceptions. Peritreme long, extending to the level of seta j_1. Female ventrianal shield elongate and pentagonal in most species and it never be vase shaped. Macrosetae on leg I-II and III absent. Leg IV with macrosetae on tarsus, but in some cases macrosetae may be present on tibia IV and Genu IV.

Type Species: ***Neoseiulus barkeri*** Hughes, 1948.

Key to the species of *Neoseiulus* included in the present study

1. Peritreme extends upto j_1; fixed digit of chelicera with 3 teeth anterior to *pilus dentilis*, non posterior to it; sternal shield smooth ..…………………………………………………………*longispinosus*

- Peritreme extends upto j_3; fixed digit of chelicera with 5 teeth anterior to *pilus dentilis*, one tooth posterior to it; sternal shield highly reticulated……………...……………………………*sasikalae* sp.nov.

Neoseiulus longispinosus **(Evans), 1952**

PLATE 9

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

Redescription

Female: Dorsal shield 278 long and 145 wide with 17 pairs of setae, mostly long except j_1, J_5 and S_5. Measurements of setae: j_1 - 13, j_4 - 50, j_5 - 60, j_6 -62, J_2 – 60, J_5 – 10, j_3 , z_2, z_4 – 50 each, Z_1 – 65, Z_4 – 60, Z_5 – 62, s_4 – 52, S_2 – 63, S_4 – 50 and S_5 – 13. Sublateral setae r_3 – 50, R_1 – 52 long lies on lateral integument. Sternal shield slightly bulged anteriorly and creased laterally and posteriorly, 63 long, 60 wide with 3 pairs of sternal setae, ST_1, ST_2 and ST_3 – 30 each. Metasternal shield with setae ST_4 - 30 long. Genital shield 65 wide with a pair of setae ST_5 – 30 long. Ventrianal shield 90 long, 75 wide, somewhat triangular, reticulated with 3 pairs of preanal setae and a pair of semilunar preanal pore; 4 pairs of setae present on the membrane around the ventrianal shield, ZV_1 - 25, ZV_2 – 28, ZV_3 – 25, JV_1, JV_2 – 30 each, JV_4 - 15 and JV_5 – 60 long, smooth. Two pairs of metapodal plates present, primary one 20 long, accessory one 17 long. Fixed digit of chelicera with 3 teeth anterior to *pilus dentilis* and none on posterior to it, movable digit with 2 teeth. Peritreme extends upto j_1. Spermatheca with saccular cervix and differentiated atrium. Macrosetae on leg IV present only on basitarsus – 85 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 $1\,\frac{2}{1}\;\frac{2}{0}\,1$, tibia III $1\,\frac{1}{1}\;\frac{2}{1}\,1$.

Male: Similar to female but smaller. Spermatodactyl with foot terminal, enlarged toe, lateral process indistinct. Ventrianal shield reticulated anteriorly, 107 long, 133 wide with a pair of elliptical pores and 3 pairs of preanal setae.

Habitat: *Cucurbita maxima* Duchesne, *Carica papaya* L., *Pisum sativum* L., and *Manihot esculenta* Crantz.

Known habitat: *Bauhinia purpuria,* Castor, *Abelmoschus esculentus, Solanum melongena, Datura* sp., *Tabernaemontana coronaria,* rose, *Dolichos lablab, Phaseolus vulgaris, Calotropis, Zinia* sp., Guava, *Pisum sativum,* Paddy, *Artocarpus integrifolia, Cocos nucifera, Manihot esculenta, Sida cordifolia,* snake gourd, *Luffa acutangula,* grass, orchid, papaya, bamboo, mulberry, beans.

Material examined: Female marked on the slide, INDIA: KERALA: Perinthalmana (Malappuram district), 18.x.2015, ex. *Cucurbita maxima,* coll. Rahul (No. N 130/1). Twelve ♀♀ and 4 ♂♂ on different habitat mentioned above from all the districts surveyed (No. N 130/2, 130/3, 130/4, 130/5).

Distribution: INDIA: Kerala, Orissa, Bihar, West Bengal, Arunachal Pradesh, Sikkim, Tamil Nadu, Karnataka, Pondicherry, Andaman Nicobar Islands, Uttar Pradesh, Lakshadwip Island. OUTSIDE INDIA: Taiwan, Japan, Indonesia, Phillipines, Hongkong, Tasmania, South Africa, New Zealand, Malayasia, Jamaica, Hawaii, South America.

Remarks: The specimen examined closely resembles with *Neoseiulus longispinosus* (Evans), 1952 in all characters like dorsal chaetotaxy, structure of spertmatheca, leg chaetotaxy, number of teeth, etc. and hence fixed as *N. longispinosus*. This was found associated with tetranychids. This was recovered from a new habitat *viz., Cucurbita maxima*.

Neoseiulus sasikalae sp.nov.

PLATE 10

Female: Dorsal shield smooth, 360 long and 215 wide with 17 pairs of setae, mostly long except J_5. Measurements of setae: j_1 - 20, j_4 , j_5, j_6, J_2 – 80 each, J_5 – 10, j_3, z_2 - 70, z_4 – 80 each, z_5 – 25, Z_1, Z_4, Z_5 – 80 each, s_4 – 85, S_2 – 80, S_4 – 60 and S_5 – 20. Two pairs of sublateral setae r_3 and R_1 – 70 each lies on lateral integument. Sternal shield, reticulated, 60 long and 70 wide with 3 pairs of sternal setae, ST_1, ST_2 and ST_3 – 30 each. Metasternal shield with setae ST_4 - 30 long. Genital shield 70 wide with longitudinal striations and a pair of setae ST_5 – 30 long. Ventrianal shield 120 long, 90 wide with anterior transverse striations and posterior longitudinal striations. Ventrianal shield with 3 pairs of preanal setae and a pair of crescent shaped pores; 4 pairs of setae present on the membrane around the ventrianal shield, ZV_1 - 20, ZV_2 – 25, ZV_3 – 28, JV_1, JV_2, JV_4 - 25 each and JV_5 – 85 long, smooth. Genital and ventrianal shield is separated by a clear skin fold. Two pairs of metapodal plates present, primary one 23 long, accessory one 13 long. Fixed digit of chelicera with 5 teeth anterior to *pilus dentilis* and 1 tooth posterior to it, movable digit with 2 teeth. Peritreme extends anteriorly upto the level of j_3. Cervix of spermatheca is fundibuliform with nodular atrium. Macrosetae on leg IV present only on basitarsus – 85 long.

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

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

Male: Dorsal chaetotaxy similar to that of female but smaller, sternogenital shield 125 long, 75 wide with setae ST_1, ST_2, ST_3, ST_4 and ST_5. Ventrianal shield 110 long and 135 wide, semicircular with 3 pairs of setae in addition to anal setae. Spermatophoral process as illustrated with enlarged subterminal foot.

Habitat: *Pisum sativum* L., *Canavalia gladiata* (Jacq.) DC.

Material examined: Holotype ♀ marked on the slide, INDIA: KERALA: Pattambi (Palakkad district), 13.viii.2015, ex. *Pisum sativum,* coll. Rahul (No. N 96/1). Three paratype slides with 5 ♀♀ marked on the slide, collection details same as holotype (No. N 96/2, 96/3, 96/4). Four paratype slides with 3 ♀♀ and 2 ♂♂ from Vadakara (Kozhikode district), 12.xi.2015, ex. *Canavalia gladiata*, coll. Rahul (No. N 96/5, 96/6, 96/7, 96/8).

Remarks: This new species closely resembles *Neoseiulus longispinosus* (Evans), 1952 in dorsal chaetotaxy, shape of ventrianal shield, but differs from it by the possession of the following features.

1. Dorsal shield of the new species is longer when compared with *N. longispinosus.*
2. Setae j_3, j_4 and r_3 are longer in the new species.
3. Fixed digit of chelicerae with 5 teeth anterior to *pilus dentilis* and 1 tooth posterior to it in the new species but 3 teeth anterior to *pilus dentilis* and none on posterior to it in *N. longispinosus.*
4. Cervix of spermatheca fundibuliform with nodular atrium instead of tubular with differentiated atrium in *N. longispinosus.*
5. Peritreme of the new species extends only upto j_3 whereas it is upto the level of j_1 in *N. longispinosus.*
6. Sternal shield is highly reticulated in the new species but it is smooth in *N. longispinosus.*
7. Length of JV_5 much longer (85) in the new species whereas it is only 60 in *N. longispinosus.*
8. Length of macrosetae on leg IV basitarsus varies in both the species.

Tribe: KAMPIMODROMINI Kolodochka, 1998

1998. Kampimodromini Kolodochka, *Vestn. Zool. Ukraine*, **38:** 59.

2007. Kampimodromini Chant and McMurtry, In: *Illustrated keys and diagnoses for the genera and subgenera of the Phytoseiidae of the world (Acari: Mesostigmata)*, p.36.

2010. Kampimodromini Kreiter *et al., Tunisian J. Plant Prot.*, **5**: 151- 178.

2015. Kampimodromini Gupta and Karmakar, *Rec. Zool. Surv. India*, **115**(Part1): 51-72.

Diagnosis: Seta S_4 absent; setae Z_1 and j_5 present; lateral dorsal setae variable in length and thickness, mostly serrated, often arising from tubercles; sternal shield with posterior margin straight or concave; ventrianal shield sometimes reduced but usually long and narrow; peritreme variable in length, peritremal shield narrow, fused anteriorly with dorsal shield; spermatheca simple, with atrium undifferentiated or small, nodular, calyx cup or dish shaped; presence or absence of incisions in the lateral margins of the dorsal shield; presence or absence and nature of the pair of pores associated with seta z_5.

Type Genus: *Kampimodromus* Nesbitt, 1951

Subtribe: PARAPHYTOSEIINA Chant and McMurtry, 2003

2003. Paraphytoseiina Chant and McMurtry, *Internat. J. Acarol*., **29**(3): 211.

2007. Paraphytoseiina Chant and McMurtry, In: *Illustrated keys and diagnoses for the genera and subgenera of the Phytoseiidae of the world (Acari: Mesostigmata)*, p.347.

Diagnosis: Lateral margin of the female dorsal shield deeply notched or incised at the level of seta s_4; some dorsolateral setae much longer than others; all dorsocentral setae minute; a pair of conspicuous pores associated with setae z_5; leg IV with greatly thickened macrosetae.

Type Genus: *Paraphytoseius* Swirski and Schechter, 1961.

Genus *Paraphytoseius* Swirski and Schechter, 1961

1961. *Paraphytoseius* Swirski and Shechter. *Isreal J. Agric. Res.,* **11**: 113.

1966. *Paraphytoseius* De Leon, *Allen Press Inc.,* 17 p.

1967. *Amblyseius (Paraphytoseius)* Ehara, *J. Fac. Sci. Hokkaido Univ. Ser., VI.* **16**: 77.

1992. *Paraphytoseius* Gupta, *Fauna of India:Phytoseiidae, ,* p. 122-123.

1983. *Proprioseius* (*Paraphytoseius*) Karg, *Mitt. Zool. Mus. Berlin.* **59**(2): 302.

1986. *Paraphytoseius* Gupta, *Rec. Zool. Surv. India Occ. Pap.,* **95**: 46.

1989. *Paraphytoseius* Denmark and Muma. *Fla. St.Coll. of Arthropods Occ. Pap.,* **4**: 44-45.

1992. *Paraphytoseius* Gupta. In: *State Fauna Ser. 3. Fauna of West Bengal, Part 3,* p. 163.

1997. *Paraphytoseius* Wei-nan, *Economic Fauna of China: Phytoseiidae,* p. 132.

2003. *Amblyseius (Paraphytoseius)* Gupta, In: *A monograph on plant inhabiting predatory mites of India. Part II: Order: Mesostigmata. Mem. Zool. Surv. India,* **20**(1): 58.

2007. *Paraphytoseius* Chant and McMurtry, In: *Illustrated keys and diagnoses for the genera and subgenera of the Phytoseiidae of the world (Acari: Mesostigmata)*, p.49.

***Diagnosis*:** Dorsal shield with 15 pairs of setae; setae j_1, j_3, s_4, Z_4 and Z_5 on the dorsal shield called landmark setae and heavy, large and serrated, located on tubercles; seta S_5 usually absent, female ventrianal shield longer than wide, seta JV_5 long and serrated, metapodal plates absent or with single plate, peritreme extending to the level of j_1; 7-11 teeth present on the fixed digit of chelicerae, leg IV with 4 macrosetae with swollen tips.

Type Species: *Typhlodromus* (*Amblyseius*) *orientalis*, Narayanan, Kaur and Ghai, 1960.

Key to the species of *Paraphytoseius* included in the present study

1. Macrosetae on Leg IV genu, tibia and basitarsus are club shaped at the tip………………………………………………...……….......*orientalis*

– Macrosetae on Leg IV genu, tibia and basitarsus are spatulated at the tip ....*bhadrakaliensis*

***Paraphytoseius bhadrakaliensis* (Gupta), 1969**

PLATE 11

1969. *Amblyseius bhadrakaliensis* Gupta, *Bull. Entomol.,* **10**(2): 126-129.

Redescription

Female: Dorsal shield 306 long, 160 wide with 2 large pores. Setae j_1, j_3, s_4, Z_4 and Z_5 long thick and serrated, measuring 30, 89, 135, 63 and 106 respectively, all other setae small or minute. sublateral setae r_3 – 40 , R_1 – 30 long lies on lateral integument. Dorsally lateral margins on the anterior half have an invagination and forms a cavity or pouch. Sternal shield creased laterally and posteriorly, 100 long, 65 wide with 3 pairs of sternal setae, ST_1, ST_2 and ST_3 – 20 each. Metasternal shield with setae ST_4 - 25 long. Genital shield 102 wide with a pair of setae ST_5 – 23 long. Ventrianal shield ovate, 100 long, 65 wide with 3 pairs of preanal setae and 4 pairs of setae present on the membrane around the ventrianal shield, ZV_1 - 23, ZV_2, ZV_3 – 20 each, JV_1 – 15, JV_2 – 18, JV_4 - 22 and JV_5 – 75 long, thick and serrate. Metapodal plates inconspicous. Fixed digit of chelicera with 1 tooth anterior to *pilus dentilis* and 4 teeth posterior, movable digit with 3 teeth. Peritreme extends upto the level of j_1. Spermatheca with pocular cervix and nodular atrium. Macrosetae on leg IV: genu - 25, tibia – 37 and basitarsus – 45, all with spatulated 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: *Benincasa hispida* (Thunb.) Cogn., *Brassica oleracea* L.

Known habitat: *Abelmoschus esculentus, Brassica oleracea*.

Material examined: Female marked on the slide, INDIA: KERALA: Takkekad (Kasaragod district), 24.x.2015, ex. *Benincasa hispida,* coll. Rahul (No. P 153/1). Two ♀♀ collection details same as above (No. P 153/2, 153/3). Two ♀♀ from Chelari (Malappuram district), 28.vii.2015, from the same host plant mentioned above, coll. Rahul (No. P 153/4). Two ♀♀, Ambalavayal (Wayanad district), 14.xii.2016, ex. *Brassica oleracea*, coll. Rahul (No. P 153/5, 153/6).

Distribution: Andaman Islands, Arunachal Pradesh, Assam, Jammu and Kashmir, Karnataka, Kerala, Meghalaya, Orissa, Punjab, Tamil Nadu, Tripura.

Remarks: The specimen studied closely resembles with *Paraphytoseius bhadrakaliensis* (Gupta), 1969 in general appearance, dorsal chaetotaxy, measurements of setae, leg chaetotaxy, structure of spermatheca, etc., and hence fixed so. In the present survey *P. bhadrakaliensis* was recovered from a new habitat, *Benincasa hispida.*

Paraphytoseius orientalis **Narayanan *et al.*, 1960**

PLATE 12

1960. *Typhlodromus* (*Amblyseius*) *orientalis* Narayanan *et al.*, *Proc. of the Nat. Inst. Sci. India,* **26**: 384-394.

Redescription

Female: Dorsal shield rugose, 280 long and 150 wide. Setae j_1, j_3, s_4, Z_4 and Z_5 long thick and serrate, measuring 25, 75, 100, 70 and 100 respectively, all other setae small or minute. Setae r_3 – 50, R_1 – 35 long, both on lateral integument. Dorsally lateral margins on the anterior half have an invagination and form a cavity or pouch. Sternal shield bulged anteriorly, creased laterally and posteriorly 85 long, 75 wide with 3 pairs of sternal setae, ST_1, ST_2 and ST_3 – 20 each. Metasternal shield with setae, ST_4 - 10 long. Genital shield 85 wide with a pair of setae, ST_5 – 20 long. Ventrianal shield ovate, 100 long, 62 wide with 3 pairs of preanal setae, JV_1, ZV_2 and JV_2 – 15 each and 3 pairs of setae present on the membrane around the ventrianal shield, ZV_1 - 15, ZV_3 – 10 and JV_5 – 65 long, serrate. Two pairs of metapodal plates present, primary one 18 and accessory one 10 long. Fixed digit of chelicera with 10 teeth, movable digit with 2 teeth. Peritreme extends upto j_3. Spermatheca with pocular cervix and nodular atrium. Macrosetae on leg IV: genu - 20, tibia – 31 and basitarsus – 48, all thick with spatulated 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 $1\,\frac{2}{1}\,\frac{1}{1}\,1$, tibia III $1\,\frac{1}{1}\,\frac{2}{1}\,1$.

Male: Dorsal chaetotaxy similar to that of female, spermatodactyl has foot terminal, lateral process present and toe up–turned. The ventrianal shield lightly reticulated with 3 pairs of preanal setae.

Habitat: *Benincasa hispida* (Thunb.) Cogn., and *Cucurbita maxima* Duchesne.

Known habitat: *Datura metal,* paddy, fern, *Rubus* sp,, *Cajanus cajan*, banana, brinjal, pear, rose, tea, beans, eucalyptus, cashew nut, sunflower, *Shorea robusta*, *Chromolaena odorata, Ipomea*, *Alibizzia lucida,* cotton, *Polygonum* sp., *Eupatorium odoratum, Momordica charantia, Raphanus sativus, Hibiscus,Trichosanthes anguina, mutabilis, Dalbergia* sp., *Vigna unguiculata*, mango, jackfruit, arecanut, sweet gourd, *Dolichos lablab, Abelmoschus esculentus*, *Lantana*, orchid.

Material examined: Female marked on the slide, INDIA: KERALA: Kadalundi (Kozhikode district), 2.xi.2015, ex. *Benincasa hispida,* coll. Rahul (No. P 186/1). Three ♀♀ collection details same as above (No. P 186/2, 186/3, 186/4). Two ♀♀, Kavumvattam (Kozhikode district), 24.x.2015, ex. *Cucurbita maxima,* coll. Rahul (No. P 186/5). Two ♀♀ and 2 ♂♂ from Perinthalmanna (Malappuram district), 18.ix.2015, ex. *Cucurbita maxima*, coll. Rahul (No. Tp 186/6).

Distribution: INDIA: Kerala, Tripura, Arunachal Pradesh, Mizoram, Maharashtra, West Bengal, Andaman and Nicobar Islands, Orissa, Bihar, Meghalaya, Sikkim, Assam, Jammu and Kashmir, Tamil Nadu, Kerala, Karnataka, Punjab, Andra Pradesh, Uttar Pradesh. OUTSIDE INDIA: Philippines, Hong Kong, Malayasia, Thailand, Nigeria, China, Madagascar and Pakisthan.

Remarks: The specimen studied agrees with *Paraphytoseius orientalis* Narayanan *et al.,* 1960 in dorsal chaetotaxy, setal measurements, structure of spermatheca, leg chaetotaxy, etc., and hence fixed so. In the present survey *P. orientalis* was recovered from two new habitats *viz*., *Benincasa hispida* and *Cucurbita maxima.*

Tribe: **TYPHLODROMIPSINI Chant and McMurtry, 2005**

2005 Typhlodromipsini Chant and McMurtry, *Internat. J. Acarol*. **31**(3): 318.

2007 Typhlodromipsini Chant and McMurtry, In: *Illustrated keys and diagnoses for the genera and subgenera of the Phytoseiidae of the world (Acari: Mesostigmata)*, p.55-57.

2008. Typhlodromipsini Chant and McMurtry, Guanilo *et al., Zootaxa*, **1880**:1-47.

Diagnosis: Setae s_4, Z_4 and Z_5 not greatly longer than other dosolateral setae, not elongate, whip-like; seta Z_5 often thick, spine-like; posterior margin of sternal shield usually straight; peritreme usually extending to the level of seta j_1; fixed digit of chelicerae multidentate; legs II and III, and usually I, with macrosetae.

Type Genus: ***Typhlodromips*** De Leon, 1965.

Key to the genera in the Tribe Typhlodrompsini

1. Dorsal shield with waist at level of seta R_1; dorsal shield usually reticulate; usually with scale-like markings on the anterolateral margin of dorsal shield, seta R_1 never inserted on the dorsal shield of female, posterior margin of the sternal shield striate or concave, never with posterior projection, seta Z_4 variable in length but never minute …………………………………………………...*Typhlodromips* De Leon

- Dorsal shield without prominent waist at level of R_1; usually with distinct longitudinal striations along anterolateral margin of dorsal side, lateral setae j_3, z_2, z_4, Z_1, S_2, S_4 and S_5 short or minute, subequal; seta R_1 inserted on the edge of the dorsal shield of the females of some species, posterior margin of the sternal shield sometimes with a median projection or sometimes lightly sclerotized, seta Z_4 variable in length, sometimes minute. Seta J_1 absent; seta s_4 less than twice the length of any other lateral setae…….............................……*Scapulasieus* Karg and Oomen- Kalsbeek .

Genus *Typhlodromips* De Leon, 1959

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

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

1966. *Typhlodromips* De Leon, *In Studies on the Fauna of Suriname and other Guyanas*. p. 93.

1967. *Typhlodromips* Denmark and Muma, *Fla. Ent.,* **50**(3): 171.

1970. *Typhlodromips* Muma and Denmark, *Arthropods of Florida*, **6**: 78.

1972. *Typhlodromips* Denmark and Muma, *Fla. Ent.,* **55**(1): 24.

1973. *Typhlodromips* Denmark and Muma, *Rev. Brazil. Biol.,* **33**(2): 251.

1975. *Typhlodromips* Denmark and Muma, *Internat. J. Acarol.,* **4**(1): 7-8.

1978. *Typhlodromips* Knisley and Denmark, *Fla. Ent.,* **61**(1): 10.

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

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

1983. *Amblyseius* (*Typhlodromips*) Wainstein, *Entomol.,* **62**(1): 313.

1986. *Typhlodromips* Gupta, *Fauna of India: Phytoseiidae,* p.159.

1987. *Typhlodromips* Gupta, *Rec. Zool. Surv. India, Occ. Pap.,* **95**: 57.

1998. *ochii* species group, Ehara and Amano, *Species Diversity*. **3**(1): 41.

2003. *Amblyseius (Typhlodromips)* Gupta, In: *A monograph on plant inhabiting predatory mites of India. Part II: Order: Mesostigmata. Mem. Zool. Surv. India,* **20**(1): 82.

2007. *Typhlodromips* Chant and McMurtry, In: *Illustrated keys and diagnoses for the genera and subgenera of the Phytoseiidae of the world (Acari: Mesostigmata)*, p.63.

2008. *Typhlodromips* Guanilo *et al., Zootaxa,* **1880**: 1-47.

Diagnosis: Dorsal shield much longer than wide with strong reticulation, 6 pairs of dorsocentral setae, 2 pairs of median setae and 2 pairs of sublateral setae on interscutal membrane. Fixed digit of chelicerae with 8 or more teeth lie on proximal to strong *pilus dentilis;* peritreme long, extending upto the level of j_1; sternal shield as wide or wider than long; ventrianal shield pentagonal; macrosetae may be present on genu and occasionally on tibia of all the legs; but macrosetae are present on genu, tibia and basitarsus of leg IV. Spermatodactyl of males with terminal foot and distinct lateral process.

Type Species: *Typhlodromus (Typhlodromopsis) simplicissimus* De Leon, 1959.

Typhlodromips syzygii Gupta, 1975

PLATE 13

1975. *Amblyseius syzygii* Gupta, *Internat. J. Acarol.,* **1**(2): 26-45.

Redescription

Female: Dorsal shield fully reticulated, 350 long, 250 wide with 17 pairs of setae. Measurements of setae: j_1 - 15, j_3 - 10, s_4 - 20, Z_4 – 37, Z_5 – 75 (serrate), all other setae small or minute. Sternal shield, 75 long, 73 wide with 3 pairs of sternal setae, ST_1 , ST_2 and ST_3 – 15 each. Metasternal shield with setae ST_4 - 15 long. Genital shield 85 wide with a pair of setae ST_5 – 13 long. Ventrianal shield vase shaped 110 long, 78 wide with 3 pairs of preanal setae and a pair of crescent shaped preanal pores; 4 pairs of setae present on the membrane around the ventrianal shield. ZV_1 - 20, ZV_2, ZV_3 – 15, JV_1, JV_2 – 15 each, JV_4 – 19 and JV_5 – 35 long, smooth. Two pairs of metapodal plates present primary one 20 and accessory one 13 long. Fixed digit of chelicera with 4 teeth anterior to *pilus dentilis* 4 teeth posterior to it, movable digit with 3 teeth. Peritreme extends beyond j_1. Spermatheca saucer shaped with pocular cervix and nodular atrium. Macrosetae on leg IV: genu - 45, tibia – 38 and basitarsus – 49.

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: *Amaranthus dubius* Mart. ex Thell., *Pisum sativum* L., *Amorphallus paeonifolis* (Dennst.) Nicolson and *Abelmoschus esculentus* L.

Known habitat: *Syzgium cumini*, *Cucumis melo,* guava, jute, maize, beans, sugarcane, litchi, undertermined plant, leaf litter, mulberry, *Shorea robusta, Amorphallus companulatus, Azadirachta indica*, Mango, *Ficus cunea*, tea, bamboo, *Dolichos lablab*, jack fruit, orchid, citrus, *Pisum sativum, Amorphallus paeonifolis, Abelmoschus esculentus*.

Material examined: Female marked on the slide, INDIA: KERALA: Perinthalmana (Malappuram district), 18.x.2015, ex. *Pisum sativum,* coll. Rahul (No. Tp 114/1). Seven ♀♀ marked on the slide, Parapanagadi (Malappram district), 18.x.2015, ex. *Amaranthus dubius,* coll. Rahul (No. Tp 114/2, 114/3, 114/4, 114/5, 114/6, 114/7, 114/8). One♀ from Pazhoor (Kozhikode district), 25.ix.2015, ex. *Amorphallus paeonifolis*, coll. Rahul (No. Tp 114/9). Two ♀♀ marked on the slide, Chittur (Palakkad district), 18.i.2017, ex. *Abelmoschus esculentus,* coll. Rahul (No. Tp 114/9, 114/10).

Distribution INDIA: West Bengal, Bihar, Orissa, Sikkim, Mizoram, Uttar Pradesh, Tripura and Meghalaya. OUTSIDE INDIA: Thailand.

Remarks: The specimen examined closely resembles *Typhlodromips syzygii* Gupta, 1975 in general appearance, dorsal chaetotaxy, saucer shaped spermatheca, etc., hence fixed so. In the present survey *T. syzygii* was recovered from a new habitat *viz*., *Amaranthus dubius*. This is a new record from Kerala.

Genus *Scapulaseius* Karg and Oomen – Kalsbeek, 1987

1987. *Amblyseius (Scapulaseius)* Karg and Oomen – Kalsbeek, *Zool. Jahr. Syst*. **118**(1): 132.

1987. *markwelli* species group, Schicha, *Phytoseiidae of Australia and neighbouring areas. Indira Publ. House, Michigan.*p.25.

1998. *japonicus* species group, Ehara and Amano, *Species Diversity,* **3**(1): 26

1999. *oguroi* species group, Wu and Ou, *Syst. Appl. Acarol*., **4:**103

2005. *Scapulaseius* Chant and McMurtry, *Internat. J. Acarol*. **31**(4): 331

2007. *Scapulaseius* Chant and McMurtry, In: *Illustrated keys and diagnoses for the genera and subgenera of the Phytoseiidae of the world (Acari: Mesostigmata)*, p.219.

2014. *Scapulaseius* Demite *et al., Zootaxa,* **3795** (5): 571-577.

2015. *Scapulaseius* Gupta and Karmakar, *Rec. Zool. Surv. India*: **115**(Part-1): 51-72.

Diagnosis: Dorsal shield usually without a constriction at level of setae R_1. Dorsal setae short to minute and subequal except in Z_5 and sometimes Z_4. Setae J_1 and z_6 absent; setae z_2 and z_4 not longer than distances to bases of setae next behind; peritreme extending at the level of j_1; 3 pairs of sternal setae; 3 pairs of preanal setae, a pair of preanal pores; genu II and III with macrosetae. Males usually have 3 or 4 pairs of preanal setae.

Type Species: ***Amblyseius (Scapulaseius) stilus*** Karg and Oomen- Kalsbeek, 1987.

Key to the species of *Scapulaseius* included in the present study

1. Cervix of spermatheca elongated, flask shaped with undifferentiated atrium ………………………………………………..........*meghalayensis*

- Cervix of spermatheca tubular flared, cervix which is looped posteriorly with nodular atrium ……………………..............*suknaensis*

Scapulaseius meghalayensis **Gupta, 1978**

PLATE 14

1978. *Amblyseius meghalayensis* Gupta, *Indian J. Acarol.,* **2**(2): 60-77.

Redescription

Female: Dorsal shield 325 long, 235 wide, lateral margins reticulated with 17 pairs of setae. Measurements of setae: j_1 - 20, j_3 - 15, s_4 – 25, Z_4 – 50, Z_5 – 75, S_2 - 17, S_4 - 15, S_5 – 20, r_3 – 15, R_1 – 10 all other setae small. Sternal shield flattened anteriorly, creased laterally and posteriorly, 72 long, 62 wide with 3 pairs of sternal setae ST_1 - 20, ST_2 and ST_3 – 25 each. Metasternal shield with setae ST_4 - 20 long. Genital shield 62 wide with a pair of setae ST_5 – 20 long. Ventrianal shield vase shaped, lateral margins are concave, 100 long, 70 wide with 3 pairs of preanal setae and a pair of elliptical preanal pores; 4 pairs of setae present on the membrane around the ventrianal shield. ZV_1 – 15, ZV_2 – 20, ZV_3 – 8, JV_1 – 15, JV_2 – 22, JV_4 – 10 and JV_5 – 25 long, smooth. A clear band is present between genital and ventrianal shield. Two pairs of metapodal plates present, primary one 22 and accessory one 15 long. Fixed digit of chelicera with 4 teeth anterior to *pilus dentilis* and 4 teeth posteror to it, movable digit with 3 teeth. Peritreme extends anteriorly upto the base of j_1. Spermatheca with double walled, elongated and flask shaped cervix and undifferentiated atrium. Macrosetae on leg IV: genu - 44, tibia - 37 and basitarsus – 50, all pointed.

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

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

Male: Not studied.

Habitat: *Pisum sativum* L.

Known habitat : Guava, Undetermined plant

Material examined: Female marked on the slide, INDIA: KERALA: Thenjipalam (Malappuram district), 5.v.2015, ex. *Pisum sativum,* coll. Rahul (No.S 5/1). Four slides with 4 ♀♀ collection details same as above (No. S 5/2, 5/3, 5/4, 5/5).

Distribution : INDIA: Assam, Meghalaya.

Remarks: This specimen studied resembles in almost all characters of *Scapulaseius meghalayensis* Gupta, 1978 hence fixed so. In the present survey *S. meghalayensis* was recovered from a new host plant *viz*., *Pisum sativum.* This is a new record from Kerala.

Scapulaseius suknaensis Gupta, 1970

PLATE 15

1970. *Amblyseius suknaensis* Gupta, *Oriental Ins.,* **4**: 185-191.

Redescription

Female: Dorsal shield 355 long, 212 wide with 17 pairs of setae. Measurements of setae: j_1, j_3, s_4, S_4 – 20 each, Z_4 – 75, Z_5 – 100 (serrate), all other setae small or minute. Sternal shield creased anteriorly and posteriorly, lateral margins are deeply concave,78 long, 62 wide with 3 pairs of sternal setae, ST_1 - 28, ST_2 and ST_3 – 20. Metasternal shield with setae ST_4 - 20 long. Genital shield 75 wide with a pair of setae ST_5 – 20 long. Ventrianal shield, pentagonal, 90 long, 85 wide with 3 pairs of preanal setae and a pair of crescent shaped preanal pores; 4 pairs of setae present on the membrane around the ventrianal shield. ZV_1 - 12, ZV_2 – 10, ZV_3 – 12, JV_1 - 8, JV_2, JV_4 – 10 each and JV_5 – 25 long, smooth. Two pairs of metapodal plates present, primary one 15 and accessory one 10 long. Fixed digit of chelicera with 4 teeth anterior to *pilus dentilis* 4 teeth posterior to it, movable digit with 2 teeth. Peritreme extends anteriorly upto j_1. Cervix of spermatheca tubular flared which is looped posteriorly with nodular atrium. Macrosetae on leg IV: genu - 26, tibia – 19 and basitarsus – 65.

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

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

Male: Not studied.

Habitat: *Amaranthus dubius* Mart. ex. Thell.

Known habitat: *Datura metel, Shorea robusta, Colocasia esculenta, glycosmis,* brinjal, fig, mango, palm, *Tectona grandis*, rose, Neem, cashewnut, bamboo, wood apple, fern, bitter guard, mulberry, *Eupatorium odoratum,* papaya, citrus, *Dolichos lablab, Lantana,* guava, *Euphorbia.*

Material examined: Female marked on the slide, INDIA: KERALA: Feroke (Kozhikode district), 2.xi.2016, ex. *Amaranthus dubius,* coll. Rahul (No. S 189/1). Five ♀♀ collection details same as above (No. S 189/2, 189/3, 189/4, 189/5, 189/6).

Distribution : INDIA : Tripura, West Bengal, Arunachal Pradesh, Andaman and Nicobar Islands, Orissa, Meghalaya, Assam, Sikkim, Mizoram, Uttar Pradesh, Kerala.

Remarks: This specimen agrees with almost all the features of *Scapulaseius suknaensis* Gupta, 1970 having similar dorsal chaetotaxy, structure of spermatheca, shape of starnal and genital shields, number of teeth, etc., hence fixed so. In the present survey *S. suknaensis* was recovered from a new habitat *viz*., *Amaranthus dubius*

Tribe: AMBLYSEIINI Muma, 1961

1961. Amblyseiini Muma, *Fla. Sta. Mus. Bull*., **5**(7): 273.

1962. Amblyseiini Wainstein, *Acarologia,* **4**: 26.

2004. Amblyseiini Chant and McMurtry, *Internat. J. Acarol.,* **30**(3): 171-228.

2007. Phytoseiidae Chant and McMurtry, In: *Illustrated keys and diagnoses for the genera and subgenera of the Phytoseiidae of the world (Acari: Mesostigmata)*, p.68.

Type Genus: ***Amblyseius*** Berlese, 1914.

Key to Substribes and Genus of Tribe Amblyseiini

1. Sternal shield narrower, length: width =1:1, female ventrianal shield usually longer than wide; sternal shield usually smooth; lightly reticulate; genital shield smooth; ventrianal shield may be lightly striate; peritremal shield narrow, ectal strip rarely present; legs II and III usually and leg I often with macrosetae; leg IV with 3 macrosetae, Setae z_2, z_4 minute; Setae j_5, S_2, S_4 present; Setae J_2, S_5, Z_1 present or absent ……..Amblyseiina Muma

– Sternal shield broader, length: width ratio less than one, female ventrianal shield broader, genital shield and ventrianal shield almost equal. Sternal and genital shields smooth or reticulate, ventrianal shield smooth or striate or reticulate, legs III-IV with or without macroseta, setae z_2 and z_4 often may be long, setae j_5, J_2 S_2, S_4 and Z_1 present or absent……………................…..Proprioseiopsina* Chant and McMurtry

* Seta S_4 present, leg I without macroseta on tarsus..... ……............................ ....Genus: *Proprioseiopsis* Muma

Subtribe: AMBLYSEIINA Muma, 1961

2004 Amblyseiina Muma, Chant and McMurtry, *Internat. J. Acarol.,* **29**(1): 179.

2007. Amblyseiina Muma, Chant and McMurtry, In: *Illustrated keys and diagnoses for the genera and subgenera of the Phytoseiidae of the world (Acari: Mesostigmata)*, p.69.

Type Genus: ***Amblyseius*** Berlese, 1914.

Key to to the genera of Subtribe Amblyseiina Muma

1. Ratio of setae S_4: S_2 > 2.7: 1.0, setae S_5 present ………………………
…... *Transeius* Chant and McMurtry

- Ratio of setae S_4: S_2 > 3.0: 1.0, female ventrianal shield well developed, Genu II and Tibia III each with one macrosetae or rarely none……...*Amblyseius* Berlese

Genus *Transeius* Chant and McMurtry, 2004

2004. *Transeius* Chant and McMurtry, *Internat. J. Acarol.*, **30**(4): 179.

2007. *Transeius* Chant and McMurtry, In: *Illustrated keys and diagnoses for the genera and subgenera of the Phytoseiidae of the world (Acari: Mesostigmata)*, p.69.

2013. *Transeius* Santos *et al., Internat. J. Acarol.,* **39**(4): 290-292.

Diagnosis: Adult female with 33 pairs of setae; setae Z_4, Z_5, s_4 and S_5 prominent. Setae z_2, z_4, S_4, S_5 and setae on dorsocentral region are short or very minute; s_4: S_2 < 2.7:1. Ratio of seta s_4 more than 3 times Z_1; seta Z_5 setiform, smooth or lightly barbed; sternal shield longer than wide; genital shield have the same width as the ventrianal shield; peritreme exdends at the level of seta j_1; fixed digit of chelicera usually multidentate; shape of spermatheca variable; leg IV with macrosetae on genu II and III, and few species with macrosetae only on leg IV.

Type Species: ***Amblyseius bellottii*** Moraes and Mesa, 1988.

Transeius tetranychivorus (Gupta), 1978

PLATE 16

1978. *Typhlodromips tetranychivorus* Gupta, *Oriental Ins.,* **12**: 327-338.

Redescription

Female: Dorsal shield 375 long, 220 wide with 17 pairs of setae all being smooth. Measurements of setae: j_1 - 30, j_3 - 44, z_2 – 13, z_4 – 30, s_4 – 75, S_2 – 43, Z_4 – 64, Z_5 - 87, r_3 – 25, all other setae small or minute. Sternal shield bulged anteriorly, creased laterally and posteriorly - 85 long, 72 wide with 3 pairs of sternal setae, ST_1 - 25, ST_2 - 20 and ST_3 – 27. Metasternal shield with setae ST_4 - 25 long. Genital shield 75 wide with a pair of setae ST_5 – 25 long. Ventrianal shield vase shaped, 120 long, 85 wide with 3 pairs of preanal setae and a pair of crescent shaped preanal pores; 4 pairs of setae present on the membrane around the ventrianal shield. ZV_1, ZV_2 – 20 each, ZV_3 – 25, JV_1, JV_2 – 20 each, JV_4 – 20 and JV_5 – 50 long, smooth. A clear skin fold is present between genital and ventrianal shield. Two pairs of metapodal plates present, primary one 20 and accessory one 11 long. Fixed digit of chelicera with 4 teeth anterior to *pilus dentilis* and 2 teeth posterior to it, movable digit with 3 teeth. Peritreme extends anteriorly upto j_1. Spermatheca with poculiform cervix and nodular atrium. Macrosetae on leg IV: genu - 50, tibia – 40 and basitarsus – 68.

Leg chaetotaxy: genu II $2\,\frac{2}{1}\,\frac{2}{0}\,1$, 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: *Solanum melongena* L.

Known habitat: Brinjal, Palm, *Hibiscus mutabilis*, citrus, *Dolichos lablab*, *Sechium edule*, mulberry, papaya, *Lablab niger*.

Material examined: Female marked on the slide, INDIA: KERALA: Thaliparamba (Kannur district), 8.xi.2015, ex. *Solanum melongena,* coll. Rahul (No. T 313/1). Six ♀♀ marked on the slide, collection details same as holotype (No. E 313/2, 313/3, 313/4, 313/5, 313/6, 313/7).

Distribution: INDIA: Tripura, Tamil Nadu, Kerala, Karnataka, Bihar, Utter Pradesh.

Remarks: The specimen studied resembles almost all characters of *Transeius tetranychivorus* (Gupta), 1978 having similar dorsal chaetotaxy, setal measurements, position of peritreme, structure of spermatheca, etc., hence fixed so.

Genus *Amblyseius* Berlese, 1914

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

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

1948. *Amblyseiopsis* Garman, *Agri. Exptl. Stn. Bull.,* **520**: 17.

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

1955. *Amblyseiopsis* Muma, *Ann. Ent. Soc. Amer.,* **48**: 264.

1957. *Typhlodromus* (*Amblyseius*) Chant, *Can. Ent.,* **89**: 528-532.

1959. *Typhlodromus* (*Typhlodromopsis*) De Leon, *Fla. Ent.,* **42**: 113.

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

1962. *Athlaseius* Wainstein, *Acarologia*, **4**: 17.

1965. *Amblyseialus* Muma, *Fla. Entomol.*, **48**: 245-254.

1968. *Chelaseius* Muma and Denmark, *Fla. Entmol.,* **61**: 232.

1970. *Neoledius* Muma and Denmark, *Fla. Entmol.,* **51**: 232.

1973. *Ehareius* Tuttle and Muma, *Tech. Bull.Agr. Exp. Sta. Univ. Arizona, Tueson.* **208**: 14.

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

1983. *Proprioseiopsis* (*Peloiseius*) Karg, *Mitt. Zool. Mus. Berlin.* **59**(2): 303.

1984. *Amblyseius* (*Amblyseius*) Wei and Zhao, *Zootaxonomica Sinica*, **9**: 156-158.

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

1987. *Amblyseius* (*Amblyseius*) Gupta, *Rec. Zool. Surv. India, Occ. Pap.,* **95**: 6.

1988. *Amblyseius* (*Amblyseius*) Gupta, In: *Progress in Acarology,* **1:** 403-410.

1989. *Amblyseius* (*Amblyseius*) Denamrk and Muma, *Occasional Papers of the Florida State Collection of Arthropods*. **4**: 82.

1990. *Amblyseius* (*Amblyseius*) El-Banhawy and Abou-Awad, *Insect Sci. Appl*., **11**: 899-901.

1991. *Amblyseius* (*Amblyseius*) Papadoulis and Emmanouel*, Entomol. Hell,* **9:** 35.

1992. *Amblyseius* (*Amblyseius*) Chant and Yoshida- Shaul, *Internat. J. Acarol.,* **18** (3):179.

1992. *Amblyseius* (*Amblyseius*) Ryu and Lee, *Korean J. Entomol.,* **22**(1): 23-42.

1992. *Amblyseius* (*Amblyseius*) Gupta, In: *State Fauna Ser. 3, Fauna of West Bengal Part 3,* p.151.

2003. *Amblyseius* (*Amblyseius*) Gupta, In: *A monograph on plant inhabiting predatory mites of India. Part II: Ordr: Mesostigmata. Mem. Zool. Surv. India,* **20**(1): 1-185.

2007. *Amblyseius* Chant and McMurtry, In: *Illustrated keys and diagnoses for the genera and subgenera of the Phytoseiidae of the world (Acari: Mesostigmata)*, p.73.

***Diagnosis*:** Dorsal shield with 13 - 17 pairs of setae. They are medium sized phytoseiids, usually with undivided dorsal scutum, and 3 or 4, usually 4 pairs of anterior lateral setae well anterior to s_4. The genus *Amblyseius* is diagnosed in having a slightly sclerotized dorsal shield, female ventrianal shield with variety of shapes, chelicerae with many teeth, leg I, II, III and IV with macrosetae, spermatheca highly variable in form, seta s_4, Z_4 and Z_5 usually greatly elongated with a few exceptions and caudoventral setae ZV_3 unstable and absent on a number of species.

Type Species: *Zercon obtusus* Koch, 1839.

Key to the species of genus *Amblyseius* included in the present study

1. Ventrianal shield vase shaped with concave lateral margins 2

– Ventrianal shield pentagonal or squarish 10

2. Spermatheca saucer shaped or cup shaped... 3

– Spermatheca elongated/fundibuliform 8

3. Spermatheca saucer shaped 4

– Spermatheca cup shaped.. 6

4. Ventrianal shield with a septum below the elliptical pore………….......
………………………………………………………………*velayudhani*

– Ventrianal shield without any septum 5

5. Movable digit of chelicera with one tooth..... ………………*cucurbitae*

– Movable digit of chelicera with 4 teeth……………...…...*dioscoreae*

6. Macrosetae on genu and basitarsus IV same length ………………
…………………………………………………… *santhoshi* sp.nov.

– Macrosetae on genu and basitarsus IV unequal in length..................7

7. Movable digit of the chelicera toothless...................................*indirae*

– Movable digit of the chelicera with 2 teeth .... *sijiensis*

8. A clear septum is present between genital and ventrianal shield... ....*herbicolus*

– Septum is absent………….. .... ……………….9

9. Spermatheca with nodular atrium .... *aerialis*

– Spermatheca with unflared cervix..*largoensis*

10. Cervix of spermatheca looped 11

– Cervix of spermatheca not looped...13

11. Spermatheca with tubular fundibular cervix………………………...12

– Spermatheca with thick walled saccular cervix..... ……………………. ……………………………………………………….*paraaerialis*

12. Movable digit of chelicera with 3 teeth………….............. ……*sachini*

– Movable digit of chelicera with 4 teeth................................... *amithae*

13. Length of Z_5 is more than 300............................. …………………14

– Length of Z_5 much less than 300……………………......................15

14. Length of Z_4 and S_4 is equal………………..…………*ramani* sp.nov.

– Length of S_4 is shorter than Z_4………………..………*muraleedarani*

15. Striations are present around the ventrianal shield as well as two sides of genital shield…………………………………………......*manasi*

– Striations are absent.. 16

16. A clear skin fold is present between genital and ventrianal shield.......... …..……….............*kulini*

– No integumental fold between them……………………….………17

17. Macrosetae on tibia and basitarsus IV same length…………………….

……………………………………………………………….*cinctus*

– Macrosetae on tibia and basitarsus IV is unequal in length…………18

18. Macrosetae on basitarsus IV longer than that on tibia IV………......................…………………………………..*orientalis*

– Macrosetae on basitarsus IV shorter than that on tibia IV……………. …………...….*channabasavannai*

Amblyseius aerialis (Muma), 1955

PLATE 17

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

Rediscription

Female: Dorsal shield smooth, 360 long, 260 wide with 17 pairs of setae. Setae j_1, j_3, s_4, Z_4 and Z_5 being long and whip like; z_2 longer than z_4 setae. Measurements of setae: j_1 - 30, j_3 - 50, s_4 - 100, Z_4 - 125, Z_5 – 250 long, other setae being minute or small and almost equal in size. Sternal shield 76 long and 75 wide with 3 pairs of sternal setae ST_1, ST_2 and ST_3 measuring 20,22 and 21 respectively. It is smooth, slightly creased anteriorly and posteriorly, lateral margins are deeply concave, Metasternal shield with setae ST_4 - 20 long. Genital shield 85 wide with a pair of setae ST_5 - 23 long. Ventrianal shield vase shaped, 105 long, 80 wide, with 3 pairs of preanal setae and a pair of elliptical pores; 4 pairs of setae present around the ventrianal shield. ZV_1 - 20, ZV_2 - 15, ZV_3 - 10, JV_1 - 20, JV_2 - 10, JV_4 – 10 and JV_5 - 85 long, smooth. Two pairs of metapodal plates present, primary one 25 and accessory one 14 long. Fixed digit of chelicera with 5 teeth anterior to *pilus dentilis* and 6 teeth posterior to it; movable digit with 4 teeth. Peritreme extends anteriorly upto j_1. Spermatheca with tubular cervix and nodular atrium. Macrosetae on leg IV: genu - 150, tibia – 100 and basitarsus - 75. Genu I-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 $1 \frac{2}{0} \frac{2}{0} 1$, tibia III $1 \frac{2}{1} \frac{1}{1} 1$.

Male: Not studied.

Habitat: *Amaranthus dubius* Mart. Ex Thell

Known habitat: *Citrus limon*, *Brevipalpus*, *Opuntia*, *Musa cavendishii*, *Fraxinus*, *Rubus ulmifolius*, *Ulmus campestris*, Ornamental plants.

Material examined: Female marked on the slide, INDIA: KERALA: Pariyaram (Kannur district), 8.xi.2015, ex. *Amaranthus dubius*, coll. Rahul (No.A 12/1). Eight ♀♀ marked on the slide, collection details same as above (No. A. 12/2, 12/3, 12/4, 12/5, 12/6, 12/7, 12/8, 12/9).

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

Remarks: The specimen examined closely resembles almost all characters of *Amblyseius aerialis* (Muma), 1955 having similar dorsal chaetotaxy, setal measurements, leg chaetotaxy, structure of spermatheca, etc., and hence fixed so. In the present study *A. aerialis* (Muma) was recovered from a new habitat *viz., Amaranthus dubius* and was seen associated with tenuipalpid mite population.

Amblyseius amithae **Rahul and Mary Anitha, 2017**

PLATE 18

2017. *Amblyseius amithae* Rahul and Mary Anitha, *Biological Forum: An Internat. J.,* **9**(2): 224-226.

Female: Dorsal shield smooth, 350 long, 310 wide with 17 pairs of setae. Measurements of setae: j_1 - 35, j_3 - 50, s_4 - 100, Z_4 - 130, Z_5 – 300, all other setae minute or small. Sternal shield length and width is equal- 70 long with 3 pairs of sternal setae ST_1-25, ST_2-30 and ST_3-21. Metasternal shield with setae ST_4 - 21 long. Genital shield 90 wide with a pair of setae ST_5 - 20 long. Ventrianal shield 110 long, 90 wide, with 3 pairs of preanal setae and a pair of elliptical preanal pores little below the level of third pair of preanal setae. Four pairs of setae present around the ventrianal shield. ZV_1, ZV_2, ZV_3 -10 each, JV_1-11, JV_2-12, JV_4-11 and JV_5 - 85 long, smooth. Two pairs of metapodal plates present, primary one 20 and accessory one 10 long. Fixed digit of chelicera with 3 teeth anterior to *pilus dentilis* and 4 teeth posterior to it; movable digit with 4 teeth. Peritreme extends anteriorly upto j_1 and curves down. Cervix of spermatheca is short 13 long, tubular-fundibular with differentiated atrium. Macrosetae on leg IV: genu - 107, tibia – 65 and basitarsus - 62.

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

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

Male: Unknown

Habitat: *Amaranthus dubius* Mart.ex Thell.

Material examined: Holotype ♀ marked on the slide, INDIA: KERALA: Kavumvattam (Kozhikode district), 24.x.2015, ex. *A. dubius*, coll. Rahul (No.A 136/1). Four paratype slides with 4♀♀, collection details same as holotype (No. A 136/2, 136/3, 136/4, 136/5). ZSIK Regd. No. ZSI/WGRC/IR/INV 12220 (Holotype), 12221-12223 (Paratypes)

Remarks: This new species resembles *Amblyseius channabasavannai* Gupta and Daniel, 1978 in the dorsal chaetotaxy, shape of ventrianal shield, position of peritreme etc., but differs from it by the following characters.

1. Dorsal shield is wider (310) in the new species than *A. channabasavannai* Gupta and Daniel (210-230).
2. Setae j_1 (35), s_4 (100) and Z_5 (300) are longer in the new species but it is 28, 82 and 250 respectively in *A. channabasavannai*.
3. Fixed digit of chelicerae with 5 teeth anterior to *pilus dentilis* in the new species instead of 4.
4. Cervix of spermatheca is short (13) with differentiated atrium in the new species while it is long (32) with undifferentiated atrium in *A. channabasavannai*.

5. Longer nature of setae JV_5 (85 long) in the new species when compared to *A. channabasavannai* (67-72).

6. Length of macrosetae present on leg IV basitarsus 62 long in the new species while it is only 45 in *A. channabasavannai*.

This new species also resembles *Amblyseius chilcotti* Chant, 1971 having similar structure of spermatheca, shape of ventrianal shield etc., but differs from it by the following characters.

1. Dorsal shield is small in the new species (350 long) when compared with *A. chilcotti* Chant (384).

2. The length of setae Z_5 300 in the new species but it is only 165 in *A. chilcotti*.

3. Fixed digit of chelicera with a strong *pilus dentilis* in the new species whereas it is absent in *A. chilcotti*.

4. Number of teeth on the movable digit of chelicera is 4 in the new species instead of 2-3 in *A. chilcotti*.

5. Differences exists in the relative length of macrosetae present on leg IV, genu - 107, tibia – 65 and basitarsus – 62 in the new species but it is 97,85 and 78 respectively in *A. chilcotti*.

Amblyseius channabasavannai Gupta and Daniel, 1978

PLATE 19

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

Redescription

Female: Dorsal shield smooth, 363 long, 250 wide which is smooth anteriorly and rugose posteriorly with 17 pairs of setae; j_1, j_3, s_4, Z_4 and Z_5 long. Measurements of setae j_1 - 25, j_3 - 50, s_4 - 87, Z_4 - 125, Z_5 - 240, all other setae being minute. Sternal shield creased anteriorly and laterally, 87 long, 75 wide with 3 pairs of sternal setae ST_1, ST_2 and ST_3 measuring 25 each. Metasternal shield with setae ST_4 - 20 long. Genital shield 85 wide with a pair of setae, ST_5 - 20 long. Ventrianal shield smooth, pentagonal shaped, 130 long, 100 wide, with 3 pairs of preanal setae and a pair of elliptical pores; 4 pairs of setae present around ventrianal shield. ZV_1 - 20, ZV_2 - 15, ZV_3 - 10, JV_1 - 15, JV_2 - 10, JV_4 – 10 and JV_5– 65 long, smooth. Clear band separates genital and ventrianal shield. Two pairs of metapodal plates present, primary one 18 and accessory one 11 long. Fixed digit of chelicera multidentate with a strong *pilus dentilis*; movable digit with 4 teeth. Peritreme extends anteriorly upto j_1 and slightly curves down. Spermatheca with tubular-pocular cervix and undifferentiated atrium. Macrosetae on leg IV: genu - 88, tibia – 68 and basitarsus - 62.

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 female, but smaller. The ventrianal shield with transverse striations anteriorly, 102 long, 151 wide a pair of elliptical pores and 3 pairs of preanal setae. The spermatodactyl has foot subterminal and toe slightly forked.

Habitat: *Pisum sativum* L., *Capsicum annuum* L and *Plectranthus rotundifolius* Spreng.

Known habitat: Chrysanthemum, polyanthia, chamba, *Dahlia*, palm, *Mangifera indica*, Citrus, *Shorea robusta*, *Lantana*, jute, *Azadirachta indica, Musa paradisia , Cocos nucifera.*

Material examined: Female marked on the slide, INDIA: KERALA: Pattambi (Palakkad district), 13.viii.2015, ex. *Pisum sativum*, coll. Rahul (No.A 95/1). Four ♀♀ marked on the slide, collection details same as above (No. A 95/2, 95/3, 95/4, 95/5). Three ♀♀ and 2 ♂♂ from Feroke (Kozhikode district), 19.viii.2015, ex. *Capsicum annuum*, coll. Rahul (No. A 95/6, 95/7, 95/8). Four ♀♀ from Nileswaram (Kasaragod district), 10.iii.2016, ex. *Plectranthus rotundifolius,* coll. Rahul (95/9, 95/10, 95/11, 95/12). Several ♀♀ and ♂♂ were collected from the same habitats from different districts surveyed.

Distribution: INDIA: Kerala, Tamil Nadu, Meghalaya, Arunachal Pradesh, West Bengal, Sikkim.

Remarks: The specimen studied closely resembles almost all characters of *Amblyseius channabasavannai* Gupta and Daniel, 1978 and hence fixed so. In the present study *A. channabasavannai* was recovered from 3 new habitats *viz., Pisum sativum* L., *Capsicum annuum* L. and *Plectranthus rotundifolius* Spreng. It was seen associated with tenuipalpid and tetranychid populations in the field.

Amblyseius cinctus Corpuz and Rimando, 1966

PLATE 20

1966. *Amblyseius cinctus* Corpuz and Rimando, *The Philippine Agricuturist,* **50**: 114-136.

Redescription

Female: Dorsal shield smooth, 353 long, 300 wide with 17 pairs of setae; j_1, j_3, s_4, Z_4 and Z_5 being long and measures 38, 63, 90, 125 and 220 respectively, all other setae minute measuring 5-8 long. Sternal shield smooth, creased laterally and posteriorly, 78 long, 87 wide with 3 pairs of sternal setae ST_1, ST_2 and ST_3 – 25 each. Metasternal shield with setae ST_4 - 20 long. Genital shield 100 wide with a pair of setae ST_5 - 20 long. Ventrianal shield smooth, pentagonal, 170 long, 95 wide with 3 pairs of preanal setae and a pair of preanal pores; 4 pairs of setae present around ventrianal shield. ZV_1, ZV_2, ZV_3 – 10 each, JV_1 - 20, JV_2 - 15, JV_4 – 12 and JV_5– 87 long, smooth. Two pairs of metapodal plates present, primary one 20 and accessory one 9 long. Fixed digit of chelicera with 4 teeth anterior to *pilus dentilis* and 9 teeth posterior to it; movable digit with 4 teeth. Peritreme extends anteriorly upto j_1. Spermatheca with tubular-flared cervix, 10 long and differentiated atrium. Macrosetae on leg IV: genu - 115, tibia - 80 and basitarsus - 70.

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

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

Male: Not studied.

Habitat: *Capsicum annuum* L.

Known habitat: *Panicum pilipes, Streblus asper, Acalypha* sp., *Vitis* sp., mulberry, *Juniper sp., Citrus* sp., *Sida rhombifolia,* bamboo, papaya, *Casuarina* sp., *Hibiscus* sp.

Material examined: Female marked on the slide, INDIA: KERALA: Kakkur (Kozhikode district), 17.ix.2015, ex. *C. annuum*, coll. Rahul (No.A 242/1). Five ♀♀ marked on the slide, collection details same as above (No.A 242/2, 242/3, 242/4, 242/5, 242/6).

Distribution: OUTSIDE INDIA: Philippines and Thailand.

Remarks: The specimen studied resembles almost all characters such as structure of spermatheca, shape of sternal and ventrianal shields, leg chaetotaxy, etc., of *Amblyseius cinctus* Corpuz and Rimando, 1966, hence fixed so. In the present study *A. cinctus* was recovered from a new host plant *viz., Capsicum annuum* L. This is a new record from India.

Amblyseius cucurbitae Rather, 1985

PLATE 21

1985. *Amblyseius cucurbitae* Rather, *Revista Parasitol.*, **46**(1-2): 291-293.

Redescription

Female: Dorsal shield smooth, 353 long, 275 wide with 17 pairs of setae; j_1, j_3, s_4, Z_4 and Z_5 being long and measures 35, 40, 100, 110 and 250 respectively, all other setae minute measuring 5-10 long. Sternal shield smooth, creased laterally and posteriorly, 75 long, 89 wide with 3 pairs of sternal setae ST_1, ST_2 and ST_3 – 25 each. Metasternal shield with setae ST_4 - 20 long. Genital shield 96 wide with a pair of setae, ST_5 - 20 long. Ventrianal shield smooth, vase shaped, 110 long, 78 wide with 3 pairs of preanal setae and a pair of preanal pores; 4 pairs of setae present around ventrianal shield. ZV_1, ZV_2, ZV_3 – 12 each, JV_1 - 15, JV_2 - 15, JV_4 – 12 and JV_5– 75 long, smooth. Two pairs of metapodal plates present, primary one 20 and accessory one 9 long. Fixed digit of chelicera with 8 teeth; movable digit with one tooth. Peritreme extends anteriorly upto j_1. Spermatheca with slightly corniform cervix and bifid atrium. Macrosetae on leg IV: genu - 150, tibia - 87 and basitarsus - 75.

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

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

Male: Not studied.

Habitat: *Pisum sativum* L., *Cucurbita pepo* L., *Capsicum annuum* L.

Known habitat: *Catalpa bignonoids, Cucurbita pepo, Platanus orientalis*, *Abelmoschus moschatus, Cucurbita maxima.*

Material examined: Female marked on the slide, INDIA: KERALA: Kavumvattam (Kozhikode district), 24.x.2015, ex. *Pisum sativum*, coll. Rahul (No.A. 242/1). One ♀ marked on the slide, ex. *Cucurbita pepo*, place and date of collection same as above (No. A. 242/2). Two ♀♀ marked on the slide, Chaliyam (Kozhikode district), 5.xi.2015, ex. *Capsicum annuum* coll. Rahul (No. A. 242/3,242/4).

Distribution: INDIA: Kerala, Srinagar, Jammu and Kashmir.

Remarks: The material examined agrees with *Amblyseius cucurbitae* Rather, 1985 in almost all characters, hence fixed so. In the present study *A. cucurbitae* was recovered from 2 new host plant *viz., Capsicum annuum* and *Pisum sativum*. This is a new record from Kerala.

Amblyseius dioscoreae Rahul *et al*., 2016

PLATE 22

2016. *Amblyseius dioscoreae* Rahul *et al*., *J. Adv. Zool*., **37**(2): 75-79.

Female: Dorsal shield smooth, 380 long, 260 wide with 17 pairs of setae. Measurements of setae: j_1 - 40, j_3 - 65, Z_4 - 115, Z_5 - 300**,** s_4 - 110, all other setae minute or small. Sternal shield 85 long, 80 wide with 3 pairs of setae ST_1 - 30, ST_2 – 28 and ST_3 - 20. Lateral and anterior margins of sternal shield slightly concave. Setae ST_4 – 25 long placed on metapodal plates. Genital shield 100 wide with ST_5 -25.Ventrianal shield 100 long and 70 wide, vase shaped with concave lateral margins. Three pairs of preanal setae measuring JV_1, ZV_2, JV_3-20 each and a pair of semilunar pores. Four pairs of setae present on the area around ventrianal shield measuring JV_4- 15, JV_5-60, ZV_1-10 and ZV_3- 10. Two pairs of metapodal plates present, primary one 20 and accessory one 10. Peritreme extends anteriorly up to j_1. Cervix of spermatheca is short – 13 long and tubular with bifid atrium. Fixed digit of chelicerae with 4 teeth anterior to *pilus dentilis,* 6 teeth posterior to it; movable digit with 4 teeth. Macrosetae on leg IV: genu- 126, tibia- 98 and basitarsus 50.

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

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

Male: Dorsal chaetotaxy similar to that of female but smaller, sternogenital shield 130 long, 70 wide with setae ST_1, ST_2, ST_3, ST_4 and ST_5. Ventrianal shield 90 long and 110 wide with 3 pairs of setae in addition to anal setae.

Spermatophoral process as illustrated with enlarged subterminal foot and slightly corked toe.

Habitat: *Dioscorea alata* (L.), *Pisum sativum* L., *Coccinia grandis* (L.) and *Moringa oleifera* Lam.

Material examined: Holotype ♀ marked on the slide along with other 2♀♀, INDIA: KERALA: Manjeri (Malappuram district), 25.xi.2015.ex: *Dioscorea alata*, coll. Rahul (No. A. 271/1). One Paratype ♀, collection details same as holotype (No. A. 271/2). 2♀♀ from Kavumvattam (Kozhikode district), 24.x.2015.ex: *Pisum sativum*, coll. Rahul (No.A.152). 2♀♀ from Pattambi (Palakkad District), 5.xi.2015.ex: *Coccinia grandis*, coll. Rahul (No. A. 160/1, 160/2). 2♀♀ from Edakkad (Kannur district), 4.vi.2015.ex: *Moringa oleifera*, coll. Rahul (No.A.170/1, 170/2). ZSIK Regd. No. ZSI/WGRC/IR/INV 12224 (Holotype), 12225-12229 (Paratypes).

Remarks: This new species resembles *Amblyseius largoensis* (Muma), 1955 in general appearance, shape of sternal and ventrianal shield but differs in the following characters:

1. Cervix of the spermatheca is short, tubular with bifid atrium in the new species but it is long with parallel wall in *A. largoensis* (Muma).
2. Fixed digit of chelicerae bears 6 teeth posterior to *pilus dentilis* in the new species where as it is 3 in *A. largoensis*.
3. Number of teeth on movable digit of chelicera 4 in the new species instead of 2 in *A. largoensis.*
4. Three pairs of pores present in *A. largoensis* whereas it is absent in the new species.

5. The length of Z_5 in this new species is longer (300) than *A. largoensis* (250).

6. The length of Z_4 is longer in the new species (115) but Z_4 in *A. largoensisis* it is 105 long.

7. Macrosetae on leg IV genu- 126, tibia-98, and tarsus- 50 long in new species, where as it is 98, 70 and 48 respectively in *A. largoensis*.

8. The tibia II and III of the new species is $1\frac{2}{1}\ \frac{1}{1}1$ and $1\frac{2}{1}\ \frac{1}{1}1$

Where as it is $1\frac{1}{1}\ \frac{2}{1}1$ and $1\frac{1}{1}\ \frac{1}{1}1$ in *A. largoensis*.

***Amblyseius herbicolus* (Chant, 1959)**

PLATE 23

1959. *Typhlodromus (Amblyseius) herbicolus* Chant, *Can. Entomol.,* **91**: 84-85.

Redescription

Female: Dorsal shield 370 long, 250 wide with 17 pairs of setae; j_1, j_3, s_4, Z_4 and Z_5 being long. Measurements of setae: j_1 - 38, j_3 - 50, s_4 - 125, Z_4 - 100, Z_5 - 280, all other setae being minute. Sternal shield concave laterally and posteriorly, 88 long, 78 wide with 3 pairs of sternal setae ST_1, ST_2 – 28 each and ST_3 - 22 long. Metasternal shield with setae ST_4 - 20 long. Genital shield 80 wide with a pair of setae, ST_5 - 30 long. Ventrianal shield vase shaped, 115 long, 70 wide with 3 pairs of preanal setae and a pair of preanal pores, lateral margins are concave slightly above the level of ventrianal pores; 4 pairs of setae present around ventrianal shield. ZV_1 - 15, ZV_2 - 12, ZV_3 - 10, JV_1 - 15,

JV_2 - 20, JV_4 – 10 and JV_5– 75 long, smooth. A clear skin fold is present between genital and ventrianal shield. Two pairs of metapodal plates present, primary one 25 and accessory one 15 long. Fixed digit of chelicera multidentate with a strong *pilus dentilis*; movable digit with 3 teeth. Peritreme extends anteriorly beyond j_1. Spermatheca with slender fundibular cervix and wafer like atrium. Macrosetae on leg IV: genu - 115, tibia - 95 and basitarsus - 70.

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

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

Male: Not studied.

Habitat: *Pisum sativum* L., *Artocarpus heterophyllus* Lam., *Momordica charantia* L., *Canavalia gladiata* (Jacq.) DC and *Dolichos lablab* L.

Known habitat: *Aegle marmelos*, *Aporus dioca*, *Dolichos lablab*, litchi, *Nephelium litchi,* bamboo, guava, apple, peach, mango, *Shorea robusta*, banana, vine, marigold, cinnamon, coconut, mulberry, weed, papaya, orange, orchid, citrus, grass, *Dioscorea, Phaseolus* sp., *Rosa* sp., *Morus* sp., *Crotolaria* sp. *Dolichos lablab*, *Ipomea batatus,* Tea, *Ficus cunea.*

Material examined: Female marked on the slide, INDIA: KERALA: Kadalundi (Kozhikode district), 2.xi.2015, ex. *Artocarpus heterophyllus*, coll. Rahul (No.A 178/1). Two ♀♀ marked on the slide, Nenmaara (Palakkad district), 1.vii.2015, ex. *Pisum sativum*, coll. Rahul (No.A 178/2, 178/3). Two ♀♀ from Pazhayangadi (Kannur district), 4.vi.2015, ex. *Momordica charantia*, coll. Rahul (No. A 178/4, 178/5). Two ♀♀ from Malaparamba

(Kozhikode district), 9.vii.2015, ex. *Canavalia gladiata*, coll. Rahul (No. A 178/6, 178/7). Two ♀♀ marked on the slide, Vengeri (Kozhikode district), 30.vii.2016, ex. *Dolichos lablab*, coll. Rahul (No.A 178/8, 178/9).

Distribution: INDIA: Kerala, West Bengal, Arunachal Pradesh, Tripura and Mizoram. OUTSIDE INDIA: China, U.S.A, Philippines, Thailand, Taiwan, Papua New Guinea, Australia, Japan, Madagascar, South Africa, Mexico, Brazil, West Indies, Portugal, Pakistan, Turkey and Egypt.

Remarks: This species resembles with *Amblyseius herbicolus* (Chant), 1959 in all characters such as setal length, general appearance, structure of spermatheca, leg chaetotaxy, etc., and hence fixed so. In the present study *A. herbicolus* (Chant), was recovered from four new habitats *viz., Pisum sativum* L., *Artocarpus heterophyllus* Lam., *Momordica charantia* L. and *Canavalia gladiata* (Jacq.) DC. It was seen associated with spider mite population.

***Amblyseius indirae* Gupta, 1985**

PLATE 24

1985. *Amblyseius* (*Amblyseius*) *indirae* Gupta, *Entomon,* **10**(3): 209-214.

Redescription

Female: Dorsal shield 340 long, 210 wide with 17 pairs of setae; j_1, j_3, s_4, Z_4 and Z_5 being long. Measurements of setae j_1 - 38, j_3 - 45, s_4 - 110, Z_4 - 100, Z_5 - 225, all other setae being minute. Sternal shield concave laterally and posteriorly, 75 long, 75 wide with 3 pairs of sternal setae ST_1, ST_2 and ST_3 - 22 long. Metasternal shield with setae ST_4 - 20 long. Genital shield 75 wide with a pair of setae, ST_5 - 30 long. Ventrianal shield vase shaped, 100 long, 75 wide with 3 pairs of preanal setae and a pair of preanal pores, lateral margins are concave slightly above the level of ventrianal pores; 4 pairs of setae present around ventrianal shield. ZV_1 - 10, ZV_2 - 12, ZV_3 - 10, JV_1 - 15, JV_2 -

20, JV_4 – 10 and JV_5– 55 long, smooth. Two pairs of metapodal plates present, primary one 25 and accessory one 15 long. Fixed digit of chelicera with 4 teeth anterior to *pilus dentilis* and 5 teeth posterior to it; movable digit toothless. Peritreme extends anteriorly beyond j_1. Spermatheca with saccular slightly flared cervix and atrium is undifferentiated. Macrosetae on leg IV: genu - 130, tibia - 110 and basitarsus - 75.

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: *Cucurbita maxima* Duchesne and *Murraya koenigii* (L.).

Known habitat: *Cucurbita maxima, Z. jambos, Z. malaccense, Cucumis melo, Cocos nucifera, Piper longum, Anacardium occidentale,* Undetermined Plant.

Material examined: Female marked on the slide, INDIA: KERALA: Pariyaram (Kannur district), 8.xi.2015, ex. *Cucurbita maxima*, coll. Rahul (No.A 49/1). Four ♀♀ and 2 ♂♂ from Kunduparamba (Kozhikode district), 25.x.2015. ex. *Murraya koenigii*, coll. Rahul (No. A. 49/2, 49/3, 49/4, 49/5)

Distribution: INDIA: Karnataka and Kerala.

Remarks: This specimen studied agrees with *Amblyseius indirae* Gupta, 1985 in almost all characters such as setal length, general appearance, structure of spermatheca, leg chaetotaxy, etc., and hence fixed so. It was seen associated with tenuipalpids as well as tetranychids.

Amblyseius kulini Gupta, 1978

PLATE 25

1978. *Amblyseius kulini* Gupta, *Indian J. Acarol.,* **2**(2): 62-65.

Redescription

Female: Dorsal shield smooth, 335 long, 235 wide with 17 pairs of setae; setae j_1, j_3, s_4, Z_5 and Z_4 being long and measures 25,50,85,220 and 100 respectively, all other setae minute or small. Sternal shield smooth, creased anteriorly and laterally, 70 long and 80 wide with 3 pairs of sternal setae ST_1, ST_2 and ST_3 - 20 each. Metasternal shield with setae ST_4 - 20 long. Genital shield 80 wide with a pair of setae ST_5 - 20 long. Genital and ventrianal shields are separated by a membraneous fold. Ventrianal shield pentagonal shaped with slightly concave lateral margins, 120 long, 75 wide with 3 pairs of preanal setae and a pair of preanal pores; 4 pairs of setae present around ventrianal shield. ZV_1 - 10, ZV_2 - 20, ZV_3 - 10, JV_1 - 15, JV_2 - 10, JV_4 – 20 and JV_5 – 70 long, smooth. Two pairs of metapodal plates present, primary one 22 and accessory one 15 long. Fixed digit of chelicera with 5 teeth anterior to *pilus dentilis* and 6 teeth posterior to it; movable digit with 3 teeth. Peritreme extends anteriorly upto j_1. Cervix of spermatheca 9 long, saccular with small 'C' shaped atrium. Macrosetae on leg IV: genu - 100, tibia - 75 and basitarsus - 60.

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

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

Male: Unknown.

Habitat: *Solanum melongena* L.

Known habitat: *Bambusa* sp.

Material examined: Female marked on the slide, INDIA: KERALA: Shornur (Palakkad district), 5.xi.2015, ex. *Solanum melongena*, coll. Rahul (No.A 162). Six ♀♀ collection details same as above.

Distribution: INDIA: Assam.

Remarks: The specimen examined agrees with almost all characters of *Amblyseius kulini* Gupta, 1978 hence fixed so. In the present study *A. kulini* Gupta, was recovered from a new host plant *viz., Solanum melongena*. This is a new record from Kerala.

***Amblyseius largoensis* (Muma), 1955**

PLATE 26

1955. *Amblyseiopsis largoensis* Muma, *Ann. Ent. Soc. Am.*, **48**: 262-272.

Redescription

Female: Dorsal shield 340 long, 260 wide with 17 pairs of setae; j_1, j_3, s_4, Z_4 and Z_5 being long. Measurements of setae j_1 - 35, j_3 - 50, s_4 - 80, Z_4 - 100, Z_5 - 250, all other setae being minute. Sternal shield concave laterally, posteriorly and medially, anterior margin is deeply concave, 87 long, 75 wide with 3 pairs of sternal setae ST_1, ST_2 and ST_3 - 22 long. Metasternal shield with setae ST_4 - 20 long. Genital shield 60 wide with a pair of setae, ST_5 - 25 long. Ventrianal shield vase shaped, 110 long, 75 wide with 3 pairs of preanal setae and a pair of preanal pores, lateral margins are deeply concave slightly below the level of ventrianal pores; 4 pairs of setae present around ventrianal shield. ZV_1 - 15, ZV_2 - 12, ZV_3 - 10, JV_1 - 15, JV_2 - 20, JV_4 – 10 and JV_5– 70 long, smooth. Two pairs of metapodal plates present, primary one 25 and accessory one 18 long. Fixed digit of chelicera with 4 teeth anterior to *pilus dentilis* and 3 teeth posterior to it; movable digit with 2 teeth. Peritreme extends anteriorly to the j_1. Spermatheca with tubular, unflared cervix and nodular atrium. Macrosetae on leg IV: genu - 100, tibia - 70 and 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 $1\,\frac{2}{1}\,\frac{2}{1}\,1$, tibia III $1\,\frac{1}{1}\,\frac{2}{1}\,1$.

Male: Not studied.

Habitat: *Musa acuminata* Colla

Known habitat: *Mangifera indica, Piper nigrum, Bauhinia acuminata, Cocos nucifera*, *Calophyllum inophyllum, Musandra corymbosa, Tabernaemontana coronaria,* castor, beans, citrus, pomegranate*, Dalbergia,* eucalyptus, *Tectona grandis,* black berry, sugarcane, *Cassia,* cashewnut, bamboo, arecanut, *Eugenia,* fig, guava, pepper*, Nerium,* litchi, plum, *Manglistia insignis,* chilli, *Shorea* sp., papaya, *Musa sp*., poppy, pine cone, grass, dahlia, peach, *Cassia fistula, Citrus medica, Basicophia javanica,* china rose, undet, plants, cucurbits, *Phoenix paludosa, Jasminum sambac, Bougainvillea spectabilis, Mallotus* sp., *Alstonia scholaris,* cucumber, coconut, *Calotropis, Anona squamosa,* banana, ornamental plant, palm, banyan, *Suaeda nufiflora,* Gamar, peach, apple, tea, sapota, jackfruit, wood apple, money plant, cotton, *Shorea robusta,* arum.

Material examined: Female marked on the slide, INDIA: KERALA: Thekkumthara (Wayanad district), 8.xi.2015, ex. *Musa acuminata*, coll. Rahul (No.A 13/1). Four ♀♀ marked on the slide, collection details same as above (No.A 13/2, 13/3, 13/4, 13/5).

Distribution: INDIA: West Bengal, Manipur, Tripura, Nagaland, Arunachal Pradesh, Assam, Orissa, Sikkim, Andhra Pradesh, Tamil Nadu, Pondicherry, Kerala, Uttar Pradesh, Punjab, Himachal Pradesh, Jammu and Kashmir, Gujarat, Andaman and Nicobar Islands, Lakshadweep Islands, Mizoram, Bihar, Meghalaya, Karnataka. OUTSIDE INDIA: Japan, Guatemala, Hondurus, Puerto Rico, Brazil, Costa Rica, New Zealand, Mexico, Jamaica, Trinidad, South Africa, Kenya, U.S.A., Israel, Western and Northern Iran, Hong Kong, Philippines, Taiwan, Thailand, China, Papua New Guinea, New Caledonia.

Remarks: This specimen resembles with *Amblyseius largoensis* (Muma), 1955 in almost all characters such as setal length, general appearance, structure of spermatheca, leg chaetotaxy, etc., and hence fixed so.

Amblyseius manasi Rahul and Mary Anitha, 2016

PLATE 27

2016. *Amblyseius manasi* Rahul and Mary Anitha, *Int. J. Pure Appl. Zool.,* **4**(4): 302- 305.

Female: Dorsal shield smooth, 340 long, 210 wide with 17 pairs of smooth setae. Measurements of setae: j_1 - 30, j_3 - 50, Z_4 - 150, Z_5 - 285**,** s_4 - 110**,** all other setae minute. Sternal shield smooth, 80 long, 70 wide and slightly concave anteriorly with 3 pairs of setae ST_1 - 30, ST_2 - 28 and ST_3 - 25. ST_4 - 20 long lies on metasternal shield. Genital shield is 80 wide with ST_5-30 long. A clear integumental shield present between genital and ventrianal shield. Ventrianal shield 120 long and 70 wide, pentagonal, smooth with 3 pairs of preanal setae measuring JV_1 - 15, ZV_2 - 12, JV_2 -12 and a pair of elliptical pores. Four pairs of setae present on the area around the ventrianal shield JV_4 - 12, JV_5 - 90, ZV_1- 15 and ZV3- 13. Striations are present around the ventrianal shield as well as two sides of genital shield. Two pairs of metapodal plates present, Primary one 17 long and accessory one 7 long. Peritreme extends anteriorly up to j_1 and curves down. Cervix of spermatheca is 15 long, tubular with undifferentiated atrium and wide major duct. Minor duct of spermatheca is also visible. Fixed digit of chelicera with 4 teeth anterior to *pilus dentilis* 6 teeth posterior to it; movable digit with 4 teeth. Macrosetae present on leg IV- genu- 110, tibia- 60 and basitarsus- 70**.**

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 $1\ \frac{2}{1}\ \frac{1}{1}\ 1$.

Male: Unknown

Habitat: *Capsicum frutescens* L., *Amaranthus dubius* Mart. ex Thell and *Momordica charantia* L.

Material examined: Holotype ♀ marked on the slide, INDIA: KERALA: Kakkodi (Kozhikode District), 30.vii.2015, ex: *Capsicum frutescens*, coll. Rahul (No. A.87/1). Two paratype ♀♀, collection details same as holotype (No. A.87/2, A.87/3). One ♀ from Kavumvattam (Kozhikode District), 24.x.2015, ex: *Amaranthus dubius*, coll. Rahul (No. A.154). one ♀ from Pattambi (Palakkad District), 5.xi.2015, ex: *Momordica charantia*, coll. Rahul (No. A 165). ZSIK Regd. No. ZSI/WGRC/IR/INV 12230 (Holotype), 12231 (Paratype).

Remarks: This new species closely resembles *Amblyseius paraaerialis* Muma, 1967 in general appearence and shape of ventrianal shield but differs from it by the following characters:

1. The length of setae s_4 (110), Z_4 (150) and Z_5 (285) are much longer in the new species than *A. paraaerialis*, Muma s_4 (72), Z_4 (89) and Z_5 (161).

2. Number of teeth on movable digit of chelicera is 4 in the new species instead of 3 in *A. paraaerialis*.

3. Number of the teeth on fixed digit of chelicera posterior to *pilus dentilis* is 6 in the new species instead of 1-2 in *A. paraaerialis*.

4. Spermatheca with long, tubular cervix and rounded atrium, major ducts are widely separated with clear minor duct in the new species whereas in *A. paraaerialis*, it is tubular, looped cervix with undifferentiated atrium.

5. Ventral setae JV_5 (90) long in the new species whereas in *A. paraaerialis*, it is 65.

6. Striations are present around the ventrianal shield as well as two sides of genital shield in the new species whereas it is absent in *A. paraaerialis*.

7. Longer nature of macrosetae on leg IV genu, tibia and basitarsus- Genu-110, tibia- 60 and basitarsus- 70 in the new species whereas it is 70,49 and 52 respectively in *A. paraaerialis*.

8. A clear fold is seen in between ventrianal shield and genital shield in the new species but it is absent in *A. paraaerialis*.

This new species also resembles *Amblyseius guianensis* De Leon, 1966 in relation to the size of body, general appearence and number of teeth on movable and fixed digits of chelicera but differs from it by the possession of the following features:

1. Length of the setae j_3 (50), Z_4 (150), Z_5 (285) and s_4 (110) in the new species are larger when compared with *A. guianensis* (33, 111, 221 and 90 respectively).

2. Spermatheca with long, tubular cervix (15) and undifferentiated atrium in the new species whereas in *A. guianensi*, cervix is weakly vesicular (24) with nodular atrium.

3. Measurement of macrosetae on leg IV genu (109) is larger in the new species whereas it is shorter in *A. guianensis* (99)

Amblyseius muraleedharani Gupta, 1986

PLATE 28

1986. *Amblyseius muraleedharani* Gupta, Fauna of India: Phytoseiidae, p.57-59.

Redescription

Female: Dorsal shield 360 long, 230 wide with 17 pairs of setae; j_1, j_3, s_4, Z_4 and Z_5 being long. Measurements of setae j_1 - 30, j_3 - 50, s_4 - 100, Z_4 - 135, Z_5 - 265, all other setae being minute. Sternal shield concave posteriorly and anteriorly, 85 long, 65 wide with 3 pairs of sternal setae ST_1, ST_2 and ST_3 - 25 long. Metasternal shield with setae ST_4 - 20 long. Genital shield 60 wide with a pair of setae ST_5 - 22 long. Ventrianal shield pentogonal, slightly sclerotised, 125 long, 110 wide with 3 pairs of preanal setae and a pair of preanal pores; 4 pairs of setae present around ventrianal shield. ZV_1 - 15, ZV_2 - 12, ZV_3 - 10, JV_1 - 15, JV_2 - 20, JV_4 – 10 and JV_5– 50 long, smooth. Two pairs of metapodal plates present, primary one 25 and accessory one 15 long. Fixed digit of chelicera with 7 teeth; movable digit with one tooth. Peritreme extends anteriorly upto j_1. Spermatheca with fundibular cervix and undifferentiated atrium. Macrosetae on leg IV: genu - 150, tibia - 100 and basitarsus - 85.

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

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

Male: Not studied.

Habitat: *Pisum sativum* L.

Known habitat: *Tinospora cordifolia,* Tea, pea

Material examined: Female marked on the slide, INDIA: KERALA: Manjeri (Malappuram district), 8.xi.2015, ex. *P. sativum*, coll. Rahul (No.A 47/1). Six ♀♀ marked on the slide, collection details same as above (No.A 47/2, 47/3, 47/4, 47/5, 47/6, 47/7).

Distribution: INDIA: Kerala, Tamil Nadu

Remarks: The specimen studied agrees with *Amblyseius muraleedharani* Gupta, 1981 in almost all characters, hence fixed so.

Amblyseius orientalis **Ehara, 1959**

PLATE 29

1959. *Amblyseius orientalis* Ehara, *Acarologia*, **1**: 285-295.

Redescription

Female: Dorsal shield 346 long, 264 wide with 17 pairs of setae; j_1, j_3, s_4, Z_4 and Z_5 being long. Measurements of setae j_1 - 25, j_3 - 55, s_4 - 100, Z_4 - 105, Z_5 - 275, all other setae being minute. Sternal shield concave posteriorly and anteriorly, 90 long, 100 wide with 3 pairs of sternal setae ST_1, ST_2 and ST_3 - 20 long. Metasternal shield with setae ST_4 - 20 long. Genital shield 90 wide with a pair of setae ST_5 - 20 long. Ventrianal shield pentogonal, 125 long, 100 wide with 3 pairs of preanal setae and a pair of preanal pores; 4 pairs of setae present around ventrianal shield. ZV_1 - 10, ZV_2 - 12, ZV_3 - 13, JV_1 - 20, JV_2 - 20, JV_4 – 10 and JV_5– 88 long, smooth. Two pairs of metapodal plates present, primary one 25 and accessory one 15 long. Fixed digit of chelicera with 4 teeth anterior to *pilus dentilis* and 5 teeth posterior to it; movable digit with 3 teeth. Peritreme extends anteriorly upto j_1. Spermatheca with saccular-flared cervix and nodular atrium. Macrosetae on leg IV: genu - 100, tibia - 72 and basitarsus - 75.

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

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

Male: Not studied.

Habitat: *Capsicum annuum* L.

Known habitat: *Quercus crispula, Murraya koenigii,* Undetermined Plant. *Capsicum annuum.*

Material examined: Female marked on the slide, INDIA: KERALA: Sulthan Batheri (Wayanad district), 25.xi.2015, ex. *Capsicum annum*, coll. Rahul (No.A 17/1). Six ♀♀ marked on the slide, collection details same as above (No.A 17/2, 17/3, 17/4, 17/5, 17/6, 17/7).

Distribution: INDIA: Kerala, Assam. OUTSIDE INDIA: China, Jiangxi, Hawaii, Japan, Russia, South Korea.

Remarks: This specimen resembles with *Amblyseius orientalis*, Ehara 1959 in almost all characters such as setal length, general appearance, structure of spermatheca, leg chaetotaxy, etc., and hence fixed so.

Amblyseius paraaerialis **Muma, 1967**

PLATE 30

1967. *Amblyseius paraaerialis* Muma. *Fla. Ent.* **50**: 270 – 271.

Redescription

Female: Dorsal shield 350 long, 250 wide with 17 pairs of setae; j_1, j_3, s_4, Z_4 and Z_5 being long. Measurements of setae j_1 - 25, j_3 - 50, s_4 - 75, Z_4 - 90, Z_5 - 150, all other setae being minute. Sternal shield smooth, concave posteriorly and laterally, 78 long, 82 wide with 3 pairs of sternal setae ST_1, ST_2 and ST_3 - 25 long. Metasternal shield with setae ST_4 - 20 long. Genital shield 90 wide with a pair of setae ST_5 - 20 long. Ventrianal shield pentagonal, 125 long, 100 wide with 3 pairs of preanal setae and a pair of preanal pores; 4 pairs of setae present around ventrianal shield. ZV_1 - 15, ZV_2 - 12, ZV_3 - 15, JV_1 - 20, JV_2 - 20, JV_4 – 10 and JV_5– 70 long, smooth. Two pairs of metapodal plates present, primary one 20, triangular shaped and accessory one 8 long. Fixed digit of chelicera with 6 teeth anterior to *pilus dentilis* and 2 teeeth posterior to it; movable digit with 3 teeth. Peritreme extending anteriorly beyond j_1. Spermatheca with short-thick walled saccular cervix and undifferentiated atrium. Macrosetae on leg IV: genu - 75, tibia - 46 and basitarsus - 50.

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

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

Male: Not studied.

Habitat: *Capsicum annuum* L., *Momordica charantia* L and *Spinacia oleracea* L.

Known habitat: Citrus, Undetermined Plant, *Psidium guajava, Artocarpus hirsuta, Amorphophallus companulatus,* Egg fruit, *Syzygium jambos, Momordica charantia,* palm, bamboo.

Material examined: Female marked on the slide, INDIA: KERALA: Kadalundi (Kozhikode district), 2.xi.2015, ex. *Capsicum annuum*, coll. Rahul (No.A 163/1). Two ♀♀ collected from Pattambi (Palakkad district), 5.xi.2015, ex. *Momordica charantia,* coll. Rahul (No.A 163/2, 163/3). Two ♀♀ collected from Manjeri (Malappuram district), 25.xi.2015, ex. *Spinacia oleracea,* coll. Rahul (No.A 163/4, 163/5).

Distribution: INDIA: Arunachal Pradesh, Meghalaya, West Bengal, Kerala, Assam. OUTSIDE INDIA: China, Malaysia, Thailand.

Remarks: This species resembles with *Amblyseius paraaerialis* Muma, 1967, in almost all characters such as setal length, general appearance, structure of spermatheca, leg chaetotaxy, dorsal chaetotaxy, etc., and hence fixed so. In the present study *A. paraaerialis* was collected from two new host plants *viz., Capsicum annuum* and *Spinacia oleracea*.

Amblyseius ramani sp. nov.

PLATE 31

Female: Dorsal shield 380 long, 315 wide with 17 pairs of setae. Measurements of setae: j_1 - 38, j_3 - 50, s_4 - 150, Z_4 - 155, Z_5 - 310, all other setae minute or small. Sternal shield smooth, 90 long and 100 wide with 3 pairs of sternal setae ST_1 - 28, ST_2 - 25 and ST_3 - 21. Metasternal shield with setae, ST_4 - 20 long. Genital shield 100 wide with a pair of setae, ST_5 - 20 long. Ventrianal shield 120 long, 90 wide, with concave lateral margins. Three pairs of preanal setae and a pair of elliptical pores are present near the posterior pair of preanal setae. Four pairs of setae present around ventrianal shield. ZV_1 - 15, ZV_2, ZV_3 - 10 each, JV_1, JV2 - 13 each, JV_4 - 10, JV_5 - 75 long, smooth. Two pairs of metapodal plates present, primary one 21 and accessory one 11 long. Fixed digit of chelicera with 4 teeth anterior to *pilus dentilis* and 5 teeth posterior to it; movable digit with 2 teeth. Peritreme extends anteriorly upto j_1 and slightly curved inward. Cervix of spermatheca is 24 long, tubular with rounded nodular atrium. Macrosetae on leg IV: genu - 142, tibia - 92 and basitarsus - 89.

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

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

Male: Unknown

Habitat: *Amaranthus viridis* L., *Ipomoea batatas* (L.) Lam

Material examined: Holotype ♀ marked on the slide, INDIA: KERALA: Pariyaram (Kannur district), 8.xii.2015 ex. *Amaranthus viridis*, coll. Rahul

(No.A 767/1). Two paratype ♀♀ marked on the slide from Edakkad (Kannur district), 4.vi.2015, same habitat mentioned above, coll. Rahul (No. A 767/2, 767/3). One ♀ from Thaliparamba (Kannur district), 8.xii.2015, ex. *Ipomoea batatas,* coll. Rahul (No. A 767/4).

Remarks: This new species closely resembles *A. herbicolus* (Chant), 1959 in general appearance, dorsal cheatotaxy, structure of chelicera, but differs from it in the spermathecal structure and possession of the following features:

1. Width of the dorsal shield is larger (315) in the new species when compared with *A. herbicolus* (236).
2. Measurements of ventrianal shield varies in both species.
3. Setae Z_4 and Z_5 being long in the new species but it is very shorter in *A. herbicolus*.
4. Macrosetae on genu and basitarsus IV longer in the new species (142 and 92 respectively) but it is shorter in *A. herbicolus* (129 and 70 respectively).
5. Cervix of spermatheca is 24 long, tubular with rounded nodular atrium in the new species whereas it is with fundibular cervix and swollen atrium.
6. Differences exits in the leg chaetotaxy.
7. In the new species fixed digit of chelicera with 4 teeth anterior to *pilus dentilis* and 5 teeth posterior to it but in *A. herbicolus* fixed digit with 2 teeth anterior to *pilus dentilis* and 3 teeth posterior.
8. Movable digit with 2 teeth in the new species instead of 3 in *A. herbicolus*.

Amblyseius sachini **Rahul and Mary Anitha, 2017**

PLATE 32

2017. *Amblyseius sachini* Rahul and Mary Anitha, *Biological forum- An Internat. J.,* **9**(2): 224-226.

Female: Dorsal shield smooth, 275 long, 190 wide with 17 pairs of setae, mostly small except j_1, j_3, s_4, Z_4 and Z_5 being long measuring 25, 65, 75, 100 and 200 respectively. Sternal shield smooth, 63 long, 66 wide with 3 pairs of sternal setae ST_1, ST_2 and ST_3 – 20 each. Metasternal shield conspicuous with setae ST_4 - 21 long. Genital shield 63 wide with a pair of setae ST_5 - 18 long. Genital and ventrianal shield is separated by an integumental fold present in between them. Ventrianal shield 90 long, 75 wide with 3 pairs of preanal setae and a pair of elliptical pores; 4 pairs of setae present around ventrianal shield. ZV_1 - 10, ZV_2 - 8, ZV_3 – 10, JV_1 - 8, JV_2, JV_4 – 10 each and JV_5– 62 long, smooth. Two pairs of metapodal plates present, primary one 20 and accessory one 11 long. Fixed digit of chelicera with 5 teeth anterior to *pilus dentilis* and 4 teeth posterior to it; movable digit with 3 teeth. Peritreme extends anteriorly upto j_1 and curves slightly inward. Cervix of spermatheca is 10 long, tubular-fundibular shaped which is gently looped with a nodular atrium. Macrosetae on leg IV: genu - 100, tibia - 62 and basitarsus - 48.

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

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

Male: Unknown.

Habitat: *Capsicum annuum* L.

Material examined: Holotype ♀ marked on the slide, INDIA: KERALA: Kadalundi (Kozhikode district), 2.xi.2015, ex. *Capsicum annum*, coll. Rahul (No.A 163/1). Two paratype slides with two ♀♀, collection details as that of the holotype (No. A 163/2, 163/3). ZSIK Regd. No. ZSI/ WGRC/IR/INV 12232 (Holotype), 12233-12234 (Paratypes).

Remarks: This species resembles *Amblyseius paraaerialis* Muma, 1967 but it is differentiated by the possession of the following characters.

1. Dorsal shield is shorter (275 long, 190 wide) than *A. paraaerialis* Muma, (350 long, 255 wide).

2. Differences exists in the relative length of setae like j_3, s_4, Z_4 and Z_5 which are longer in the new species but it is shorter in *A. paraaerialis*.

3. Fixed digit of chelicerae with 4 teeth posterior to *pilus dentilis* instead of 1-2 teeth in *A. paraaerialis*.

4. In the new species cervix of spermatheca is tubular – fundibular, gently looped with nodular atrium whereas in *A. paraaerialis* it is short, well looped, thick walled and saccular with undifferentiated atrium.

5. Differences in the length of macrosetae on leg IV genu, tibia and basitarsus for the new species (100, 62 and 48 respectively) instead of (73, 46 and 56).

6. Presence of a clear band between genital and ventrianal shield.

Amblyseius santhoshi **sp. nov.**

PLATE 33

Female: Dorsal shield rugose anteriorly, 312 long, 210 wide with 17 pairs of setae. Z_5 weakly serrate, all other setae smooth. Measurements of setae: j_1 - 30, j_3 - 40, s_4 - 50, Z_4 - 52, Z_5 – 120, all other setae minute or small. Sternal shield 85 long and 75 wide with 3 pairs of sternal setae ST_1, ST_2, and ST_3 - 20 each. Metasternal shield with setae ST_4 -20 long. Genital shield 80 wide with a pair of setae ST_5 - 20 long. Ventrianal shield 100 long, 85 wide, with deeply concave lateral margins, 3 pairs of preanal setae and a pair of crescent shaped preanal pores; 4 pairs of setae present around ventrianal shield. ZV_1 - 15, ZV_2, ZV_3 - 10 each, JV_1 - 10, JV_2, JV_4 - 20 each and JV_5 - 45 long, smooth. Two pairs of metapodal plates present, primary one 18 and accessory one 11 long. Fixed digit of chelicera with 5 teeth anterior to *pilus dentilis* and 5 teeth posterior to it; movable digit with 5 teeth. Peritreme extends anteriorly upto j_1. Cervix of spermatheca corniform with 'C' shaped atrium. Macrosetae on leg IV: genu - 65, tibia – 58 and basitarsus - 65.

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

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

Male: Unknown

Habitat: *Amaranthus viridis* L.

Material examined: Holotype ♀ marked on the slide, INDIA: KERALA: Manjeri (Malappuram district), 25.xi.2015 ex. *Amaranthus viridis*, coll.

Rahul (No.A 312/1). Three paratype slides with 4 ♀♀ collection details same as that of holotype (No. A 312/2, 312/3, 312/3).

Remarks: This new species resembles with *Amblyseius crotalariae* Gupta, 1977 but can be differentiated from it by the possession of the following characters.

1. The setae j_1 (30), j_3 (40) and Z_5 (120) being longer in the new species than *A. crotalariae* Gupta (22, 22 and 75 respectively).

2. Fixed digit of chelicera with 5 teeth anterior to *pilus dentilis* and 5 teeth posterior to it in the new species whereas it is with 4 teeth anterior to *pilus dentilis* and 2 teeth posterior to it in *A. crotalariae*.

3. Movable digit of chelicera with 5 teeth in the new species instead of 2-3 in *A. crotalariae*.

4. Cervix of spermatheca is corniform with 'C' shaped atrium in the new species but in *A. crotalariae*, it is double walled poculiform with nodular atrium.

5. Shape of ventrianal shield varies in both species.

6. Differences in the length of macrosetae on leg IV genu and tibia for the new species (65 and 58 respectively) instead of 55 and 40 in *A. crotalariae*.

Amblyseius sijiensis Gupta, 1986

PLATE 34

1986. *Amblyseius (Typhlotromips) sijiensis* Gupta, Fauna of India: Phytoseiidae, p. 183-185.

Redescription

Female: Dorsal shield slightly reticulated, 312 long, 228 wide with 17 pairs of setae. Measurements of setae: j_1 - 35, j_3 - 25, S_2 - 12, s_4 - 35, Z_4 – 62, Z_5 – 100, all other setae small or minute. Sternal shield creased laterally, 75 long, 70 wide with 3 pairs of sternal setae, ST_1, ST_2 and ST_3 – 20 each. Metasternal shield with setae ST_4 - 15 long. Genital shield 67 wide with a pair of setae ST_5 – 15 long. Ventrianal shield vase shaped with concave lateral margins, 100 long, 90 wide with 3 pairs of preanal setae and a pair of crescent shaped preanal pores; 4 pairs of setae present on the membrane around the ventrianal shield. ZV_1 - 20, ZV_2, ZV_3 – 15, JV_1, JV_2 – 15 each, JV_4 – 20 and JV_5 – 30 long, smooth. Two pairs of metapodal plates present, primary one 20 and accessory one 10 long. Fixed digit of chelicera with 4 teeth anterior to strong *pilus dentilis* 3 teeth posterior to it, movable digit with 2 teeth. Peritreme extends upto j_1. Spermatheca with saccular cervix and nodular atrium. Macrosetae on leg IV: genu - 75, tibia – 50 and basitarsus – 62.

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: *Amaranthus dubius* Mart. ex Thell.

Known habitat: *Colocasia* sp., fig, *Tectona grandis, Shorea robusta, Eupatorium odoratum, Datura metel,* fern, harsinger, bitter gourd, papaya, mulberry, undetermined plant

Material examined: Female marked on the slide, INDIA: KERALA: Manjeri (Malappuram district), 25.xi.2015, ex. *Amaranthus dubius,* coll. Rahul (No. A 267/1). Four ♀♀ marked on the slide collection details same as above (A 267/2, 267/3, 267/4, 267/5)

Distribution: INDIA: West Bengal, Orissa, Tripura, Meghalaya, Assam, Kerala, Andaman and Nicobar Islands.

Remarks: This specimen examined closely resembles *Amblyseius sijiensis* Gupta, 1986 in general appearance, dorsal chaetotaxy, shape of spermatheca, etc., hence fixed so. In the present study *A. sijiensis* was recovered from a new host palnt *viz*., *Amaranthus dubius*.

Amblyseius velayudhani Santhosh and Mary Anitha, 2016

PLATE 35

2016. *Amblyseius velayudhani* Santhosh and Mary Anitha, *Entomon,* **41**(1): 67-70.

Redescription

Female: Dorsal shield smooth with scattered muscle marks, 320 long, 230 wide with 17 pairs of setae; setae j_1 - 25, j_3 - 45, s_4 - 60, Z_4 - 94, Z_5 - 235, other setae minute or small. Sternal shield creased anteriorly and posteriorly, lateral margins are deeply concave, 75 long and wide with 3 pairs of sternal setae ST_1, ST_2, and ST_3 - 20 each. Metasternal shield with setae ST_4 -16 long. Genital shield 75 wide with a pair of setae ST_5 - 15 long. A clear septum is present between the genital and ventrianal shield. Ventrianal shield vase shaped 100 long, 65 wide, with 3 pairs of preanal setae and a pair of elliptical pores; 4 pairs of setae present area around ventrianal shield. ZV_1 - 9, ZV_2 - 10, ZV_3 - 7, JV_1 - 10, JV_2 - 7, JV_4 – 7 and JV_5 - 50 long, smooth. Ventrianal shield has a division below the elliptical pore but the shield is not separated each other. Two pairs of metapodal plates present, primary one 10 and accessory one 7 long. Fixed digit of chelicera with 6 teeth anterior to *pilus dentilis* and 7 teeth posterior to it; movable digit with 3 teeth. Peritreme extends anteriorly upto j_1. Spermatheca with tubular cervix and short atrium. Macrosetae on leg IV: genu - 116, tibia – 75 and basitarsus - 64.

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

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

Male: Dorsal chaetotaxy similar to that of female, spermatodactyl and ventrianal shield as illustrated.

Habitat: *Amaranthus viridis* L.

Known habitat: *Ocimum sanctum, Cucurbita maxima* and *Murraya koenigii*.

Material examined: Female marked on the slide, INDIA: KERALA: Edakkad (Kannur district), 18.viii.2015, ex. *A. viridis*, coll. Rahul (No.A 217/1). Several ♀♀ and ♂♂ were collected from the same habitat different districts surveyed.

Distribution: INDIA: Kerala.

Remarks: The specimen studied resembles with almost all characters of *Amblyseius velayudhani* Santhosh and Mary Anitha, 2016 except the length of some setae but having clear septum below the elliptical pores on ventrianal shield, similar structure of spermatheca, leg chaetotaxy, etc., and hence fixed so. In the present study *A. velayudhani* was recovered from a new host plant, *Amaranthus viridis*.

Subtribe: PROPRIOSEIOPSINA Chant and McMurtry, 2004

2004. Proprioseiopsina Chant and McMurtry, *Internat. J. Acarol.*, **13**(3): 219.

2007. Proprioseiopsina Chant and McMurtry, In: *Illustrated keys and diagnoses for the genera and subgenera of the Phytoseiidae of the world (Acari: Mesostigmata)*, p.85-87.

Diagnosis: Dorsal shield varying from much longer than wide to more nearly ovoid in shape; dorsal setae setiform, smooth or lightly barbed, setae s_4, Z_4 and Z_5 often extremely elongate, whipe-like, usually much longer than the other dorsal setae; sternal shield with posterior margin straight or concave; genital shield usually narrower than ventrianal shield; ventrianal shield varying from narrower to broader, triangular pattern; peritreme usually extending to level of seta j_1; spermathecal morphology highly variable; chelicerae of normal size, with dentition of the fixed digit varying from many to few teeth; legs II-IV usually with strong macrosetae.

Type Genus: ***Proprioseiopsis*** Muma, 1961.

Genus *Proprioseiopsis* Muma, 1961

1961. *Proprioseiopsis* Muma, *Bull. Fla. St. Mus.,* **5**(7): 277.

1962. *Amblyseius* (*Pavlovskeius*) Wainstein, *Acarologia,* **4**: 12.

1963. *Amblyseius* Schuster and Prichard, *Hilgardia,* **34**: 255.

1965. *Amblyseius* Chant, *Can.Ent.,* **97**(4): 371.

1966. *Amblyseiulus* De Leon, *In* Studies on the Fauna of Suriname and other Guyanas, **8**: 93.

1968. *Amblyseius (Proprioseiopsis)* van der Merwe, *Entomol. Mem. S. Africa Dept. Agric. Tech. Services,* **18:**161.

1970. *Proprioseiopsis* Muma and Denmark, *Arthropods of Florida,* **6**: 32.

1973. *Proprioseiopsis* Tuttle and Muma, *Tech. Bull. Agr. Exp. Sta. Univ. Arizona,* **208**: 7.

1974. *Proprioseiopsis* Denmark, *Fla. Ent.,* **57**(2): 145.

1975. *Amblyseius (Proprioseiopsis)* Denmark and Muma, *Internat. J. Acarol.,* **4**(1): 3.

1976. *Amblyseius (Proprioseiopsis)* Blommers, *Bijdragen To: de Dierkunde,* **46**(1): 99.

1977. *Proprioseiopsis* Ehara and Bhandhufalck, *J. Fac. ed. Tottori Univ.,* **27**(2): 71.

1978. *Proprioseiopsis* Knisley and Denmark, *Fla. Ent.,* **61**(1): 147.

1981. *Proprioseiopsis* Denmark and Andrews, *Fla. Ent.,* **64**(1): 147.

1982. *Proprioseiopsis* Karg, *Zool, Jb. Syst. Bd.,* **109**: 196.

1983. *Proprioseiopsis* Karg, *Mitt. Zool. Mus. Berlin*, **59**(2): 303.

1986. *Proprioseiopsis* Gupta, *Fauna of India: Phytoseiidae,* p.131.

1987. *Proprioseiopsis* Daneshvar, *Ent. Phyt. Appliq.,* **54**(1-2): 22.

2003. *Amblyseius (Proprioseiopsis)* Gupta, In: *A monograph on plant inhabiting predatory mites of India. Part II: Ordr: Mesostigmata. Mem. Zool. Surv. India,* **20**(1): 1-185.

2007. *Proprioseiopsis* Chant and McMurtry, In: *Illustrated keys and diagnoses for the genera and subgenera of the Phytoseiidae of the world (Acari: Mesostigmata)*, p.219.

2013. *Proprioseiopsis* Tixier *et al., Zootaxa,* **3721**(2): 101-142.

2015. *Proprioseiopsis* Gupta and Karmakar, *Rec. Zool. Surv. India*, **115** (Part-1): 51-72.

2017. *Proprioseiopsis* Fahad *et al., Acarologia,* **57**(2): 275-294.

Diagnosis: Dorsal shield well sclerotized with 3 pairs of dorsal setae, 3 pairs of median setae, 8 pairs of lateral setae, 2 pairs of sublateral setae on the interscutal membrane. Sternal shield as wider than long, straight or concave margin, reticulated or smooth with 3 pairs of sternal setae. Ventrianal shield pentagonal or shield- shaped with preanal pores. Peritreme long, extending to or between setae j_1. Spermathecal cervix fundibuliform, poculiform or saccular with undifferentiated or nodular atrium. Chelicerae normal in size with 0 - 3 teeth on movable digit and 3 - 12 on fixed digit. Leg I devoid of macroseta and leg II- IV with macrosetae.

Type Species: *Typhlodromus (Amblyseius) terrestris* Chant, 1959.

Key to the species of genus *Proprioseiopsis* included in the present study

1. Seta Z_5 very long ever 500 microns, terminal portion extremely thin……………………………………………........................... *peltatus*

– Seta Z_5 never so long measures less than 100 microns and terminal portion never extremely thin ....*narayani* sp. nov.

***Proprioseiopsis narayani* sp.nov.**

PLATE 36

Female: Dorsal shield 350 long, 300 wide. Measurements of setae: j_1 - 30, j_3 - 58, s_4 - 100, Z_4 – 120, Z_5 – 90, S_2 – 25, S_4 – 20, others being minute or small. Sternal shield well sclerotized, 50 long, 80 wide with 3 pairs of sternal setae, ST_1, ST_2 and ST_3 – 30 each. Metasternal shield with setae ST_4 - 30 long. Genital shield 110 wide with a pair of setae ST_5 – 30 long and lateral margins are finely striated. Ventrianal shield pentagonal, anteriorly with transverse striations and posteriorly with longitudinal striations, 112 long, 115 wide with 3 pairs of preanal setae and a pair of preanal pores; 4 pairs of setae present on the membrane around the ventrianal shield, ZV_1 - 30, ZV_2 - 25, ZV_3 – 30, JV_1 – 30, JV_2 – 25, JV_4 - 30 and JV_5 – 80 long, smooth. Two pairs of metapodal plates present, primary one 23 long, accessory one 13 long. Fixed digit of chelicera with 2 teeth anterior to *pilus dentilis* and 2 teeth posterior to it, movable digit with 1 tooth. Peritreme extends upto the level of j_1 and curves down. Spermatheca with fundibuliform cervix and nodular atrium. Macrosetae on leg IV: genu - 48, tibia – 38 and basitarsus – 48.

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 $1\,\frac{2}{2}\;\frac{1}{0}\,1$.

Male: Unknown

Habitat: *Pisum sativum* L.

Material examined: Holotype ♀ marked on the slide, INDIA: KERALA: Thenjipalam (Malappuram district), 5.v.2015, ex. *Pisum sativum,* coll. Rahul

(No. Pr 17/1). Three paratype slides with 3 ♀♀, collection details same as above (No. Pr 17/2, 17/3).

Remarks: This species resembles *Proprioseiopsis peltatus* Van der Merwe, 1968 in general appearance, dorsal chaetotaxy and position of peritreme, etc., but differs in the following characters.

1. Dorsal shield is much longer in the new species when compared with *P. peltatus*.
2. Measurement of $Z_4 = S_4$ in *P. peltatus* but in the new species $Z_4 \neq S_4$.
3. Setae Z_4 is more longer in the new species.
4. Cervix of spermatheca is fundibuliform with nodular atrium instead of conical and undifferentiated.
5. Shape of ventrianal shield is pentagonal in the new species whereas it is triangular in *P. peltatus.*
6. Lateral margins of genital shield have light striations in the new species but striations are absent in *P. peltatus.*
7. Macrsetae on leg IV genu and basitarsus is equal in the new species but it varies in *P. peltatus.*
8. A clear band separates genital and ventrianal shield.

Proprioseiopsis peltatus Van der Merwe, 1968

PLATE 37

1968. *Amblyseius* (*Amblyseius*) *peltatus* Van der Merwe, *Ent. Mem. Dept. Agr. Tech. Serv. Rep. S. Afr.,* **18**: 119.

Redsecription

Female: Dorsal shield 312 long, 240 wide, lateral margins highly sclerotized with 16 pairs of setae, j_1, j_3, s_4, Z_4 and Z_5 long all other setae minute. Posteriorly the dorsal shield is flattened and gives a triangular shape to the body. Measurements of setae: j_1 - 30, j_3 - 56, s_4 - 100, Z_4 – 100, Z_5 – 75, others minute or small. Sternal shield reticulate laterally, deeply concave on anterior, lateral and posterior margins, 50 long, 90 wide with 3 pairs of sternal setae, ST_1 - 25, ST_2 – 26 and ST_3 – 24. Metasternal shield with setae ST_4 - 28 long. Genital shield 100 wide with a pair of setae ST_5 – 25 long. Ventrianal shield triangular, highly sclerotized, 95 long, 110 wide with 3 pairs of preanal setae and a pair of preanal pores; 4 pairs of setae present on the membrane around the ventrianal shield, ZV_1 - 28, ZV_2 - 25, ZV_3 – 20, JV_1 – 30, JV_2 – 25, JV_4 - 22 and JV_5 – 75 long, smooth. Genital and ventrianal shields are in close approximity. Two pairs of metapodal plates present, primary one 23 long, accessory one 13 long.. Fixed digit of chelicera with 4 teeth anterior to *pilus dentilis* and none on posterior to it, movable digit with 1 tooth. Peritreme extends upto the level of j_1. Spermatheca with conical cervix and undifferentiated atrium. Macrosetae on leg IV: genu - 63, tibia – 38 and basitarsus – 75.

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

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

Male: Unknown

Habitat: *Amaranthus dubius* Mart. ex Thell*, Dolichos lablab* (L.) Sweet

Known habitat: *Punica granatum, Combretum quagrangularae, Dioscorea* sp., *Achyranthes aspera, Bridella* sp., *Carica papaya,* fern, soy bean, citrus, corn, strawberry, *Dolichos lablab*.

Material examined: Female marked on the slide, INDIA: KERALA: Malaparamba (Kozhikode district), 9.vii.2015, ex. *Amaranthus dubius,* coll. Rahul (No. Pr 7/1). Five ♀♀ collection details same as above (No. Pr 7/2, 7/3, 7/4, 7/5, 7/6). One ♀ from Ramanattukara (Kozhikode district), 28.vii.2015, ex. *Dolichos lablab*, coll. Rahul (No. Pr. 7/7).

Distribution: INDIA: West Bengal. OUTSIDE INDIA: Australia, South Africa, Papua New Guinea, Thailand, Madagaskar.

Remarks: The specimen studied very closely resembles to *Proprioseiopsis peltatus* Van der Merwe, 1968 in almost all characters. All the setal measurements, structure of spermatheca, shape of genital and ventrianal shields etc., are very similar to *P. peltatus* and hence fixed so. In the present study *P. peltatus* was recovered from a new habitat *viz*., *Amaranthus dubius.* This is a new record from Kerala.

Tribe: EUSEIINI Chant and McMurtry, 2005

2005. Euseiini Chant and McMurtry, *Internat. J. Acarol.,* **31**(3): 191.

2007. Euseiini Chant and McMurtry, In: *Illustrated keys and diagnoses for the genera and subgenera of the Phytoseiidae of the world (Acari: Mesostigmata)*, p.107-108.

2010. Euseiini Kreiter *et al., Tunisian J. Plant Prot*., **5**(2): 151-178.

2015. Euseiini Gupta and Karmakar, *Rec. Zool. Surv. India*, **115**(Part-1): 51-72.

***Diagnosis*:** Setae s_4, Z_4, and Z_5 are very short, presence of a posterior projection on the posterior margin of the sternal shield, female ventrianal shield is reduced, vase shaped with a pair of crescentic pores. Genital shield wider than ventrianal shield. Peritreme has become shorter on many species. The preanal setae on the male are arranged in a tangential row.

Type Genus: *Amblyseius (Amblyseius)* Section *Euseius* Wainstein, 1962

Key to the Subtribe/Genera of tribe Euseiini

1. Chelicera normal in size and shape with prominent teeth evenly distributed along fixed digit; peritreme usually extending to the level of a j_1; deutosternal groove narrower 4-7 µm wide………............................... ....Subtribe: Typhlodromalina*Chant and McMurtry

* Dorsal setae of medium length, subequal; dorsal shield usually ornamented in addition to anterolateral striations; seta Z_4 longer than distance between its base and that of seta S_4.. ....Genus: *Typhlodromalus* Muma

_ Chelicera reduced in size, stubby, with a group of small teeth clustered at the distal end of the fixed digit; peritreme usually not extending beyond seta j_3, often much shorter; deutosternal groove wider, 7- 9 µm wide …………………………………Subtribe: Euseiina*Chant and McMurtry

* Seta Z_1 present…………………………...…..Genus: *Euseius* Wainstein

Subtribe: EUSEIINA Chant and McMurtry, 2005

2005. Euseiina Chant and McMurtry, *Internat. J. Acarol*., **31**(3): 209.

2007. Euseiina Chant and McMurtry, In: *Illustrated keys and diagnoses for the genera and subgenera of the Phytoseiidae of the world (Acari: Mesostigmata)*, p.118.

2010. Euseiini Kreiter *et al., Tunisian J. Plant Prot*., **5**(2): 151-178.

2015. Euseiini Gupta and Karmakar, *Rec. Zool. Surv. India*, **115**(Part-1): 51-72.

Diagnosis: Dorsal shield often more rotund than usual, usually without reticulation but often with anterolateral striations; Setae s_4, Z_4, and Z_5 never greatly elongated or whip like; chelicerae reduced in size, stubby, with a number of small teeth clustered at the distal end of the fixed digit; deutosternal groove wider than usual; setae JV_1 often inserted well behind the anterior margin of the ventrianal shield; peritreme usually short, not extending to level of seta J_1. Males with 3 pairs of preanal setae arranged in a triangular pattern.

Type Genus: *Amblyseius (Amblyseius)* Section *Euseius* Wainstein, 1962

Genus *Euseius* Wainstein, 1962

1962. *Amblyseius (Amblyseius) sacchari Sec*. Wainstein, *Acarologia,* **4**: 15.

1965. *Amblyseius* (*Euseius*) De Leon, *Fla. Entomol.,* **48**(2): 121.

1967. *Euseius* De Leon, *Allen press inc. Kansas,* U S A., 86 pp.

1979. *Euseius* Chaudhri *et al., Univ. Agr. Faisalabad,* p. 56.

1982. *Euseius* Karg, *Zool, Jb. Syst. Bd.,* **109**: 196.

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

1987. *Euseius* Gupta, *Rec. Zool. Surv. India Occ. Pap.,* **95**: 29-30.

1988. *Amblyseius(Amblyseius) finlandicus* group, Ueckermann, *Entomol. Mem. Dep. Agric. Water Supply, Rep. S. Africa,* **73**: 61.

1989. *Euseius* Cobanoglu, *Turk. Entomol. Derg.,* **13**(3): 164.

1992. *Euseius* Gupta, In: *State Fauna Ser. 3. Fauna of West Bengal, part 3,* p.154.

1995. *Euseius* Amitai, *Entomol. Hell.,* **10**: 19-20.

1997. *Euseius* Gupta and Chatterrjee, In: *State Fauna Ser. 6. Fauna of Delhi,* p. 520.

2003. *Euseius* Gupta, In: *A monograph on plant inhabiting predatory mites of India. Part II: Order: Mesostigmata. Mem. Zool. Surv. India,* **20**(1):31.

2007. *Euseius* Chant and McMurtry, In: *Illustrated keys and diagnoses for the genera and subgenera of the Phytoseiidae of the world (Acari: Mesostigmata)*, p.118.

2009. *Euseius* Okassa *et al., Can. J. Zool.,* **87**(8): 689-698.

2015. *Euseius* Lopes *et al., Zootaxa,* **4048**(2): 174-190.

***Diagnosis*:** Females with dorsal shield smooth to moderately reticulated with 6 pairs of dorsocentral setae, 9 pairs of laterals and 2 pairs of median setae, Z_5 being longest. Posterior margin of sternal shield usually with median lobe and genital shield distinctly wider than ventrianal shield. Ventrianal shield is reduced, vase shaped or ovoid in females. Peritreme usually short, not reaching to the level of setae j_3; chelicera reduced, with small teeth on fixed digit clustered apically and with inner margin strongly concave, and movable digit with one or no tooth. Macrosetae usually present on genu IV, tibia IV and tarsus IV, and sometimes also on genu II and genu III.

Type Species: *Seiulus finlandicus* Oudemans, 1915.

Key to species of genus *Euseius* included in the present study

1. All setae of dorsal shield minute, except Z_5 and j_1......…………………..2
– Besides j_1 and Z_5 there are some other long setae……………......…...6
2. Setae S_2 and S_5 unequal.... ……………………………………..……...4

– S_2 and S_5 equal ....……………………………………………………3

3. Macrosetae on leg IV spatulated or knobbed ..... ……………………..5

– Macrosetae on leg IV simple, not spatulated.....………………...*ovalis*

4. S_4 longer than S_2 and S_5, which two are equal………...*.rhododendronis*

– S_4 and S_5 equal and longer than S_2 ………..……*kadalundiensis* sp.nov.

5. Macrosetae on leg IV slightly knobbed at the tip………..............… ………………………................………*ummalathoorensis* sp.nov.

– Macrosetae on leg IV spatulate…...…………………...*sativae* sp.nov.

6. j_1 and j_3 either equal or j_3 longer than j_1 .... ……………………………7

– j_1 longer than j_3………………………………………..……...10

7. j_3 longer than j_1…………………………………………..………9

_ j_3 as long as j_1……………………………………………………..8

8. Peritreme extends at the base of j_3……………………..…….*coccineae*

_ Peritreme only up to the base of z_2…………..……*malabarensis* sp.nov

9. S_4 noticeably longer than Z_4……………………......…………*alstoniae*

– S_4 and Z_4 almost equal………………………..……………*delhiensis*

10. S_5 longer than S_4……………………………………..…..*finlandicus*

_ S_5 as long as or shorter than S_4…………………………......*bambusae*

Euseius alstoniae Gupta, 1975

PLATE 38

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

Redescription

Female: Dorsal shield smooth anteriorly, rugose posteriorly, 325 long, 225 wide with 17 pairs of simple setae. Measurements of setae: j_1 - 28, j_4, j_5 – 10 each, j_6 - 25, J_2 – 30, J_5 – 10, j_3 - 30, z_2 – 28, z_4 – 30, s_4 – 50, Z_1 – 20, S_2 - 30, S_4 – 20, S_5 - 30, Z_5 – 54, z_5 – 20, Z_4 – 24. Sublateral setae r_3 and R_1 arise from the lateral margins of dorsal shield, 20 long. Sternal shield flattened posteriorly and creased laterally, 76 long, 70 wide with 3 pairs of sternal setae ST_1 – 25, ST_2 and ST_3 – 28 each. Metasternal shield with setae ST_4 - 20 long. Genital shield 88 wide with a pair of setae ST_5 – 20 long. Ventrianal shield ovate, 90 long, 70 wide with 3 pairs of preanal setae and a pair of elliptical preanal pores. Four pairs of setae present on the membrane around the ventrianal shield, ZV_1 - 20, ZV_2 - 15, ZV_3 – 14, JV_1, JV_2 – 20 each, JV_4 – 20 and JV_5– 28 long, smooth. Two pairs of metapodal plates present, primary one 17 and accessory one 10 long. Fixed digit of chelicera with 2 apical teeth, movable digit with one tooth. Peritreme extends anteriorly upto z_2. Spermatheca with tubular cervix and nodular atrium. Macrosetae on leg IV: genu-50, tibia - 31 and basitarsus – 75.

Leg chaetotaxy: genu II $2\ \frac{2}{0}\ \frac{1}{0}\ 1$, 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 with foot terminal, toe bifid. Ventrianal shield as figured.

Habitat: *Canavalia gladiata* (Jacq.) Dc and *Coccinia grandis* (L.) Voigt.

Known habitat: *Alstonia scholaris, Feronia elephanta,* pomogrenate, *Tabernaemontana coronaria, Pyrus malus*, chilli, cotton, Zinia sp., sapota, date palm, Acacia, *Nerium indicum, Malus sylvestris*, cucurbits, palm, mango, pear, maize, sugarcane, *Dalbergia sisoo, Butea monosperma, Magnolia grandiflora, Terminalia arjuna, Cassia occidentalis*, rose,wood apple, peach, grass, guava, bitter gourd, ficus, *Nyctanthes arbortristis*, citrus, vines, ornamental plants, beans, mulberry, sunflower, *Carica papaya, Jasminum grandiflorum, Maranta arundinacea, Lantana, Calotropis procers, Canavalia gladiata*.

Material examined: Female marked on the slide along with ♂, INDIA: KERALA: Kunduparamba (Kozhikode district), 12.vi.2015, ex. *Canavalia gladiata,* coll. Rahul (No.E 218/1). Two ♀♀, collection details same as above (No. E 218/2, 218/3). One ♀ from Ashokapuram (Kozhikode district), 9.xi.2015, ex. *Coccinia grandis* (No. E. 218/4).

Distribution: INDIA: West Bengal, Tripura, Gujarat, Arunachal Pradesh, Uttar Pradesh, Meghalaya, Orissa, Bihar, TamilNadu, Karnataka, Jammu and Kashmir, Haryana, Punjab, Madhya Pradesh, Rajasthan, Kerala.

Remarks: This specimen agrees with *Euseius alstoniae* Gupta, 1975 in almost all characters such as similar dorsal chaetotaxy, number of teeth, structure of spermatheca, leg chaetotaxy, etc., hence fixed so. In the present survey *E. alstoniae* was recovered from a new host plant *viz., Coccinia grandis.* They were found associated with tetranychid species.

Euseius bambusae Ghai and Menon, 1967

PLATE 39

1967. *Amblyseius bambusae* Ghai and Menon, *Oriental Ins.,* **1**: 66-67.

Redescription

Female: Dorsal shield slightly reticulated, 344 long, 225 wide with 17 pairs of simple setae. Measurements of setae: j_1 - 32, j_3 - 12, z_2 – 20, z_4 – 20, s_4 – 15, S_2 - 16, S_4 – 20, S_5 - 20, Z_5 – 50, Z_4 – 15, others being small or minute. Sternal shield bulged anteriorly and creased laterally and posteriorly, 75 long, 70 wide with 3 pairs of sternal setae ST_1, ST_2 and ST_3 – 27 each. Metasternal shield with setae ST_4 - 25 long. Genital shield 85 wide with a pair of setae ST_5 – 25 long. Genital and ventrianal shields are separated by a septum. Ventrianal shield vase shaped, 97 long, 75 wide, lateral margins concave, with 3 pairs of preanal setae and a pair of preanal pores; 4 pairs of setae present on the membrane around the ventrianal shield. ZV_1, ZV_2 – 20 each, ZV_3 – 15, JV_1- 25, JV_2 – 21, JV_4 – 20 and JV_5– 28 long, smooth. Two pairs of metapodal plates present, primary one 18 and accessory one 10 long. Fixed digit of chelicera with 3 apical teeth, movable digit with one tooth. Peritreme terminates anteriorly between z_2 and j_3. Spermatheca with fundibuliform cervix and differentiated atrium. Macrosetae on leg IV: genu- 32, tibia - 35 and basitarsus – 50.

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

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

Male: Not studied.

Habitat: *Brassica oleracea* L.

Known habitat: Bamboo, *Pyrus communis, Butea monosperma, Dalbergia* sp., pine, *Ficus religiosa, Coffea arabica,* Undetermined Plants.

Material examined: Female marked on the slide, INDIA: KERALA: Malaparamba (Kozhikode district), 20.iv.2016, ex. *B. oleracea.,* coll. Rahul (No.E 324/1). Four ♀♀, collection details same as above (No. E 324/2, 324/3, 324/4, 324/5).

Distribution: INDIA: Tripura, West Bengal, Karnataka, Tamil Nadu, Andra Pradesh.

Remarks: The specimen studied agrees with almost all characters of *Euseius bambusae* Ghai and Menon, 1967 and hence fixed so. In the present study *E. bambusae* was recovered from a new host plant *viz., Brassica oleracea*. This is a new record from Kerala.

***Euseius coccineae* Gupta, 1975**

PLATE 40

1975. *Amblyseius coccineae* Gupta, *Internat. J. Acarol.,* **1**(2): 26-45.

Redescription

Female: Dorsal shield reticulated, 320 long, 250 wide with 17 pairs of simple setae. Measurements of setae: j_1 - 25, j_3 - 12, z_2 – 20, s_4 – 30, Z_5 – 50, Z_4 – 10, other setae small or minute. Sternal shield slightly creased anteriorly and posteriorly, 87 long, 85 wide with 3 pairs of sternal setae ST_1, ST_2 and ST_3 – 20 each. Metasternal shield with setae ST_4 - 15 long. Genital shield 85 wide with a pair of setae, ST_5 – 15 long. Ventrianal shield 95 long, 65 wide, lateral margins are slightly concave, with 3 pairs of preanal setae and a pair of semilunar preanal pores; 4 pairs of setae present on the membrane around the ventrianal shield. JV_5 – 25 long, smooth. A pair of metapodal plates present, primary one 20 and accessory one 11 long. Fixed digit of chelicera with 2 apical teeth, movable digit toothless. Peritreme extends anteriorly at the base of j_3. Spermatheca with double walled saccular cervix and nodular atrium. Macrosetae on leg IV: genu- 38, tibia - 32 and basitarsus – 50.

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: Not studied.

Habitat: *Pisum sativum* L.

Known habitat: *Coccinea indica,* citrus, marigold, *Tabernaemontana coronaria,* cashew nut, mango, castor, jackfruit, coconut, bamboo, *Terminalia* *arjuna, Eugenia* sp., arum, *Ficus, Polianthes tuburosa, Shorea robusta, Eucalyptus* sp., Fig, guava, *Bougaivillea* sp., pear, mulberry, papaya, *Schima wallachi,* sugarcane, cotton, tea, *Sonnertia alba, Antegonen leptopus,* china rose, sissoo, *Dolichos lablab, Annona squamosa, Alstonia scholaris.*

Material examined: Female marked on the slide, INDIA: KERALA: Mankav (Kozhikode district), 19.xi.2015, ex. *Pisum sativum,* coll. Rahul (No.E. 110/1). Five ♀♀, collection details same as above (No. E. 110/2, 110/3, 110/4, 110/5, 110/6).

Distribution: INDIA: Tripura, West Bengal, Tamilnadu, Andra Pradesh, Arunachal Pradesh, Sikkim, Meghalaya, Assam, Orissa, Bihar, Pondicherry, Gujarat, Madhya Pradesh, Jammu and Kashmir, Uttar Pradesh, Kerala, Karnataka.

Remarks: The specimen studied agrees with almost all the features of *Euseius coccineae* Gupta, 1975 hence fixed so. In the present study *E. coccineae* was recovered from a new host plant *viz., Pisum sativum*.

Euseius delhiensis (Narayanan and Kaur), 1960

PLATE 41

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

Redescription

Female: Dorsal shield reticulated, 300 long, 220 wide with 17 pairs of simple setae. Measurements of setae: j_1 - 35, j_3 - 50, z_2 – 35, s_4 – 64, j_4 - 20, j_6 - 35, J_2 – 35, z_4 – 50, Z_1 - 30, S_2 - 35, Z_4 – 10, 35, S_4 – 30, S_5 – 35, Z_5 – 75, r_3 – 20, R_1 - 15 . Sternal shield creased anteriorly and laterally, 70 long, 80 wide with 3 pairs of sternal setae ST_1, ST_2 and ST_3 – 20 each. Metasternal shield with setae ST_4 - 15 long. Genital shield 85 wide with a pair of setae, ST_5 – 25 long. Ventrianal shield 103 long, 85 wide with 3 pairs of preanal setae and a pair of semilunar preanal pores; 4 pairs of setae present on the membrane around the ventrianal shield. JV_5 – 35 long, smooth. Only primary metapodal plate is present which is 25 long. Fixed digit of chelicera with 3 apical teeth, movable digit with a sharp tooth. Peritreme terminate anteriorly between z_2 and z_4. Spermatheca with tubular cervix and nodular atrium. Macrosetae on leg IV: genu- 55, tibia - 46 and basitarsus – 55.

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: *Canavalia ensiformis* (L.) DC.

Known habitat: *Maranta arundinaceae, Luffa acutangula, Canavalia ensiformis,* beans, *Hibiscus esculentus, Gossypium* sp., *Syzygium javanicum, Bougainvillea,* guava, citrus, maize, *Ceratonia siliqua*, *Piliostigma thonningii*.

Material examined: Female marked on the slide, INDIA: KERALA: Kanjangad (Kasaragod district), 9.xi.2015, ex. *Canavalia ensiformis,* coll. Rahul (No.E. 51/1). Six ♀♀, collection details same as above (No. E. 51/2, 51/3, 51/4, 51/5, 51/6, 51/7).

Distribution: INDIA: West Bengal, Delhi, Uttar Pradesh, Kerala. OUTSIDE INDIA: Algeria, Canary Islands, Cape Verde, Cyprus, Egypt, Ghana, Greece, Iran, Israel, Jordan, Morocco, Oman, Peru, Saudi Arabia, Spain, Syria, Tunisia, Turkey, Yemen.

Remarks: The specimen studied closely resembles *Euseius delhiensis* (Narayanan and Kaur), 1960 in general appearance, shape of shields, structure of spermatheca, macrosetal length on leg IV, etc., hence fixed so.

Euseius finlandicus (Oudemans), 1915

PLATE 42

1915. *Seiulus finlandicus* Oudemans, *Ent. Ber*., **4**: 183.

Redescription

Female: Dorsal shield highly reticulated, 300 long, 200 wide with 17 pairs of simple setae. Measurements of setae: j_1 - 25, j_3 - 20, z_2 – 17, s_4 – 28, Z_5 – 50, Z_4 – 20, j_4 - 20, z_4 – 17, S_2 - 20, S_4 – 25, S_5 – 30. Sternal shield 82 long, 92 wide with 3 pairs of sternal setae ST_1, ST_2 and ST_3 – 25 each. Metasternal shield with setae ST_4 - 20 long. Genital shield 85 wide with a pair of setae ST_5 – 20 long. Ventrianal shield 90 long, 82 wide with 3 pairs of preanal setae and a pair of semilunar preanal pores; 4 pairs of setae present on the membrane around the ventrianal shield. JV_5 – 25 long, smooth. Only primary metapodal plate is present whixh is 20 long. Fixed digit of chelicera with 2 apical teeth, movale digit is toothless. Peritreme extending anteriorly upto j_3. Spermatheca with tubular flared cervix and nodular atrium with distinct minor duct. Macrosetae on leg IV: genu- 46, tibia - 30 and basitarsus – 50 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 $1\,\frac{2}{1}\,\frac{2}{1}\,1$, tibia III $1\,\frac{2}{1}\,\frac{1}{1}\,1$.

Male: Not studied.

Habitat: *Amaranthus viridis* L.

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

Material examined: Female marked on the slide, INDIA: KERALA: Nadakkav (Kozhikode district), 12.xi.2015, ex. *Amaranthus viridis,* coll. Rahul (No.E. 21/1). Four ♀♀ and a ♂, Parappanagadi (Malappuram district), 8.viii.2015, ex. *Amaranthus viridis*, coll. Rahul (No. E. 21/2, 21/3, 21/4, 21/5). Two females collected from Ashokapuram (Kozhikode district) same habitat mentioned above. Many ♀♀ from the habitat mentioned above from almost all the districts surveyed.

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

Remarks: The specimen studied agrees with almost all characters of *Euseius finlandicus* (Oudemans), 1915 having similar general appearance, shape of shields, structure of spermatheca, macrosetal length on leg IV, etc., hence fixed so.

Euseius kadalundiensis **sp. nov.**

PLATE 43

Female: Dorsal shield 500 long, 275 wide with 17 pairs of setae. All the setae minute measuring 6-10 long. Sternal shield 100 long, 88 wide with 3 pairs of sternal setae ST_1, ST_2 and ST_3 - 30 each. Metasternal shield with setae ST_4 - 30 long. Genital shield 98 wide with a pair of setae ST_5 – 35 long. Ventrianal shield 135 long, 95 wide, with 3 pairs of preanal setae and a pair elliptical preanal pores; 4 pairs of setae present on the membrane around the ventrianal shield. ZV_1 – 32, ZV_2 – 20, ZV_3 – 22, JV_1 – 25, JV_2, JV_4 and JV_5 – 20 each. Two pairs of metapodal plates present, primary one 38 and accessory one 15 long. Fixed digit of chelicera with 10 teeth, movable digit with 3 teeth. Peritreme terminates anteriorly at the base of j_3. Spermatheca with tubular cervix and undifferentiated atrium. Macrosetae on leg IV: genu- 40, tibia - 37 and basitarsus – 55.

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

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

Male: Unknown.

Habitat: *Manihot esculenta* Crantz.

Material examined: Holotype ♀ marked on the slide, INDIA: KERALA: Kadalundi (Kozhikode district), 2.xi.2015, ex. *Manihot esculenta,* coll. Rahul (No.E 188/1). Four paratype slides with 6 ♀♀, collection details same as holotype (No. E 188/2, 188/3, 188/4, 188/5).

Remarks: The specimen examined resembles with *Euseius rhododendronis* Gupta, 1970 but clearly differentiated from it by the following characters.

1. Dorsal shield is longer (500 long) than *E. rhododendronis* (330 long).
2. All setae minute in the new species but in *E. rhododendronis* all the setae minute except j_1, j_3, s_4, and Z_5, which are longer in size.
3. The ratio between the length and width of sternal shield is 1.1 in the new species instead of 0.6 in *E. rhododendronis*.
4. The size of genital and ventrianal shield is much greater when compared with *E. rhododendronis*.
5. Fixed digit of chelicerae with 10 teeth instead of 3 in *E. rhododendronis*.
6. Movable digit of chelicerae with 3 teeth where as toothless in *E. rhododendronis*.
7. Cervix of spermatheca tubular in shape with undifferentiated atrium but it is tubular with nodular atrium in *E. rhododendronis*.
8. Length of macrosetae on leg IV basitarsus varies 55 long in the new species but it is only 42 long in *E. rhododendronis*.

Euseius malabarensis sp.nov.

PLATE 44

Female: Dorsal shield 313 long, 210 wide with 17 pairs of setae. All the setae smooth. Measurements of setae: j_1 - 25, j_3 - 15, s_4 – 20, S_2 – 23, S_4 - 25, S_5 – 15, Z_4 – 20, Z_5 - 50, all other setae small or minute. Sternal shield 73 long, 65 wide with 3 pairs of sternal setae ST_1, ST_2 and ST_3 – 20 each. Metasternal shield with setae ST_4 - 15 long. Genital shield 78 wide with a pair of setae ST_5 – 20 long. Ventrianal shield 100 long, 70 wide with 3 pairs of preanal setae and a pair of elliptical preanal pores; 4 pairs of setae present on the membrane around the ventrianal shield. ZV_1, ZV_2 – 10 each, ZV_3 – 15, JV_1, JV_2 – 20 each, JV_4 – 15 and JV_5 – 25 long, smooth. A clear band is present between genital and ventrianal shield. Two pairs of metapodal plates present, primary one 20 and accessory one 15 long. Fixed digit of chelicera with 2 apical teeth, movable digit toothless. Peritreme extends anteriorly upto z_2. Spermatheca with vesicular cervix and nodular atrium. Macrosetae on leg IV: genu, tibia – 35 each and basitarsus – 45.

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

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

Male: Unknown.

Habitat: *Pisum sativum* L.

Material examined: Holotype ♀ marked on the slide, INDIA: KERALA: Koorachund (Kozhikode district), 10.xi.2015, ex. *Pisum sativum,* coll. Rahul

(No.E. 230/1). Six paratype slides with 6♀♀, collection details same as holotype (No. E. 230/2, 230/3, 230/4, 230/5, 230/6, 230/7).

Remarks: This specimen resembles *Euseius bambusae* Ghai and Menon, 1967 in general appearance, dorsal chaetotaxy, shape of sternal and ventrianal shields etc., but differs from it by the possession of following features.

1. Dorsal shield is much shorter when compared with *E. bambusae.*
2. Length of the setae j_1 and j_3 smaller.
3. Length and width of the sternal shield is smaller in the new species.
4. Movable digit is toothless in the new species but it is with single tooth in *E. bambusae*.
5. Cervix of spermatheca is vesicular with nodular atrium in the new species whereas it is fundibular with differentiated atrium in *E. bambusae*.
6. Measurement of macosetae on leg IV of both the species different.

***Euseius ovalis* (Evans), 1953**

PLATE 45

1953. *Typhlodromus ovalis* Evans, *Ann. Mag. Nat. Hist.,* **6**: 449-467.

Redescription

Female: Dorsal shield smooth, 330 long, 220 wide with 17 pairs of setae, except j_1 and Z_5, all others being small. Measurements of setae: j_1 - 30, Z_5 – 50, all other setae measuring 6-9 long. Sternal shield smooth, bulged anteriorly, creased laterally and posteriorly, 88 long, 75 wide with 3 pairs of sternal setae ST_1 - 28, ST_2 and ST_3 – 25 each. Metasternal shield with setae ST_4 - 25 long. Genital shield 85 wide with a pair of setae ST_5 – 22 long. Ventrianal shield ovate, 94 long, 65 wide, with 3 pairs of preanal setae and a pair of elliptical preanal pores; 4 pairs of setae present on the membrane around the ventrianal shield. ZV_1 – 15, ZV_2 – 20, ZV_3 – 8, JV_1 – 15, JV_2 – 22, JV_4 – 10 and JV_5 – 25 long, smooth. Two pairs of metapodal plates present, primary one 22 and accessory one 10 long. Fixed digit of chelicera with 2 apical teeth, movable digit one tooth. Peritreme extends anteriorly upto j_3. Cervix of spermatheca is fundibuliform with undifferentiated atrium. Macrosetae on leg IV: genu - 40, tibia - 35 and 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 $1 \, \frac{2}{0} \, \frac{2}{1} \, 1$, tibia III $1 \, \frac{1}{1} \, \frac{2}{1} \, 1$.

Male: Not studied.

Habitat: *Amorphophallus paeonifolius* (Dennst.) Nicolson and *Momordica charantia* L.

Known habitat: *Momordica charantia,* Castor, *Nerium,* Napier grass, *Holarrhena antidysenterica,* Arecanut, Lucern, Cashew nut, *Macrocos paniculatus*, Pigeon pea, *Ficus religiosa,* Tiurel, *Luffa acutangula, Glycosomus, Terminalia arjuna, Pentaphylla, Dolichos lablab, Bougainvillea spectabilis,* grass, jackgruit, *Cassia fistula,* Banana, *Bauhinia purpuria,* coconut, *Tabernae montana,* Beans, mango, sugarcane, cotton, paddy, chilli, oil seed plant, *Bauhinia* sp., papaya, pomegranate, rose, chrysanthemum, Bamboo, *Amaranthus viridis, Coffea arabica. Vitex pubescens*, *Eucalyptus.,*

Material examined: Female marked on the slide, INDIA: KERALA: Kadalundi (Kozhikode district), 2.xi.2015, ex. *Amorphophallus paeonifolius,* coll. Rahul (No.E. 187/1). Two paratype slides with 2 ♀♀ collection details same as above (No. E. 187/2, 187/3). Four ♀♀ from Edakkad (Kannur district), 4.vi.2016, ex. *Momordica charantia,* coll. Rahul (No. E. 187/1,187/2, 187/3, 187/4)

Distribution : INDIA: West Bengal, Tripura, Assam, Arunachal Pradesh, Sikkim, Andhra Pradesh, Karnataka, Tamil Nadu, Pondicherry, Kerala, Gujarat, Punjab, Mizoram, Meghalaya, Bihar, Manipur, Maharashtra, Andaman and Nicobar Islands, Lakshadweep Islands. OUTSIDE INDIA : Philippines, Taiwan, Mauritius, Mexico, Hongkong, Malaysia, Indonesia, Japan, Australia, New Zealand, Okinawa island, Hawaii.

Remarks: The specimen studied agrees with *Euseius ovalis* (Evans), in all characters and hence fixed so. In the present survey *E. ovalis* was recovered from a new host plant *viz*., *Amorphophallus paeonifolius.*

Euseius rhododendronis Gupta, 1970

PLATE 46

1970. *Amblyseius rhododendronis* Gupta, *Oriental Ins.,* **4**: 185-191.

Redescription

Female: Dorsal shield 340 long, 235 wide, reticulate laterally with 17 pairs of setae, all the setae small except j_1 and Z_5 which are longer and thicker. Measurements of setae: j_1 - 37, j_3 - 15, s_4 – 20, Z_5 – 40, Z_4 – 15, other setae small or minute. Sternal shield creased laterally and posteriorly, 87 long, 75 wide with 3 pairs of sternal setae ST_1 - 25, ST_2 – 22 and ST_3 – 25 long. Metasternal shield with setae ST_4 - 25 long. Genital shield 95 wide with a pair of setae ST_5 – 25 long. Ventrianal shield slightly pentagonal 100 long, 75 wide, with 3 pairs of preanal setae and a pair of preanal pores; 4 pairs of setae present on the membrane around the ventrianal shield. ZV_1 – 20, ZV_2 – 22, ZV_3 – 18, JV_1, JV_2 – 20 each, JV_4 – 18 and JV_5 – 25 long, smooth. Fixed digit of chelicera with 2 apical teeth, movable digit toothless. Peritreme terminates at the base of z_2. Spermatheca with tubular cervix and nodular atrium. Macrosetae on leg IV: genu, tibia – 30 each and basitarsus – 45, all with rounded 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: Not studied

Habitat: *Amaranthus dubius* Mart. ex Thell.

Known habitat: *Rhododentron* sp., litchi, undetermined plant, Tiurel, pear, coffee, *Zingiber officinale, Luffa acutangula, Momordica charantia, Musa paradisiacal, Trichosanthes anguina, Shorea robusta.*

Material examined: Female marked on the slide, INDIA: KERALA: Feroke (Kozhikode district), 2.xi.2015, ex. *Amaranthus dubius,* coll. Rahul (No.E. 177/1). Two paratype slides with 3 ♀♀ collection details same as above (No. E. 177/2, 177/3, 177/4). Two ♀♀ from Chittur (Palakkad district), 18.iii.2016. ex. *Amaranthus dubius,* coll. Rahul (No.E. 177/5, 177/6).

Distribution: INDIA: Tripura, West Bengal, Sikkim, Mizoram, Tamil Nadu, Karnataka and Kerala. OUTSIDE INDIA: Thailand.

Remarks: The species studied agrees with almost all the characters of *Euseius rhododendronis* Gupta, 1970 having similar dorsal chaetotaxy, setal measurements, number of teeth, structure of spermatheca, etc., hence fixed so. In the present survey *E. rhododendronis* was recovered from a new host plant *viz*., *Amaranthus dubius.*

Euseius sativae sp.nov.

PLATE 47

Female: Dorsal shield 350 long, 235 wide, lateral margins reticulate with 17 pairs of setae. Measurements of setae: j_1 - 30, j_3 - 20, s_4 – 15, S_2, S_4, S_5 – 20 each, Z_4 – 15, Z_5 - 40, all other setae small or minute. Sternal shield concave anteriorly, 78 long, 75 wide with 3 pairs of sternal setae ST_1, ST_2 and ST_3 – 25 each. Metasternal shield with setae ST_4 - 15 long. Genital shield 88 wide with a pair of setae ST_5 – 15 long. Ventrianal shield 113 long, 78 wide, lateral margins slightly bulged out with 3 pairs of preanal setae and a pair of cresecent shaped preanal pores; 4 pairs of setae present on the membrane around the ventrianal shield. ZV_1 – 10, ZV_2 – 15, ZV_3 – 10, JV_1, JV_2 – 20 each, JV_4 – 15 and JV_5 – 25 long, smooth. A clear band is present between genital and ventrianal shield. Primary metapodal plate 20 long and accessory one absent. Fixed digit of chelicera with 2 apical teeth, movable digit with one tooth. Peritreme extends anteriorly at the base of z_2. Cervix of spermatheca is long, vesicular, expanded in the mid region and gradually tapering towards both the ends with rounded vesicle; atrium is undifferentiated. Macrosetae on leg IV: genu - 31, tibia - 28 and basitarsus – 42.

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 $1\,\frac{2}{1}\,\frac{1}{1}\,1$.

Male: Unknown.

Habitat: *Pisum sativum* L.

Material examined: Holotype ♀ marked on the slide, INDIA: KERALA: Balussery (Kozhikode district), 5.v.2015, ex. *Pisum sativum,* coll. Rahul (No.E. 205/1). Paratype slides with 5 ♀♀, collection details same as holotype (No. E. 205/2, 205/3, 205/4, 205/5, 205/6).

Remarks: This specimen resembles *Euseius sacchari* Ghai and Menon, 1967 in general appearance, dorsal chaetotaxy etc., but differs in the following characters.

1. j_3 of the new species is longer (20 long) than *E. sacchari* Ghai and Menon (8-15 long).

2. Length and width of the sternal shield is smaller in the new species when compared with *E. sacchari*.

3. In the new species setae S_2, S_4 and S_5 equal in length but S_4 and S_5 are equal and longer than S_2 in *E. sacchari*.

4. Peritreme terminates anteriorly at the base of z_2 in the new species but it is terminates between j_3 and z_2 in the *E. sacchari*.

5. Movable digit with one tooth in the new species but it is toothless in *E. sacchari*.

6. Cervix of spermatheca is long, vesicular with undifferentiated atrium in the new species whereas it is tubular with nodular atrium in *E. sacchari*.

7. Lateral margin of ventrianal shield is bulged out giving a convex appearance in the new species but it is deeply concave in *E. sacchari*.

8. A clear band present between genital and ventrianal shield which is absent in *E. sacchari*.

9. Presence of small septum in the ventrianal shield below the preanal pores is absent in *E. sacchari*.

10. Only a pair of metapodal plate is present instead of two pairs in *E. sacchari*.

***Euseius ummalathoorensis* sp. nov.**

PLATE 48

Female: Dorsal shield reticulated anteriorly on the lateral margins, 350 long, 252 wide with 17 pairs of simple setae. All seate short except j_1 - 37, j_3 -22 and Z_5 -48. Sternal shield 75 long, 85 wide with 3 pairs of sternal setae ST_1, ST_2 and ST_3 - 20 each. Metasternal shield with setae ST_4 - 15 long. Genital shield 85 wide with a pair of setae ST_5 – 15 long. Ventrianal shield 97 long, 73 wide, with 3 pairs of preanal setae and a pair preanal pores; 4 pairs of setae present on the membrane around the ventrianal shield. ZV_1, ZV_2 – 10 each, ZV_3 – 15, JV_1, JV_2, JV_4 – 10 each, JV_5 – 28 long, smooth. A clear band is present between genital and ventrianal shield. Two pairs of metapodal plate present, primary one 25 and accessory one 13 long. Fixed digit of chelicera with 2 apical teeth, movable digit toothless. Peritreme extends anteriorly upto z_2. Cervix of spermatheca medially vesicular with undifferentiated atrium. Macrosetae on leg IV: genu- 30, tibia - 25 and basitarsus – 40.

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: Unknown.

Habitat: *Abelmoschus esculentus* (L.) Moench.

Material examined: Holotype ♀ marked on the slide, INDIA: KERALA: Ummalathoor (Kozhikode district), 25.ix.2015, ex. *Abelmoschus esculentus,* coll. Rahul (No.E. 103/1). Three paratype slides with 5 ♀♀, collection details same as holotype (No. E. 103/2, 103/3,103/4).

Remarks: This specimen examined resembles with *Euseius rhododendronis* Gupta, 1970 in the dorsal chaetotaxy, number of teeth on chelicerae, etc. but can be differentiated from all other known species by the possession of the following characters.

1. Longer nature of j_1 (37) and j_3 (22) in the new species when compared to j_1 (27) and j_3 (18) of *E. rhododendronis*.

2. The length of Z_5 is smaller in the new species (48 long) but Z_5 in *E. rhododendronis* it is 60 long.

3. Peritreme of the new species extends upto z_2 but in *E. rhododendronis* it terminates beyond j_3.

4. Cervix of spermatheca is medially vesicular with undifferentiated atrium in the new species but it is tubular with nodular atrium in *E. rhododendronis*.

5. Shape of ventrianal shield varies in both the species.

6. Macrosetae on leg IV with dilated tips in the new species but it is setaceous in *E. rhododendronis*.

7. A clear band present between genital and ventrianal shield which is absent in *E. rhododendronis*.

SUBFAMILY: PHYTOSEIINAE Berlese, 1916

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

1941. Phytoseiinae Vitzthum, *Acarina,* 768 pp.

1962. Chantiini Pritchard and Baker, *Hilgardia*, 33:211.

1985. Phytoseiinae Wei – nan and Zhao- quan, *Acta Zootaxonomica*, **10:** 393-398.

1986. Chantiinae Chant and Yoshida-Shaul, *Can. J. Zool.,* **64**(9): 2025.

1987. Phytoseiinae Gupta, *Rec. Zool. Surv, India*, *Occ. Pap*., **95**:78.

1989. Phytoseiinae Cobanoglu, *Turk. Entomol. Derg.,* **13**: 163-178.

1992. Phytoseiinae Denmark, *Fla. St. Coll. of Arthropods, Occ. Pap.,* **7**(0): 3

1993. Phytoseiinae Schicha and O' Dowd, *J. Aust. Ent. Soc*., **32**: 297-305.

1995. Phytoseiinae Yoshida-Shaul and Chant, *Acarologia*, **36**: 3.

2003. Phytoseiinae Gupta, In: *A monograph on plant inhabiting predatory mites of India. Part II: Order: Mesostigmata. Mem. Zool. Surv. India,* **20**(1): 95.

2007. Phytoseiinae Chant and McMurtry, In: *Illustrated keys and diagnoses for the genera and subgenera of the Phytoseiidae of the world (Acari: Mesostigmata)*, p.125.

2008. Phytoseiinae Guanilo *et al., Zootaxa,* **1729**: 49-60.

2015. Phytoseiinae Gupta and Karmakar, *Rec. Zool. Surv. India*, **115**(Part-1): 51-72.

Diagnosis**:** Dorsal shield undivided with 5-6 pairs of dorsocentral setae, 2-3 pairs of median setae, 7-11 pairs of lateral setae with 5 or more well anterior to s_4, 1 or 2 pairs of sublateral setae on interscutal membrane, ventrianal shield with 1 - 4 pairs of preanal setae; 1-3 pairs of ventrolateral setae; and 0-3 macrosetae on leg IV. Males have an entire, shield shaped ventrianal shield with 3 or 4 pairs of ventrianal setae.

Type Genus: *Phytoseius* Ribaga, 1904

Genus *Phytoseius* Ribaga, 1904

1904. *Phytoseius* Ribaga, *Riv. Pat.Veg.*, **10:** 177.

1951. *Phytoseius* Nesbitt, *Zool. Verh.,* **12**: 16.

1952. *Phytoseius* Baker and Wharton, *An Intro. Acarol.,* p. 88.

1953. *Phytoseius* Cunliffe and Baker, *Pinn. Biol. Lab. Publ.,* No. **1**: 22.

1954. *Phytoseius* Womersley, *Aust. J. Zool.,* **2**(1): 187.

1959. *Phytoseius* Chant, *Can. Ent.,* **91**: 105.

1960. *Phytoseius* Chant and Athias-Henriot, *Entomophaga,* **5**: 213.

1961. *Dubininellus* Muma, *Fla. Sta. Mus. Bull.,* **5**(7): 293.

1962. *Phytoseius* (*Pennaseius*) Prichard and Baker, *Hilgardia.* **33**: 223.

1963. *Pennaseius* Schuster and Prichard, *Hilgardia,* **34**: 299.

1965. *Phytoseius* Chant and Baker, *Mem. Ent. Soc. Can.,* **41**: 8.

1966. *Phytoseius* Corpuz, *Philip. Agr.,* **50:** 732.

1968. *Phytoseius* Muma and Denmark, *Fla. Ent.,* **51**: 229.

1970. *Phytoseius* (*Euryseius*) Wainstein, *Zool. Zh.,* **51**: 1726.

1972. *Phytoseius* Denmark and Muma, *Fal. Ent.,* **55**(1): 28.

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

1975. *Phytoseius,* Denmark and Muma, *J. Agr. Univ. Puerto Rico,* **59**(4): 295.

1977. *Phytoseius* Ehara and Bhandhufalck, *J. Fac. Ed. Tottori Univ.,* **27**(2): 46.

1978. *Phytoseius* Denmark and Muma, *Internat. J. Acarol.,* **4**(1): 14.

1981: *Phytoseius* Denmark and Andrews, *Fla. Ent.,* **64**(1): 153.

1982. *Phytoseius* Daneshvar and Denmark, *Internat. J. Acarol.,* **8**: 6.

1984. *Phytoseius* Schicha, *Internat. J. Acarol.,* **10**(2):177.

1986. *Phytoseius* Gupta, *Fauna of India: Phytoseiidae*, p.219.

1987. *Phytoseius* Gupta, *Rec. Zool. Surv, India, Occ. Pap*., **95**:79.

1989. *Phytoseus* Cobanoglu, *Turk. Entomol. Derg.,* **13**: 163-178.

1992. *Phytoseius* Denmark, *Fla. St. Coll. of Arthropods, Occ. Pap.,* **7**: 1-43.

1992. *Phytoseius* Chant and Yoshida-Shaul, *Internat, J. Acarol.,* **18** (1):11.

2003. *Phytoseius (Pennaseius)* Gupta, In: *A monograph on plant inhabiting predatory mites of India. Part II: Order: Mesostigmata. Mem. Zool. Surv. India,* **20**(1): 96.

2007. *Phytoseius* Chant and McMurtry, In: *Illustrated keys and diagnoses for the genera and subgenera of the Phytoseiidae of the world (Acari: Mesostigmata)*, p.125.

2015. *Phytoseius* Sousa *et al., Acarologia*, **55**(1): 5-18.

Diagnosis: Female dorsal shield entire, smooth or rugose with 15-16 pairs of setae; 5-6 pairs of dorsocentral setae, 2 pairs of median setae and 7 pairs of lateral setae, all long setae on dorsal shield thick and serrate; R_1 either present or absent. Ventrianal shield longer than wide with 1-3 pairs of preanal setae. Macrosetae on leg IV spatulate, club shaped or thickened.

Type Species: *Gamasus plumifer* Canestrini and Fanzago, 1876.

Phytoseius intermedius Evans and Macfarlane, 1962

PLATE 49

1962. *Phytoseius* (*Dubininellus*) *intermedius* Evans and Macfarlane, *Ann. Mag. Nat. His. Ser, 3,* **4**: 587-588.

Redescription

Female: Dorsal shield highly sclerotized, 275 long, 150 wide with 15 pairs of setae. All setae long and serrate except j_4, j_5, J_5 and z_5 which are short and simple. Measurements of setae: j_1 - 20, j_4, j_5, j_6, J_5 – 10 each, j_3 - 20, z_2 – 20, z_3 – 35, z_4 – 10, s_4 – 56, s_6 – 71, Z_5 – 50, Z_4 – 60, r_3 - 30. Sternal shield creased laterally and posteriorly, 60 long, 53 wide with 3 pairs of sternal setae ST_1, ST_2 and ST_3 – 15 each. Metasternal shield with setae ST_4 - 12 long. Genital shield 65 wide with a pair of setae ST_5 – 20 long. Ventrianal shield 72 long, 50 wide with 3 pairs of preanal setae and 3 pairs of setae present on the membrane around the ventrianal shield, ZV_1 - 15, ZV_2 - 10, ZV_3 – 13, JV_1, JV_2 – 12 each and JV_5– 20 long, smooth. Only primary metapodal plate present which is 22 long. Fixed digit of chelicera with 2 teeth, movable digit with one strong tooth. Peritreme extends anteriorly upto j_1. Spermatheca with saccular cervix and nodular atrium. Leg IV devoid of macrosetae.

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 but smaller, spermatophoral process with foot subterminal and toe slightly corked. Ventrianal shield smooth, 66 long, 115 wide with 3 pairs of preanal setae.

Habitat: *Amaranthus dubius* Mart. ex Thell.

Known habitat: *Aloe*, Brinjal, *Calotropis procera, Datura stramonium,* fig, litchi, papaya, *Solanum mirialum, Zizyphus jujube.*

Material examined: Female marked on the slide along with ♂, INDIA: KERALA: M.C.C Campus (Kozhikode district), 6.vi.2015, ex. *Amaranthus dubius,* coll. Rahul (No.Ph. 4/1). Six ♀♀ and a ♂, collection details same as above (No. Ph. 4/2, 4/3, 4/4, 4/5, 4/6, 4/7).

Distribution: INDIA: West Bengal, Tripura, Bihar, Jammu and Kashmir, Uttar Pradesh and Andaman Island. OUTSIDE INDIA: Madagascar, Japan, Pakistan, Belgian Congo, South Rhodesia and Central Africa.

Remarks: The specimen agrees with *Phytoseius intermedius* Evans and Macfarlane, 1962 having similar dorsal chaetotaxy, number of teeth, structure of spermatheca, shape of spermatophoral process, leg IV setation, etc., and hence fixed so. In the present survey *P. intermedius* was recovered from a new host plant, *Amaranthus dubius.* This is a new record from Kerala.

SUBFAMILY: TYPHLODROMINAE Wainstein, 1962.

1958. *Typhlodromus* Scheuten, Evans, *J. Linnean Soc. Zool.,* **43**: 223.

1957. *Typhlodromus (Typhlodromus)* Scheuten and Chant, *Can. Entomol*., **89** (11): 531.

1962. Typhlodromini Wainstein, *Acarol.,* **4**:26.

1973. Gigagnathinae Wainstein, *Zool. Zh*., **52**: 276.

1983. Gigagnathini Karg, *Mitt. Zool.Mus. Berlin,* **59**(2):299.

1986. Cydnodromellinae Chant and Yoshida-Shaul. *Can. J. Zool*., **64**(12): 2812.

1994. Typhlodrominae Wainstein, Chant and McMurtry. *Internat. J. Acarol*., **20**(4): 285.

1997. Typhlodrominae Walter, *Aust. J. Entomol.,* **36**: 333-338.

2007. Typhlodrominae Chant and McMurtry, In: *Illustrated keys and diagnoses for the genera and subgenera of the Phytoseiidae of the world (Acari: Mesostigmata)*, p.131.

2014. Typhlodrominae Tixier and Kreiter, *Biological J. Linn. Soc*., **112**: 606-624.

2015. Typhlodrominae Santos *et al., Neotropical Biodiversity,* **1**(1): 22-35.

2017. Typhlodrominae Fayaz *et al., Acarologia,* **57**(4): 869-876.

Diagnosis: Dorsal shield with either or both of setae z_3 and s_6 present on the podonotum and with at least one of setae Z_1, S_2, S_4, and S_5 present on the opisthonotum.

Type Genus: *Typhlodromus* Scheuten, 1958.

Tribe: TYPHLODROMINI Wainstein, 1962

1953. *Typhlodromus* Scheuten, Evans, *Ann. Mag. Nat. Hist.,* **6**: 449.

1957. *Typhlodromus* (*Typhlodromus*) Chant, *Can. Entomol*., **89**(11): 528.

1962. Typhlodromini Wainstein, *Acarologia*, **4**:26.

2007. Typhlodromini Chant and McMurtry, In: *Illustrated keys and diagnoses for the genera and subgenera of the Phytoseiidae of the world (Acari: Mesostigmata)*, p.144.

2008. Typhlodromini Ueckermann *et al., Zootaxa,* **1901**: 1-122.

2015. Typhlodromini Wainstein, Santos *et al., Neotropical Biodiversity,* **1**(1): 22-35.

2017. Typhlodromini Wainstein, Fahad *et al., Acarologia,* **57**(2): 275-294.

Diagnosis: Presence of setae z_3 and s_6, and dorsal setae J_2, S_2 and R_1, and caudoventral setae JV_2 and ZV_3; absence of setae z_6, J_1 and Z_3 and the presence of setae S_4 –and JV_4; dorsal setae Z_1 and S_5 and caudoventral setae JV_3 and JV_4 are variable in their occurrence.

Type Genus: ***Typhlodromus*** Scheuten, 1857.

Genus *Typhlodromus* Scheuten, 1857

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

1982. *Typhlodromus* Karg, *Zool.Jb. Syst. Bd.,* **109**: 206.

1986. *Typhlodromus* Gupta, *Fauna of India: Phytoseiidae,* p. 262.

1987. *Typhlodromus* Gupta, *Rec. Zool. Surv. India, Occ. Pap.,* **95**: 100.

1992. *Typhlodromus* Gupta, *Progress in Acarol.,***1**: 404.

1989. *Typhlodromus* Cobanoglu, *Turk. Entomol. derg.,* **13**(3): 163-178.

1992. *Typhlodromus* Gupta, In: *State Fauna Ser.3, Fauna of West Bengal, Part 3,* p.177.

1992. *Typhlodromus* Denmark, *Fla. St. Coll.of Arthropods,* **7**(0): 1-43.

1992. *Typhlodromus* Ryuand Lee, *Korean J. Entomol.,* **22**: 23-42.

1993. *Typhlodromus* Schicha and Dowd, *J. Aust. Entomol. Soc.,* **32**: 297-305.

1995. *Typhlodromus* Yoshida – Shaul and Chant, *Acarol.,* **36**: 3-19.

1997 *Typhlodromus* Gupta and Chatterjee, In: *State Fauna Ser. 6, Fauna of Delhi,* p.526.

2003. *Typhlodromus (Amblydromella)* Gupta, In: *A monograph on plant inhabiting predatory mites of India. Part II: Order: Mesostigmata. Mem. Zool. Surv, India,* **20** (1): 115.

2007. *Typhlodromus (Anthoseius)* Chant and McMurtry, In: *Illustrated keys and diagnoses for the genera and subgenera of the Phytoseiidae of the world (Acari: Mesostigmata)*, p.147.

2010. *Typhlodromus (Typhlodromus)* Tixier *et al., Ann. Entomol. Soc. Am*., **103**(2): 165-180.

2011. *Typhlodromus (Anthoseius)* Hernandes *et al., Acarologia,* **51**(4): 431-448.

2013. *Typhlodromus (Anthoseius)* Fayaz *et al., Persian J. Acarol*., **2**(3): 369-387.

2017. *Typhlodromus (Anthoseius)* Fayaz *et al., Acarologia,* **57**(2): 255-267.

***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 shield 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 to 7 setae each, tibia IV with 6 setae.

Type Genus: ***Typhlodromus pyri*** Scheuten, 1857.

Subgenus *Anthoseius* De Leon, 1959

1959. *Anthoseius* De Leon, *Entomol. News*., **70**(10): 258.

1960. *Amblydromella* Muma, *Can. Entomol*., **92**(1): 60.

1951.*Clavidromus* Muma, *Zool.Verhandl.,The Netherlands,* **45**: 55.

1905.*Typhlodromella* Muma, *Entomol.The Netherlands,* **48**:78.

1961.*Chanteius* (*Chlehodromus*) Wainstein, *Trudy Inst. Zool.Akad. Nouk Gruzinskoy SSR* **18**: 19.

1965. *Mumaseius* De Leon, *Entomol. News* **76**(1): 23.

1968 *Orientiseius* Muma and Denmark, *Florida Entomol.,* **51**: 238.

1968. *Typhlodromus* (*Anthoseius*) Van der Merwe, *Entomol. Mem.S. Africa. Tech. Services.***18**: 20.

1969. *Indodromus* Ghai and Menon, *Ori. Insects,* **3**: 348.

1972. *Anthoseius* (*Anthoseius*) Wainstein, *Zool. Zh.,* **51**: 1477.

1972. *Anthoseius* (*Amblydromellus*) Wainstein, *Zool. Zh.,* **51**: 1478.

1973. *Berethria* Tuttle and Muma, *Agric. Expt. Stn. Tech. Bull., Univ. Arizona, Tueson* **208**: 35.

1988. *Vittoseius* Kolodochka, *Vestn. Zool.,* **4**: 42.

1992. *Anthoseius (Litoseius*) Kolodochka, *Vest. Zool.,* **2**: 22.

1959. *T. rhenanus* group, Chant, *Can. Entomol. Suppl.,* **12** : 62.

1959. *T. barkeri* group, Chant, *Can. Entomol. Suppl.,* **12** : 62.

2002. *Amblydromella (Anthoseius)* Denmark and Welbourn, *Internat. J. Acarol.,* **28**(4): 291-316.

2007. *Typhlodromus (Anthoseius)* Chant and McMurtry, In: *Illustrated keys and diagnoses for the genera and subgenera of the Phytoseiidae of the world (Acari: Mesostigmata)*, p.149.

2011. *Typhlodromus (Anthoseius)* Hernandes *et al., Acarologia,* **51**(4): 431-448.

2013. *Typhlodromus (Anthoseius)* Fayaz *et al., Persian J. Acarol*., **2**(3): 369-387.

2017. *Typhlodromus (Anthoseius)* Fayaz *et al., Acarologia,* **57**(2): 255-267.

***Diagnosis*:** This subgenus is characterised by the presence of seta S_5. Dorsal setae z_3, s_6, J_2, S_2, S_5 and R_1 and caudoventral setae JV_2 and ZV_3 present. Dorsal setae Z_6, J_1, Z_1 and Z_3 absent.

Type Species: ***Anthoseius hebetis*** De Leon, 1959.

Typhlodromus (Anthoseius) bambusicolus Gupta, 1977

PLATE 50

1986. *Typhlodromus bambusicolus* Gupta, *Indian J. Acarol.,* **2**: 2-4.

Redescription

Female : Dorsal shield reticulated, 300 long, 175 wide, Measurement of setae : j_1– 16, j_4–14, j_5–17, j_6–17, J_2– 23, J_5– 8, J_3– 25, z_2– 17, z_3–17, z_4–23, S_2–28, S_4– 26, S_5–16, Z_5–50 serrated, z_5–19, Z_4–25, r_3, R_1–17 long. Sternal shield 80 long, 75 wide with sternal setae ST_1-19, ST_2 and ST_3- 17 each. ST_4 – 19 long on metasternal shield. Genital shield 76 wide with ST_5–20 long. Ventrianal shield 80 long, 78 wide with a pair of pores. Four pairs of preanal setae JV_1– 8, JV_2– 6, ZV_2– 8, JV_3– 8. Setae around ventrianal shield ZV_1–16, ZV_3–12, JV_4–12, JV_5– 20 long and smooth. Two pairs of metapodal plates, primary one 18 long and accessory one 10 long. Spermatheca with cup shaped cervix. Peritreme extending beyond j_1 and curved inwards. Fixed digit of chelicera bears 5 teeth anterior to *pilus dentilis* and none posterior to it, movable digit with 1 teeth. Macroseta on leg IV: genu–15, tibia –20, baritarsus – 25, all spatulated.

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

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

Male: Not studied.

Habitat: *Solanum lycopersicum* L.

Known habitat: Bamboo, citrus, *Saraca ashoka, Ricinus communis*, *Theobroma cocoa, Coffea arabica, Solanum virginianum*

Material Examined: Female marked on the slide INDIA: KERALA: Ottapalam (Palakkad district), 21.iv.2016, ex. *Solanum lycopersicum*, coll. Rahul (No. T. 25/1). Five ♀♀ collection details same as above (No. T. 25/2, 25/3, 25/4, 25/5, 25/6).

Distribution: INDIA: Assam, Tripura, Kerala

Remarks: This specimen agrees with *Typhlodromus (Anthoseius) bambusicolus* Gupta, 1977 having similar dorsal chaetotaxy, number of teeth, structure of spermatheca, etc., and hence fixed so. In the present survey *T (A). bambusicolus* was recovered from a new host plant, *Solanum lycopersicum.*

6.3. FAMILY II: BLATTISOCIIDAE Garman, 1948.

1948. Blattisociidae Garman, *Conn. Agr. Exp. St. Bull.*, **520**: 5-27.

1973. Blattisociidae Athias-Henriot, *Bull. Soc. Ento. France*, P.227.

2010. Blattisociidae Lindquist and Moraza, *Zootaxa*, **2243**: 1–21.

2012. Blattisociidae Nemati *et al.*, *Internat. J. Agri. Crop Sci.*, **4** (19): 1415-1420.

2013. Blattisociidae Silva *et al.*, *Biotemas*, **26** (4): 253-262.

2015. Blattisociidae Mahjoori *et al.*, *Entomofauna*, **36**(8): 97-108.

2016. Blattisociidae Moraes *et al.*, *Zootaxa*, **4112**(1):1-299.

Diagnosis: Mites of this family can be recognized by the presence of fused podonotal and opisthonotal shields; sometimes it is not fused; podonotal shield usually with 11 pairs of setae whereas the opisthonotal shield with 7 – 10 pairs of setae. Lateral cuticle is usually unsclerotised with 6 pairs of setae. Third pair of sternal setae (ST_3) off sternal shield (rarely on sternal shield in *Lasioseius*, absent in *Krantzoseius* and *Mucroseius* as well as in some members *Aceodromus* and *Proctolaelaps*), when metasternal plates were present it is usually inserted on them together with sternal seta ST_4; Genital shield usually truncate posteriorly. Ventrianal shield usually bear 2–7 pairs of setae in addition to the circumanal setae. Peritrematic shield broadly connected to exopodal shield, curving behind coxa IV and peritreme extends anteriorly upto j_2. Fixed digit of chelicera with 4-20 teeth and setiform *pilus dentilis*; movable digit often tridentate. Spermathecal apparatus phytoseiid type (not typically so in *Zercoseius*). Leg chaetotaxy, genu I-IV: 13, 10, 8, 9 respectively and tibia I-IV: 13, 10, 8, 10; leg IV with macrosetae.

Type Species: ***Aceodromus*** Muma, 1961

Morphology and terminology

Blattisociidae have ascid type of setal patterns and arrangements except the number of setae. Dorsal shield entire, elongated or hemispherical, with fused, smooth or ornamental podonotal and opisthonotal shields. There is no distinct lateral incisions at the line of fusion; delineated strips are absent along the lateral margins. Podonotal shield with 15-25 pairs of setae whereas the opisthonotal region with 8-16 pairs of setae. Lateral cuticle with 0-16 pairs of setae. Anteriorly epistome smooth or deticulate; corniculi with pointed tips, they are well separated each other and sub parallel. The corniculi 1-4 times as long as their basal width.

Ventrally there are 3 distinct shields; sternal shield with 2-3 pairs of setae; genital shield generally truncate posteriorly, with or without a pair of setae; anal plate or ventrianal shield with 7 pairs of setae; posteroventral integument with not more than 15 pairs of setae. Peritremal plate free or fused posteriorly with exopodal plate curving behind coxa IV, except in *Arctoseius* it is fused anteriorly with dorsal shield. Tectum smooth, minutely denticulate or with 2 or 3 processes, gnathosoma frequently with well developed denticles. Chelicerae small, short with varied dentition; movable digit with 0-4 teeth and fixed digit with 4-20 teeth. Phytoseiid type of spermathecal apparatus, including a sclerotized calyx and an associated minor duct. Specialized setae on palp with two tines, setation on leg I-IV, genu: 13(12), 11(10), 9(8), 10(8-9); tibia: 13(12), 10(9), 8(9), 10(9), legs with well developed pretarsi and claws. Males with simple cheliceral spermatophoral process and genital opening at anterior edge of sternum. They have 1-12 teeth on fixed digit of chelicerae in addition to apical teeth whereas movable digit with a single tooth in addition to apical tooth.

The taxonomic characters were followed from Evans (1958), Karg (1993) and Bregetova (1977).

Key to the subfamilies of family Blattisociidae

1. Pretarsus of legs II to IV with paradactyli elongated, slightly to usually much longer than claws, acuminate or rarely blunt apically, and with median lobe of pulvillus slender, acuminate or rarely blunt apically; tarsi II-IV with dorso-apical pair of setae longer than pretarsus, often reaching distally to same area as apices of paradactyli; gnathosoma with anterior pair of hypostomatic setae and inner pair of palp trochanter setae elongated, often whip or strap-like…......Platyseiinae

\- Pretarsus of legs II to IV with paradactyli usually inconspicuous, generally shorter than claws, and with median lobe of pulvillus broadly rounded; tarsi II-IV with dorso-apical pair of setae shorter than pretarsus, not reaching distally to same area as apices of claws or paradactyli; gnathosoma with anterior pair of hypostomatic setae and inner pair of palptrochanter setae usually not elongated ………………..…………………………………………..Blattisociinae

SUBFAMILY: PLATYSEIINAE Evans, 1957

1957. Platyseiinae Evans, *Linn. Soc. Land. (Zool.),* **43**: 244.

1960. Platyseiinae Evans and Hyatt, *Bull. Br. Mus. Nat. Hist. Zool.,* **6**(2): 27-101.

1963. Platyseiinae Chant, *Can. J. Zool.,* **41**(2): 243-305.

1965. Platyseiinae Lindquist and Evans, *Mem. Entomol. Soc. Can.*, **47**: 1-64.

1991. Platyseiinae Evans and Baker, *J. Zool.,* **224**(1): 121-126.

2003. Platyseiinae Lindquist, *Indira Publishing House*, pp. 155-182.

2009. Platyseiinae Krantz and Walter, *Texas Tech University press,* 124-232.

2016. Platyseiinae Lindquist and Moraza, *Acarologia,* **56**(3): 293-319.

Diagnosis: Dorsal shield entire with 19 - 22 pairs of setae on podonotal region, opisthonotal region with 12 - 15 pairs of setae. They have rostral and internal setae on long whip-like palp trochanter; on the apices of leg II-IV contains several enlarged and acutely pointed structures, including the pretarsal paradactyli and a median projection of the pulvillus; tarsi II and III with a pair of long lanceolate setae; para-anal setae in line with posterior margin of anus or posterior to anus; peritremal plate extending behind posterior margin of coxa IV and peritreme often developed posterior to stigma.

Type Genus: ***Sejus*** Koch, 1843

Genus: *Cheiroseius* Berlese, 1916.

1916. *Cheiroseius* Berlese, *Radia*, **12**: 19-67.

1960. *Cheiroseius* Evans and Hyatt, *Bull. Br. Mus. Nat. Hist. Zool.,* **6**(2): 27-101.

2000. *Cheiroseius* Ma Liming, *Acta Arachnologica Sinica*, **2000**(2)**:** 75-77

2004. *Cheiroseius* Bhattacharyya and Bhattacharyya, *Zootaxa,* **403**: 1-11.

2008. *Cheiroseius* Faraji *et al., Zoosyst Evol*., **84(2):** 211-214.

2014. *Cheiroseius* Mehranian, *Biologia,* **69**(3): 50-53.

2016. *Cheiroseius* Karg and Schorlemmer, *Soil Organisms,* **88**(3): 165-174.

***Diagnosis*:** Anterior rostral and internal palp trochanter setae long, whip-like, tapering only near the tip. Opisthonotal region of dorsal shield with 12-15 pairs of setae, including J_{1-5}. Female with sternal setae ST_1 and ST_3 sub equal in length; ST_4 in soft cuticle; para anal setae inserted level with posterior to hind margin of anus and it is usually larger than post anal setae; phytoseiid type of spermatheca; fixed digit of chelicerae with a deep receptacle that receives the tip of the movable digit; peritreme extending along coxa IV. Legs II-IV with median lobe of pulvillus slender, acute or normally rounded; Genu

II with 10 setae; Femora I and II with 11 and 10 setae respectively. Male with or without metasternal setae; median lobes of pulvillus of legs II-IV acute.

Type Species: ***Sejus viduus*** Koch, 1839

Cheiroseius kozhikodensis sp.nov.

PLATE 53

Female: Dorsal shield smooth, 364 long, 180 wide, oval, with 34 pairs of dorsal setae. All dorsal setae simple with divided tips; setae S_4, S_5 and Z_5 are serrated; j_1 - 15, j_2 - 16, j_3 - 18, j_4- 15, j_5 – 18, j_6 - 28, z_1 - 10, z_2 -18, z_3 -25, z_4 - 30, z_5 - 20, s_1 – 15, s_2 - 17, s_3- 25, s_4 - 48, s_5 -s_6 - 30, r_3 - 12 on humeral region of shield, moderately short and simple, in posterior part, J_1 – J_2 - 25, J_3 – 17, J_4 - 28, J_5 - 10, Z_1 – 25, Z_2 – 20, Z_3 – 25, Z_4 - 35, Z_5 - 61, S_1 – 25, S_2 – S_4 - 30, S_5 - 30, R_6 – 30. Sternal shield 79 long, 69 wide with 3 pairs of sternal setae, ST_1 – ST_3 – 25 long. Metasternal shield bearing setae ST_4 – 20 long. Genital shield 51 wide with a pair of simple setae, ST_5 - 20 long; ventrianal shield 120 long, 128 wide somewhat triangular and reticulated, with 4 pairs of JV_2, JV_2, JV_3, ZV_2 all simple, JV_1, ZV_1 anteriorly and ZV_2 laterally. Two pairs of metapodal plates. Primary one 24 long and accessory one 12. Anterior half of peritremal shield relatively narrow and extends anteriorly to the level of setae j_1. Peritrematal-exopodal shield curved around coxa IV. Fixed digit of chelicera with12 teeth; movable digit with 3 strong teeth. Legs: I - 370, II - 300, III - 270, IV – 370 long. Leg IV with macrosetae on tibia and tarsus, 39 and 32 long respectively.

Leg chaetotaxy: genu IV $2\,\frac{2}{1}\,\frac{3}{0}\,1$, tibia IV $2\,\frac{1}{1}\,\frac{3}{1}\,2$.

Male: Unknown

Habitat: *Amaranthus viridis* L.

Material examined: Holotype ♀ marked on the slide INDIA: KERALA: Kollam, (Kozhikode district), 24.x.2015. ex: *Amaranthus viridis*, coll. Rahul (No. C. 139/1). Three paratype slides with 5 ♀♀ collection details same as above (No. C. 139/2, 139/3, 139/4).

Remarks: This new species resembles *Cheiroseius mutilus* Berlese, 1916 in general appearance, laterally directed j_1, caudally extended and hooked peritreme, shape of ventrianal shield, etc. but differs in the following characters:

1. Idiosomal length of the new species (364 long) seems to be short when compared with *C. mutilus* (550 long).
2. All setae except S_4, S_5 and Z_5 smooth in the new species whereas in *C. mutilus* all setae are smooth.
3. Setae r_1 is absent in the new species.
4. In the new species only two pairs of setae present around the ventrianal shield whereas in *C. mutilus* 6 pairs are present.
5. Sternal shield without any ornamentation.
6. Leg I strikingly longer than idiosoma in *C. mutilus* but it is almost equal in the new species.

Genus: *Lasioseius* Berlese, 1916

1916. *Lasioseius* Berlese, *Radia*, **12**: 19-67.

1941. *Aceoseius* Sellnick, *Zool. Anz*., **133**:149.

1946. *Borinquolaelaps* Fox, *J. Parasitol*., **32**: 450.

1958. *Lasioseius* Evans, *Proc. Zool. Soc. Lond*., **131**: 189.

1969. *Lasioseius* Aswegen and Loots, *Naturwetenskappe,* **3**: 1-25.

1972. *Lasioseius* Hurlbutt, *Acarologia,* **13**: 289.

1980. *Lasioseius* Karg, *Zool. Jb. Syst*., **107**: 344-367.

1985. *Lasioseius* Gupta, *Handbk. Plant mites of India,* p. 330.

1989. *Lasioseius* Walter and Lindquist, *Can. J. Zool.,* **67**: 2797-2813.

1994. *Lasioseius* Karg, *Mitt. Zool. Mus. Berl*., **70**: 124.

1997. *Lasioseius* Walter and Lindquist, *Invert. Taxon*., **11**: 525-547.

2003. *Lasioseius* Gupta, *Mem. Zool. Surv. India,* **20**(1): 185 p.

2006. *Lasioseius* Christian and Karg, *Abh. Ber. Naturkundemus Gorlitz*, **77**(2): 99-250.

2016. *Lasioseius* Abo-Shnaf *et al., Syst. Appl. Acarol.,* **21**(5):607-646.

Diagnosis: Female with 12-23 pairs of setae on podonotal region and 10-15 pairs on opisthonotal region, mostly tricarinate; The venter of female is characterised by a sternal shield having 3 pairs of setae, a pair of metasternal plates each with a simple seta, a genital shield bearing one pair of setae; ventrianal shield with 5 – 7 pairs of setae. Genital shield usually truncate posteriorly. Movable digit of chelicerae in most subgenera with 3 teeth (rarely 4). Fixed digit with a setiform *pilus dentilis* with saw like dental raw of teeth; spermatodactyl of males finger shaped. The spermatheca phytoseiid type. Cervix of spermatheca well sclerotised. Genu II and III with 11 and 9 setae respectively. Corniculi short and tectum tridentate.

Type Species: *Seius musicatus* Berlese, 1887

Key to the species of genus *Lasioseius* included in the present study

1. Dorsal shield with 30 or more pairs of setae 2

– Dorsal shield with fewer than 30 pairs of setae 7

2. Anterior region of the dorsal shield with only 5 pairs of setae in the j series…………………………………...………………………3

– Anterior region of the dorsal shield with 6 pairs of setae in the j series .... …………4

3. Spermatheca with tubular cervix………………………..*quadrisetosus*

– Spermatheca with bell shaped cervix……………*vengeriensis* sp.nov.

4. Ventrally longitudinal striations are present around genital and ventrianal shield and these shields are separated by a clear skin fold………....... ...…………………………*kurumpoyilensis* sp.nov.

– No striations on ventral side and skin fold is absent between genital and ventraianl shield...................................………………………...5

5. All legs are devoid of macroseta....……………………….. *glomerulus*

– Usually leg IV with macroseta…………………...........................6

6. Two pairs of pores are present around ventrianal shield ……………….......... …………………………………*arjuni* sp.nov.

– Pores are absent...*furcisetus*

7. Leg IV with macrosetae only on basitarsus and tarsus………………. .... …………………………………*seethae* sp.nov.

– Leg IV with macrosetae on genu, tibia, basitarsus and tarsus…………… ………………...……………………*phytoseioides*

***Lasioseius arjuni* sp.nov.**

PLATE 54

Female: Dorsal shield well sclerotized, 350 long, 178 wide with 32 pairs of setae; 18 pairs on anterior shield and 14 pairs on posterior shield. Six pairs of setae in the j series, 5 pairs in z series and series s with 6 pairs of setae. Measurements of setae on anterior side: j_1 - 13, j_2, j_3 and j_4 - 25 each, j_5 – 20, j_6 – 18, z_1 – 13, z_2 – 18, z_3 – 25, z_4, z_5 – 22 each, z_6 - 18, s_1, s_2 – 18 each, s_3 – 25, s_4 – 20, s_5 – 22, s_6 – 22 long. r series with 2 pairs of setae r_3 – 38 and r_5 – 18 long. Posteriorly 4 pairs of setae on J series, J_1, J_2 – 18, J_3 – 25, J_5 – 8. Series Z and S with 5 pairs of setae measuring S_1, S_2 – 26 each, S_3 – 27, S_4 – 25, S_5 – 35, Z_1 - 18, Z_2, Z_3 – 25 each, Z_4 – 30 and Z_5 – 50 long. R series with 2 pairs of setae 15 each. All the setae on dorsal shield serrated and swollen distally.

Sternal shield well sclerotized, 95 long, 73 wide with 3 pairs of setae ST_1, ST_2 – 25 each and ST_3 – 20 long. Setae ST_4 – 25 long placed on metapodal plates. Genital shield 75 wide with ST_5 -12 long. Ventrianal shield 105 long and 106 wide, triangular shaped with transverse striations on anterior margin. Four pairs of preanal setae present, all are simple and minute. Four pairs of setae and 2 pairs of small pores are present on the area around the ventrianal shield. Setae JV_5 43 long and serrated distally. Two pairs of metapodal plates present, primary one 18 and accessory one 13 long. Peritremal plate well developed and fused posteriorly. Peritreme extends anteriorly upto j_1. Spermatheca not distinct. Fixed digit of chelicera with 10 teeth; movable digit with 4 teeth. Tectum denticulate. Leg I, II and III lack macrosetae on genu, tibia and tarsus. Macrosetae present on Leg IV, basitarsus 43 long and tarsus 35 long.

Leg chaetotaxy: genu I $2\,\frac{3}{3}\,\frac{2}{2}\,0$, tibia I $1\,\frac{4}{2}\,\frac{3}{1}\,1$;

genu II $0\,\frac{3}{2}\,\frac{3}{2}\,1$, tibia II $2\,\frac{3}{2}\,\frac{1}{1}\,1$.

Male: Unknown

Habitat: *Cucurbita maxima* Duchesne.

Material examined: Holotype ♀ marked on the slide INDIA: KERALA: Vengeri (Kozhikode district), 30.vii.2015. ex: *Cucurbita maxima*, coll. Rahul (No. L. 82/1). Two paratype slides with 4 ♀♀ collection details same as above (No. L. 82/2, 82/3).

Remarks: This new species resembles *Lasioseius matthyssei* Chant, 1963 in general appearance, but differs in the following characters:

1. Size of the body is smaller in the new species (350 long and 178 wide) when compared with *L. matthyssei* (400 long and 240 wide).

2. Fixed digit of chelicera with 10 teeth in the new species instead of 13-14 in *L. matthyssei*.

3. Movable digit of chelicera with 4 teeth in the new species whereas in *L. matthyssei* it is 2-3.

4. Length and width ratio of ventrianal shield is 0.9 in the new species but it is 1.1 in *L. matthyssei*.

5. Two pairs of pores present around the ventrianal shield in the new species but pores are absent in *L. matthyssei*.

6. Leg I devoid of macrosetae in the new species but in *L. matthyssei* leg I bears macrosetae on genu, tibia and tarsus.

7. Macrosetae present only on the leg IV basitarsus and tarsus of the new species but in *L. matthyssei* it is present on all the segments.

8. In the new species, sternal shield has reticulation whereas in *L. matthyssei* sternal shield is smooth.

Lasioseius furcisetus Athias-Henriot (1959)

PLATE 55

1959. *Lasioseius furcisetus* Athias-Henriot, *Bull. de la Soc. Hist. Nat. de Afr. du Nord,* **50**: 158-195.

Redescription

Female: Dorsal shield covered by small oval pits which formed a web-like structure, 350 long, 200 wide with 31 pairs of setae, 16 pairs on anterior shield and 15 pairs on posterior shield. Six pairs of setae in the j and z series and series s with 4 pairs of setae. Measurements of setae on anterior side: j_1 – 25, j_2 – 18, j_3, j_4, j_5, j_6 – 25 each, z_1 – 10, z_2 – 27, z_3, z_4 – 31 each, z_5 – 27, z_6 – 25, s_1 – 38, s_3, s_4 – 30 each, s_5 – 30 and s_6 – 25 long. r series with 2 pairs of setae r_3 – 38 and r_5 – 15 long. Posteriorly setae J, Z and S series, each with 5 pairs of setae, measuring J_1- 30, J_2- 32, J_3 – 35, J_4 – 32, J_5 – 12, S_1 - 27, S_2 – 25, S_3 – 30, S_4 – 32, S_5 – 38, Z_1 – 30, Z_2 – 35, Z_3 – 32, Z_4 – 48 and Z_5 – 63 long. R series with 2 pairs of setae, R_2 and R_5 – 15 long. All the setae on dorsal shield serrated. Sternal shield smooth, 75 long, 65 wide with 3 pairs of setae ST_1 – 15, ST_2 – 20 and ST_3 – 15 long. Setae ST_4 – 18 long placed on metapodal plates. Genital shield 73 wide with ST_5 -15 long. Ventrianal shield large, reticulated, 100 long and 110 wide, somewhat triangular in shape and slightly creased lateral margin at the point of 4^{th} pair of preanal setae. Four pairs of preanal setae present, all are simple measuring 10 each and two pairs of setae present on the area around the ventrianal shield, JV_5 – 30 long. Two pairs of metapodal plates present, primary one 25 and accessory one 15 long. Peritremal plate well developed and fused posteriorly. Peritreme extends anteriorly upto j_1. Spermatheca not distinct. Fixed digit of chelicera with 11 teeth; movable digit with 2 teeth. Leg I with macrosetae on tarsus, leg II and III devoid of macrosetae; macrosetae on leg IV basitarsus – 31 and tarsus – 38 long.

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

genu II $1\,\frac{3}{1}\;\frac{3}{1}\,2$, tibia II $1\,\frac{2}{1}\;\frac{3}{2}\,1$.

Male: Unknown

Habitat: *Capsicum annuum* L.

Known habitat: *Pinus sylvestris, Betula pendula, Prunus domestica, Formica polyctena,* Nest of white-tailed sea eagle, *Aphyllophorales* Fungi, *Vitis* sp.

Material examined: Female marked on the slide, INDIA: KERALA: Pazhoor (Kozhikode district), 25.ix.2015, ex. *Capsicum annuum*, coll. Rahul (No.L. 104/1). Five ♀♀ marked on the slides, collection details same as above (No. L. 104/2, 104/3, 104/4, 104/5, 104/6).

Distribution: OUTSIDE INDIA: Russia, Paris, Egypt, Algeria, Bulgaria, Latvia, Poland, South Korea and California.

Remarks: The specimen examined closely resembles almost all characters of *Lasioseius furcisetus* Athias-Henriot, 1959 hence fixed so. In the present survey *L. furcisetus* was recovered from a new host plant *viz., Capsicum annuum*. This is a new record from India.

***Lasioseius glomerulus* Karg, 1979**

PLATE 56

1979. *Lasioseius glomerulus* Karg, *Deut. Entomol. Zeit.,* **26**(1-3): 1-8.

Redescription

Female: Dorsal shield reticulated, 356 long, 206 wide with 36 pairs of setae, 21 pairs on anterior shield and 15 pairs on posterior shield. Six pairs of setae in the j, z and series. Measurements of setae on anterior side: j_1 – 25, j_2 – 18, j_3 – 37, j_4, j_5 and j_6 – 25 each, z_1 – 10, z_2 – 25, z_3 – 27, z_4 – 25, z_5 and z_6 – 20 each, s_1 – 18, s_2 – 10, s_3 – 21, s_4 – 32, s_5 – 44 and s_6 – 25 long. r series with 5 pairs of setae r_1 – 12, r_2 – 18, r_3 – 48, r_5 and r_6 – 18 each. Posteriorly setae J, Z and S series with 5 pairs of setae, J_1 – 30, J_2 – 25, J_3, J_4 – 30 each, J_5 – 12, S_1, S_2, S_3 – 30 each, S_4 – 37, S_5 – 42, Z_1 – 25, Z_2, Z_3 – 30 each, Z_4 – 44 and Z_5 – 65 long. R series without setae. All the setae on dorsal shield trispinate. Sternal shield reticulated, 81 long, 78 wide with 3 pairs of setae ST_1 – 25, ST_2 – 22 and ST_3 – 20 long. Setae ST_4 – 15 long placed on metapodal plates. Genital shield is reticulated laterally, 69 wide with ST_5 – 15 long. Ventrianal shield reticulated, 106 long, 115 wide, triangular in shape with 4 pairs of preanal setae. Five pairs of setae present on the area around the ventrianal shield. Genital and ventrianal shield is separated by a septum. Two pairs of metapodal plates present, primary one 20 and accessory one 12 long. Peritremal plate well developed and fused posteriorly. Peritreme extends anteriorly upto j_1. Spermatheca not distinct. Fixed digit of chelicera multidentate; movable digit with 5 teeth. Legs are devoid of macrosetae.

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

genu II $1\frac{3}{2}\ \frac{3}{1}2$, tibia II $1\frac{2}{0}\ \frac{2}{2}1$.

Male: Unknown

Habitat: *Cucurbita pepo* L.

Known habitat: *Nothofagus dombeyi* and *Myrceugentia exsucca*.

Material examined: Female marked on the slide, INDIA: KERALA: Pazhoor (Kozhikode district), 25.ix.2015, ex. *Cucurbita pepo*, coll. Rahul (No.L. 323/1). Three ♀♀ marked on the slide, collection details same as above (No. L. 323/2, 323/3, 323/4).

Distribution: OUTSIDE INDIA: Argentina and Hungria.

Remarks: The specimen examined closely resembles almost all characters of *Lasioseius glomerulus* Karg, 1979 and hence fixed so. In the present survey *L. quadrisetosus* was recovered from new host plant *viz., Cucurbita pepo*. This is a new record from India.

Lasioseius kurumpoyilensis sp.nov.

PLATE 57

Female: Dorsal shield heavily sclerotized, 375 long, 215 wide with 32 pairs of setae, 17 pairs on anterior shield and 15 pairs on posterior shield. Six pairs of setae on j and z series; 4 pairs of setae on s series. Measurements of setae on anterior side: j_1 - 25, j_2 – 27, j_3 – 30, j_4 - 25, j_5 – 30, j_6 – 25, z_1 – 12, z_2, z_3 - 28, z_4 – 20, z_5 – 37, z_6 - 40, s_3 – 25, s_4 – 37, s_5 – 25, s_6 – 30 long. r series with 2 pairs of setae, r_3 – 27 and r_4 – 18 long. Posteriorly J, Z and S series with 5 pairs of setae, measuring J_1 - 30, J_2 – 35, J_3 – 32, J_4 – 35, J_5 – 12, S_1 - 30, S_2 – 43, S_3 – 35, S_4 – 37, S_5 – 43, Z_1 - 30, Z_2 – 25, Z_3 – 35, Z_4 – 62 and Z_5 – 72 long. R series with 2 pairs of setae, R_1 – 13 and R_5 – 23 long. All the setae on dorsal shield slightly thickened at the base and serrated. Sternal shield is well sclerotized with slightly concave posterior margin, 85 long, 72 wide with 3 pairs of setae, ST_1 – 18, ST_2, ST_3 – 15 each. Setae ST_4 – 18 long placed on metapodal plates. Genital shield 78 wide with ST_5 -12 long. Ventrianal shield 138 long and 131 wide, triangular shaped with transverse striations on anterior margin. Four pairs of preanal setae present, all simple and minute. Four pairs of setae and 2 pairs of small pores present on the area around the ventrianal shield. A clear skin fold separates genital and ventrianal shield. JV_5 38 long and serrated distally. Two pairs of metapodal plates present, primary one 30 and accessory one 18 long. Ventrally longitudinal striations are seen on the area around genital and ventrianal shield. Peritremal plate well developed and fused posteriorly. Peritreme extends anteriorly upto j_1. Spermatheca not distinct. Fixed digit of chelicerae with 8 teeth; 4 teeth on movable digit. Tectum minutely denticulate. Leg I with macrosetae on basitarsus and tarsus but leg II and III devoid of macrosetae; leg IV with macrosetae on basitarsus and tarsus 31 and 35 long respectively.

Leg chaetotaxy: genu I $1 \frac{3}{2} \frac{2}{3} 1$, tibia I $1 \frac{4}{2} \frac{3}{1} 1$;

genu II $2 \frac{2}{1} \frac{1}{1} 2$, tibia II $1 \frac{2}{2} \frac{3}{1} 1$.

Male: Unknown

Habitat: *Manihot esculenta* Crantz.

Material examined: Holotype ♀ marked on the slide INDIA: KERALA: Kurumpoyil (Kozhikode district), 30.vii.2015. ex: *Manihot esculenta*, coll. Rahul (No. L. 249/1). Two paratype slides with 4 ♀♀, collection details same as above (No. L. 249/2, 249/3).

Remarks: This new species resembles *Lasioseius ometes* (Oudemans), 1903 in general appearance, but differs in the following characters:

1. Dorsal shield with 32 pairs of setae in the new species instead of 36 pairs in *L. ometes*.

2. In the new species all setae on dorsal shield are swollen distally and serrated but in *L. ometes* only the setae on posterior margins are slightly swollen and serrated.

3. Interscutal membrane with only 3 pairs of setae in the new species but it is 9 pairs in *L. ometes*.

4. Posterior margin of sternal shield is slightly concave in the new species whereas in *L. ometes* it is deeply excavated to the level of second pair of sternal setae.

5. Movable digit of chelicerae with 4 teeth in the new species whereas only 3 in *L. ometes*.

6. In the new species a clear skin fold is present between genital and ventrianal shield but in *L. ometes* they are close to each other.

7. R series with only 2 pairs of setae in the new species whereas in *L. ometes* there are 5 pairs.

Lasioseius phytoseioides **Chant, 1963**

PLATE 58

1963. *Lasioseius phytoseioides* Chant, *Can. J. Zool.,* **41**: 243-305.

Redescription

Female: Dorsal shield reticulated, 430 long, 238 wide with 23 pairs of setae, 13 pairs on anterior shield and 10 pairs on posterior shield. Five pairs of setae in the j series, series z with 2 pairs and series s with 4 pairs. Measurements of setae on anterior side: j_1 – 33, j_2 – 40, j_3, j_4 – 20 each, j_6 – 27, z_3 - 35, z_5 – 40, s_1 – 38, s_2 – 15, s_3 – 43 and s_4 – 50 long. r series with 4 pairs of setae r_3 – 50, r_2, r_4 and r_6 - 15 each. Posteriorly J series with 3 pairs of setae, Z series with 3 pairs and S series with 4 pairs of setae, measuring J_1- 25, J_3 – 2, J_5 – 18, S_1 - 47, S_2 – 43, S_3 – 56, S_4 – 70, Z_2 – 50, Z_4 – 55 and Z_5 – 75 long. R series with 2 pairs of setae R_2 and R_5 – 27 long. All the setae on dorsal shield smooth and simple except J_5 which is slightly serrated. Sternal shield smooth, 90 long, 100 wide with 3 pairs of setae ST_1 – 25, ST_2, ST_3 – 20 each. Setae ST_4 – 22 long placed on metapodal plates. Genital shield 88 wide with ST_5 -25 long. Ventrianal shield large, 170 long and 185 wide, reticulated and triangular shaped. Six pairs of preanal setae present, all are simple measuring 20 each. One pair of setae JV_5 - 60 long present on the area around the ventrianal shield. Two pairs of metapodal plates present, primary one 20 and accessory one 15 long. Peritremal plate well developed and fused posteriorly. Peritreme extends anteriorly upto j_1. Spermatheca not distinct. Fixed digit of chelicerae with 16 teeth; movable digit with 2 teeth. Leg I with macrosetae on tarsus, leg II and III devoid of macrosetae; macrosetae on leg IV genu, tibia – 37 each, basitarsus – 44 and tarsus – 78 long.

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

genu II $1\frac{3}{1}\frac{3}{1}2$, tibia II $1\frac{2}{1}\frac{3}{2}1$.

Male: Not studied

Habitat: *Cucumis sativus* L.

Known habitat: Clover

Material examined: Female marked on the slide, INDIA: KERALA: Thenjipalam (Malappuram district), 5.v.2015, ex. *Cucumis sativus* , coll. Rahul (No.L 24/1). Three paratype slides with 4 ♀♀, collection details same as above (L. 24/2, 24/3, 24/4).

Distribution: OUTSIDE INDIA: Lousiana.

Remarks: The specimen examined closely resembles almost all characters of *Lasioseius phytoseioides* Chant, 1963 except the number of teeth on movable digit. However it is fixed as *L. phytoseioides*. In the present survey *L. phytoseioides* was recovered from a new host plant *viz., Cucumis sativus*. This is a new record from India.

Lasioseius quadrisetosus Chant, 1960

PLATE 59

1960. *Lasioseius quadrisetosus* Chant, *Can. J. Entomol.,* **92**: 58-65.

Redescription

Female: Dorsal shield poorly reticulated, 350 long, 206 wide with 31 pairs of setae, 16 pairs on anterior shield and 15 pairs on posterior shield. Series j, z and s with 5 pairs of setae. Measurements of setae on anterior side: j_1 – 25, j_2, j_3 – 30 each, j_4, j_6 – 25 each, z_1 – 12, z_2 – 27, z_3, z_4, z_5 – 25 each, s_1 – 25, s_2 – 30, s_3 – 33, s_4 – 40 and s_5 – 35. r series with 3 pairs of setae r_3 – 38, r_4 and r_3 – 12 each. Similarly posterior side with J Z and S series with 5 pairs of setae, measuring J_1 – 26, J_2 – 30, J_3 – 32, J_4 – 35, J_5 – 10, S_1 - 30, S_2 – 35, S_3 – 37, S_4 – 33, S_5 – 38, Z_1 – 27, Z_2 – 23, Z_3 – 33, Z_4 – 47 and Z_5 – 60 long. R series without any setae. All the setae on dorsal shield thick and clubbed. Sternal shield reticulated, flattened posteriorly, 98 long, 72 wide with 3 pairs of setae ST_1, ST_2 – 18 each and ST_3 – 15. Setae ST_4 – 13 long placed on metapodal plates. Genital shield is reticulated laterally, 72 wide with ST_5 – 15 long. Ventrianal shield reticulated, 110 long, 125 wide, triangular in shape with 4 pairs of preanal setae. Four pairs of setae present on the area around the ventrianal shield. Genital and ventrianal shield is separated by a septum. Two pairs of metapodal plates present, primary one 25 and accessory one 18 long. Peritremal plate well developed and fused posteriorly. Peritreme extends anteriorly upto j_1. Spermatheca with tubular cervix. Fixed digit of chelicerae multidentated; movable digit with 4 teeth. Macrosetae present only on basitarsus of leg IV which is 47 long.

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

genu II $1 \frac{3}{1} \; \frac{3}{1} 1$, tibia II $0 \frac{3}{1} \; \frac{2}{1} 1$.

Male: Not studied

Habitat: *Artocarpus heterophyllus* Lam.

Known habitat: Citrus.

Material examined: Female marked on the slide, INDIA: KERALA: Payyoli (Kozhikode district), 24.x.2015, ex. *Artocarpus heterophyllus*, coll. Rahul (No.L. 146/1). Six ♀♀ marked on the slides, collection details same as above (No. L. 146/2, 146/3, 146/4, 146/5, 146/6, 146/7).

Distribution: INDIA: Assam.

Remarks: The specimen examined closely resembles almost all characters of *Lasioseius quadrisetosus* Chant, 1960 in general appearance, setal measurements etc. and hence fixed so. In the present survey *L. quadrisetosus* was recovered from a new host plant *viz., Artocarpus heterophyllus*. This is a new record from Kerala.

Lasioseius seethae sp.nov.

PLATE 60

Female: Dorsal shield heavily sclerotized, 428 long, 237 wide with 24 pairs of setae, 12 pairs on anterior shield and 12 pairs on posterior shield. Five pairs of setae in the j series, series z with 2 pairs and series s with 4 pairs. Measurements of setae on anterior side: j_1, j_2 – 38, j_3 – 27, j_4 - 20, j_6 – 26, z_1 – 10, z_2 - 38, s_1 – 50, s_2 – 18, s_3 – 44 and s_5 – 50 long. r series with 4 pairs of setae r_3 – 45, r_4 – 18, r_5 – 13 and r_6 - 10 long. Posteriorly J series with 3 pairs of setae, Z series with 4 pairs and S series with 5 pairs of setae, measuring J_1, J_3 – 13 each, J_5 – 14, S_1 - 50, S_2 – 45, S_3 – 44, S_4 – 38, S_5 – 70, Z_1 - 13, Z_2 – 75, Z_3, Z_4 – 70 and Z_5 – 88 long. R series with 4 pairs of setae, R_1, R_3, R_4 - 10 each and R_5 – 27 long. All the setae on dorsal shield simple except Z_5 which is serrated. Sternal shield smooth, 110 long, 100 wide with 3 pairs of setae, ST_1 – 25, ST_2, ST_3 – 20 each. Setae ST_4 – 22 long placed on metapodal plates. Genital shield 90 wide with ST_5 -22 long. Ventrianal shield large, 148 long and 215 wide, triangular shaped and reticulated. Six pairs of preanal setae present all are simple measuring 20 each. One pair of setae JV_5 - 75 long, present on the area around the ventrianal shield. Genital and ventrianal shields separated by a septum. Two pairs of metapodal plates present, primary one 25 and accessory one 13 long. Peritremal plate well developed and fused posteriorly. Peritreme extends anteriorly upto j_1. Spermatheca as illustrated. Fixed digit of chelicera with 13 teeth; movable digit with 2 teeth. Leg I with macrosetae on tarsus, leg II and III devoid of macrosetae; leg IV with macrosetae on basitarsus 75 long and tarsus 81 long.

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

$$\text{genu II} \quad 1\,\frac{2}{3}\;\frac{3}{1}\,0, \qquad\qquad \text{tibia II} \quad 2\,\frac{2}{1}\;\frac{3}{1}\,1.$$

Male: Dorsal shield same as that of female. Ventrally sternogenital shield 210 long and 100 wide with setae ST_1, ST_2, ST_3, ST_4 and ST_5. Ventrianal shield 145 long and 110 wide with 6 pairs of setae. Male chelicerae with spermatodactyl process as illustrated.

Habitat: *Capsicum annuum* L.

Material examined: Holotype ♀ marked on the slide INDIA: KERALA: Koorachund (Kozhikode district), 10.xi.2015, ex: *Capsicum annuum*, coll. Rahul (No. L. 224/1). Three paratype slides with 5 ♀♀ and 2 ♂♂, collection details same as above (No. L. 224/2, 224/3, 224/4).

Remarks: This new species resembles *Lasioseius japonicus* Ehara, 1965 in general appearance, but differs in the following characters.

1. Dorsal shield is shorter in the new species (428) but it is much longer in *L. japonicus* (530).
2. Idiosoma of the new species with only 24 pairs of setae in the new species instead of 36 in *L. japonicus*.
3. Z_5 of the new species is much longer and slightly serrated but it is shorter and simple in *L. japonicus*.
4. Shape of the spermatheca varies in both species.
5. In the new species only a single pair of setae present on the area around ventrianal shield whereas 2 pairs are present in *L. japonicus*.
6. Leg III devoid of macrosetae in the new species but it present on the basitarsus of *L. japonicus*.

Lasioseius vengeriensis sp.nov.

PLATE 61

Female: Dorsal shield smooth, 344 long, 194 wide with 31 pairs of setae, 16 pairs on anterior shield and 15 pairs on posterior shield. Five pairs of setae in the j, z and s series. Measurements of setae on anterior side: j_1, j_2, j_3 – 30 each, j_4, j_5 – 22 each, z_1 – 12, z_2 – 22, z_3 - 20, z_4 , z_5 – 22 each, s_1, s_2, s_3 – 25 each, s_4 – 38, s_5 – 35 long. r series with 2 pairs of setae, r_3 – 44 and r_2 – 20 long. Posteriorly setae J, Z and S series with 5 pairs of setae, measuring J_1 - 25, J_2 – 20, J_3 , J_4 – 25, J_5 – 10, S_1 - 20, S_2 – 38, S_3 – 30, S_4 – 28, S_5 – 30, Z_1 , Z_2 , Z_3 – 25 each, Z_4 – 32 and Z_5 – 63 long. R series with 2 pairs of setae, R_1 – 20 and R_3 – 38 long. All the setae on dorsal shield speculate. Sternal shield smooth, 94 long and 69 wide with 3 pairs of setae ST_1 – 20, ST_2 – 18, ST_3 – 20 long. Setae ST_4 – 20 long placed on metapodal plates. Genital shield 63 wide, with ST_5 -18 long. Ventrianal shield 112 long and 97 wide, triangular shaped with transverse striations on anterior margin. Four pairs of preanal setae present all are simple and minute. Five pairs of setae present on the area around the ventrianal shield. A clear skin fold separates genital and ventrianal shield. JV_5 70 long and smooth. Two pairs of metapodal plates present, primary one 25 and accessory one 18 long. Peritremal plate well developed and fused posteriorly. Peritreme extends anteriorly upto j_1. Spermatheca with bell shaped cervix. Fixed digit of chelicera with 13 teeth; movable digit with 4 teeth. Tectum minutely trispinate. Leg I, II and III devoid of macrosetae; leg IV with macrosetae on basitarsus 38 long and tarsus 32 long.

Leg chaetotaxy: genu I $1 \frac{3}{2} \frac{2}{3} 1$, tibia I $1 \frac{4}{2} \frac{3}{1} 1$;

genu II $2 \frac{2}{1} \frac{1}{1} 2$, tibia II $1 \frac{2}{2} \frac{3}{1} 1$.

Male: Unknown

Habitat: *Solanum melongena* L.

Material examined: Holotype ♀ marked on the slide INDIA: KERALA: Vengeri (Kozhikode district), 30.vii.2015. ex: *Solanum melongena* , coll. Rahul (No. L. 90/1). Two paratype slides with 3♀♀, collection details same as above (No. L 90/2, 90/3).

Remarks: This new species resembles *Lasioseius meridionalis* Chant, 1963 in general appearance, but differs in the following characters:

1. Dorsal shield is shorter in the new species but it is much longer in *L. meridionalis.*
2. Dorsal shield with 31 pairs of setae in the new species instead of 36 in *L. meridionalis.*
3. All setae in the new species is speculate but in *L. meridionalis* all the setae smooth except Z_5 which is serrated.
4. Only 3 pairs of marginal setae are present in the new species whereas in *L. meridionalis* 8 pairs of marginal setae present.
5. Size of the ventrianal shield being small in the new species when it is compared with *L. meridionalis.*
6. Peritreme extends anteriorly upto j_1 in the new species but it extends only upto z_1 in the *L. meridionalis.*
7. Movable digit of chelicerae with 4 teeth in the new species instead of 3 in *L. meridionalis.*
8. On the margin of dorsal shield 4 pairs of accessory plates are present in *L. meridionalis* but it is absent in the new species.

SUPERORDER: ACARIFORMES

ORDER I: TROMBIDIFORMES

Suborder: PROSTIGMATA

Superfamily: BDELLOIDEA Duges, 1834

1834. Bdelloidea Duges, *Annales des Sciences Naturelles, Zoologie*, **2**(1): 5-46.

2007. Bdelloidea Ueckermann *et al., Acarologia*, **XLVII** (3-4): 127-138.

2010. Bdelloidea Lin and Zhang, *Prog. in Chinese Acarol.*, **4**: 1-345.

2011. Bdelloidea Walter and Latonas. *The Royal Alberta Museum, Edmonton*, 64 - 65.

2011. Bdelloidea Zhang *et al., Zootaxa,* **3148:** 129-138.

2016. Bdelloidea Bagheri and Paktinat, *Proceeding of the 22nd Iranian Plant Protection Congress, Karaj, Iran*, p. 494.

2017. Bdelloidea Rostami *et al*., *Per. J. Acarol*., **6**(4): 245-258.

Diagnosis: They are soft bodied to hard bodied mites with sclerotized plates. Chelicerae scissors like over a snout or cone like gnathosoma. Rostrum and hypostome elongated, palpi modified for grasping, 2 pairs of sensillae are present on the propodosomal region, eyes present or absent. Empodium present on each claws; 2-3 pairs of discs present on the female genital aperture and it is with many pairs of acetabula. Tarsus and tibia with several sensory setae, trichoboth on tibia IV.

Key to the families of superfamily Bdelloidea

1. Female genital aperture with a pair or internal setae and spines. Genital aperture with 3 pairs of acetabula. Palpal claw absent, palpal segment terminating without spines or apophyses or raptorial structures. Tarsal empodium pad like. ……………………………………..............Bdellidae

- Female genital aperture without internal setae and spines. Genital aperture with 2-3 pairs of acetabula. Palpal segment terminating with a claw. Palpal solenidion when present non-setiform; with strong spines or apophyses. Tarsal empodium claw like …………………............Cunaxidae

6.4. Family I: BDELLIDAE Duges, 1834

1834: Bdellidae Duges, *Ann. Sci. Naturelles.* **1**(2) (*Zool.)*: 21.

1944. Bdellidae Baker and Balock, *Proc. Entomol. Soc. Wash*., **46**(7): 176-184.

1964. Bdellidae Atyeo, *Pacific insects monograph*, **7**: 166-169.

1976. Bdellidae Wallace and Mahon, *Acarologia*, **18**: 65-123.

1979. Bdellidae Kuznetsov and Livshits, *Proc.of the Nikita Botanical Gardens*. **79**: 51-105.

1987. Bdellidae Swift and Goff, *Internat. J. Acarol*., **13**(1): 29-49.

1995. Bdellidae Ostovan and Kamali, *J. Agri. Sci*., **1**(3 & 4): 29-43.

2003. Bdellidae Van der Schyff *et al*., *African Plant Protection*. **9**(1): 2-19.

2006. Bdellidae Lin *et al*., *Wuyi Sci. J*., **22**: 1-31,

2009. Bdellidae Bednarskaya, *Optimization and Protection of Ecosystems*, **20**: 20-24.

2013. Bdellidae Maslov and Khaustov, *Vestnik zoologii*, **47**(2): 52-56.

2016. Bdellidae Hernandes *et al., Zootaxa,* **4152**(1): 1-83.

Diagnosis*:* They are readily recognized by an elongated, snout-like gnathosoma, elbowed pedipalps bearing two long terminal setae. There are usually a number of simple eyes on the propodosoma and thorax. Ventral hypostome with 2,6 or 7 pairs of venterolateral setae and 2 pairs of setae on lateral lips. Palpi 5 segmented, tracheal opening near cheliceral bases. Idiosoma divided into propodosoma and hysterosoma. Four dorsal sensillae present on psuedostigmatic organ; 2, 4 or 5 eyes present. Legs 8 segmented including short pretarsus with 2 claws and a pad like, rayed pulvillus. Genital tracheae, when present, well developed, 3 pairs of genital suckers, anal cleft terminal.

Type Genus: ***Bdella*** Linnaeus, 1758.

Morphology and terminology

Body is divisible into two parts, gnathosoma and idiosoma. The major idiosomal divisions of bdellids are regularly referred to as the propodosoma and hysterosoma. Anterior gnathosoma bears two elongated and chelate chelicerae, a ventral hypostome and 2 geniculate palpi. The elongated, elbowed pedipalps have two long tactile setae apically. The prodorsal region may have one or two paired and an unpaired median eye. Propodosoma with two anterior pairs of legs, eyes and pseudostigamtic organs, whereas hysterosoma with 2 pairs of posterior legs, genitalia and anus with one or more pairs of anal setae. On the venter of hysterosoma there are two longitudinally striated genital plates, which bear regular or irregular genital setae. Area around the genital plate has bilaterally arranged pairs of paragenital setae. Legs are 8 segmented *viz.,* coxa, trochanter, basifemora, telofemora, genu, tibia, pretarsus and tarsus, with tactile sensory setae. In addition to this, long sensory seta in deep, heavily sclerotized sockets (Trichobothria) or hollow chemosensory setae (Solenidia) are present. Genu I – IV with decreasing number of attenuate sensory setae (Plate 63 A, B).

Setal nomenclature used in the descriptions follows Kethley (1990) except for propodosomal setae, which follows the nomenclature given by Fisher *et al*. 2011.

at - Anterior sensillum

pt - Posterior sensillum

lps	-	Lateral propodosomal setae
mps	-	Median propodosomal setae
c1	-	Internal humaral
c2	-	External humaral
d1	-	Internal dorsal
e1	-	External lumbral
f1	-	Internal sacral
f2	-	External sacral
h1	-	Internal clunal
h2	-	External clunal
ps	-	Postanal
Vh	-	Ventral hypostomal setae
VES	-	Ventral end setae
DES	-	Dorsal end setae
t		Tactile setae

Key to the subfamilies, genera and species of the family Bdellidae included in the present study.

1. Venter of hypostome with 6-7 pairs of strong setae and 2 pairs of small adoral setae, without well developed genital tracheae............................ …………………..Subfamily: Bdellinae*

* Palp tibiotarsus truncate, considerably shorter than palpal basifemur, chelicerae bearing 2 setae……...Genus: *Bdella*

_ Venter of hypostome with 2 pairs of strong setae and 2 pairs of small adoral setae with well developed genital tracheae …..Subfamily: Cytinae *

* Thickened chelicerae with massive chelae, and an unpaired eye between the anterior sensilla……………………………..………....Genus: *Cyta***

** Two pairs of eyes present lateral to pt with longitudinal striae between each pair..*Cyta bharathani* sp.nov.

SUBFAMILY I: BDELLINAE Grandjean, 1938

1938. Bdellinae Grandjean, *Ann. Soc. Ento. France,* **107**: 1-24.

1960. Bdellinae Atyeo, *University of Kansas Science Bulletin,* **40**: 345-499.

1972. Bdellinae Wallace and Mahon, *Acarologia*, **14**(4): 544-580.

1991. Bdellinae Gupta, *Rec. Zool. Surv. India,* **88**(2): 220.

2016. Bdellinae Hernandes *et al., Zootaxa,* **4152**(1): 1-83.

Diagnosis: Venter of hypostome with 6-7 pairs of strong setae, 2 pairs of small adoral setae; undeveloped genital tracheae. Trichoboth absent on tibia II; palpal tibiotarsus expanded distally.

Type Species: ***Acarus longicornis*** Linnaeus, 1758

Genus: *Bdella* Latreille, 1795

1795. *Bdella* Latreille, *J. Des Lettres et des Arts,* Paris, **4:** 18.

1896. *Bdella* Michael, *Transactions of the Linnean Society of London*, **2** (6): 477–528.

1963. *Bdella* Atyeo, *University of Nebraska*, **4**(8): 167-210.

1991. *Bdella* Gupta, *Rec. Zool. Surv. India,* **88**: 220.

2008. *Bdella* Hernandes *et al., Internat. J Acarol.,* **34**(3): 259-266.

2009. *Bdella* Mary Anitha *et al., Geobios*, **36**: 3-4.

2016. *Bdella* Hernandes *et al., Zootaxa,* **4152**(1): 1-83.

***Diagnosis**:* Palpal tibiotarsus shorter than palpal basifemur. Chelicera have 2 long hairs, the proximal one is far back, the distal one is attached to the middle of the chelicerae; movable digit sickle shaped. Idiosoma with 2 longitudinal, relatively distinct dorsal plates. Legs are not noticeably thick.

Type Species: ***Acarus longicornis*** Linnaeus, 1758

Key to the species of the genus *Bdella* included in the present study

1. The ratio between at: pt is more than 1, and the ratio of VES to DES is 1.25…………………………………………………....*hispidae* sp. nov

_ The ratio between at: pt is less than 1, while the ratio of VES to DES is 1.4…………………………………………………………..*distincta*

Bdella distincta Baker and Balock, 1944

PLATE 64

1944. *Bdella distincta* Baker and Balock, *Proc. Ent. Soc. Washington,* **46**(7): 179.

Redescription

Female: Length of the body excluding gnathosoma 645 long and 375 wide; hypostome length 184, width 64. Measurements of dorsal setae: at – 50, lps – 50, mps – 46, pt – 100, C1 – 50, C2 – 50, d1 – 45, e1 – 35, f1 – 30, f2 – 30, h1 – 35 and h2 – 40 long. Distance between anterior and posterior sensillum is 75 and 100 respectively. Dorsal propodosomal shield with finely broken longitudinal striae. Two pairs of eyes lateral to pt with transverse striae between each pair. Eye diameter: anterior – 10, posterior – 14 and distance between lens – 3. Hysterosomal striae smooth, and thick; striae are finely broken along dorsum. All dorsal setae distally branched except at, pt and lps. Gnathosoma with 6 pairs of hypostomal setae; vg1 – 23, vg2 – vg3 – 25 long. Chelicera 187 long with 2 dorsal strong setae, proximal one 41 long and distal one 61 long. Striae on chelicera longitudinal; movable and fixed chela similar in shape. Anal region with a pair of distally branched paranals posterior to laterally directed striae; postanals branched, flanking termination of cleft. Length of palp 205; palpal chaetotaxy as follows: trochanter - none; basifemur 4t; telofemur 1t; genu 4t; tibiotarsus 3t, 1s distal and two long end setae *viz*., ventral end setae (VES) - 138 long and dorsal end setae (DES) - 100 long. Ventral side of the idiosoma with smooth striations. Two genital halves each with 8 small, equal setae aligned in roughly longitudinal arrangement. Paragenital setae 9 pairs. One median paired setae between coxae III. Length of Leg I - 351, Leg II – 364, Leg III – 438 and Leg IV – 451.

Leg chaetotaxy: Coxae I – IV: 4-4-5-3; trochanter I – IV: 0-0-0-0; basifemur I – IV: 1-1-1-1; telofemur I – IV: 12-12-7-10; genu I: 1 solinidion plus 4 tactile and 2 sensory setae; genu II – No solinidion, 3 tactile and 3 sensory setae; genu III : No solinidion, 4 tactile and 2 sensory setae; genu - IV: 1 solinidion plus 1 tactile and 4 sensory setae; tibia I - II: 1 smooth trichobothrium plus 4 tactile and 3 sensory setae; tibia III: 3 tactile and 6 sensory setae; tibia IV: 1 smooth trichobothrium plus 2 tactile and 5 sensory setae; tarsus I: 1 solinidion plus 2 tactile and 18 sensory setae; tarsus II: No solinidion, 3 tactile and 13 sensory setae; tarsus III: 2 smooth trichobothria plus 2 tactile and 14 sensory setae; tarsus IV – 2 smooth trichobothria plus 14 sensory setae.

Male: Not studied.

Habitat: *Capsicum annuum* L.

Known habitat: *Bambusa paravariabilis*, pine cones.

Material examined: Female marked on the slide, INDIA: KERALA: Pazhoor (Kozhikode district), 25.ix.2015, ex. *Capsicum annuum*, coll. Rahul (No. B. 105/1). Six ♀♀ collection details same as above (No. B. 105/2, 105/3, 105/4, 105/5, 105/6, 105/7).

Distribution: OUTSIDE INDIA: United States, Puerto Rico, Philippines, Indonesia, Japan, China, Thailand, Taiwan, Hawaii, Guadaloupe, Brazil.

Remarks: This species examined agrees with *Bdella distincta* Baker and Balock, 1944 in almost all characters, hence fixed so. In the present survey *B. distincta* was recovered from a new host plant *viz., Capsicum annuum.* This is a new record from India.

Bdella hispidae sp. nov.

PLATE 65

Female: Length of the body excluding gnathosoma 400 long and 240 wide; hypostome length 170, width 80. Measurements of dorsal setae: at – 60, lps – 20, mps – 30, pt – 50, C1 – C2 – 30 each, d1 – 30, e1, f1 and f2 – 20 each, h1 – 22 and h2 – 30 long. Distance between anterior and posterior sensillum is equal in length. Propodosomal striae are longitudinal. Two pairs of eyes lateral to pt with longitudinal striae between each pair. Eye diameter: anterior – 10, posterior – 15 and distance between lens – 4. Hysterosomal striae longitudinal along dorsum but medially with slight curves. All dorsal setae plumose except at, pt and lps. Gnathosoma with 6 pairs of hypostomal setae; vg1 – vg5 almost equal in length 25 long, vg6 – 17 long. Chelicerae 133 long with 2 dorsal strong setae, proximal one 25 long and distal one 51 long; movable and fixed chelae similar in shape. Length of palp 135 long, palp chaetotaxy as follows: trochanter - none; basifemur 4t; telofemur 2t; genu 4t; tibiotarsus 3t, 1s distal and two long end setae *viz*., ventral end setae (VES) - 100 long and dorsal end setae (DES) - 80 long. Ventral side of the idiosoma with smooth striations. Two genital halves each with 4 setae aligned in roughly longitudinal manner. Paragenital setae 2 pairs. One median paired setae between coxae III. Length of Leg I - 256, Leg II – 241, Leg III – 302 and Leg IV – 315 long.

Leg chaetotaxy: Coxae I – IV: 4-2-4-2; trochanter I – IV: 1-1-2-1; basifemur I – IV: 2-2-2-1; telofemur I – IV: 5-4-3-3; genu I – III: 3 tactile and 2 sensory setae; genu - IV: 3 tactile setae; tibia I: 1 smooth trichobothrium plus 4 tactile and 4 sensory setae; tibia II: 4 tactile and 2 sensory setae; tibia III: 4 tactile and 1 sensory setae; tibia IV: 4 tactile setae; tarsus I: 3 tactile and 11 sensory setae; tarsus II: 4 tactile and 6 sensory setae; tarsus III: 2 smooth trichobothria plus 3 tactile and 9 sensory setae; tarsus IV – 2 smooth trichobothria plus 2 tactile and 14 sensory setae.

Male: Unknown.

Habitat: *Benincasa hispida* (Thunb.) Cogn.

Material examined: Holotype ♀ marked on the slide, INDIA: KERALA: Kadalundi (Kozhikode district), 2.xi.2015, ex. *Benincasa hispida*, coll. Rahul (No. B. 164/1). Three pratype slides with 4 ♀♀ collection details same as above (No. B. 164/2, 164/3, 164/4).

Remarks: This new species resembles *Bdella muscorum* Ewing, 1909 but differs in the following characters:

1. Size of the body excluding gnathosoma greatly varies in both species, it is only 400 long in the new species but it is 600 long in *B. muscorum.*
2. Length of the palp is 135 long in the new species but it is 176 long in *B. muscorum.*
3. Size of the chelicerae small compared with *B. muscorum.*
4. The proximal setae on chelicerae reach at the level of insertion of the dorsal setae in *B. muscorum* but in the new species, it is not like that.
5. Each genital plate with 4 genital setae in the new species instead of 8 in *B. muscorum.*
6. Only 4 pairs of paragenital setae present in the new species but there are 9-10 pairs in *B. muscorum.*
7. One median paired setae between coxae III in the new species but it is absent in *B. muscorum.*
8. Leg chaetotaxy in both the species varies greatly.

SUBFAMILY II: CYTINAE Grandjean, 1938.

1938. Cytinae Grandjean, *Ann. Soc. Ent. France,* **107**: 1-24.

1959. Cytinae Meyer and Ryke, *Ann. Alag. Nat. His.,* **13**(2): 375.

1960. Cytinae Atyeo. *Univ. Kansas Sci. Bull.,* **40**: 416.

1963. Cytinae Atyeo. Bull. *Univ. Nebraska SI. Allls*., **4**(8): 121.

1972. Cytinae Wallace and Mahon, *Acarologia*, **14**(4): 544-580.

1987. Cytinae Michocka, *Monografie Fauna Polski,* **14**: 72.

2002. Cytinae Gupta, *Mem. Zool. Surv. India,* **19**(2): 1-183.

***Diagnosis*:** Striated integument and unpaired median eye between the anterior sensillae; presence of 2 pairs of ventral hysterosomal setae; 3 pairs of trichoboths; well developed genital treacheae; truncate palpal tibiotarsus; subequal end setae longer than palpal femur; Chelicerae normal or thickened; movable chela crescent-shaped, each bears 2 setae, one of which is inserted at the base of the fixed digit; a single seta present immediately anterior to the genital opening. Trichobothrium absent on tarsus IV.

Type Species: *Scirus latirostiris* Hermann, 1804.

Genus: *Cyta* von Heyden, 1826

1826. *Cyta* von Heyden. *Isis*, **19**(6): 608.

1959. *Cyta* Meyer and Rykc. *linn. Alag. Nat. Nist*., **13**(2): 377.

1960. *Cyta* Atyeo, *Univ. Kansas Sci. Bull*., **40**: 416.

1987. *Cyta* Swift and Goff, *Internat. J. Acarol*., **13**(1): 36.

2002. *Cyta* Gupta, *Mem. Zool. Surv. India,* **19**(2): 1-183.

2012. *Cyta* Vrabec *et al., Folia faunistica Slovaca*, **17** (4): 329-336.

2014. *Cyta* Eghbalian, *Zootaxa*, **3847**(4): 567-575.

2016. *Cyta* Hernandes *et al*., *Zootaxa*, **4152**(1):1-83.

2017. *Cyta* Rostami *et al., Persian J. Acarol*., **6**(4): 245-258.

Diagnosis: The genus *Cyta* von Heyden is characterized by having relatively stout and short chelicerae which is thickened with massive chela; two ventral setae on hypostome. All but one species bear an unpaired median eye on anterior region of prodorsum, except being *Cyta magdalenae* den Heyer 1981, which has no eyes at all. Trichobothria, when present, may be 1, 3 or none.

Type Species: *Scirus latirostris* Hermann, 1804.

***Cyta bharathani* sp. nov.**

PLATE 66

Female: Length of the body excluding gnathosoma 450 long and 290 wide; hypostome length 107, width 60. Measurements of dorsal setae: at – 69, mps – 53, pt – 69, C1 – 64, C2 – 61, d1 – 50, e1- 46, f1- 35, f2 – 23, h1 – 33 and h2 - 25 long. Propodosomal striae are transverse but laterally longitudinal. Two pairs of eyes lateral to pt with longitudinal striae between each pair. Eye diameter: anterior – 10, posterior – 6 long and distance between lens – 17. Hysterosomal striae continuous along the dorsum. All dorsal setae smooth. Gnathosoma with 4 pairs of hypostomal setae; vg1- 15, vg2 – 30, vg3 - 15 and vg5 – 30 long. Chelicerae 118 long with 2 dorsal strong setae, proximal one 44 and distal one 52 long. Length of palp 164 long, palp chaetotaxy as follows: trochanter - none; basifemur 4t; telofemur 1t; genu 3t; tibiotarsus 4t, 1s distal and two long end setae *viz*., ventral end setae (VES) - 75 long and dorsal end setae (DES) - 60 long. Ventral side of the idiosoma with smooth striations. Two genital halves each with 2 setae aligned in roughly longitudinal arrangement. Paragenital setae 2 pairs. One median paired setae between coxae IV. Length of Leg I - 330, Leg II – 369, Leg III – 358 and Leg IV – 384 long.

Leg chaetotaxy: Coxae I – IV: 3-2-1-3; trochanter I – IV: 1-1-0-2; basifemur I – IV: 2-3-0-2; telofemur I – IV: 5-3-2-1; genu I – 3 tactile and 3 sensory setae; genu II: 3 tactile and 1 sensory setae; genu III: 1 tactile seta; genu IV: 1 trichobothrium plus 1 tactile setae; tibia I: 4 tactile and 3 sensory setae; tibia II: 3 tactile and 2 sensory setae; tibia III: 1 trichobothrium plus 1 tactile seta; tibia IV: none; tarsus I: 5 tactile and 14 sensory setae; tarsus II: 2 tactile and 15 sensory setae; tarsus III: 1 smooth trichobothria plus 6 tactile and 9 sensory setae; tarsus IV – 1 smooth trichobothria plus 3 tactile and 10 sensory setae.

Male: Unknown.

Habitat: *Amorphophallus paeoniifolius* (Dennst.) Nicolson.

Material examined: Holotype ♀ marked on the slide, INDIA: KERALA: Koottalida (Kozhikode district), 7.xi.2015, ex. *Amorphophallus paeoniifolius*, coll. Rahul (No. B. 258/1). Three paratype slides with 3 ♀♀ collection details same as above (No. B. 258/2, 258/3, 258/4).

Remarks: This new species resembles *Cyta troglodyte* Hernandes *et al.,* 2011 but can be differentiate from it by the possession of following characters:

1. Size of the body seems to be short in the new species when compared with *C. troglodyte.*
2. Palpal chaetotaxy of both species is different.
3. No separation between prodorsal and hysterosomal regions in the new species but they are separated by sejugal furrow in *C. troglodyte.*
4. Genital valve of the new species is with 2 setae instead of 3 in *C. troglodyte.*
5. Leg chaetotaxy greatly varies in both species.

6. Chelicera of the new species with both proximal and distal setae whereas in *C. troglodyte* only proximal setae is present.

7. Length of all the legs is shorter in the new species when compared with *C. troglodyte.*

6.5. Family II: CUNAXIDAE Thor, 1902

1902. Cunaxidae Thor, *Verh. Zool. Bot. Ges. Wien.,* 159-164.

1906. Cunaxidae Oudemans, *Tijdschrift voor Entomologie,* 237-270.

1960. Cunaxidae Muma, *Ann. Entomol. Soc. America,* **53**: 321-326.

1975. Cunaxidae Smiley, *Ann. Entomol. Soc. America*, **68**(2): 227-244.

1977. Cunaxidae Chaudhri, *Pakistan J. Agri. Sci*., **14**: 41-52.

1985. Cunaxidae Gupta, *Handbk. Plant Mites of India,* p. 313.

1991. Cunaxidae Gupta, *Rec. Zool. Surv. India*, **88**(1-4): 207-239.

1995. Cunaxidae Sathiamma, *Entomon*, **18**: 377-382.

1997. Cunaxidae Hu, *J. Ninbo Teachers College,* **15**(1): 56-59.

2005. Cunaxidae Sergeyenko, *Acarina,* **13**(2): 159-163.

2009. Cunaxidae Kaluz, *Zootaxa*, **2198**: 27-40.

2011. Cunaxidae Den Heyer, *Zoosymposia,* **6**: 1304.

2014. Cunaxidae Skvarla *et al*., *ZooKeys,* **418**: 1-103.

Diagnosis: Body is small and diamond shaped with 2 pairs of setae (lps and mps) and 2 pairs of setose sensilla (*at* and *pt*). They are characterised by the presence of spined, raptorial palpi; pedipalps 3-5 segmented with a strong claw; apophyses present; subcapitulum wedge shaped with 6 pairs of setae; chelicerae with or without seta. Dorsal hysterosoma with 8 pairs of seta. Genital aperture with 2-3 pairs of acetabula. Coxae I and II fused and coalesce medially to form a sternal shield; coxae III and IV extend caudally beyond the genital plates; Coxae usually with 0-4 pairs of setae; Genital plates bears 3 or 4 setae; tarsal empodium claw like.

Type Genus: *Cunaxa* Von Heyden, 1826

Morphology and Terminology

Body is divisible into gnathosoma and idiosoma.

Gnathosoma: Pedipalps 4 or 5 segmented, ends in a strong claw. Femora is divided into basi and telofemora. Apophysis present on the tibiotarsi. Subcapitulum wedge shaped with six pairs of setae *viz.,* $hg_{1–4}$ and 2 pairs of adoral setae, of these hg_4 often longest pair of subcapitular setae. Chelicerae with or without seta near the cheliceral digit.

Idiosoma: Dorsally idiosoma is diamond shaped. Dorsal idiosomal shields and plates smooth; dots or papillae forming lines, reticulations forming polygonal cells, or cells which form rows. Dorsal proterosoma covered with a sclerotized shield that bears 2 pairs of setae (*lps* and *mps*) and 2 pairs of setose sensilla (*at* and *pt*). Dorsal hysterosoma complemented with large shields or plates and platelets, with one or more pairs of setae. Dorsal hysterosomal setae with 8 pairs of setae (c_1–h_1, c_2, f_2, and h_2).

Ventral idiosoma with 1 or a few small platelets. Additional plates were formed by the fusion of coxae with the body. Coxae I–II fused and may coalesce medially to form a sternal shield. Coxae III–IV fused and may extend caudally beyond the genital plates. Each coxa complemented with 0–4 setae. Genital plates (anal valves) bear 3 or 4 pairs setae. Anal plates (anal valves) bear 1–2 setae (ps_{1-2}).

Legs 7 segmented; coxa, trochanter, basifemur, telofemur, genu, tibia and tarsus. Trichobothrium present on leg tibia IV. Ambulacral claws present on either side of a 4-rayed empodium.

Length of the body is measured from the anterior edge of the propodosomal shield to the posterior edge of the idiosoma. Leg length is measured from the proximal edge of the trochanter to the distal end of the claw (Skvarla *et al*., 2011). The setal nomenclature of Den Heyer and Castro (2008) is followed for the idiosoma except for the propodosomal setae, which follows the notation of Fisher *et al*. (2011). Leg chaetotaxy follows that of Den Heyer (1981).

The abbreviations of setal names are as follows:

$P_1 – P_2$	:	Propodosomal setae
D_1 - D_5	:	Dorsal setae
L_1	:	Lateral setae
ad	:	Adoral setae
at	:	anterior trichobothria
pt	:	posterior trichobothria
lps	:	lateral proterosomal setae
mps	:	median proterosomal setae
c1	:	internal humerals
c2	:	external humerals
d1	:	internal dorsals
e1	:	internal lumbals
f1	:	internal sacrals
f2	:	external sacrals
h1	:	internal clunals
h2	:	external clunals
hg	:	hypognathal setae
T	:	Trichobothria

Key to the subfamilies, genera and species of family Cunaxidae included in the present study.

1. Pedipalp 5 segmented and extend beyond the subcapitulum by atleast the distal half of the tibiae. Apophyses may be present on the telofemora and between the genua and tibiotarsi………..............Subfamily: Cunaxiinae

_ Pedipalp composed of 3 segments, a bladder or bulb like apophysis may be present on tibiotarsi……………… ....Subfamily: Cunaxoidinae*

* Setae L_4 absent, venter with or without coxae I-II forming a pentagonal shaped sternal plate………………....….Genus: *Neocunaxoides*** Smiley

** Setae D_4 not located on the platelet or sclerotized area; palpal tibiotarsus with 2 knob like apophysis……………………..………Species: *andrei*

SUBFAMILY: CUNAXIINAE Oudemans, 1902

1902. Cuanxiinae Oudemans, *Tijdschrift voor Entomologie,* **45**: 58-60.

1992. Cunaxiinae Smiley, The Predatory mite family Cunaxidae (Acari) of the World with a new classification, *Indira Publishing House, USA*. p.134.

2011. Cunaxiinae Den Heyer *et al., J. Nat. Hist.*, **45**(27-28): 1667-1678.

2014. Cunaxiinae Skvarla *et al., Zookeys,* **418**: 1-103.

Diagnosis : Palp 5 segmented. Inner median surface of palp tarsus with simple or rod like or spine like setae. Palp genu with setose, subtriangular apophysis, tibiotarsus terminates in a small claw. Chelicera. broad basally, narrow distally. Propodosoma dorsally with or without shield, may be reticulated, striated or smooth. Hysterosoma with or without shield, also may be reticulated, striated or smooth. Tarsus I-IV tapering distally, may be stubby also tibia IV with a trichobothrium.

Type Genus: ***Cunaxa*** Von Heyden, 1826

Key to the genera and species of the subfamily Cunaxiinae included in the present study

1. Palpal genu apically without elongate apophysis; tarsi I-IV long, slender and attenuate without conspicuous lateral, bilobed flanges terminally…………………………..................................Genus: *Cunaxa*

_ The palpal genu apically with or without an elongate apophysis; tarsi I-IV, stout, short terminating conspicuous bilobed flanges………................ ....Genus: *Dactyloscirus**

* Internal margin of telofemur having inwardly curved apophysis which is blunt…………………………………......... *Dactyloscirus esculentae* sp nov.

Genus: *Cunaxa* Von Heyden, 1826.

1826. *Cunaxa* von Heyden, *Isis of Oken*, **18**(6): 609.

1941. *Cunaxa* Thor and Willmann, *Das. Tierreich*, **71**: 165.

1960. *Cunaxa* Muma, *Ann. Ent. Soc. Amer*., **53**(3): 322.

1975. *Cunaxa* Smiley, *Ann. Ent. Soc. Amer*., **68**(2): 238.

1978. *Cunaxa* Den Heyer, *Phytophylactica*, **11**(1): 218.

1979. *Cunaxa* Chaudhri *et al*., *Univ. Agri. Faisalabad*, p. 182.

1980. *Cunaxa* Gupta and Ghosh, *Rec. zool. Surv. India*, **77**: 194.

1998. *Cunaxa* Khaustov and Kuznetzov, *Zool. Zh*., **77**(11): 1332-1341.

2014. *Cunaxa* Skvarla *et al., Zookeys,* **418**: 1-103.

2015. *Cunaxa* Barbar, *Acarologia*, **55**(4): 459-465.

2017. *Cunaxa* Mitra *et al., J. Entomol. Zool. Studies,* **5**(6): 1804-1811.

Diagnosis: Pedipalps 5 segmented; an apophysis on the telofemora present or absent. Stout spine-like setae on the genua and tibiotarsi present or absent. Tibiotarsi end in a strong claw. Subcapitulum with 6 pairs of setae: 2 pairs of adoral setae and 4 pairs of subcapitular setae. Dorsal shields may be smooth or patterned with random dots, but never reticulated. Lateral platelets absent. Coxae II–IV setal formula 1-3-2. Genital plates each bear 4 setae; Anal plates bear 1 pair of setae. Tarsi long and slender. Tarsi constricted distally but the tarsal lobes are small and not conspicuous. A trichobothrium on tibia IV present.

Type Species: ***Scirus setirostris*** Hermann, 1804

Key to the species of *Cunaxa* included in the present study

1. Propodosomal reticulated and hysterosomal shields smooth, palpal telofemur inner surface without flange or apophysis…….*pushpae* sp. nov.

_ Propodosomal shield reticulate, smooth or striated, hysterosoma striated, palpal telofemur without flange or apophysis…………………..............2

2. Setae D_3 not extending past boundary of hysterosomal shield…......... ……………………………………………..............……......*womersleyi*

_ Setae D_3 length not extending past base of setae D_4…...................... *soansi*

Cunaxa pushpae **sp. nov.**

PLATE 69

Female: Length of the body including gnathosoma 562 long and 300 wide. Dorsal shield 379 long, 210 wide. Gnathosoma 112 long, 69 wide. Hypostome subrectangular, cone shaped distally with 4 pairs of hypognathal setae and 2 pairs of adoral setae. Propodosoma with a reticulated subrectangular shield originating behind the base of gnathosoma, extending to anterior region of hysterosoma. Propodosomal shield with anterior sensillae 210 long, posterior sensillae 276 long. Hysterosoma with subrectangular smooth median shield and setae D_1, D_2 and D_3. Hysterosoma separated from propodosoma by smooth striae. Thick transverse striations are present along the lateral margins of the dorsal shield. All dorsal setae extremely short (less than 16 microns). Chelicerae 88 long, terminates with 2 digits, one dorsolateral simple seta present. Length of palp 170 long, palpi 5 segmented, trochanter - none; basifemur with one dorsomedial seta; telofemur inner surface without apophysis, medially with one dorsal simple seta; genu inner surface with spine like seta, dorsolaterally with simple seta and outer surface ventrally with simple seta; tibiotarsus inner surface with one large simple seta, medially with seta, outer surface with two dorsolateral simple setae, terminating with one simple seta and small claw. Ventral side of the idiosoma smooth without dot like lobes, coxae I -IV contiguous. Hysterosoma with 5 pairs of simple setae between coxae II on the distal part of the body in addition to setae of genital and anal region. Genitoanal region in the form of a long slit with 4 pairs of setae in a row. Length of leg: Leg I and Leg II – 330 each, Leg III – 320 and Leg IV – 390 long.

Leg chaetotaxy: Coxae I – IV: 3-1-2-1; trochanter I – IV: 1-1-1-3; basifemur I – IV: 4-3-2-2; telofemur I – IV: 4-4-4-4; genu I: 2 attenuate solinidia plus 5; genu II - III : 1 attenuate solinidion plus 5; genu - IV: 2 attenuate solinidia plus 5; tibia I - III: 1 attenuate solinidion plus 5; tibia IV: 1 smooth trichobothrium plus 4; tarsus I: 2 attenuate solinidia plus 8; tarsus II: 1 attenuate solinidion plus 9; tarsus III: 11; tarsus IV – 10. Each tarsus terminates in two claws with a forked empodium.

Male: Unknown.

Habitat: *Coccinia grandis* (L.) Voigt

Material examined: Holotype ♀ marked on the slide, INDIA: KERALA: Ashokapuram (Kozhikode district), 9.xi.2015, ex. *Coccinia grandis*, coll.

Rahul (No. C. 206/1). Three paratype ♀♀, collection details same as above (No. C. 206/2, 206/3, 206/4).

Remarks: This new species resembles *Cunaxa myabunderensis* Gupta and Ghosh, 1980 but differs from in the following features:

1. Length of the body large (562 long) in the new species when it is compared with *C. myabunderensis* (420 long).
2. Propodosoma and hysterosoma with reticulated shields in the new species but in *C. myabunderensis* the body is smooth without any shields.
3. Inner surface of palpal telofemur without apophysis in the new species but spur like apophysis is present in the *C. myabunderensis*.
4. Chelicerae of the new species bears both fixed and movable digits but in *C. myabunderensis*, fixed digit is absent.
5. Leg chaetotaxy varying among these two species.

Cunaxa soansi Rahul _et al._, 2017

PLATE 70

2017. *Cunaxa soansi* Rahul *et al.*, *Biological Forum – An Internat. J.*, **9**(1): 07-09.

Female: Length of the body including gnathosoma 538 long and 300 wide. Gnathosoma 138 long, 88 wide. Hypostome is subrectangular, cone shaped distally with 4 pairs of hypognathal setae and 2 pairs of adoral setae. Dorsal shield 269 long, 225 wide. Propodosoma with transversely striated subrectangular shield originating behind the base of gnathosoma, extending to anterior region of hysterosoma. Propodosomal shield with anterior sensillae 202 long and posterior sensillae 230 long and setae P_1 and P_2. Hysterosoma with subrectangular longitudinally striated median shield and setae D_2 and D_3. Hysterosoma separated from propodosoma by smooth striae. Thick longitudinal striations are present along the lateral margins of the dorsal shield. Measurements of setae: Propodosomal setae P_1 and P_2 equal in length, 30 long, D_1 – 18, D_2 – 25, D_3, D_4 – 30 each, D_5 – 35 and L_1 – 18 long. Chelicerae 120 long, terminating in single digit, dorsal and ventral sides with lobes; with one dorsolateral simple seta. Length of palp 195 long, palpi 5 segmented, trochanter - none; basifemur – none, telofemur inner surface with one elongate apophysis, outer surface with 2 dorsolateral simple setae; genu inner surface with spine like seta, outer surface dorsally and ventrally with simple seta; tibiotarsus inner surface with one large simple seta, medially with one stout spine like seta, adjacently with one simple seta, outer surface with one dorsolateral simple seta, terminating with one simple seta and small claw. Ventral side of the idiosoma with smooth stariations, coxae I - II and coxae III – IV contiguous. Hysterosoma with 5 pairs of simple setae between coxae II and distal part of the body in addition to setae of genital and anal region. Genital shield with two halve with 4 simple genital setae in a row. Length of Leg I – 360, Leg II – 375, Leg III – 395 and Leg IV – 450 long.

Leg chaetotaxy: Coxae I – IV: 2-1-2-4; trochanter I – IV: 1-1-2-2; basifemur I – IV: 4-4-3-2; telofemur I – IV: 4-4-4-4; genu I - 2 attenuate solinidia plus 6; genu II – 2 attenuate solinidia plus 5, genu III - 1 attenuate solinidion plus 4, genu IV: 1 attenuate solinidion plus 5; tibia I – 1 attenuate solinidion plus 4, tibia II - 1 attenuate solinidion plus 5; tibia III: 1 attenuate solinidion plus 4; tibia IV: 1 smooth trichobothrium plus 4, tarsus I - 1 attenuate solinidion plus 6; tarsus II: 2 attenuate solinidia plus 14, tarsus III - 1 attenuate solinidion plus 15, tarsus IV – 11.

Male: Unknown.

Habitat: *Manihot esculenta* Crantz.

Material examined: Holotype ♀ marked on the slide, INDIA: KERALA: Kunduparamba (Kozhikode district), 15.vi.2015, ex. *Manihot esculenta*, coll. Rahul (No. C 292/1). Three paratype ♀♀, collection details same as holotype (No. C 292/2, 292/3, 292/4). ZSIK Regd. No. ZSI/WGRC/IR/INV 12235 (Holotype), 12236-12237 (Paratypes).

Remarks: This new species is closely resembles to *Cunaxa terrula* Den Heyer, 1979 but can be clearly separated from it by the following characters:

1. Size of the body being small in the new species (400 long) when compared with *C. terrula* (495 long).

2. Hysterosomal shield complimented with setae D_1 and D_2 in the new species but in *C. terrula* it is with setae D_1, D_2 and D_3.

3. Propodosomal setae P_1 and P_2 equal in length in the new species whereas P_1 about one half as long as P_2 in *C. terrula*.

4. In the new species the length of setae D_1, D_2 and D_3 greatly varies but in *C. terrula* they are about equal in length.

5. Setae D_4 and D_5 being simple in the new species instead of setose in *C. terrula*.

6. Length of the palp is smaller in the new species (195 long) when it is compared with *C. terrula* (230 long).

7. Palp basifemur without any seta in the new species but in *C. terrula* it is with one dorsomedial simple setae.

8. Inner surface of tibiotarsus having a nobe like apophysis in the new species but it is absent in *C. terrula*.

9. Chelicerae with single digit in the new species instead of 2 in *C. terrula.*

10. Hysterosomal shield is subrectangular in shape in the new species but it is squarish in *C. terrula.*

11. Both species differ in setal counts on leg.

Cunaxa womersleyi Baker and Hoffmann, 1948

PLATE 71

1948. *Cunaxa womersleyi* Baker and Hoffmann, *An. Esc. Nac. Cienc. BioI. Mexico*. **6**: 234-235.

Redescription

Female: Length of the body including gnathosoma 420 long and 204 wide. Dorsal shield 187 long, 141 wide without any striations. Gnathosoma 120 long, 69 wide. Hypostome subrectangular, cone shaped distally with 4 pairs of hypognathal setae and 2 pairs of adoral setae. Propodosoma with a smooth subrectangular shield originating behind the base of gnathosoma, extending to anterior region of hysterosoma. Propodosomal shield with anterior sensillae 70 long and posterior sensillae 185 long and setae P_1 and P_2. Hysterosoma with subrectangular smooth median shield and setae L_1, D_1, D_2 and D_3. Hysterosoma separated from propodosoma by smooth striae. Thick longitudinal striations are present along the lateral margins of the dorsal shield. Measurements of setae: Propodosomal setae P_1 - 31 and P_2 – 8 long, D_1 – 44, D_2 – D_3 equal in length 19 long, D_4 – 40, D_5 – 42 and L_1 – 22 long. Chelicerae 104 long, terminating with 2 digits and one dorsolateral simple seta. Length of palp 165 long, palpi 5 segmented, trochanter - none; basifemur with one dorsomedial simple seta, telofemur inner surface with one elongate finger like apophysis and dorsomedial simple seta, genu inner surface apically with spine like seta and dorsolateral slender simple seta, tibiotarsus inner surface with one large simple seta, medially with one stout spine like seta and without spur like process, adjacently with medial simple seta, outer surface with one dorsolateral simple seta, terminating with one simple seta and small claw. Ventral side of the idiosoma smooth without dot like lobes, coxae I - II and coxae III – IV contiguous. Hysterosoma with 5 pairs of simple setae between coxae II and distal part of the body in addition to setae of genital and anal region. Genital shield with two halve with 4 simple genital setae in a row. Length of Leg I – 106, Leg II – 110, Leg III – 118 and Leg IV – 125 long.

Leg chaetotaxy: Coxae I – IV: 2-2-2-1; trochanter I – IV: 1-1-2-2; basifemur I – IV: 2-3-4-1; telofemur I – IV: 4-4-4-4; genu I: 2 attenuate solinidia plus 5; genu II: 1 attenuate solinidion plus 5, genu III - IV: 1 attenuate solinidion plus 5, tibia I: 2 attenuate solinidia plus 5, tibia II: 5; tibia III: 1 attenuate solinidion plus 5; tibia IV: 1 smooth trichobothrium plus 5; tarsus I: 1 attenuate solinidion plus 13; tarsus II: 1 attenuate solinidion plus 13; tarsus III: 13; tarsus IV – 7. Each tarsus terminates in two claws and forked empodium.

Male: Unknown.

Habitat: *Benincasa hispida* (Thunb.) Cogn, *Trichosanthes cucumerina* L.

Known habitat: *Sciurus niger,* papaya.

Material examined: Female marked on the slide, INDIA: KERALA: Mongam (Malappuram district), 16.viii.2015, ex. *Benincasa hispida*, coll. Rahul (No. C. 295/1). Five ♀♀ collection details same as above (No. C. 295/2, 295/3, 295/4, 295/5, 295/6). Two ♀♀ from Ramanattukara (Kozhikode district), 5.v.2015, ex. *Benincasa hispida,* coll. Rahul (No. C 295/7, 295/8). Three ♀♀ from Manarkkad (Palakkad district), 10. x.2015, ex. *Trichosanthes cucumerina,* coll. Rahul (No. C 295/9, 295/10, 295/11).

Distribution: INDIA: West Bengal. OUTSIDE INDIA: U S A, Florida.

Remarks: This species examined closely resembles with *Cunaxa womersleyi* Baker and Hoffmann, 1948, hence fixed so. In the present survey *C. womersleyi* was recovered from a new host plant *viz., Benincasa hispida.* This is a new record from Kerala.

Genus: *Dactyloscirus* Berlese, 1916

1916. *Scirus* (*Dactyloscirus*) Berlese, *Redia*, **12** (1): 131.

1941. *Scirus* (*Dactyloscirus*) Thor and Willmann, *Das. Tierreich*, **71**(1): 173.

1952. *Scirus* (*Dactyloscirus*) Baker and Hoffmann, *An. Esc. Nac. Cienc. Biol. Mexico*, **5**(3-4): 230-241.

1975. *Dactyloscirus* Smiley, *Ann. Ent. Soc. Amer*., **68**(2): 230.

1977. *Dactyloscirus* Chaudhri, *Pak. J. Agric. Sci*., **14**: 47.

1980. *Dactyloscirus* Chaudhri, *Univ. Agr. Faisalabad*, p.43.

1982. *Dactyloscirus* Michocka, *Acarologia*, **23**: 328.

1984. *Dactyloscirus* Sepasgosarian, *Zeit. Anz. Zool*., **71**: 139.

1992. *Dactyloscirus* Smiley, *Cunaxa (Acari) of the World, Indira Publication House,* p. 214-245.

1996. *Dactyloscirus* Swift, *Analesdel Instituto Biologia, Universidad Nacional Autonoma de Mexico, Serie Zoologia.,* **67**(2): 225-237.

2006. *Dactyloscirus* Bashir and Afzal, *Pak. J. Zool*., **38**(4): 273-278.

2014. *Dactyloscirus* Skvarla *et al., Zookeys,* **418**: 1-103.

Diagnosis: Pedipalps 5 segmented; an apophysis between the genua and tibiotarsi usually present. This apophysis long or short and generally ends in a bulbous, hyaline tip; basifemora and telofemora complemented with spine like setae; Subcapitulum complemented with 6 pairs of setae. Idiosoma has at least one sclerotized plate that bears 2 pairs of setose sensillae (*at* and *pt*) and 2 pairs of simple setae (*lps* and *mps*). 0–4 other major plates and platelets present. Setal formula for coxae I–IV 3-3-3-3 (including paracoxal seta).

Genital plates each bear 4 setae; anal plates bear 1 pair of setae. Integument between plates striated and bears 5–7 pairs of additional setae. A sclerotized aedeagus often visible in association with the genital plates. Tarsi constricted apically, resulting in large tarsal lobes. Trichobothrium on leg tibia IV present.

Type Species: ***Scirus (Dactyloscirus) eupaloides*** Berlese, 1916

Dactyloscirus esculentae **sp. nov.**

PLATE 72

Female: Length of the body including gnathosoma 925 long and 400 wide. Dorsal shield 500 long, 400 wide. Gnathosoma 120 long, 69 wide. Hypostome subrectangular, cone shaped distally with 4 pairs of hypognathal setae and 2 pairs of adoral setae. Propodosoma with reticulated without a distinct shield originating behind the base of gnathosoma, extending to anterior region of hysterosoma. Propodosomal shield with anterior sensillae 400 long and posterior sensillae 650 long and setae P_1 and P_2. Hysterosoma without subrectangular smooth median. Hysterosoma separated from propodosoma by smooth striae. Thick longitudinal striations are present along the lateral margins of the dorsal shield. Measurements of setae: Propodosomal setae P_1 and P_2 equal in length, 20 long., D_1 – 22, D_2 – D_4 equal in length 20 long, D_5 – 25 and L_1 – 16 long. Chelicerae broad basally and narrow anteriorly, 225 long with curved movable digit of chelicerae. Length of palp 365 long, palpi 5 segmented, trochanter - none; basifemur with one dorsal simple seta; telofemur inner surface with one short medial seta, above this an elongate spine like apophysis and dorsolateral surface with spine like seta; genu inner surface with one medially long simple seta, above this one short spine like seta with elongate spine like apophysis, apically with dorsomedial simple seta, outer surface with dorsomedial spine like seta; tibiotarsus inner surface medially with long simple seta, above this one short thorn like seta, adjacently with ventral simple seta, terminating with one simple seta and small claw. Ventral side of the idiosoma with longitudinal striations, coxae I - IV contiguous. Hysterosoma with 6 pairs of simple setae between coxae II and distal part of the body in addition to setae of genital and anal region. Genital shield with two halve with 4 simple genital setae in a row. Length of Leg I – 650, Leg II – 550, Leg III – 650 and Leg IV – 700 long.

Leg chaetotaxy: Coxae I – IV: 3-2-3-2; trochanter I – IV: 1-0-2-1; basifemur I – IV: 5-5-4-2; telofemur I – IV: 4-4-4-4; genu I: 2 attenuate solinidia plus 6; genu II: 7, genu III - 2 attenuate solinidia plus 4; genu IV: 1 attenuate solinidion plus 4, tibia I: 2 attenuate solinidia plus 3, tibia II: 1 attenuate solinidion plus 5; tibia III: 1 attenuate solinidion plus 4; tibia IV: 1 smooth trichobothrium plus 4; tarsus I: 4 attenuate solinidia plus 6; tarsus II: 2 attenuate solinidia plus 11; tarsus III: 1 attenuate solinidion 9; tarsus IV – 14. Each tarsus terminates in two claws and forked empodium.

Male: Unknown.

Habitat: *Colocasia esculenta* (L.) Schott.

Material examined: Holotype ♀ marked on the slide, INDIA: KERALA: Kanayamkod (Kozhikode district), 24.x.2015, ex. *Colocasia esculenta*, coll. Rahul (No. D. 142/1). Four paratype ♀♀ collection details same as above (No. C 142/2, 142/3, 142/4, 142/5). Two ♀♀ from Kalpetta (Wayanad district), 10.xi.2015, from the same host plant mentioned above (No. D. 142/6, 142/7). One ♀ from Chittur (Palakkad district), 15.vii.2015, from the same host plant mentioned above (No. D. 142/8)

Remarks: This new species closely resembles to *Dactyloscirus campbelli* Smiley, 1992 but can be clearly separated from it by the following characters:

1. Body size of the new species is very small (560 long and 400 wide) when compared with *D. campbelli* (1293 long and 506 wide).

2. Basal flagellate setae on tibiotarsus is absent in the new species.

3. Relative lengths of hypophysis on telofemur different.

4. Hysterosoma without lateral shields in the new species whereas in *D. campbelli* hysterosoma with elongate reticulated lateral shields.

5. A distinct propodosomal shield is absent in the new species.

6. Leg chaetotaxy varying among these two species.

This new species also resembles with *Dactyloscirus dolichosetosus* Den Heyer, 1979 but differs from the foolowing characters:

1. Apophysis present on telofemur is inwardly curved and ends bluntly in the new species.

2. The strong spine which is present at the internal margin of the segment is also very well developed and horn like in the new species, such characters are not present in *D. dolichosetosus.*

3. The post propodosomal sensory setae much longer than the body length compared to that of *D. dolichosetosus*.

4. The straiation pattern on the propodosomal region is V – shaped whereas it is transverse in *D. dolichosetosus*

SUBFAMILY: CUNAXOIDINAE Den Heyer, 1979

1979. Cunaxoidinae Den Heyer, *Acarologia*, **20**(3): 338-193.

1984. Cunaxoidinae Sepasgosarian, *Zeitschrift für Angewandte Zoologie*, **71**: 135-153.

1992. Cunaxoidinae Smiley, *The predatory mite family Cunaxidae (Acari) of the world with a new classification*, Indira Publishing House, 356 pp.

2002. Cunaxoidinae Gupta, *Mem. Zool. Surv. India*, **19**(2): 1-183.

2007. Cunaxoidinae Corpuz-Raros, *Asia Life Science*, **16**(2): 153-17.

2009. Cunaxoidinae Den Heyer and Castro, *Zootaxa,* **2140**: 1-15.

2011. Cunaxoidinae Den Heyer, *Zoosymposia,* **6**: 1304.

2013. Cunaxoidinae Den Heyer *et al*., *J. Nat. His*., **47**(31-32): 2049-2070.

2014. Cunaxoidinae Skvarla *et al*., *ZooKeys*, **418**: 1-103.

Diagnosis: Palpi 3 segmented, palpal trochanter without setae. Femurogenu and tibiotarsus complemented with 5 or 6 setae; tibiotarsus with bladder like setae; subcapitulum with setae hg_{1-4} and with or without adoral setae. Dorsally female idiosoma with posterosomal shield which is complemented with setae *lps, mps, at* and *pt*; dorsal setae c1 and h1 present, sometimes setae c2, f2 and h2 also present; coxae I-IV fused. Leg tibia IV with trochanter.

Type Genus: ***Eupalus*** Koch, 1838

Genus: *Neocunaxoides* Smiley, 1975.

1975. *Neocunaxoides* Smiley, *Ann. Entomol. Soc. America*, **68**(2): 227-244.

1977. *Neocunaxoides* Chaudhari, *Pak. J. Agric. Sci.*, **14**: 227-244.

1978. *Neocunaxoides* Den Heyer, *Acarologia*, **20**(3): 338-193.

1982. *Neocunaxoides* Michocka, *Acarologia*, **23**: 334.

1984. *Neocunaxoides* Sepasogosarian, *Zeit. Anz. Zool.*, **71**: 139.

1991. *Neocunaxoides* Gupta, *Rec. Zool. Surv. India*, **88**(1-4): 207-239.

1996. *Neocunaxoides* Corpuz-Raros, *Asia Life Sciences*, **5**(2): 125-14.

2001. *Neocunaxoides* Lin *et al., Syst. Appl. Acarol.*, **6**: 145-153.

2003. *Neocunaxoides* Lin *et al*., *Syst. Appl. Acarol.,* **8**: 101-106.

2007. *Neocunaxoides* Corpuz-Raros and Gruezo, *Asia Life Sciences*, **16**(2): 175-181.

***Neocunaxoides andrei* (Baker and Hoffmann), 1975**

PLATE 73

1948. *Cunaxoides andrei* Baker and Hoffmann, *An. Esc. Nac. Cicnc. Bioi. Mexico*, **5** : 249-250.

1975. *Neocunaxoides andrei* Smiley, *Ann. Ent. Soc. Amer.*, **68**(2): 237.

Redescription

Female: Length of the body including gnathosoma 424 long and 180 wide. Dorsal shield 189 long, 120 wide with dot like punctuations. Gnathosoma 143 long, 65 wide. Hypostome subrectangular, attenuate distally with subcuticular reticulations. Thick longitudinal striations are present along the lateral margins of the dorsal shield. Anterior sensillae 71 long, posterior one 79 long and serrate. Measurements of setae: Propodosomal setae P_1 and P_2 equal in length, 20 long. Setae L_1, D_1 – D_3 almost equal in length, 20 long. Length of palp 85 long, palpi 3 segmented, trochanter none; femeragenu with 2 anterior outer lateral setae, posteriorly with 2 lateral setae and dorsally with 2 setae; tibiotarsus with 2 outer lateral setae, inner surface with a basal tooth, 2 setae above it and a mushroom shaped seta medially and a claw at the terminal end of the segment. Ventral side of the idiosoma with longitudinal striations, anterior portion divided medially forming two distinct plates with coxae I and II, each plate with 6 setae. Coxae III and IV fused to form two separate, strong, elongate lateral plates, each with 6 pairs of simple setae. Medial plate adjacent to anterior plate is without setae. Four pairs of setae present adjacent to lateral and genital plates. Genital plate with 4 pairs of subequal simple setae. Length of Leg I – 156, Leg II – 135, Leg III – 150 and leg IV – 160 long.

Leg chaetotaxy: Coxae I – IV: 3-2-3-3; trochanter I – IV: 1-1-2-2; basifemur I – IV: 3-5-4-2; telofemur I – IV: 5-6-4-2; genu I: 1 attenuate solinidion plus

6; genu II – III: 1 attenuate solinidion plus 5: genu IV: 1 attenuate solinidion plus 4; tibia I – II: 1 attenuate solinidion plus 5; tibia III: 1 attenuate solinidion plus 4; tibia IV: 1 trichobothrium plus 3; tarsus I: 4 attenuated solinidia plus 6; tarsus II: 1 attenuate solinidion plus 10; tarsus III: 14; tarsus IV – 16.

Male: Unknown.

Habitat: *Cucurbita maxima* Duchesne.

Known habitats: Citrus, cotton, pine cone, soil, undetermined plant, graminaceous plant.

Material examined: Female marked on the slide, INDIA: KERALA: Cheliya (Kozhikode district), 24.x.2015, ex. *Cucurbita maxima*, coll. Rahul (No. C. 197/1). Six ♀♀, collection details same as above (No. C. 197/2, 197/3, 197/4, 197/5, 197/6, 197/7). Two ♀♀ from Sulthan Batheri (Wayanad district), 1.xii.2015, from the same habitat mentioned above (No. C. 197/8, 197/9). One female from Kadalundi (Kozhikode district), 12.x.2015, from the same habitat (No. C. 197/10). Two ♀♀ from Shornur (Palakkad district), 15. vii. 2015, from the same habitat (No. C. 197/11, 197/12).

Distribution: INDIA: Tripura. OUTSIDE INDIA: U S A.

Remarks: The specimen examined resembles closely *Neocunaxoides andrei* (Baker and Hoffmann), 1975 in almost all characters, hence fixed so. In the present survey *N.* andrei was recovered from new a host plant *viz., Cucurbita maxima.* This is a new record from Kerala.

ORDER II: SARCOPTIFORMES

Suborder: ORIBATIDA

Superfamily: Acaroidea Latreille, 1802

1802. Acaroidea Latreille, *Histoire naturelle, générale et particulière, des Crustacés et des Insectes*, xx pp.

1998. Acaroidea Colloff, *Allergy*, **53** (48): 7-12.

2009. Acaroidea Krantz and Walter, *A Manual of Acarology* 3rd ed. *Texas Tech University Press*, pp. 124-232.

2011. Acaroidea Klimov and Tolstikov, *Acarina*, **19** (2): 252-264.

2017. Acaroidea Dunlop *et al*., *Nat. His. Mus. Bern*, 1-290.

Diagnosis: Gnathosoma normally formed; chelicera chelate. Idiosoma with smooth cuticle, tuberculate and rarely sclertotized. Shield like sclerotization on propodosoma, rarely in the form of two parallel sclerites, occasionally absent. Sejugal furrow may be present or absent. Dorsal and paraproctal chaetome complete or strongly reduced. Coxisternal skeleton normally developed with addition of paired apodematic elements in ventral sejugal region. Oviporus in the form of an inverted V, internally with strongly folded pseudovipositor. Male normally with para-anal suckers, occasionally reduced or absent. Suckerlike setae on tarsus IV. Pretarsi with or without membranous ambulacrum, empodial claws may or may not be present.

6.6. Family: Acaridae Latreille, 1802

1802. Acaridae Latreille, *Histoire naturelle, générale et particulière, des Crustacés et des Insectes*, xx pp.

1945. Acaridae Nesbitt, *Can. J. Res*., **3**(6): 139-188.

1960. Acaridae Krantz, *Pan. Pacific Ent*., **36**:157-166.

1976. Acaridae Fain, *Acarologia,* **18**(2): 302-328.

1985. Acaridae Gupta, *Hand bk. Plant mites of India*, pp.407.

1993. Acaridae Hunter, *Acta Zool. Mex*., **58**: 1-37.

2011. Acaridae Klimov and Tolstikov, *Acarina*, **19** (2): 252-264.

2017. Acaridae Sanchez *et al*., *Rev. Alerg. Mex*., **64**(2):153-162.

***Diagnosis*:** Soft bodied mites, a more heavily sclerotized body has evolved independently. Body not greatly widened posteriorly. If propopdosoma overhangs gnathosoma anteriorly, then rostral setae inserted on its ventral surface. Grandjean's organ structure ranges from a small lobe to an elongate, fingerlike process; it may also be broad and strongly fimbriate. Hypopus, mouth parts absent, sucker plate present on venter of opisthosoma. Coxal fields III usually quadrate or longer than wide. Tarsi I with a single empodial claw.

Type Genus: ***Acarus*** Linnaeus, 1758

Morphology and Terminology

The infracapitulum with normally a setal complement of two pairs, lacks adoral setae and rutella but is characterised by a pair of anterior ventral cuticular flaps. Pedipalp two segmented. Pedipalp small, comprising of 2 free podomeres and closely adpressed to the sides of the hypognathum. Body distinguished into two regions by a sejugal furrow into propodosoma and hysterosoma. Body stout, white and completely sclerotized. Chelicera chelate (Plate 80 A, B). Body setae are;

v i	:	vertical internals
v e	:	external verticals
sc e and sc i	:	both pairs of scapulars
sa i	:	internal sacrals
sa e	:	external sacrals

h i	:	internal humerals
h e	:	external humerals
l a	:	anterior laterals
l p	:	posterior laterals
d 1	:	first dorsals
d 2	:	second dorsals
d 3	:	third dorsals
d 4	:	fourth dorsals

Grandjean's organ situated anterolaterally on the propodosoma and pilose supra coxal seta on leg I protect the podocephalic canal. A pair of oil glands usually present opening dorsolaterally on the opisthosoma and a pair of pseudostigmatic organ present on propodosoma. Dorsal propodosoma without crista metopica.

Genital orifice normally a longitudinal slit, occasionally transverse also located in the intercoxal region and is often provided with two genital suckers. Males with sclerotized penis. Male and female genital opening present between coxae III and IV. Two copulatory suckers are present on the sides of male anus. Epimera I fused with sternum, all others are free.

Ambulacrum of legs comprising of a median claw with a prominent pretarsus or an associated membranous pad, or a stalked sucker-like organ; trichobothria never present on idiosoma; stigma and tracheae absent. Legs III and IV pointed posteriorly. Tarsal tip bearing a large conspicuous clawlike empodium. Tarsus I bears characteristic setae. Relative length of setae on tarsus IV is important. In males some setae on the hind tarsus may be modified as suckers for holding the lateral sides of the female during mating. The tarsal solenidia bacilliform while those of tibia and genu setiform. Tibial solenidia usually long and whip-like.

The idiosomal chaetotaxy nomenclature is based on Griffiths *et al*. (1990) as modified by Norton (1998). The leg chaetotaxy are based Grandjean (1939).

SUBFAMILY: ACARINAE Latreille, 1802

1802. Acarinae Latreille, *Histoire naturelle, générale et particulière, des Crustacés et des Insectes*, xx pp.

1945. Acarinae Nesbitt, *Can. J. Res*., **3**(6): 139-188.

1998. Acarinae Klimov, *Far Eastern entomologist*, **63**: 1-36.

Type Genus: ***Acarus*** Linnaeus, 1758

Key to the genera and species of the subfamily Acarinae included in the present study

1. Dorsal setae v i at least twice the length of v e...............................*Acarus**

* Solenidion omega 1 gradually tapers from base to apex, and there is virtually no terminal expansion...*A. gracilis*

- Setae v e and v i about the same length.....................................*Tyrophagus**

* Coxal plate II with a sinuous posterior margin so that the plate narrows sharply along the distal 1/3 distal 2/3 of tarsus I ω1 obviously widened...*T. putrescentiae*

Genus: *Acarus* Linnaeus, 1758

1758. *Acarus* Linnaeus, *Syst. Nat. ed*., **10**(1): 616 p.

1964. *Acarus* Griffiths, *Bull. Br. Mus. Nat. Hist*., **11**: 411-464.

1970. *Acarus* Griffiths, *Bull. Brit. Mus. Nat. Hist. Zool*., **19**: 85-126.

1992. *Acarus* Hamsten and Johansson, *Exp. Appl. Acarol*., **16**: 117-128

2004. *Acarus* Webster *et al*., *Mol. Phylogenet. Evol*., **32**: 817-822.

2011. *Acarus* Klimov and Tolstikov, *Acarina*, **19** (2): 252-264.

2015. *Acarus* Iraola *et al*., *Allergol Immunopathol*, **43**: 332-338.

Diagnosis: Body outline oval in shape. Chelicerae well developed. Integument surface is smooth, without striations, and setae are sparse. Setae ve situated between the level of internal vertical setae (vi) and one-third the distance to scapular setae (se, si). Bell-shaped structure present at entrance of canal of spermatheca in female. Male with leg I enlarged and bearing a ventral apophysis (external projection from body wall) on femur. Grandjean's organ complex, multifurcate. Genu I with solenidion. Apodemes of first legs are joined in Y shape. Ventral apex of tarsus I with proral (p,q) setae thin and unguinal (u,v) setae short, stout spines. Legs are all long and end in a claw.

Type Species: ***Acarus siro*** Linnaeus, 1758

Acarus gracilis Hughes, 1957

PLATE 76

1957. *Acarus gracilis* Hughes, *Ann. Mag. Nat. Hist*., **10**: 753-761.

Redescription

Female: Idiosoma 400 long and 250 wide with narrower anterior end and rounded posterior end. A transverse constriction divides propodosoma and hysterosoma. A scale like lines can be seen on the dorsal surface. Propodosomal shield covers the dorsal surface above the bases of leg I and II. A pair of lateral sclerites encircles the dorsal surface of leg I. All the dorsal setae pectinate; vertical internal setae (v i) extended forward over the gnathosoma, but do not reach the tip of chelicerae. Vertical externals (v e) are much shorter than v e. Scapular setae (sc e and sc i) almost equal length (60 long). Setae d 4, h i, h v, 1 a, 1 p, and sa e shorter in length. D 1 longer than d 3.,Sa i 280 long. Ventrally setae pa_1 are longer, anal setae a 3 are not more than length of a 1 or a 2 . The chaetotaxy of the legs of the adult is very similar to that of the other species except for the shape of omega 1. Solenidion omega 1 gradually tapers from base to apex, and there is virtually no terminal expansion. Omega 1 is short, being not longer than psi of the genu; many of the tarsal setae are longer than the respective tarsi and often leaf-like in shape. Seta e is present on tarsus III and IV. Number of setae on leg segments tibia to trochanter is much less.

Male: Not studied.

Habitat: *Pisum sativum* L. and *Canavalia gladiata* (Jacq.) DC.

Known habitat: Bat dung, old grain debris, residues beneath floor of wheat, bird's nest, and bee hives.

Material examined: Female marked on the slide along with 3♀♀, INDIA: KERALA: Mankav (Kozhikode district), 19.ix.2015, ex. *Pisum sativum*, coll, Rahul (No. A. 102/1). Six ♀♀ from Kunduparamba (Kozhikode district), 12.vii.2015, ex. *Canavalia gladiata*, coll. Rahul (No A. 102/2, 102/3, 102/4, 102/5, 102/6, 102/7)

Distribution: OUTSIDE INDIA: Iberian Peninsula, Spain, Czechoslovakia and Japan

Remarks: The species examined agrees with *Acarus gracilis* Hughes, 1957 in almost all characters, hence fixed so. In the present survey *A. gracilis* was recovered from two new host plant *viz., Pisum sativum* and *Canavalia gladiata.* This is a new record from India.

Genus: *Tyrophagus* Oudemans, 1924

1924. *Tyrophagus* Oudemans, *Acarologische Aanteekenengen LXXVII 77, Ent. Ber.*, **6**: 250.

1949. *Tyrophagus* Volgin, *Doklady Akademii Nauk USSR, Zoology*, **65**(3): 385-388.

1959. *Tyrophagus* Robertson, *Aust. J. Zool.,* **7**(2): 146-181.

1961. *Tyrophagus* Robertson, *Bull. Ent. Res.,* **52**: 501-529.

1962. *Tyrophagus* Samšiňák, *Časopis Československé Spoleènosti Entomologické*, **59**: 266-280.

1979. *Tyrophagus* Griffiths, *Recent Advances in Acarology*, *Proceedings of the 5th International Congress of Acarology*, **1**: 199–212.

1981. *Tyrophagus* Robertson, *Bulletin of Zoological Nomenclature,* **38**: 125-129.

1985. *Tyrophagus* Gupta, Hand bk. Plant mites of India. p.409.

1985. *Tyrophagus* Fain, *Revue de Zoologie Africaines*, **99**: 159-164.

1988. *Tyrophagus* Czaikowska *et al.*, *Mededelingen van de Faculteit Landbouwwetenschappen, Rijksuniversiteit Gent.*, **53**(2): 799-809.

1989. *Tyrophagus* Leal *et al., Agricultural and Biological Chemistry*, **53**:12: 3279-3284.

1992. *Tyrophagus* Gupta, In: *State Fauna Ser. 3, Fauna of West Bengal,* **Part 3:** p.186.

1995. *Tyrophagus* Gupta, In: *State Fauna Ser. 4, Fauna of Meghalaya,* **Part 2**: p. 44.

1996. *Tryrophagus* Chatterjee and Gupta, *J. Beng. Nat. Hist. Soc. (NS),* **15**: 27.

1997. *Tyrophagus* Gupta and Chatterjee, In: *State Fauna Ser. 6, Fauna of Delhi*, p. 528.

2007. *Tyrophagus* Fan and Zhang, *Fauna of New Zealand*, **56**: 291 p.

Diagnosis*:* Setae ve situated near anterior lateral corners of prodorsal sclerite. Setae ve barbed, subequal with vi and longer than length of genu and peritreme. Setae si longer than se. Some hysterosomal setae like c1, d1, and d2 shorter than the distance to the next posterior seta. Dorsal terminal tarsal setae needle shaped. Ventral tarsal setae 5, of which 3 of them are thickened. Supracoxal setae of gnathosoma simple. Coxal plate II well-developed and broad. Genu I with solenidion σ' slightly longer than σ''. Tarsi I-II more than twice as long as their basal width. Ventral apophysis absent on tarsus I. Proral setae (p) thinner than unguinal setae (u) but equal in length. Grandjean's organ finger-like. (not bi- or trifurcate at tips). Leg I of male not enlarged.

Type species: ***Acarus putrescentiae*** **Schrank, 1781**

Tyrophagus putrescentiae **(Schrank), 1781**

PLATE 77

1781. *Acarus putrescentiae* Schrank, *Enum. Ins. Aust. Indig*., 521.

Redescription

Female: Idiosoma 490 long, 315 wide. Chelicera 90 long, cheliceral seta *cha* conical, 6 long, subcapitular setae *m* - 40, palpal supracoxal seta *elcp* - 14 long, dorsal palptibial seta - 20 long, lateral palptibial seta - 15, dorsal palptarsal seta -10, palptarsal solenidion small in size. Prodorsal shield nearly pentagonal, its lateral margins slightly concave. Eyespots present. Grandjean's organ fingerlike, 15 long, its basal lobe with 2 large and 2 small spiniform teeth. Supracoxal seta *scx* widened at bases of pectinations. Measurements of setae: vi - 100, ve - 60, sci - 180, sce - 120. Hysterosomal setae c1 - 50, c2 - 250, cp - 180, c3 - 50, d1 - 120, d2 - 45, e1 - 320, e2 - 275, f2 - 350, h1 - 390, h2 - 370, h3 - 320. Venterally coxal plates I extending postero-medially slightly beyond apex of prosternal apodeme; coxal plates II with sinuous posterior border, narrowing sharply medially, becoming consitguous with apex of its apodeme. Setae 3a - 80, g - 30, 4a - 100. Pseudanal setae ps1 - 250 long, ps2 - 170 long, ps3 - 25. Adanal setae ad1 and ad2 - 20 each, ad3 - 15 long. Spermathecal duct narrowing rapidly from copulatory opening and then gradually widening to base of spermathecal sac.

Leg: Leg I. 220 long; femur I 60, vF simple, 55 long; genu I 40 long, σ' 55, σ" 25, cG 45, mG 60; tibia I 30, □ 110, gT 45, hT 50; tarsus I 90 long, distal 2/3 ω1 widening, 20 long, ε 5 and ω2 short, ω3 25, aa 24, ba 30, wa 50, ra and la 30, d 35, e, f, s , u, v, p and q are small. Leg II. 200 long; femur II 50, vF 60; genu II 38, σ 20, cG 35, mG 50; tibia II 30, □ 120, gT 40, hT 50; tarsus II 85 long, ω slightly widening at apex, 25 long, ba 30, wa 40, ra 35, la 25, d 35, e, f, s, u, v, p and q are small. Leg III. 225 long; femur III 45; genu III 35, σ 25, nG 60; tibia III 30, □ 125, kT 60; tarsus III 90 long, , w setiform, 34 long, r setiform, 35 long, d 25, f 25, e, s, u, v, p and q are small. Leg IV. 260 long; femur IV 50, wF 50; genu IV 45; tibia IV 35, □ 120, kT 55; tarsus IV 100 long, w setiform, 35 long, r setiform, 30 long, d 35, e, f 30, s, u 4, v, p and q.

Male: Not studied.

Habitat: *Cucumis sativus* L., *Benincasa hispida* (Thunb.) Cogn., *Capsicum annuum* L., *Coccinia grandis* (L.) Voigt.

Known habitat: nests of honey bees, bumble bees, and stingless bees, foods stored with high fat and protein levels such as linseed, peanut, cheese, ham, oats, barley, flour, cereals, stored foods and home dust, *Saraca indica*, mango, ornamental plant, rose, *Luffa acutangula*. Elsewhere on diverse habitats.

Material examined: Female marked on the slide along with 2♀♀, INDIA: KERALA: Thenjipalam (Malappuram district), 5.v.2015, ex. *Cucumis sativus*, coll, Rahul (No. T. 291/1). Two ♀♀ from Ramanattukara (Kozhikode district), 28.vii.2015, ex. *Benincasa hispida*, coll. Rahul (No T. 291/2, 291/3). Five ♀♀ from Kadalundi (Kozhikode district), 2.xi.2015, ex. *Capsicum annuum*, coll. Rahul (No T. 291/4, 291/5, 291/6, 291/7, 291/8). Three ♀♀ from Bekal (Kasaragod district), 2.xi.2015, ex. *Coccinia grandis*, coll. Rahul (No T. 291/9, 291/10, 291/11).

Distribution: INDIA: Meghalaya, West Bengal, Uttar Pradesh, Haryana, cosmopolitan.

Remarks: The species examined agrees with *Tyrophagus putrescentiae* (Schrank), 1781 in almost all characters, hence fixed so. In the present survey *T. putrescentiae* was recovered from four new host plants *viz., Cucumis sativus*, *Benincasa hispida*, *Capsicum annuum* and *Coccinia grandis.* This is a new record from Kerala.

RAHUL. M. P. “STUDIES ON PREDATORY MITES INHABITING VEGETABLE CROPS OF NORTH KERALA” THESIS. PG & RESEARCH DEPARTMENT OF ZOOLOGY, MALABAR CHRISTIAN COLLEGE, CALICUT , UNIVERSITY OF CALICUT, 2018.

CHAPTER 7
INTRODUCTION

The extent of diversity shown by the predatory mites in terms of feeding often helps them to enjoy wide distribution in various habitats. Some plant feeding mites often cause serious damage to the crop production, if not managed appropriately; examples are *Tetranychus urticae, T. kanzawai, Panonychus ulmi* and *P. citri.* Biological control of spider mites has been proven to be effective in many agricultural crops (Helle and Sabelis, 1985).

Over the past 50 years, mites of the family Phytoseiidae have been widely studied because of the ability of several species to control phytophagous mites and small insect pest in various crops worldwide (McMurtry and Croft, 1997; Gerson *et al.,* 2003). Phytoseiid mites are wide spread all over the world and consists of about 2,436 valid species placed under 91 genera and 3 subfamilies (Demite *et al*., 2014). An updated checklist of Indian phytoseiid mites consists of a total of 211 species under 21 genera, 8 tribes and 3 subfamilies (Gupta and Karmakar, 2015). Currently there are 25 species of phytoseiid mites sold commercially for biocontrol purpose. *Amblyseius swirskii, N. cucumeris* and *Phytoseiulus persimilis* are in the list of top ten most important biocontrol agents (van Lenteren, 2012).

Several members of this family are efficient predators since they have short life cycle than their prey, equivalent reproductive capacity, good searching capacity, the ability to survive on low prey population and the ability to survive on alternative food source such as nectar, pollen, honey, plant sap etc. Several species from India have been recognized to possess high potential in biological control. *Neoseiulus longispinosus, A. channabasavannai, A. largoensis* etc. are excellent examples.

According to the classification of predatory mites based on feeding specialization there are 4 life styles in phytoseiid mites. Type I predators which are specialized predators of *Tetranychus* sps. and more rarely *Oligonychus* sps. Example for Type I predator is *Phytoseiulus persimilis*. Type II phytoseiids for example, *Neoseiulus californicus* feed on *Tetranychus* sps. as well as many other small mites and even pollen and plant exudates. Type III and IV are considered more generalist predators that feed on various mites, pollen, insects and they avoid strongly webbed tetranychids. *Typhlodromalus* sps. are Type III predators. Type IV such as *Euseius finlandicus* prefer pollen grains than mites and insect pests. They multiply throughout the year in tropical and sub tropical areas (McMurtry and Croft, 1997).

Phytoseiid mites have 5 developmental stages – egg, larva, protonymph, deutonymph and reproductive adult. Life cycle of a phytoseiid is short, usually takes 6 to 7 days to complete and shows reproductive diapause under low temperature (Veerman, 1992). They exhibit facultative diapause. The quantity and quality of food influences the duration of development. In most phytoseiids sex determination is by parahaploidy or pseudo-arrhenotoky but some species show thelytoky (Wysoki and Bolland, 1983). Egg production in female is more during early period of adult life and gradually decreases. Male and female sex ratio is 1:3 in most species.

Considerable works have been done on the biology, ecology and biocontrol aspects of many species of predatory mites on several spider mites. There existed a lacuna on information pertaining to the biological control of *T. urticae* and *T. neocaledonicus* with predators. Tetranychids may cause damage to several plant species (Bolland *et al*., 1998; Silva *et al.,* 2009). They feed on parenchyma and extract the cell contents, causing a reduction in the photosynthetic capacity affecting the crop production directly. In view of this, a study was conducted to explore the diversity of predatory mites feeding on pest mites infesting vegetable crops in North Kerala.

The result of the present survey revealed the occurrence of 42 species of phytoseiid mites of which two species *viz., Neoseiulus sasikalae* sp.nov. and *Amblyseius dioscoreae* sp. nov. (*Amblyseius dioscoreae* Rahul *et al.,* 2016) were selected for detailed biological studies. Both species were recognized as very active in the field as well as in the laboratory conditions. They showed voracious feeding habits on various stages of tetranychid mites.

Genus *Neoseiulus* was erected by Hughes in 1948 with *N. barkeri* Hughes as type species. According to Demite *et al.* (2014) genus *Neoseiulus* includes 389 described species found in all zoogeographic regions, except Antarctica (Chant and McMurtry, 2003). It comes under the largest subfamily Amblyseiinae with approximately 1,500 nominal species (Chant and McMurtry, 2007). *Neoseiulus* species have been commercially reared to be used as biological control agents of several species of thrips, other small insect pests and mites in Europe and North America over last 20 years.

Amblyseius is one of the largest genus belonging to the family Phytoseiidae. Many members of this genus feed on other pest mites and even thrips. The erection of the genus, *Amblyseius* was done by Berlese in 1914 and *Zercon obtuse* Koch (1839) was designated as its type species. The status of subgenus to genus *Amblyseius* was made by Chant (1959). Wainstein (1962) again recognized *Amblyseius* and erected 7 subgenera and 8 sections. Genus *Amblyseius* is the largest group under the subfamily Amblyseiinae with 400 described species from the world. (Demite *et al*., 2014).

Predatory potential of each life stage of the predator was evaluated separately on each stage of the respective pest mites at 30±2°C, 70±10% RH and 14 hours light and 10 hours dark photoperiod. Besides this, breeding biology of the above two species of phytoseiid mites were also studied at 3 different temperatures *viz.,* 20±2°C, 25±2°C and 30±2°C, 70±10% RH. The developmental duration of male and female life stages, hatchability, survivability, longevity and life table parameters were also recorded.

Family Tetranychidae was erected by Donnadieu in 1975, it is regarded as one of the most important family of the Acari represented by members that are important pests of agricultural crops and other plants of varied economic use owing to their faunistic diversity and the degree of injury caused to their host plants due to their feeding habits. At least 1,233 species belonging to 2 sub families and 73 genera have been described so far. Tetranychid mites are called spider mites because of their ability to spin silk.

Spider mite infestations must be detected early and managed immediately to prevent outbreaks. Spider mite eggs are attached to fine silk webbing and hatch in approximately three days. The life cycle is composed of the egg, the larva, two nymphal stages (protonymph and deutonymph) and the adult. The length of time from egg to adult varies greatly depending on temperature. Under optimum conditions, spider mites complete their development in 5 – 20 days. There are many overlapping generations per year. The adult female lives two to four weeks and is capable of laying several hundred eggs during her life. They feed by penetrating the plant tissue with their mouthparts and are found primarily on the underside of the leaf. The mites feeding causes greying or yellowing of the leaves. Necrotic spots occur in the advanced stages of leaf damage.

The two spotted spider mite, *Tetranychus urticae* is the most common and destructive mite. It has an extremely wide host range thrives under hot, dry summer conditions. As a major pest in India, the vegetable mite, *T. neocaledonicus* has a wide range of distribution throughout the tropical and subtropical areas and attacks over 110 different plants including flowers, fruits, vegetables, field crops, fodder crops and so on.

Giving due consideration to the increasing instances of mite infestation in Kerala, the present investigation was undertaken with an intention to gather knowledge on the biological control aspects of the common spider mites, damaging our vegetable crops. Accordingly, the present study was organized, mainly concentrating on the feeding and breeding biology of phytoseiid mites especially *N. sasikalae* sp. nov. and Amblyseius *dioscoreae* Rahul *et al.,* 2016.

RAHUL. M. P. “STUDIES ON PREDATORY MITES INHABITING VEGETABLE CROPS OF NORTH KERALA” THESIS. PG & RESEARCH DEPARTMENT OF ZOOLOGY, MALABAR CHRISTIAN COLLEGE, CALICUT , UNIVERSITY OF CALICUT, 2018.

CHAPTER 8
REVIEW OF LITERATURE

The present review of literature includes the important works on the feeding and breeding biology of phytoseiid mites. Parrot *et al.* (1906) were the first to report the efficiency of phytoseiid mite, *Seius pomi* upon the prey mite *Eryophyes pyri*. Since then Quayle (1912), Ewing (1914), Gilliat (1935) and Garman (1948) were some of the workers who stressed the potential value of phytoseiid mites in regulating the population of several plant mites including spider mites. Chant (1961a), McMurtry and Johnson (1966), Mcmurtry and Scriven (1975) reported that alternate food increased the intensity of predation.

Chant (1961) carried out laboratory experiments on *Typhlodromus occidentalis* preying upon *Tetranychus telarius* showed that the oviposition and prey consumption rate of the predator depends on the number of available prey. Swirski and Dorzia (1969) reported that *T. occidentalis* when preying upon *Tetranychus cinnabarinus* and *Eutetranychus orientalis* gave high rates of oviposition and also high percentage of young instars. Satpathy and Mania (1969) observed the morphological peculiarities of the eggs of *A. finlandicus*.

Smith and Newsom (1970) suspected that shifting of 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. Swirski *et al*. (1970) noticed that some phytoseiids could develop exclusively on tetranychids, few others in combinations with eriophyids, some others on pest mites and pollen, whereas certain others on pollen alone. Gupta *et al*. (1971) reported that the tetranychids infesting citrus plants in Punjab could be controlled by *A. finlandicus.* Wei and Lang (1973) studied the oviposition and noted that mating leads to oviposition and often continous egg laying does not demand continous or frequent matings. Pruszynski and Cone (1973) studied the life span, prey consumption rate and fecundity of *Typhlodromus occidentalis* preying on *T. urticae* at varying temperatures.

El-Banhawy (1975) studied the feeding behavior and biology of *Amblyseius brazili* with a diet of *Aponychus spinosus* and *T. desertorum* and it showed that both male and female sexes showed a life cycle of egg to adult stage completing in 7 days. McMurtry and Scriven (1975) studied the mass rearing technique for *Phytoseiulus persimilis*. Amano and Chant (1978) studied the sperm transfer behavior in phytoseiid mites and reported 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. Mori and Saito (1979) experimentally established that *P. persimilis, A. longispinosus* and *A.deloni* Muma and Denmark could effectively help in the suppression of the two spotted spider mite, *T. urticae.* A study conducted on the developmental biology of *A. (N) longispinosis* by Shih and Shieh (1979) reported that duration of egg, larva, protonymph and deutonymph 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 at 24^0C, 70% RH. 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 kairamones. Jagadish and Nageshchandra (1979) worked on *A.* (*T.*) *tetranychivorous* feeding on *Raoiella indica* reported that the average incubation period, larval, protonymphal and deutonymphal periods were 1.92, 1.06 and 0.92 for females and 1.92, 1.14 and 1.42 days for males respectively.

Dhooria (1981) studied the predatory behaviour of *A. (E.) alstoniae* and reported that both nymphs and adults fed on prey mite *Eutetranychus orientalis* larva and protonymphs more readily than other stages. A study on life history of *A. (N.) longispinosus* by Saito and Mori (1981) reported that the maximum rate of egg production was noted on the tenth day after mating. Moraes and McMurtry (1981) studied morphological changes during molting and hatching observed that larva emerged posterior first, from the narrow end of the egg. Hatching took 8 min to complete. According to Yousef and El-Halawany (1982) the adult stage of *A. gossypii* was seen to consume about 90% of the total prey available. Mallik and Channabasavanna (1983) studied the life history and life table of *N. longispinosus* and reported that duration of different stages like egg, larva, protonymph and deutonymphs were 42 hours 44 minutes, 12 hours 25 minutes, 20 hours 53 minutes and 21 hours 51 minutes respectively. 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. Gupta (1986) reported that maximum rate of egg production of phytoseiid predator was 2.5 per day during winter season and mostly when there is abundant food. The mean total eggs laid per female depends 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.

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 was 29, 38, 38 and 46 at 18, 22, 25 and 30°C respectively. 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.

Schausberger (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. 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 (42.6 hrs). It was also noticed that larvae was a non feeder. 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). The predatory potential and mass rearing of *A.(N.) longispinosus* on *T. macfarlanei* under laboratory conditions observed that the adults fed 14.22 $\pm$ 0.66 eggs 2.41 $\pm$ 0.87 larvae, 1.72 $\pm$ 0.57 nymphs and 1.05 $\pm$ 0.97 of the adults of pests (Manjunatha *et al*., 1995). 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. The biology and life table parameters of *N. californicus* feeding upon *T. urticae* and *E. discordis* noted that the longevity of adult females feeding on *T. urticae* eggs and nymphs were 31.58 and 35.7 respectively, whereas those feeding on *T. discordis* were 39.2 days (El-Laithy and Elsawi, 1998). 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. Mass rearing technique for *A. (N.) longispinosus* was developed by Mallik *et al.* (1999).

Kazak *et al.* (2002) traced the development time, survival and fecundity rates of *N. umbraticus* preying upon *T. cinnabarinus* at temperatures of 20°C, 25°C, and 30°C, RH of 65 $\pm$10% reported that the oviposition rates decreased as temperature increased. Gotoh *et al.* (2004) studied the development, survivorship and life-history parameters of *A. californicus* on eggs of *T. urticae*. They noticed that more than 97.3% of *A. californicus* eggs hatched and more than 81.6% of newly hatched larvae attained maturity at temperatures between 15 and 35 °C. Canlas *et al.* (2006) studied the life history characteristics and predation of *Neoseiulus californicus* on the two-spotted spider mite, *Tetranychus urticae* found that developmental time from egg to adult emergence decreased when temperature increased. Total development period of immature stages was longest at 15°C and shortest at 35°C for both male and female. Sex ratio favored females and temperature did not exert a critical effect on sex determination. The net reproductive rate (R_0) was highest at 25°C (22.92 females/female) and lowest at 30°C (16.74 females/female). The mean generation time decreased from 20.61 to 16.79 days with increasing temperatures upto 30°C. The intrinsic rate of natural increase ranged from 0.162 to 0.285, and was maximum at 25°C. A gravid *N. californicus* female consumed more eggs, larvae and nymphs than adult male or female of *T. urticae*. Gorgi *et al.* (2009) studied the functional response and prey consumption of *Phytoseius plumifier* with *T. urticae* at 6 different temperatures *viz.,* 15, 20, 25, 30, 35 and 37°C found that the total female prey consumption increased with temperature increase. They reported that developmental rate, preoviposition, oviposition periods and longevity tend to reduce with increase in temperature. Negm *et al.* (2014) studied biology, predation, and life table parameters of *Neoseiulus barkeri* found that oviposition period was significantly shorter at 35°C than at 25°C. Li *et al.* (2015) studied the development rate and reproductive biology of *N. bicaudus* feeding on *T. turkestani* at 6 constant temperatures *viz.,* 18, 22, 26, 29, 32 and 35 ºC found that the duration of the egg, larva, protonymph, total immature, and pre-oviposition stages were decreased as temperatures increased. The intrinsic rate of natural increase and the finite rate of increase were larger as temperature increased. It was also noted that doubling time decreased as temperature increased. As temperature increased, the duration of the oviposition period first increased and then decreased. Reichert *et al.* (2017) evaluated the biological performance of *N. idaeus* when fed on *T. urticae*, *T. ludeni* and *Mononychellus planki*. The results demonstrated that *N. idaeus* is able to reach the complete development feeding on all the 3 tetranychid species.

***Tetranychus* species on vegetable crops**

Sharma and Kushwaha (1984) investigated the varietal preference of *T. neocaledonicus* on 4 varieties of brinjal in Rajasthan. Gupta (1985) reported the infestation of *T. ludeni* on different vegetable crops. Pande and Sharma (1986) studied the biology of *T. neocaledonicus* on cucurbits at 5 different temperature found that the mite did not survive at a temperature beyond 37°C. Singh and Mukherjee (1989) reported the outbreak of *T. ludeni* on cowpea from Uttar Pradesh. Kapoor *et al.* (1997) studied the seasonal incidence of spider mites infesting okra and brinjal from Punjab. Sugeetha and Srinivasa (1999) studied the seasonal abundance of *T. macfarlanei* on okra varieties in Bangalore. *T. urticae* was found to infest *Phaseolus vulgaris* in Kinnaur district of Himachal Pradesh (Singh *et al.,* 2000).

Varela *et al.* (2003) reported the wide distribution of *Tetranychus* species on vegetable crops belonging to the family Solanaceae. Patil and Nandihalli (2009) studied the seasonal incidence of *T. macfarlanei* infesting brinjal from Karnataka. Rai and Indrajeet (2011) reported 6 species of tetranychid mites infesting commonly grown vegetable crops from eastern Uttar Pradesh. Prasad and Singh (2011) reported 3 species of tetranychid mites infesting brinjal crop *viz., T. urticae, T. macfarlanei* and *T. ludeni*. Shah and Shukla (2014) found that population of spider mite remained active throughout the year in polyhouse. Kumar *et al*. (2015) studied the population dynamics of *T. urticae* infesting okra.

RAHUL. M. P. “STUDIES ON PREDATORY MITES INHABITING VEGETABLE CROPS OF NORTH KERALA” THESIS. PG & RESEARCH DEPARTMENT OF ZOOLOGY, MALABAR CHRISTIAN COLLEGE, CALICUT , UNIVERSITY OF CALICUT, 2018.

CHAPTER 9

MATERIALS AND METHODS

During the present study, *T. urticae* Koch and *T. neocaledonicus* Andre, infesting the vegetable plants *Canavalia gladiata* (Jacq.) DC. and *Pisum sativum* L respectively were selected for studying the feeding potential of two new species of phytoseiid mites *viz., N. sasikalae* sp. nov. and *A. dioscoreae* sp.nov. (*A. dioscoreae* Rahul *et al.,* 2016). The above spider mites were recognized as widely distributed mite pests of *C. gladiata* and *P. sativum* in many of the surveyed areas.

Canavalia gladiata, usually called sword bean is a cultivated vegetable plant under the family Fabaceae. It is a protein rich vegetable grown throughout the year. Besides protein, fibers, carbohydrates and fats are also present. In Japan and Korea the bean is used against a number of diseases like vomiting, asthma, obesity, dysentery or even cancer.

Pisum sativum, commonly known as pea, originally from Mediterranean region is also grown in many parts of the world. It has long been important in diet due to its content of fiber, protein, starch and vit. B. It is an excellent food source for humans. Its ability to fix nitrogen in roots makes pea a good fertilizer.

Spider mites, *T. urticae* and *T. neocaledonicus* are major pests in a wide range of protected crops across the world. They are economically very important due to its high potential to destroy a wide range of agricultural crops. They are extremely phytophagous. Heavy infestation often led to bronzing and blotching of leaves followed by premature leaf fall.

9.1. Raising of prey mite population.

Stock culture of prey mites, *T. urticae* and *T. neocaledonicus*.

Canavalia gladiata and *P. sativum* seedlings were planted in earthern pots of 75×75×75 cm^3 size kept near the laboratory for artificial infestation with *T. urticae* and *T. neocaledonicus* respectively. *Tetranychus urticae* infested leaves of *C. gladiata* and *T. neocaledonicus* infested leaves of *P. sativum* were collected from various localities, brought to the laboratory in separate covers. Adult pest mites were transferred to the host plants when new leaves began to sprout and allowed to multiply.

After two months, adult pest mites were transferred on to the abaxial surface of excised respective host plant leaves. These leaves were placed on moist cotton pads laid on plastic trays (42×30×6.5 cm^3). Five such sets of culture trays were maintained in the laboratory for easy availability of different stages of prey mites. These culture units were maintained in an environmental chamber that was controlled at 30±2°C, 70±10% RH and 14 hrs light and 10 hrs dark photophase.

9.2. Raising of predator mite population

Stock culture of predatory mites, *N. sasikalae* sp. nov. and *A. dioscoreae* Rahul *et al.,* 2016.

Predatory mites *N. sasikalae* and *A. dioscoreae* feeding on *T. urticae* and *T. neocaledonicus* respectively were collected from the respective host plants and brought to the laboratory in separate polythene bags. Stock cultures of predatory mites were maintained on respective host plant leaves infested with respective pest mites. To prevent the escape of predatory mites from the experimental set up hydrophilic cotton was over saturated with water. Different stages of prey mites were offered as food for rearing predatory mites. Sufficient stocks of predatory mites were built up in the laboratory using leaf floatation technique in plastic trays.

9.3. Feeding biology

For this purpose, uninfested host plant leaf bits of 3×3 cm^2 size were laid on water saturated cotton placed in Petri dishes of 10 cm diameter with their abaxial surface up. Culturing was started from fresh male and female predatory mites. The number of prey supplied to predator was determined according to preliminary observations of the consumption capacity. Thus they were provided with enough (25 Nos.) different stages of respective pest mites.

For studying the feeding preference, separate culture sets containing different stages of prey mites were prepared *viz.,* egg, larva, protonymph, deutonymph and adult. Then different stages of predatory mites *viz*., larva, protonymph, deutonymph, adult male and female were released individually to each culture cell for making observations on the feeding potential of particular life stage. There were thus 5 experimental sets *viz.,* set 1. Prey egg Vs adult female predator, set 2. Prey egg Vs adult male predator, set 3. Prey egg Vs predator deutonymph, set 4. Prey egg Vs predator deutonymph and set 5. Prey egg Vs predator larva.

Like this different stages of predators were released individually with different stages of prey mites *viz.,* larva, protonymph, deutonymph and adults. Twenty five numbers of each life stages of the prey were kept into each culture cell and were exposed to a single number of each stages of the predator, newly hatched in the case of larvae and newly emerged in the case of other stages. Adults and nymphs of predatory mites were starved for 6 hours before starting the experiment. These culture cells were observed under a stereo microscope in every 24 hrs to determine how many prey had been consumed, but larvae were observed thrice daily. Each experiment was replicated 5 times. Prey consumed were replaced by live ones to maintain the required number. Observations were also made on feeding behaviour, mode of feeding and feeding potential of predator on various stages of the prey. All these experiments were studied by maintaining the culture cells with conditions of 30±2°C at 70±10% RH in an environmental chamber which was locally made. The same experiments were performed for the other predatory mite *A. dioscoreae*, using the prey mite, *T. neocaledonicus* to find out the differences between the consumption of various life stages of pest mites.

9.4. Breeding biology

The developmental studies of the above two predators were tested at 3 different temperatures *viz.,* 20±2°C, 25±2°C and 30±2°C at 70±10 RH by adopting leaf floatation technique. Studies were initiated by releasing virgin females individually on leaf disc with abundant prey mite stages. Then was added a newly emerged male either from the same batch or from different batch of the same age, maintained at same condition. Soon after copulation male was removed and female was allowed to lay eggs. Repeated observations were made at 6 hrs interval until the first egg was laid to calculate the pre-oviposition period. Thereafter the number of eggs laid by each female was recorded at 24 hrs intervals until the death of the female to calculate oviposition period, fecundity, post-oviposition period and longevity. Besides this, incubation, hatching, developmental duration of active stages as well as quiescent stages, moulting etc. were also recorded. This was repeated 10 times.

Life table study was initiated with eggs of similar ages, obtained by transferring 50 gravid females from the stock culture. After 12 hrs females were removed and eggs (100) were transferred to culture cells singly. Mixed life stages of prey mites were added to each cell. Predator development was monitored twice per day at 9 AM and 5 PM, recording the age from the midpoint of time interval until the commencement of the oviposition period. The number of eggs deposited was checked once in a day during the oviposition period. Eggs were reared to adulthood to determine the sex ratio of the offsprings. Leaf discs were renewed thrice per week. Missing mites were excluded from calculations.

Life tables were constructed from the observed age specific survival rate (l_x) and age specific fecundity rate (m_x). The following life table parameters were estimated; intrinsic rate of natural increase (r_m), net reproductive rate (R_o), gross reproductive rate (Σm_x), mean generation time (TC), finite rate of natural increase (λ), weekly multiplication and doubling time (DT) using methods of Birch (1948), Deevey (1947) and Mackauer (1983).

Net reproductive rate ($R_o = \sum l_x m_x$) is defined as the ratio of population multiplication in each generation, Intrinsic rate of natural increase was calculated using the formula ($r_m = (L_n R_o)/ T$); Mean generation time (T) is the mean time from birth of parent to birth of offspring. This was calculated using the formula $T = (R_o = \sum l_x m_x) / r_0$; Finite rate of natural increase (λ) is the multiplication per female in unit time of population with stable age distribution. This was calculated as, λ = antilog r_m. Doubling time (DT) is the time in days that was required by a population to double in number and was calculated by the formula $DT = L_n^2 / r_m$. The precise value of mean length of generation was calculated as $T = \sum X l_x m_x / \sum l_x m_x$. Weakly multiplication of population (W_m) was calculated by using the formula $W_m = (erm)^7$. The mortality and survival rates were recorded every day for all immature and adult stages.

Data obtained were subjected to ANOVA. Means were separated by Duncan's multiple Range Test at $P < 0.05$. Based on the results, comparative assessment of the feeding potential of two species of predatory mites were also made and the results were tabulated and presented graphically. Microphotographs, sketches, measurements etc. were also made for the two predatory mites.

RAHUL. M. P. “STUDIES ON PREDATORY MITES INHABITING VEGETABLE CROPS OF NORTH KERALA” THESIS. PG & RESEARCH DEPARTMENT OF ZOOLOGY, MALABAR CHRISTIAN COLLEGE, CALICUT , UNIVERSITY OF CALICUT, 2018.

CHAPTER 10
OBSERVATION

10.1. Feeding Biology

10.1.1. Feeding biology of *Neoseiulus sasikalae*.

Feeding potential of different stages of predatory mites *viz., N. sasikalae* sp.nov. and *A. dioscoreae* Rahul *et al.,* 2016 on different stages of the prey mites, *T. urticae* and *T. neocaledonicus* were assessed at a temperature of 30$\pm$ 2^{o}C and 70±10% RH.

Feeding behaviour (Plate 81, Fig. 8).

All stages of predatory mite except larva were found moving very fast, searching the prey. When the predator was starved for one day, it was observed that the searching movement was more vigorous. The web constructed by the prey mite hinders the fast movement of predators.

When the predatory mite comes across a potential tetranychid, first it touches the prey with tarsus I, then grasps with leg II. Using chelicerae, cut open the cuticle of the prey. Then pairs of legs and turns the prey around several times before feeding. By the contraction of the pharynx muscles, the liquid body contents were sucked into the predator's gut. The body colour of the predator was found changing and the coloured body fluid of the prey mite could be clearly seen through the transparent body of the predator.

The mode of consumption of eggs by the predator was more or less similar to that of nymphs and adults. The prey eggs were rolled by the combined action of chelicerae and pedipalp at the time of feeding. However, the palps were found laid over the egg and chelicerae were found extended towards the eggs. Several punctures were produced on the surface of egg with the help of protruded chelicerae, through which the contents were sucked, leaving behind the empty egg shell. Prey eggs were the most preferred food for all feeding stages of the predator. Adult females were noted to consume more eggs than males.

A known number of (25) eggs, larvae, protonymph, deutonymph and adults of the prey were provided as food to 5 different stages of the predators individually. The number of different stages of prey consumed by each stage of the predator was counted after a time period of 24 hours.

The mean values of feeding potential of different stages of *N. sasikalae* were calculated and significant combinatios of different stages of the predator against different stages of the prey mite were assessed using, Scheffe's test (Table 4, 5). Table 3 shows that predator larva of *N. sasikalae* was a non feeder of any of the stages of prey mite *T. urticae*. Eighty eight percentage of eggs of *T. urticae* was consumed by the female predator which was significantly higher than any other stages of the predator. They also consumed higher number of larva (66%), protonymph (44%) and deutonymph (19%) of the prey. But consumption of the adult (2%) was negligible (Tabe 3. Figure 8).

Deutonymph of the predator was the next stage that fed well on eggs, larvae, protonymph and deutonymph of the prey. The males and protonymphs also showed significant degree of predation on different prey stages (Table 3).

The data obtained were on subjected to ANOVA for testing the significance. Here the p – value less than 0.01 shows high significance. Accordingly, significant results were obtained on the predatory habit of *N. sasikalae* against *T. urticae* (Table 5). Based on the results of consumption rates of different stages of *N. sasikalae* against different stages of *T. urticae* in 24 hrs, categorized normal plots and categorized box plots were constructed for testing the validity of assumption of normality. As shown in Figure 6 all the 15 categories, the points were closed to a positively slopped straight line, hence the assumption of normality is valid.

The data obtained when analysed statistically adopting Scheffe's test various significant combinations of predator and prey were revealed (Table 5). Here p - value < 0.01 was considered as highly significant.

Figure 8 represents the percentage of life stages of *T. urticae* consumed by different stages of *N. sasikalae* in 24 hours. As indicated in the graph, female of *N. sasikalae* exhibited maximum rate of consumption of eggs of *T. urticae*. It was decreased in the order female > deutonymph > male > protonymph. In the case of pest deutonymph stage, it was in the order female > male > deutonymph. When prey stage was adult the rate of consumption was in the order female>male. But in the case of prey protonymph stage, the rate of consumption was in the order female > deutonymph > male > protonymph.

TABLE 3

Percentage of predation by *N. sasikalae* sp.nov. on different stages of *T. urticae* in 24 hours

Pest / Predator	Egg	Larva	Protonymph	Deutonymph	Adult
Adult female	88	66	44	19	2
Adult male	50	31	21	11	1
Larva	0	0	0	0	0
Protonymph	24	28	25	0	0
Deutonymph	74	59	41	2	0

TABLE 4

Mean values of feeding potential of different stages of *N. sasikalae* against diffferent stages of the prey mite, *T. urticae* (n=25)

1. Prey - Egg

Predator	Mean±SE	F	p-level
Female	22.04±0.38		
Male	12.56±0.19		
Larva	0	1294.3	0.000
Protonymph	6.12±0.28		
Deutonymph	18.40±0.21		
All group	11.82±0.72		

2. Prey – Larva

Predator	Mean±SE	F	p-level
Female	16.60±0.30		
Male	7.84±0.19		
Larva	0	974.28	0.000
Protonymph	6.88±0.26		
Deutonymph	14.84±0.16		
All group	9.23±0.54		

3. Prey – Protonymph

Predator	Mean±SE	F	p-level
Female	10.88±0.17	711.59	0.000
Male	5.32±0.11		
Larva	0		
Protonymph	6.16±0.09		
Deutonymph	10.28±0.21		
All group	6.52±0.23		

4. Prey – Deutonymph

Predator	Mean±SE	F	p-level
Female	4.68±0.62	339.87	0.000
Male	2.84±0.18		
Larva	0		
Protonymph	0		
Deutonymph	0.40±0.12		
All group	1.58±0.17		

5. Prey – Adult

Predator	Mean±SE	F	p-level
Female	0.40±0.10		
Male	0.16±0.07		
Larva	0	9.846	0.000
Protonymph	0		
Deutonymph	0		
All group	0.11±0.02		

10.1.2. Feeding biology of *Amblyseius dioscoreae* Rahul *et al.,* 2016

(Plate 82, Fig 7, 8)

Taking into consideration the consumption rate of different stages of *A. dioscoreae* against different stages of *T. neocaledonicus* in 24 hrs normal plots were drawn for testing the validity of assumption of normality. As shown in Plate 88 the points were closed to a positively slopped straight line, hence the assumption of normality is valid.

Figure 13 represents the mean number of life stages of *T. neocaledonicus* consumed by *A. dioscoreae* in 24 hrs. As indicated in the graph, the females of *A. dioscoreae* consumed maximum number of eggs of *T. neocaledonicus*. It was decreased in the order female > deutonymph > protonymph > male > larva. In the case of prey larva it was in the order female > deutonymph > protonymph > male > larva. But in the case of protonymph it was female > deutonymph > male > protonymph. Deutonymph and adult stages of the prey mites were not predated by any stages of the predator (Table 6, Figure 12, 13)

The data obtained on the consumption rate of different stages of *A. dioscoreae* on different stages of prey mite, *T. neocaledonicus* were analysed statistically adopting Scheffe's test revealed various significant combinations of predator vs prey as presented in Table 8. 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.

When the feeding potential of two predators were evaluated, consumption by all stages of *N. sasikalae* was significantly higher compared to the stages *A. dioscoreae* (Table 3, 6, 9). Larva of *N. sasikalae* was a non feeder of any of the life stages of *T. urticae*. Irrespective of the predator, the pest eggs were more susceptible followed by larvae and protonymph (Figure

13). Adults and deutonymph of prey were the least preferred stages by both predators.

The feeding efficiency of individual stages of the same predator was found varying considerably. Adult females of both predators appeared more active in feeding. Average time taken for the consumption of different stages of the prey was noted. It was observed that *A. dioscoreae* took lesser time to suck the internal contents of the prey than *N. sasikalae*. It was noted that adult female of *N. sasikalae* took only 1.5 minutes to suck the internal content of the prey egg, whereas male took 2.6 minutes for sucking. While in the case of *A. dioscoreae* adult female took 3 minutes and male took 4.1 minutes. The average time taken by different stages on the predator increased with progressive development of the prey.

10.2. BREEDING BIOLOGY

10.2.1. Developmental studies of *N. sasikalae* sp.nov.

Developmental studies of the phytoseiid predator *N. sasikalae* were carried out in the laboratory at 3 different temperatures 20±2°C, 25±2°C and 30±2°C under 70±10 % RH by adopting leaf floatation technique. Regular observations were made to gather informations on behavioural aspects like mating, incubation, hatching, moulting etc. Repeated observations were also made per hour to collect data on preoviposition, oviposition, post oviposition, fecundity and total longevity of both sexes.

Mating behaviour

Phytoseiids lack eyes and rely on mechano and chemoreceptors which were present on their abdomen and anterior pair of legs, for sensing their surroundings and prey (Gerson *et al.,* 2003). The process of mating could be observed immediately after the emergence of the adult female and it was quite a prolonged process continuing for several minutes. The males exhibited high searching behaviour for females more vigorously on leaf discs than a female did for males. After locating the active female, the male established a contact with the females with their first pair of legs, and then it was found climbing on the back of the female. This was followed by the orientation phase, and the male succeeded to climb the dorsum of female. The females were found moving about carrying the males on their dorsum, later the male moved posteriorly until they could establish a venter to venter position with the females. Then the males made a firm grip over the females with their legs in such a way that its posterior hysterosomal margin could be seen beyond that of the female. The paired mites were found moving very fast on the leaf discs. In paired condition, the female predators were found to be non feeders. The males holding their females in between first and second pairs of legs, whereas the third and fourth pairs of legs were clasped around the female's hysterosoma. By getting a comfortable position, the male press the spematophoral process between the coxae of third and fourth legs of the female where the cervix of spermatheca opens out. Then the male found lifting up the hysterosoma of the respective female, which appeared to move up and down and gently transferred the spermatophores. The mating behaviour lasted for 30 - 45 minutes. After mating, the males got separated from the females and moved fastly. The female remained stationary for some time and then moved and started feeding on the eggs of the prey. It was observed that the same pairs sometimes mated repeatedly on the same day. A single male was found to mate with more than one female.

Preoviposition

Preoviposition period was the time taken by a mated female to initiate the process of egg deposition. After mating, the females reared at a temperature of 20°C took an average time of 3.45±0.43 days for laying the first egg. At 25°C the preoviposition period was 2.45±0.11 whereas at 30°C it was 1.91±0.04 days (Table 12).

Oviposition

The deposition of the first egg marked the onset of oviposition and the average oviposition period at 20°C was 19.85±0.23 days; at 25°C was 17.65±0.36 and at 30°C was 16.40±0.21 days (Table 12). Eggs were laid singly or in pairs in horizontal position on the lower surface of leaves near to the mid rib or on the web made by the prey mites. The eggs were found glued to the leaf surface by a sticky material secreted by the female. During the oviposition period the abdomen of the adult female became bulged and the developing egg could be seen clearly through the skin. It was noticed that a single female was found laying an average number of 1.96±0.02 eggs per day at 30°C whereas it was 1.33±0.13 and 1.40±0.16 at 20 and 25°C (Table 12).

Post oviposition

The oviposition period of the adult females were succeeded by the post oviposition period. The cessation of egg laying marked the start of post oviposition period. The mean post oviposition period in females reared at 30°C was 6.42±0.09 whereas it was 8.1±0.10 at 25°C and 9.15±0.16 days at 20°C (Table 12). This period was recognized by a reduced rate of food consumption, followed by an inactive phase, leading to death. In the present study it was noticed that post oviposition was decreased at increased temperature (Table 12).

Incubation, hatching and emergence of larva

Freshly laid eggs were oval, transparent, white and shining (Plate 98) and gradually turned dirty white before hatching. A slit was apperaed at one end of the egg through which the larval hysterosoma protruded out. The vigorous tilting of the legs and wriggling movements of the larva, the slit got widened through which 2nd and 3rd pairs of larval legs came out. The entire larval body came out of the egg case as a result of the pressure exerted by the larva. Finally the egg case got removed by the wriggling movements of the second pair of legs. The whole process of hatching required 20 - 30 minutes for completion. Hatchability and survival (maturity) rate are given Table 11. More than 85% of egg hatchability was recorded at all 3 temperatures tested and more than 60% of maturity was noted. The mean duration of incubation period of eggs of future males were 2.66±0.03, 1.65±0.02 and 1.38±0.03 days at 20, 25 and 30°C respectively. Whereas the eggs that were about to be females had incubation period of 2.76±0.03, 1.79±0.01 and 1.44±0.01 days (Table 10).

Developmental duration

The developmental duration of all stages of *N. sasikalae* were shown in Table 10. The developmental duration of all stages were seen to be influenced by temperature. As the temperature decreases the developmental durations were seen to increase.

Larva

The newly hatched larva was crystal white in colour with 3 pairs of legs (Plate 98). Soon after emergence the larva was inactive for a few minutes and then started moving about on the leaf disc. The larva did not show any feeding behaviour but was found nibbling on the leaf surface. After a short active period, the larva entered into an inactive state noted as the first quiescent stage. During the quiescent stage the body became sluggish in nature and remained stationery on the leaf disc. They exhibited a characteristic posture by stretching the mouth parts and first pair of legs pointing anteriorly and the posterior legs was stretched backwardly. Mean duration of male larval development including quiescent stage at 20°C was 0.99±0.09; at 25°C, 0.54±0.01 and at 30°C, 0.27±0.01. In females at 20, 25 and 30°C were 1.11±0.05, 0.57±0.01 and 0.31±0.00 respectively (Table 10).

Protonymph

Larva had undergone first moulting which led to the emergence of white coloured protonymph. Compared to larva, newly emerged protonymph was larger in size, with 4 pairs of legs. They were found to be actively moving around the leaf surface and initiated feeding. They consumed pest larval stages than eggs. At the end of the active period, the protonymph entered into the second period of quiescent stage. The total protonymphal period including quiescent stage at 20°C was 2.73±0.15, at 25°C was 0.81±0.02 and 0.80±0.04 days at 30°C in males whereas in females, it was 2.95±0.11, 0.87±0.02 and 0.82±0.02 days at 20, 25and 30°C respectively (Table 10).

Deutonymph

Second quiescent stage moulted into an active deutonymphal stage, which could be differentiated from the adult by its small size. They were seen voraciously feeding on all stages of prey mites except adults. After the active period, deutonymph underwent quiescence. Mean duration of male deutonymphal development including quiescent stage at 20°C was 2.70±0.17; at 25°C was 0.76±0.01 and at 30°C, 0.66±0.04. In females at 20, 25 and 30°C were 3.24±0.18, 0.87±0.01 and 0.79±0.01 days respectively (Table 10).

Quiescent stage

All active developmental stages of *N. sasikalae* were found to be followed by an inactive or quiescent phase. Quiescent mites stopped feeding and remained stationary at one place. They were found moving slightly when disturbed otherwise they displayed highly restricted movements. At the beginning of quiescent phase, the body became more or less swollen in appearance and opaque in nature. During this period the instar assumed a characteristic posture. The body was held slightly raised, the mouth parts and first pair of legs were stretched in a forward direction and posterior legs were in backward direction. As the process of moulting approached, they showed twisting movements of body in sideways. The time period of quiescence at 3 temperatures tested is shown in Table 10.

Moulting and emergence

The emergence of the active life stages of *N. sasikalae* from the respective quiescent phase was resulted through the process of moulting. The process was initiated with the appearence of a longitudinal slit at the posterior end of the hysterosoma. The slit further proceeded anteriolaterally and the third and fourth pairs of legs of the moulting instars were found extruded through the split skin. The continuous wriggling movements of the body and constant movements of the legs led to the emergence of active stage. Sometimes the remnants of the exuvial skins were found attached to the body but were later removed by the legs. The moulting skin was very delicate, entire and appeared as wrinkled. The average time taken for moulting was 20 - 25 minutes.

Female survival rate, Fecundity, Longevity and Life table

Fecundity and longevity were greatly affected by temperature. When temperature increases longevity decreases whereas in the case of fecundity when temperature increases fecundity also increases (Table 12). Maximum longevity was noted for females reared at 20°C followed by 25 and 30°C (32.30 ± 0.21, 28.20±0.38 and 23.93±0.25 days) whereas in the case of males were 26.70 ± 0.55, 26.50±0.29 and 19.56±0.14 days (Table 12). The total number of eggs laid per female at 20^oC was 24.20±0.20; at 25^oC it was 24.50±0.25 and at 30^oC it was 32.20±0.22. Average daily oviposition per females were 1.33 ± 0.13, 1.40 ± 0.16 and 1.96± 0.02 at 20, 25 and 30^oC. Sex ratios were noted to be female biased at all the 3 temperatures tested (Table 12).

Life table parameters estimated were given in Table 13. Figure 15 represents age specific survival rate and fecundity rate curves. The intrinsic rate of natural increase was found to be same at 25 and 30 followed by 20°C. The mean generation time was found to be same at 20 and 30°C. The net reproductive rate, gross reproductive and weekly multiplication rate were increased with increase of temperatures. The finite rate of increase was found to be same at 25 and 30°C. The doubling time was decreased with increase in temperature. Even though the oviposition period and longevity were significantly different at 20 and 25°C, the average numbers of eggs laid per day at these temperatures were almost equal (Table 13).

Morphological descriptions of developmental stages

Egg

The freshly laid eggs of *N. sasikalae* were slightly longer than wide, appeared to be smooth, transparent white in colour which gradually turned dirty white (Plate 81). Surfaces of the eggs are rough in nature and the yolk granules were evenly distributed. Under high magnification, egg that was about to hatch shows the miniature larva at one end. The eggs measures 165-195 long and 115-150 wide (Table 14).

Larva

Soon after emergence the larva was glistening white in appearance with 3 pairs of legs (Plate 81). The larva measures 200-255 long, 150-160 wide with 9 pairs of setae on the dorsal shield. Setae Z_5 and s_4 being the longest and measures 85 and 70 respectively. Measurements of other setae: j_1-17 and Z_4 - 50. Setae j_3, j_4, z_2 and z_3 minute. Ventrally, steranal shield and genital shield were clearly visible. ST_4 absent; preanal setae were present (Plate 79).

Protonymph

Dorsal shield 262-275 long, 165-170 wide with 17 pairs of setae and 4 pairs of legs (Table 14). Measurements of setae: j_1-18, j_3-65, z_2-69, j_4-80, j_5-78, j_6-74, z_5-25, s_4-80, Z_1-79, S_2-80, J_2-80, S_4-60, Z_4-80, S_5-20, Z_5-80, J_5-80, r_3- 70, R_1- 69. A clearly visible sternal shield with 3 pairs of sternal setae. Metasternal and genital setae visible without prominent shields; JV_5 85 long. Ventrianal shield with preanal setae; 4 pairs of setae present around the shield (Plate 81).

Deutonymph

Deutonymph was similar to that of adult except in the size of the body (Plate 81). Dorsal idiosoma 305-320 long, 175-190 wide with17 pairs of setae. Measurements of setae : j_1 - 20, j_4, j_5, j_6, J_2 – 80 each, J_5 – 10, j_3, z_2 - 70, z_4 – 80 each, z_5 – 25, Z_1, Z_4, Z_5 – 80 each, s_4 – 85, S_2 – 80, S_4 – 60 and S_5 – 20. Two pairs of sublateral setae r_3 and R_1 – 70 each, lies on lateral integument (Table 14).

Adult

Dorsal shield of female 350-366 long, 200-215 wide with 17 pairs of setae. Males 290-305 long, 175-180 wide (Table 14, Plate 81). Morphological descriptions are given in chapter 6 (Plate 10).

TABLE 14

Measurements of life stages of *N. Sasikalae* sp. nov. (Mean±SD)

Predator	Length	Width
Egg	183.5±9.73	130.5±13.42
Larva	238±18.43	152.6±3.62
Protonymph	267.2±7.34	166.2±2.04
Deutonymph	313±4.83	182.5±4.85
Female	360.3±4.87	209±5.67
Male	294.3±5.81	179±2.10

10.2.2. Developmental studies of *A. dioscoreae* Rahul *et al.*, 2016

Mating behaviour

The mating behaviour of *A. dioscoreae* was found to be similar to that of *N. sasikalae* except in the duration of mating. Mating takes place immediately after the third moult. The time taken for mating lasted for 20 - 25 minutes.

Preoviposition

The mean durations of the preoviposition period of *A. dioscoreae* at 20°C was 3.20±0.13 days for laying the first egg. At 25°C the preoviposition period was 2.70±0.15 whereas at 30°C it was 2.25±0.05 days (Table 17). The females showed feeding preference towards prey egg and larval stage during the preoviposition period.

Oviposition

The average time taken for the deposition of eggs after the process of mating as observed during the study was at 20°C was 20.50±0.22 days; at 25°C was 17.10±0.17 and at 30°C was 14.01±0.05 days (Table 17). The eggs were laid singly on the lower surface of leaves in horizontal position close to the mid rib. The eggs were found glued to the leaf surface by a sticky material secreted by the female. The abdomen of the adult female became swollen and the developing egg could be seen clearly through the skin. It was noticed that a single female was found laying an average number of 1.84±0.05 eggs per day at 30°C whereas it was 1.40±0.05 and 1.60±0.16 at 20 and 25°C (Table 17).

Post oviposition

The average post oviposition period in females reared at 30°C was 4.13±0.03 whereas it was 10.50±0.22 at 20°C and 6.90±0.17 days at 25°C (Table 17). During this period the predator was in inactive phase without consuming any stages of the prey and finally leads to death.

Incubation, hatching and emergence of larva

Freshly laid eggs were transparent, glistening with smooth surface (Plate 98). Then the colour changed to yellowish white before hatching. Hatching process was same as that of *N. sasikalae*. The process of hatching required 20 - 30 minutes to complete. Hatchability and survival (maturity) rates are given in Table 16. Maximum hatchability was noted at 30°C (81%) followed by 25 and 20°C whereas maximum survival rate was noted at 30°C (60%) and at 20 and 25°C the survival rates were same (55%). The mean duration of incubation period of eggs of future males were 2.39±0.02, 1.75±0.00 and 1.38±0.00 days at 20, 25 and 30°C respectively. But the eggs that were about to be females had incubation period of 2.48±0.01, 1.80±0.01 and 1.41±0.01 days (Table 15).

Developmental duration

The developmental duration of all stages of *A. dioscoreae* were shown in Table 15. The developmental duration of all stages were seen to be influenced by temperature. As the temperature decreases the developmental durations were seen to increase.

Larva

The newly emerged larva was crystalline white in colour with 3 pairs of legs (Plate 82). After emergence the larva started moving about on the leaf surface in search of food. They consumed all stages of the prey except deutonymphal and adult stages. Mean duration of male larval development including quiescent stage at 20°C was 2.07±0.03; at 25°C, 1.44±0.02 and at 30°C, 1.23±0.04. In females at 20, 25 and 30°C were 2.21±0.02, 1.52±0.03 and 1.37±0.02 respectively (Table 15).

Protonymph

After the period of first quiescent stage, the larva moulted into the next active protonymphal stage. When compared to the larva, protonymph was larger with 4 pairs of legs. Protonymph was a more voracious feeder than the larva. The total protonymphal period including quiescent stage at 20°C was 2.09±0.06, at 25°C was 1.59±0.04 and 1.32±0.02 days at 30°C in males whereas in females, it was 2.23±0.02, 1.74±0.01 and 1.32±0.02 days at 20, 25and 30°C respectively (Table 15; Plate 80).

Deutonymph

The second quiescent phase got moulted into the deutonymph stage which could be distinguished from the adult predator by its small size and narrow abdomen. Mean duration of male deutonymphal development including quiescent stage at 20°C was 1.58±0.03; at 25°C was 2.30±0.01 and at 30°C, 2.22±0.01 days. In females at 20, 25 and 30°C were 1.62±0.02, 2.35±0.00 and 2.63±0.05 days respectively (Table 15).

Moulting and emergence of larva was same as that of *N. sasikalae*.

Female survival rate, Fecundity, Longevity and Life table

Fecundity and longevity were greatly affected by temperature. When temperature increases longevity decreases whereas in the case of fecundity when temperature increases fecundity also increases (Table 17). Mean longevity of female reared at 20, 25 and 30°C were 34.20±0.44, 26.70±0.36 and 23.88±0.30 whereas male longevity was 26.90±0.52, 20.50±0.22 and 15.64±0.09 days respectively (Table 17). The total number of eggs laid per female at 20°C was 28.69±0.10; at 25°C it was 29.33±0.12 and at 30°C it was 30.20±0.16. Average daily oviposition per females were 1.4 ± 0.05, 1.60 ± 0.16 and 1.84± 0.05 at 20, 25 and 30°C. Sex ratios were noted to be female biased at all the 3 temperatures tested (Table 17).

Life table parameters estimated were given in Table 18. Figure 16 represents age specific survival rate and fecundity rate curves. The intrinsic rate of natural increase, finite rate of increase and weekly multiplication rates were increased when temperature increased. The net reproductive rates were found to be same at 20 and 30°C. The mean generation time decreases when temperature increases. The maximum gross reproductive was at 30°C followed by 20 and 25°C. Doubling time was found to be decreasing when temperature increases.

Morphological descriptions of developmental stages

Egg

The freshly laid eggs are longer than wider, appeared to be transparent and glistening with smooth surface. The yolk granules were evenly distributed within the eggs. The eggs measures 85-115µ long, 70-90µ wide (Table 19; Plate 82).

Larva

The larva measures 110-128 long, 87-95 wide with 9 pairs of setae. Setae Z_5 and s_4 being the longest and measures 85 and 70 long respectively. Measurements of setae; j_1-15, j_4, j_6 - 6 each, j_3 - 18; z_2, z_4 – 5, s_4 – 20, S_2 - 10; Z_5-85; Z_4 - 15. All other setae on dorsal shield absent. Sternal shield bears 3 pairs of setae ST_1, ST_2, ST_3 – 10 each, genital shield and ventrianal shield not clear; 3 pairs of preanal setae and a pair of anal setae present, JV_5 – 15 long.

Protonymph

Protonymphs were yellowish in colour. Dorsal shield 140-155 long, 110-125 wide with 16 pairs of setae and 4 pairs of legs. Measurements of setae: j_1-22, j_4, j_6, j_5, j_2 – 7 each, j_3 – 25, z_2, z_4 – 5 each; s_4 – 50, Z_2 -8, S_2, S_5 – 10 each, Z_4-35, Z_5 - 100, z_5-7. Three pairs of sternal setae, 15 long; 3 pairs of preanal setae and a single pair of anal setae present; JV_5 – 20 long (Table 19; Plate 82).

Deutonymph

Deutonymph was similar to that of adult except in the size of the body. Dorsal idiosoma 190 - 230 long, 150 - 165 wide with 17 pairs of setae. Measurements of setae: j_1-30, j_4, j_2, j_5 - 10 each, j_6 – 10, j_3 -40, z_2, z_4 -10 each, s_4 – 95, Z_1 – 5, S_2, S_4, S_5, - 10, Z_5 – 210, z_5 - 5 and Z_4 – 90; R_3 and R_1 on lateral integument. Ventral region with 3 pairs of sternal setae 20 each; one pair of genital setae, 25 long; one pair of meta sternal setae; 3 pairs of preanal setae; one pair of anal setae; JV5 – 40 long (Table 19; Plate 82).

Adult

Dorsal shield of females 330 - 385 long, 248 - 262 wide with 17 pairs of setae. Males also have 17 pairs of setae, 250-300 long and 225-260 wide (Table 19, Plate 82). Morphological descriptions are given in chapter 6 (Plate 22).

TABLE 19

Measurements of life stages of *A. Dioscoreae* Rahul *et al.,* 2016

(Mean±SD)

Predator	Length	Width
Egg	98.2±10.30	77.5±6.62
Larva	117.8±5.92	92.1±3.17
Protonymph	147.3±4.39	116.8±5.78
Deutonymph	212.5±12.96	115.8±5.02
Female	356±20.92	254.5±4.94
Male	270±16.99	243±12.29

RAHUL. M. P. “STUDIES ON PREDATORY MITES INHABITING VEGETABLE CROPS OF NORTH KERALA” THESIS. PG & RESEARCH DEPARTMENT OF ZOOLOGY, MALABAR CHRISTIAN COLLEGE, CALICUT , UNIVERSITY OF CALICUT, 2018.

CHAPTER 11
DISCUSSION

The result of the survey yielded a total of 62 species of predatory mites belonging to 20 genera, one subgenera and 6 families under 3 suborders, Monogynaspida, Prostigmata and Oribatida. The mites were recovered from 32 species of vegetable plants belonging to 27 genera, 16 families grown in 47 different localities distributed in 6 districts of North Kerala *viz.,* Palakkad, Malappuram, Kozhikode, Wayanad, Kannur and Kasaragod. Out of the 62 species identified 23 species belonging to 11 genera appeared to be new to science.

The suborder Monogynaspida was found represented by 3 families *viz.,* Ascidae, Phytoseiidae and Blattisociidae while Prostigmata comprised of 2 families, Bdellidae and Cunaxidae. The suborder Oribatida, was represented by a single family Acaridae.

Family Ascidae was represented by a single new species under the genus *Asca viz., Asca babithae* sp.nov. But in the case of Blattisociidae, 9 species were recovered of which 5 were new to science. This could be catogorized under two subfamilies *viz.,* Platyseiinae and Blattisociinae. The subfamily Platyseiinae was represented by a new species under the genus *Cheiroseius viz., C. kozhikodensis* sp.nov. Under the subfamily Blattisociinae a total of 8 species were identified under the genus *Lasioseius*, of which 4 were new to science.

However the species diversity of Monogynaspida was remarkable, as the family Phytoseiidae constituted the largest family of predatory mites comprising 42 species out of the total 62 recovered during the study. This observation clearly reveals the prevalence of phytoseiid mites on vegetable plants of Kerala. The family Phytoseiidae has been reported as one of the largest family under Mesostigmata with a total of 2,735 described species from the world which comprised 2,452 valid species (Demite *et al.,* 2015). A total of 211 species under 21 genera, 3 subfamilies were known from India (Gupta and Karmakar, 2015). As far as our knowledge of phytoseiid mites in Kerala is concerned, it is really in its infancy. Mary Anitha (2002) reported 32 species of phytoseiid mites from Kerala of which 12 were new to science. Thereafter Sajna (2015) reported 37 species of which 18 were new taxa. Later, Santhosh (2017) described 38 species of phytoseiid mites inhabiting medicinal plants of North Kerala. The present investigation not only helped to reveal the species diversity of phytoseiid mites from Kerala but also served to add 12 new species to the family. Extensive studies on the predatory potential of these new species serve to open new avenues in the biological control for the effective management of spider mite populations and also small insect pests to certain extend.

Results of the present study reveal the prevalence of species diversity of the genus *Amblyseius* on the various species of vegetable plants surveyed. Most of them were found in association with spider mites and other small insect pests. Phytoseiid mites, especially those belonging to the genera *Amblyseius, Neoseiulus, Phytoseiulus* etc. have been considered as important biological control agents against tetranychids, thrips, white flies and so on (McMurtry and Rodriguez, 1989). The distribution of species of various genera like *Amblyseius, Euseius, Neoseiulus, Paraphytoseius* etc. as observed during the study in association with spider mites and small insects also support the above findings.

Out of 20 genera recovered during the study, genus *Amblyseius* belonging to the subfamily Amblyseiinae was the dominant one represented by19 species of which 6 were new to science thereby forming the most abundant genus of predatory mites surveyed during the study. *Amblyseius channabasavannai* was a species recovered from all the district surveyed indicating its dominance in distribution.

Under the genus *Euseius* 11 species were identified of which 4 were new taxa. *E. finlandicus* was found in association with eriophyid mites and this observation agrees with the findings of Schausberger (1999). The other genera recovered were *Neoseiulus, Paraphytoseius, Scapulaseius, Proprioseiopsis* - 2 species each and *Transeius, Typhlodromips, Phytoseius, Typhlodromus* single species each. Genus *Proprioseiopsis* is a generalist predator of tydeid mites (Momen, 2011), but in the present study *P. peltatus* was found in association with tetranychid and eriophyid mites. During the present study 2 species under the genus *Neoseiulus* were recovered, of which *N. sasikalae* was seen predating upon *T. urticae*.

The suborder Prostigmata was found represented by two families Bdellidae and Cunaxidae. Out of the 3 species identified under the family Bdellidae 2 were new to science *viz., Bdella hispidae* and *Cyta bharathani*. The family Cunaxidae was found represented by 5 species under the subfamilies Cunaxinae and Cunaxoidinae, of which 2 were new taxa. The above two families still remain as relatively unstudied group in India except certain isolated examples, despite their significant predatory role (Gupta, 1985; Mary Anitha, 2002).

The second aspect of the present study was to evaluate the feeding potential and breeding biology of two species of predatory mites *viz., N. sasikalae* and *A. dioscoreae*. *N. sasikalae* was collected from *Canavalia* *gladiata* infested with *T. urticae* whereas *A. dioscoreae* was collected from *Pisum sativum* infested with *T. neocaledonicus*. The laboratory studies on feeding potential was carried out at a temperature of 30±2°C, 70±10% RH.

Results of the feeding studies revealed that both the species preferred immature stages of the prey than adult stage. Prey egg was the most preferred food for all life stages of the predators. Mallik (1982) reported that predatory mite *N. longispinosus* showed preference for *T. ludeni* eggs than any other stages. The order of preference exhibited a decreasing trend *i.e.*, egg > larva > protonymph > deutonymph > adult. Such an order of preference was shown by *Euseius ovalis* to the life stages of prey mite *T. urticae* was reported by Liyaudheen *et al.* 2014. Significantly more prey eggs were consumed than protonymphs, which may be explained by the size difference of the prey and the inability of an egg to exhibit any defence, as indicated by the lower estimated handling time. Mated females are the most effective predators requiring biomass for egg production, whereas males are comparatively ineffective (Shipp and Whitefield, 1991). Nguyen and Shih (2011) reported that the daily predation rate of gravid female is higher than that of male.

In the present study, the larva of *N. sasikalae* was proved as a non feeder of any of the life stages of prey mite, *T. urticae*. This was found supporting the findings of Ibrahim and Palacio (1994). This suggests that larva of *N. sasikalae* have no role in controlling the pest mite *T. urticae*; depite the above observation, the larva of *A. dioscoreae* was found feeding on eggs and larval stages of *T. neocaledonicus*.

The present study demonstrated a significantly higher success of *N. sasikalae* capturing younger stages of *T. urticae* compared with adult prey, possibly due to a cryptic defence mechanism as capture success is typically reduced when the prey resist attack (Holt and Lawton, 1994). The preference to eggs and larvae of prey mites with higher feeding potential may help to control the proliferation of pest population at the field level. Croft and Mcmurtry (1972) reported that several phytoseiid mites were consuming tetranychids eggs.

Amblyseius dioscoreae consumed all stages of *T. neocaledonicus* (except adult and deutonymph) offered in the present study. There was a strong preference for younger stages of the prey, particularly the eggs.

In the present study adult females of *N. sasikalae* consumed maximum rate of eggs and showed a minimum rate of consumption of adult prey (2%). Predator protonymph also consumed egg and larval stages of the prey. All these findings helps in concluding that all stages of *N. sasikalae* except larval stage have enough predatory potential to control the spider mite, *T. urticae.*

The rate of consumption of different stages of the predator on different stages of the prey showed variations. The rate of consumption by the female predator of *N. sasikalae* was maximum on all stages of prey mite. The maximum rate of consumption was observed in the case of prey eggs and minimum was on prey adults. This was true for males also. The predatory efficacy of deutonymphal stage of *N. sasikalae* was higher than male. Here the order of predation was female > deutonymph > male > protonymph, whereas in the case of *A. dioscoreae* the predatory efficacy decreased in the sequence female > deutonymph > protonymph > male > larva. Thus the results of the present study helped to establish the predatory efficiency of females of both predatory mites. It is also evident that role of females and deutonymphs in the control of spider mites will be more effective than that of males and other developmental stages.

In the case of *N. sasikalae,* the adults as well as deutonymphal and protonymphal stages consumed higher number of life stages of the prey, whereas, the adult as well as deutonymphal stages of the prey mite was not found predated by any of the life stages of *A. dioscoreae*. This suggests that *N. sasikalae* is the more efficient predator than *A. dioscoreae*. The results of statistical analysis based on Scheffe's test and ANOVA also support this by confirming that the consumption rates of all stages of *N. sasikalae* except larval stage were significantly higher than that of *A. dioscoreae*, thereby establishing it as a more efficient predator.

Developmental biology of two species of predatory mites, *N. sasikalae* and *A. dioscoreae* were tested at 3 different temperatures, 20±2°C, 25±2°C and 30±2°C, 70±10% RH. The mites are poikilotherms and temperature is the main factor influencing their biology, ecology and population dynamics (Palyvos and Emmanouel, 2009; Hart *et al*., 2002). Each mite species has its optimal temperature for development and reproduction. Such information is useful for assessing the potential of predatory mites to suppress a pest population (Midthassel *et al*., 2013). It was observed that fecundity and longevity were greatly influenced by temperature. When temperature increases longevity decreases whereas in the case of fecundity when temperature increases fecundity also increases.

Developmental duration of all stages was influenced by temperature. When temperature increases from 20°C - 30°C then developmental duration decreases (Canas *et al.,* 2006; Rahman *et al.,* 2013). The oviposition period was significantly shorter when temperature increases. This trend was same in the case of *N. barkeri* (Negm *et al.,* 2014). Developmental duration of immature stages was found to decrease with increase in temperature. This is in agreement with the finding of Raza *et al.* (2005). The total developmental time from egg to adult was longest at 20°C. In the present study shortest developmental period of 3.38±0.01 days for females and 3.15 days for males were recorded at 30°C. During the present study immature development was found to be slightly faster in males than females. This is in agreement with *Euseius* (*Neoseiulus*) *finlandicus* (Broufas and Koveos, 2001). Pre oviposition, oviposition, post oviposition, female longevity, male longevity became shorter with increase in temperature. The intrinsic rate of natural increase is one of the criteria that are extensively used in evaluating the efficacy of many predatory mites against spider mites (Tanigoshi, 1982). The intrinsic rate of natural increase was same 25 and 30°C followed by 20°C. Mean generation time was almost same at 20 and 30°C followed by 25°C.

The net reproductive rate, gross reproductive rate, weekly multiplication rate increased when temperature increased. Whereas doubling time decreased as temperature increased. This is in accordance with the findings of Li *et al.* (2015). As temperature increased duration of oviposition period decreased. The sex ratio of phytoseiid mite is characterized by a female bias (Amano and Chant, 1978; Tanigoshi, 1982). This was true with both species studied. It is showed that temperature did not exert a critical effect on sex determination.

The total developmental period of *A. (Neoseiulus) longispinosus* on *T. urticae* was 4.3 days at 25-28°C (Ibrahim and Palacio, 1994) whereas in the case of *N. sasikalae* the developmental period was 4.13 days at 25°C. This indicates its high multiplication capacity to surpass the multiplication of the prey mite which takes more than 9 days for egg to adult development (Ullah *et al.,* 2012).

In both the species the process of mating could be observed immediately after the emergence of the female. Similar observations were reported by Hoy and Smilanick (1979) who recorded mating in *Amblyseius* species soon after emergence of female. Amano and Chant (1978) reported that multiple matings are required by some species to complete oviposition. In the present study also multiple matings were observed. Eggs of the predators turned dirty white in colour and a similar case was reported by Liang (1969).

Phytoseiid mites are pseudo-arrehenotokous which means that mating is essential for oviposition and repeated mating may be necessary for maximum egg production (Ragusa and Swirski, 1977). Mating occurs by venter to venter position with the smaller male hanging underneath the female with the spermatodactyl inserted into the spermatheca (Momen and El Saway, 1993). The same pattern of mating was observed in the present study also.

The fecundity and daily egg deposition were higher at 30°C. Longevity of both species were found appreciable at 20°C in the present study. These findings indicate the influence of temperature on the biology of predatory mites. Generally mites avoid adverse maximum field temperature by selecting sites with lower temperature (Broufas and Koveos, 2001). Predatory mites manages to live in higher temperature by increasing the intrinsic rate of natural increase, here it is 0.18 and 0.17 at 30°C and 0.12 each at 20°C. This observations were found to be a desirable value in many predatory mites (Rahman *et al.,* 2013).

Among the two species of predatory mites studied, again *N. sasikalae* is considered as the successful candidate for the biological control of spider mites owing to its faster rate of multiplication, oviposition and higher survival rate. All these results point towards the necessity of conservation and augmentation of these two predatory mites for controlling the spider mites infesting vegetable crops.

RAHUL. M. P. “STUDIES ON PREDATORY MITES INHABITING VEGETABLE CROPS OF NORTH KERALA” THESIS. PG & RESEARCH DEPARTMENT OF ZOOLOGY, MALABAR CHRISTIAN COLLEGE, CALICUT , UNIVERSITY OF CALICUT, 2018.

CHAPTER 12

SUMMARY

Predatory mites have received considerable recognition worldwide owing to their potential as biological control agents of phytophagous mites and more recently of insect pests. They are the most important biocontrol agents not only because those are voracious feeders but also because many of them are abundantly available in the fields. Studies show that the members of the predatory mite families like Phytoseiidae, Blattisociidae, Cheyletidae, Cunaxidae, Stigmaeidae, Bdellidae, Tydeidae, Ascidae, Anystidae, Erythraeidae, Hemisarcoptidae, Hydryphantidae, Acaridae, Laelapidae and some Tarsonemidae have proved themselves as potential predators which can suppress the mite pests on various crops.

Among the predatory mites, family Phytoseiidae have received maximum attention globally. Phytoseiids are predominant predators of different phytophagous mites particularly tetranychid and eriophyid mites. Mass multiplication methods have been developed to use these predators in commercial scale on a variety of crops. Several species of phytoseiids are commercially available for pest control.

The first part of the present work deals with taxonomic study performed based on the survey conducted on vegetable crops. The result of the survey yielded a total of 62 species of predatory mites belonging to 20 genera, one subgenus and 6 families under 3 suborders, Monogynaspida, Prostigmata and Oribatida. The mites were recovered from 32 species of vegetable plants belonging to 27 genera, 16 families grown in 47 different localities distributed in 6 districts of North Kerala *viz.,* Palakkad, Malappuram, Kozhikode, Wayanad, Kannur and Kasaragod. Out of the 62 species identified, 23 species belonging to 11 genera appeared to be new to science and 5 of them have been already published.

The suborder Monogynaspida was found represented by 3 families *viz.,* Ascidae, Phytoseiidae and Blattisociidae while Prostigmata comprised of 2 families, Bdellidae and Cunaxidae. The suborder Oribatida, was represented by a single family Acaridae.

Family Ascidae was represented by a single new species under the genus *Asca viz., Asca babithae* sp.nov. But in the case of Blattisociidae, 9 species were recovered of which 5 were new to science. This could be catogorized under two subfamilies *viz.,* Platyseiinae and Blattisociinae. The subfamily Platyseiinae was represented by a new species under the genus *Cheiroseius viz., C. kozhikodensis* sp.nov. Under the subfamily Blattisociinae a total of 8 species were identified under the genus *Lasioseius*, of which 4 were new to science.

However the species diversity of Monogynaspida was remarkable, as the family Phytoseiidae constituted the largest family of predatory mites comprising 42 species out of the total 62 recovered during the study. This observation clearly reveals the prevalence of phytoseiid mites on vegetable plants of Kerala. The present investigation not only helped to reveal the species diversity of phytoseiid mites from Kerala but also served to add 12 new species to the family.

Results of the present study reveal the prevalence of species diversity of the genus *Amblyseius* on various species of vegetable plants surveyed. Most of them were found in association with spider mites and other small insect pests. Phytoseiid mites, especially those belonging to the genera

Amblyseius, Neoseiulus, Phytoseiulus etc. have been considered as important biological control agents against tetranychids, thrips, white flies and so on.

Out of the 20 genera recovered during the study, genus *Amblyseius* belonging to the subfamily Amblyseiinae was the dominant one represented by19 species of which 6 were new to science thereby forming the most abundant genus of predatory mites surveyed during the study. Under the genus *Euseius* 11 species were identified of which 4 were new taxa. The other genera recovered were *Neoseiulus, Paraphytoseius, Scapulaseius, Proprioseiopsis* 2 species each and *Transeius, Phytoseius, Typhlodromus* single species each.

The suborder Prostigmata was found represented by two families Bdellidae and Cunaxidae. Out of the 3 species identified under the family Bdellidae 2 were new to science *viz., Bdella hispidae* and *Cyta bharathani*. The family Cunaxidae was found represented by 5 species under the subfamilies Cunaxinae and Cunaxoidinae, of which 2 were new taxa.

The second aspect of the present study was to evaluate the feeding potential and breeding biology of two species of predatory mites *viz., N. sasikalae* and *A. dioscoreae* preying upon different stages of the pest mites, *T. urticae* and *T. neocaledonicus*. Various developmental stages of the predators were provided with different prey life stages and periodic observations were made to record details on feeding behaviour and potential. The study was carried out in the laboratory conditions of 30±2°C, 70±10% RH.

Results of the feeding studies revealed that both the species preferred immature stages of the prey than adult stage. Prey egg was the most preferred food for all life stages of the predators. The order of preference exhibited a decreasing trend *i.e*., egg > larva > protonymph > deutonymph > adult. In the present study, the larva of *N. sasikalae* was proved as a non feeder of any of the life stages of prey mite, *T. urticae*. Data collected on the above observations were tabulated and analysed statistically based on Scheffe's test, ANOVA etc. and presented. Comparative assessment of the feeding potential of the two species of the predatory mites were also made. Categorised normal plots and graphs were constructed for comparing the feeding rates of each predator stage on different prey stage.

The breeding biology of the above two predators were tested at 3 different temperatures *viz.,* 20±2°C, 25±2°C and 30±2°C at 70±10 RH by adopting leaf floatation technique. 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. During development they show stages of inactiveness called quiescence. Larva bears only 3 pairs of legs. 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.

Pre-oviposition period, oviposition period, fecundity, post-oviposition period and longevity etc. were recorded for the two predatory mites. Besides this incubation, hatching, developmental duration of active stages as well as quiescent stages, moulting etc. were also recorded. Oviposition period was maximum for females reared at 20°C followed by 25 and 30°C. Maximum number of eggs laid by females maintained at 30°C.

Life tables were constructed from the observed age specific survival rate and age specific fecundity rate. The following life table parameters were estimated; intrinsic rate of natural increase, net reproductive rate, gross reproductive rate, mean generation time, finite rate of natural increase, weekly multiplication and doubling time were recorded. The mortality and survival rates were also recorded.

Data obtained were subjected to ANOVA. Means were separated by Duncan's multiple Range Test at $P < 0.05$. Based on the results, comparative assessment of the feeding potential of two species of predatory mites were also made and the results were tabulated and presented graphically. Microphotographs, sketches, measurements etc. were also made for the two predatory mites.

The taxonomic part of the present thesis includes the morphological descriptions of the 62 species of predatory mites recovered during the period of study, supplemented with appropriate figures and photographs. The host range of all new species and already described species are given in the text. Dichotomus keys were also prepared for the separation of subfamilies, tribes, subtribes, genera and species included in the present study.

RAHUL. M. P. “STUDIES ON PREDATORY MITES INHABITING VEGETABLE CROPS OF NORTH KERALA” THESIS. PG & RESEARCH DEPARTMENT OF ZOOLOGY, MALABAR CHRISTIAN COLLEGE, CALICUT , UNIVERSITY OF CALICUT, 2018.

REFERENCES

Afzal, M., Bashir, M.H., Raza, A.B.M. and Kamran, M., 2010. Contribution to the fauna of family Phytoseiidae (Acari) from Pakistan. *Pak. J. Zool*., **42**: 719-723.

Alberti, G. 2002. Ultrastructural investigations of sperm and genital systems in Gamasida (Acari: Anactinotrichida) Current state and perspectives for future research. *Acarologia*, **42**: 107-126.

Albertii, G. and Di Palma, A. 2002. Fine structure of the phytoseiid type sperm access system (Acari: Gamasida: Phytoseiidae). In: Bernini, F., Nannelli, R., Nuzzaci, G. and de Lillo, E. (Eds.), *Acarid Phylogeny and Evolution: Adaptation in Mites and Ticks. Proceedings of the 4th Symposium of EURAAC. Siena, 2000*. Kluwer Academic Publishers, Dordrecht, 241– 252 pp.

Amano, H. and Chant, D.A. 1978. Some factors affecting reproduction and sex ratios in two species of predaceous mites, *Phytoseiulus persimilis* Athias-Henriot and *Amblyseius andersoni* (Chant) (Acarina: Phytoseiidae). *Can. J. Zool*., **56**: 1893-1607.

Aponte, O. and McMurtry, J.A. 1995. Revision of the genus *Iphiseiodes* De Leon (Acari: Phytoseiidae). *Internat. J. Acarol*., **21**: 165-183.

Ashfaq, M. and Chaudhri, W.M. 1984. Two new species of the genus *Forcellinia* Oudemans (Acarina: Acaridae) from Pakistan. *Pak. Entomologist*, **6**: 25-36.

Ashfaq, M. and Sarwar, M. 1999. A new species (Hypopus) of the genus *Lackerbaueria* (Acarina: Acaridae) from Pakistan. *Acarina*, **7**: 53-56.

Atyeo, W.T. 1958. The genus *Bonzia* in the New World. *J. Kans. Entomol. Soc.*, **31**(2), 173-174.

Atyeo, W.T. 1960. A revision of the mite family Bdellidae in North and Central America (Acarina: Prostigmata), *Kans. Univ. Sci. Bull.*, **40**(8): 345-499.

Atyeo, W.T. 1963. New species and records of Bdellidae from Macquarie and the Auckland Islands (Acarina). *Pacific Insects*, **5** (2): 445-450.

Bagheri, M., Paktinat-Saeij, S., Tatiane, M.M.G. and de Castro. 2016. A new species of *Cunaxoides* (Acari: Trombidiformes: Cunaxidae) from Iran. *Persian J. Acarol.*, **5**(1): 1-8.

Bahrami, F., Kamali, K. and Fathipour, Y. 2007. Life history and population growth parameters of *Tyrophagus putrescentiae* (Acari: Acaridae) on *Fusarium graminearum* in laboratory conditions. *J. Entomol. Soc. Iran*. **26**:7-18.

Baker, E.W. and Balock, J.W. 1944. Mites of the family Bdellidae. *Proc. Entomol. Soc. Washington*, **46** (7): 176-184.

Baker, E.W. and Hoffmann, A. 1948. Acaros de la Familia Cunaxidae. *An. Esc. Nac. Cienc. Biol. Mex.*, **5**(3-4): 229-273.

Baker, E.W. and Wharton, G.W. 1952. *An Introduction to Acarology*. Mac Millan Co., New York, 465 pp.

Bashir, M.H., Afzal, M. and Ali, S. 2005. Description of a new cunaxid mite *Cunaxa reticulatus* (Acari) from Pakistan. *Pak. Entomol.,* **27**(2): 57-60.

Bashir, M.H., Afzal, M., Ashfaq, M., Ali, S., Kamran, M. and Honey, S.F., 2014a. Subfamily Coleoscirinae (Acari: Trombidiformes: Cunaxidae), with description of one new species from Pakistan. *J. Insect Sci.,* **14**(1): 1-14.

Bashir, M.H., Afzal, M., Honey, S.F. and Ashfaq, M. 2012. Description of two new species (Hypopi) of genus *Acotyledon* Oudemans (Acarina: Acaridae) from Pakistan. *Pak. J. Zool*., **44**: 745-751.

Bashir, M.H., Honey, S.F., Ali, S., Kamran, M., Khan, B.S. and Afzal, M. 2014b. Two new species of family Acaridae infesting stored products from district Gujranwala, Punjab, Pakistan. *Internat. J. Agric. Biol*., **16**: 347-352.

Beard, J. and Walter, D.E. 1996. Australian Mites of the Genera *Paraphytoseius* Swirski and Shechter and *Paraamblyseius* Muma (Acarina: Phytoseiidae). *Aust. J. Entomol*., **35**: 235-241.

Beaulieu, F. and Walter, D.E. 2007. Predation in perched and forest floor soils: Observations on Australian mesostigmatic mites. *Acarologia*, **47**: 43-54.

Berlese, A. 1903. Acari Nuovi I. *Redia*, **1**: 235-252.

Berlese, A. 1913. Systema Acarorum genera in familiis suis disposita. *Acar. Italica*, **1-2**: 3-19.

Berlese, A. 1916. Centuria prima Sesta di Acari Nuovi. *Redia*, **12**(1): 19-67.

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

Bhattacharyya, A.K. and Bhattacharyya, S.K. 2004. Two new species of the genus *Cheiroseius* Berlese, 1916 (Ascidae: Mesostigmata) from the Indian Thar Desert. *Zootaxa*, **403**: 1-11.

Bhattacharyya, A.K. and Sanyal, A.K. 2002. Three new species and some new records of the genus *Gamasellodes* Athias Henriot (Acarina: Ascidae) from India. *Acarologia*, **42** (3): 229-238.

Bhattacharyya, S.K. 1968. Studies on Indian mites (Acarina : Mesostigmata). 6. Six records and descriptions of nine new species. *Acarologia*, **10**: 527-549.

Bhattacharyya, S.K. 1969. Studies on Indian Mites (Acarina: Mesostigmata). 7· Six species found under bark in North East Frontier Agency. *Zoologische Jahrbucher, Abteilung fur Systematik, Oekologie und Geographie der Tiere,* **96**: 69-80.

Bhattacharyya, S.K. 1972. Studies on Indian mites (Acarina, Mesostigmata). 9. Additional species found under bark in North East Frontier Agency, *Acarologia*, **12**: 272-279.

Bhattacharyya, A.K. and Bhattacharyya, S.K. 2001. A new species of the genus *Lasioseius* Berlese (Acari: Gamasida: Ascidae) from India. *Rec. Zool. Surv. India*, **99**: 23-26.

Bhattacharyya, A.K., Sanyal, A.K. and Bhattacharyya, T. 2000. Two new species of the genus *Lasioseius* (Mesostigmata: Ascidae) from India. *Rec. Zool. Surv. India*, **98**: 93-99.

Bhattacharyya, S.K. 1978. Five new species and a new record of Mesostigmata (Acari) from West Bengal, India. *Indian J. Acarol.,* **2**: 78-87.

Bolland, H.R., Gutierrez, J. and Flechtmann, C.H.W. 1998. *World catalogue of the spider mite family (Acari: Tetranychidae)*. Leiden: Brill Academic Publishers, 392 pp.

Bregetova, N.G. 1977. Family Antennoseiidae Karg, 1965. In: Gilyarov, M.S. (Ed.) *A key to the soil-inhabiting mites, Mesostigmata*. Nauka, Leningrad, 393-406 pp.

Brich, L.C. 1948. The intrinsic rate of natural increase of an insect population. *J. Anim. Ecol*., **17**:15-26.

Britto, E.P.J., Barreto, M.R. and de Moraes, G.J. 2017. Description of the new species of *Asca* Heyden (Acari: Ascidae) from Mato Grosso, North western Brazil. *Internat. J. Acarol.,* **43**(4): 286-290.

Broufas, G.D. and Koveos, D.S. 2001. Development, survival and reproduction of *Euseius finlandicus* (Acari: Phytoseiidae) at different constant temperatures. *Exp. Appl. Acarol*., **25**: 441-460.

Bu, G.S. and Li, L.S. 1987. Two new species of *Pulaeus* from China (Acariformis: Cunaxidae). *J. Southwest Agri. Univ.,* **9**: 22-26.

Bu, G.S. and Li, L.S. 1998. Taxonomic notes on and key to known species of the genus *Rhizoglyphus* (Acari: Acaridae) from China. *Syst. Appl. Acarol*., **3**: 179-182.

Canlas, L.J., Amano, H., Ochiai, N. and Takeda, M. 2006. Biology and predation of the Japanese strain of *Neoseiulus californicus* (McGregor) (Acari: Phytoseiidae). *Syst. Appl. Acarol.,* **11**: 141-157.

Channabasavanna, G.P., Rao, K.N.S. and Ranganath, H.R. 1981. A new *Caloglyphus* (Astigmata: Acaridae) from poultry litter in India with taxonomic comments on the genus. *Indian J. Acarol*., **6**: 57-63.

Chant, D.A. 1955. Notes on mites of the genus *Typhlodromus* Scheuten, 1857 (Acarina: Laelaptidae), with descriptions of the males of some species and the female of a new species. *Can. Entomol*., **87** (9): 496-503.

Chant, D.A. 1958. Immature and adult stages of some British Phytoseiidae Berlese 1916 (Acarina). *J. Linn. Soc. Zool*., **63** (294): 599-643.

Chant, D.A. 1959. Phytoseiid mites (Acarina: Phytoseiidae) I. Bionomics of seven species in south-eastern England. II. A taxonomic review of the family Phytoseiidae, with descriptions of 38 new species. *Can. Entomol*., **91**: (Suppl. 12): 45-164.

Chant, D.A. 1961. An experiment in biological control of *Tetranychus telarius* (L.) (Acarina:Tetranychidae) in a greenhouse using the predacious mite *Phytoseiulus persimilis* Athias-Henriot (Phytoseiidae). *Can. Entomol*., **93**:437-443.

Chant, D.A. 1963. The subfamily Blattisocinae Garman (Aceosejinae Evans) (Acarina: Blattisociidae Garman) (Aceosejidae Baker and Wharton) in North America, with descriptions of new species. *Can. J. Zool*. **41**: 243-305.

Chant, D.A. 1965. Generic concepts in the family Phytoseiidae (Acarina: Mesostigmata). *Can. Entomol*., **97**: 351-374.

Chant, D.A. 1985. Systematics and Taxonomy. In: Helle, W. and Sabelis, M.W. (Eds.) *Spider Mites: their biology, natural enemies and control* (World crop Pests Vol. lB). Elsevier Science Publishers, Amsterdam. 3-32 pp.

Chant, D.A. and McMurtry, J.A 2003. A review of the subfamily Amblyseiinae Muma (Acari: Phytoseiidae). Part I. Neoseiulini new tribe. *Internat. J. Acarol*., **29** (1): 3-46.

Chant, D.A. and McMurtry, J.A. 1994. A review of the subfamilies Phytoseiinae and Typhlodrominae (Acari: Phytoseiidae). *Internat. J. Acarol*., **20**: 223-310.

Chant, D.A. and McMurtry, J.A. 2005. A review of the subfamily Amblyseiinae Muma (Acari: Phytoseiidae): Part VI, The tribe Euseiini n. tribe, subtribes Typhlodromalina n.subtribe, Euseiina n. subtribe and Ricoseiina n. subtribe. *Internat. J. Acarol*., **31**(3): 187-224.

Chant, D.A. and McMurtry, J.A. 2007. *Illustrated Keys and Diagnoses for the Genera and Subgenera of the Phytoseiidae of the World (Acari: Mesostigmata).* Indira Publishing House, West Bloomfield, Michigan, 1-220 pp.

Chant, D.A. and Yoshida- Shaul, E. 1991. Adult ventral setal patterns in the family Phytoseiidae (Acari:Gamasina). *Internat. J. Acarol.,* **17**(3): 187-199.

Chant, D.A. and Yoshida- Shaul, E. 1992. Adult idiosomal setal patterns in the family Phytoseiidae (Acari: Gamasina). *Internat. J. Acarol.,* **18** (3):177-193.

Chant, D.A. and Yoshida-Shaul, E. 1983. A new subfamily Cydnodromellinae, in the family Phytoseiidae (Acarina: Gamasina). *Can. J. Zool*., **64**: 2811-2823.

Chant, D.A. and Yoshida-Shaul, E. 1989. Adult dorsal setal patterns in the family Phytoseiidae (Acari: Gamasina). *Internat. J. Acarol.,* **15**(4): 219-233.

Chaudhri, W.M. 1968. Six new species of mites of the genus *Amblyseius* Berlese from Pakistan. *Acarologia*, **10**(4): 550-562.

Chen, J.X., Guo, J.J., Ci Yi, T. and Jin, D.C. 2018. A new species of *Neobonzia* (Acariformes: Cunaxidae: Coleoscirinae) with a key to species of China. *Syst. Appl. Acarol.,* **23**(1): 104-112.

Chillar, B. S., Gulati, R. and Bhatnagar, P. 2007. *Agricultural Acarology*. Daya Publishing House, Delhi: 355pp.

Chinniah, C. and Mohanasundaram, M. 2001. Five new species of predatory mites (Acarina: Phytoseiidae) from Kerala, India. *Entomon.,* **26**(1): 65-77.

Chmielewski, W. 1999. Acceptance of buckwheat grain as a food by *Tyrophagus putrescentiae* (Schr.) (Acari: Acaridae). *Fagopyrum*, **16**: 95-97.

Christian, A. and Karg, W. 2006. The predatory mite genus *Lasioseius* Berlese, 1916 (Acari, Gamasina). *Abh. Ber. Naturkundemus.Görlitz*, **77**(2): 99-250.

Corpuz-Raros, L.A. 1996. Philippine predatory mites of the family Cunaxidae (Acari). Genus *Pulaeus* Den Heyer with records of two species from Central Kalimantan, Borneo and Java, Indonesia. *Philippine Entomologist*, **10**(2): 119-138.

Corpuz-Raros, L.A. and Garcia, R.C. 1996. Philippine predatory mites of the family Cunaxidae (Acari). 4. Genera *Pseudobonzia* Smiley and *Scutascirus* Den Heyer. *Philippine Entomologist*, **10**(1): 15-28.

Croft, B.A. and McMurtry, J.A. 1972. Minimum release of *Typhlodromus occidentalis* to control *Tetranychus mcdanieli* on apple. *J. Eco. Entomol.*, **65**: 188-191.

Croft, B.A., Luh, H.K. and Schausberger, P. 1999. Larval size relative to larval feeding, cannibalism of larvae, egg or adult female size and larval - adult setal patterns among phytoseiid mite species. *Exp. Appl. Acarol.*, **23**(7): 599 - 610.

Darvishzadeh, I. and Kamali, K. 2009. Faunistic survey of Mite (Acari) associated with Grapevine in Safiabad, Khuzestan, Iran. *J. Entomol. Res.*, **1**(1): 79-93.

De Leon, D. 1957. Three new *Typhlodromus* from southern Florida (Acarina: Phytoseiidae). *Fla. Entomol.*, **40**: 143-144.

De Leon, D. 1958. Four new *Typhlodromus* from southern Florida (Acarina: Phytoseiidae). *Fla. Entomol.*, **41**: 73-76.

De Leon. 1963. A new genus and twelve new species of mites from Mexico and Southeast United states (Acarina: Blattisociidae). *Fla. Entomol.*, **46**(2): 197-207.

Deevey, E.S., 1947. Life tables for natural populations of animals. *Q. Rev. Bio.*, **22**: 283-314.

Demite, P.R., McMurtry J.A. Moraes G.J. 2014. Phytoseiidae Database: a website for taxonomic and distributional information on phytoseiid mites (Acari). *Zootaxa,* **3795**: 571-577.

Demite, P.R., Moraes, G.J. de, McMurtry, J.A., Denmark, H.A. and Casteho, R.C. 2015. Phytoseiidae database. Available from: www.lea.esalq.usp. br/phytoseiidae (accessed 14.11.2015).

Den Heyer, J. 1975. A new genus *Cunabdella* (Prostigmata: Acari) with a description of a new species from the Ethiopian Region. *Acarologia*, **16**(4): 664-670.

Den Heyer, J. 1976. *Scutascirus*, a new Cunaxid genus (Prostigmata: Acari) from South Africa. *Wetenskaplike Bydraes van die Pu vir Cho Reeks B. Natuurwetenskappe*, **93**: 1-10.

Den Heyer, J. 1977. Six new species of *Pseudobonzia* Smiley, 1975 (Prostigmata: Acari) from the Ethiopian Region. *J. Entomol. Soc. S. Afri.*, **40**(2): 171-194.

Den Heyer, J. 1978a. Four new species of *Armascirus* gen. nov. (Prostigmata: Acari) from the Ethiopian Region. *J. Entomol. Soc. S. Afri.*, **41**(2): 217-239.

Den Heyer, J. 1978b. Coleoscirinae, a new cunaxid subfamily and two new South African species of *Coleoscirus* Berlese, 1916 (Prostigmata: Acari). *Acarologia*, **20**(4): 522-541.

Den Heyer, J. 1979a. Notes on the cunaxid genus *Dactyloscirus* (Actinedida: Acarida) with descriptions of two new species from the Ethiopian Region. *Phytophylactica*, **11**: 87-98.

Den Heyer, J. 1979b. *Pulaeus*, a new cunaxid genus (Prostigmata: Acari). *Acarologia*, **21**(1): 18-31.

Den Heyer, J. 1979c. *Scutopalus*, a new cunaxid genus from the Ethiopian Region (Prostigmata: Acari). *Acarologia*, **21**: 187–193.

Den Heyer, J. 1980a. Six new species of subfamily Coleoscirinae (Cunaxidae: Actinedida: Acarida). *Phytophylactica*, **12**: 105-128.

Den Heyer, J. 1980b. *A new classification system for the family Cunaxidae (Actinedida: Acarida)*. Publications of the University of the North Series A, **23**: 1–12.

Den Heyer, J. 1981. *Systematics of the family Cunaxidae Thor, 1902 (Actinedida: Acarida)*. Publications of the University of the North, Series A, **24**: 1-19.

Den Heyer, J. 2011. Cunaxid Base: Family Cunaxidae Database (version Jan 2010). In: Bisby, F.A., Roskov, Y.R., Orrell, T.M., Nicholson, D., Paglinawan, L.E., Bailly, N., Kirk, P.M., Bourgoin, T., Baillargeon, G. Ouvrard, D. (Eds.), Species 2000 and ITIS Catalogue of Life: 24th October 2011. Species 2000: Reading, UK. Digital resource.

Den Heyer, J. and Castro, T.M.M.G. 2008 . A new cunaxid genus with descriptions of two new species from Brazil (Acari: Prostigmata: Bdelloidea: Cunaxidae). *Zootaxa*, **1731**: 42-50.

Den Heyer, J. and Castro, T.M.M.G. 2009. Four new cunaxoidinae genera (Acari: Prostigmata: Cunaxidae) and the description of two new Neotropical species. *Zootaxa*, **2140**: 1-15.

Den Heyer, J., Ueckermann, E.A. and Khanjani, M. 2013. Iranian Cunaxidae (Acari: Prostigmata: Bdelloidea). Part III. Subfamily Cunaxoidinae. *J. Nat. His*., **47**(31-32): 2049-2070.

Denmark, H.A. 1982. Revision of *Galendromus* Muma, 1961 (Acarina: Phytoseiidae). *Internat. J. Acarol*., **8**: 133-167.

Denmark, H.A. and Andrews, K.L. 1981. Plant associated Phytoseiidae of El Salvador, Central America (Acarina: Mesostigmata). *Fla. Entomol*., **64**: 147-58.

Denmark, H.A. and Kolodochka, L.A. 1993. Revision of the genus *Indoseiulus* Ehara (Acari: Phytoseiidae). *Internat. J. Acarol*., **19**(3): 249-257.

Denmark, H.A. and Muma, M.H. 1970. Some phytoseiid mites of Paraguay (Phytoseiidae: Acarina). *Fla. Entomol*., **53**: 219-227.

Denmark, H.A. and Muma, M.H. 1989. A revision of the genus *Amblyseius* Berlese, 1914 (Acari: Phytoseiidae). *Occ. Pap. Fla. St. Coll. of Arthropods*, **4**: 1-149.

Denmark, H.A. and Rather, A.Q. 1984. Revision of the genus *Typhlotoctomis* Muma, 1961 (Acarina: Mesostigmata). *Internat. J. Acarol*., **10**(3): 163-177.

Denmark, H.A. and Rather, A.Q. 1996. Revision of the genus *Neoseiulella* Muma (Acari: Phytoseiidae). *Internat. J. Acarol*., **22**(1): 43-77.

Denmark, H.A. and Welbourn, W.C. 2002. Revision of the genera *Amblydromella* Muma and *Anthoseius* de Leon (Acari: Phytoseiidae). *Internat. J. Acarol.,* 28(4): 291-316.

Dhooria, M.S. 1981. Feeding behavior of predatory mites, thrips and beetles of the citrus mite *Eutetranychus orientalis*. *Acarol. Newslett*., **10**: 4-6.

Diaz, A., Okabe, K., Eckenrode, C., Villani, M. and Oconnor, B. 2000. Biology, ecology and management of the bulb mites of the genus *Rhizoglyphus* (Acari: Acaridae). *Exp. Appl. Acarol*., **24**: 85-113.

Doker, I. 2018. Redescription of two new records and description of *Neoseiulella kazaki* sp.nov. (Acari: Phytoseiidae) from Turkey. *Syst. Appl. Acarol.,* **23**(1): 113-122.

Doker, I., Kazak, C. and Karut, K. 2017. Three new species of the family Phytoseiidae (Acari: Mesostigmata) from Turkey. *Zootaxa*, **4243**(3): 565-576.

Duges, A. 1834. Recerches sur L'ordre des Acarines III. *Anni. Sci*., **2**(2): 1-46.

Dusbabek, F., Literak, I., Capek, M. and Havlicek, M. 2007. Ascid mites (Acari: Mesostigmata: Ascidae) from Costa Rican humming birds (Aves: Trochilidae), with description of three new species and a key to the *Proctolaelaps belemensis* species group. *Zootaxa*, **1484**: 51-67.

Eghballan, A.H., Khanjani, M. and Ueckermann, E. 2017. Two new species of *Spinibdella* and *Odontoscirus* (Acari: Prostigmate: Bdellidae) from Western Iran. *Acarologia*, **57**(4): 779-789.

Ehara, S. 1967. Phytoseiid mites from Okinawa Island (Acarina: Mesostigmata). *Mushi*, **40**(6): 67-82.

Ehara, S. 2002. Phytoseiid mites (Acari: Phytoseiidae) from Sumatra with a description of a new species. *Acta Arachnologica*, **51**: 125-133.

EL-Banhawy, E.M. 1975. Biology and feeding behaviour of the predatory mite, *Amblyseius brazili* (Mesostigma: Phytoseiidae). *Entomophaga*, **20**: 353-360.

El-Banhawy, E.M. and Knapp, M. 2011. Mites of the family Phytoseiidae Berlese from Kenya (Acari: Mesostigmata). *Zootaxa*, **2945**: 1-176.

Eliaderani, F.K., Nemati, A. and Kocheili, F. 2013. Some mesostigmatic mites from Iran with their world distribution. *J. Crop Prot*. **2** (2): 127-138.

El-Laithy, A.Y.M., and El-Sawi, S.A. 1998. Biology and life table parameters of the predatory mite *Neoseiulus californicus* fed on different diet. *Zeitschrift fur Pflanzenkrankheiten und Pflanzenschutz,* **105**(5): 532-537.

Evans, G.O. 1957. An introduction to the British Mesostigmata (Acarina) with keys to families and genera. *J. Linn. Soc. Land. (Zool.)* **43**: 203-259.

Evans, G.O. 1958. A revision of the British Aceosejinae (Acarina: Mesostigmata). *Proc. Zool. Soc. Lond*., **131**: 177-229

Evans, G.O. 1963. Observation on the chaetotaxy of the legs in the free-living Gamasina (Acari: Mesostigmata). *Bull. Br. Mus. Nat. Hist*., *(Zool.)*, **10**: 275-303.

Evans, G.O. 1992. *Principles of Acarology*. CAB International, Wallingford, 563 pp.

Evans, G.O. and Hyatt, K.H. 1960. A revision of the Platyseiinae (Mesostigmata: Aceosejidae) based on material in the collections of the British Museum (Natural History). *Bull. Br. Mus. Nat. Hist*., *(Zool.)*, **6**: 27-101.

Ewing, H.E. 1917. New Acarina. Part II, Description of new species and varieties from Iowa, Missouri, Illinois, Indiana and Ohio. *Bull. Am. Mus. of Nat. Hist*., **37**(2): 149-172.

Ewing, H.E., 1914. The common red spider or spider mite. *Bull. Ore. Agric. Exp. Stn.* **121**: 95 pp.

Ezulike, T.O. and Odebiyi, J.A. 1985. Life history of *Amblyseius fustis* (Pritchard and Baker), an indigenous predator of the cassava red mite, *Oligonychus gossypii* (Zacher) in South Western Nigeria. *Insect Sci. Appl*., **6**(2): 193- 197.

Fan, Q.H. and Zhang, Z.Q. 2004. Revision of *Rhizoglyphus* Claparede (Acari: Acaridae) of Australasia and Oceania. *Syst. Appl. Acarol. Soc. London*, 374 pp.

Fan, Q.H. and Zhang, Z.Q. 2007. *Tyrophagus* (Acari: Astigmata: Acaridae). *Fauna of New Zealand*, **56**: 291 pp.

Faraji, F., Çobanoğlu, S. and Çakmak, I. 2011. A checklist and a key for the Phytoseiidae species of Turkey with two new species records (Acari: Mesostigmata). *Internat. J. Acarol.,* **37**(1): 221-243.

Fayaz, B.A. and Khanjani, M. 2013. Redescription of four species of phytoseiid mites (Acari: Mesostigmata) associated with alfalfa farms in western Iran. *Persian J. Acarol*., **2**(1): 9-24.

Ferguson, C.A. 1985. A new genus and species of mite (Acari: Acaridae) from Mexico. *Zool. J. Linn. Soc*. **85**(3): 275-290.

Fisher, J.R., Skvarla, M.J., Bauchan, G.R., Ochoa, R. and Dowling, A.P.G. 2011. *Trachymolgus purpureus* sp. n., an armored snout mite (Acari, Bdellidae) from the Ozark Highlands: morphology, development, and key to *Trachymolgus* Berlese. *Zookeys*, **125**: 1–34.

Garman, P. 1948. Mite species from apple trees in Connecticut. *Bull. Conn. Agric. Exp.Sta*., **520**: 1-27.

Gerson, U., Smiley, R.L. and Ochoa, R. 2003. *Mites (Acari) for pest control*. Oxford, Blackwell Science, (Wash. D. C.), 539pp.

Ghai, S. and Menon, R.M.G. 1969. Taxonomic studies on Indian mites of the family Phytoseiidae (Acarina). Two new genera and species of Phytoseiidae. *Ori. Ins.,* **3**(4): 347-352.

Gilliat, F.C. 1935. Some predators of the European red mite *Paratetranychus pilosus* C. and F., in Nova Scotia. *Can. J. Res.,* **13**: 19-38

Goff, M.L. 1987. A catalog of Acari of the Hawaiian Islands. *Hawaii Inst. Trop. Agric. Res. Ser*., **75**: 1–75.

Gondim, Jr., M.G.C. and Moraes, G.J. 2001. Phytoseiid mites (Acari: Phytoseiidae) associated with palm trees (Arecaceae) in Brazil. *Syst. Appl. Acarol.,* **6**(1):65-94.

Gorgi, M.K., Fathipour, Y. and Kamali, K. 2009. The effect of temperature on the functional response and prey consumption of *Phytoseius plumifer* (Acari: Phytoseiidae) on the two- spotted spider mite. *Acarina,* **17**(2): 231-237.

Gotoh, T., Yamaguchi, K. and Mori, K. 2004. Effect of temperature on life history of the predatory mite *Amblyseius (Neoseiulus) californicus* (Acari: Phytoseiidae). *Exp. Appl. Acarol*., **32**: 15-30.

Grandjean, F. 1938. Observations sur les Bdelles (Acariens). *Ann. Soc. Entomol. Fr.,* **107**: 1-24.

Grandjean, F. 1939. La chaetotaxie des pattes chez les Acaridiae. *Bull. Soc. Zool. Fr*., **64**(1): 50-56.

Griffiths, D.A., Atyeo, W.T., Norton, R.A. and Lynch, C.A. 1990. The idiosomal chaetotaxy of astigmatid mites. *J. Zool*., **220**(1): 1-32.

Gupta, S.K. 1970. Preliminary note on the plant mites (Acarina) from West Bengal. *Sci. and Cult*., **36**: 98-99.

Gupta, S.K. 1974. A review of Indian phytoseiid mites with a note on their zoogeography. *Entomol. Rec*., **86**: 141–144.

Gupta, S.K. 1975. Mites of the genus *Amblyseius* (Acarina: Phytoseiidae) from India with descriptions of eight new species. *Internat. J. Acarol*., **1**(2): 26-45.

Gupta, S.K. 1977a. Description of four species of *Amblyseius* Berlese from India. *Entomol. Mon. Mag*., **112**: 53-58.

Gupta, S.K. 1977b. Phytoseiidae (Acarina: Mesostigmata) of Andaman Nicobar islands with descriptions of eight new species. *Ori. Ins.,* **11**(4): 623-638.

Gupta, S.K. 1977c. New species and records of *Typhlodromus* and *Phytoseius* from Eastern India (Acarina: Phytoseiidae). *Indian J. Acarol*., **2**: 1-11.

Gupta, S.K. 1977d. Some undescribed and little known species of *Amblyseius* (Acarina: Phytoseiidae) from Western and Northern India. *Indian J. Acarol*., **1**: 28-37.

Gupta, S.K. 1978a. Studies on Indian Phytoseiidae (Acarina: Mesostigmata): some *Typhlodromus* mites from South India with descriptions of new species. *Bull. Zool. Surv. India*, **1**(1): 47-54.

Gupta, S.K. 1978b. Some new species and records of *Amblyseius* from Eastern India (Acari: Phytoseiidae). *Indian. J. Acarol*., **2**(2): 60-77.

Gupta, S.K. 1978c. Some Phytoseiidae from South India with descriptions of five new species. *Ori. Ins*., **12**(3): 327-338.

Gupta, S.K. 1979. The genus *Paraphytoseius* Swirski and Shechter with a new subgenus and one new species from India. *Bull. Zool. Surv. India*, **2**(1): 79-82.

Gupta, S.K. 1980a. New species of *Iphiseius* Berlese and *Paraamblyseius* Muma from India (Acarina: Phytoseiidae). *Entomol*. mon. Mag., **115**: 213-218.

Gupta, S.K. 1980b. New species and new record of *Paraamblyseius* Muma (Acarina, Phytoseiidae) from India. *Entomol. mon. Mag*., **116**: 33–36.

Gupta, S.K. 1980c. New species and records of *Phytoseius* mites (Acarina: Mesostigmata) from South India. *Bull. Zool. Surv. India*. **3**(1–2): 51–54.

Gupta, S.K. 1980d. Three new Phytoseiidae (Acarina) from North East India. *Entomol. Mon. Mag*., **115**: 209-212.

Gupta, S.K. 1981a. On a collection of Phytoseiidae (Acari: Mesostigmata) from Himachal Pradesh (India), with descriptions of two new species. *Indian J. Acarol*., **5**: 32-36.

Gupta, S.K. 1981b. Phytoseiidae (Acari: Mesostigmata) from Jammu and Kashmir, India, with descriptions of five new species. *Indian J. Acarol*., **5**: 37-49.

Gupta, S.K. 1982a. Phytoseiidae (Acari) of Kumaon and Garhwal Himalaya. *Indian J. Acarol*., **6**(1-2): 24-34.

Gupta, S.K. 1982b. On a collection of Phytoseiidae (Acarina: Mesostigmata) from Madhya Pradesh and Uttar Pradesh with description of a new species of *Phytoseius* Ribaga. *Rec. Zool. Surv. India*. **79**: 367-371.

Gupta, S.K. 1985. Hand Book: *Plant Mites of India*. Zool. Surv. India, Culcutta. 520 pp.

Gupta, S.K. 1986. Fauna of India (Acari: Mesostigmata). Family Phytoseiidae. *Zool. Surv. India*, *Calcutta*, 350 pp.

Gupta, S.K. 1987. A taxonomic review of oriental Phytoseiidae with key to genera and species. *Rec. Zool. Surv. India, Occ. Pap.*, **95**: 1-167.

Gupta, S.K. 1991. Studies on predatory prostigmatid mites of northeast India with descriptions of new species and new records from India. *Rec. Zool. Surv. India*, **88** (2): 207-239.

Gupta, S.K. 1995. Plant mite (Acari). In: Fauna of Meghalaya, State fauna series, 4, Part 2: 17-50.

Gupta, S.K. 2000. *Arachnida: Acari: Prostigmata, Astigmata and Mesostigmata. In: Fauna of Tripura, State fauna series 7*, Part **2**: 7-31.

Gupta, S.K. 2002. A Monograph on Plant Inhabiting Predatory Mites of lndia Part I Orders: Prostigmata, Astigmata and Cryptostigmata. *Mem. Zool. Surv. India*, **19**(2): 1-183.

Gupta, S.K. 2003. A monograph on plant inhabiting predatory mites of India. Part II: Order: Mesostigmata. *Mem. Zool. Surv. India*, **20**(1):1-185.

Gupta, S.K. and Ghosh, S.K. 1980. Some Prostigmatid Mites (Acarina) from Andaman and Nicobar Islands. *Rec. Zool. Surv. India*, **77**: 189-213.

Gupta, S.K. and Karmakar, K. 2015. An updated checklist of Indian Phytoseiid mites (Acari: Mesostigmata) In: *Rec. Zool. Surv. India*, **115(**1): 51-72.

Gupta, S.K., Dhooria, M.S. and Sidhu, A.S. 1971. A note on predators of citrus mites in Punjab. *Sci. and Cult*., **37**(10): 484.

Gwiazdowicz, D.J. 2003. Description of *Iphidozercon poststigmatus* sp. n. (Acari: Ascidae) with a key to Palearctic species of the genus *Iphidozercon*. *Biologia Bratislava,* **58**(2): 151–154.

Gwiazdowicz, D.J. 2004. *Iphidonopsis sculptus* gen. n. sp. n, a new mite genus of the family Ascidae (Acari, Gamasida) from Poland. *Biol*., **59**(2): 153-158.

Haines, C.P. 1981. Laboratory studies on the role of an egg predator, *Btattisocius tarsalis* (Berlese) (Acari: Ascidae), in relation to the natural control of *Ephestia cautella* (Walker) (Lepidoptera, Pyralidae) in warehouses. *Bull. Entomol. Res*., **71**: 555 -574.

Hallan J. 2005. Synopsis of the Described Arachnida of the World - http://insects.tamu.edu/research /collection/hallan/acari/0ReportHi.htm

Halliday, R.B., Walter, D.E. and Lindquist, E.E. 1998. Revision of the Australian Ascidae (Acarina: Mesostigmata). *Invert. Tax*.**12**: 1-54.

Hart, A.J., Bale, J.S., Tullett, A.G., Worland, M.R. and Walters, K.F.A. 2002. Effects of temperature on the establishment potential of the predatory mite *Amblyseius californicus* McGregor (Acari: Phytoseiidae) in the UK. *J. Ins. Physiol*., **48**(6): 593-599.

Helle, W. and Sabelis, M.W. 1985. Spider mites: their biology, natural enemies and control. *Amsterdam, Elsevier*, V 1B, 458p.

Hennann, J.F. 1804. III Ciron (*Scirus*). *Mem. Apteologique*, 60-62pp.

Hernandes, F.A. 2013. Revision of Nathan Banks' type specimens of Bdellidae Dugès (Acari: Trombidiformes) of the Museum of Comparative Zoology, Cambridge. *Internat. J. Acarol*., **39** (1): 1-9.

Hernandes, F.A. and Feres, R.J.F. 2006. *Tetrabdella neotropica* (Acari: Bdellidae), a new genus and species from Brazil. *Zootaxa*, **1135**: 57-68.

Hernandes, F.A., Bernardi, L.F.O. and Ferreira, R.L. 2011. Snout mites from caves in Brazil, with description of a new species. *J. Nat. His*., **45**: 799-812.

Hernandes, F.A., Daud, R.D. and Feres, R.J.F. 2007. A new species of *Hexabdella* (Acari: Bdellidae) from Brazil. *Zootaxa*, **1501**: 57-63.

Hernandes, F.A., Daud, R.D. and Feres, R.J.F. 2008. Two new species of Bdellidae (Acari: Prostigmata) from Brazil. *Internat. J. Acarol*., **34**(3): 259-266.

Hernandes, F.A., Skvarla, M.J., Fisher, J.R., Ashley, D., Ronald Ochoa, P.G., Ueckermann, E.A. and Bauchan, G.R. 2016. Catalogue of snout mites (Acariformes: Bdellidae) of the world, *Zootaxa*, **4152** (1): 1-83.

Holt, R.D. and Lawton, J.H. 1994. The ecological consequences of shared natural enemies. *Ann. Rev. Ecol. Syst.,* **25**: 495-520.

Horn T.B., Körbes J.H., Granich, J., Senter, M. and Ferla, N.J. 2016. Influence of laying hen systems on the mite fauna (Acari) community of commercial poultry farms in southern Brazil. *Parasitol. Res*., **115**(1): 355-366.

Hoy, M.A. and Smilanick, J.M. 1979. A sex pheromone produced by immature and adult females of the predatory mite, *Metaseiulus occidentalis* (Acarina: Phytoseiidae). *Entomol. Exp. Appl*., **26**: 291-300.

Hughes, A. M. 1976. *The mites of stored food and houses*. Tech. Bull. No. 9, Ministry of Agriculture Food and Fisheries, London, 400 P.

Ibrahim, Y.B. and Palacio, V.B. 1994. Life history and demography of the predatory mite *Amblyseius longispinosus* Evans. *Exp. Appl. Acarol*., **18**(6): 361-369.

Ibrahim, Y.B. and Rahiman, R.E.A. 1997. Influence of prey density, species and developmental stages on the prdatory behaviour of *Amblyseius longispinosus* (Acari: Phytoseiidae). *Entomophaga*, **42**(3): 319-327.

Inayatullah and Shahid M. 1993. Three new predatory mites of genus *Pseudocunaxa* Smiley (Acarina: Cunaxidae) from Pakistan. *Pak. J. Zool*., **25**(4): 315-320.

Inayatullah and Shahid, M. 1989. Two new predatory mites of genus *Neocunaxoides* Smiley (Acarina: Cunaxidae) from Pakistan. *Pak. J. Zool*., **21**(3): 221-228.

Jafari, S., Fathipour, Y. and Faraji, S. 2011. Redescriptions of *Amblyseius meghriensis* Arutunjan and *Typhlodromus haiastanius* (Aruntujan) with discussion on using preanal pores as a character in the subgenus *Anthoseius* (Mesostigmata: Phytoseiidae). *Internat. J. Acarol*., **37**: 244-254.

Jagadish, P.S. and Nagesha Chandra, B.K. 1979. Biology of *Typhlodromips tetranychivorus* (Acari: Phytoseiidae) on red palm mite *Raoiella indica* (Acari: Tenuipalpidae) in Contributions to Acarology in India, *Proc. of the First All India Symposium on Acarol*., Apr. 23-25, 1979, Bangalore, Chanabasavanna, G.P. (Ed.). *Acarol. Soc. India*, Bangalore, India. pp 173-179.

Johnston, D.E. and Bruce, W.A. 1965. *Tyrophagus neiswanderi*, a new acarid mite of agricultural importance. *Res. Bull. (Ohio Agric. Exp. Stn.)*, **977**: 1-17.

Jose, V.T., Shah, A.H. and Patel, C.B. 1989. Feeding potentiality of some important predators of the spider mite, *Tetranychus macfarlani*, a pest on cotton, 357-360 pp. In: Channabasavanna, G.P. and Viraktamath, C.A. (Eds.), *Progress in Acarol*., Vol.2.

Kalúz, S. and Fenda, P. 2005. *Mites (Acari, Mesostigmata) of the family Ascidae of Slovakia*. Institute of Zoology, Slovak Academy of Sciences, NOI Press, Bratislava, 168 P.

Kaluz, S. and Josef, S. 2018. Two new species of the family Cunaxidae (Acari: Prostigmata) from Madagaskar. *Zootaxa*. **4378**(4): 549-562.

Kapoor, V.C., Paul, M. and Kapur, J. 1997. Seasonal inicidence of mite species infesting okra (*Hibiscus esculentus*) and brinjal (*Solanum melongena*) in Punjab. *Indian J. Agric. Sci*., **67**: 324-324.

Karg, W. 1969. Untersuchungen zur Kenntnis der Ascaoidea Karg, 1965 (Acarina, Parasitiformes) mit der Beschreibung von acht neuen Arten. *Zool. Anz*., **182** (5/6): 393-406.

Karg, W. 1971. *Acari (Acarina), Milben, Unterordnung Anactinochaeta (Parasitiformes). Die freilebenden Gamasina (Gamasides), Raubimilben*. *Die Tierwelt. Deutschlands*, **59**: 344-451.

Karg, W. 1980. Die Raubmilbengattung *Lasioseius* Berlese, 1916. *Zoologische Jahrbücher Abteilung für Systematik, Ökologie und Geographie der Tiere*, **107**: 344-367.

Karg, W. 1981. Die Raubmilbengattung *Cheiroseius* Berlese, 1916. *Zool. Jb. Syst*. **108**:51-69.

Karg, W. 1993. Acari (Acarina), Milben. Parasitiformes (Anactinochaeta). Cohors Gamasina Leach. Raubmilben. *Die Tierwelt Deutschlands*, **59**: 1-523.

Karg, W. and Huhta, V. 2009. Taxonomic remarks on Phytoseiidae Berlese (Acari: Mesostigmata), with description of three new species from Finland. *Internat. J. Acarol* ., 35(6): 511-520.

Karmakar, K. and Gupta, S. K. 2014. Description of four new species of phytoseiid mites (Acari:Mesostigmata) from West Bengal. *Rec. Zool. Surv. India*, **114** (Part-4): 687-700.

Kazak, C., Yildix, S. and Sekeroglu, E. 2002. Biological characteristics and life tables of *Neoseiulus umbraticus* Chant, (Acarina: Phytoseiidae) at three constant temperatures. *J. Pest Sci.*, **75**: 113-117.

Kazemi, S. and Rajaei, A. 2013. An annotated checklist of Iranian Mesostigmata (Acari), excluding the family Phytoseiidae. *Persian J. Acarol*., **2** (1): 63-158.

Kethley, J. 1990. Acarina: Prostigmata (Actinedida). In: Dinel D.L. (Ed.). *Soil biology guide*. New York: John Wiley and Sons. 667-757 pp.

Klimov, P.B. 1999. A description of a new genus, *Umakefeq* gen. n., including three new species of mycetophagous acarid (Acariformes, Acaridae) from Eastern Palaearctic. *Acarina*, **7**(2): 93-106.

Klimov, P.B. 2000. A review of acarid mites of the tribe Caloglyphini (Acaridae: Acariformes) with description of a new genus and species from Siberia and Russian Far East. *Vestink Zool. Ukraine*, **34**: 27-35.

Klimov, P.B. and OConnor, B.M. 2003. Phylogeny, historical ecology and systematics of some mushroom-associated mites of the genus

Sancassania (Acari: Acaridae) with new generic synonymies. *Invert. Syst*., **17**: 469-514.

Klimov, P.B., OConnor, B.M. 2009. Conservation of the name *Tyrophagus putrescentiae*, a medically and economically important mite species (Acari: Acaridae). *Internat. J. Acarol*., **35** (2): 95-114.

Koch, C. L. 1839. Deutschlands Crustaceen, Myriapoden und Arachniden. *F. Pustet, Regensburg*, **24**: 10-11.

Kostiainen, T.S. and Hoy, M.A. 1996. *The Phytoseiidae as Biological Control Agents of Mite Pests and Insects. A Bibliography*. University of Florida, Gainesville. 355 pp.

Kreiter, S. and de Moraes, G.J. 1997. Phytoseiid mites (Acari: Phytoseiidae) from Guadaloupe and Martinique. *Fla. Entomol*., **80**: 376-382.

Kreiter, S. and Tixier, M.S. 2006. A new genus and a new species of Phytoseiid mites (Acari: Mesostigmata) from Southern Tunisia with analysis and discussion on its phylogenetic position. *Zootaxa,* **1237**: 1-18.

Kumar, D., Raghuraman, M. and Singh, J. 2015. Population dynamics of spider mite, *Tetranychus urticae* Koch on okra in relation to abiotic factors of Varanasi region. *J. Agrometeorology*, **17**(1): 102-106.

Laing, J.E. 1969. Life history and Life table of *Metaseiulus occidentalis*. *Ann. Entomol. Soc. Amer*., **62**(5): 978-982.

Latreille, P.A. 1795. Observations sur la variété des organes de la bouche des tiques, et distribution méthodique des insectes de cette famille d'après les caractères établis sur la conformation de ces organes. *Magasin Encyclopédique, J. des Sci. des Lettres et des Arts,* **4**: 15-20.

Latreille, P.A. 1796. *Précis des Caractères génériques des Insects, diposés dans un Ordre naturel*. Brive: del'lmprimerie de F. Bourdeaux. 192P.

Latreille, P.A. 1802. Histoire naturelle générale et particulière des crustacés et des insectes. Ouvrage faisant suite à l'histoire naturelle générale et paticulière, composé par Leclerc de Buffon, rédigée par C. S. Sonnini. Familles naturelles des genres. Tome troisième. 3-467pp.

Lee, S.W., Lee, M.H., Choi, K.M. and Hyun, J.S. 1987. Development, fecundity and prey consumption of the predaceous phytoseiid mite, *Amblyseius longispinosus* (Evans), under different temperatures. *Res. Rep. Rural Dev. Admin*. *Plant Environ. Mycol. Farm Prod. Utiliz. Korea Republic*, **29**(1): 277-281.

Li, Y.T., Qi Jiang, J.Y., Huang, Y.Q., Wang, Z.H. and Zhang, J.P. 2015. Effects of temperature on development and reproduction of *Neoseiulus bicaudus* (Phytoseiidae) feeding on *Tetranychus turkestani* (Tetranychidae). *Syst. Appl. Acarol.,* **20**(5): 478-490.

Lin, L.Z. and Zhang, Y.Z. 2010. Bdelloidea of China: a review of progress on systematics and biology, with a checklist of species. *Zoosymposia*, **4**: 42-50.

Lindquist, E.E. 2003. Observations on mites of the Subfamily Platyseiinae, with description of two new species of *Platyseius* from North America (Acari: Mesostigmata: Ascidae). In: Smith, I.M. (Ed.). An *Acarological Tribute to David R. Cook* (from Yankee Springs to Wheeny Creek). Indira Publishing House, West Bloomfield, MI, 155-182 pp.

Lindquist, E.E. and Evans, G.O. 1965. Taxonomic concepts in the Ascidae, with a modified setal nomenclature for the idiosoma of the Gamasina (Acari: Mesostigmata). *Mem. Entomol. Soc. Can.*, **47**: 1-64.

Lindquist, E.E. and Makarova, O.L. 2012. Review of the mite subfamily Arctoseiinae Evans with a key to its genera and description of a new genus and species from Siberia (Parasitiformes, Mesostigmata, Ascidae). *ZooKeys*, **233**: 1-20.

Lindquist, E.E. and Moraza, M.L. 2010. Revised diagnosis of the family Blattisociidae (Acari: Mesostigmata: Phytoseioidea), with a key to its genera and description of a new fungus- inhabiting genus from Costa Rica. *Zootaxa*, **2479**: 1-21.

Lindquist, E.E. and Moraza, M.L. 2012. A new genus of fungus-inhabiting mites of the family Blattisociidae (Acari: Mesostigmata: Phytoseioidea) from Costa Rica, with an updated key to genera of the subfamily Blattisociinae. *Redia*, **95**: 9-19.

Lindquist, E.E. and Moraza, M.L. 2016. A new genus of mites of the subfamily Platyseiinae associated with Azteca ant galleries in Cecropia trees in Costa Rica (Acari: Mesostigmata: Blattisociidae). *Acarologia*, **56** (3): 293-319.

Lindquist, E.E. 1994. Some observations on the chaetotaxy of the caudal body region of gamasine mites (Acari: Mesostigmata), with a modified notation for some ventrolateral body setae. *Acarologia*, **35**:323-326.

Lindquist, E.E., and Chant, D.A. 1964. A redescription of *Aceodromus* Muma and its transfer to the Blattisociinae (Acarina: Blattisociidae). *Can. Entomol.*, **96**: 500-507.

Lindquist, E.E., Krantz, G.W. and Walter, D.E. 2009. Order Mesostigmata. In: Krantz, G.W. and Walter, D.E. (Eds.) *A Manual of Acarology*, 3rd edition. Texas Tech University Press, Lubbock, Texas, 124-232pp.

Linnaeus, C. 1758. Systema naturae per regna tria naturae, secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis. *Editio decimal, reformata. Laurentius Salvius: Holmiae.* ii 824P.

Liyaudheen, C.K.M., Rekha, P.K., Anitha, K. and Ramani, N. 2014. Feeding potential of *Euseius ovalis* (Evans) (Acaridae: Phytoseiidae) on *Tetranychus macfarlanei* Baker and Pritchard (Acardiae: Tetranychiae) infesting okra, *J. Biopest.*, **7**: 148-151.

Lofego, A.C., de Moraes, G.J. and McMurtry, J.A. 2000. Three new species of phytoseiid mites (Acari: Phytoseiidae) from Brazil. *An. Soc. Entomol. Brasil*, **29**: 461-467.

Ma, L.M. and Yin, X. 1999. Four new species and two new record genera of the family Aceosejidae from China (Acari, Gamasina). *Acta Arachnologica Sinica*, **8**: 1-7.

Mackauer, M. 1983. Quantitative assessment of *Aphidius smithi* (Hymenoptera: Aphidiidae): fecundity, intrinsic rate of increase, and functional response. *Can. Entomol*., **115**: 399-415.

Mahjoori, M., Hajizadeh, J. and Mozhdehi M.R.A. 2015. A checklist and a key for the phytoseiid and blattisociid mites (Acari: Phytoseioidea) associated with olive orchards in Guilan Province Iran. *Entomofauna*, **36**(8): 97-108.

Mahunka, S. 1973. Auf Insekten lebende Milben (Acari: Acarida:Tarsonemida) aus Afrika II. *Acta Zool. Hung*., **19**: 289-337.

Mahunka, S. 1974. Auf Insekten lebende Milben (Acari: Acarida: Tarsonemida) aus Afrika III. *Acta Zool. Hung*., **20**: 137-154.

Mahunka, S. 1978. Schizoglyphidae fam. n. and new taxa of Acaridae and Anoetidae (Acari: Acarida). *Acta Zool. Hung*., **24**: 107-131.

Mahunka, S. 1979. The examination of myrmecophilous Acaroidea mites based on the investigations of Dr. C. W. Rettenmeyer (Acari: Acaroidea) II. *Acta Zool. Hung*., **25**: 311-356.

Makarova, O.L. and Lindquist, E.E. 2013. A new species of the gamasid mite genus *Arctoseius* Thor, 1930 (Parasitiformes, Mesostigmata, Ascidae) from Russia with a key to the multidentatus species group. *ZooKeys*, **313**: 9-24.

Mallik, B. 1982. Interaction studies of *Tetranychus ludeni* Zacher (Acari: Tetranychidae) with two predaceous phytoseiids and development model. Ph.D. Thesis, Univ. Agri. Sciences, Bangalore.

Mallik, B. and Channasavanna, G.P. 1983. Life history and life tables of *Tetranychus ludeni* and its predator *Amblyseius longispinosus* (Acari: Tetranychidae, Phytoseiidae). *Indian J. Acarol*., **8**: 1-12.

Mallik, B., Ramesh Vaidya, H. and Harishkumar, M. 1999. Mass production of the predator *Amblyseius longispinosus* (Acaria: Phytoseiidae) - A model. *J. Acarol*., **15** (1 and 2):15-17.

Manjunatha, M., Hedge, M., Patil, B.V. and Lingappa, S. 1995. Predatory potential and mass rearing of *Amblyseius longispinosus* on cotton spider mite. *Abst. Fifth National Symposium Acarology,* 72 P.

Marcic, D., Peric, P., Petronijevic, S. and Drobnjakovic, T. 2011. Cyclic ketoenols - acaricides and insecticides with a novel mode of action. Pestic. *Phytomed*, **26**(3):185-195.

Mary Anitha, L.S. 2002. Studies on Acarine predators of North Kerala, India, Ph.D Thesis, University of Calicut, Kerala.

Mary Anitha, L.S. 2005. Two new species of predatory mites (Acarina: Phytoseiidae) from Kerala (India). *Uttar Pradesh J. Zool*., **25**(1): 81-84.

Mary Anitha, L.S. 2006a. A new species of predatory mites of the genus *Amblyseius* (Acarina: Phytoseiidae) from Kerala, India. *Geobios*, **33**: 188-190.

Mary Anitha, L.S. 2006b. A new species of predatory mites (Acarina: Phytoseiidae: *Amblyseius*) from Kerala. *J. Entomol. Res*., **30**(1): 179-181.

Mary Anitha, L.S. 2006c. A new species of predatory mite, *Amblyseius* (Acarina: Phytoseiidae) from stored coffee berries. *J. biosci*., **14**: 39-41.

Mary Anitha, L.S. 2006d. Description of a new species of predatory mite, *Amblyseius* (Acarina: Phytoseiidae) from Kerala, India. *J. Zool. Soc. Kerala.* **11**(1 and 2):12-14.

Mary Anitha, L.S. and Ramani, N. 2006. Two new species of predatory mites (Acarina: Phytoseiidae) from Kerala, India, India. *Zoo's. Print J.* **21**(6): 2267-2269.

Mary Anitha, L.S. and Ramani, N. 2007. A new species of predatory mite of the genus *Amblyseius* (Acarina: Phytoseiidae) from Kerala, *India. J. Ecobiol*., **20**(3): 215-218.

Mašán, P. 1998. A new soil mite species of the genus *Zerconopsis* from Slovakia (Acarina: Ascidae). *Fragmenta entomologica (Roma)*, **30**: 75-78.

Masan, P. and Halliday, B. 2016. A new species of *Hoploseius* (Acari: Blattisociidae) associated with the red-belted bracket fungus, *Fomitopsis pinicola* (Polyporaceae) in Slovakia. *Syst. Appl. Acarol*., **21**(8):1145-1156.

Maslov, S.I. 2014. A redescription of *Pontoppidania pontica* (Acari: Astigmatina: Acaridae) inhabiting algal debris on seashores of black and azov seas of crimea (Ukraine). *Vestnik zoologii*, **48**(2): 167-172.

McMurtry J.A. and Scriven G.T. 1975. Population increase of *Phytoseiulus persimilis* on different insectary feeding programs. *J. Econ. Entomol*., **68**(3): 319-321.

McMurtry, J.A. and Croft, B.A. 1997. Life-styles of phytoseiid mites and their roles in biological control. *Ann. Rev. Entomol*., **42**:291-321.

McMurtry, J.A. and de Moraes, G.J. 1989. Some phytoseiid mites from Peru with descriptions of four new species (Acari: Phytoseiidae). *Internat. J. Acarol*., **15**: 179-188.

McMurtry, J.A. and Johnson, H.G. 1966. An ecological study of the spider mite *Oligonychus punicae* (Hirst) and its natural enemies. *Hilgardia*, **37**: 363-402.

McMurty, J.A. and Rodriguez, J.G. 1989. Nutritional ecology of phytoseiid mites. In: Slansky, F. and Rodriguez, J.G. (Eds.), *Nutritional Ecology of Insects, Mites and spiders*. Wiley and sons, New York, 609-644pp.

Mehranian, M. 2014. A new species of the genus *Cheiroseius* Berlese (Acari: Mesostigmata: Ascidae) from Iran. *Biologia*, **69**: 350-353.

Meyer, M.K.P. and Ryke, P.A.J. 1959. Cunaxoidea (Acarina: Prostigmata) occurring on plants in South Africa. *Ann. Mag. Nat. His*., **13**(2): 369-384.

Midthassel, A., Leather, S.R. and Baxter, I.H. 2013. Life table parameters and capture success ratio studies of *Typhlodromips swirskii* (Acari: Phytoseiidae) to the factitious prey *Suidasia medanensis* (Acari: Suidasidae). *Exp. Appl. Acarol*., **61**(1): 69-78.

Mohamed, A.E.M. 2013. Biological aspects and life table parameters of predator gamasid ascid mite, *Blattisocius dentriticus* (Berlese) (Acari: Gamasida: Ascidae), Egypt. *Acad. J. Biolog. Sci*., **6**(2): 97-105.

Momen, F.M. 2011. Life tables and feeding habits of *Proprioseiopsis cabonus*, a specific predator of tydeid mites (Acari: Phytoseiidae and Tydeidae). *Acarina*, **19**: 103-109.

Momen, F.M. and El-Saway, S.A. 1993. Biology and Feeding Behavior of the Predatory Mite, *Amblyseius swirskii* (Acari: Phytoseiidae). *Acarologia*, **34**(3):199-204.

Moraes, G.J. and McMurtry, J.A. 1981. Biology of *A. citrifolis* (Denmark and Muma) (Acarina-Phytoseiidae). *Hilgardia*, **49**(1):1-29.

Moraes, G.J. and Mesa, N.C. 1988. Mites of the family Phytoseiidae (Acari) in Colombia, with descriptions of three new species. *Internat. J. Acarol*., **14**: 71-88.

Moraes, G.J., Britto, E., Mineiro, J.L. and Halliday, B. 2016. Catalogue of the mite families Ascidae Voigts and Oudemans, Blattisociidae Garman and Melicharidae Hirschmann (Acari: Mesostigmata). *Zootaxa*, **4112**(1):1-299.

Moraes, G.J., Denmark, H.A. and Guerrero, J.M. 1982. Phytoseiid mites of Colombia. *Internat. J. Acarol*., **8**: 15-22.

Moraes, G.J., Lopes, P.C. and Fernando, L.C.P. 2004. Phytoseiid mites (Acari: Phytoseiidae) of coconut growing areas in Sri Lanka, with descriptions of three new species. *J. Acarol. Soc. Japan*., **77**: 1-20.

Moraes, G.J., McMurtry, J.A. and Denmark, H.A. 1986. *A catalog of the mite family Phytoseiidae. References to taxonomy, synonymies, distribution and habitat*. Embrapa, Brasilia, 353pp.

Moraes, G.J., Mesa, N.C. and Braun, A. 1991. Some phytoseiid mites of Latin America (Acari: Phytoseiidae). *Internat. J. Acarol.,* **17**(2): 117-139.

Moraes, G.J., Venancio, R., Santos, V.L.V. and Paschoal, A. D. 2015. Potential of Ascidae, Blattisociidae and Melicharidae (Acari: Mesostigmata) as biological control agents of pest organisms. In: Carrillo, D., Moraes, G.J. de and Peña, J.E. (Eds.), *Prospects for Biological Control of Plant Feeding Mites and Other Harmful Organisms*, Progress in Biological Control Series, **19**: 33-75

Mori, H. and Saito, Y. 1979. Biological control of *Tetranychus urticae* Koch (Acarina: Tetranychidae) populations by three species of phytoseiid mites (Acarina: Phytoseiidae). *J. Fac. Agric. Hokkaido Univ.*, **59**: 303-311.

Muhammad, T. and Chaudhri, W.M. 1991. Two new cunaxid mites of the genus *Armascirus* (Acari: Cunaxidae) from Pakistan. *Entomologyist*, **13**: 50-55.

Muhammad, T. and Chaudhri, W.M. 1992. Two new mite species of genus *Coleoscirus* Berlese (Acarinia: Cunaxidae) from Pakistan. *Pak. J. Zool.*, **24**(4): 309-311.

Muma, M.H. 1955. Phytoseiidae (Acarina) associated with citrus in Florida. *Ann. Entomol. Soc. Am.*, **48**(4): 262-272.

Muma, M.H. 1961. Subfamilies, genera and species of Phytoseiidae (Acarina: Mesostigmata). *Bull. Fla. Sta. Mus.*, **5**: 267-302.

Muma, M.H. 1962. New Phytoseiidae (Acarina: Mesostigmata) from Florida. *Fla. Entomol.*, **45**(1): 1-10.

Muma, M.H. and Denmark, H.A. 1970. Phytoseiidae of Florida. *Arthropods of Florida and neighboring land areas*. **6**: 1-150.

Muma, M.H. and Denmark, H.A., 1968. Some generic descriptions and name changes in the family Phytoseiidae (Acarina: Mesostigmata). *Fla. Entomol.*, **51**(4): 229-240.

Muraleedharan, N. 1995. Biological control of tea pests. pp. 97-108. In: Ananthakrishnan, T.N. (Ed.). *Biological Control of Social Forest and Plantation Crops Insects*. Oxford and IBH Publishing Co. Pvt. Ltd, New Delhi. 97-108pp.

Narayanan, E.S., Kaur, R.B. and Ghai, S. 1960. Importance of some taxonomic characters in the family Phytoseiidae Berlese, 1916, with new records and descriptions of species. *Proc. Nat. Inst. Sci. India*, **26**(6): 384-394.

Nasr, A.E., Abo-Shnaf, R. and Momen, F. 2017. Two new species of the genus *Platyseius* (Acari: Mesostigmata: Blattisociidae) from Egypt. *Acarina*, **25** (1): 61-73.

Negm, M.W., Alatawi, F.J. and Aldryhim, Y.N. 2014. Biology, Predation, and Life Table of *Cydnoseius negevi* and *Neoseiulus barkeri* (Acari: Phytoseiidae) on the Old World Date Mite, *Oligonychus afrasiaticus* (Acari: Tetranychidae). *J. Insect Sci*., **14** (177): 1-6.

Nemati, A., Gwiazdowicz, D.J., Riahi, E. and Mohseni, M. 2012. Catalogue of the Iranian mesostigmatid mites, part 2: Family Blattisociidae. *Internat. J. Agri. Crop Sci*., **4**(14): 1005-1011.

Nesbitt, H.H.J. 1944. Three new mites of the subfamily Rhizoglyphinae. *Can. Entomol*., **76**: 21-27.

Nesbitt, H.H.J. 1945. A revision of the family Acaridae (Tyroglyphidae) order Acari, based on comparative morphological studies. *Can. J. Res*., **23**: 139-188.

Nesbitt, H.H.J. 1949. Six new Mexican mites of the subfamily Rhizoglyphinae, Acarina. *Pan. Pacific Entomol*., **25**: 57-70.

Nesbitt, H.H.J. 1951. A taxonomic study of the Phytoseiidae (Family Laelaptidae) predaceous upon Tetranychidae of economic importance. *Zool. Verh*., **12**: 1-64.

Nguyen, T.V. and Shih C.I.T. 2011. Predation rates of *Neoseiulus womersleyi* (Schicha) and *Euseius ovalis* (Evans) feeding on tetranychid mites

(Acari: Phytoseiidae, Tetranychidae). *J. Asia Pac. Entomol.*, **14**: 441-447.

Norton, R.A. 1998. Morphological evidence for the evolutionary origin of Astigmata (Acari: Acariformes). *Exp. Appl. Acarol.*, **22**(10): 559-594.

Oudemans, A.C. 1903. Notes on Acari. *Tijkdschr. Ent.*, **45**:147 P.

Oudemans, A.C. 1905. Acarologische Aanteekeningen XVII. *Entmol. Ber.*, **1 23**: 222-226

Oudemans, A.C. 1926a. Acari von Svalbard fruher Spitzbergen. *Tijkdschr. Ent.*, **69**: 106-127.

Oudemans, A.C. 1926b. Kritisch Historisch overzicht der Acarologie. *Tijkdschr. Ent.*, **69**: 500 pp.

Oudemans, A.C. 1937. Namensanderung. *Archive fur Naturgeschichte (new series)*. **6**: 662 P.

Oudemans, A.C., 1924. Acarologische Aanteekeningen, 74. *Entomol. Ber.*, **136**: 249-260

Oudemans. A.C. 1923. Acarologische Aanteekeningen. LXX. *Entomol. Ber.*, **6**(129): 133-208.

Paktinat-Saeej, S., Bagheri, M., Saboori, A. and Ueckermann, E.A. 2014. *Hexabdella persiaensis* sp. nov. (Acari: Prostigmata: Bdellidae) as a first new species of the genus *Hexabdella* from Asia. *Internat. J. Acarol.*, **40**: 1-6.

Palyvos, N.E. and Emmanouel, N.G. 2009. Temperature dependent development of the predatory mite *Cheyletus malaccensis* (Acari: Cheyletidae). *Exp. Appl. Acarol.*, **47**(2): 147-158.

Pande, Y.D. and Sharma, B.L. 1986. Effect of temperature on the biology of red cucurbit mite *Tetranychus neocaledonicus* Andre, Revista. *Brasileira de Biologia*, **46**(3): 597-602.

Parrot, P.J., Hodgkiss, H.E. and Schoene, W.J. 1906. The *Eriophyidae* Part I. The apple and pear mites. *New York Agr. Expt. Sta. Bull.*, **283**: 302-303.

Patil, R.S. and Nandihalli, B.S. 2009. Efficacy of promising botanicals against red spider mite on brinjal. *Karnataka J. Agri. Sci*., **22**: 690-692.

Prasad, R. and Singh, J. 2007. Estimation of yield loss in okra caused by red spider mite (*Tetranychus urticae* Koch) under the influence of two dates of sowing. *J. Entomol*., **69** (2): 127-132.

Prasad, R. and Singh, J. 2011. Status of mite pest fauna prevailing in brinjal agro-ecosystem. *Uttar Pradesh J. Zool*., **31**: 15-23.

Prasad, R., Prasad, U.K., Sathi, S.K. and Prasad, D. 2007. Mite pest scenario and their status associated with common vegetables, In: Kumar AC (Eds.) *Envo Informatics*, Daya Publishing House, New Delhi, 63-88pp.

Prasad, V. 1965. Soil mites of Sabour (Bhagalpur). *Sci. and Cult*., **31**(9): 495-496.

Prasad, V. 1974. *A Catalogue of Mites of India*. Indira Acarology Publishing House, Ludhiana, 320 pp.

Prasad, V. 2012. *Checklist of Phytoseiidae of the World (Acari: Mesostigmata)*. Indira Publishing House, West Bloomfield, Michigan, USA, 1063 pp.

Pruszynski, S. and Cone, W.W. 1973. Biological observations of *Typhlodromus occidentalis* (Acarina: Phytoseiidae) on hops. *Ann. Entomol. Soc. Am*., **66**: 47-51.

Puttaswamy, 1978. Studies on the ecologyof *Tetranychus ludeni* Zacher (Acari: Tetranychidae) and its intraction with the predator *Typhlodromips tetranychivorus* Gupta (Acari: Phytoseiidae). Ph.D. Thesis, Univ. Agril. Sciences, Bangalore.

Quayle, H. J. 1912. Red spiders and mites of citrus trees. *Calif. Agr. Expt. Sta. Bull*., **234**: 483-530.

Ragusa, S. and Swirski, E. 1977. Feeding habits, postembryonic and adult survival, mating, virility and fecundity of the predaceous mite *AmbIyseius swirski* (Acarina: Phytoseiidae) on some coccids and mealy bugs. *Entomophaga*, **22**: 383-392.

Rahman, V.J., Babu, A., Roopakkumar, A., and Perumalsamy, K. 2013. Life table and predation of *Neosieulus longispinosus* (Acari: Phytoseiidae) on *Oligonychus coffea* (Acari: Tetranychidae) infesting tea. *Exp. Appl. Acarol*., **60**(2): 229-240.

Rahmani, H., Kamali, K. and Faraji, F. 2010. Predatory mite fauna of Phytoseiidae of northwest Iran (Acari: Mesostigmata). *Turkish J. Zool*., **34**: 497-508.

Rahul, M.P. and Mary Anitha. L.S. 2016a. A new species of predatory mite of the genus *Amblyseius* (Acari: Phytoseiidae) from Kerala, India. *Internat. J. Pure Appl. Zool*., **4**(4): 302-305.

Rahul, M.P. and Mary Anitha. L.S. 2016b. Survey of predatory mites inhabiting vegetable crops in Kozhikode district, Kerala. *Uttar Pradesh J. Zool*., **36**(2): 117-120.

Rahul, M.P. and Mary Anitha. L.S. 2017. Two New Species of *Amblyseius* (Acari: Phytoseiidae) from Kerala, India. *Biological forum – an Internat. J.,* **9**(2): 224-226.

Rahul, M.P., Mary Anitha, L.S. and Santhosh, P.P. 2017. A new species of predatory mite (Prostigmata: Cunaxidae: *Cunaxa*) from Kerala, India. *Biological forum – an Internat. J.,*. **9**(1): 7-9.

Rahul, M.P., Mary Anitha. L.S. and Santhosh, P.P. 2016. A new species of phytoseiid mite (Acari: Phytoseiidae) from Kerala, India. *J. Adv. Zool*., **37**(2): 75-79.

Rai, S.N. and Indrajeet. 2011. Note on phytophagous mites associated with common vegetables in Varanasi and Azamgarh district of Eastern Uttar Pradesh. *J. Ins. Sci*., **24**(2): 199-200.

Rao, N.S.K. 1982. *Caloglyphus karnatakaensis* sp. nov.(Acari: Acaridae) from India with taxonomic comments on the genus *Caloglyphus*. *Ind. J. Acarol.,* **7**: 37-43.

Rather, A.Q. 1984. New species and new record of the genus *Amblydromella* Muma (Acarina: Phytoseiidae) from India. *Entomol. Mon. Mag*., **120**: 103-107.

Rather, A.Q. 1985. New species and new record of *Phytoseius* Ribaga (Acari: Phytoseiidae) from India. *Acarologia*, **26**(1): 13-16

Rather, A.Q. 1986. Some phytoseiid mites from India. *Rivista Pararisit*. **41**(1–2): 291-295.

Rather, A.Q. 1987. Some new records and new species of phytoseiid mites (Acarina: Mesostigmata) from Jammu and Kashmir, India. *Z. Angew Zool*., **74**(3): 353-359.

Rather, A.Q. 1989. Studies on mites (Acari) associated with stone fruits in subtropical, temperate and cold arid zones of Jammu and Kashmir. *Prog. Acarol*., **2**: 183-189.

Rather, A.Q. 1999. Mites associated with viticulture in India with a key for their identification. *J. Acarol*., **15**(1-2): 18-24.

Raza, A.B.M., Afzal, M. and Bashir, M.H. 2005. Biology of *Euseius septicus* Chaudhari (Acari: Phytoseiidae) preying on two spotted spider mite, *Tetranychus urticae* (Acari : Tetranychidae) at different temperatures. *Pak. Entomol.*, **27**: 85-88.

Reicherta, M.B., Toldia, M., Rodea, P.A., Ferlaa, J.J. and Ferlaa, N.J. 2017. Biological performance of the predatory mite *Neoseiulus idaeus* (Phytoseiidae): a candidate for the control of tetranychid mites in Brazilian soybean crops. *Braz. J. Biol*., **77**(2): 361-366.

Reisen, W.K. and Mullen, G.R. 1978. Ecological observations on acarine associates (Acari) of Pakistan mosquitoes (Diptera:Culicidae). *Environ. Entomol*., **7**:769-776.

Ribaga, C. 1904. Gamasidi planticoli. *Riv. Patol. Veg*., **10**: 175-178.

Rishi, N.D. and Rather, A.Q. 1983. *Euseius vigmis*, a new species (Phytoseiidae: Acari) from Jammu and Kashmir. *Entomon*, **6**(3): 303-305.

Rishi, N.D. and Rather, A.Q. 1984. Records of mites and their relationship with the forest habitats in the Kashmir Valley (Jammu and Kashmir

State). In: High altitude Entomology and Wild Life Ecology, *Zool. Surv. India*, 151-153.

Rocha, M.S., Rodrigues, E.N.L. and Ferla, N.J. 2015. New species and records of cunaxid mites (Acari: Cunaxidae) from soil in Southern Brazil. *Zootaxa*, **3981**(1): 56-70.

Rowell H.J., Chant D.A., Hansell, R.I.C. 1978. The determination of setal homologies and setal patterns on the dorsal shield in the family Phytoseiidae (Acarina: Mesostigmata). *Can. Entomol.*, **110**: 859-876.

Sadana, G. L., Singh, S.P. and Kumari, M. 1990. Phytoseiid mites associated with fruit trees in Panjab, India. *Acar. Newsl.*, **17 and 18**: 16 P.

Saito, Y. and Mori, H. 1981. Parameters related to potential rate of population increase of three predacious mites in Japan (Acarina: Phytoseiidae). *Appl. Entomol. Zool.*, **16** (1): 45-47.

Sajna, H. 2015. Studies on phytoseiid mites of North Kerala, Ph.D Thesis, University of Calicut, Kerala.

Sajna, H. and Mary Anitha, L.S. 2013. Survey of Predatory Mites (Acari: Phytoseiidae) Associated With Economically Important Plants of North Kerala. *Biological Forum – An International Journal*, **5**(2): 119-122.

Sajna, H., and Mary Anitha, L.S. 2015. Description of a new species of predatory mite (Acari: Phytoseiidae: Mesostigmata) from Kerala, India. *J. Threatened Taxa*, **7**(5): 7164-7167.

Samsinak, K. 1966. Die Neuerrichtung der Gattung *Cosmoglyphus* Oudemans, 1932, gleichzeitigein Beitragzum Problem der “Copra Itch”. *Zool. Anz.*, **176**: 27-42.

Samsinak, K. 1980. *Caloglyphus rodriguezi* new species with taxonomic remarks on the tribe Caloglyphini (Acari: Acaridae). *Mitt. aus dem Zool. Mus. Ber*., **56**(2): 201-206.

Samsinak, K. 1988. *Sancassania ultima* a new mite of the tribe Caloglyphini (Acari: Acaridae). *Entomol. Mitte. aus dem Zool. Mus. Hamburg*, **9**(133): 159-164.

Santhosh, P.P. 2017. Studies on predatory mites inhabiting medicinal plants of North Kerala, Ph.D Thesis, University of Calicut, Kerala.

Santhosh, P.P. and Mary Anitha, L.S. 2016. A new species of *Amblyseius* Berlese (Acari: Phytoseiidae) from Kerala, India. *Entomon*, **41**(1):67-70.

Sarwar, M. and Ashfaq, M. 2004. Two new *Caloglyphus* Berlese mites (Astigmata: Acaridae) recorded in Pakistan. *Pak. J. scient. indust. Res*., **47**:455-461.

Sarwar, M. and Ashfaq, M. 2006. A new mite pest (Acarina: Acaridae) detected from stored commodity in the Punjab province of Pakistan. *Acarologia*, **46**: 115-120.

Sarwar, M. and Ashfaq, M. 2010a. Contribution toward the description of a new *Caloglyphus* Berlese mite (Acarina: Acaridae) from collections in Pakistan. *Biol. Divers. Consserv*., **3**: 45-50.

Sarwar, M. and Ashfaq, M. 2010b. Description of a new *Caloglyphus* Berlese mite (Acari: Acaridae) infesting pulses in Pakistan. *The Nucleus*, **47**: 61-66.

Sarwar, M. and Ashfaq, M. 2012. Studies on taxonomy of a new mite species in the genus *Caloglyphus* berlese (Acarina: Acaridae) recognized in Pakistan. *J. Cereals and Oilseeds*, **3**(2): 15-20.

Sarwar, M., Ashfaq, M. and Akbar, S., 2005. Numerical taxonomy of two new mites species of the genus *Caloglyphus* Berlese (Acaridae) from Pakistan. *Pak. J. scient. Indust. Res*., **48**: 345-353.

Sarwar, M., Ashfaq, M. and Nadeem, S., 2009. On the identity of new acarid mites in genus *Caloglyphus* Berlese occurring in Asian expanse (Pakistan) (Acarina: Acaridae). *J. Agric. biol. Sci.,* **1**: 38-47.

Sarwar, M., Bashir, M.H., Khan, B.S. and Khan, M.A. 2013. Description of two new species of genus *Caloglyphus* Berlese (Acari: Acaridae) from Pakistan. *Pak. J. Zool*., **45**(1): 101-106.

Sarwar, M., Bashir, M.H., Khan, M.A., Honey, S.F., Afzal, M. and Ali, Y., 2015. New acarid mites of the genus *Acotyledon* Oudemans (Acari: Acaridae) from Pakistan. *Pak. J. Agri. Sci*., **52**(3): 723-730.

Satpathy, J.M. and Mania, P.K. 1969. New record of a phytoseiid mite, *Amblyseius finlandicus* occurring on sugarcane with notes on its life history and binomics. *J. Bom. Nat. Hist. Soc.,* **66**(3): 648-655.

Schausberger, P. 1991. Comparative studies on the life history, life table parameters and the reproduction capacity of *Amblyseius abberrans* Oudemans and *Amblyseius finlandicus* Oudemans (Acari: Phytoseiidae). *Pflanzenschut zberinchte*, **52**(2): 53-71.

Schausberger, P. 1999. Juvenile survival and development in *Euseius finlandicus*, *Typhlodromus pyri* and *Kampimodromus aberrans* (Acari:

Phytoseiidae) feeding on con- and heterospecific immatures. *Exp. Appl. Acarol*., **23**: 297-307.

Schuster, R.O. and Pritchard, A.E. 1963. Phytoseiid mites of California. *Hilgardia*, **34**(7): 191-285.

Schweizer, J. 1961. Die Landmilben der Schweiz - Parasitiformes Reuter. Denkschr. Schweiz. *Natur. Ges*., **84**:1-207.

Sepasgosarian, H. 1984. The world genera and species of the family Cunaxidae (Actinedida: Acarida). *Zeitschrift für Angewandte Zoologie*, **71**: 135-150.

Sergeyenko, A. L. 2006. New species and new record of mites of the genus *Rubroscirus* DenHeyer, 1979 (Acarina: Prostigmata: Cunaxidae) from Ukraine. *Acarina*, **14**(1): 103-107.

Sevastyanov, V.D. and Rady, G. 1991. New species of *Entomophilous* mites family Acaridae (Sarcoptiformes) of Lower Egypt fauna. *Zool. Z*., **70**:133-139.

Shah, D.R. and Shukla, A. 2014. Seasonal incidence of spider mite, *Tetranychidae urticae* (Koch) (Tetranychidae: Acari) on gerbera (Gerbera jamesonii) under polyhouse conditions. *Pest Management in Horticultural Ecosystems*, **20**(1): 26-29.

Sharma, A. and Kushwaha, K.S. 1984. Susceptibility of different varieties of brinjal to *Tetranychus neocaledonicus* (Acari: Tetranychidae). *Indian. J. Acarol*., **8**(2):100-103.

Sher, F., Ashfaq, M. and Parvez, A. 1991. Two new (Hypopi) species of genus *Caloglyphus* Berlese (Acarina: Acaridae) from Pakistan. *Pak. Entomol*., **13**:27-34.

Shih, C.I.T. and Shieh, J.N. 1979. Biology, life table, predation potential and intrinsic rate of increase of *Amblyseius longispinosus* (Evans). *Plant Prot. Bull. Taiwan*, **21**: 175-183.

Shipp, J.L. and Whitfield, G.H. 1991. Functional response of the predatory mite, *Amblyseius cucumeris* (Acari: Phytoseiidae) on western flower thrips, *Frankliniella occidentalis* (Thysanoptera: Thripidae). *Environmental Entomol.*, **20**: 694-699.

Silva, E.A., Reis, P.R., Carvalho, T.M.B. and Altoé, B.F. 2009. *Tetranychus urticae* (Acari: Tetranychidae) on *Gerbera jamesonii* Bolus and Hook (Asteraceae). *Brazilian Journal of Biology Revista Brasileira de Biologia*, **69**(4): 1121-1125.

Singh, J. and Mukherjee, I.N. 1989. Pest status of phytophagous mites in some northern states of India. In: *Proceedings of the 1st Asia-Pacific conference of entomology (APCE), the Entomology and Zoology Association of Thailand*. Bangkok, 169-185 pp.

Singh, J., Singh, R.N. and Rai, S.N. 2000. Expanding pest status of phytophagous mites and integrated pest management. In: Upadhyay, R.K., Mukherji, K.G. and Dubey, O.P. (Eds.), *IPM-System in Agriculture, Animal Pests*. Aditya Books Private Ltd. New Delhi, **7**: 1-29 pp..

Sionti, P.G. and Papadoulis, G.T. 2003a. Two species of the genus *Neocunaxoides* Smiley (Acari: Cunaxidae) from Greece. *Internat. J. Acarol.,* **3**: 225-229.

Sionti, P.G. and Papadoulis, G.T. 2003b. Cunaxid mites of Greece (Acari: Cunaxidae). *Internat. J. Acarol.,* **4**: 315-325.

Skvarla M.J., Fisher J.R., Dowling A.P.G. 2011. A new species of *Neoscirula* (Acari: Cunaxidae: Coleoscirinae) from the Ozark Highlands (USA), with notes on biogeography. *Acarologia*, **51**(3): 283-293.

Skvarla, M.J., Fisher, J.R. and Dowling, A.P.G. 2014. A review of Cunaxidae (Acariformes: Trombidiformes) Histories and diagnoses of subfamilies and genera, keys to world species, and some new locality records. *Zookeys*, **418**: 1-103

Smiley, R. L. 1992. *The predatory mite family Cunaxidae (Acari) of the world with a new classification*. Indira Publishing House, West Bloomington, Michigan, 356 P.

Smiley, R.L. 1975. A generic revision of the mites of the family Cunaxidae (Acarina). *Ann. Entomol. Soc. America*., **68** (2): 227-244.

Smith, B.P. 1983. The potential of mites as biological control agents of mosquitoes. In: Hoy, M.A., Cunningham, G.L. and Knutson, L. (Eds.). *Proceedings of biological control of pests by mites. University of California, Berkeley*, 1982, 79-85 pp.

Smith, J.C. and Newsom. L.D. 1970. Laboratory evaluation of *Amblyseius fallacis* as a predator of tetranychid mites. *J. Econ. Entomol*. **63**: 1876-1878.

Soliman, Z.R. and Zaher, M.A. 1975. Bdellid mites of Lattakia, Syria. *Bull. de la Soc. Royale Entomol*., **59**:73-82.

Sugeetha, S. and Srinivasa, N. 1999. Seasonal abundance of red spider mite, *Tetranychus macfarlanei* on okra varieties in Bangalore. *J. Acarol*., **15** (1 and 2): 10-14.

Swift, S.F. and Goff, M.L. 1987. The family Bdellidae (Acari: Prostigmata) in the Hawaiian Islands. *Internat. J. Acarol*., **13** (1): 29-49.

Swirski, E. Amitai, S. and Dorzia, N. 1970. Laboratory studies on the feeding habits, post embryonic survival and oviposition of the predacious mites *Amblyseius chinenensis* Dosse and *Amblyseius hibisci* Chant (Acari: Phytoseiidae) on various kinds of food substances. *Entomophaga*, **15**: 93-106.

Swirski, E. and Dorzia, N. 1969. Laboratory studies on the feeding, development and fecundity of the predaceous mite *Typhlodromus occidentalis* Nesbitt (Acarina: Phytoseiidae) on various kinds of food substances. *Israel J. Agric. Res*., **19**: 143-145.

Tanigoshi, L.K. 1982. Advances in knowledge of the Phytoseiidae. In : Hoy, M.A. (Ed.) *Recent advances in Knowledge of the Phytoseiidae*. Agricultural Sciences Publications, University of California, Berkeley, 22 pp.

Thind, B.B. and Ford, H.L. 2006. Laboratory studies on the use of two new arenas to evaluate the impact of the predatory mites *Blattisocius tarsalis* and *Cheyletus eruditus* on residual populations of the stored product mite *Acarus siro*. *Exp. Appl. Acarol*., **38**: 167-180,

Thomas, H.Q., Zalom, F.G. and Nicola, N.L. 2011. Laboratory studies of *Blattisocius keegani* (Fox) (Acari: Ascidae) reared on eggs of navel orange worm: potential for biological control. *Bull. Entomol. Res*., **101**: 499-504.

Thor, S. 1902. Zur Systematic der acarinenfamilien bdellidae Koch, 1842, Grube 1859, Eupodidae Koch, 1842 und Cunaxidae Sig Thor, 1902.

Verhandllungen der kaiserlich – kongiglichen zoologish – botanischen Gesellschaft in Wien, 159-165.

Thor, S. 1913. *Biscirus* genus novum: eine neue Bdelliden-Gattung und zwei neue Untergattungen. *Zoologischer Anzeiger*, **42**: 28-30.

Thor, S. 1931. Bdellidae, Nicoletiellidae, Cryptognathidae. *Das Tierreich*, **56**: 87 pp.

Thor, S. 1937. *Hoploscirus*, eine neue schildtragende Bdellidengattung aus Tasmania, unter dem Namen Scirus dubitatus n. sp. von H. Womersley, 1933 Beschrieben. *Zoologischer Anzeiger*, **119**: 43-44.

Thor, S. and Willmann, C. 1941. Eupodidae, Penthalodidae, Penthaleidae, Rhagidiidae, Pachygnathidae, Cunaxidae. In: Thor, S. Willmann, C. (Eds), *Das Tierreich, Eine Zusammenstellung und Kennzeichung der rezenten Tierformen*. Lieferung71a. Walter De Gruyter and Co, Leipzig, 164-175.

Tseng, Y.H. 1978. Mites of the family Bdellidae from Taiwan (Acarina: Prostigmata). *J. Agri. Asso. China*, **104**: 25-51.

Tseng, Y.H. 1980. Taxonomical study of the mite family Cunaxidae from Taiwan (Acarina: Trombidiformes). *Qua. J. Taiwan Mus.*, **33** (3-4): 253-277.

Tseng, Y.H. 1981. The mite family Ascidae from Taiwan (II) - genus *Asca* Heyden (Acarina: Mesostigmata). *Chinese J. Entomol.*, **1**: 7-25.

Tseng, Y.H. and Hsieh, S.A. 1976. A new record of acarid mite *Caloglyphus mycophagus* (Megnin) from Taiwan (Acarina: Astigmata). *Taiwan Sugar Res. Inst.*, **74**: 47-52.

Tsunoda, T. 1994. Mating behaviour of the predaceous mite *Amblyseius womersleyi* Schicha (Acari: Phytoseiidae). *Appl. Entomol. Zool*., **29**(2): 141-147.

Ueckermann, E.A., Zannou, I.D., Moraes, G.J., Oliveira, A.R., Hanna, R. and Yaninek, J. 2008. Phytoseiid mites of the tribe Typhlodromini (Acari: Phytoseiidae) from sub-Saharan Africa. *Zootaxa*, **1901**: 1-122.

Ullah, M.S., Haque, M.A., Nachman, G., Gotoh, T. 2012. Temperature dependent development and reproductive traits of *Tetranychus macfarlanei* (Acari: Tetranychidae). *Exp. Appl. Acarol.*, **56**: 327-344.

van Der Schyff, J., Theron, P. D. and Ueckermann, E.A. 2004. *Hexabdella*, a new mite genus of Bdellidae (Acari: Prostigmata) from southern Africa, with descriptions of five new species. *African Plant Protection*, **10** (1): 13-25.

van Der Schyff, J., Theron, P.D. and Ueckermann, E.A. 2005. Descriptions of seven new species of the genus *Bdella* Latreille (Acari: Prostigmata: Bdellidae) from southern Africa and a redescription of *B. neograndjeani* Meyer and Ryke. *African Entomol*., **13** (2): 221-238.

van Lenteren, J.C. 2012. The state of commercial augmentative biological control: plenty of natural enemies, but a frustrating lack of uptake. *BioControl,* **57**: 1-20.

van Straalen, N.M. 1997. Community structure of soil Arthropods. In: Pankhurst, C.E., Doube, B.M. and Gupta, V.V.S.R. (Eds.), *Biological indicators of soil health*. GB International, 235-264.

Varela, A.M., Seif, A. and Lohr, B. 2003. *A guide to IPM in tomato production in Eastern and Southern Africa*. ICIPE. Science Press, Nairobi. 128pp.

Veerman, A. 1992. Diapause in phytoseiid mites: a review. *Exp. Appl. Acarol*., **14**: 1- 60.

Vitzthum, G.H. 1941. Acarina. In: Bronns, H. G. (Ed.). *Klassen and Ordnungen. des Terreiches*, **5**(4): 764-767.

Voigts, H. and Oudemans, A.C. 1905. Zur Kenntnis der Milben-Fauna von Bremen. *Abhandlungen. Naturwissenschaftlichen Verein zu Bremen*, **18**: 199-253.

Von Heyden, C. 1826. Versuch einer systematischen eintheiling de Acariden. *Isis of Oken*. **18**: 608-613.

Wadhi, S.R., Verma, B.R. and Srivastava, K.M. 1971. First record of the bulb mite, *Rhizoglyphus eclzinopus* Fumouze and Robin (Acaridae: Acarina) from India. *Indian J. Ent*., **33**: 107-108.

Wainstein, B.A. 1962. Some new predatory mites of the family Phytoseiidae (Parasitiformes) of the USSR fauna. *Entomologicheskoe Obozrenie*, **41**: 139-146.

Wallace, M.M.H. 1974. An attempt to extend the biological control of *Sminthurus viridis* (Collembola) to new areas in Australia by introducing a predatory mite, *Neomolgus capillatus* (Bdellidae). *Australian J. Zool*., **22** (4): 519-529.

Wallace, M.M.H. and Mahon, J.A. 1972. The taxonomy and biology of Australian Bdellidae (Acari). I. Subfamilies Bdellinae, Spinibdellinae and Cytinae. *Acarologia*, **14**(4): 544-580

Wallace, M.M.H. and Mahon, J.A. 1976. The taxonomy and biology of Australian Bdellidae (Acari). II. Subfamily Odontoscirinae. *Acarologia*, **18** (1): 65-123.

Walter, D.E. and Beard, J.J. 1997. A review of the Australian Phytoseiinae (Acari: Mesostigmata: Phytoseiidae). *Inverteb. Taxon.* **11**: 823-860.

Walter, D.E. and Lindquist, E.E. 1997. Australian species of *Lasioseius* (Acari: Mesostigmata: Ascidae) the *porulosus* group and other species from rainforest canopies. *Inverteb. Taxon*., **11**: 525-547.

Walter, D.E., Halliday, R.B. and Lindquist, E.E. 1993. A review of the genus *Asca* (Acarina: Ascidae) in Australia, with descriptions of three new leaf inhabiting species. *Inverteb. Taxon*., **7**: 1327-1347.

Wei, L.M. and Laing, J.E. 1973. Biology of *Amblyseius* (*Neoseiulus*) *californicus*, *Entomophaga*, 47-60.

Willmann, C. 1949. Das genus *Arctoseius* Sig Thor, 1930 (Acari). *Abh. Naturv. Ver. Bremen*, **32**: 349-358.

Wood, T.G. 1966. Three new species of *Asca* von Heyden (Acari: Blattisociidae) from New Zealand and records of *Asca* from some Southern Pacific Islands. *New Zealand J. Sci*., **9**: 41-49.

Wysoki, M. and Bolland, H.R. 1983. Chromosome studies of phytoseiid mites (Acari: Gamasida). *Internat. J. Acarol*., **9** (2): 91-94.

Yousef, A.A. and El-Halawany, M.E. 1982. Effect of prey species on the biology of *Amblyseius gossipi* El-Badry (Acari: Phytoseiidae). *Acarologia*, **23**: 113-117.

Zachvatkin, A.A. 1941. Fauna of USSR Arachnoidea VI (1) Tyroglyphoidea (Acari). *Zool. Inst. Acad. Sci*., USSR, New Ser. No. 28. English Translation 1959, Rateliffe, A., Hughes, A. M., *Amer. Inst. Biol. Sci*., 573 pp.

Zannou, I.D., Moraes, G.J.D., Ueckermann, E.A., Oliveira, A.R., Yaninek, J.S. and Hanna, R. 2007. Phytoseiid mites of the subtribe Amblyseiina (Acari: Phytoseiid) keys to world species, and some new locality records. *ZooKeys*, **418**: 1-103.

Ziad, B. and Ueckermann, E.A. 2017. Two new species and new record of Bdellidae (Acari: Trombidiformes) from Syria. *Acarologia*, **57**(4): 1089-1102.

Zou, P. and Wang, X.Z. 1989. A new species and two new records of Acaridae associated with edible fungi from China (Acarina: Acaroidea). *Acta Agric. Shanghai*, **5**: 21-24.

TABLE 2

Distribution of Predatory mites with respect to host plants in various localities of North Kerala

Sl. No.	SPECIES	HOST PLANT	LOCATION	DISTRICT
FAMILY I: ASCIDAE Voigts and Oudemans, 1905				
1.	*Asca babithae* sp. nov.	*Capsicum annuum*	Kadalundi	Kozhikode
FAMILY II: PHYTOSEIIDAE Berlese, 1916				
2.	*Neoseiulus longispinosus* (Evans), 1952	*Cucurbita maxima** *Carica papaya* *Pisum sativum* *Manihot esculenta*	Perinthalmanna Sulthan Batheri Vadakara Pariyaram Pattambi Vellachal	Malappuram Wayanad Kozhikode Kannur Palakkad Kasaragod
3.	*N. sashikalae* sp. nov.	*Pisum sativum* *Canavalia gladiate*	Pattambi Vadakara	Palakkad Kozhikode
4.	*Paraphytoseius bhadrakaliensis* Gupta, 1969	*Benincasa hispida** *Brassica oleracea*	Takkekad Chelari Ambalavayal	Kasaragod Malappuram Wayanad
5.	*P. orientalis* Narayanan *et al.,* 1960	*Benincasa hispida** *Cucurbita maxima**	Kadalundi Kavumvattam Perinthalmanna	Kozhikode Kozhikode Malappuram
6.	*Typhlodromips syzigii* Gupta, 1975	*Amaranthus dubius** *Pisum sativum* *Amorphallus paeonifolis* *Abelmoschus esculentus*	Parappanagadi Perinthalmanna Pazhoor Chittur	Malappuram Malappuram Kozhikode Palakkad

7.	*Scapulaseius meghalayensis* Gupta, 1978	*Pisum sativum**	Thenjipalam	Malappuram
8.	*S. suknaensis* Gupta, 1970	*Amaranthus dubius**	Feroke	Kozhikode
9.	*Transeius tetranychivorus* (Gupta), 1978	*Solanum melongena*	Thaliparamba	Kannur
10.	*Amblyseius aerialis* (Muma), 1955	*Amaranthus dubius**	Pariyaram	Kannur
11.	*A. amithae* Rahul and Mary Anitha, 2017	*Amaranthus dubius*	Kavumvattam	Kozhikode
12	*A. channabasavannai* Gupta and Daniel, 1978	*Pisum sativum** *Plectranthus rotundifolius** *Capsicum annuum**	Pattambi Nileswaram Feroke	Palakkad All the districts surveyed Kasaragod Calicut
13.	*A. cinctus* Corpuz and Rimando, 1966	*Capsicum annuum**	Kakkur	Kozhikode
14.	*A. cucurbitae* Rather, 1985	*Pisum sativum** *Cucurbita pepo* *Capsicum annuum**	Kavumvattam Kavumvattam Kavumvattam	Kozhikode Kozhikode Kozhikode
15.	*A. dioscoreae* Rahul *et al.,* 2016	*Dioscorea alata* *Pisum sativum* *Coccinia grandis* *Moringa oleifera*	Manjeri Kavumvattam Pattambi Edakkad	Malappuram Kozhikode Palakkad Kannur
16.	*A. herbicolus* (Chant), 1959	*Pisum sativum** *Artocarpus heterophyllus** *Momordica charantia** *Canavalia gladiata** *Dolichos lablab*	Nenmara Kadalundi Pazhayangadi Malaparamba Vengeri	Palakkad Kozhikode Kannur Kozhikode Kozhikode
17.	*A. indirae* Gupta, 1985	*Cucurbita maxima* *Murraya koenigii*	Pariyaram Kunduparamba	Kannur Kozhikode

18.	*A. kulini* Gupta, 1978	*Solanum melongena**	Shornur	Palakkad
19.	*A. largoensis* (Muma), 1955	*Musa acuminate*	Thekkumthara	Wayanad
20	*A. manasi* Rahul and Mary Anitha, 2016	*Capsicum frutescens* *Amaranthus dubius* *Momordica charantia*	Kakkodi Kavumvattam Pattambi	Kozhikode Kozhikode Palakkad
21.	*A. muraleedharani* Gupta, 1981	*Pisum sativum*	Manjeri	Malappuram
22.	*A. orientalis* Ehara, 1957	*Capsicum annuum*	Sulthan Batheri	Wayanad
23.	*A. paraarealis* Muma,1967	*Capsicum annuum** *Momordica charantia* *Spinacia oleracea**	Kadalundi Pattambi Manjeri	Kozhikode Palakkad Malappuram
24.	*A. ramani* sp. nov.	*Amaranthus viridis* *Ipomoea batatas*	Pariyaram Edakkad Thaliparamba	Kannur Kannur Kannur
25.	*A. sachini* Rahul and Mary Anitha, 2017	*Capsicum annuum*	Kadalundi	Kozhikode
26.	*A. santhoshi* sp. nov.	*Amaranthus viridis*	Manjeri	Malappuram
27.	*A. sijiensis* Gupta, 1986	*Amaranthus dubius**	Manjeri	Malappuram
28.	*A. velayudhani* Santhosh and Mary Anitha 2016	*Amaranthus viridis**	Edakkad	Kannur
29.	*Proprioseiopsis narayani* sp. nov.	*Pisum sativum*	Thenjipalam	Malappuram
30	*P. peltatus* Van der Merwe, 1968	*Amaranthus dubius** *Dolichos lablab*	Malaparamba Ramanattukara	Kozhikode Kozhikode
31.	*Euseius alstoniae* (Gupta), 1975	*Canavalia gladiata* *Coccinia grandis**	Kunduparamba Ashokapuram	Kozhikode Kozhikode
32	*E. bambusae* Ghai and Menon, 1967	*Brassica oleracea**	Malaparamba	Kozhikode
33	*E. coccineae* Gupta, 1975	*Pisum sativum**	Mankav	Kozhikode
34	*E. delhiensis* (Narayanan and Kaur), 1960	*Canavalia ensiformis*	Kanhangad	Kasaragod
35	*E. finlandicus* (Oudemans), 1915	*Amaranthus viridis**	Ashokapuram	Kozhikode

			Parappanangadi	Malappuram
36	*E. kadalundiensis* sp. nov.	*Manihot esculenta*	Kadalundi	Kozhikode
37	*E. malabarensis* sp. nov.	*Pisum sativum*	Koorachund	Kozhikode
38	*E. ovalis* (Evans), 1970	*Amorphophallus paeonifolius** *Momordica charantia*	Kadalundi Edakkad	Kozhikode Kannur
39	*E. rhododendronis* Gupta, 1970	*Amaranthus dubius**	Feroke Chittur	Kozhikode Palakkad
40	*E. sativae* sp.nov.	*Pisum sativum*	Balussery	Kozhikode
41	*E. ummalathoorensis* sp. nov.	*Abelmoschus esculentus*	Ummalathoor	Kozhikode
42	*Phytoseius intermedius* Evans and Macfarlane, 1962	*Amaranthus dubius**	MCC Campus	Kozhikode
43	*Typhlodromus* (*Anthoseius*) *bambusicolus* Gupta, 1977	*Solanum lycopersicum**	Ottapalam	Palakkad
FAMILY III: BLATTISOCIIDAE Garman, 1948				
44	*Cheiroseius kozhikodensis* sp. nov.	*Amaranthus viridis*	Kollam	Kozhikode
45	*Lasioseius arjuni* sp. nov.	*Cucurbita maxima*	Vengeri	Kozhikode
46	*L. furcisetus* Athias-Henriot, 1959	*Capsicum annuum**	Pazhoor	Kozhikode
47	*L. glomerulus* Karg, 1979	*Cucurbita pepo**	Pazhoor	Kozhikode
48	*L. kurumpoyilensis* sp. nov.	*Manihot esculenta*	Kurumpoyil	Kozhikode
49	*L. phytoseioides* Chant, 1963	*Cucumis sativus**	Thenjipalam	Malappuram
50	*L. quadrisetosus* Chant, 1960	*Artocarpus heterophyllus**	Payyoli	Kozhikode
51	*L. seethae* sp. Nov	*Capsicum annuum*	Koorachund	Kozhikode
52	*L. vengeriensis* sp. nov.	*Solanum melongena*	Vengeri	Kozhikode
FAMILY IV: BDELLIDAE Duges, 1834				
53	*Bdella distincta* Baker and Balock, 1944	*Capsicum annuum**	Pazhoor	Kozhikode
54	*B. hispidae* sp. Nov	*Benincasa hispida*	Kadalundi	Kozhikode
55	*Cyta bharathani* sp. nov.	*Amorphallus paeonifolis*	Kootalida	Kozhikode

FAMILY V: CUNAXIDAE Thor, 1902				
56	*Cunaxa pushpae* sp. nov.	*Coccinia grandis*	Ashokapuram	Kozhikode
57	*C. soansi* Rahul *et al.,* 2017	*Manihot esculenta*	Kunduparamba	Kozhikode
58	*C. womersleyi* Baker and Hoffmann, 1948	*Benincasa hispida** *Trichosanthes cucumerina*	Mongam Ramanattukara Manarkkad	Malappuram Kozhikode Palakkad
59	*Dactyloscirus esculentae* sp. Nov	*Colocasia esculenta*	Kanayamkod Kalpetta Chittur	Kozhikode Wayanad Palakkad
60	*Neocunaxoides andrei* (Baker and Hoffmann), 1975	*Cucurbita maxima**	Cheliya Sulthan Batheri Shornur Kadalundi	Kozhikode Wayanad Palakkad Kozhikode
FAMILY VI: ACARIDAE Ewing and Nesbitt, 1959				
61	*Acarus gracilis* Hughes, 1957	*Pisum sativum** *Canavalia gladiata**	Mankav Mokavoor	Kozhikode Kozhikode
62	*Tyrophagus putrescentiae* Schrank, 1781	*Cucumis sativus** *Benincasa hispida** *Capsicum annuum** *Coccinia grandis**	Thenjipalam Ramanattukara Kadalundi Bekal	Malappuram Malappuram Kozhikode Kasaragod

*New host plant

FIGURE 1

Family diversity of predatory mites

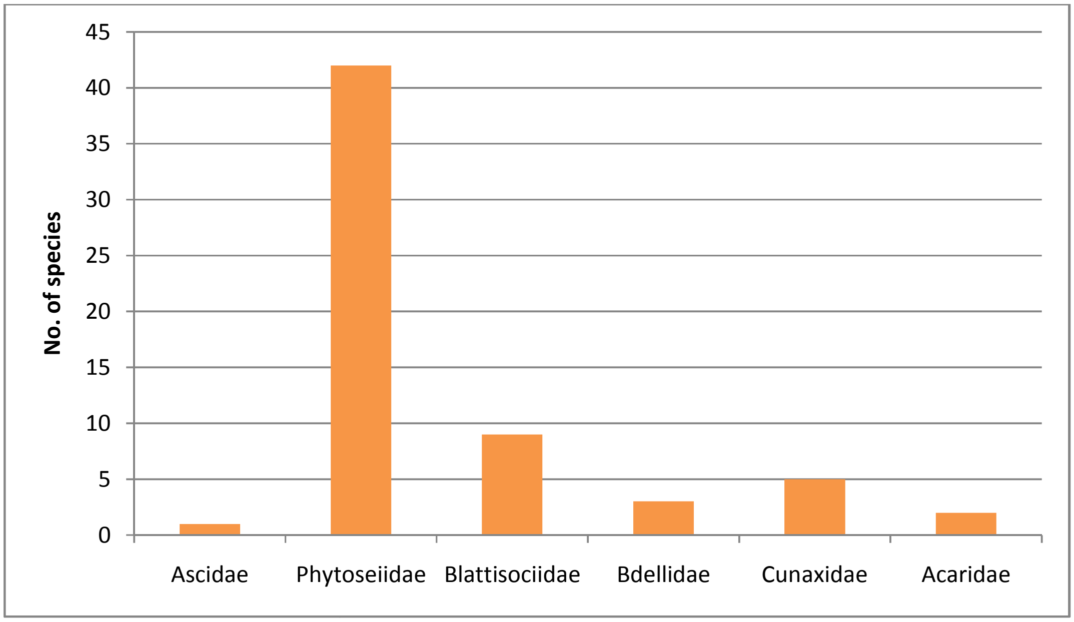


FIGURE 2

Percentage of distribution of various families of predatory mites

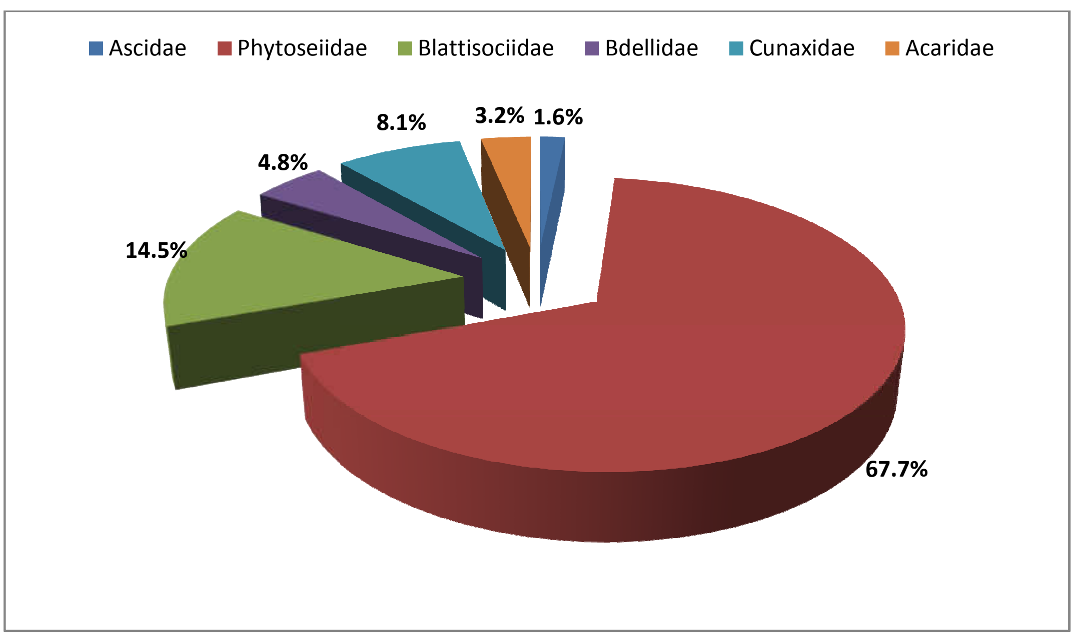


FIGURE 3

Generic diversity of order Mesostigmata

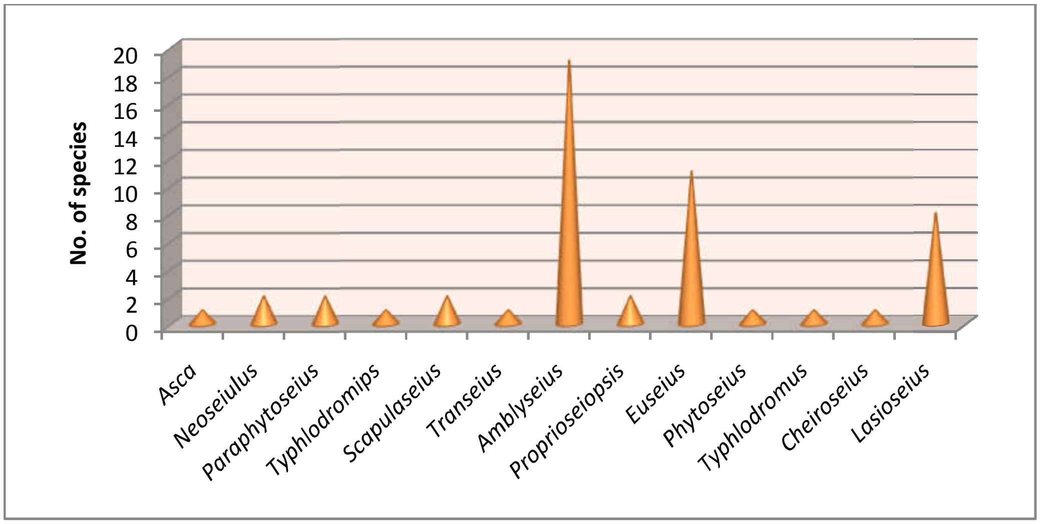


FIGURE 4

Generic diversity of the family Phytoseiidae

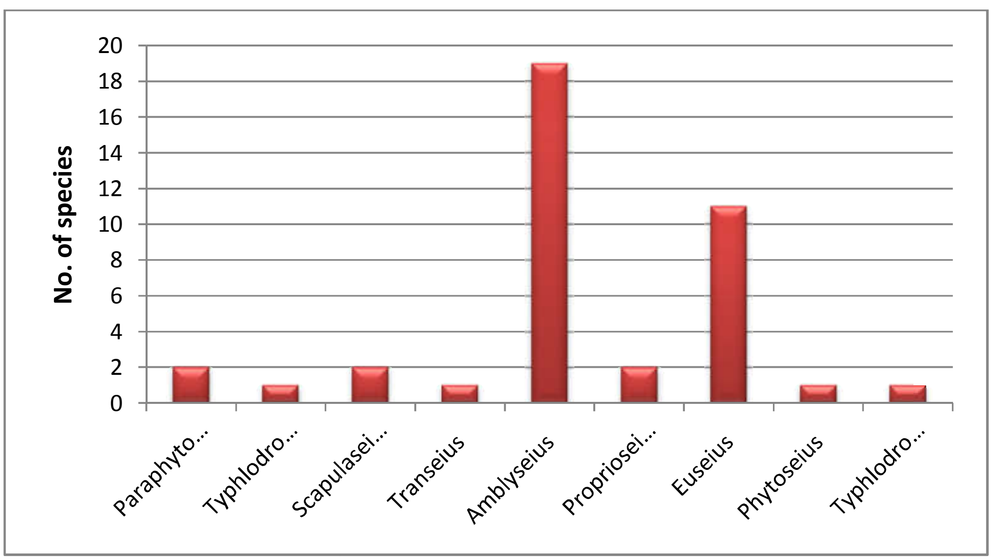


FIGURE 5

Generic diversity of the suborder Prostigmata

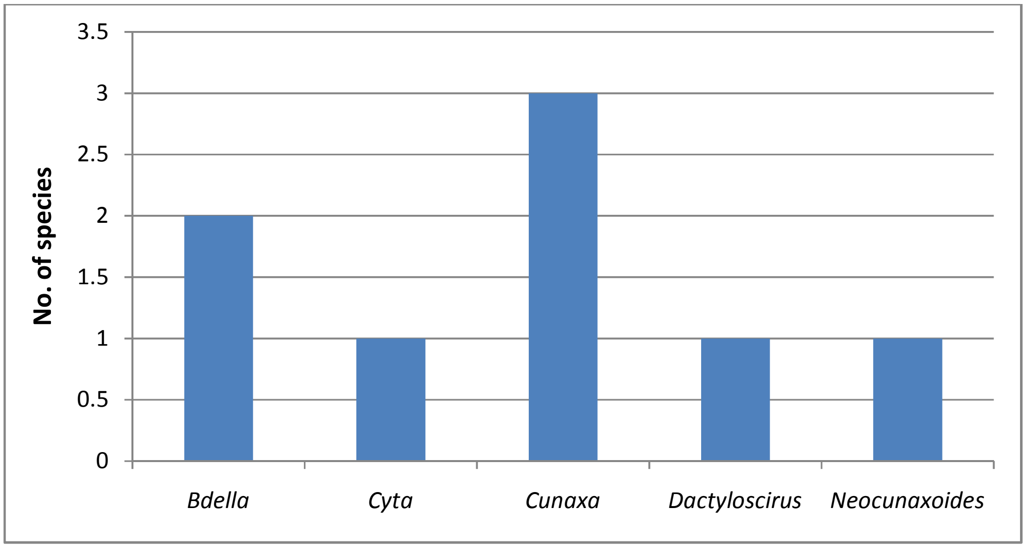


TABLE 5
Significant combinations of the different stages of the predator *N. sasikalae* sp.nov. against the different stages of the prey mite *T. urticae* using Scheffe's test

1. Prey - Egg

	Female	Male	Larva	Protonymph	Deutonymph
Female		.000**	.000**	.000**	.000**
Male			.000**	.000**	.000**
Larva				.000**	.000**
Protonymph					.000**
Deutonymph					

2. Prey - Larva

	Female	Male	Larva	Protonymph	Deutonymph
Female		.000**	.000**	.000**	.000**
Male			.000**	.045*	.000**
Larva				.000**	.000**
Protonymph					.000**
Deutonymph					

3. Prey - Protonymph

	Female	Male	Larva	Protonymph	Deutonymph
Female		.085	.000**	.000**	.085
Male			.000**	.004**	.000**
Larva				.000**	.000**
Protonymph					.000**
Deutonymph					

4. Prey - Deutonymph

	Female	Male	Larva	Protonymph	Deutonymph
Female		.000**	.000**	.000**	.000**
Male			.000**	.000**	.000**
Larva				.193	1.000
Protonymph					1.000
Deutonymph					

5. Prey - Adult

	Female	Male	Larva	Protonymph	Deutonymph
Female		.062	.000**	.000**	.000**
Male			.397	.397	.397
Larva				1.000	1.000
Protonymph					1.000
Deutonymph					

*Significance level at ≤ 0.05
** Significance level at ≤ 0.01

FIGURE 6
Categorized normal plot for the rate of consumption of different stages of *Neoseiulus sasikalae* sp.nov. on *Tetranychus urticae* in 24 hours.

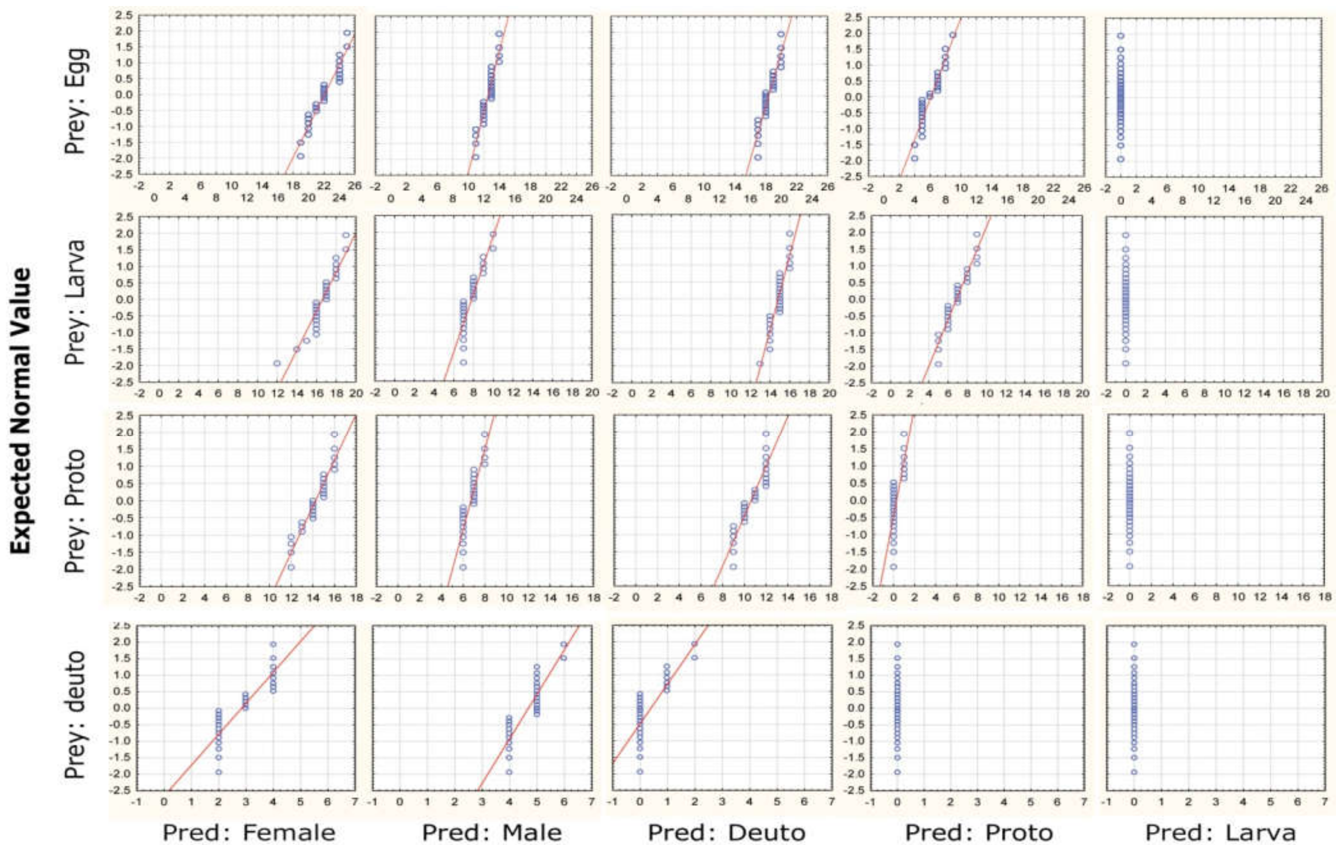


FIGURE 7

Categorized box plot for the rate of consumption of different stages of *Neoseiulus sasikalae* sp.nov. on *Tetranychus urticae* in 24 hours.

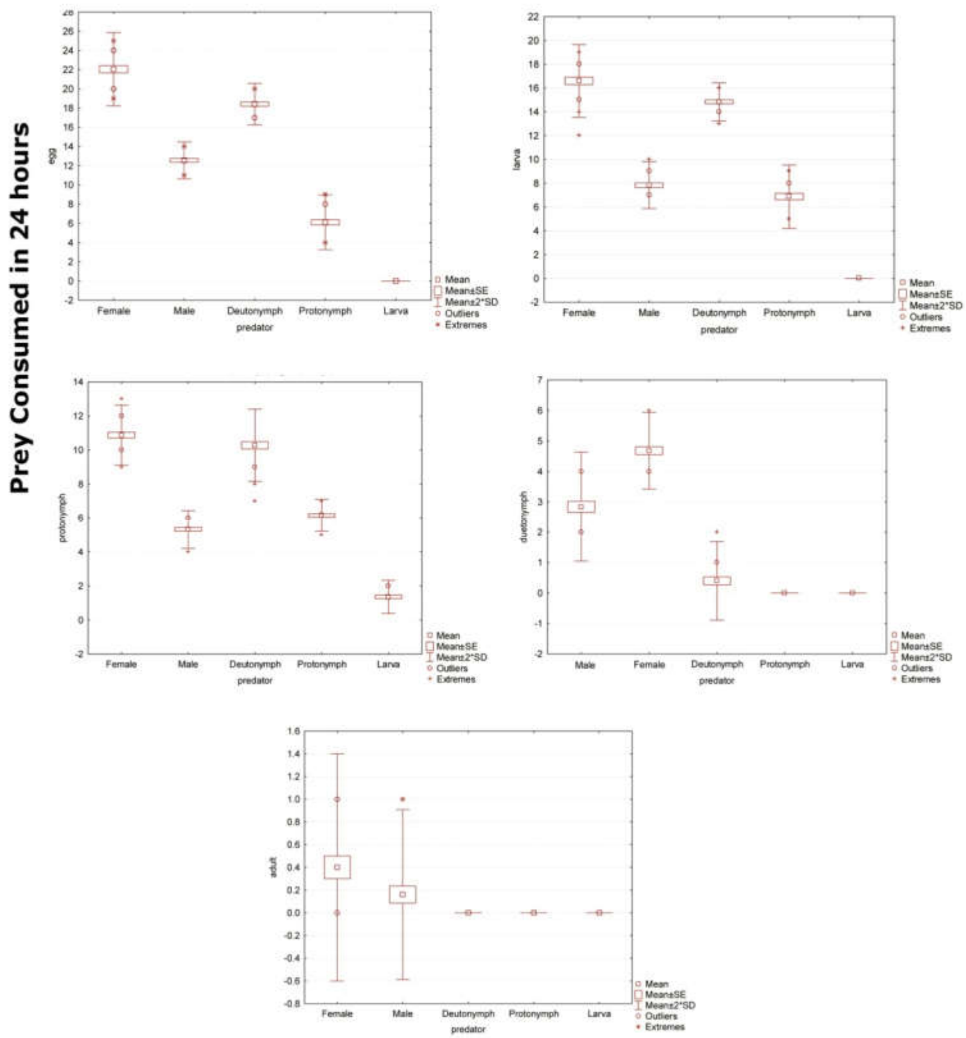


FIGURE 8

Percentage of consumption of *N. sasikalae* sp.nov. on various stages of *T. urticae* in 24 hours

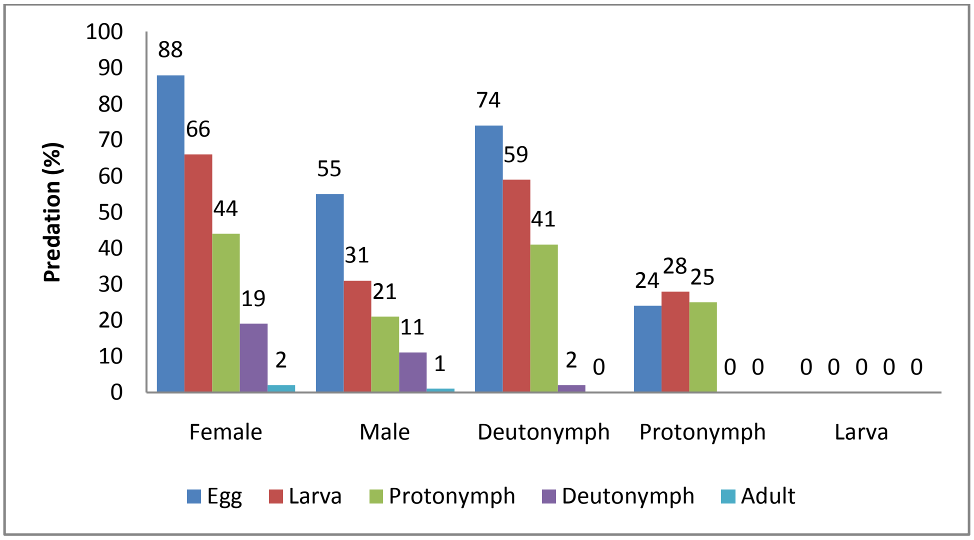


FIGURE 9

Comparison of prey consumption of *N. sasikalae* sp.nov. on various stages of *T. urticae*

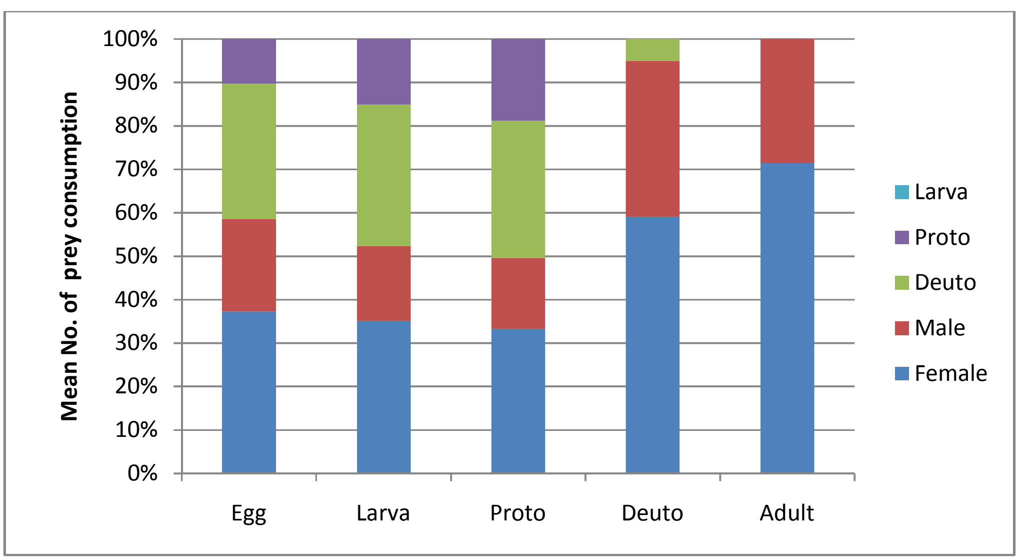


TABLE 6

Percentage of predation by *A. dioscoreae* Rahul *et al.*, 2016 on different stages of *T. neocaledonicus* in 24 hours

Pest / Predator	Egg	Larva	Protonymph	Deutonymph	Adult
Adult female	65	50	57	0	0
Adult male	31	24	27	0	0
Larva	20	9	0	0	0
Protonymph	36	29	1	0	0
Deutonymph	57	48	43	0	0

TABLE 7

Mean values of feeding potential of different stages of *A. dioscoreae* against diffferent stages of the prey mite, *T. neocaledonicus* (n=25)

1. Prey-Egg

Predator	Mean±SE	F	p-level
Female	16.32±0.18	900.146	0.000
Male	7.64±0.17		
Larva	4.88±0.13		
Protonymph	9.08±0.12		
Deutonymph	14.36±0.17		
All group	10.45±0.38		

2. Prey – Larva

Predator	Mean±SE	F	p-level
Female	12.44±0.25	474.20	0.000
Male	5.88±0.10		
Larva	2.36±0.16		
Protonymph	7.16±0.19		
Deutonymph	12.12±0.22		
All group	7.99±0.35		

3. Prey – Protonymph

Predator	Mean±SE	F	p-level
Female	14.24±0.27	1203.9	0.000
Male	6.72±0.14		
Larva	0		
Protonymph	0.28±0.09		
Deutonymph	10.64±0.24		
All group	6.37±0.51		

TABLE 8

Significant combinations of the different stages of the predator *A. discoreae* Rahul *et al.,* 2016 against different stages of the prey mite *T. neocalidonicus* using Scheffe's test

1. Prey - Egg

	Female	Male	Larva	Protonymph	Deutonymph
Female		.000**	.000**	.000**	.000**
Male			.000**	.000**	.000**
Larva				.000**	.000**
Protonymph					.000**
Deutonymph					

2. Prey - Larva

;	Female	Male	Larva	Protonymph	Deutonymph
Female		.858	.000**	.000**	.858
Male			.000**	.001**	.000**
Larva				.000**	.000**
Protonymph					.000**
Deutonymph					

3. Prey - Protonymph

	Female	Male	Larva	Protonymph	Deutonymph
Female		.000**	.000**	.000**	.000**
Male			.000**	.000**	.000**
Larva				.193	.000**
Protonymph					.878
Deutonymph					

** Significance level at ≤ 0.01

TABLE 9

Effect of feeding of predatory mites on various stages of prey mites in 24 hours (Two – way ANOVA Model)

Prey stages	Predator	Mean±SE	F	p – value
Egg	*N. sasikalae*	11.82±0.72	2.753	.098
	A. dioscoreae	10.46±0.38		
Larva	*N. sasikalae*	9.23±0.54	3.635	.058
	A. dioscoreae	7.99±0.35		
Protonymph	*N. sasikalae*	6.52±0.23	.494	.483
	A. dioscoreae	6.37±0.51		
Deutonymph	*N. sasikalae*	4.14±0.31	51.267	.000*
	A. dioscoreae	0		
Adult	*N. sasikalae*	0.11±0.02	142.585	.000*
	A. dioscoreae	0		

* Significance level at ≤ 0.01

FIGURE 10

Categorized normal plot for the rate of consumption of different stages of *Amblyseius dioscoreae* Rahul *et al.,* 2016 on *Tetranychus neocaledonicus* in 24 hours.

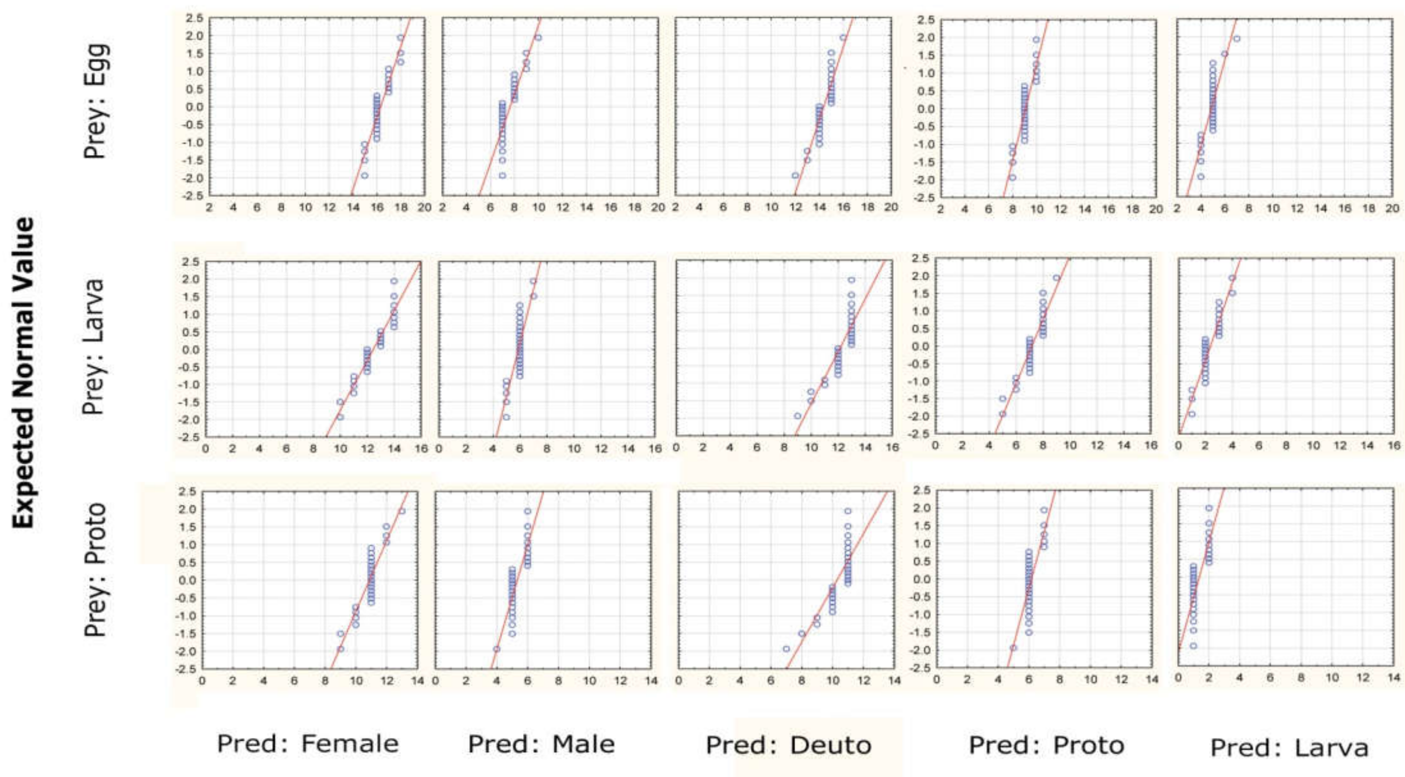


FIGURE 11
Categorized box plot for the rate of consumption of different stages of *Amblyseius dioscoreae* Rahul *et al.,* 2016 on *Tetranychus neocaledonicus* in 24 hours.

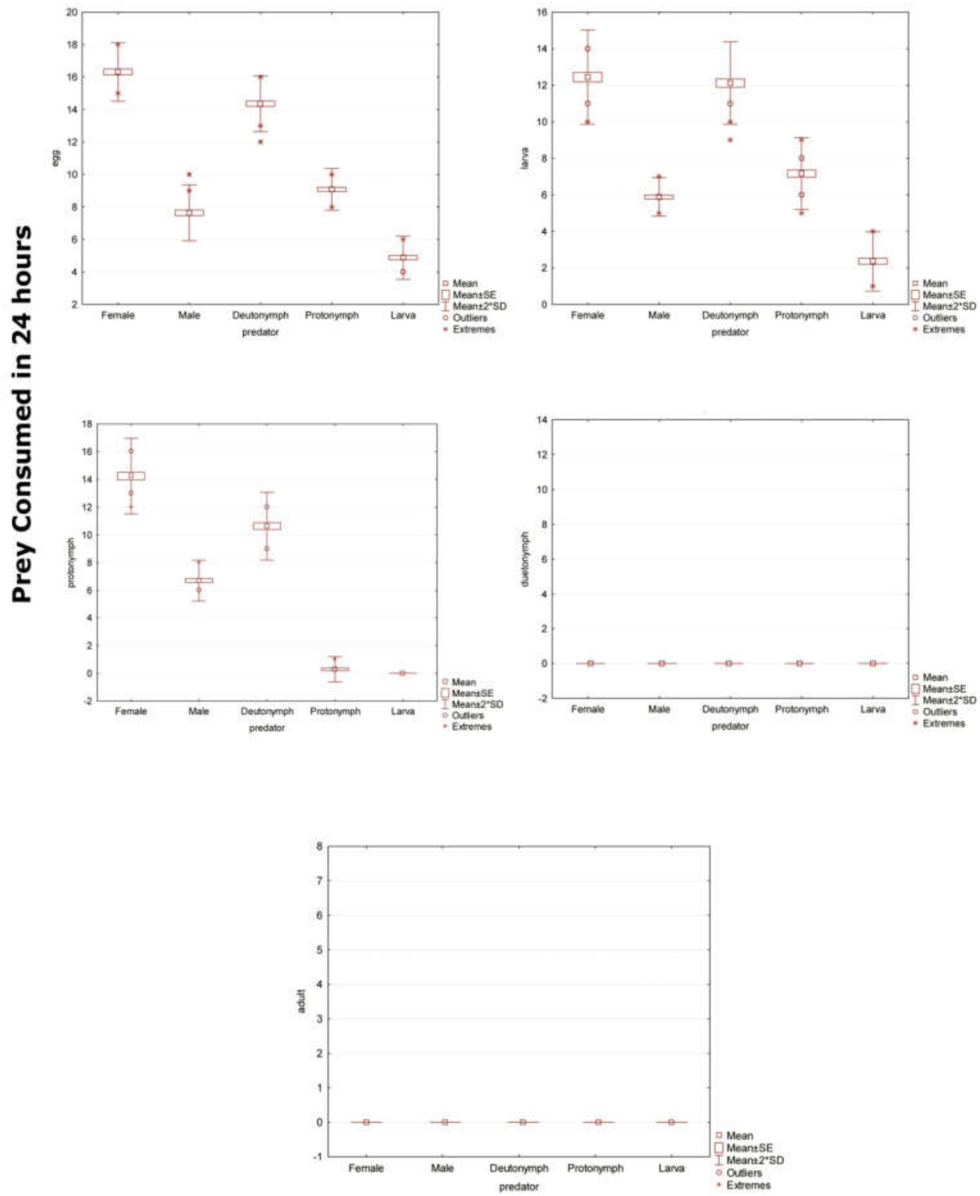


FIGURE 12

Percentage of consumption of *A. dioscoreae* Rahul *et al.* 2016, on different stages of *T. neocaledonicus*

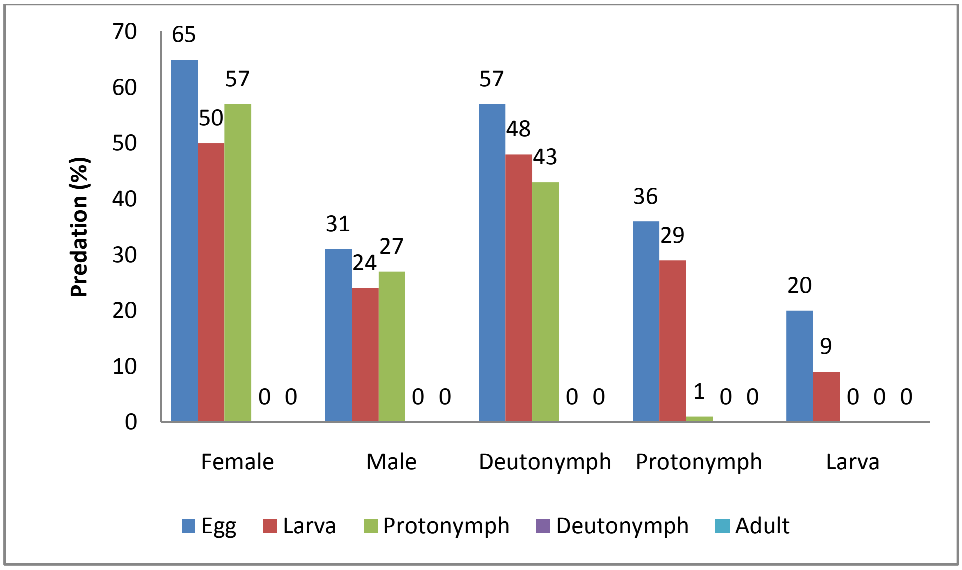


FIGURE 13

Comparison of prey consumption of different stages of *A. dioscoreae* Rahul *et al.* 2016, on different stages of *T. neocaledonicus*

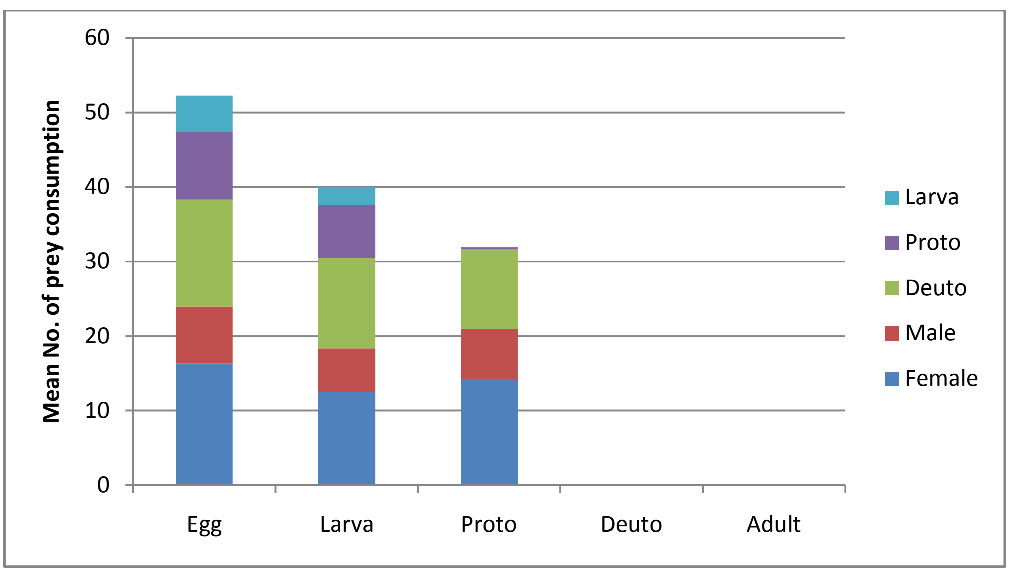


FIGURE 14

Comparison graph of prey consumption by different stages of *N. sasikalae* sp. nov. and *A. dioscoreae* Rahul *et al.*, 2016 in 24 hrs

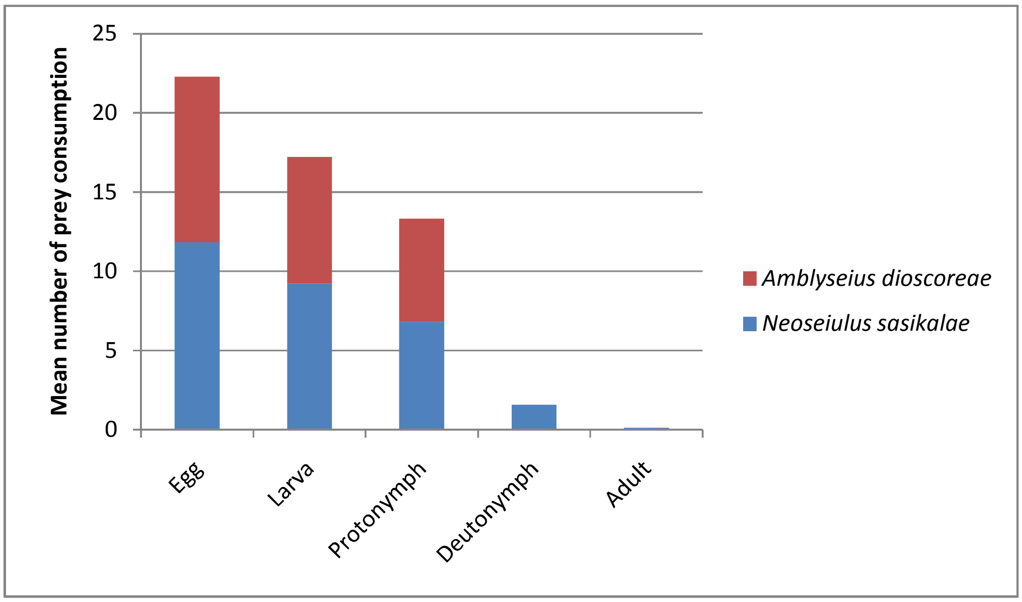


TABLE 10

Developmental duration (in days) (Mean±SE) of immature stages of *N. sasikalae* sp.nov. (n=10)

Temperature (±2°C)	Sex	Egg	Larva		Protonymph		Deutonymph		Total development period
			Active	QI	Active	QII	Active	QIII	
20	Female	2.76±0.03	0.14±0.00	0.97±0.05	1.13±0.05	1.82±0.06	1.75±0.09	1.49±0.09	10.09±0.05
	Male	2.66±0.03	0.11±0.02	0.88±0.07	1.10±0.01	1.63±0.14	1.44±0.04	1.26±0.13	9.10±0.27
25	Female	1.79±0.01	0.08±0.00	0.49±0.01	0.48±0.01	0.39±0.01	0.47±0.00	0.40±0.01	4.13±0.02
	Male	1.65±0.02	0.06±0.00	0.48±0.01	0.46±0.00	0.35±0.02	0.38±0.01	0.38±0.00	3.78±0.03
30	Female	1.44±0.01	0.09±0.00	0.22±0.00	0.40±0.01	0.42±0.01	0.45±0.01	0.34±0.00	3.38±0.01
	Male	1.38±0.03	0.08±0.00	0.19±0.01	0.39±0.02	0.41±0.02	0.36±0.01	0.30±0.03	3.15±0.00

Significance level at $p<0.05$

TABLE 11

Hatchability and survival rate of *N. sasikalae* sp.nov.

Temperature (±2ºC)	No. of eggs tested	Hatchability (%)	Maturity (%)	Mortality (%)
20	50	86	60	40
25	50	89	70	30
30	50	90	75	25

TABLE 12

Length of Pre oviposition, Oviposition, Post oviposition, Fecundity, Longevity and Sex ratio (Mean ± SE) of *N. sasikalae* sp.nov.

Parameters	Temperature (±2°C)		
	20	**25**	**30**
Pre oviposition (in days)	3.45±0.43	2.45±0.11	1.91 ± 0.04
Oviposition (in days)	19.85±0.23	17.65±0.36	16.40 ± 0.21
Post oviposition (in days)	9.15±0.16	8.1±0.10	6.42±0.09
Total No. of eggs/female	24.20±0.20	24.50±0.25	32.20±0.22
Average No. of eggs/female /day	1.33±0.13	1.40±0.16	1.96±0.02
Female longevity (in days)	32.30±0.21	28.20±0.38	23.93±0.25
Male longevity (in days)	26.70±0.55	26.50±0.29	19.56±0.14
Sex ratio (Female: Male)	1:0.34	1:0.22	1: 0.97

Significance level at $p<0.05$

TABLE 13

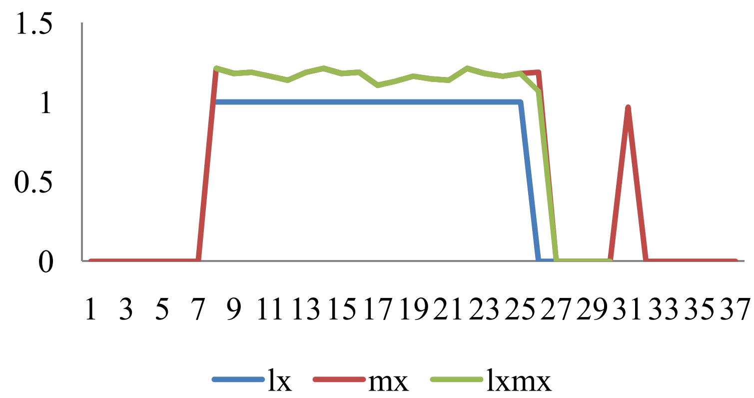
Life table parameters of *N. sasikalae* sp.nov. on *T. urticae*

Parameter	Temperature (±2°C)		
	20	**25**	**30**
Intrinsic rate of natural increase (r_m/day)	0.12	0.18	0.18
Net reproductive rate (R_0)	15.58	22.15	54.05
Gross reproductive rate (Σm_x)	15.58	22.27	34.23
Mean generation time (T)	22.03	16.93	22.02
Finite rate of increase (λ)	1.13	1.19	1.19
Weekly multiplication	2.39	3.52	3.55
Doubling time (DT)	5.54	3.85	3.83

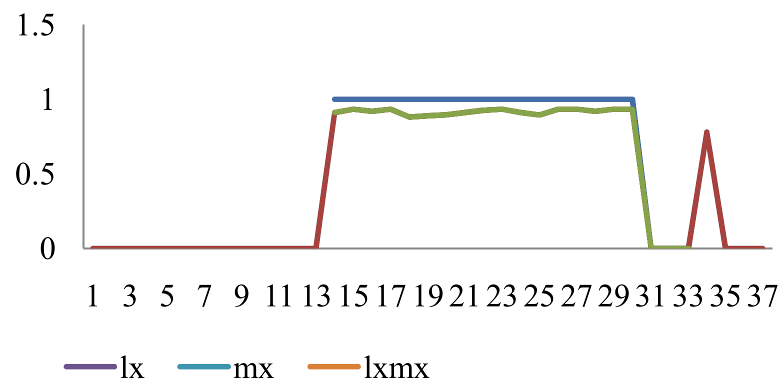
FIGURE 15

Survival and Fecundity Curves of *N. Sasikalae* sp.nov at Different temperatures

20°C



25°C



30°C

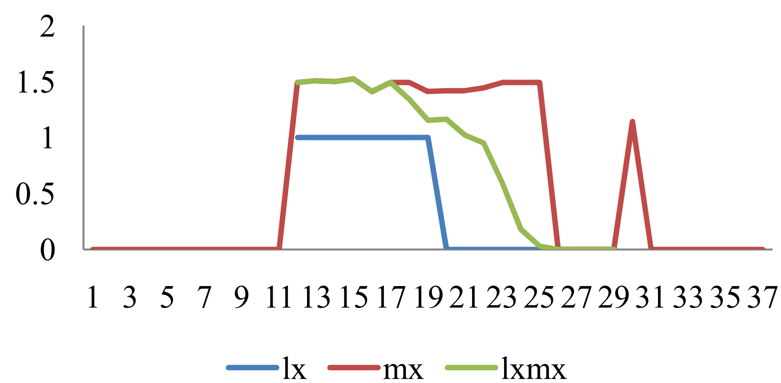


TABLE 15

Developmental time (in days) (Mean±SE) of immature stages of *A. dioscoreae* Rahul *et al.*, 2016 (n=10)

Temperature (±2°C)	Sex	Egg	Larva		Protonymph		Deutonymph		Total development period
			Active	QI	Active	QII	Active	QIII	
20	Female	2.48±0.01	1.69±0.01	0.52±0.01	1.82±0.02	0.41±0.00	1.04±0.01	0.58±0.01	8.60±0.01
	Male	2.39±0.02	1.59±0.01	0.48±0.02	1.70±0.04	0.39±0.02	1.01±0.01	0.57±0.02	8.15±0.02
25	Female	1.80±0.01	1.11±0.03	0.41±0.00	1.38±0.01	0.36±0.00	2.00±0.00	0.35±0.00	7.44±0.03
	Male	1.75±0.00	1.05±0.00	0.39±0.02	1.29±0.04	0.30±0.00	1.99±0.02	0.31±0.01	7.11±0.01
30	Female	1.41±0.00	0.99±0.01	0.38±0.01	1.59±0.08	0.31±0.00	2.30±0.05	0.33±0.00	7.24±0.12
	Male	1.38±0.00	0.90±0.04	0.33±0.00	1.04±0.02	0.28±0.00	2.01±0.01	0.21±0.00	6.21±0.01

Significance level at $p<0.05$

TABLE 16

Hatchability and survival rate of *A. dioscoreae* Rahul *et al.*, 2016

Temperature (±2ºC)	No. of eggs tested	Hatchability (%)	Maturity (%)	Mortality (%)
20	50	70	55	45
25	50	75	55	45
30	50	81	60	40

TABLE 17

Length of Pre oviposition, Oviposition, Post oviposition, Fecundity, Longevity and Sex ratio (Mean ± SE) of *A. dioscoreae* Rahul *et al.,* 2016.

Parameter	Temperature (±2^{o}C)		
	20	25	30
Pre oviposition period (in days)	3.20 ± 0.13	2.70 ± 0.15	2.25 ± 0.05
Oviposition period (in days)	20.50 ± 0.22	17.10 ± 0.17	14.01 ± 0.05
Post oviposition period (in days)	10.50±0.22	6.90±0.17	4.13±0.03
Total No. of eggs/female	28.69±0.10	29.33±0.12	30.20±0.16
Average No. of eggs/female /day	1.4±0.05	1.60±0.16	1.84±0.05
Female longevity	34.20±0.44	26.70±0.36	23.88±0.30
Male longevity	26.90±0.52	20.50±0.22	15.64±0.09
Sex ratio (Female: Male)	1:0.37	1:0.24	1:0.31

Significance level at $p<0.05$

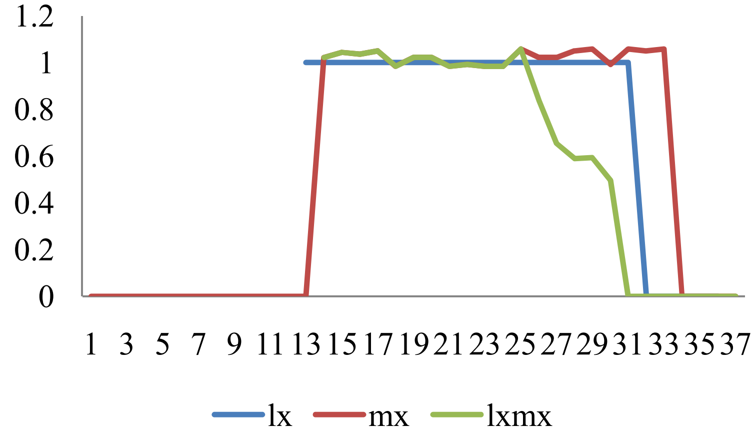
TABLE 18

Life table parameters of *A. dioscoreae* Rahul *et al.,* 2016 on *T. neocaledonicus*

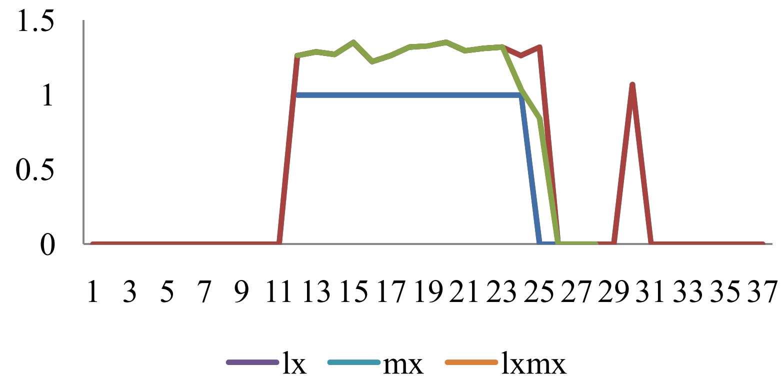
Parameter	Temperature (±2^{o}C)		
	20	25	30
Intrinsic rate of natural increase (r_m/day)	0.12	0.15	0.17
Net reproductive rate (R_0)	15.36	17.47	15.37
Gross reproductive rate (Σm_x)	20.50	18.17	20.58
Mean generation time (T)	21.18	18.28	15.91
Finite rate of increase (λ)	1.13	1.16	1.18
Weekly multiplication	2.46	2.98	3.33
Doubling time (DT)	5.37	4.44	4.03

FIGURE 16
Survival and Fecundity Curves of *A. dioscoreae* at Different Temperatures

20°C



25°C



30°C

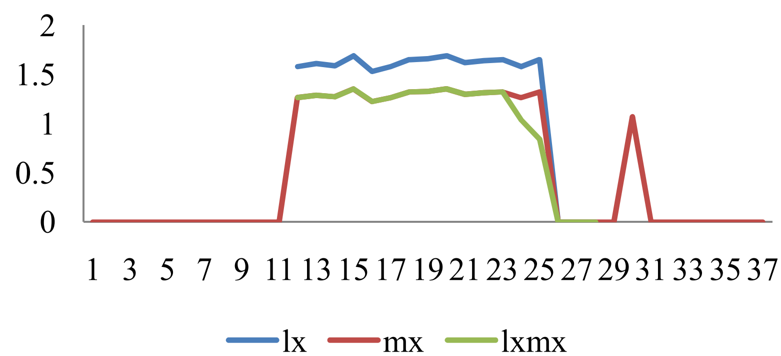
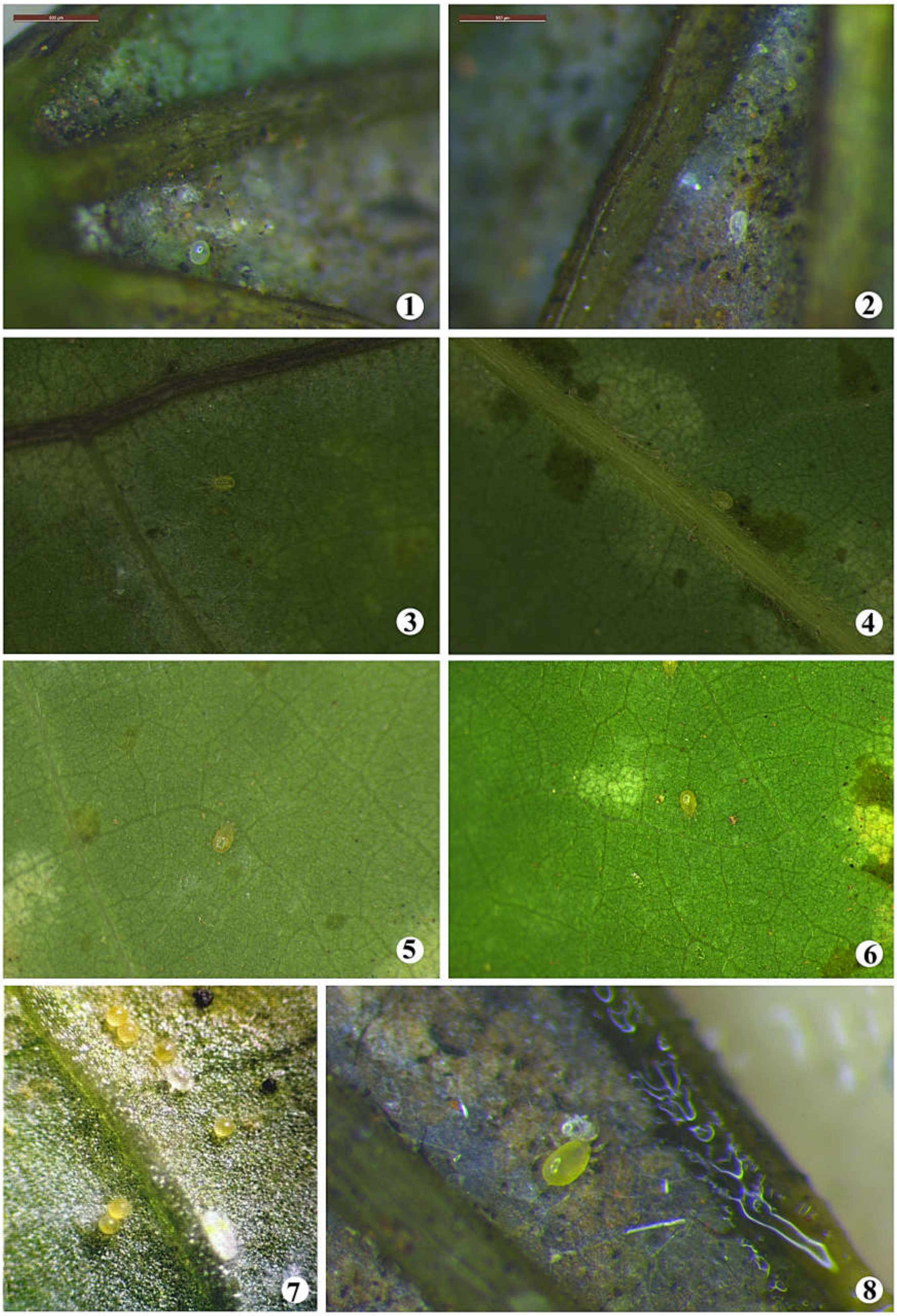
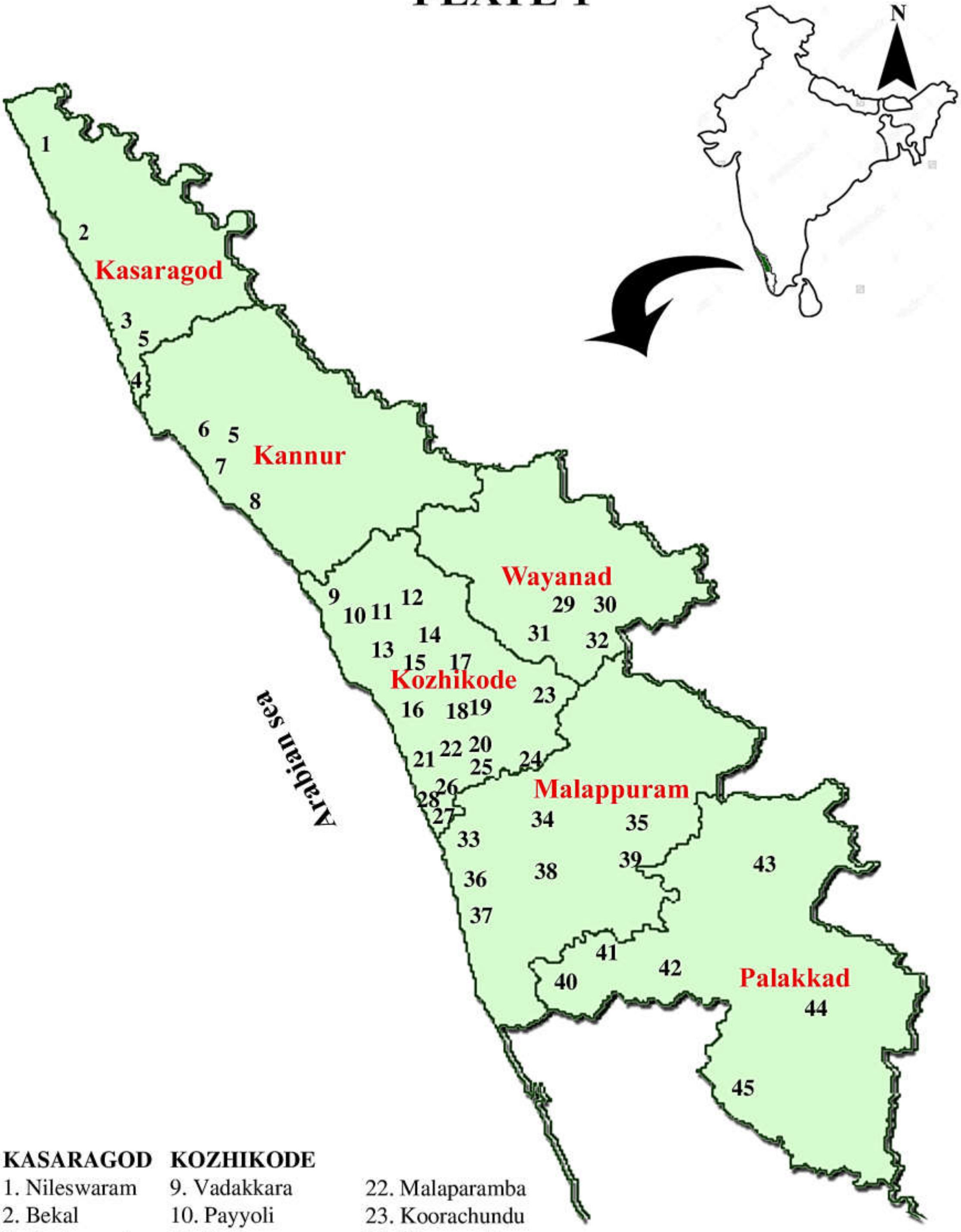


PLATE 82



Figs. 1-8. Breeding and feeding biology of A. *dioscoreae* on *T. neocaledonicus* ; **1.** Egg **2.** Larva; **3.** Protonymph; **4.** Deutonymph; **5.** Adult female; **6.** Adult male; **7.** Larva feeding on egg of the prey; **8.** Adult female feeding on larva of the prey.

PLATE 1



KASARAGOD
1. Nileswaram
2. Bekal
3. Kanhangad
4. Takkekad
5. Vellachal

KANNUR
6. Thaliparamba
7. Pariyaram
8. Pazhayangadi
9. Ambalavayal

KOZHIKODE
9. Vadakkara
10. Payyoli
11. Kollam
12. Cheliya
13. Koottalida
14. Kurumpoyil
15. Ballussery
16. Kakkoor
17. Kanayangode
18. Kunduparamba
19. Kakkodi
20. Vengeri
21. Ashokapuram
22. Malaparamba
23. Koorachundu
24. Kavumvattam
25. Pazhoor
26. Ramanattukara
27. Feroke
28. Mankave

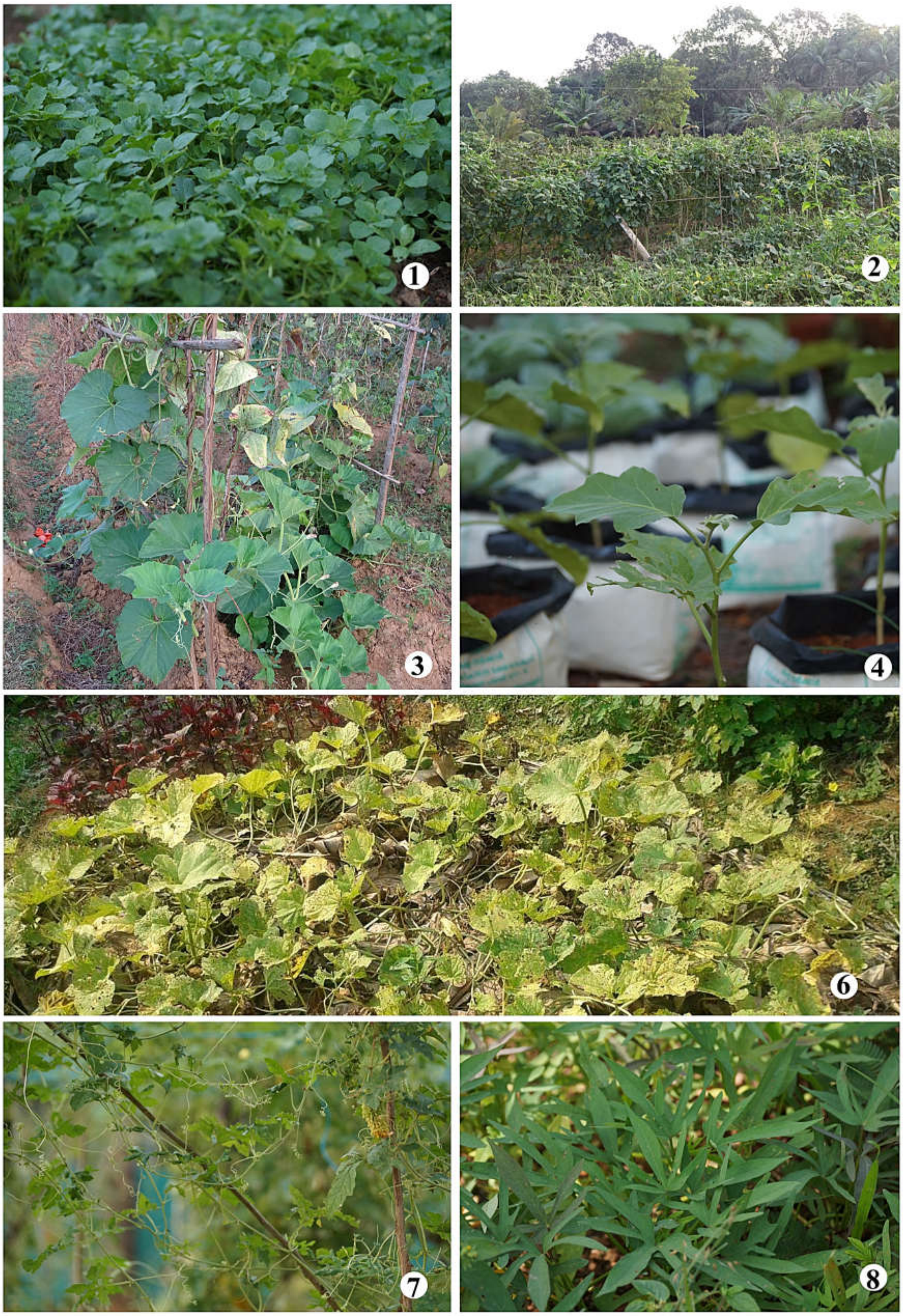
WAYANAD
29. Kalpetta
30. Sulthan Batheri
31. Ambalavayal
32. Thekkumthara

MALAPPURAM
33. Thenhipalam
34. Mongam
35. Manjeri
36. Parappanangadi
37. Chelari
38. Kottakkal
39. Perinthalmanna

PALAKKAD
40. Pattambi
41. Shornoor
42. Ottappalam
43. Mannarkkad
44. Chittoor
45. Nenmara

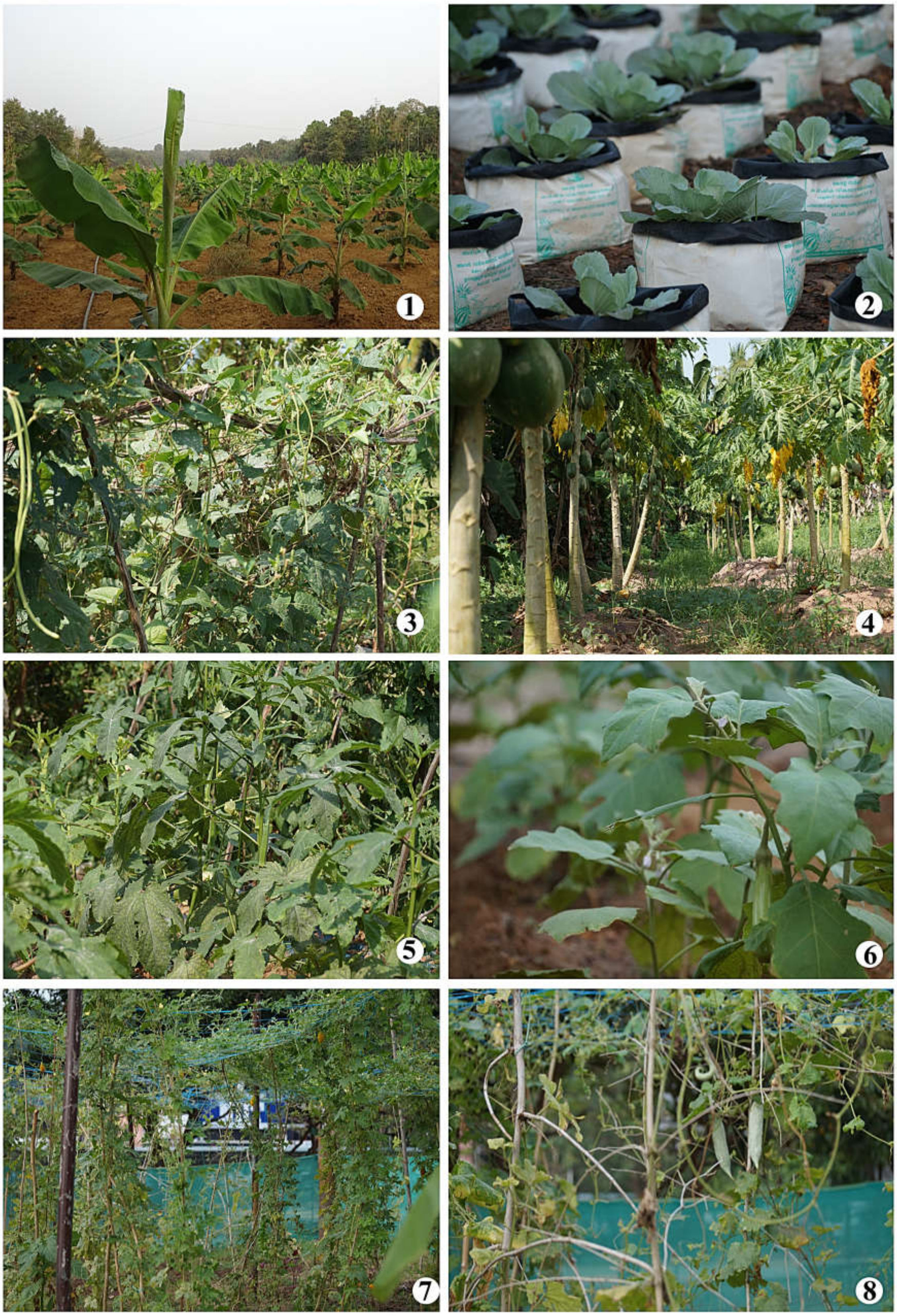
KASARAGOD (12.43^{0}N-75.20^{0}E) **KANNUR** (11.87^{0}N-75.37^{0}E)
WAYANAD (11.68^{0}N-76.13^{0}E) **KOZHIKODE** (11.07^{0}N-76.07^{0}E) **PALAKKAD** (10.78^0 N-76.65^{0}E)

PLATE 2



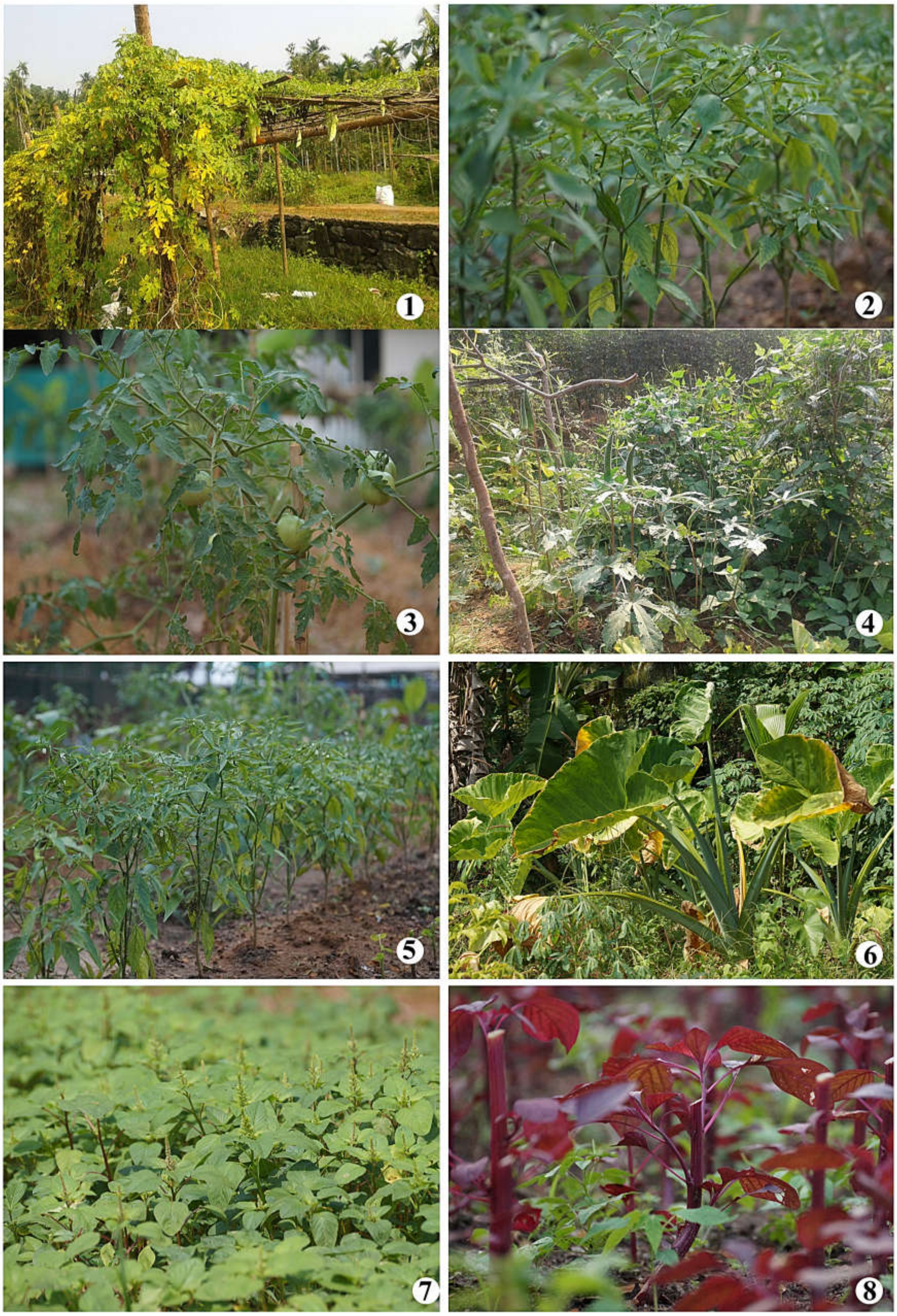
Figs. 1-3. Collection sites at Kasaragod District; **1.** Nileshwaram**; 2.** Kanhangad, **3.** Bekal; **Figs. 4-7.** Collection sites at Kannur District; **4.** Thaliparamba; **5.** Pariyaram; **6.** Pazhayangadi; **7.** Edakkad.

PLATE 3



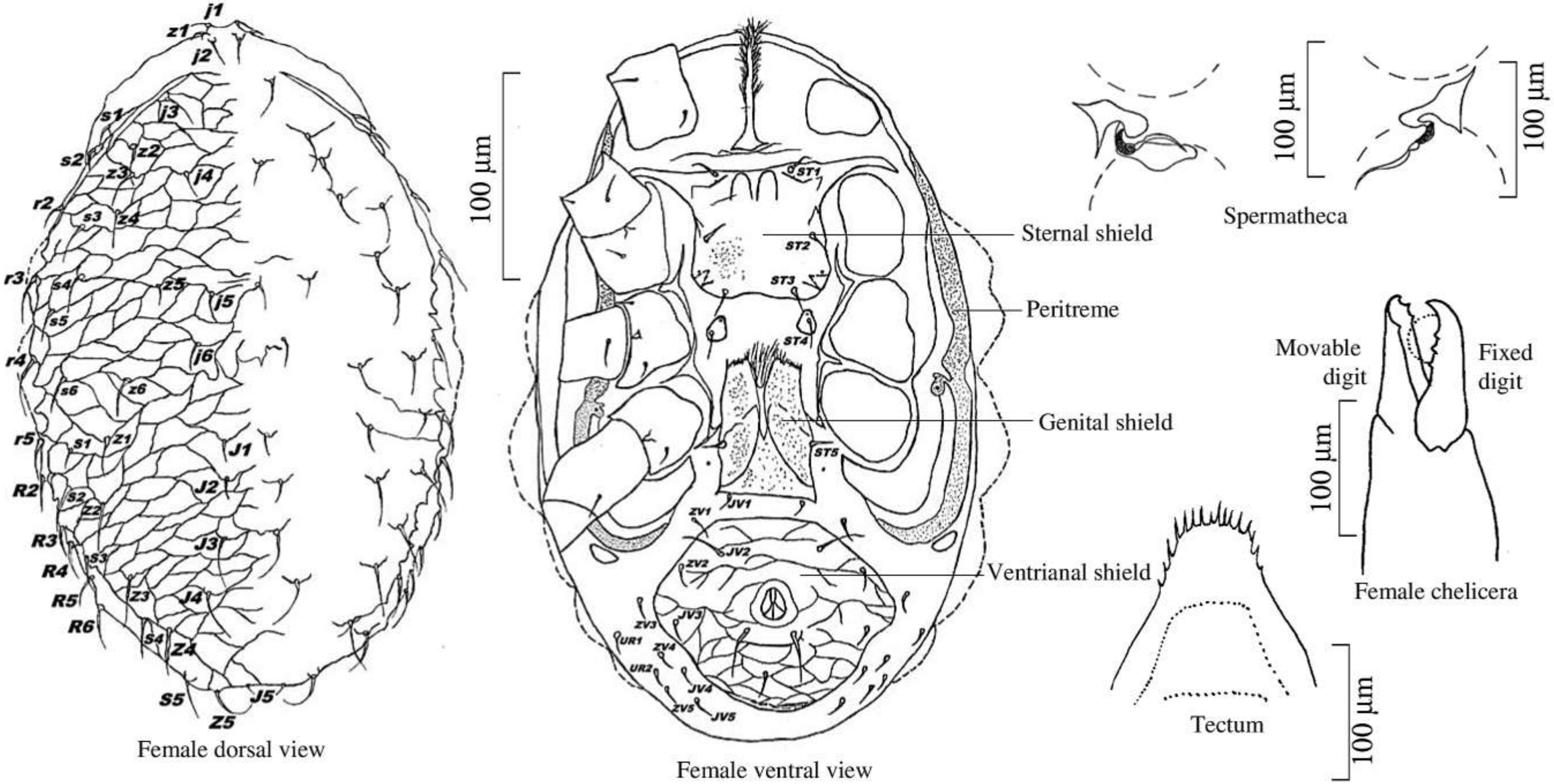
Figs. 1-4. Collection sites at Wayanad District; **1.** Thekkumthara; **2.** Ambalavayal; **3.** Kalpetta; **4.** Sulthan Batheri; **Figs. 5-8.** Collection sites at Palakkad District; **5.** Ottappalam; **6.** Shornur; **7.** Mannarkad; **8.** Pattambi

PLATE 4



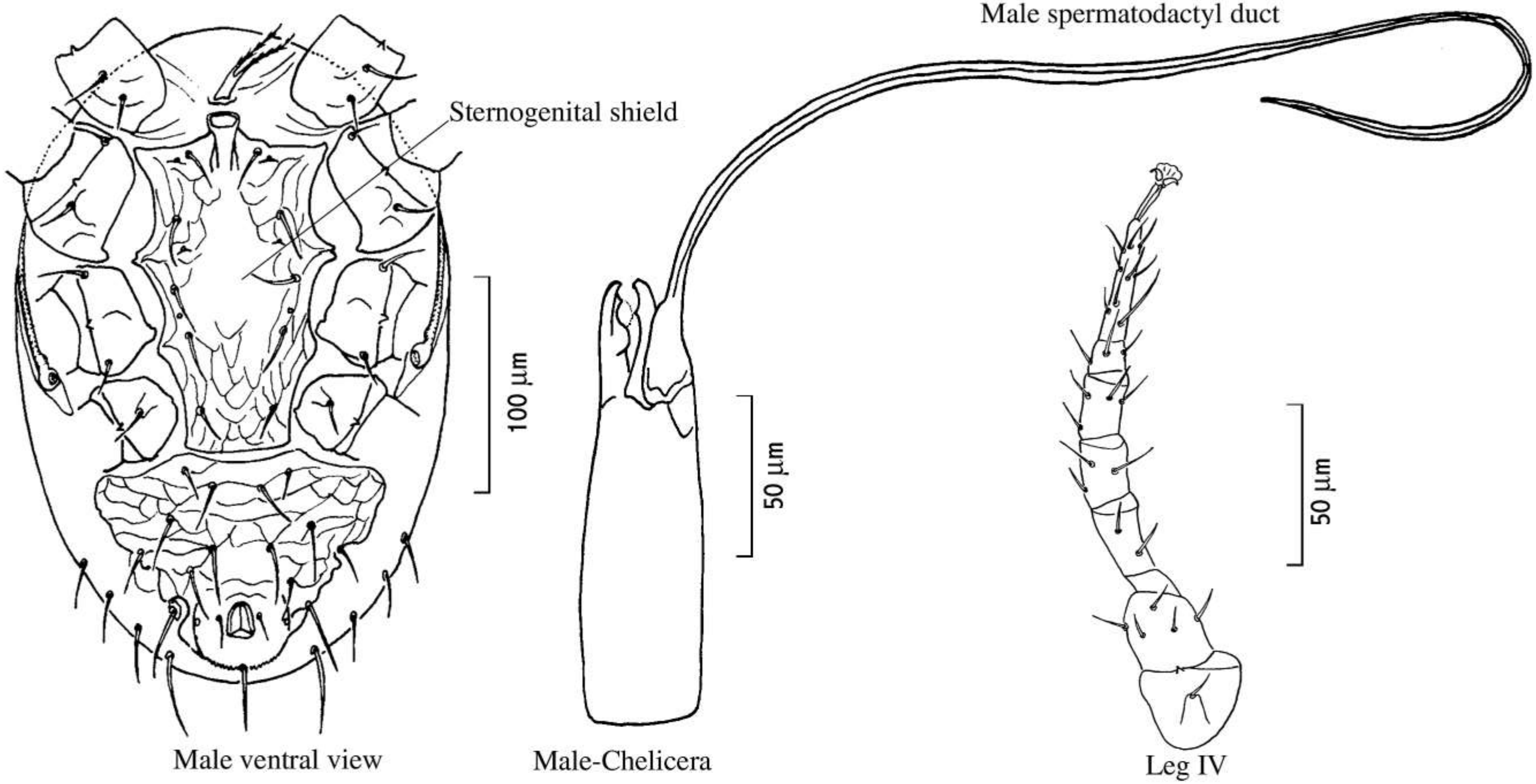
Figs. 1-6. Collection sites at Kozhikode District; **1.** Koottalida **2.** Kadalundi; **3.** Vengeri; **4.** Ummalathoor; **5.** Pazhoor; **6.** Kanayamkode; **Figs. 7-8.** Collection sites at Malappuram District; **7.** Manjeri; **8.** Parappanangadi

PLATE 5A



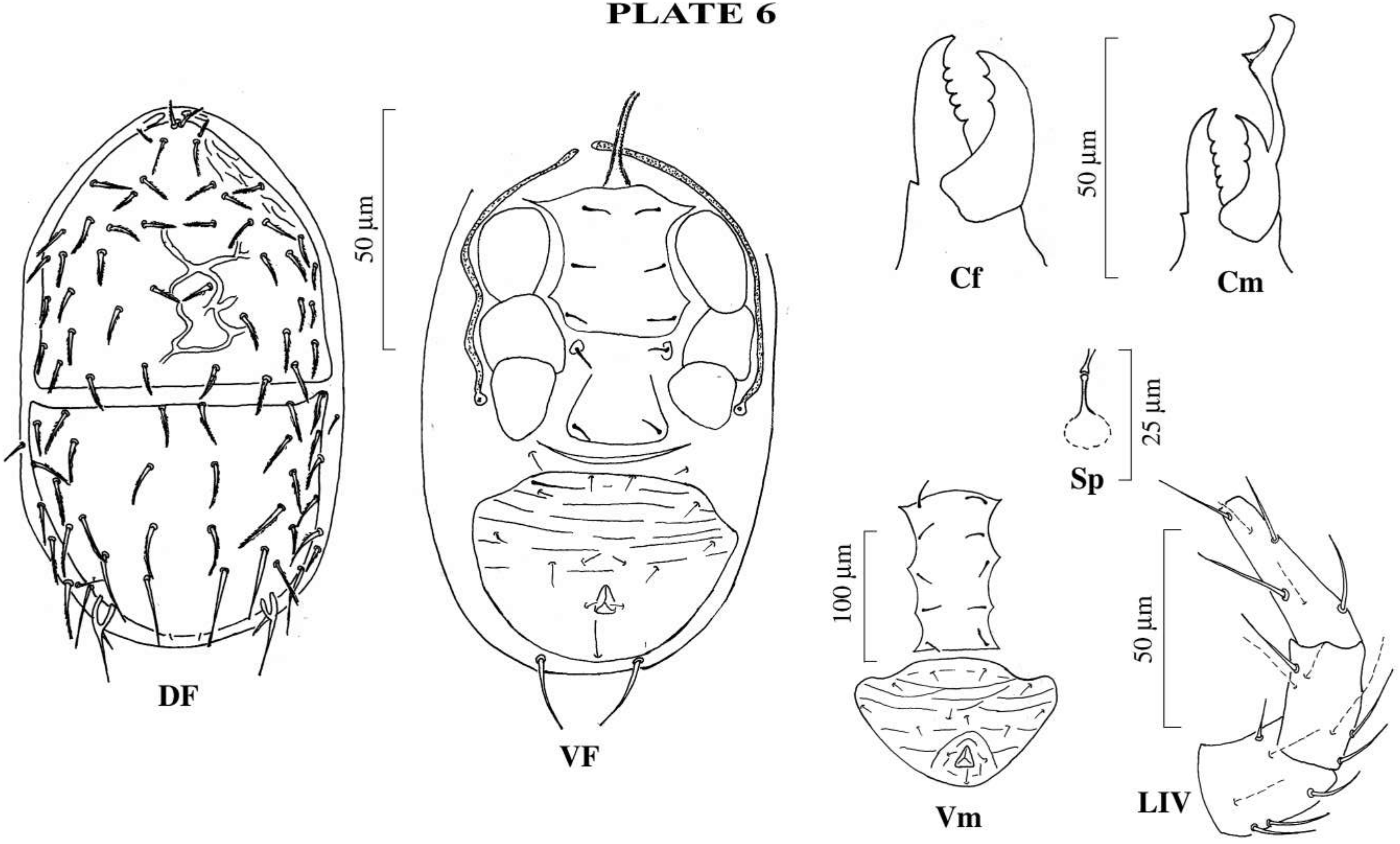
Morphological and Taxonomical Characters of the Family Ascidae A

PLATE 5A



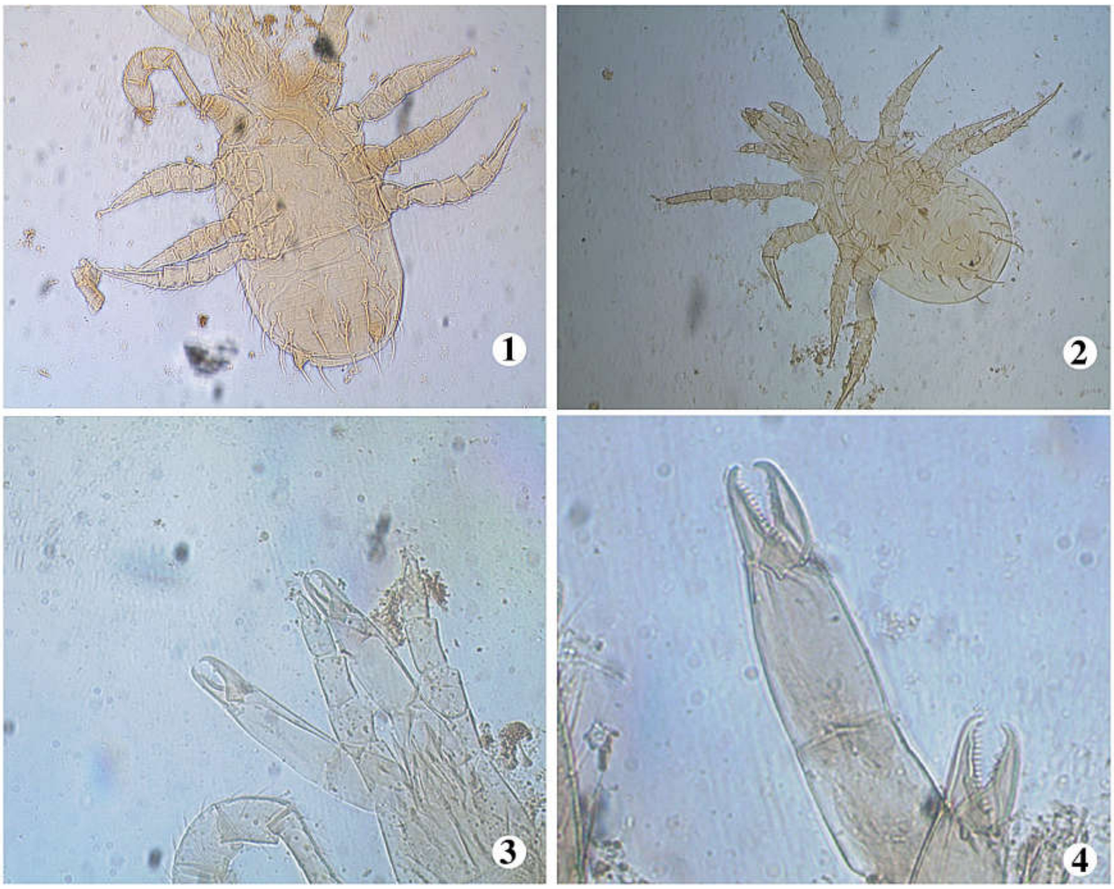
Morphological and Taxonomical Characters of the Family Ascidae B

PLATE 6



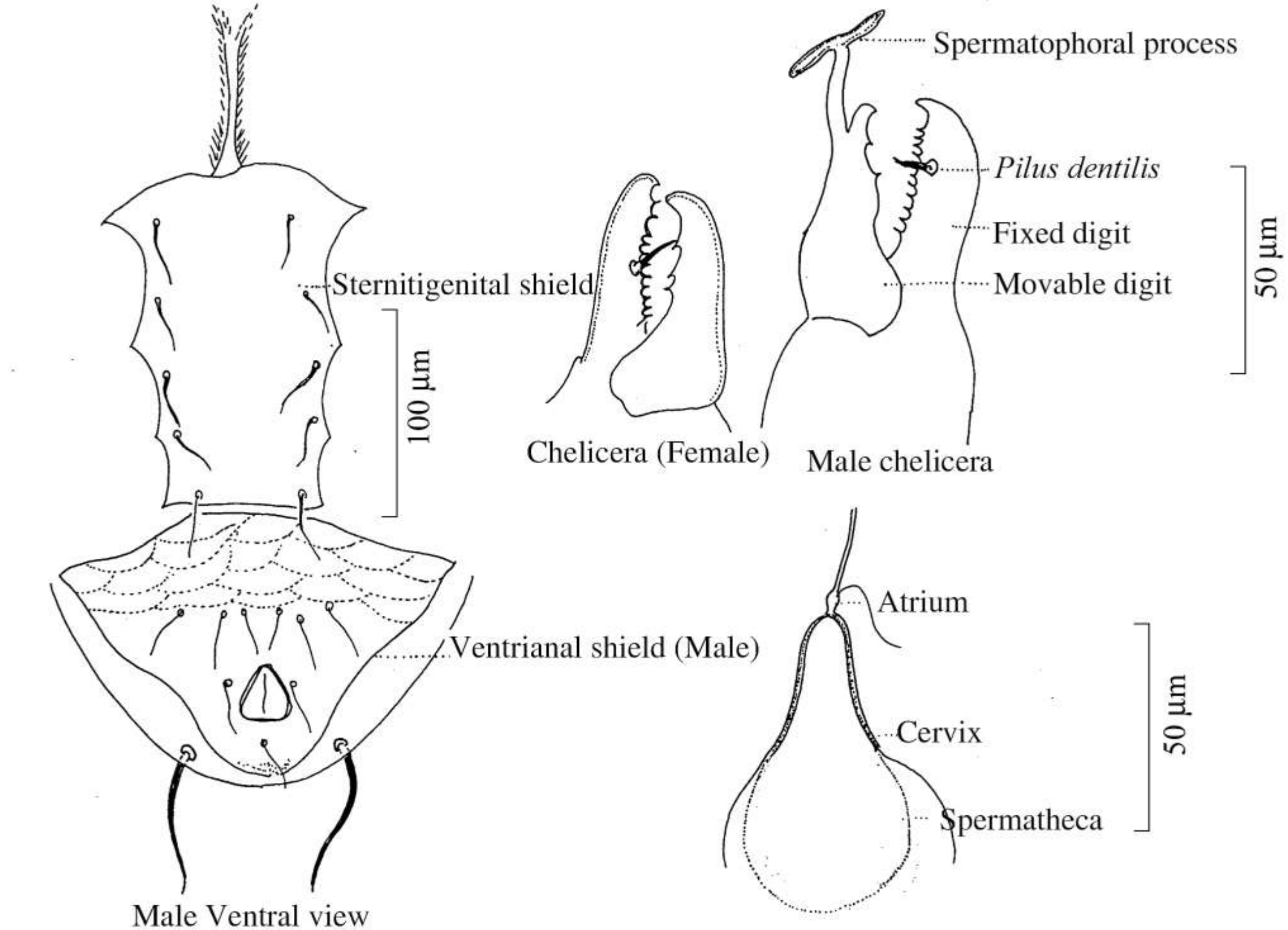
Asca babithae sp. nov.

PLATE 7



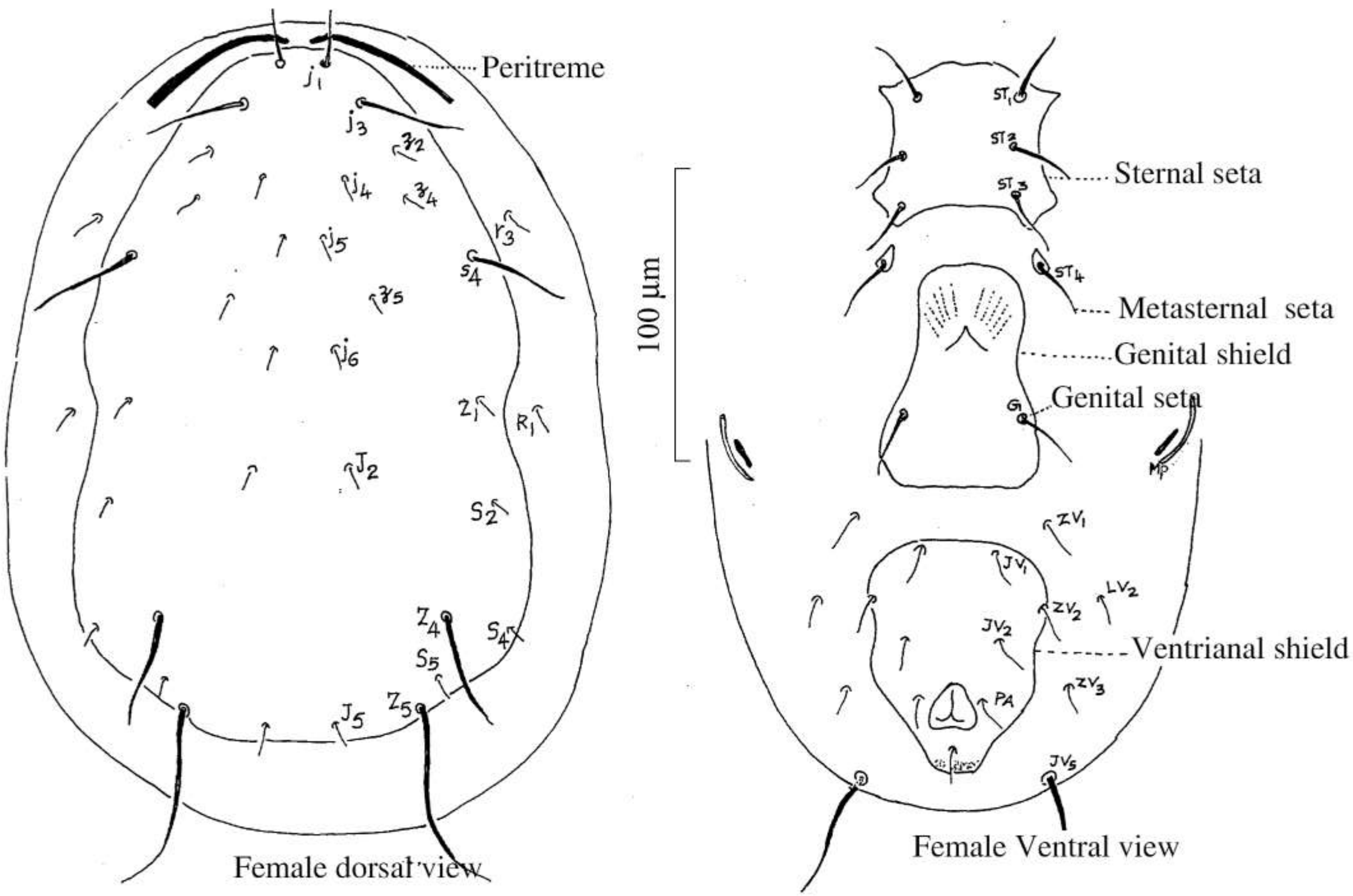
Family Ascidae: **1.** Female-Dorsal view; **2.** Female-Ventral view; **3.** Female-Hypostome; **4.** Female-chelicera.

PLATE 8B



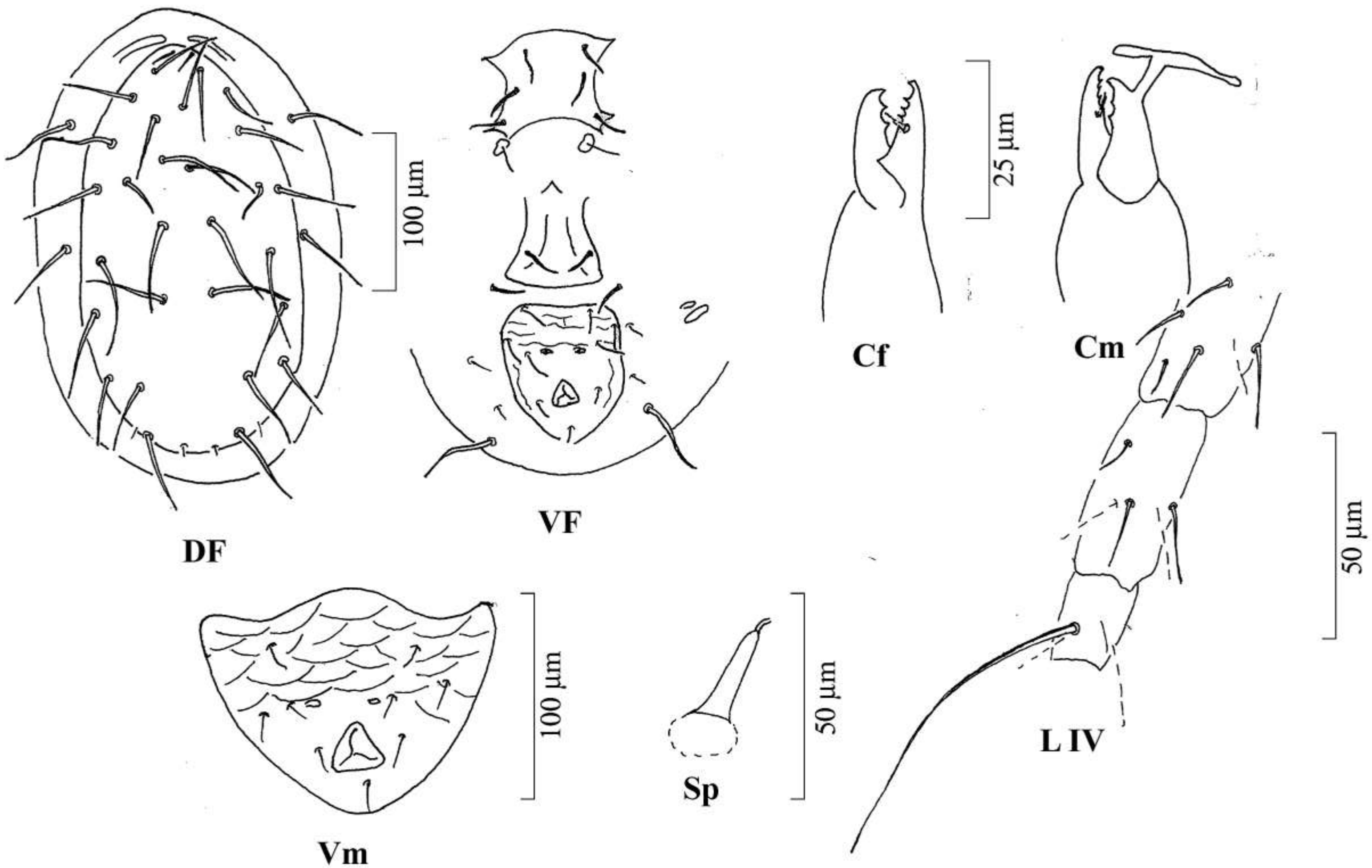
Morphological and Taxonomical Characters of the Family Phytoseiidae B

PLATE 8A



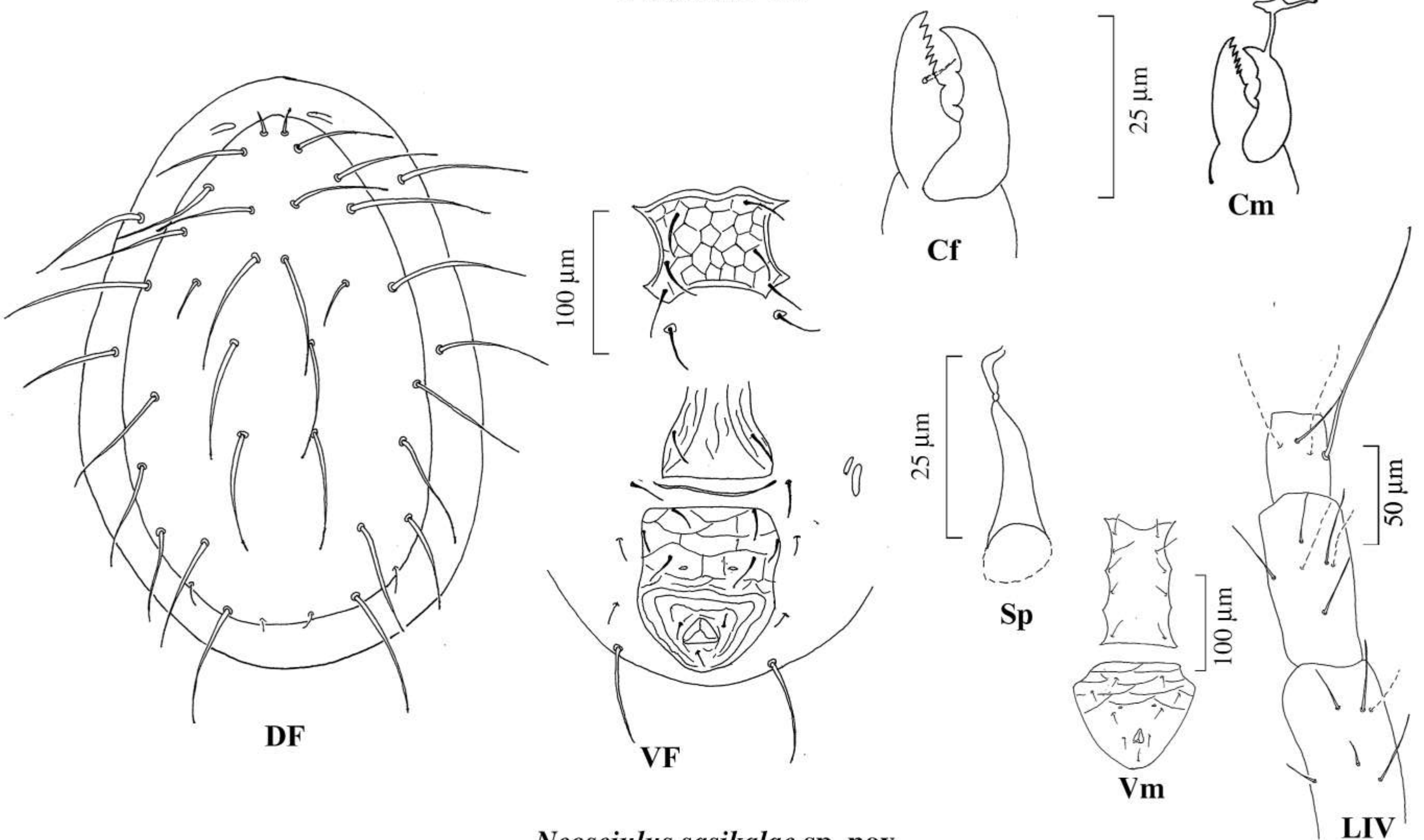
Morphological and Taxonomical Characters of the Family Phytoseiidae A

PLATE 9



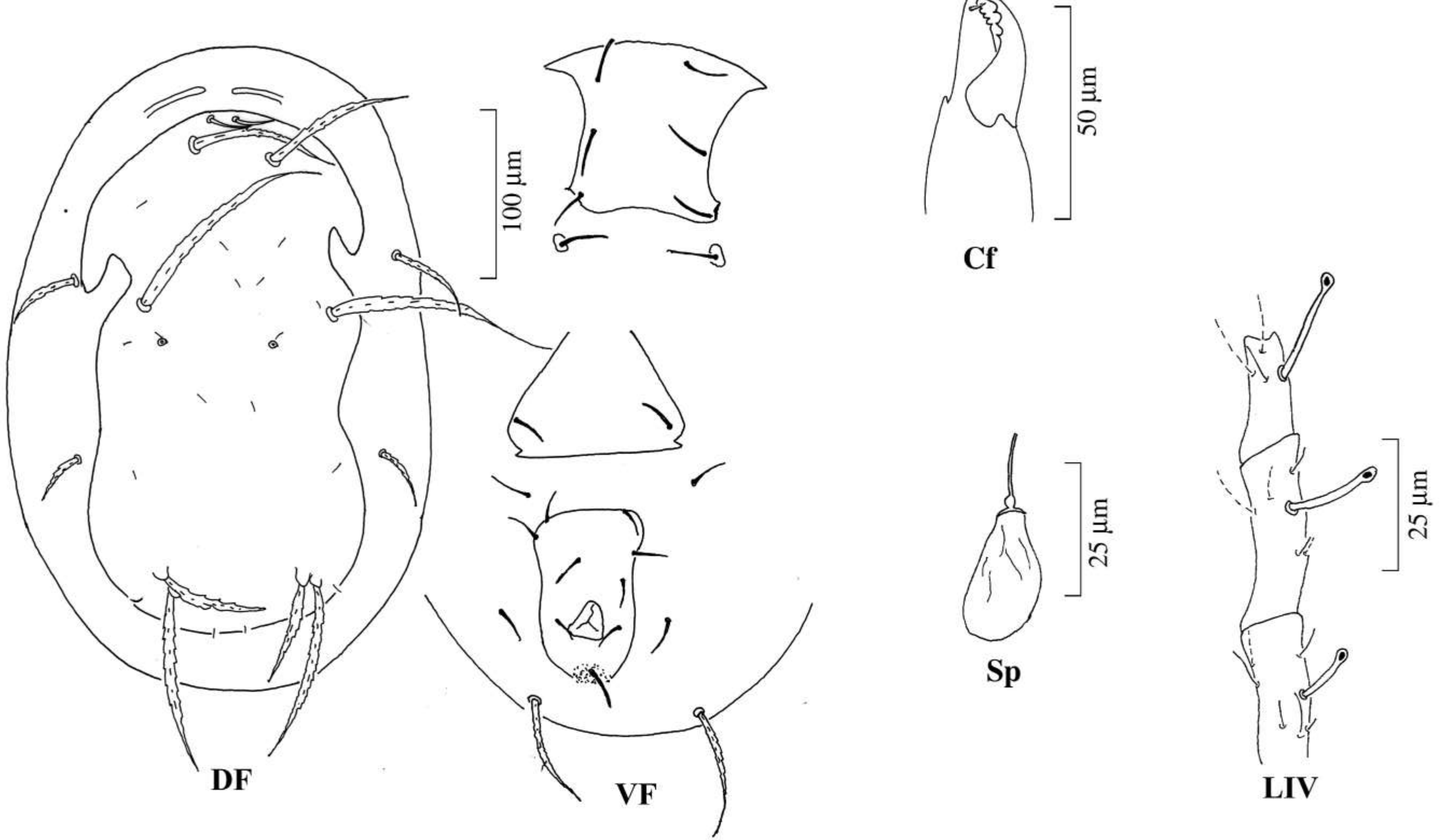
Neoseiulus longispinosus (Evans), 1952

PLATE 10



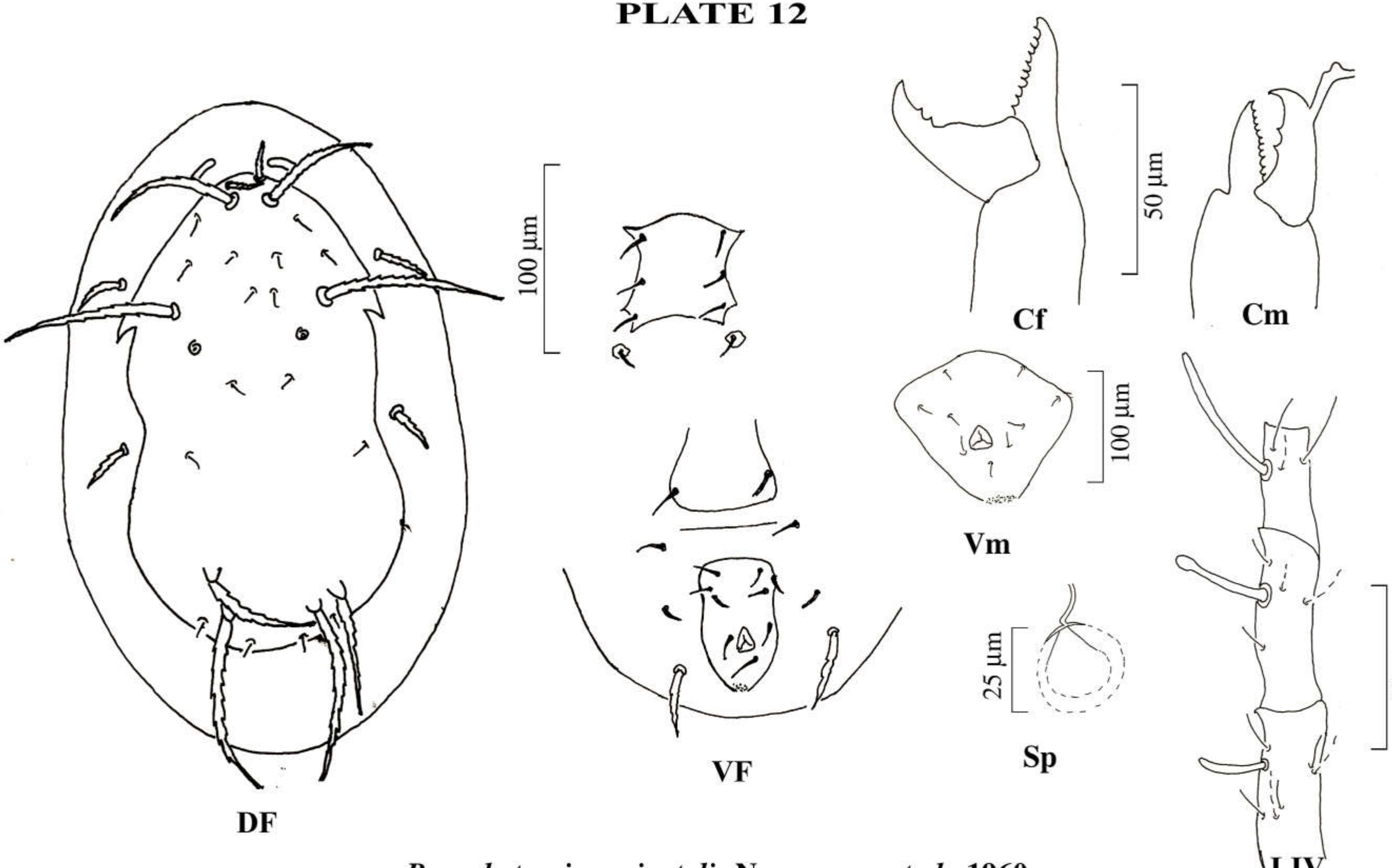
Neoseiulus sasikalae sp. nov.

PLATE 11



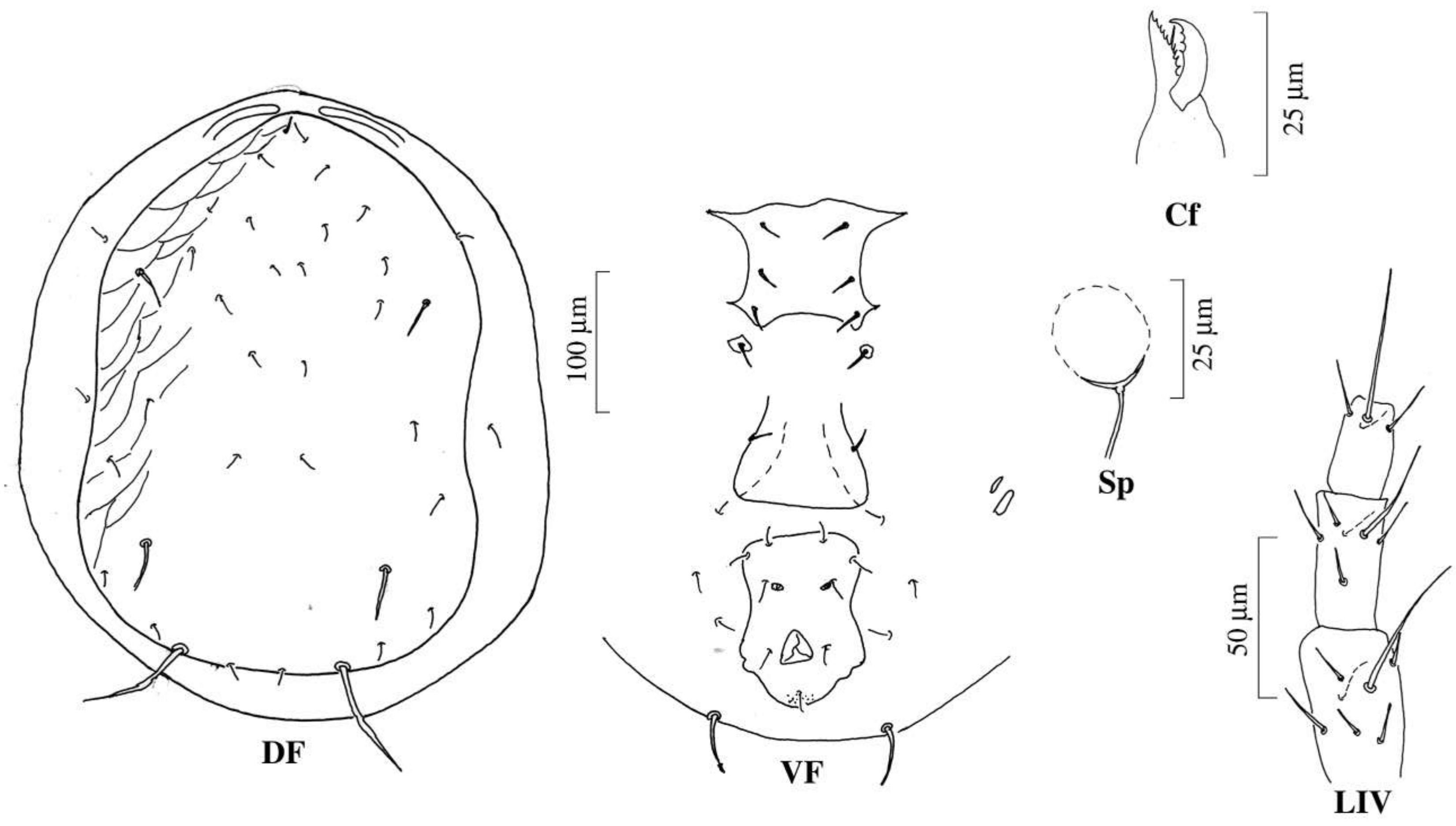
Paraphytoseius bhadrakaliensis Gupta, 1969

PLATE 12



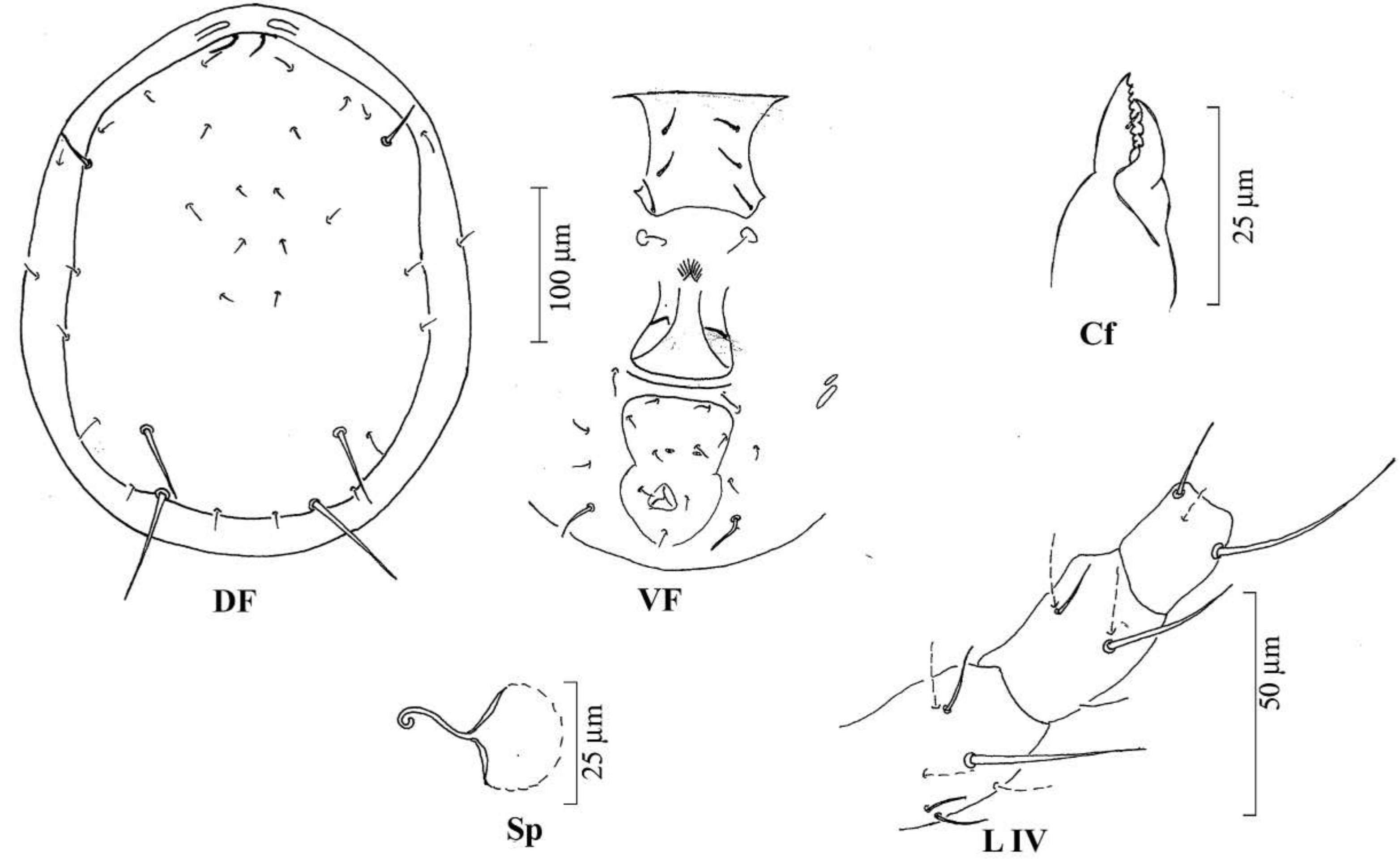
Paraphytoseius orientalis Narayanan *et al*., 1960

PLATE 13



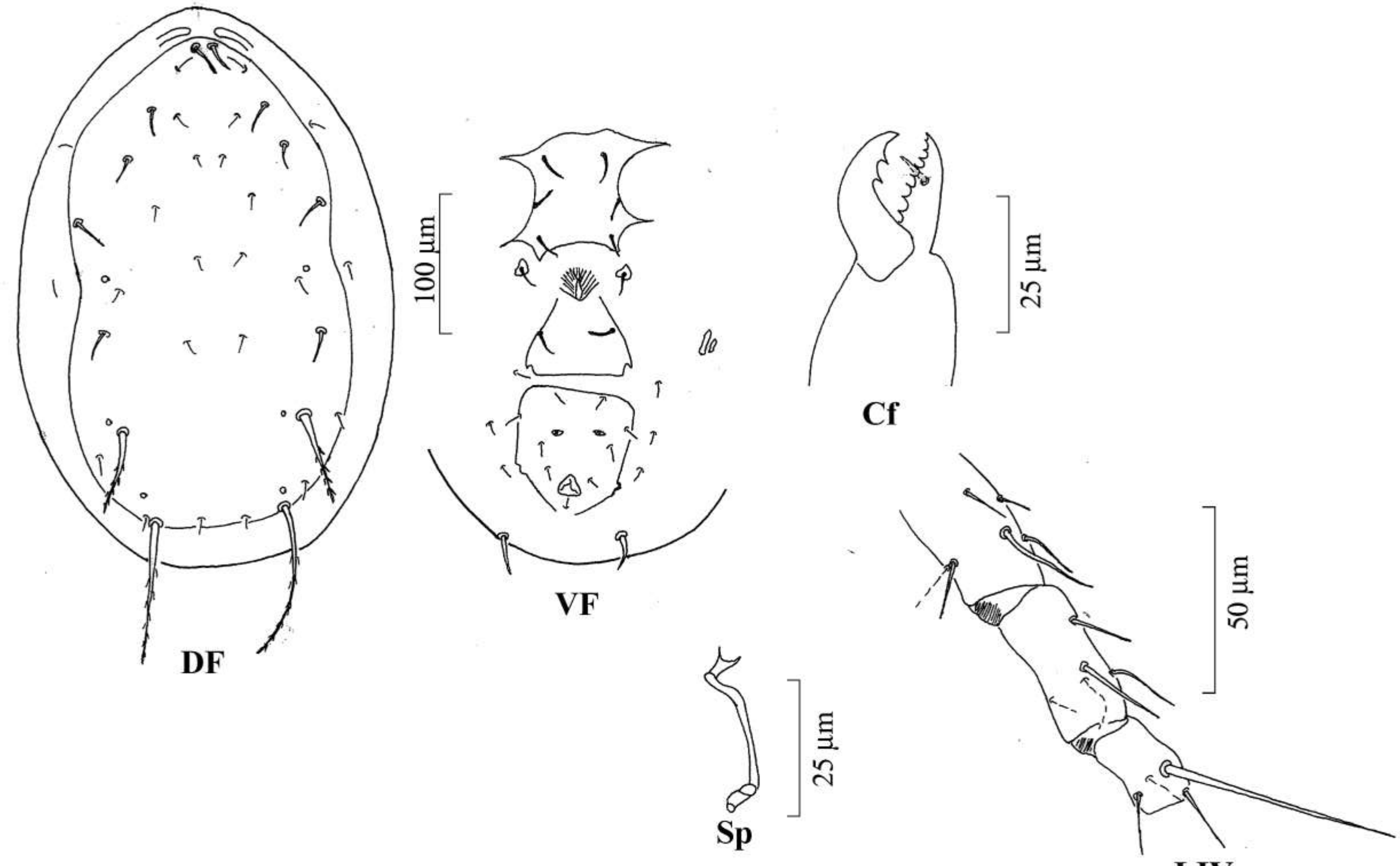
Typhlodromips syzygii Gupta, 1975

PLATE 14



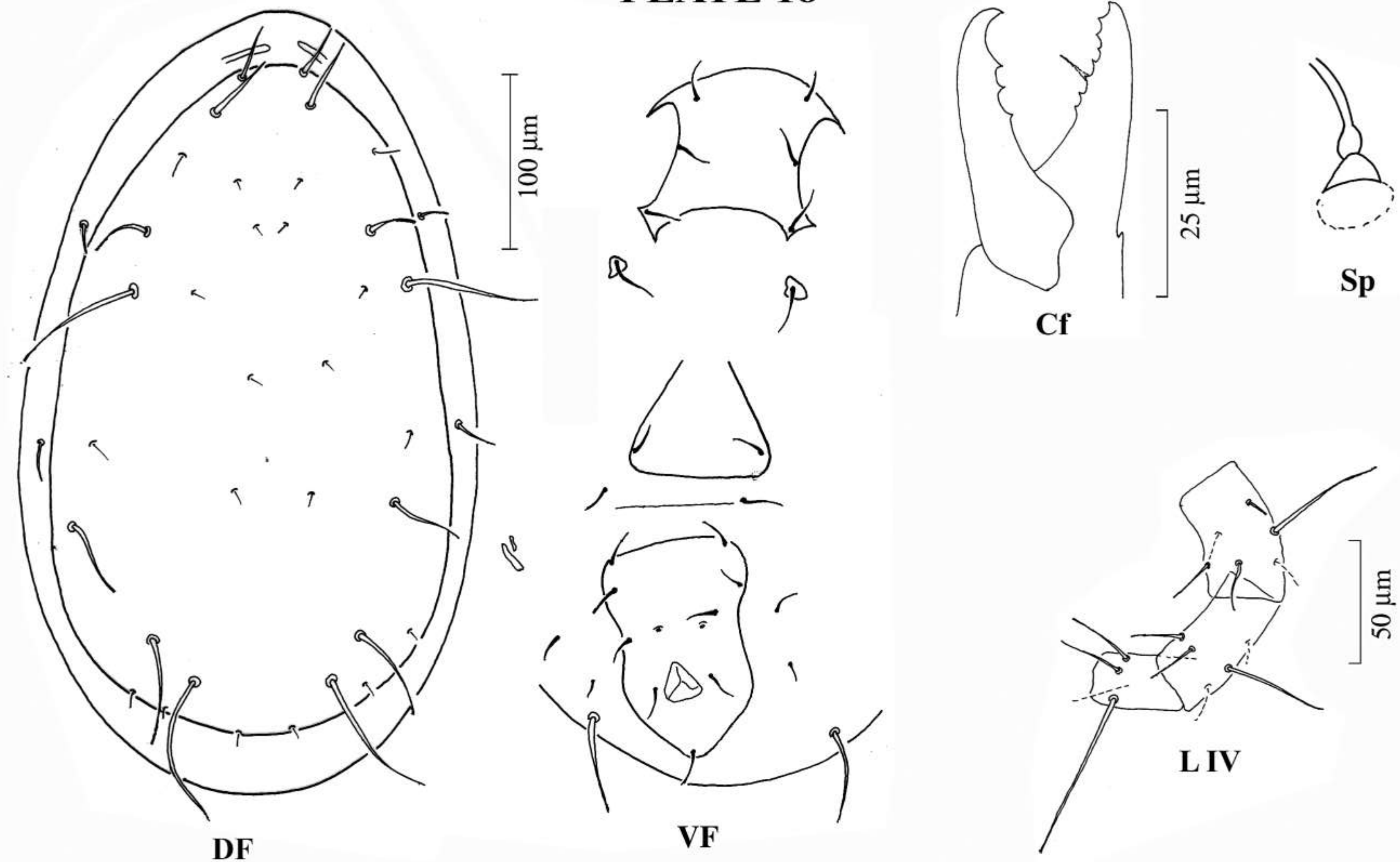
Scapulaseius meghalayensis Gupta, 1978

PLATE 15



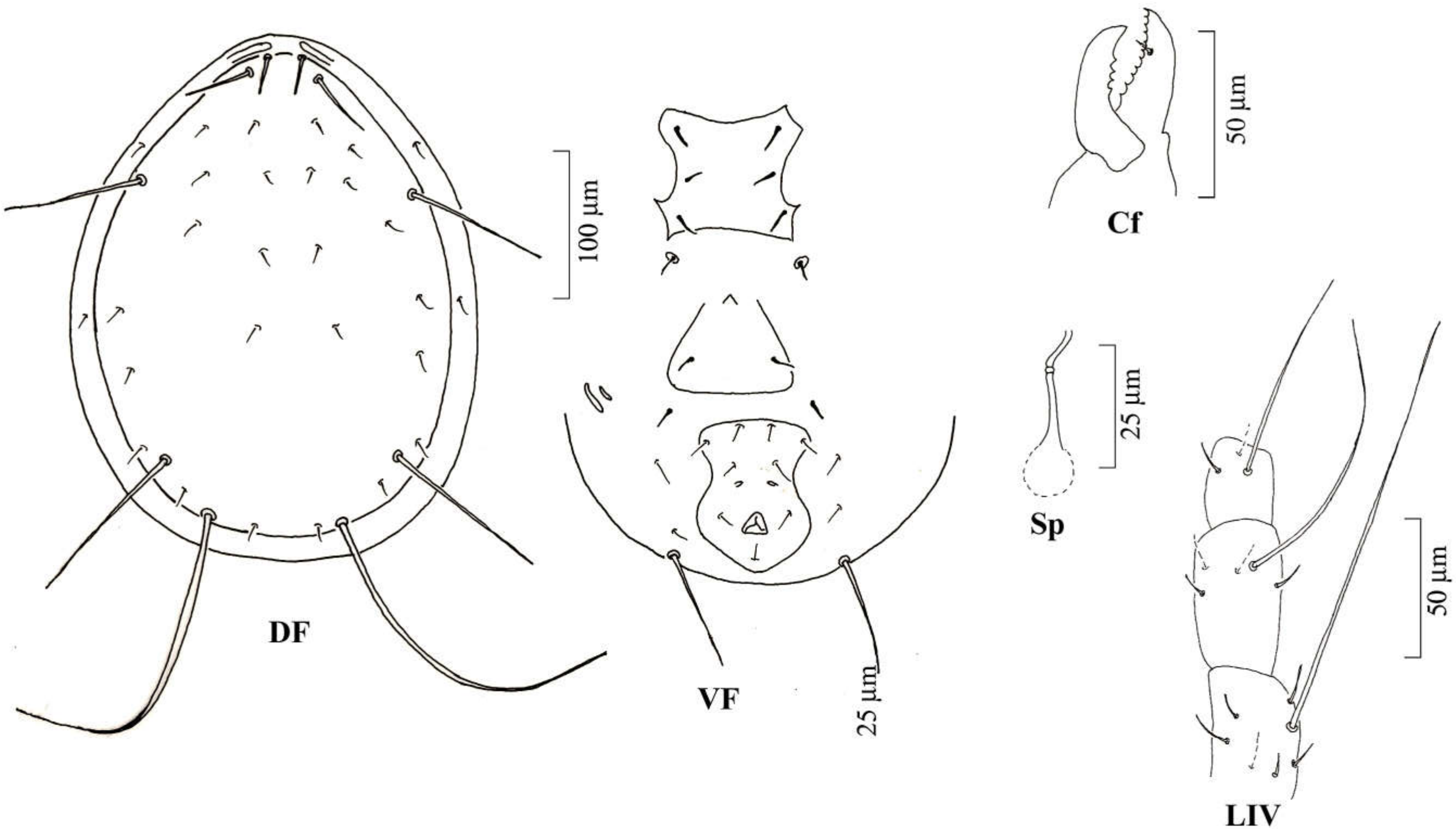
Scapulaseius suknaensis Gupta, 1970

PLATE 16



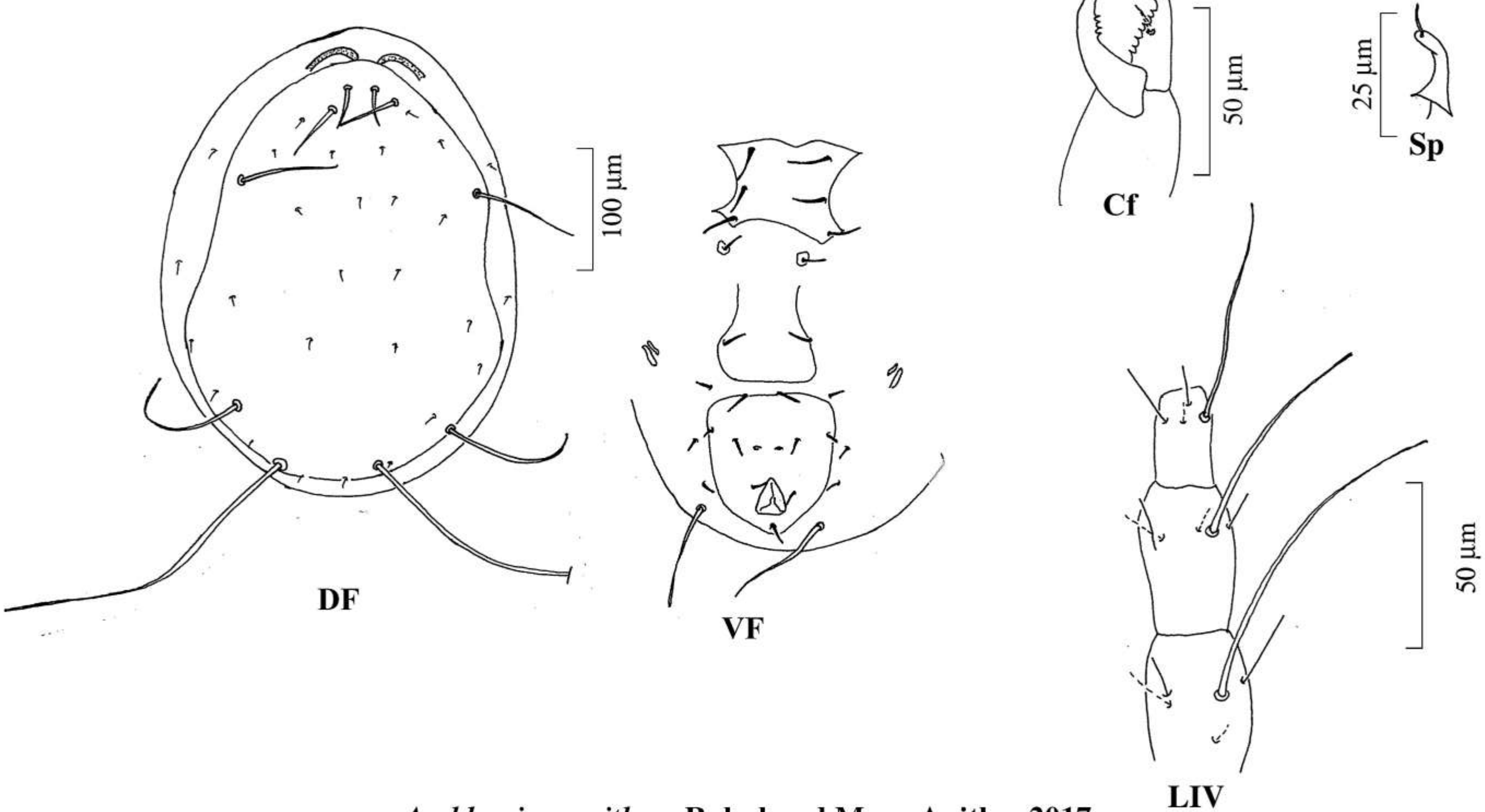
Transeius tetranychivorus (Gupta), 1978

PLATE 17



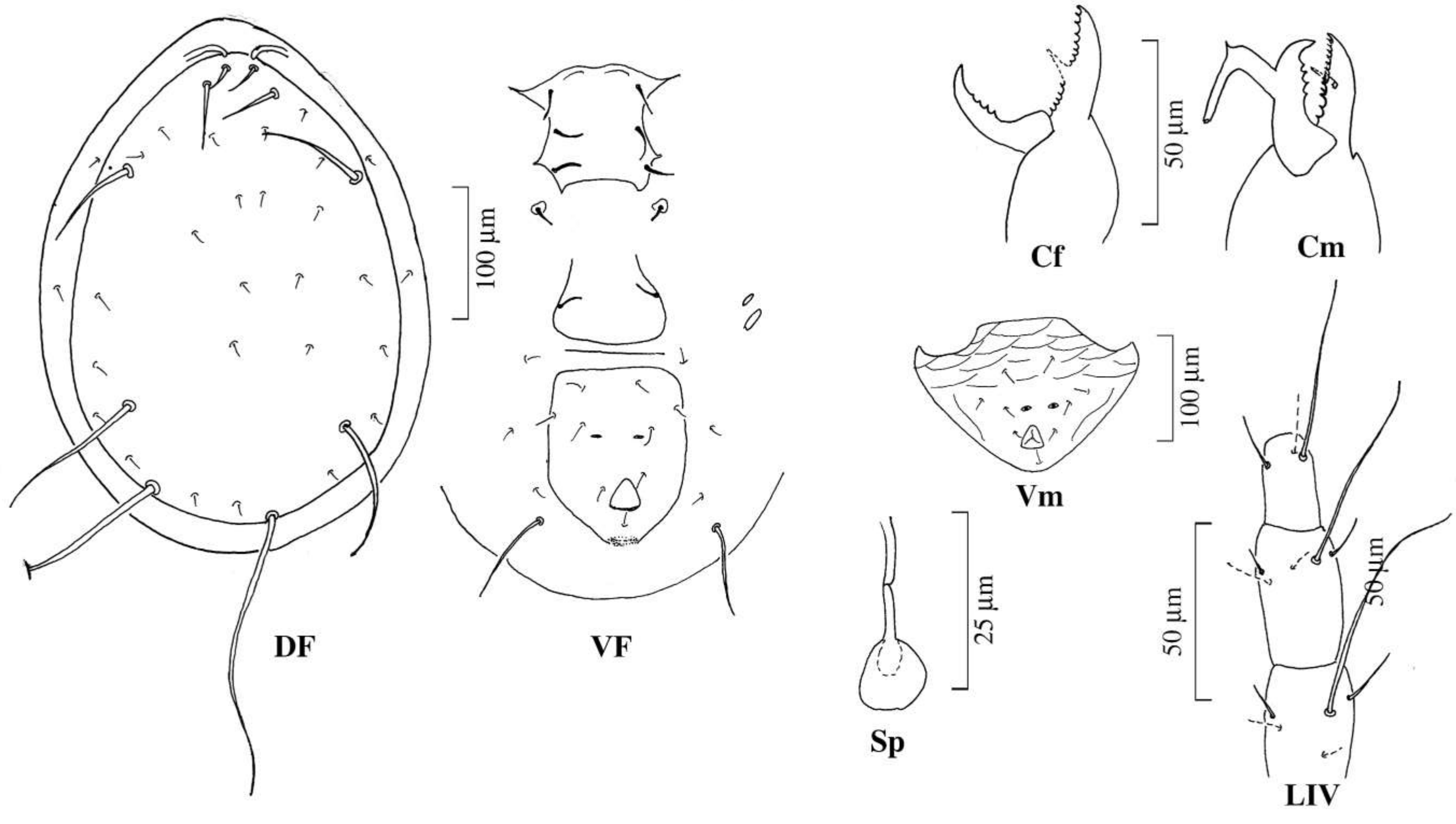
Amblyseius aerialis (Muma), 1955

PLATE 18



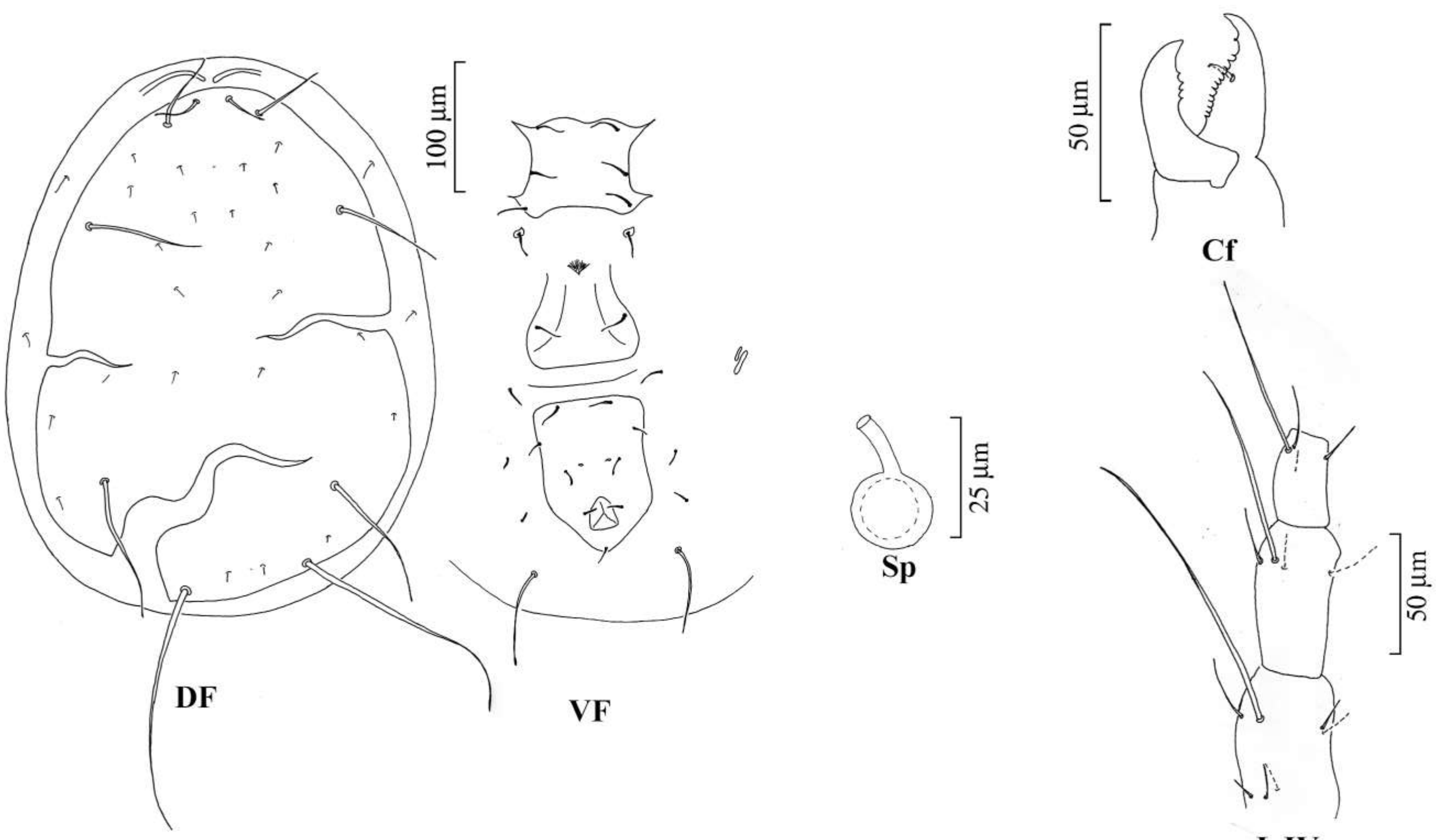
Amblyseius amithae **Rahul and Mary Anitha, 2017**

PLATE 19



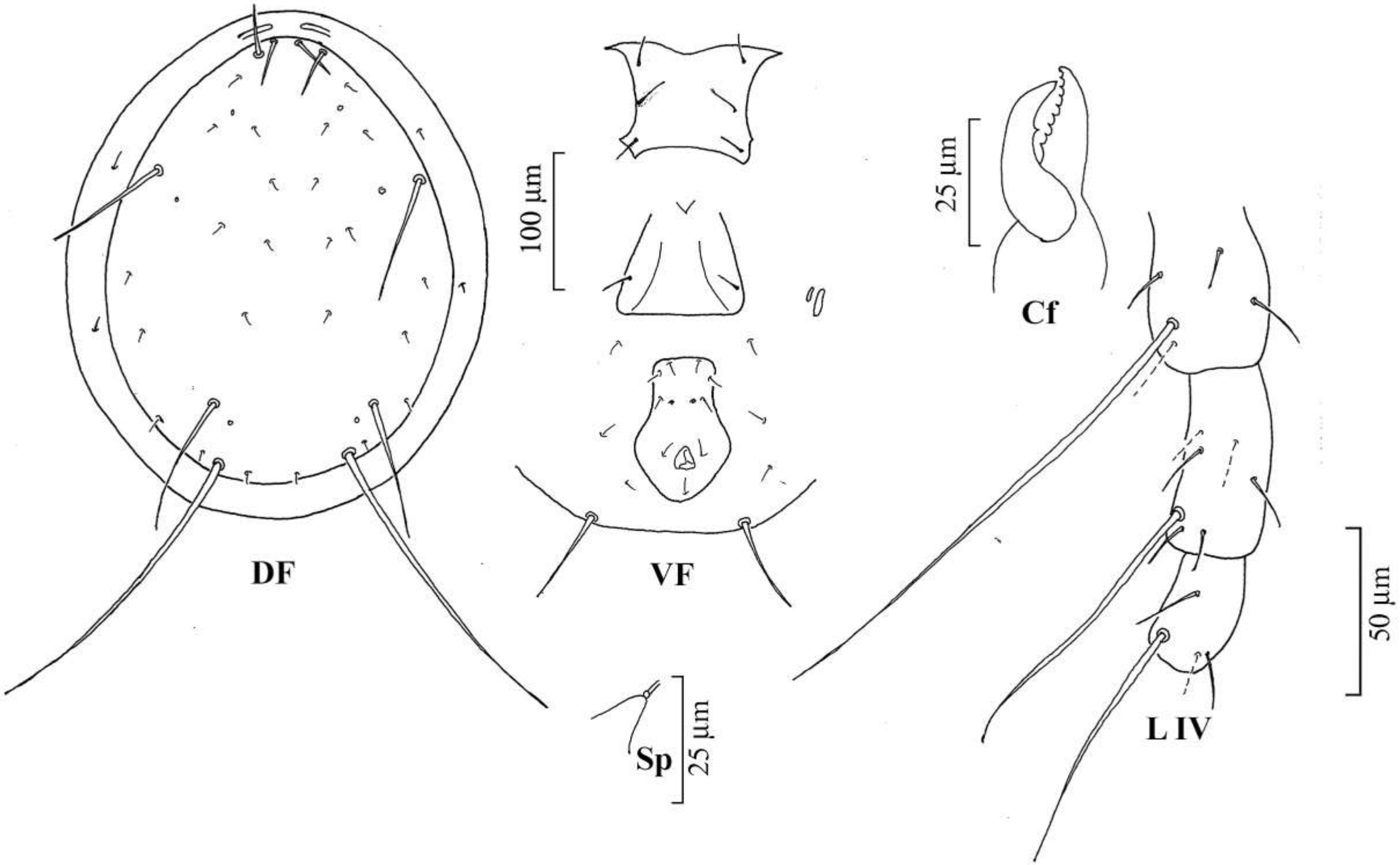
Amblyseius channabasavannai Guptha and Daniel, 1978

PLATE 20



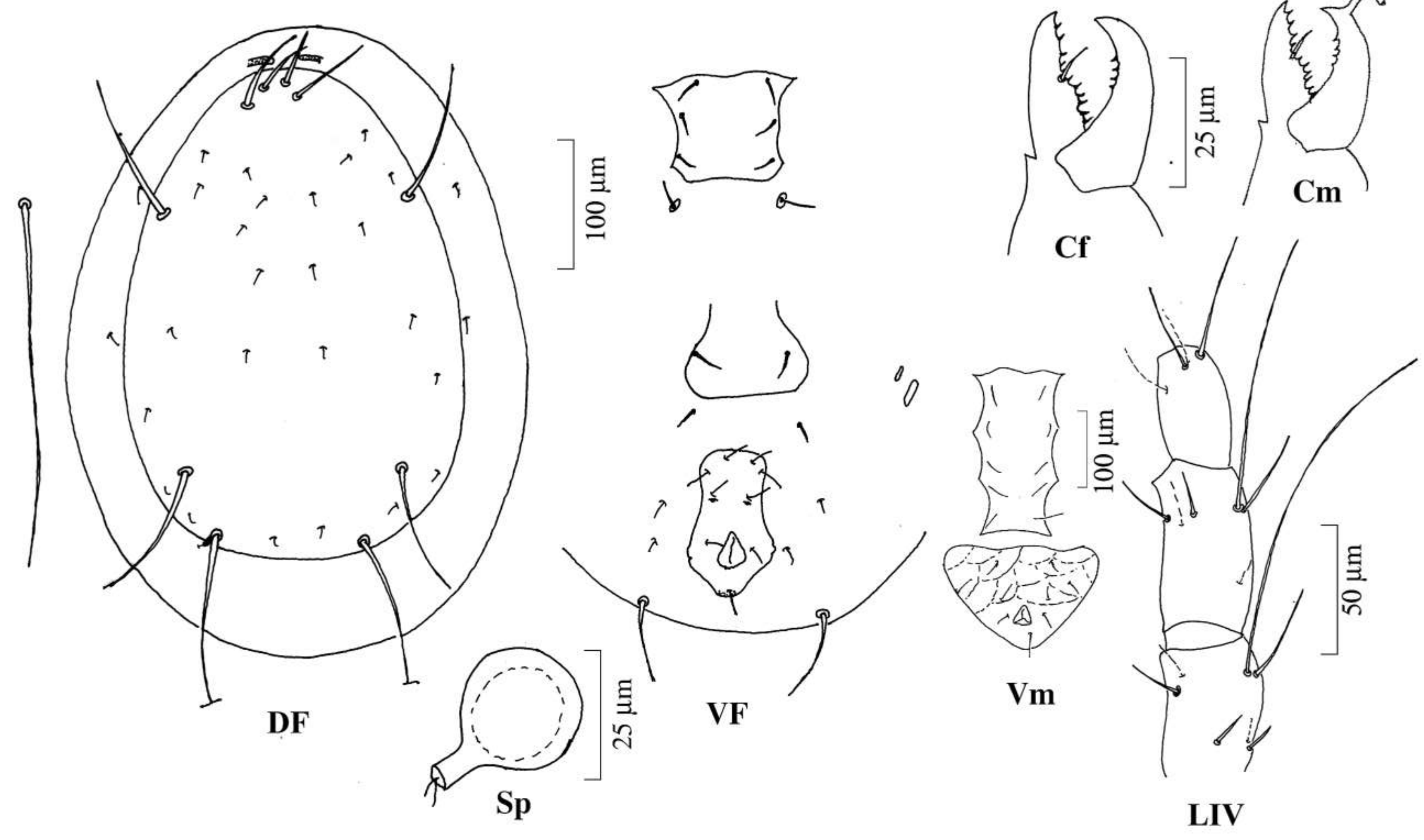
Amblyseius cinctus **Corpuz-Raros and Rimando, 1966**

PLATE 21



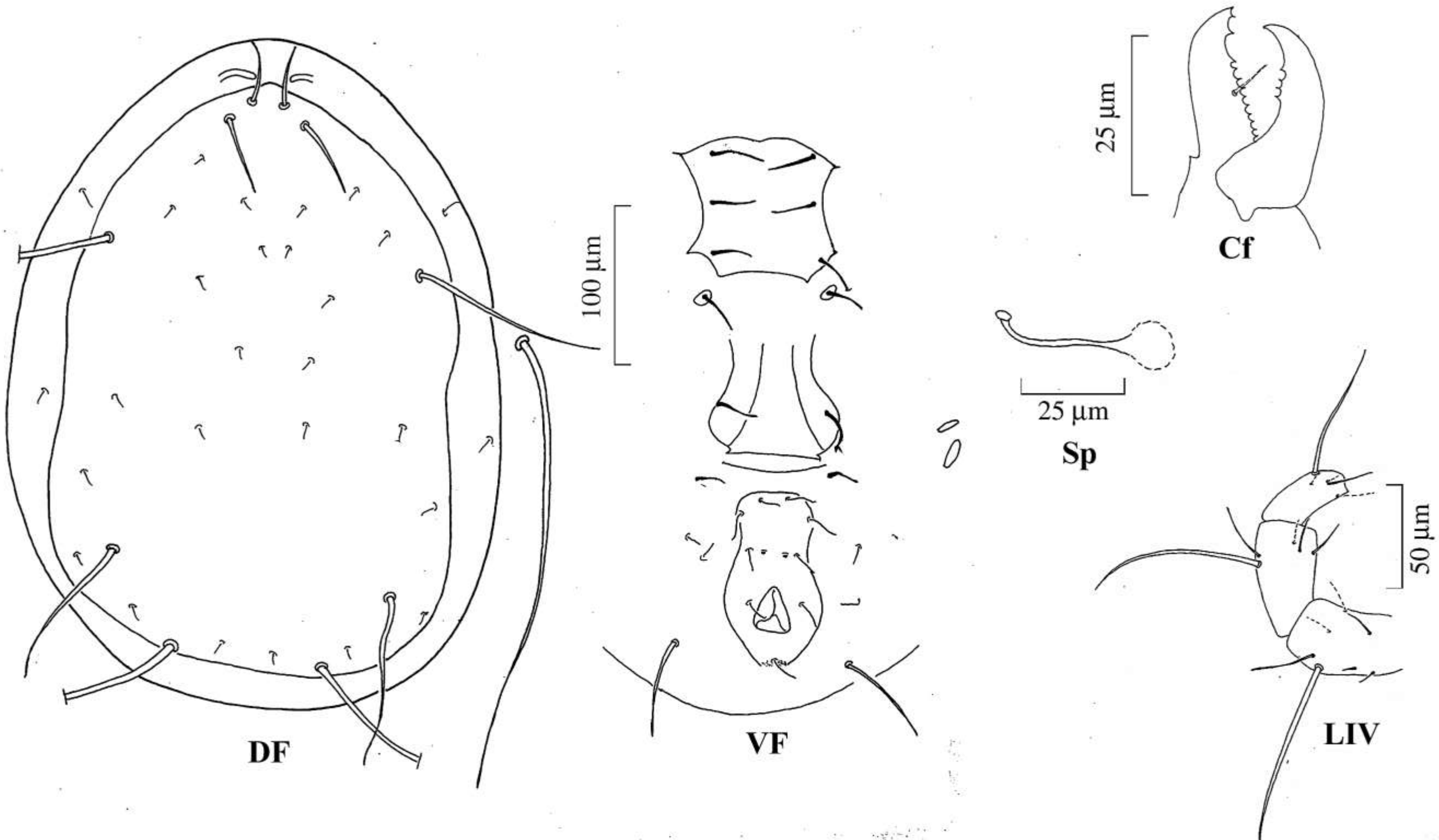
Amblyseius cucurbitae Rather, 1985

PLATE 22



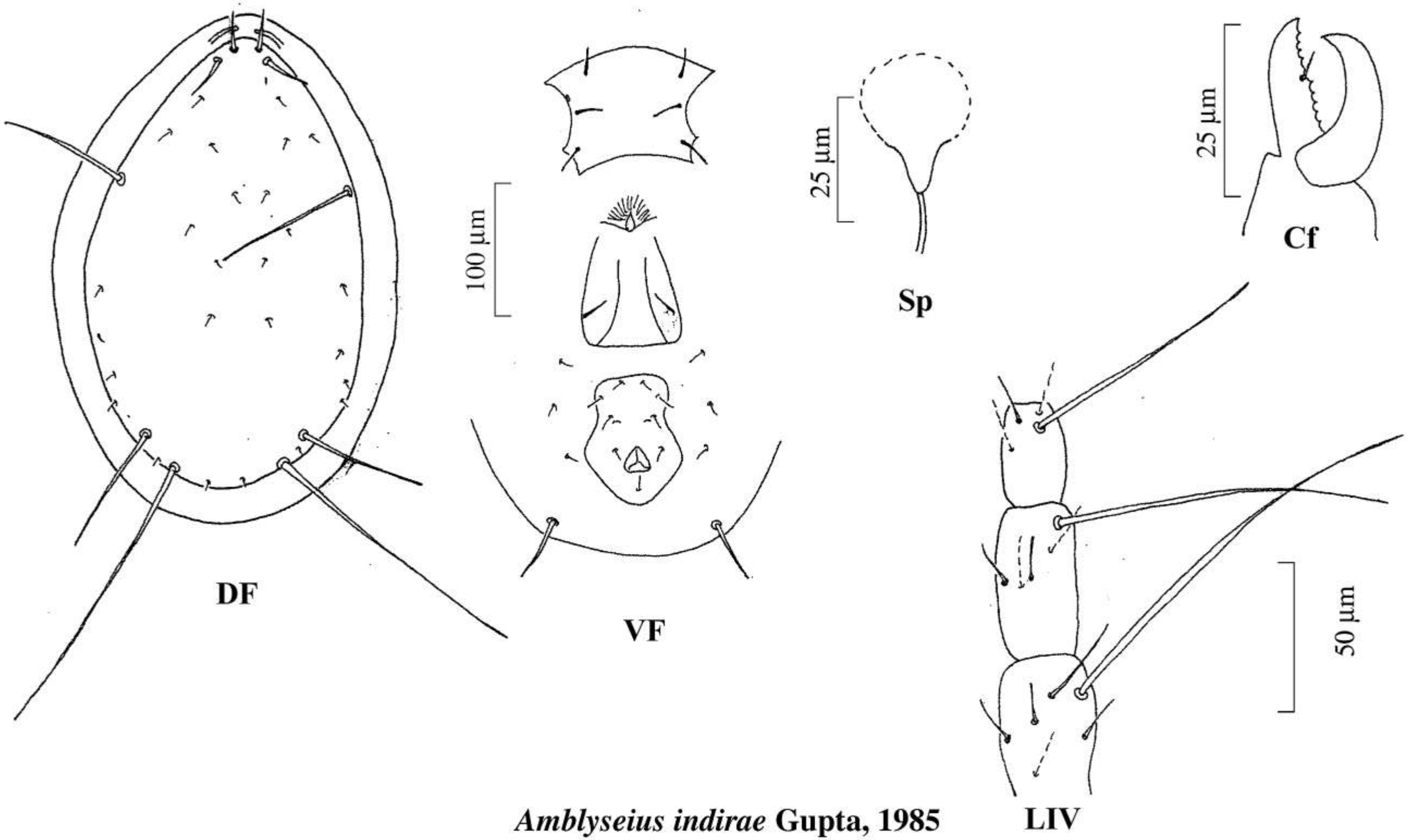
Amblyseius dioscoreae Rahul *et al*., 2016

PLATE 23



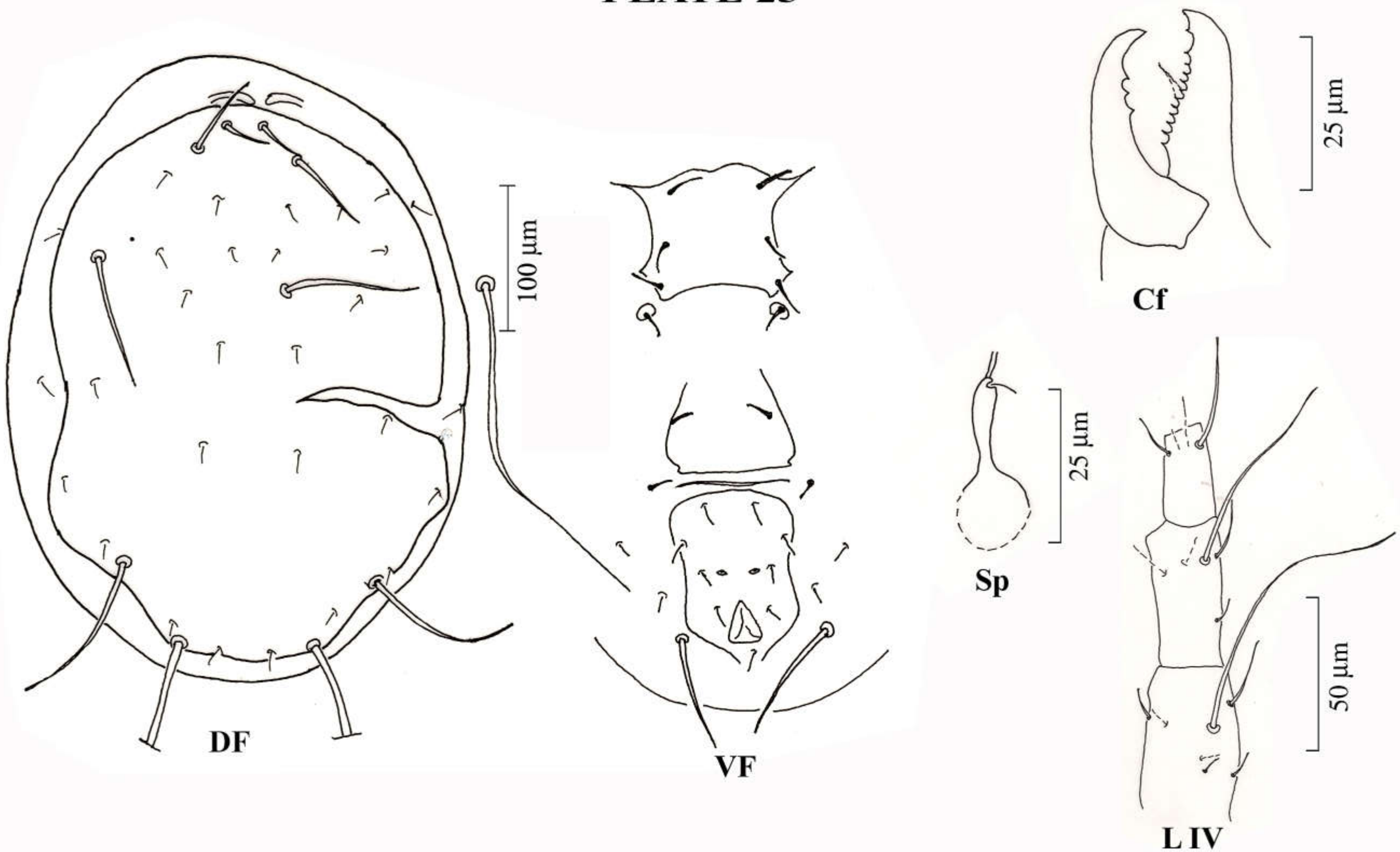
Amblyseius herbicolus **(Chant), 1959**

PLATE 24



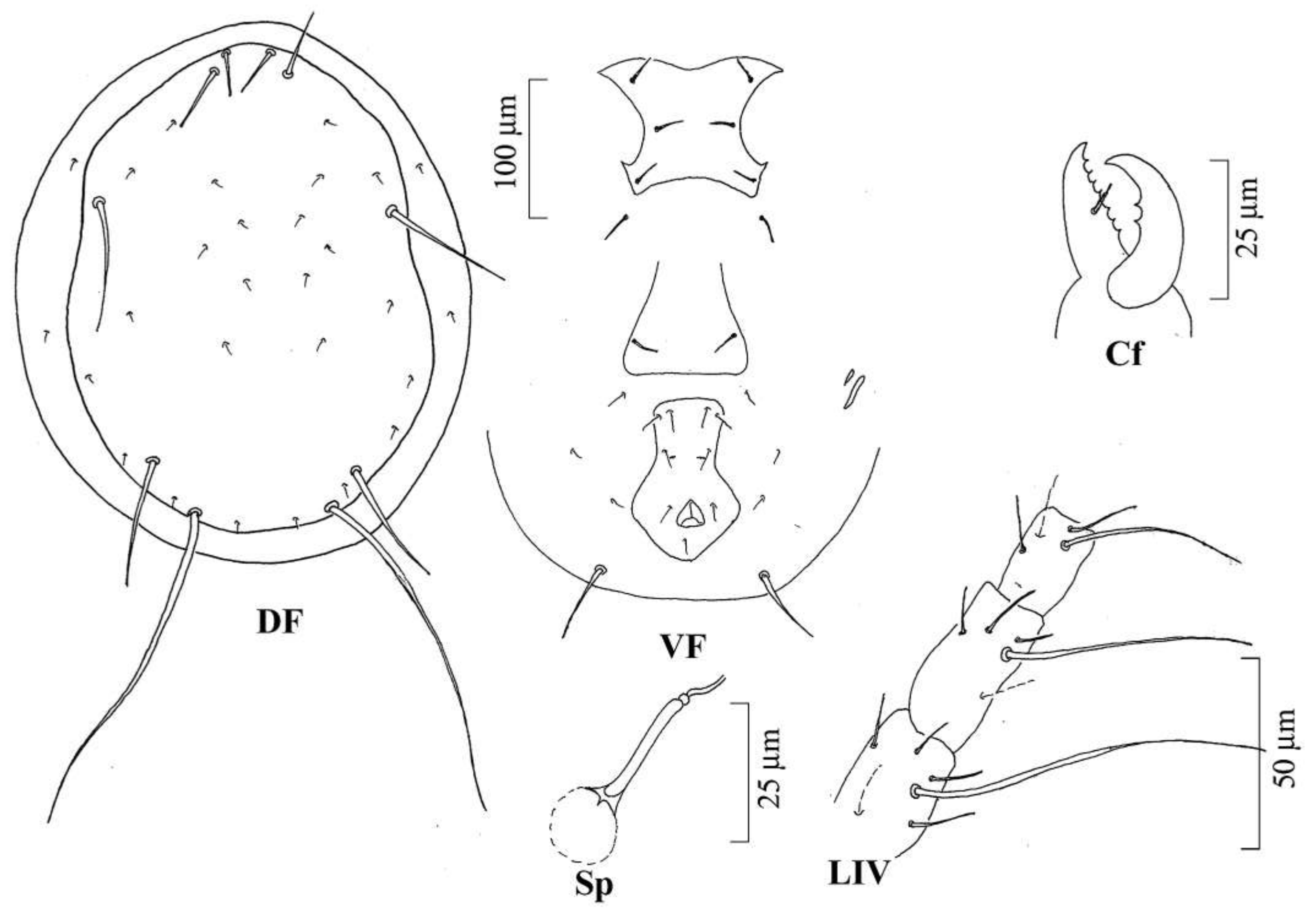
Amblyseius indirae Gupta, 1985

PLATE 25



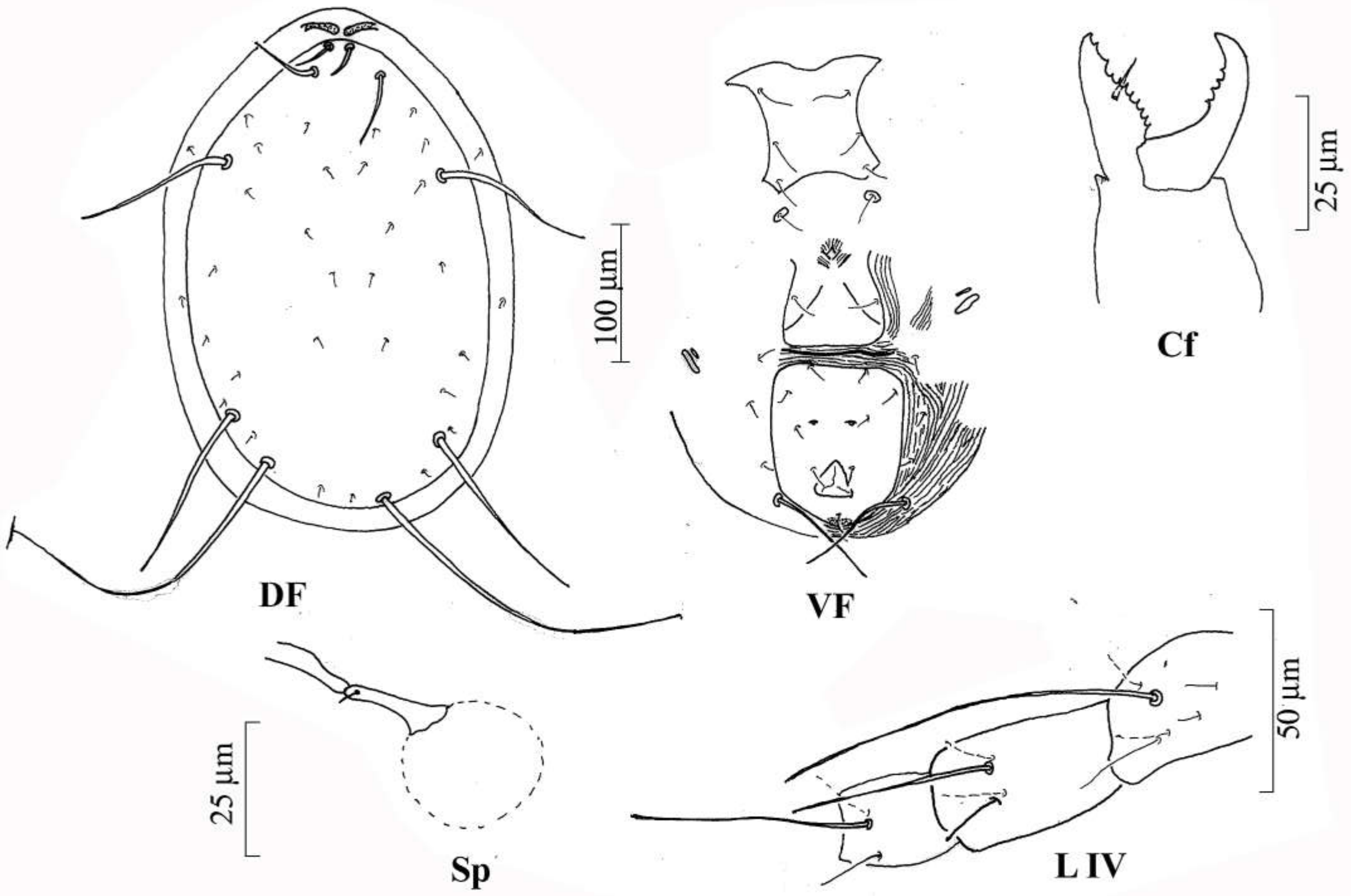
Amblyseius kulini Gupta, 1978

PLATE 26



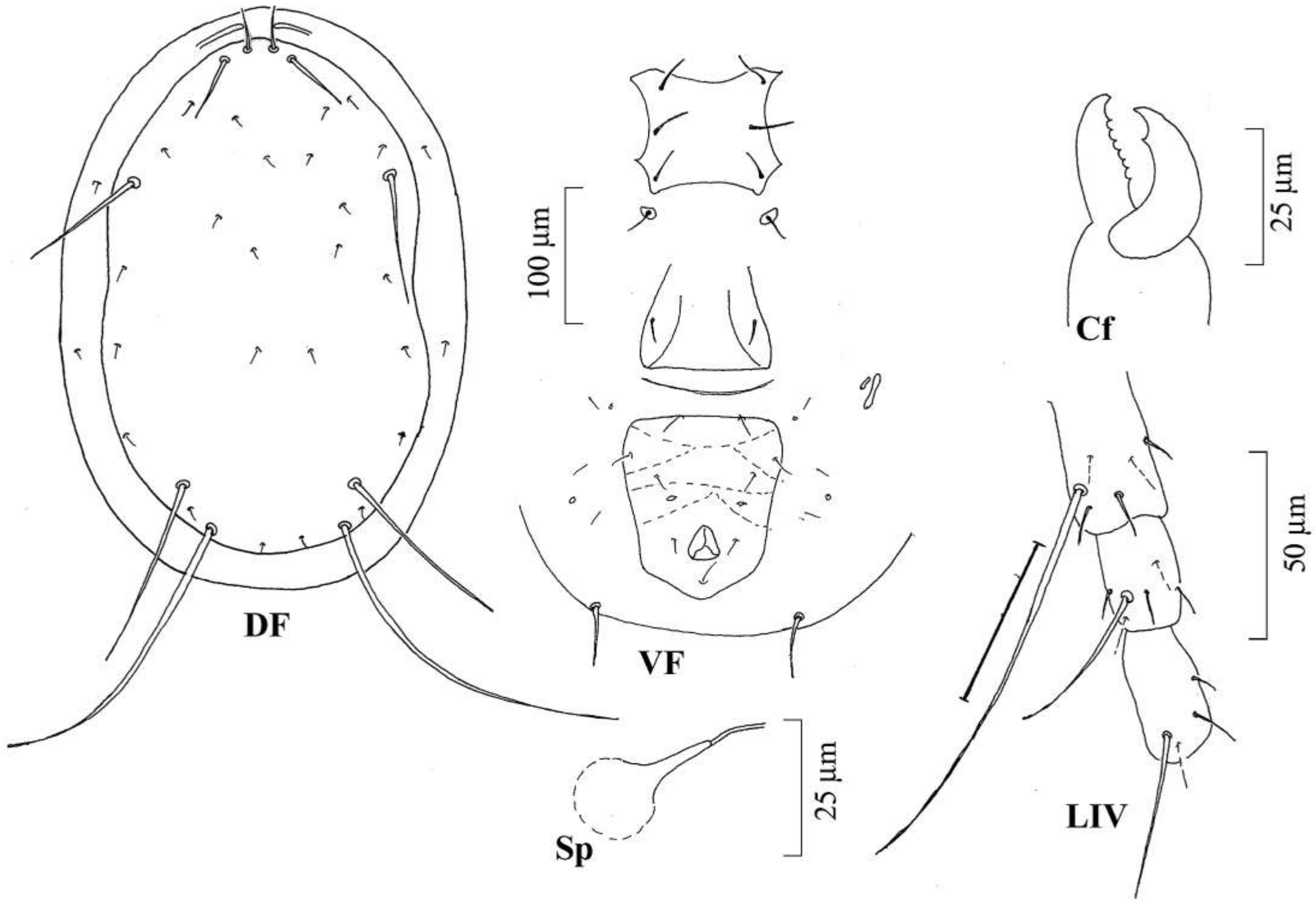
Amblyseius largoensis (Muma), 1955

PLATE 27



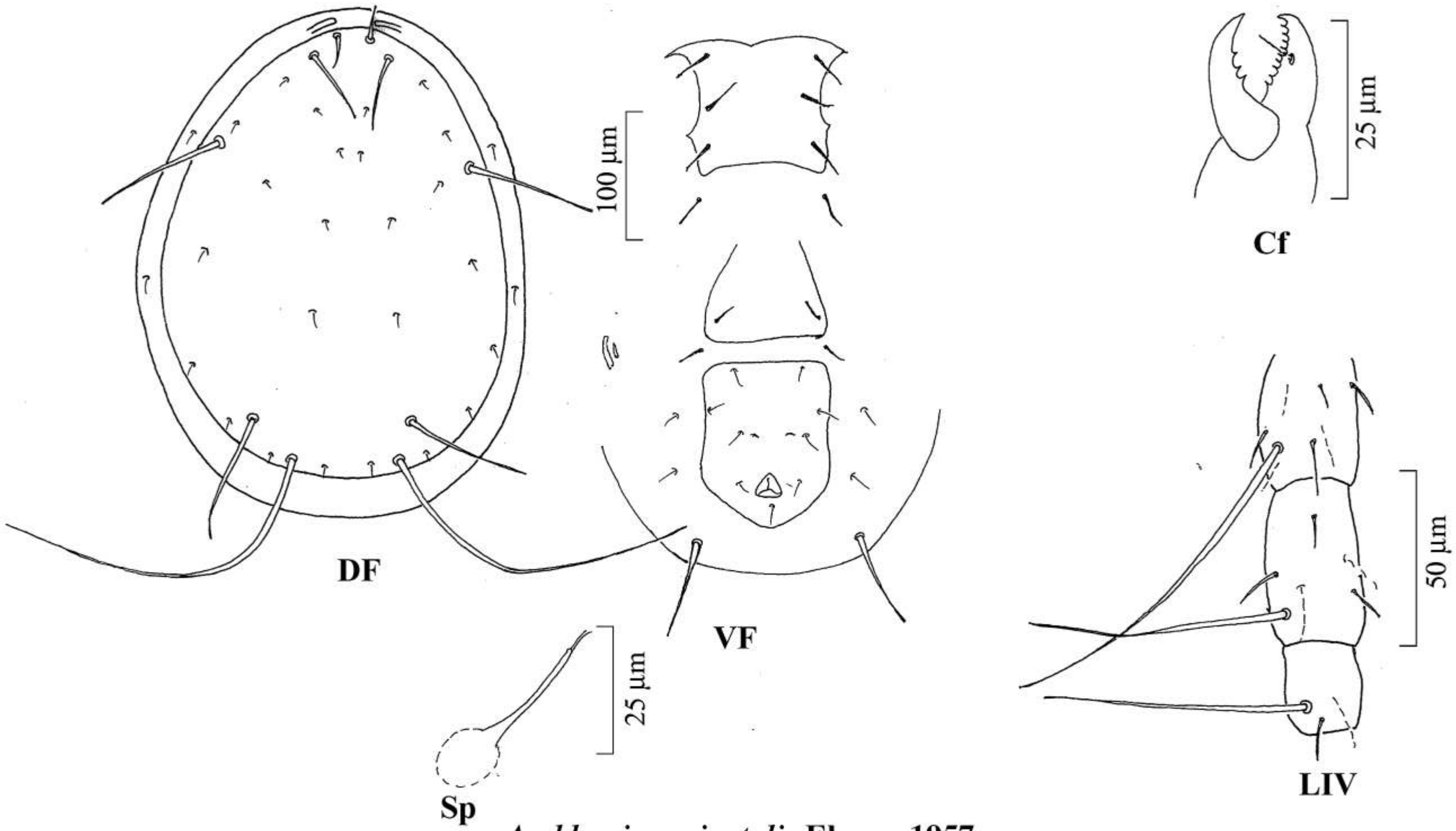
Amblyseius manasi Rahul and Mary Anitha, 2017

PLATE 28



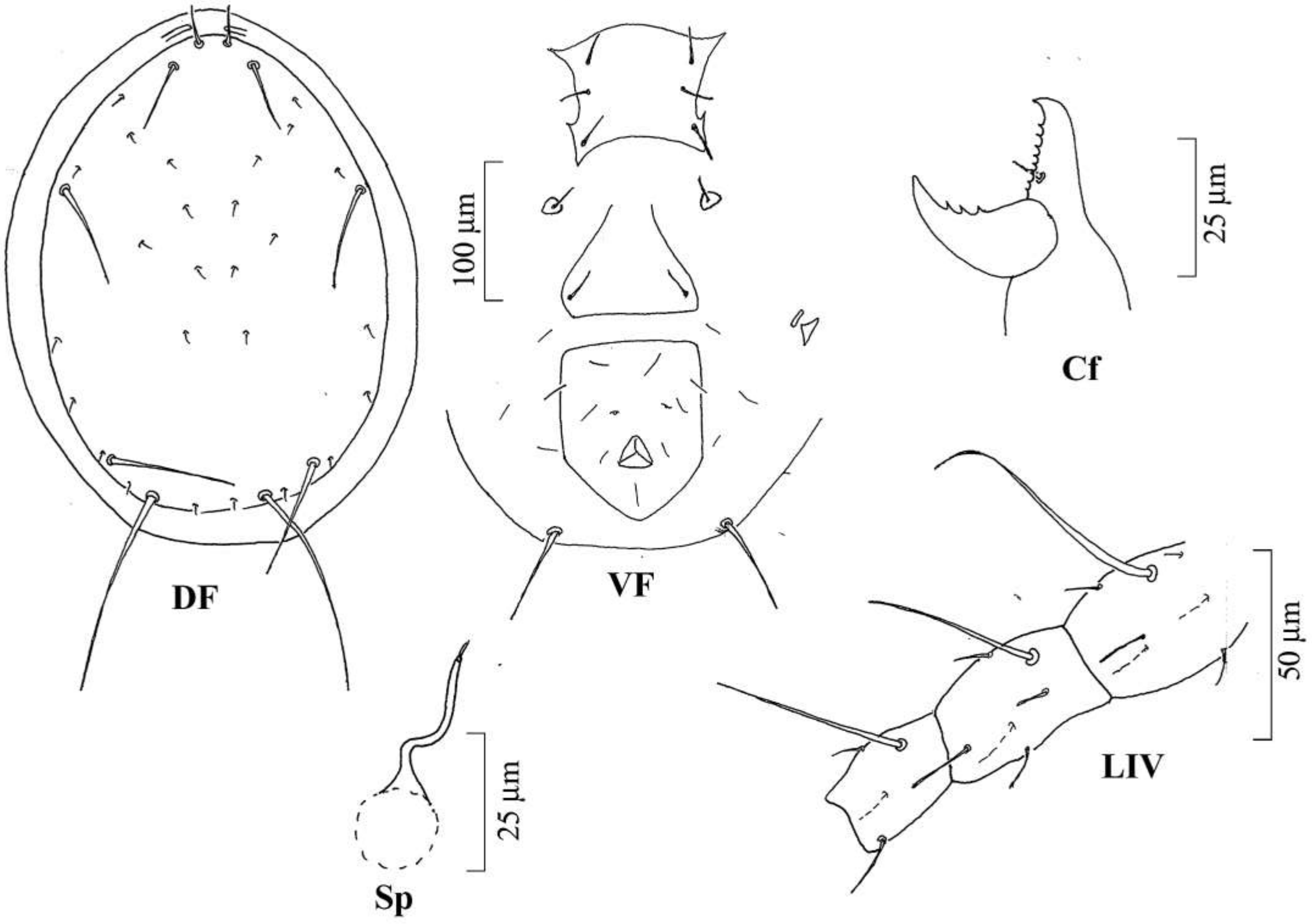
Amblyseius muraleedharani Gupta, 1981

PLATE 29



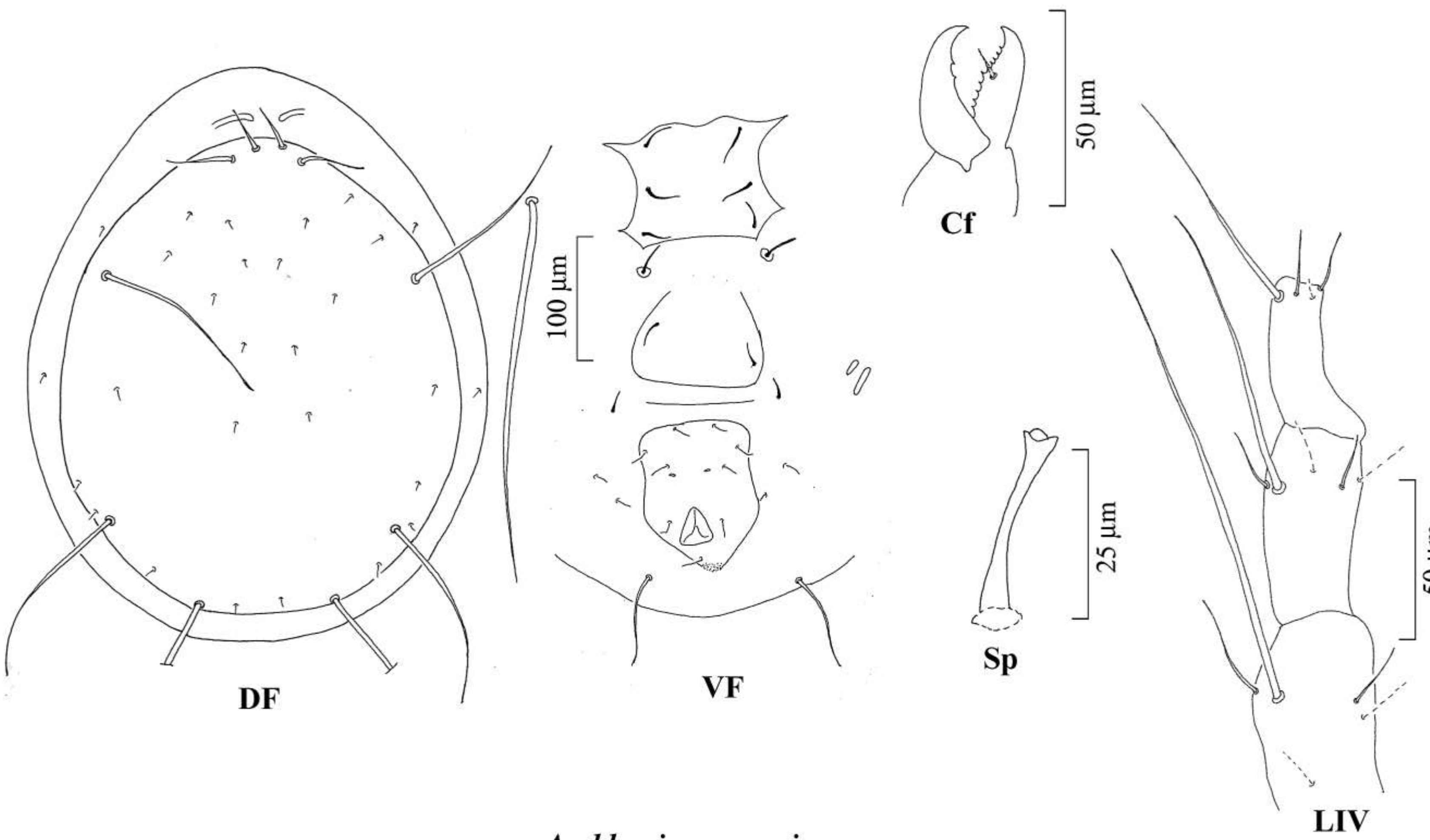
Amblyseius orientalis Ehara, 1957

PLATE 30



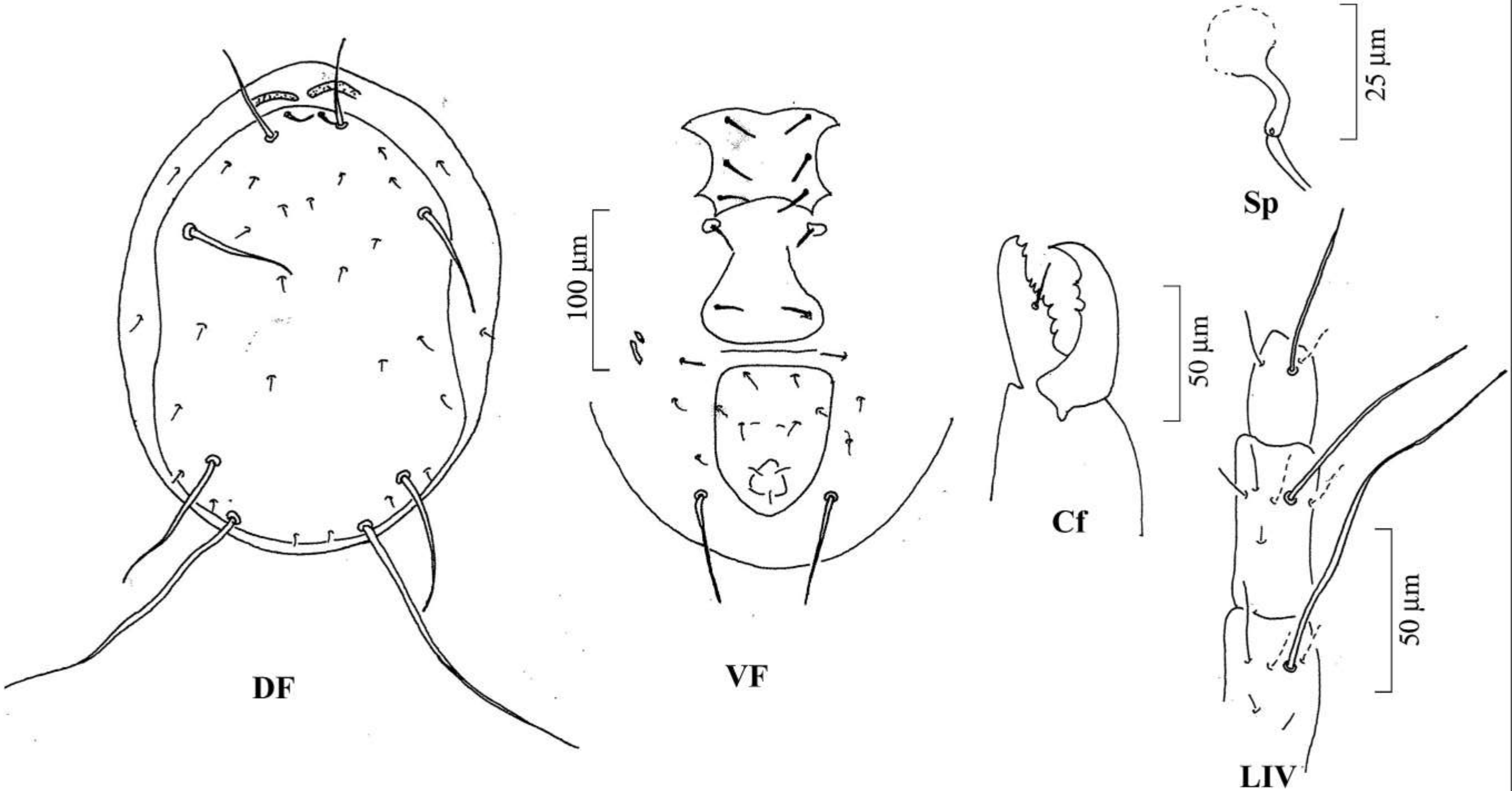
Amblyseius paraaerialis **Muma, 1967**

PLATE 31



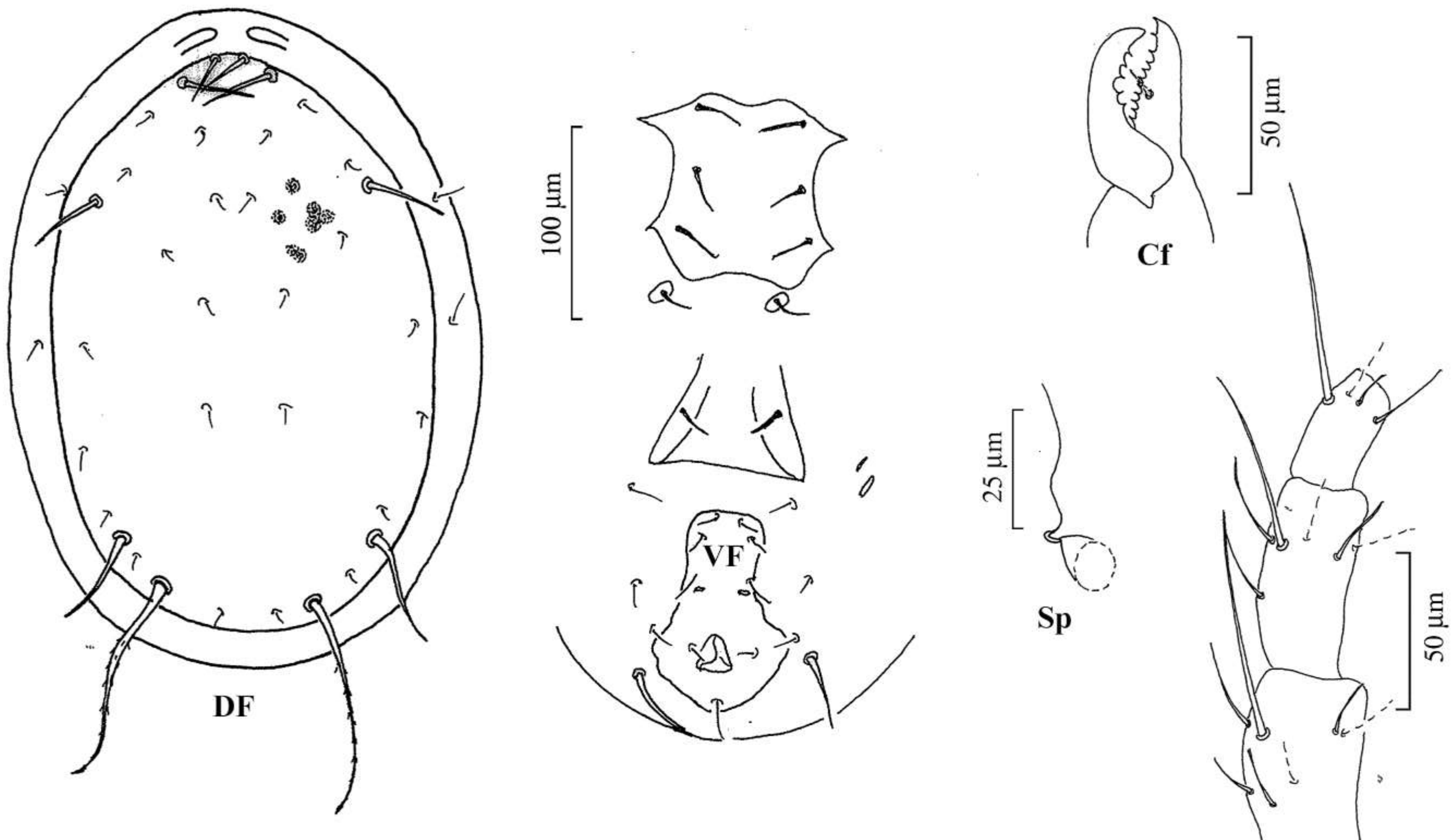
Amblyseius ramani **sp. nov.**

PLATE 32



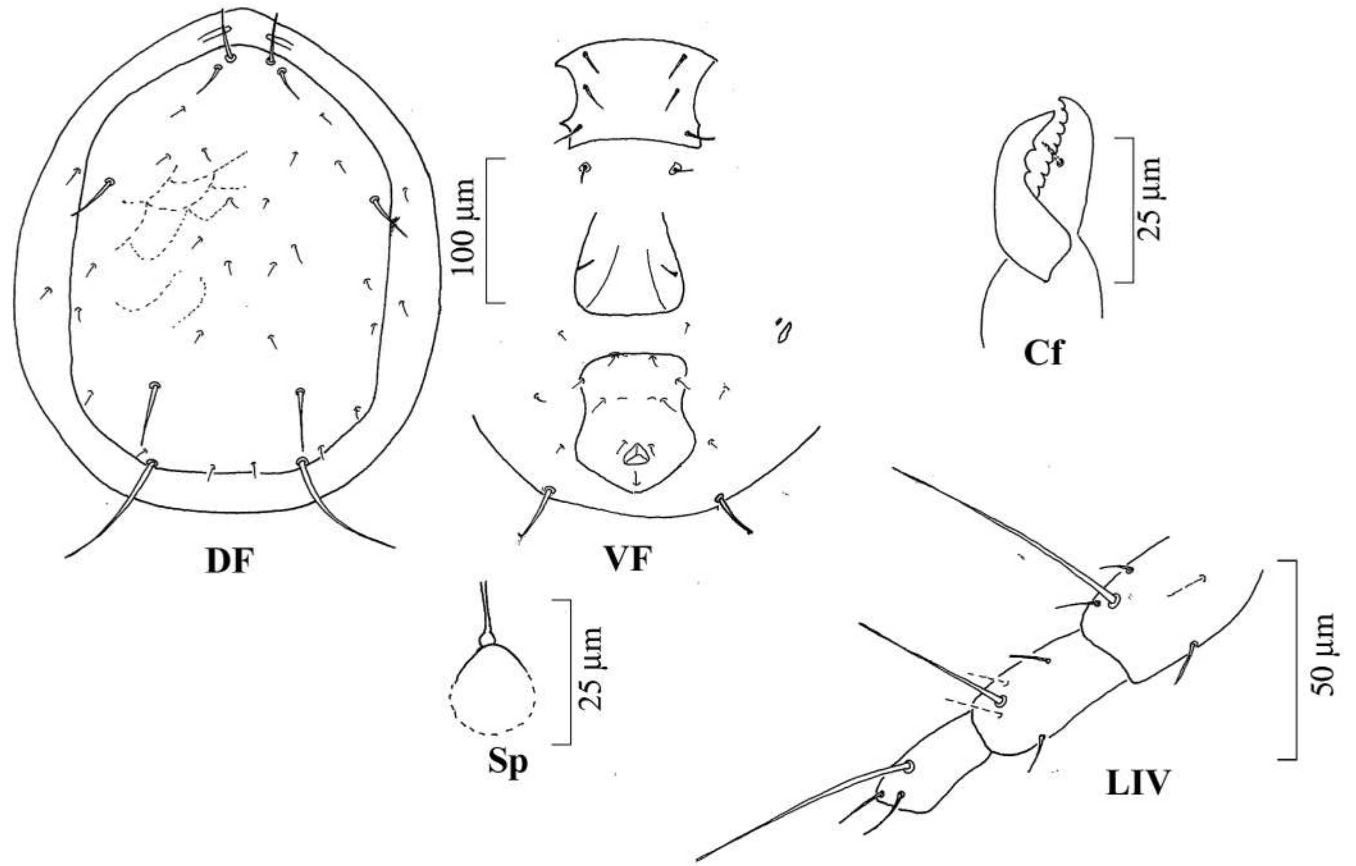
Amblyseius sachini Rahul and Mary Anitha, 2017

PLATE 33



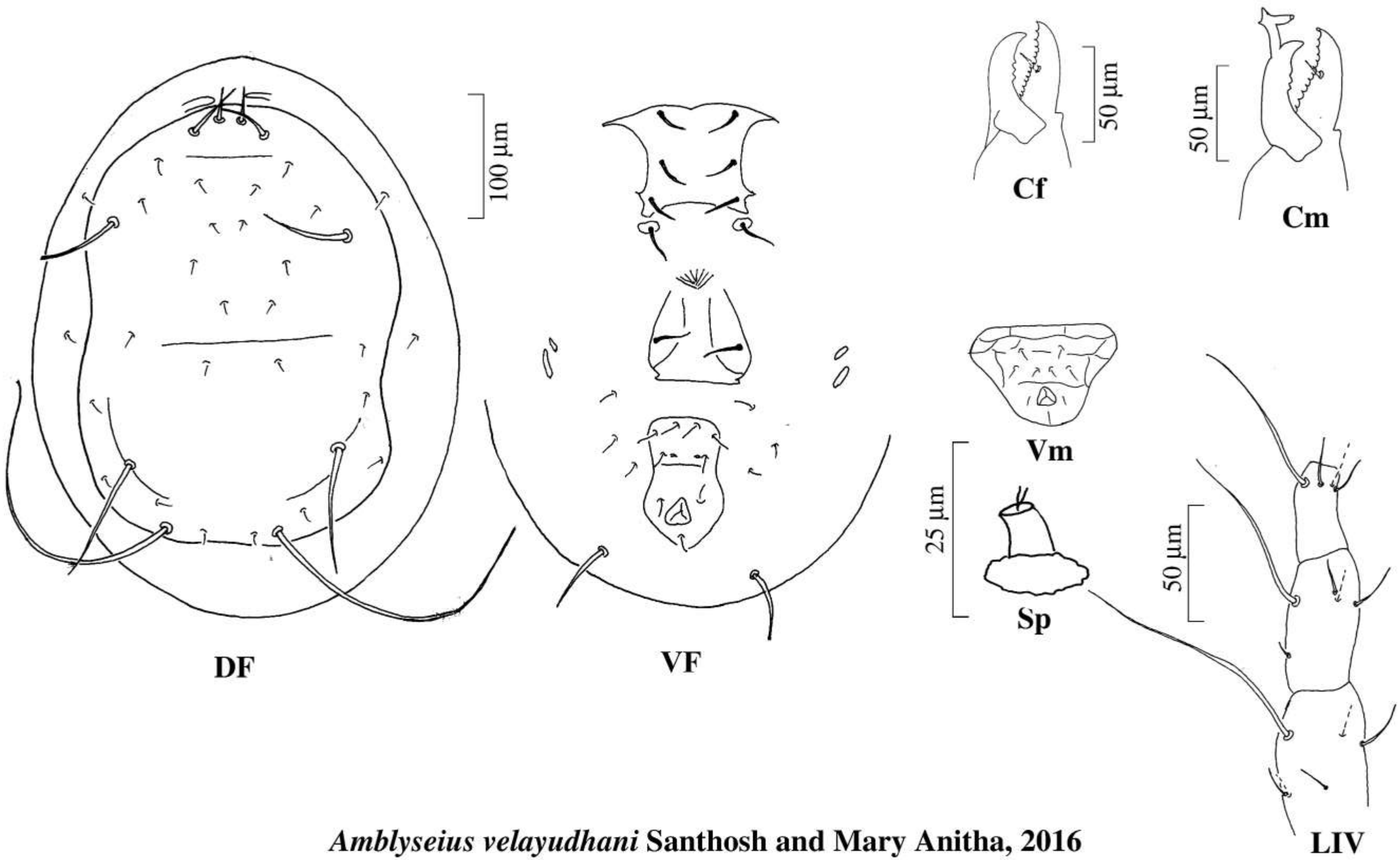
Amblyseius santhoshi sp. nov.

PLATE 34



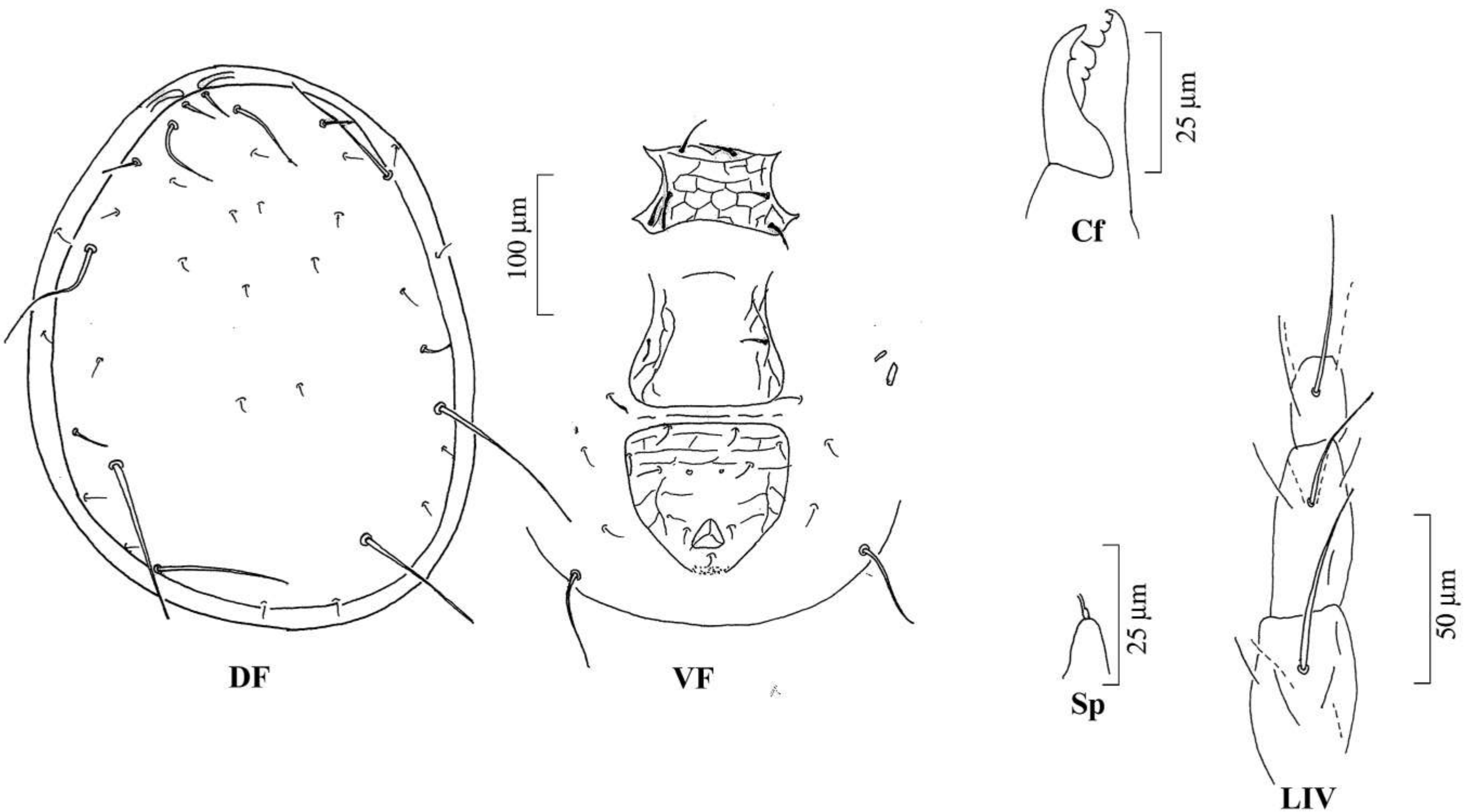
Amblyseius sijiensis Gupta, 1986

PLATE 35



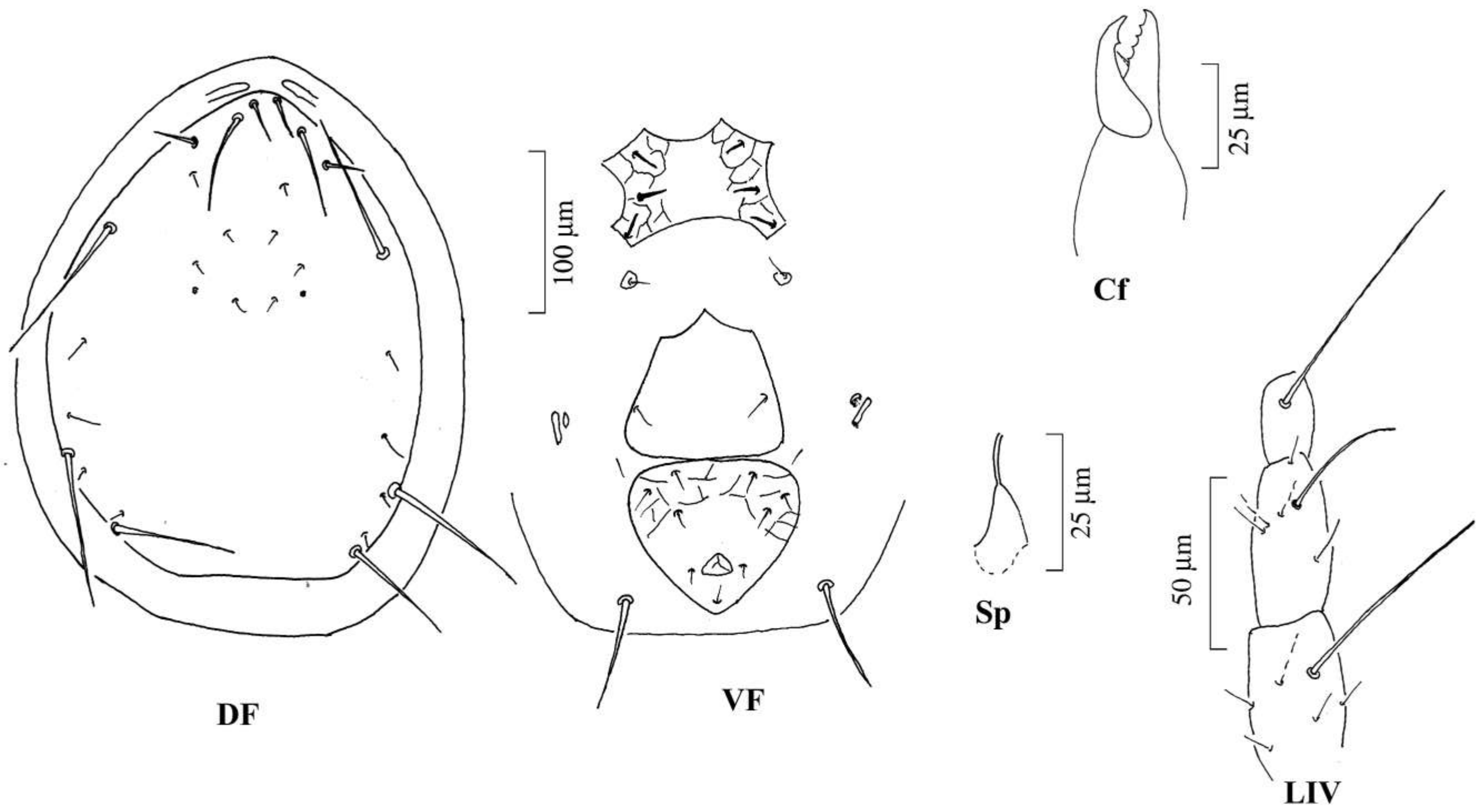
Amblyseius velayudhani Santhosh and Mary Anitha, 2016

PLATE 36



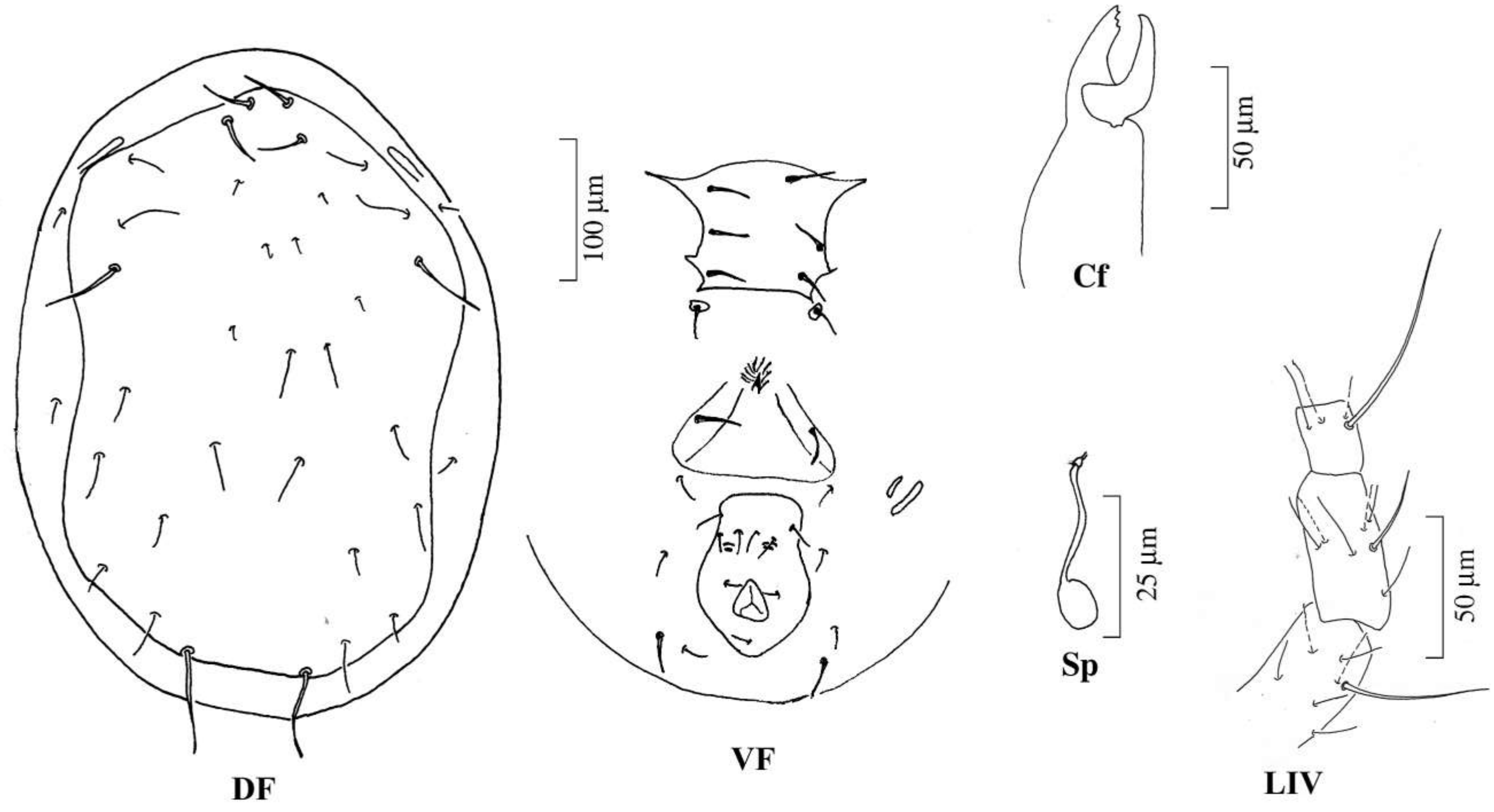
Proprioseiopsis narayani sp. nov.

PLATE 37



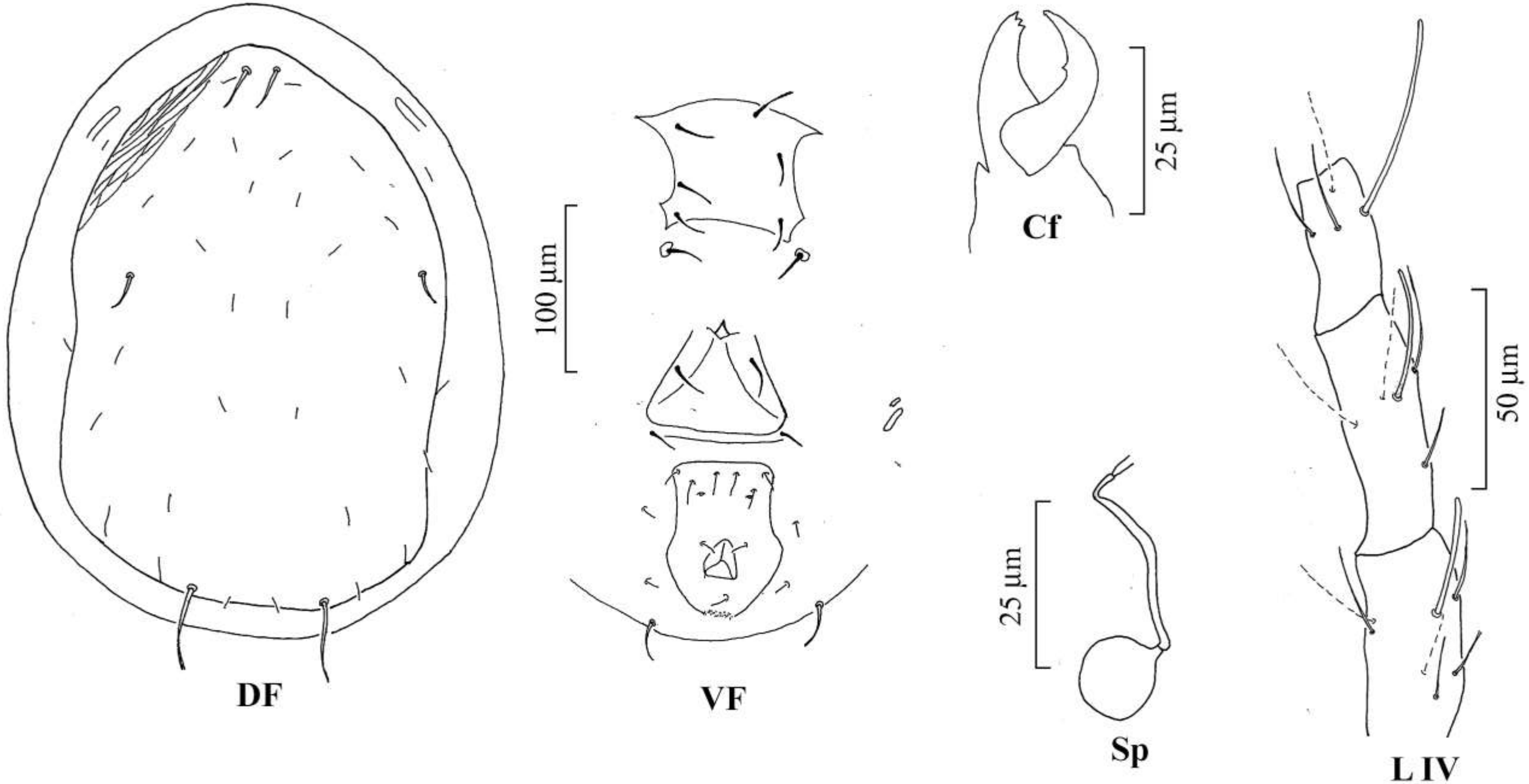
Proprioseiopsis peltatus Van der Merwe, 1968

PLATE 38



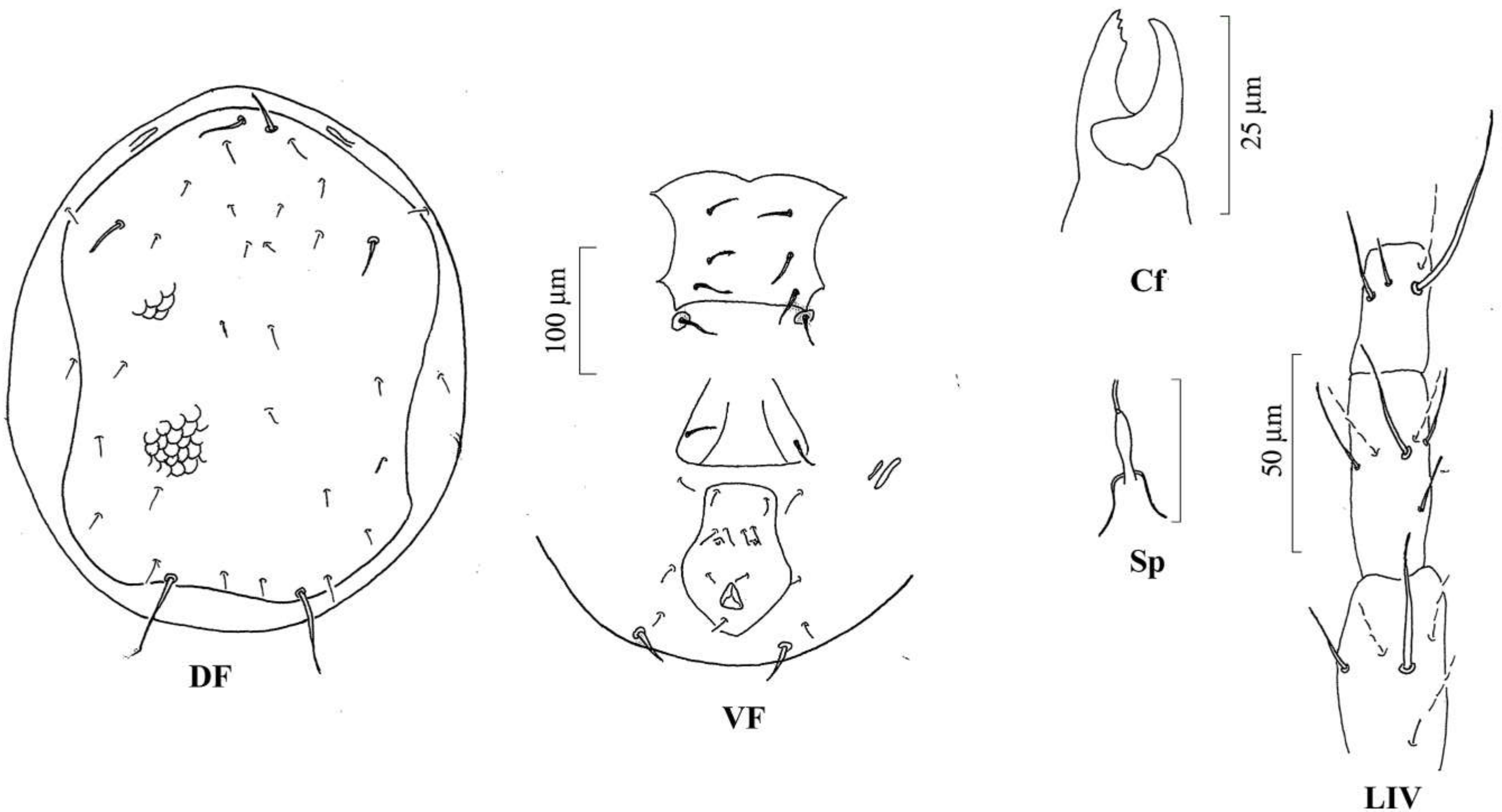
Euseius alstoniae Gupta, 1975

PLATE 39



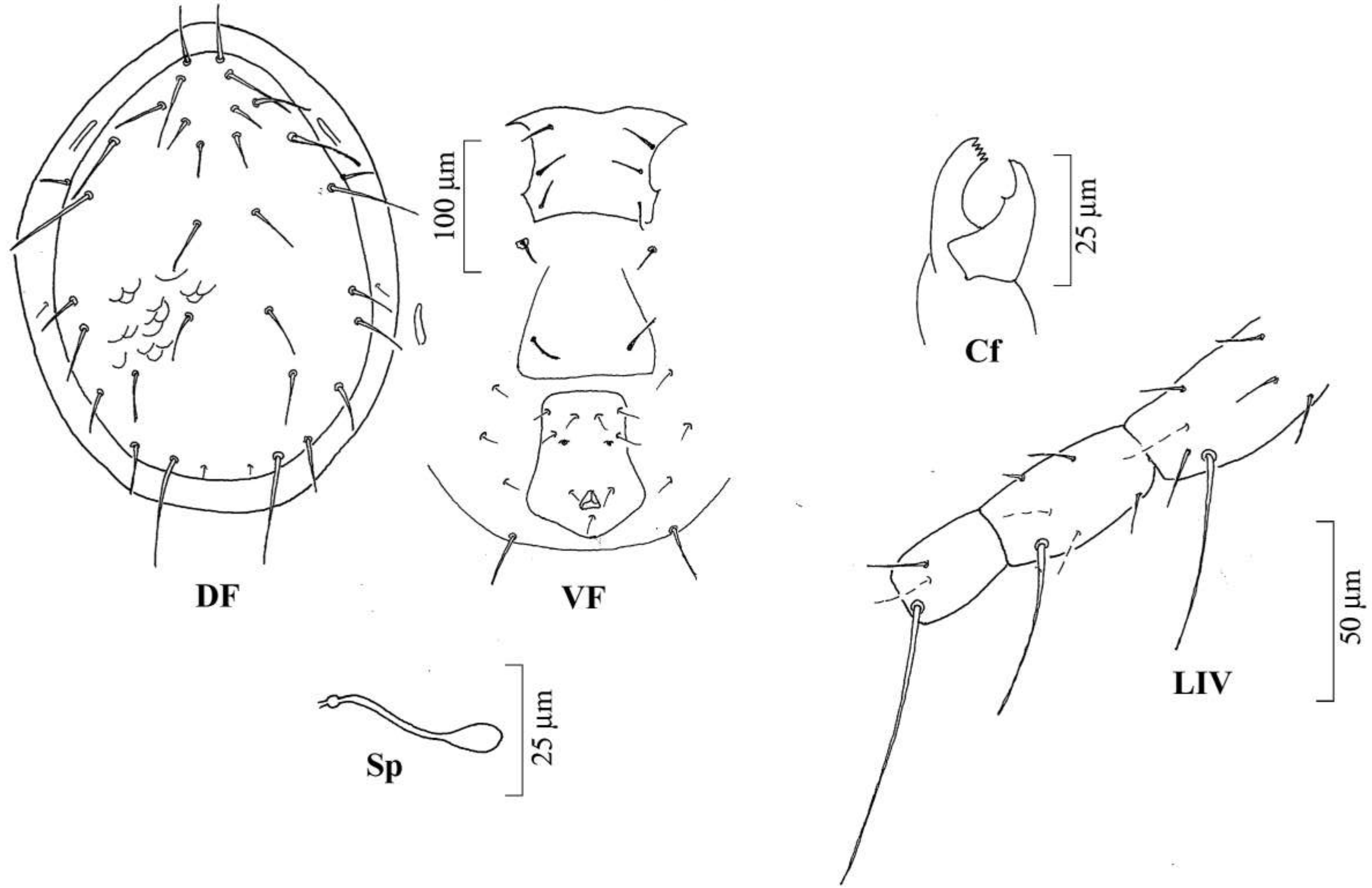
Euseius bambusae Ghai and Menon, 1967

PLATE 40



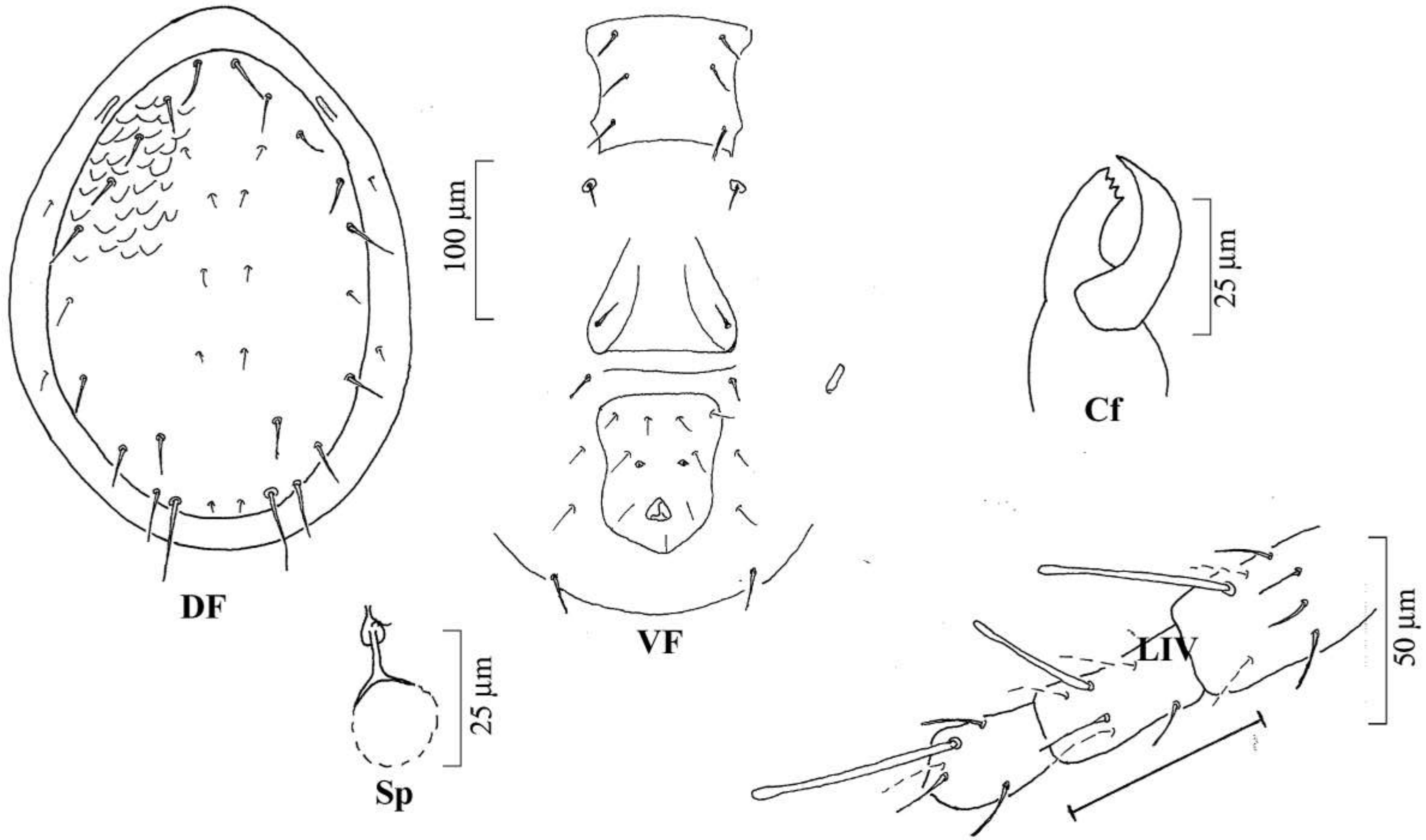
Euseius coccineae Gupta, 1975

PLATE 41



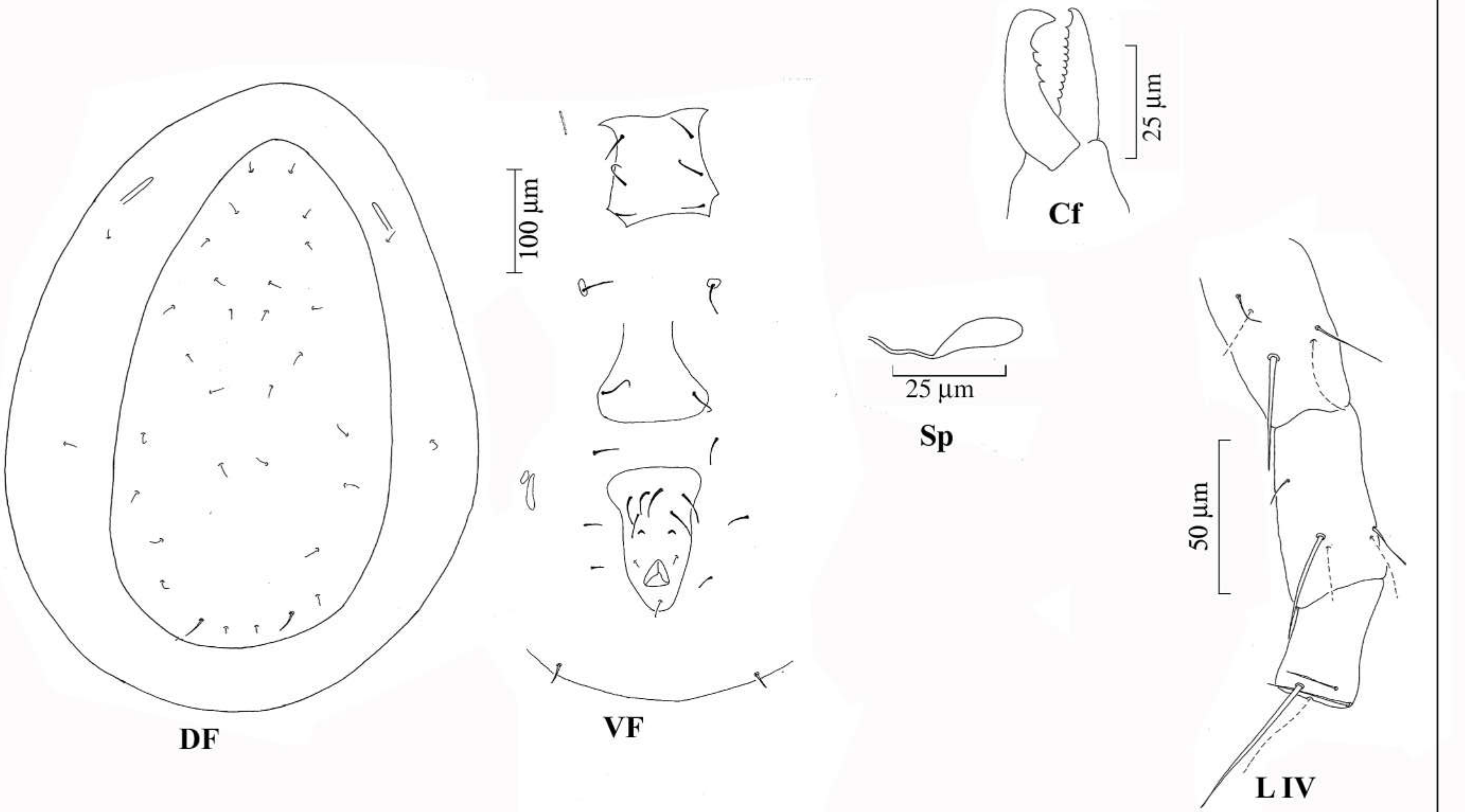
Euseius delhiensis **(Narayanan and Kaur), 1960**

PLATE 42



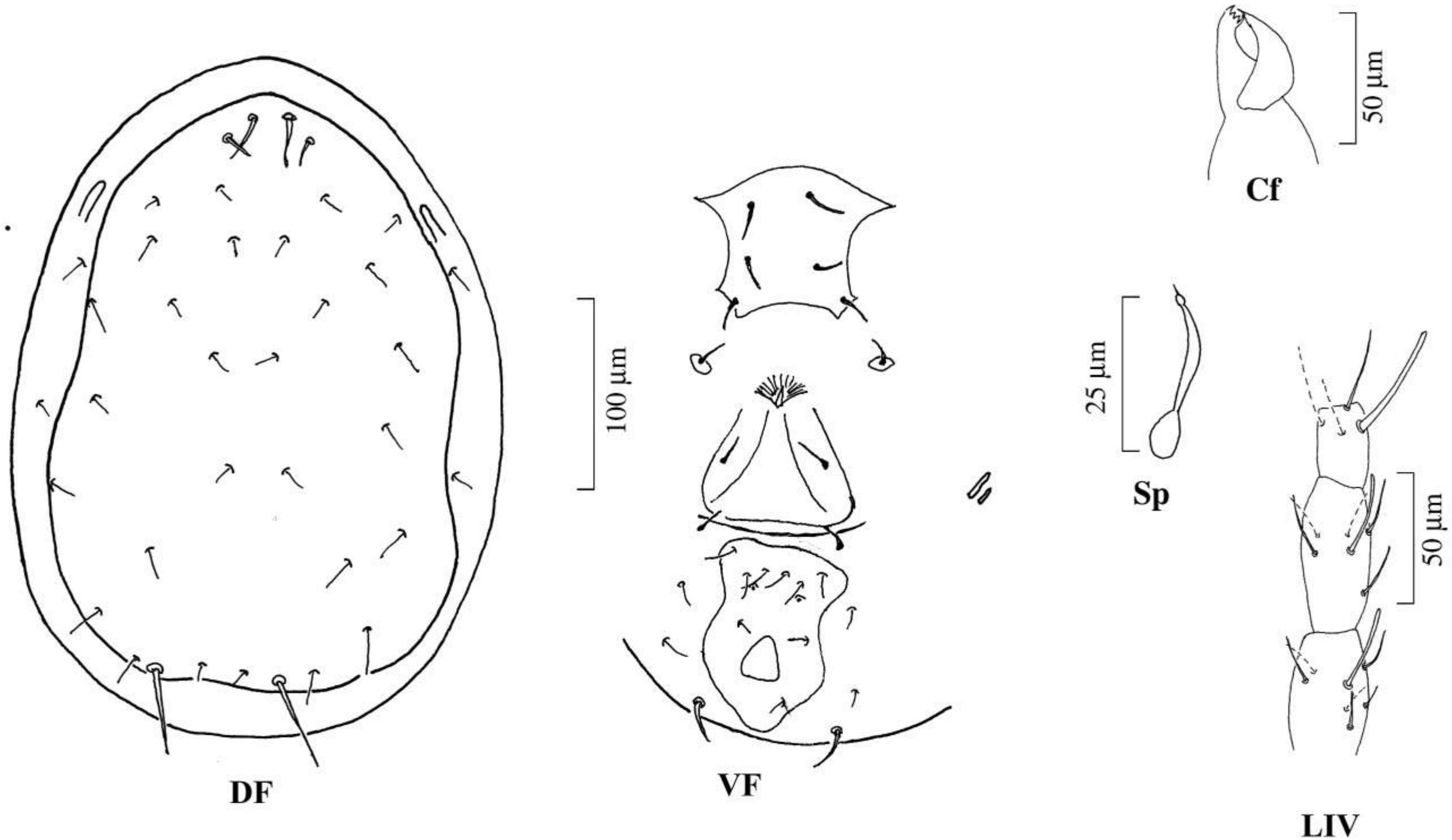
Euseius finlandicus (Oudemans), 1915

PLATE 43



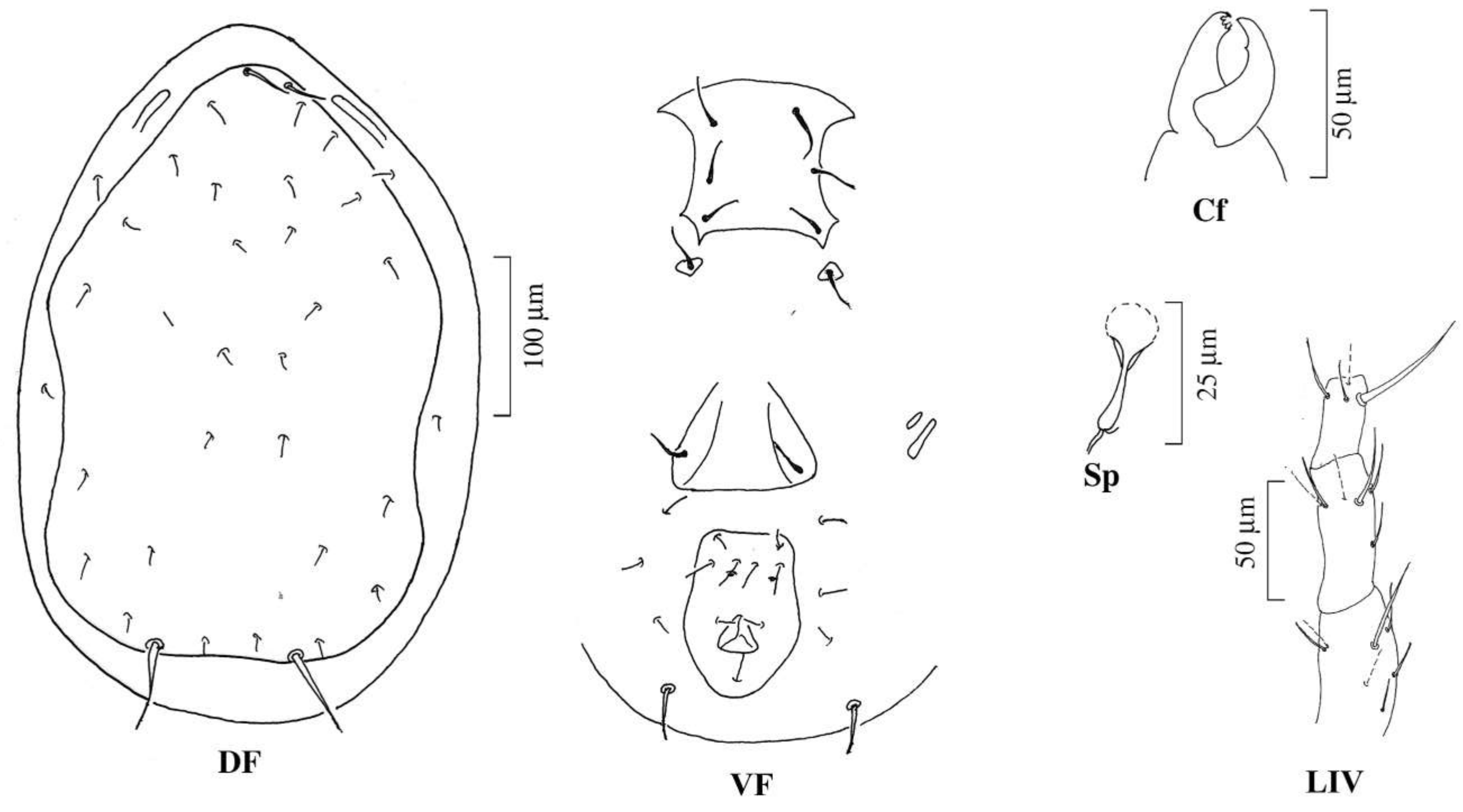
Euseius kadalundiensis sp. nov.

PLATE 44



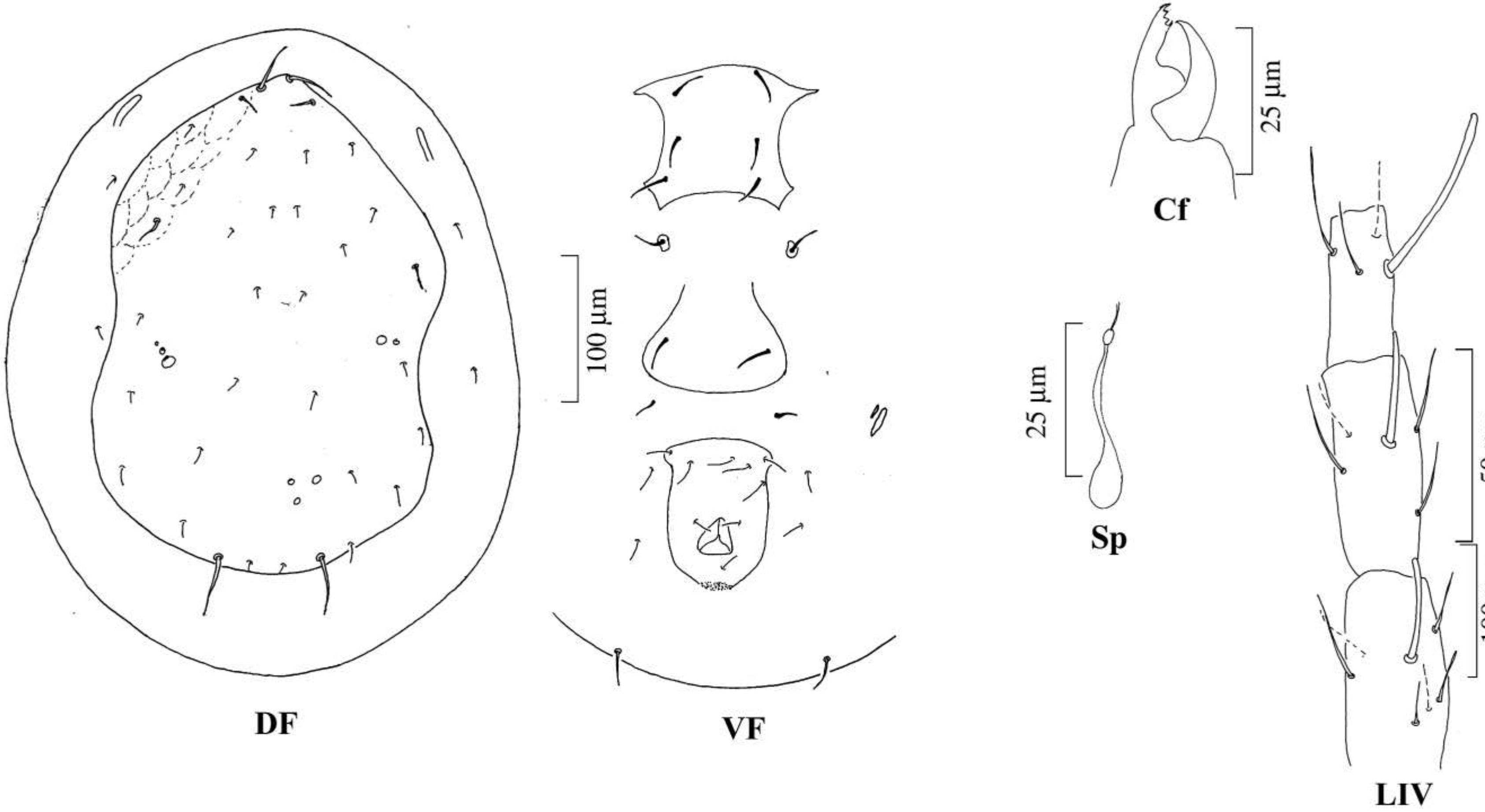
Euseius malabarensis sp. nov.

PLATE 45



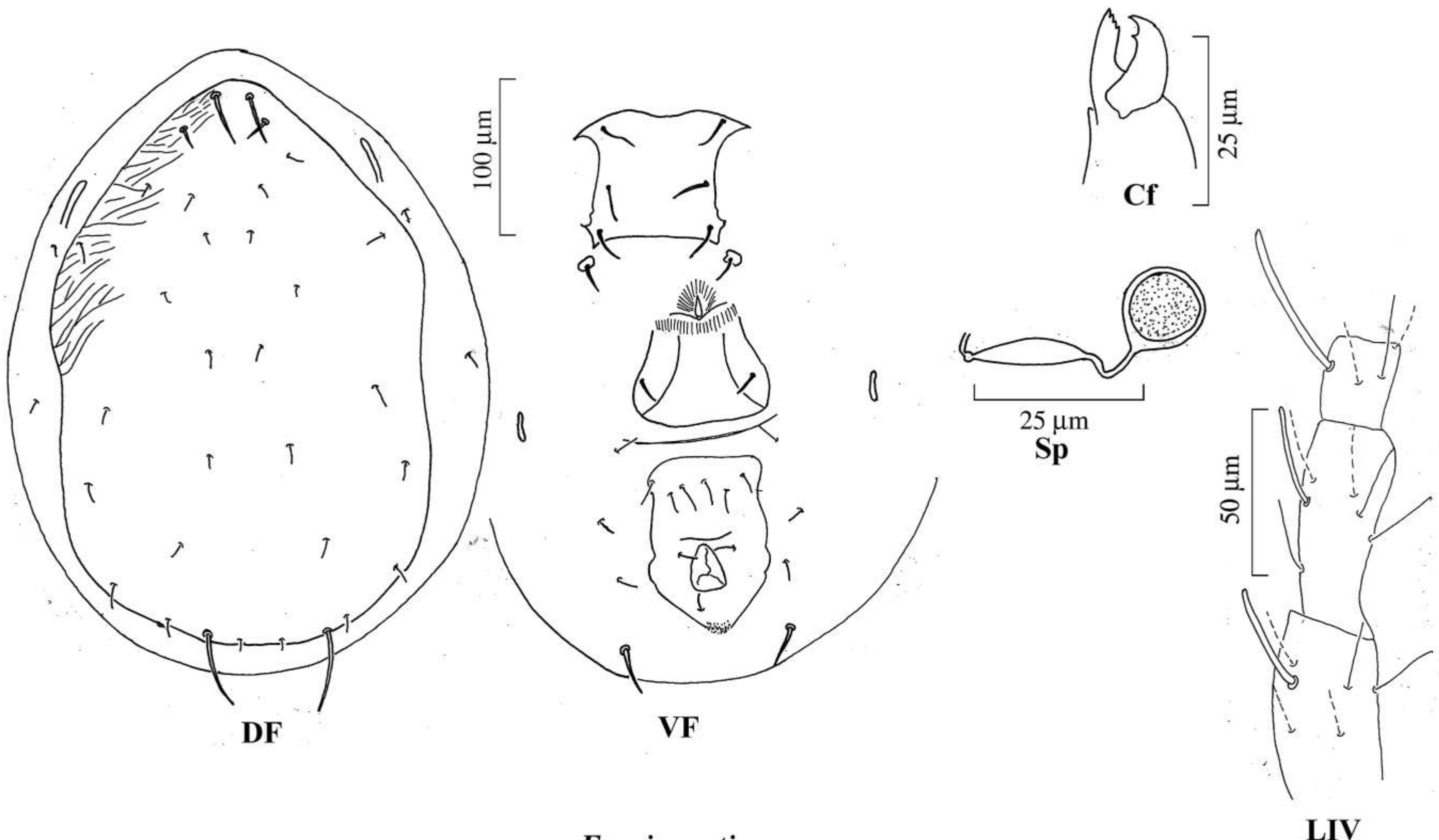
Euseius ovalis Evans, 1953

PLATE 46



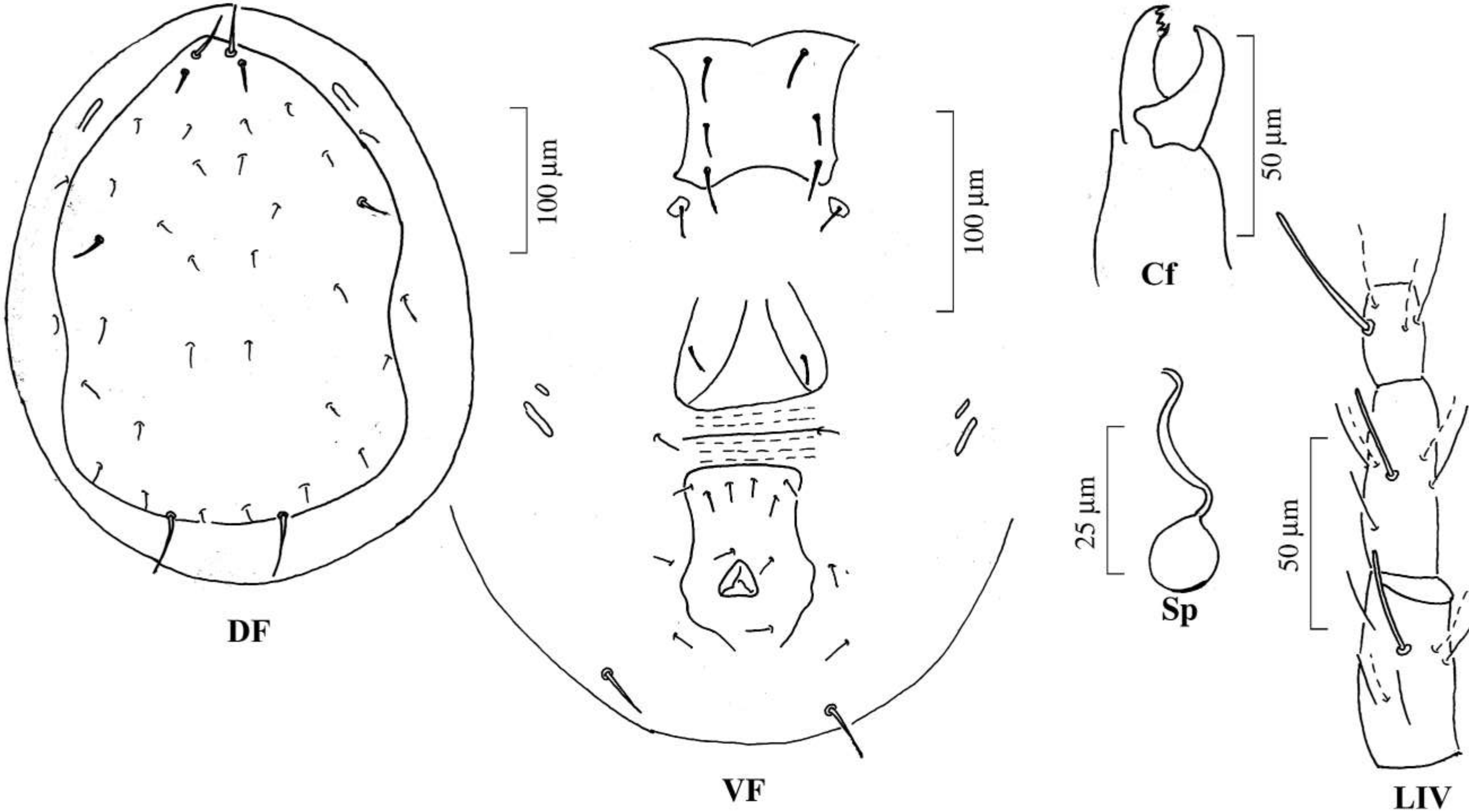
Euseius rhododendronis Gupta, 1970

PLATE 47



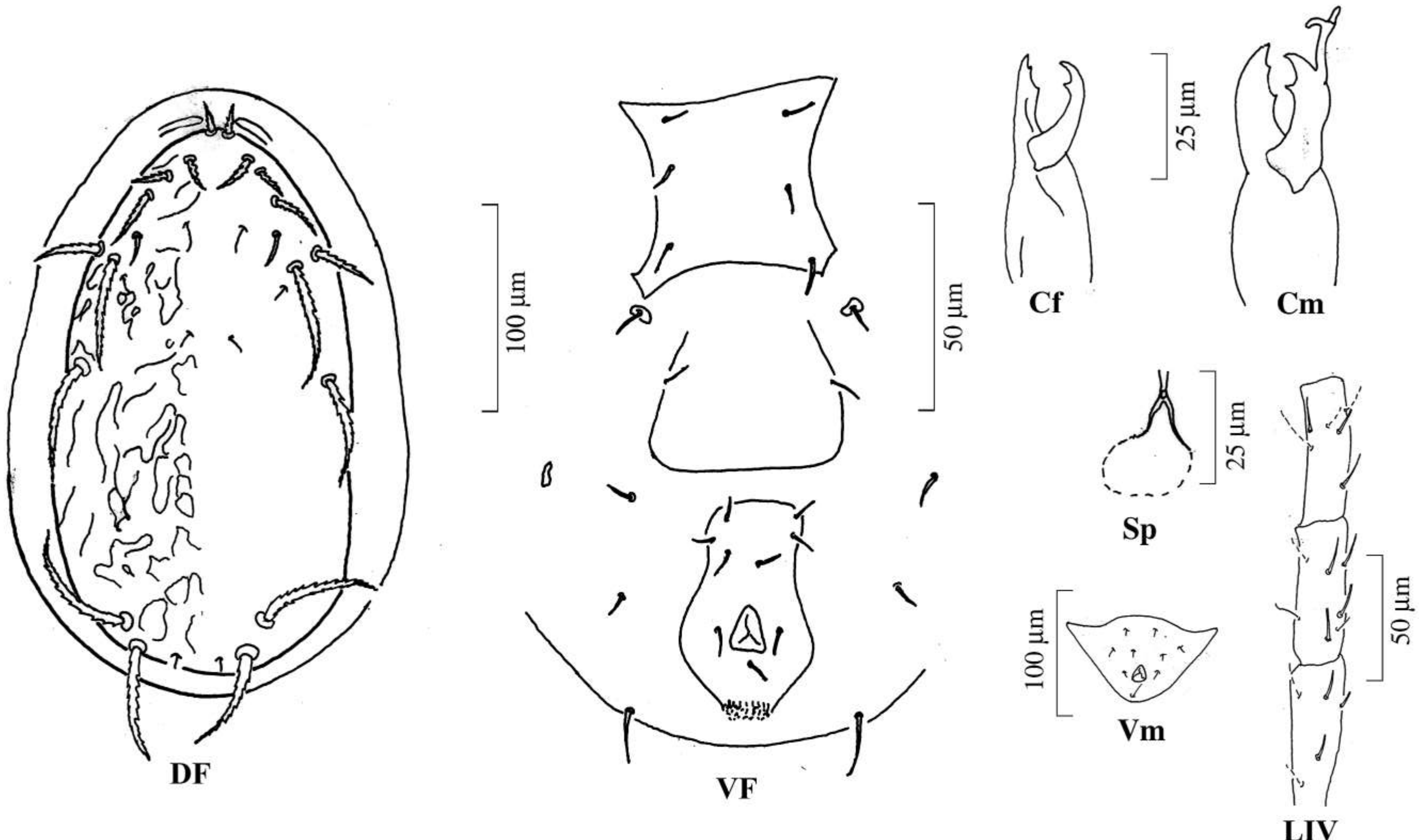
Euseius sativae **sp. nov**

PLATE 48



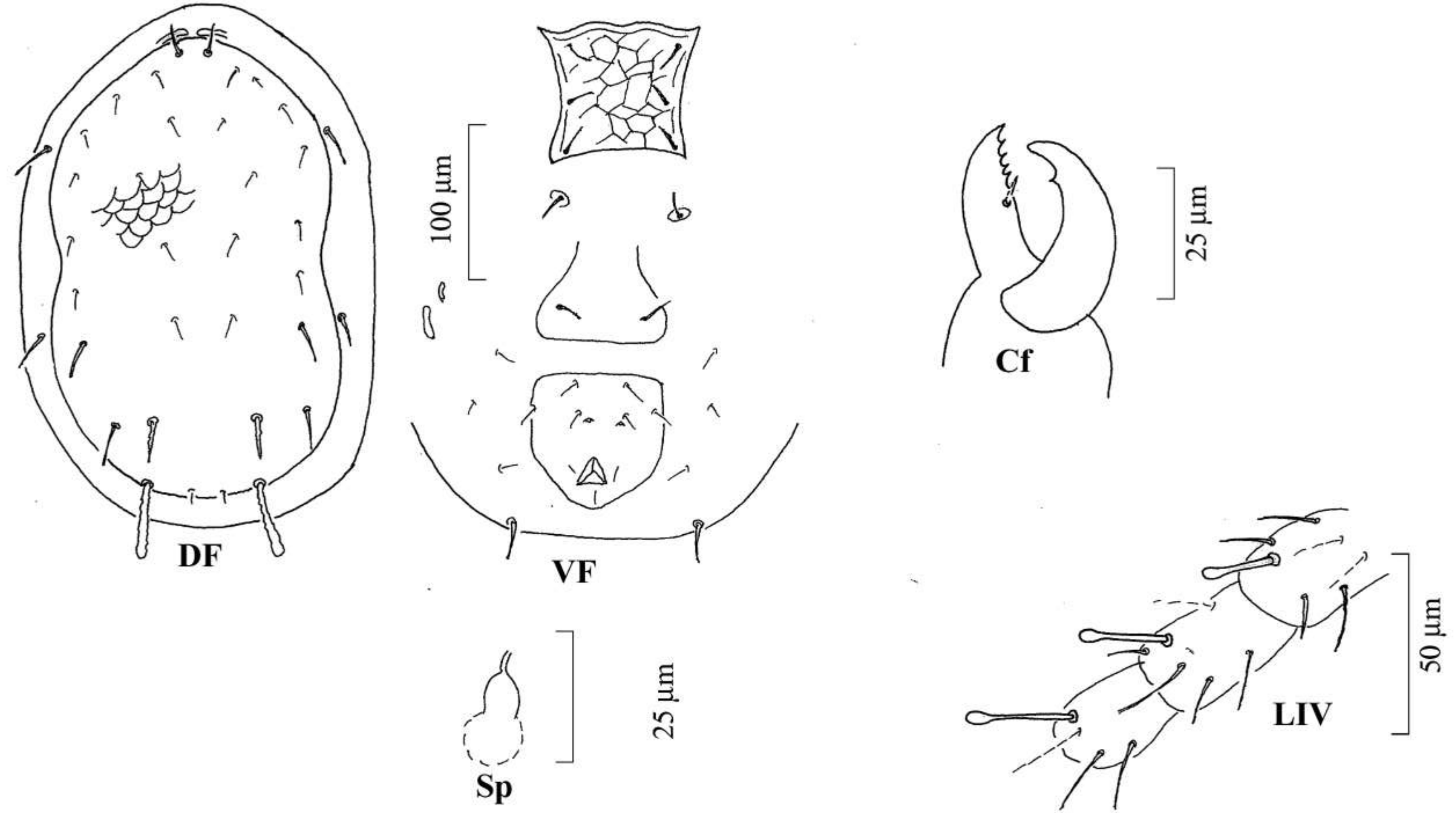
Euseius ummalathoorensis sp. nov.

PLATE 49



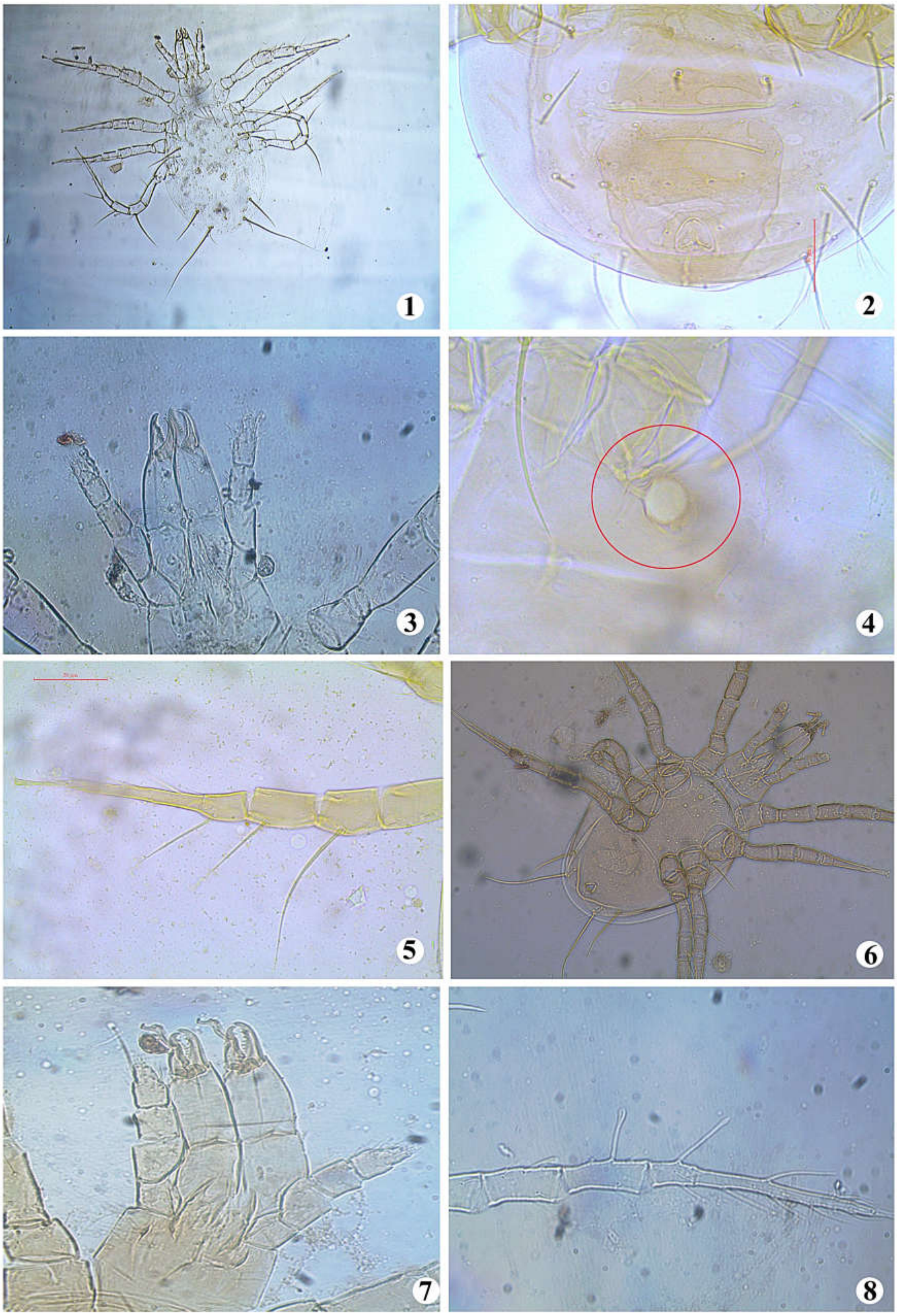
Phytoseius intermedius Evans and Macfarlane, 1962

PLATE 50



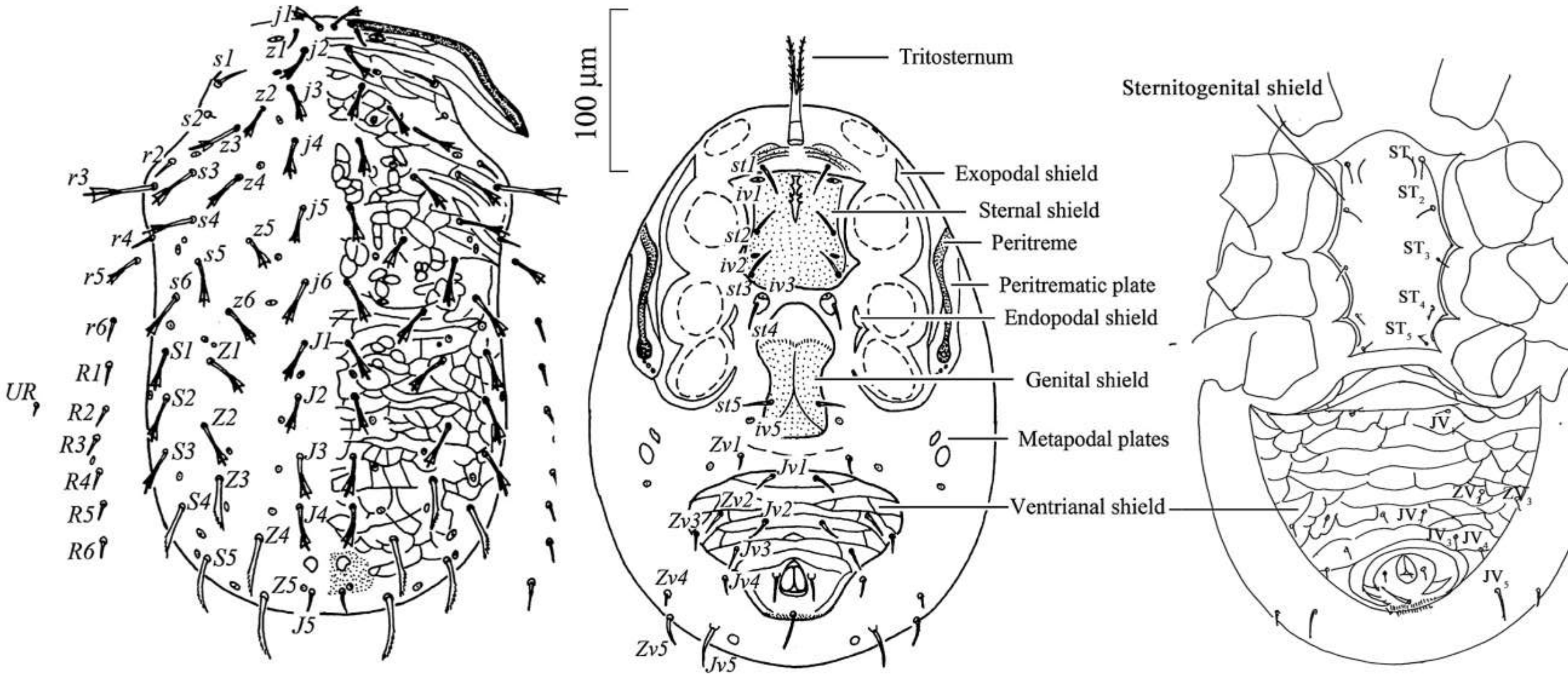
Typhlodromus (Anthoseius) bambusicolus Gupta, 1977

PLATE 51



Family Phytoseiidae: **1.** Adult female dorsal; **2.** Female ventrianal shield; **3.** Female chelisera; **4.** Spermatheca; **5.** Leg IV with macrosetae; **6.** Adult male dorsal; **7.** Male chelicera with spermatodactyl; **8.** Leg IV with barbbed macrosetae

PLATE 52A



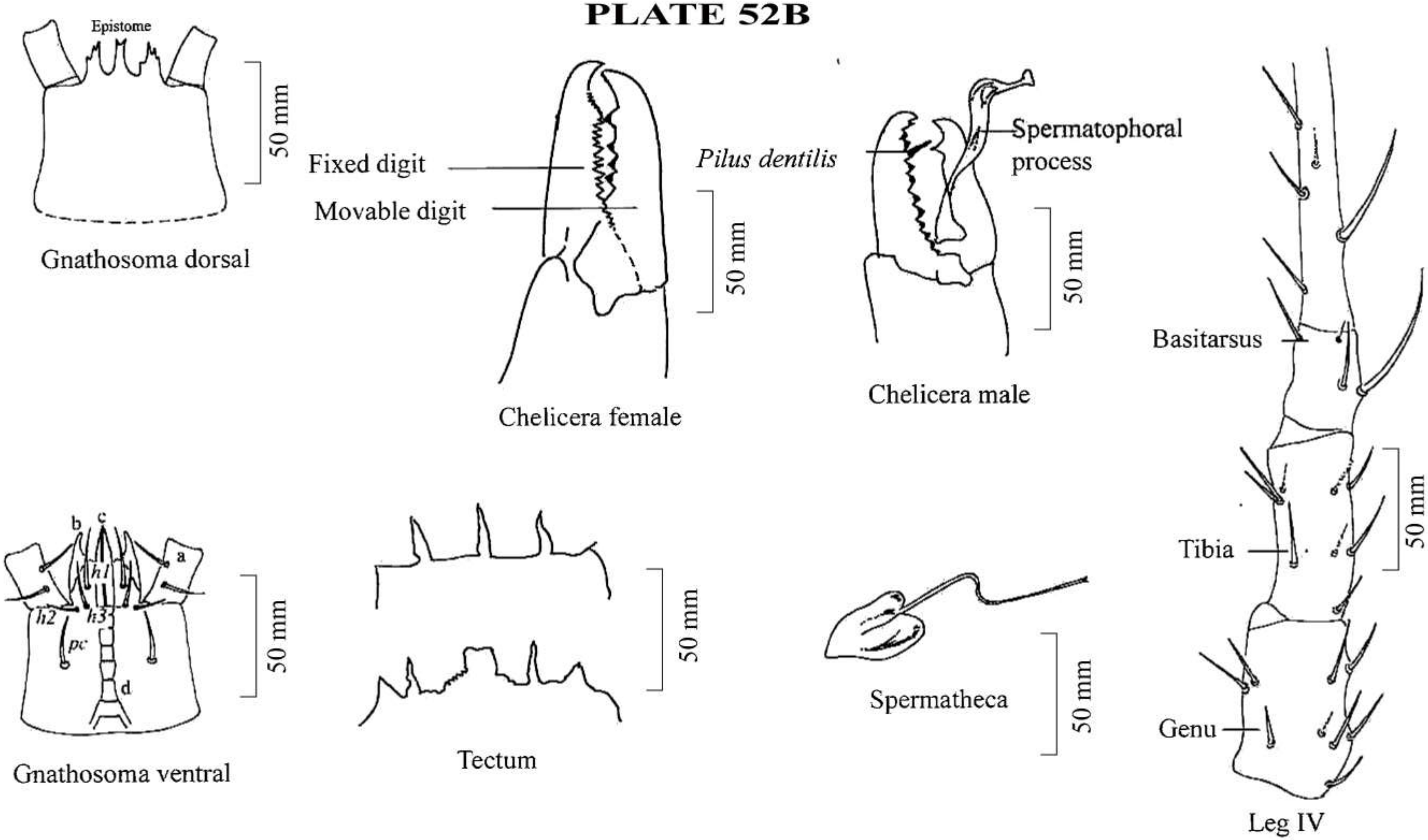
Female dorsal view

Female ventral view

Male ventral view

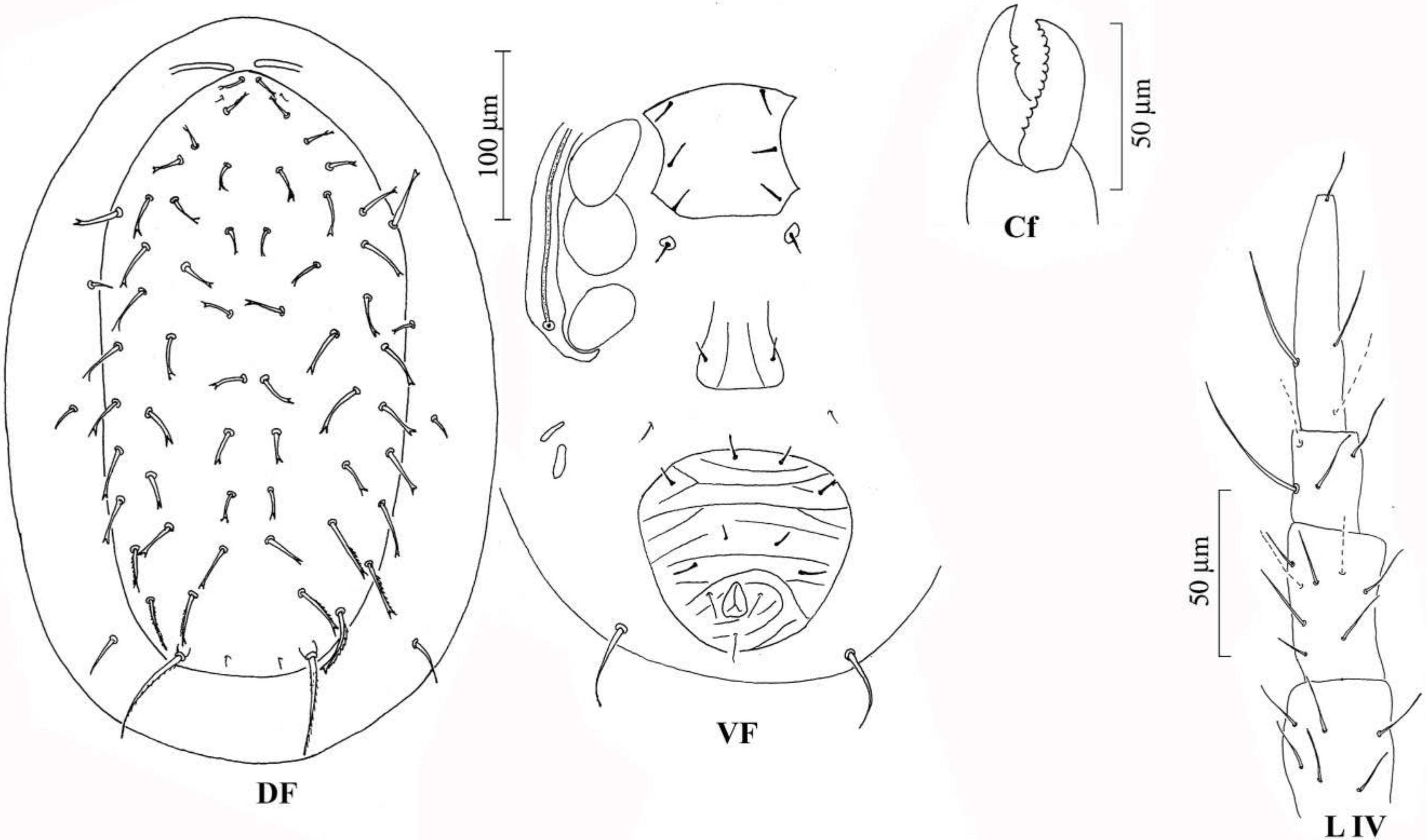
Morphological and Taxonomical characters of the family Blattisociidae A

PLATE 52B



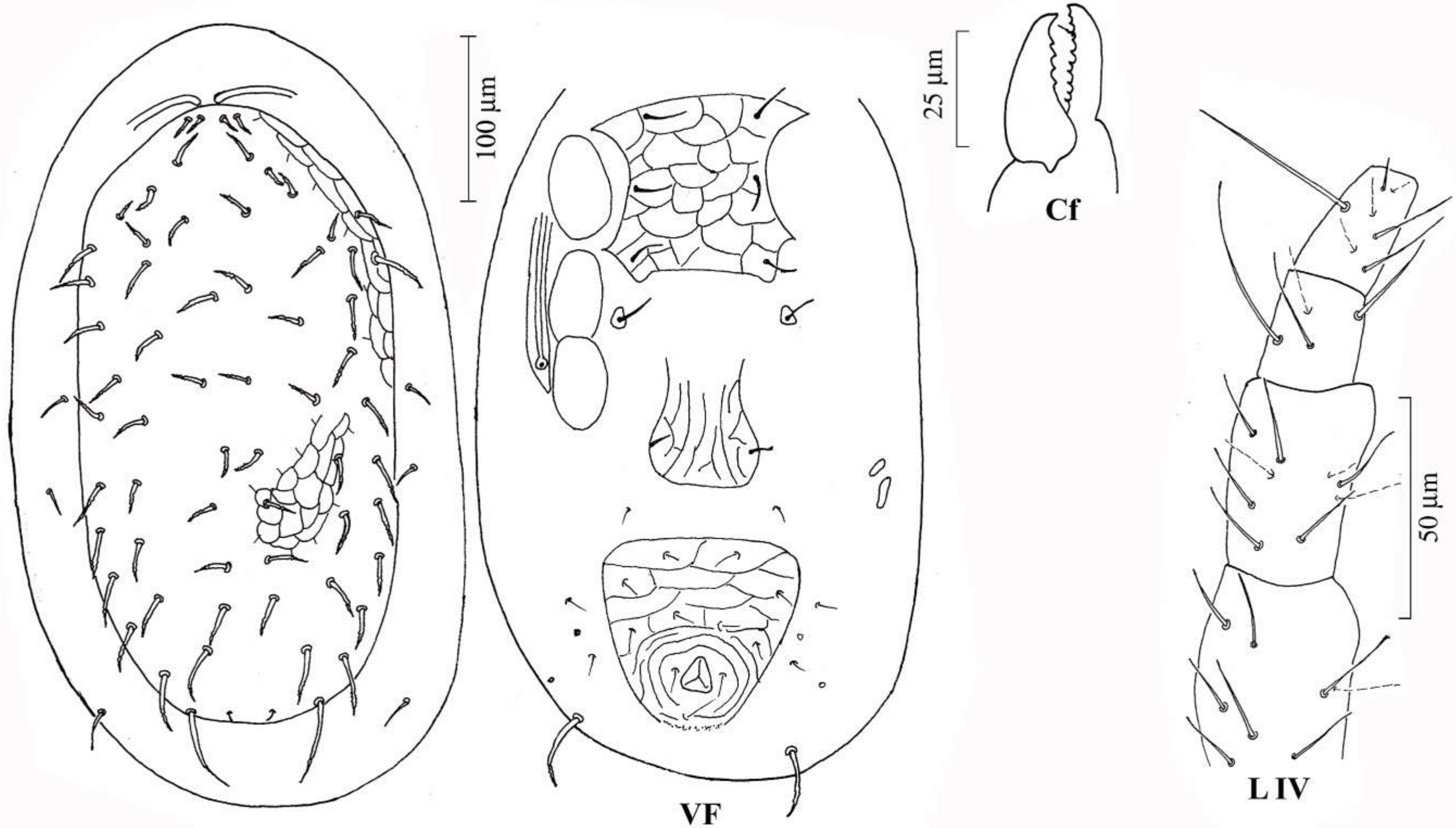
Morphological and Taxonomical characters of the family Blattisociidae B

PLATE 53



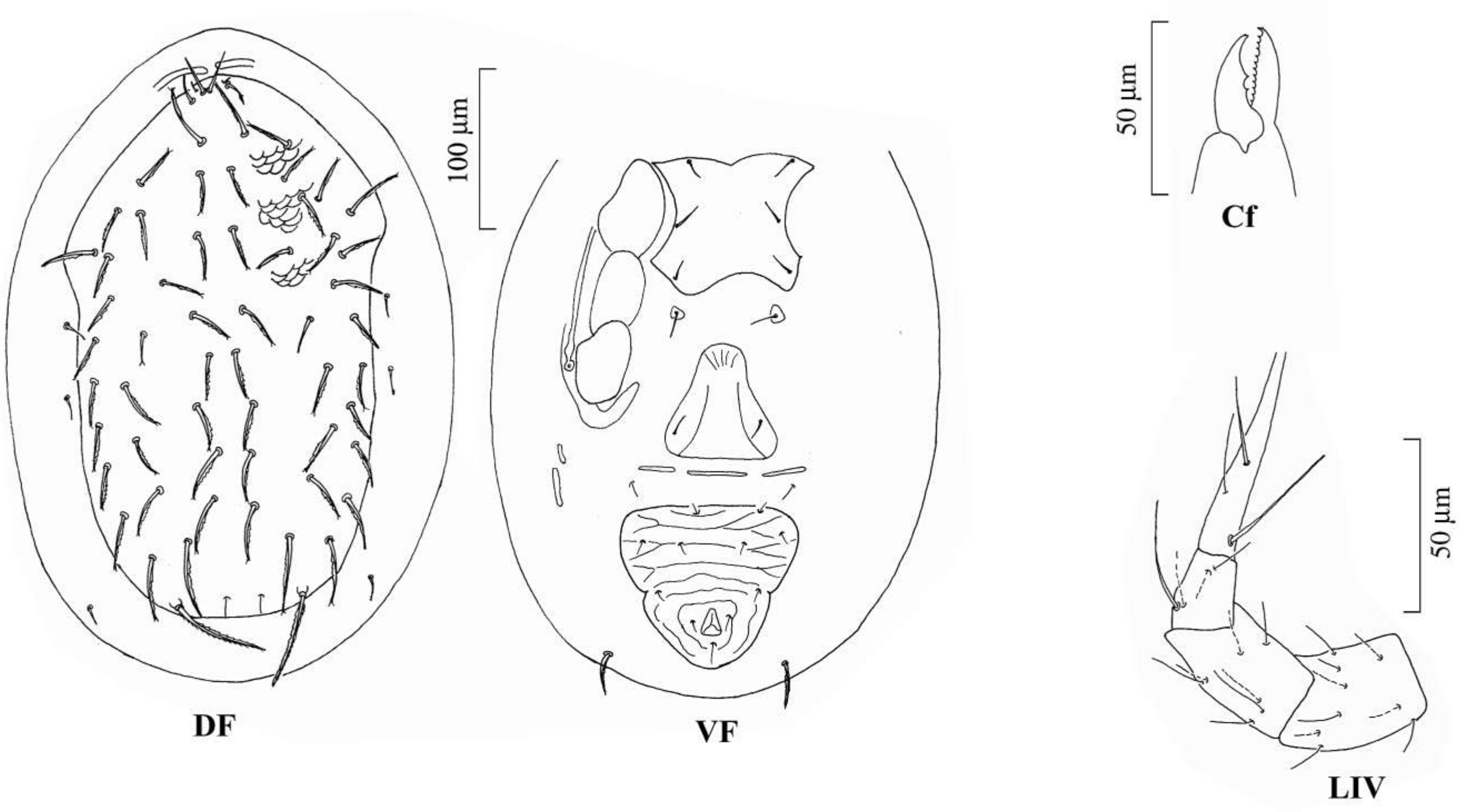
Cheiroseius kozhikodensis sp. nov.

PLATE 54



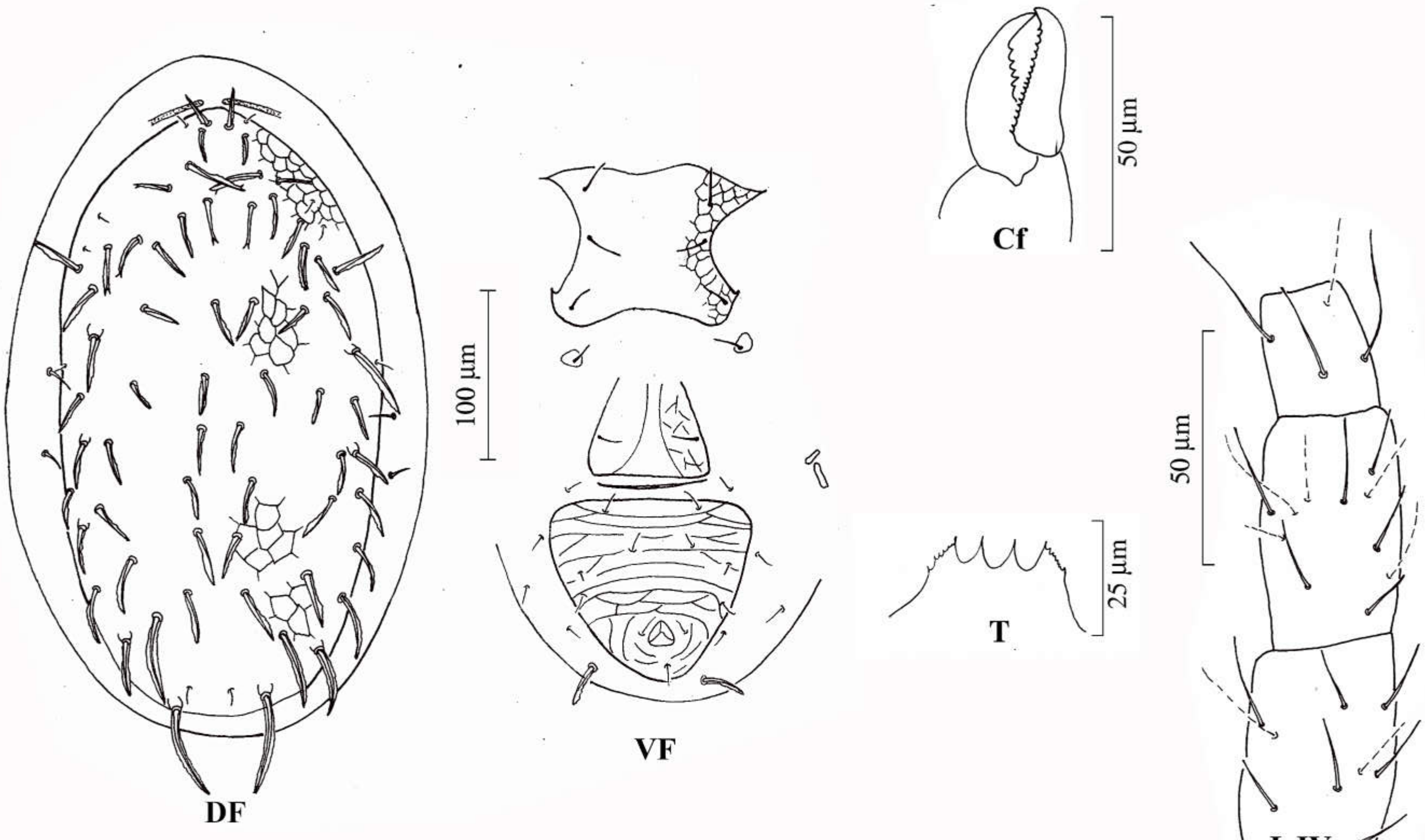
Lasioseius arjuni sp. nov.

PLATE 55



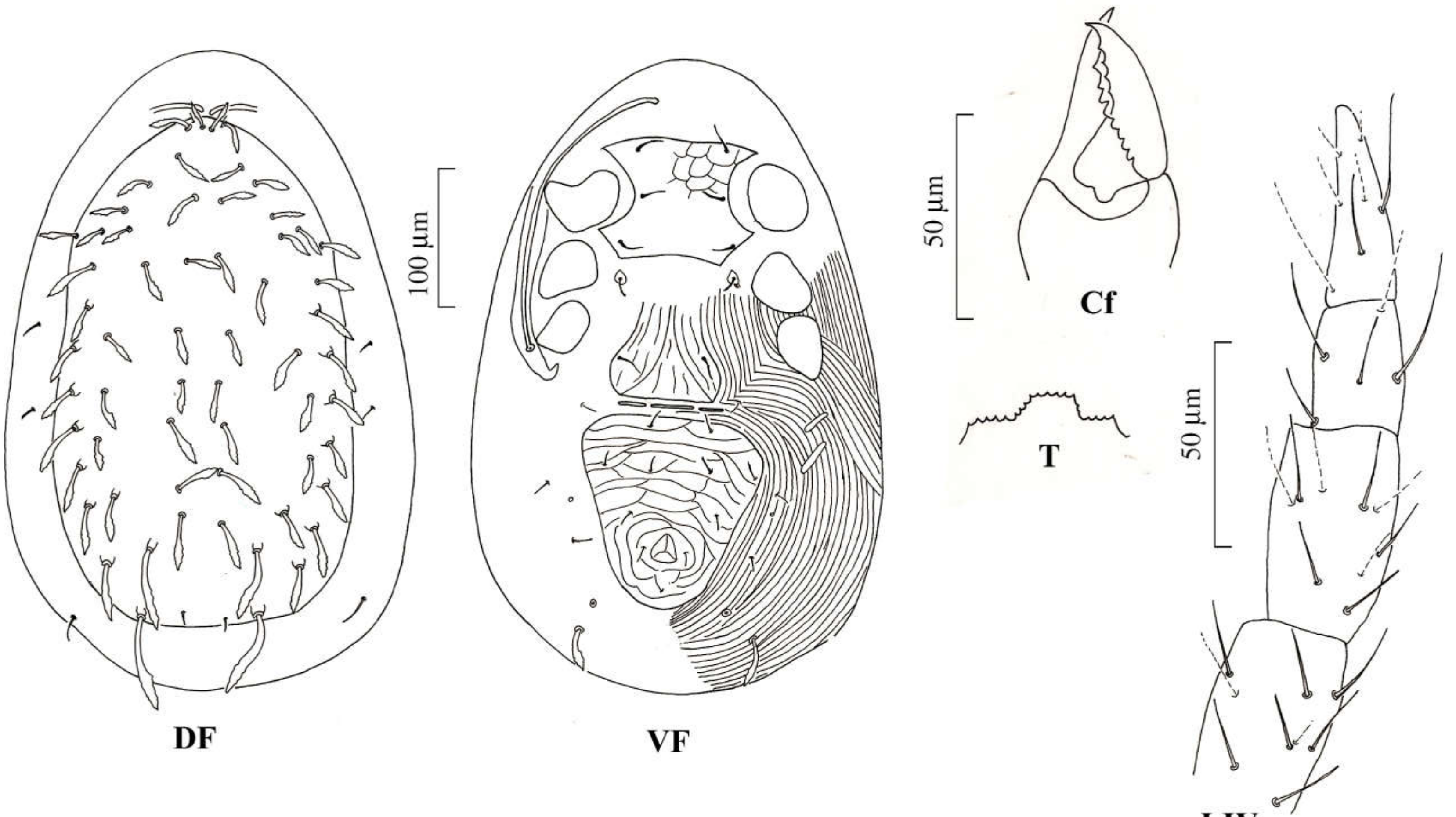
Lasioseius furcisetus **Athias-Henriot, 1959**

PLATE 56



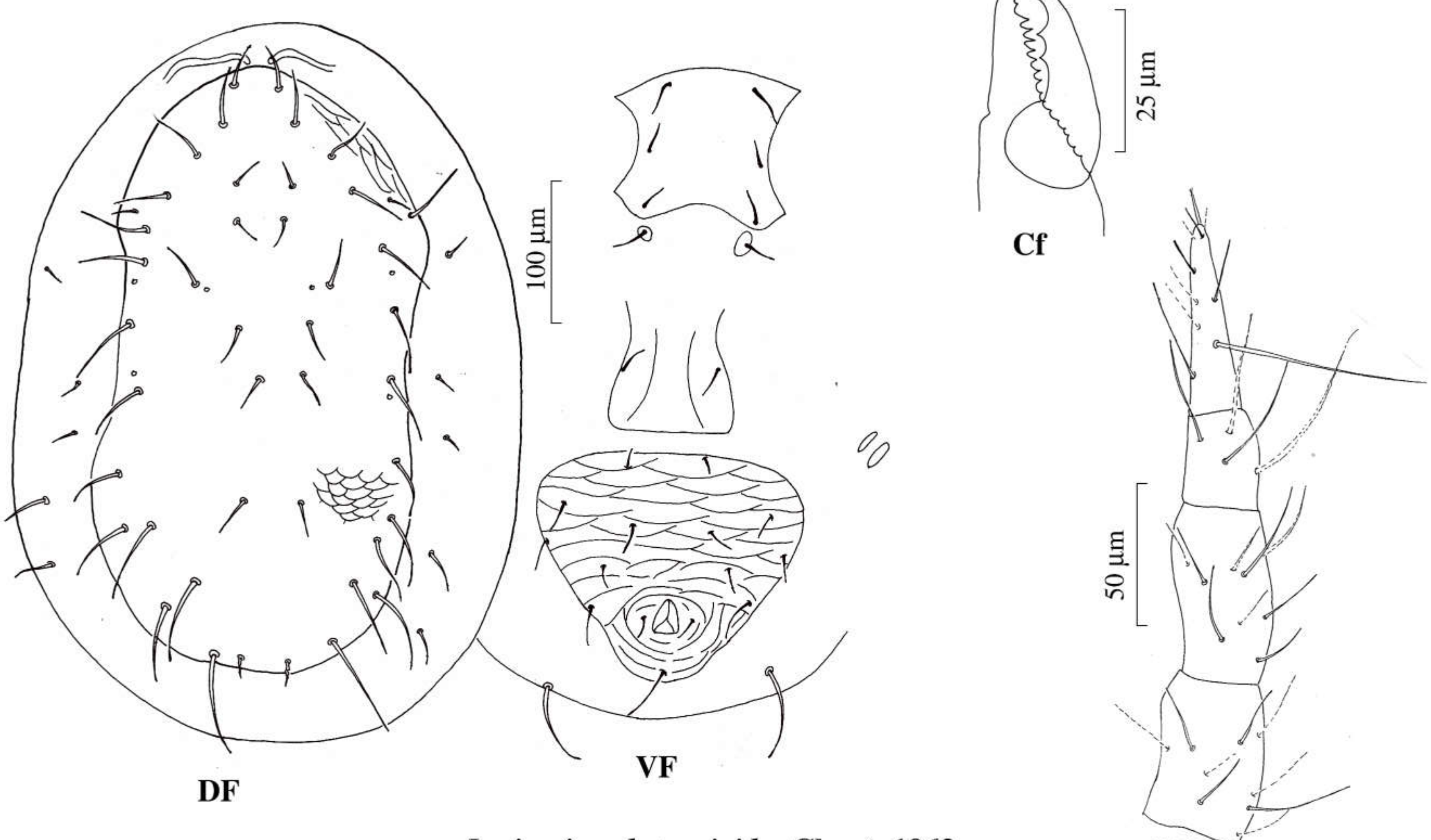
Lasioseius glomerulus Karg, 1979

PLATE 57



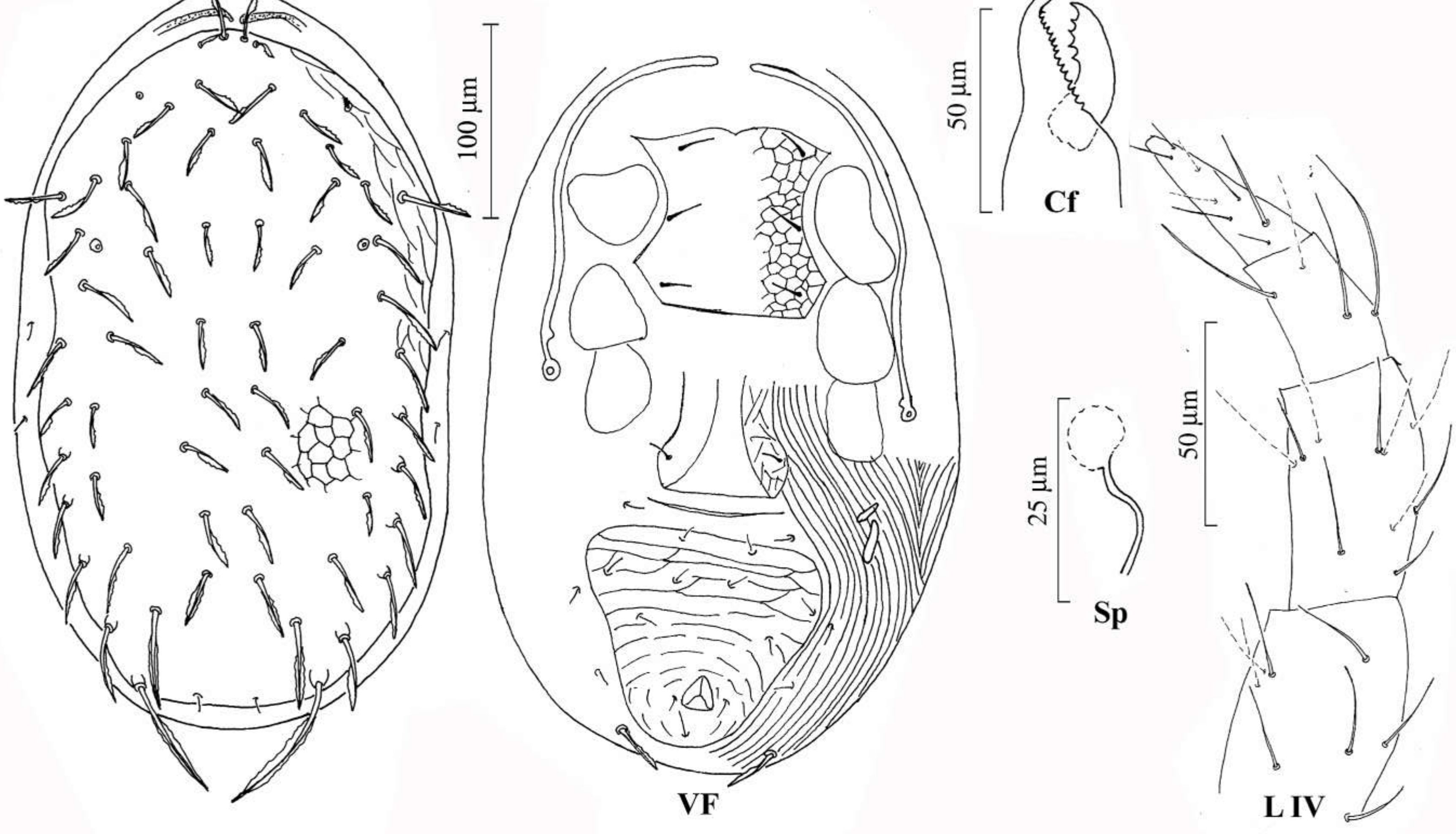
Lasioseius kurumpoyilensis sp. nov.

PLATE 58



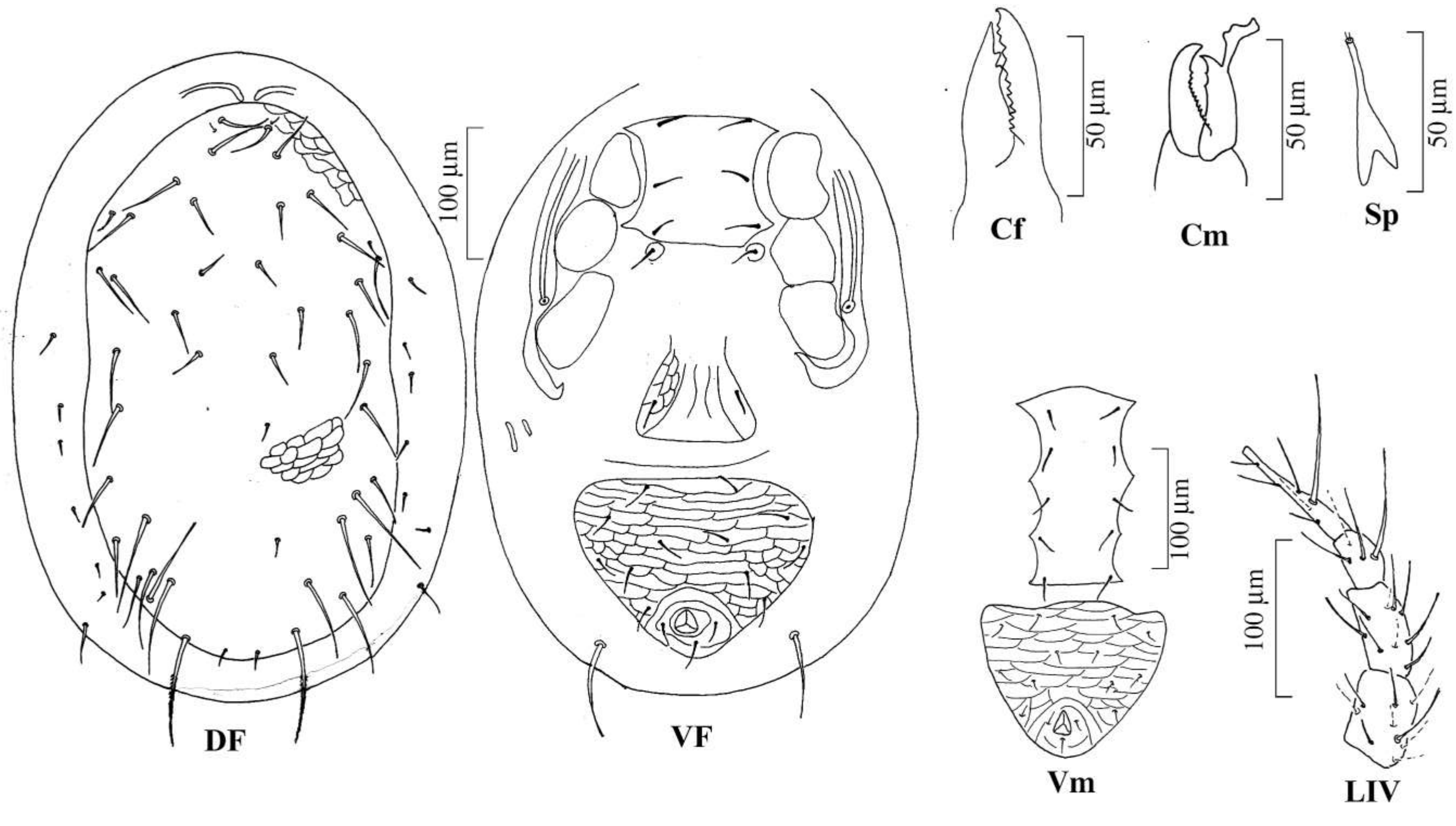
Lasioseius phytoseioides Chant, 1963

PLATE 59



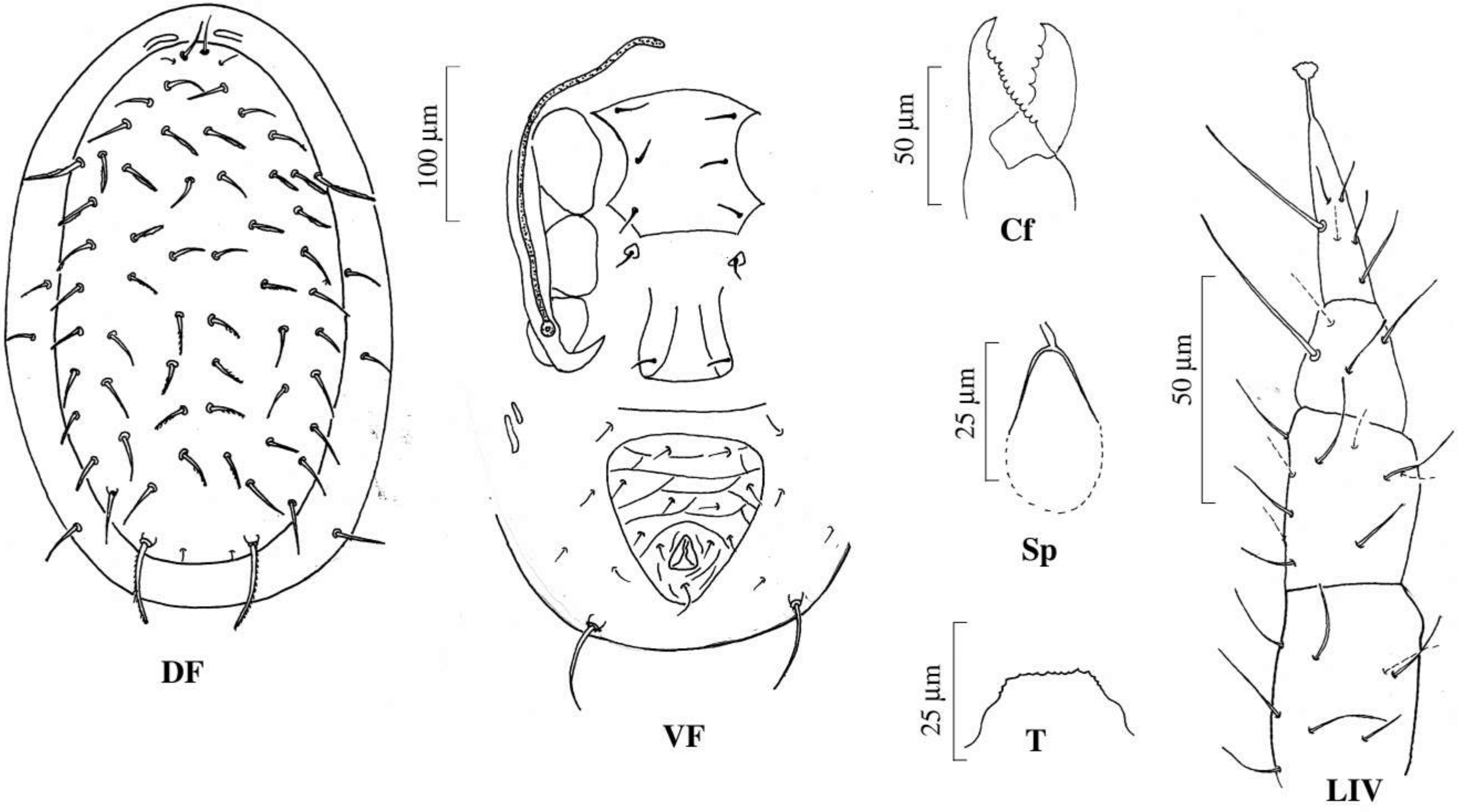
Lasioseius quadrisetosus Chant, 1960

PLATE 60



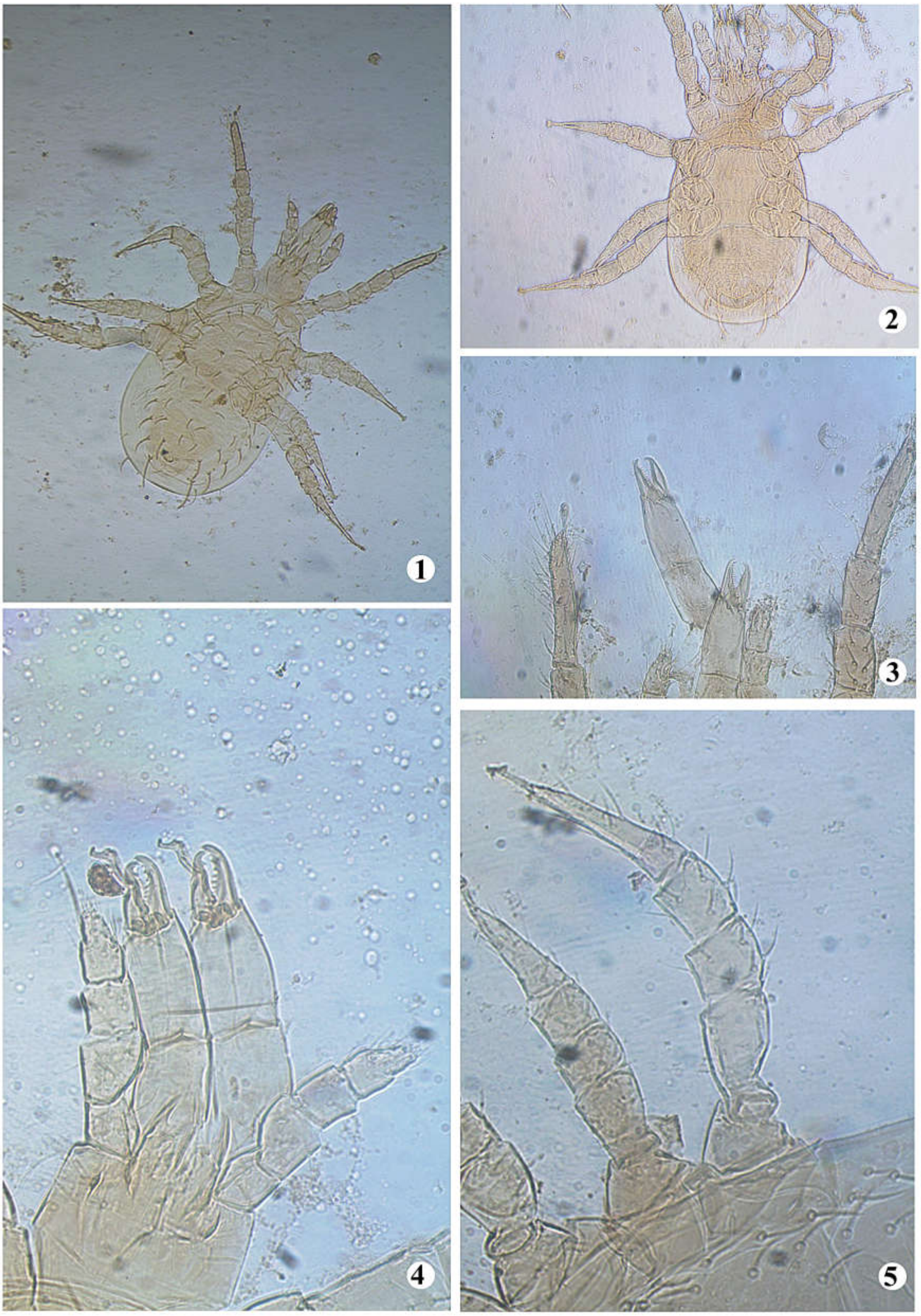
Lasioseius seethae sp. nov.

PLATE 61



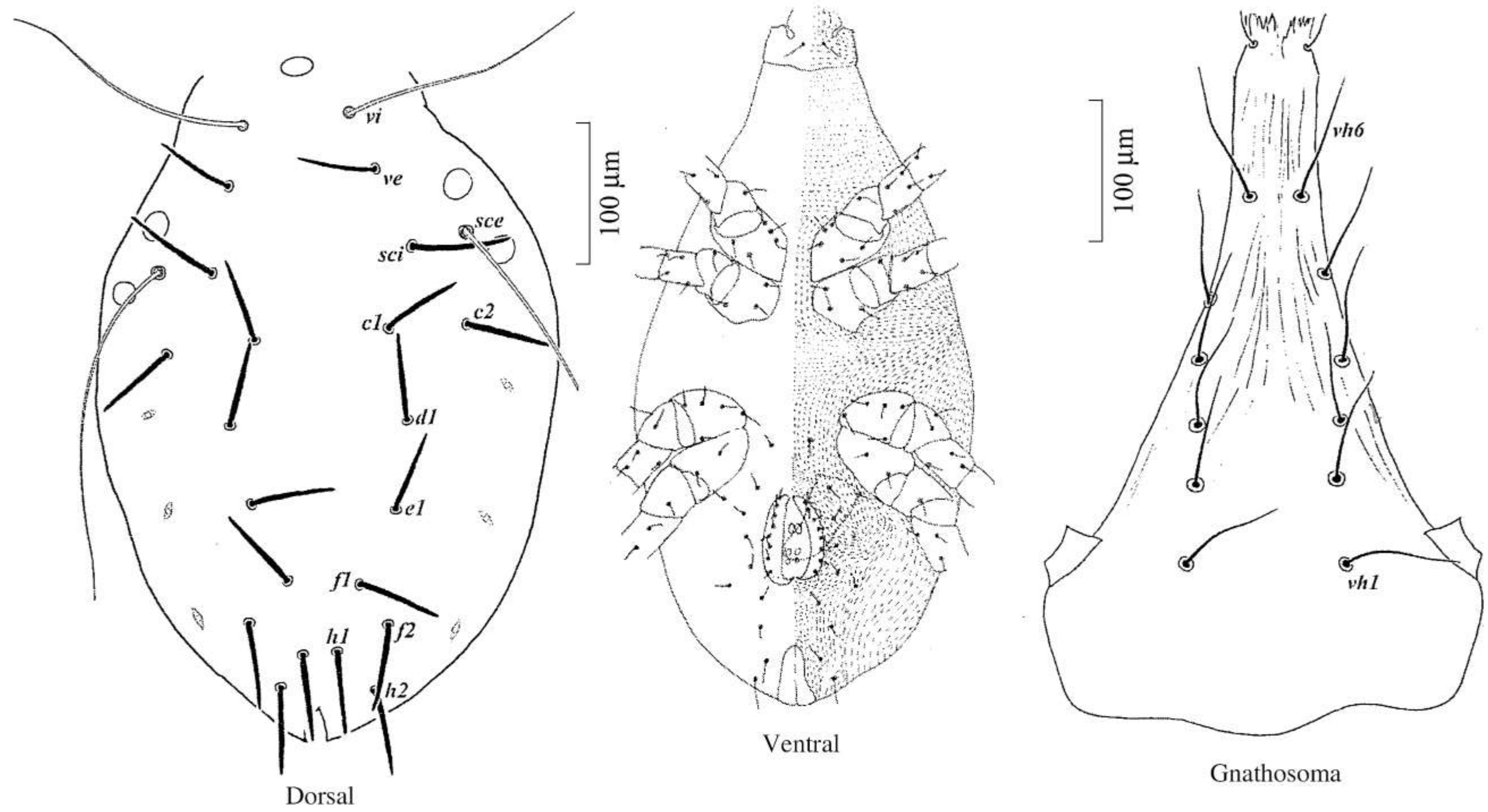
Lasioseius vengeriensis **sp. nov.**

PLATE 62



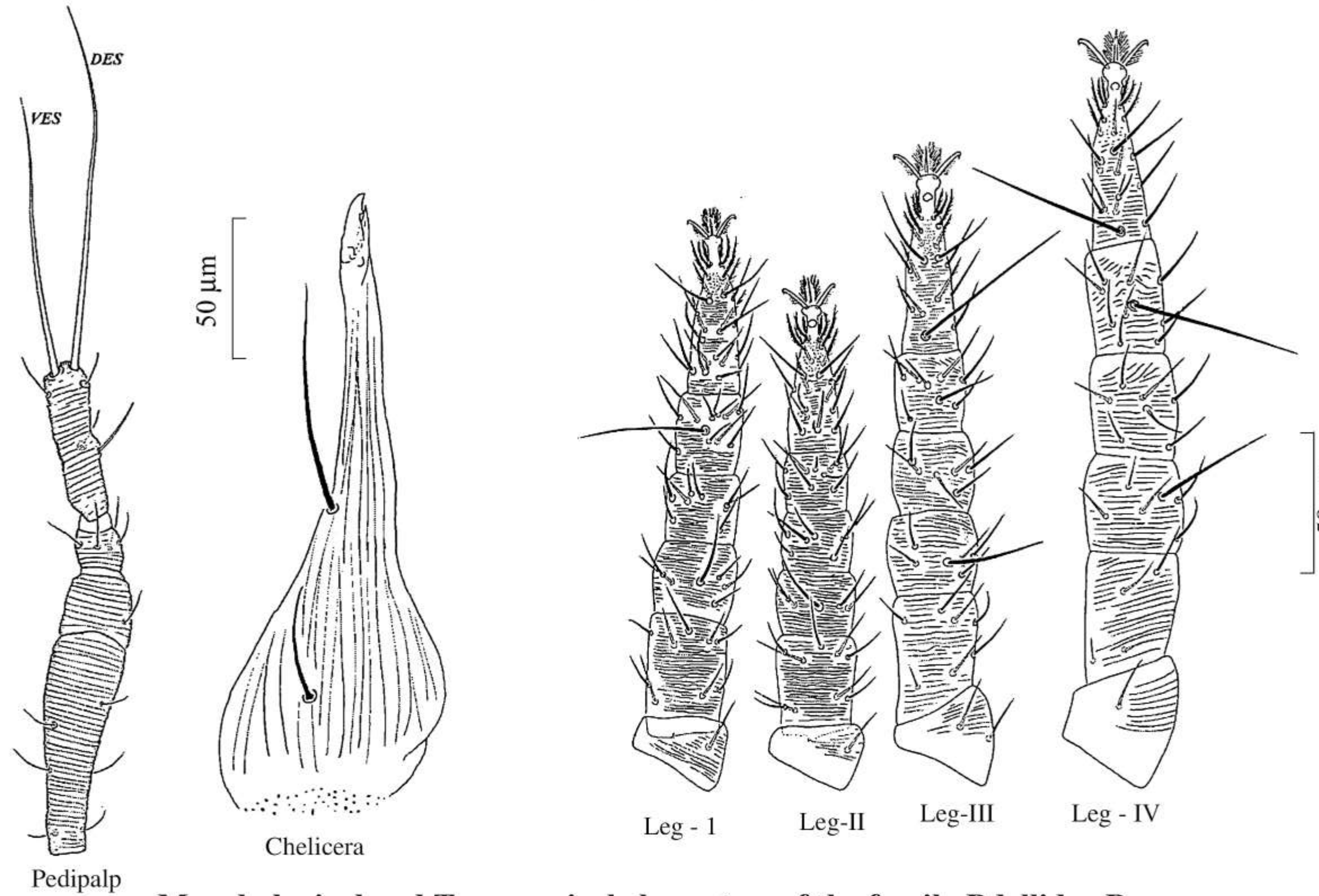
Family Blattisociidae: **1.** Female-Dorsal view **2.** Male-Dorsal view; **3.** Female - chelicera; **4.** Male chelicera with spermatodactyl; **5.** Leg IV setation.

PLATE 63A



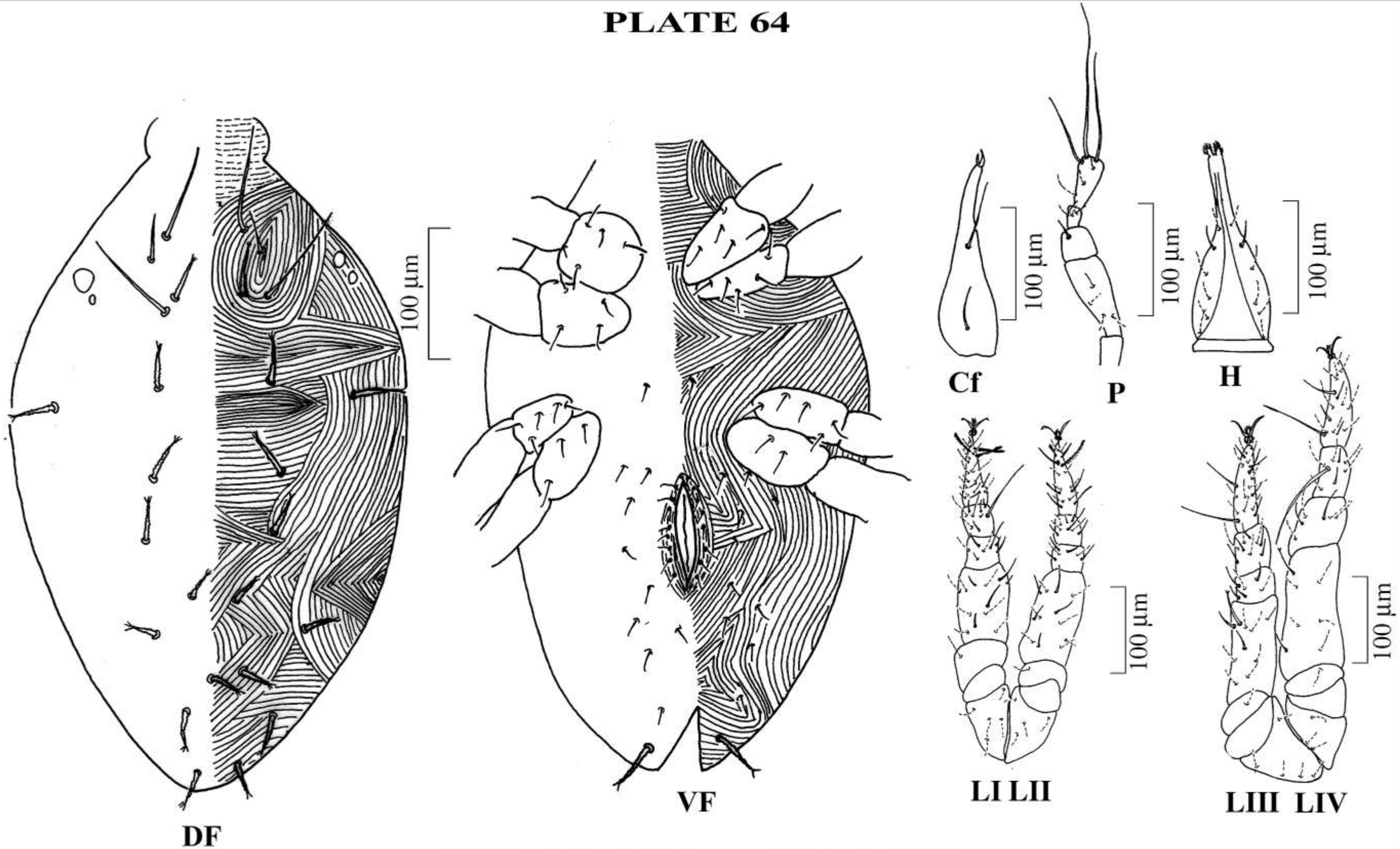
Morphological and Taxonomical characters of the family Bdellidae A

PLATE 63B



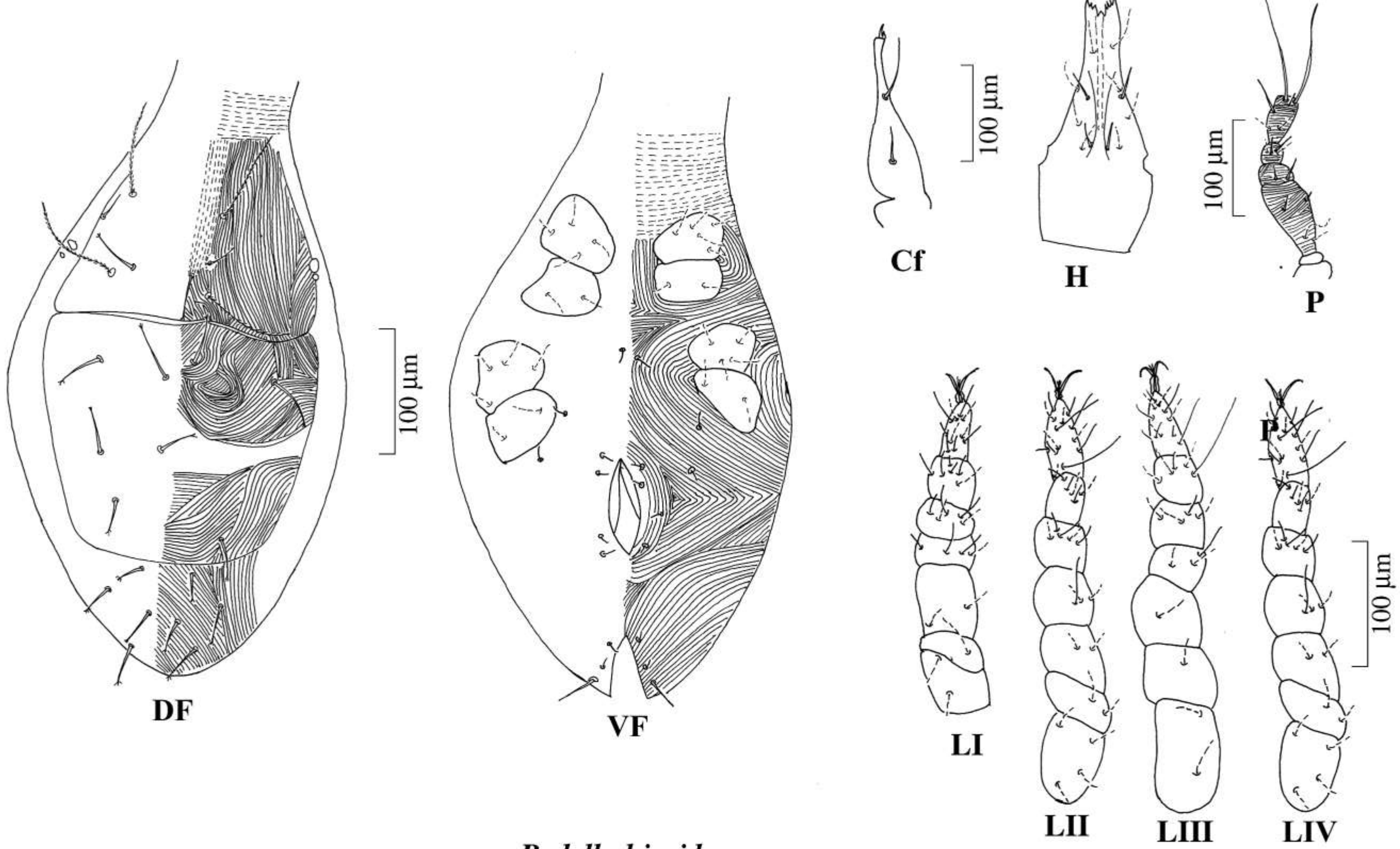
Morphological and Taxonomical characters of the family Bdellidae B

PLATE 64



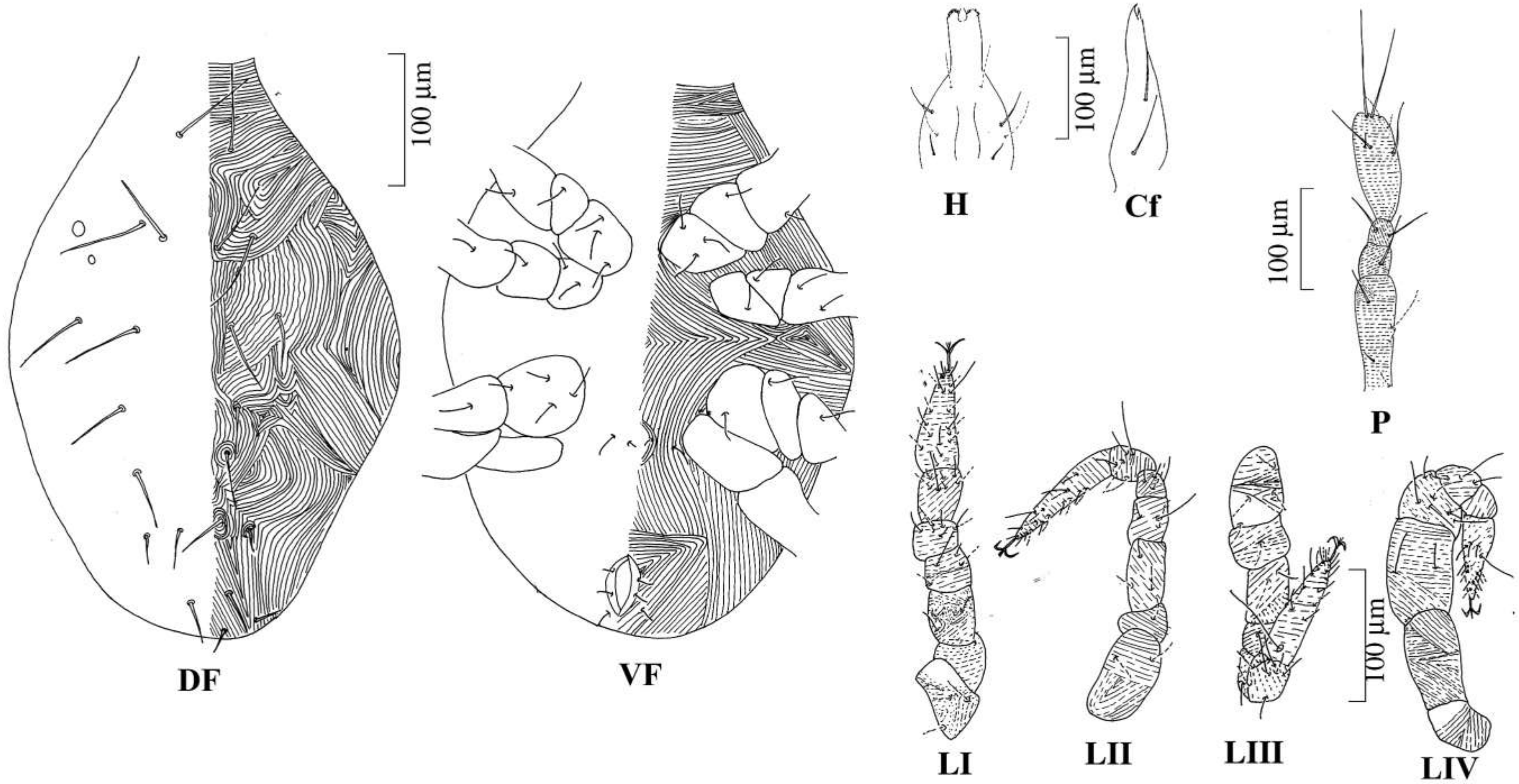
Bdella distincta Baker and Balock, 1944

PLATE 65



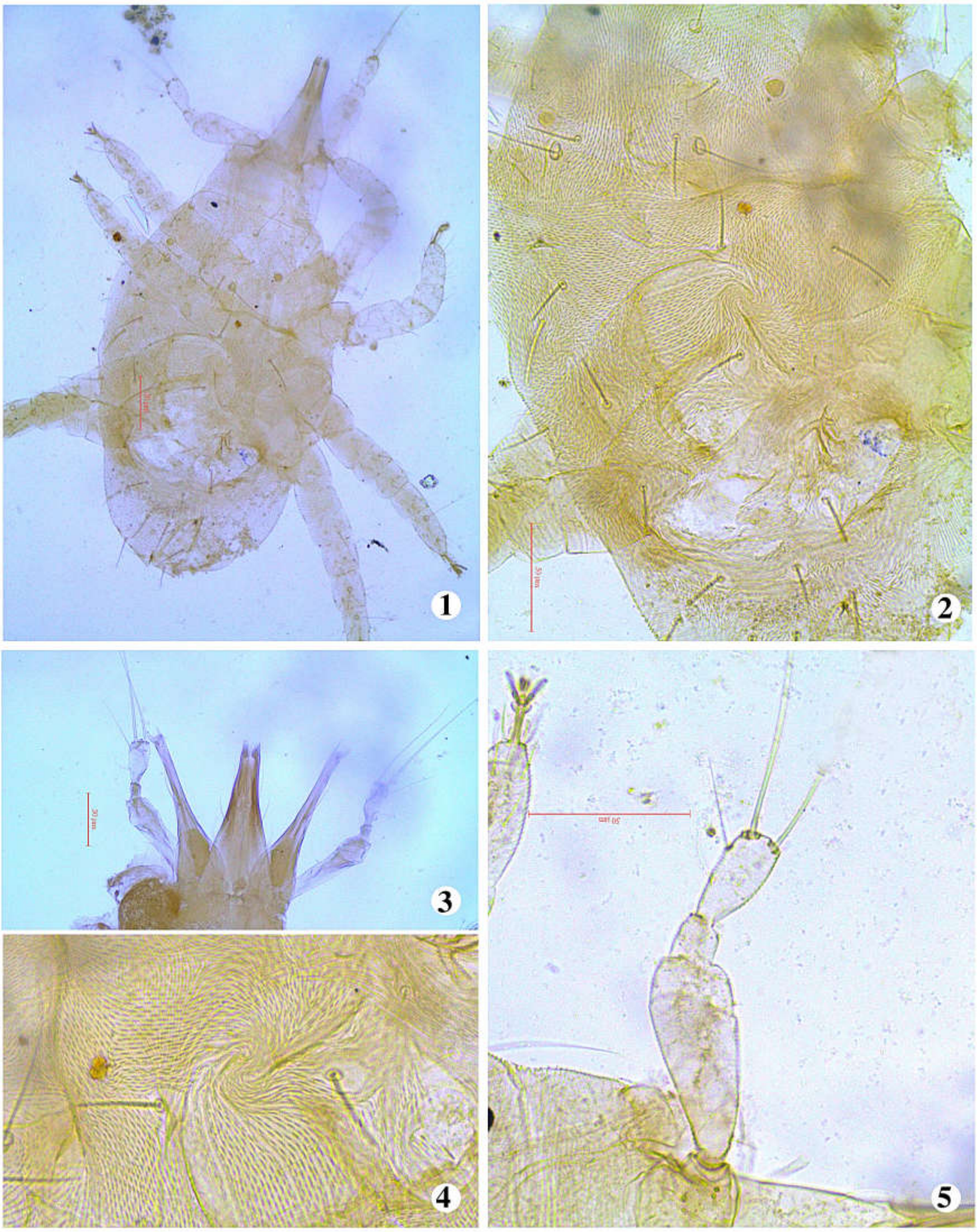
Bedella hispidae **sp. nov.**

PLATE 66



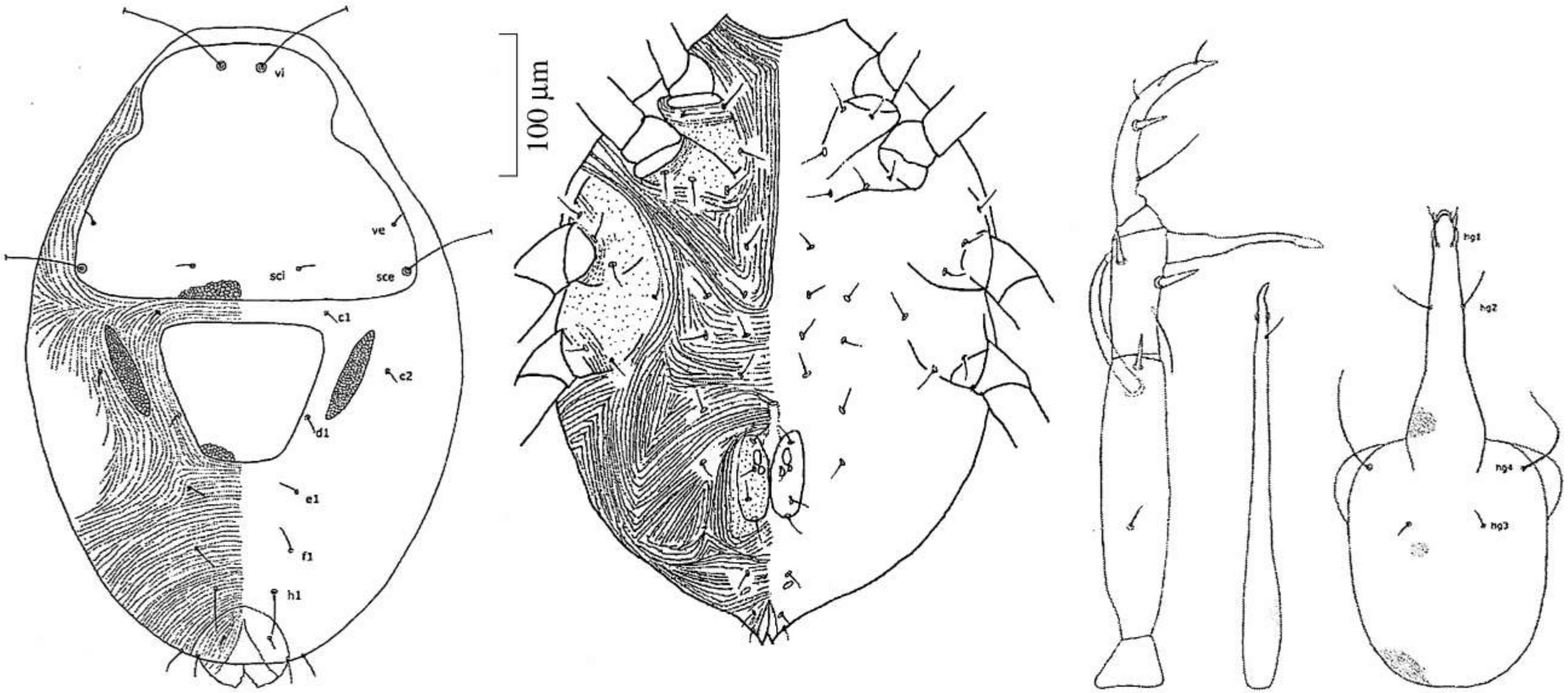
Cyta bharathani sp. nov.

PLATE 67



Family Bdellidae: **1.** Adult entire view; **2.** Adult dorsal view; **3.** Hypostome with chelicera; **4.** Dorsal scelrotisation; **5.** Pedipalp.

PLATE 68A



Female - Dorsal view

Female - Ventral view

Pedipalp

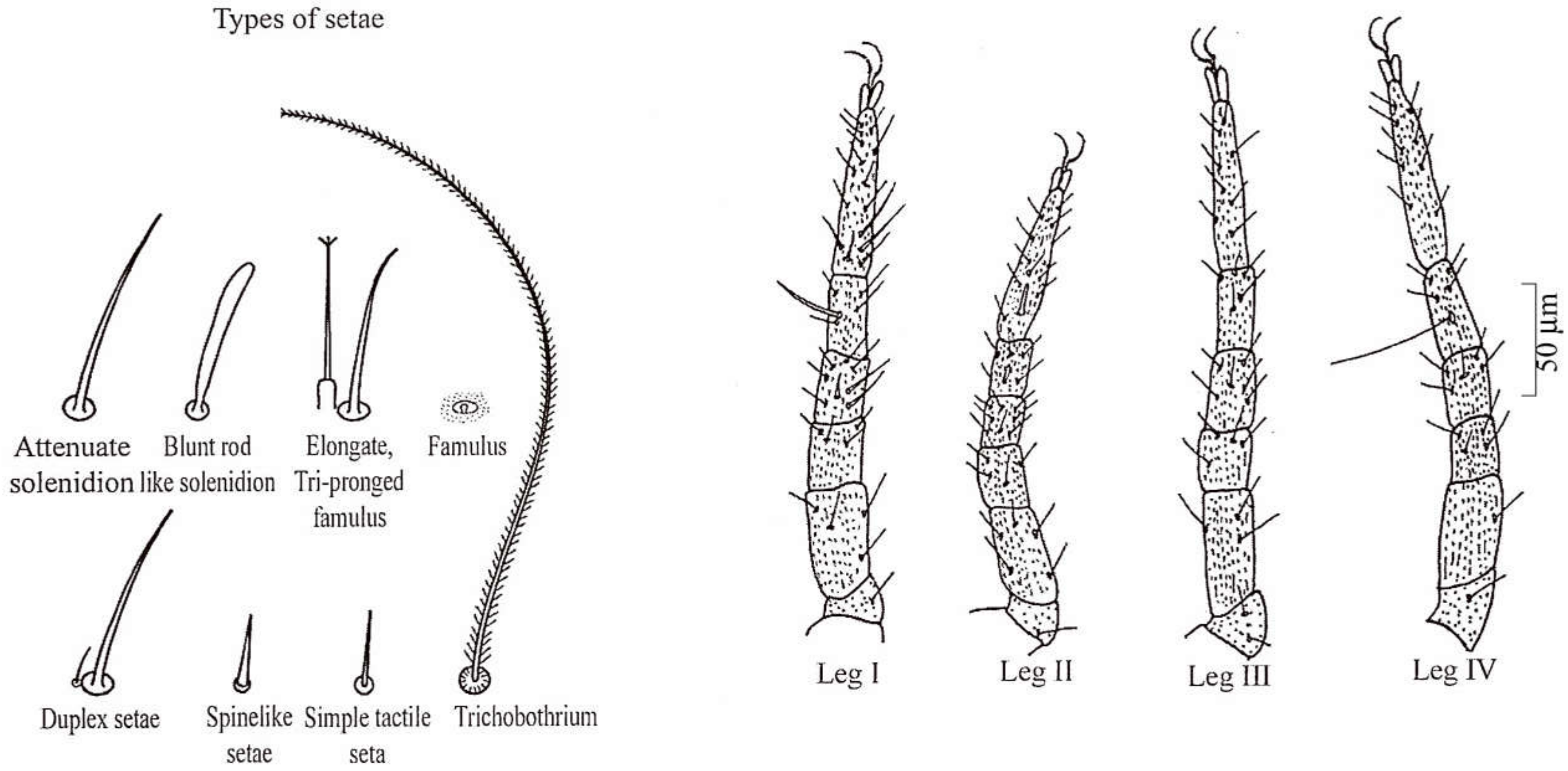
Chelicera

Hypostome

100 µm

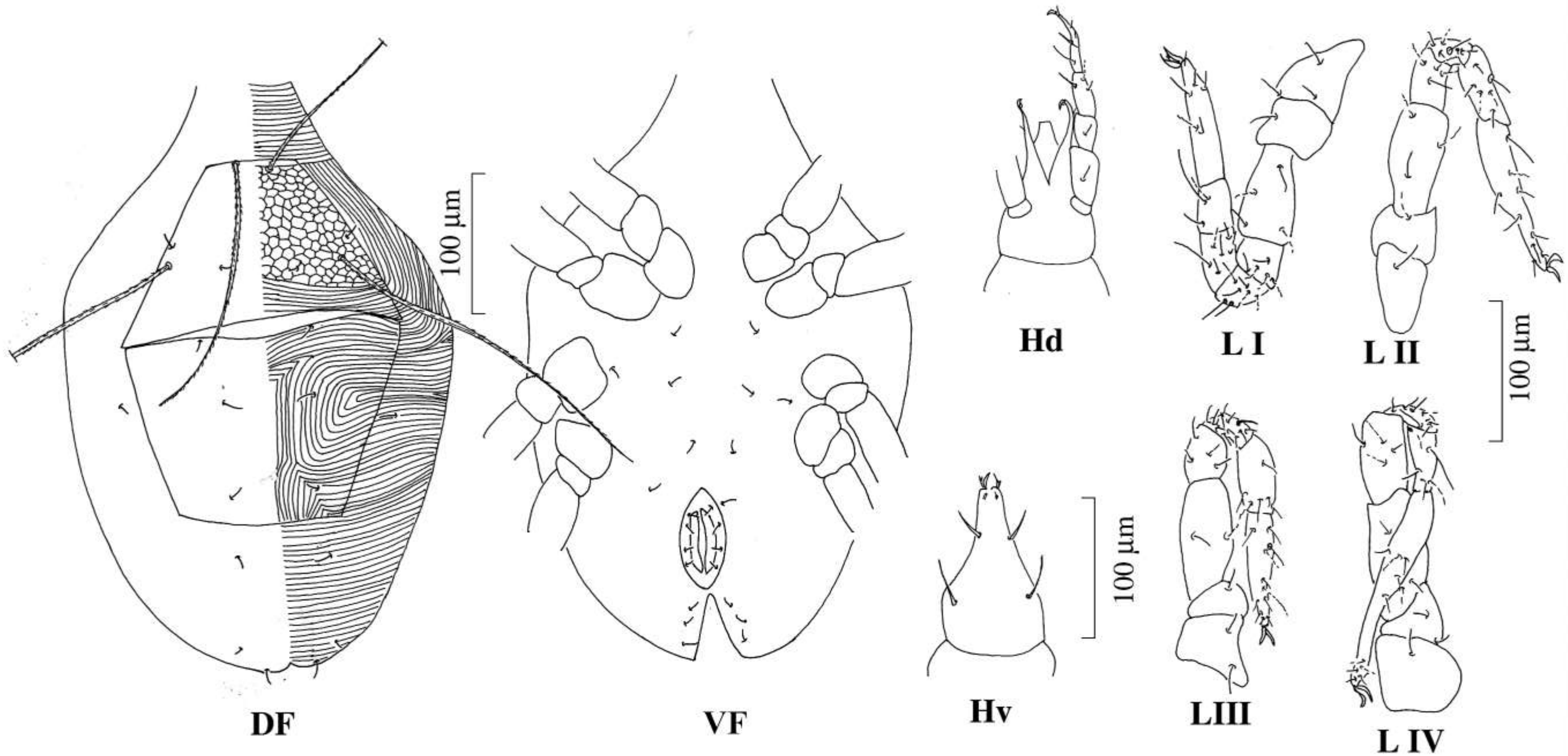
Morphological and Taxonomical Characters of the Family Cunaxidae A

PLATE 68B



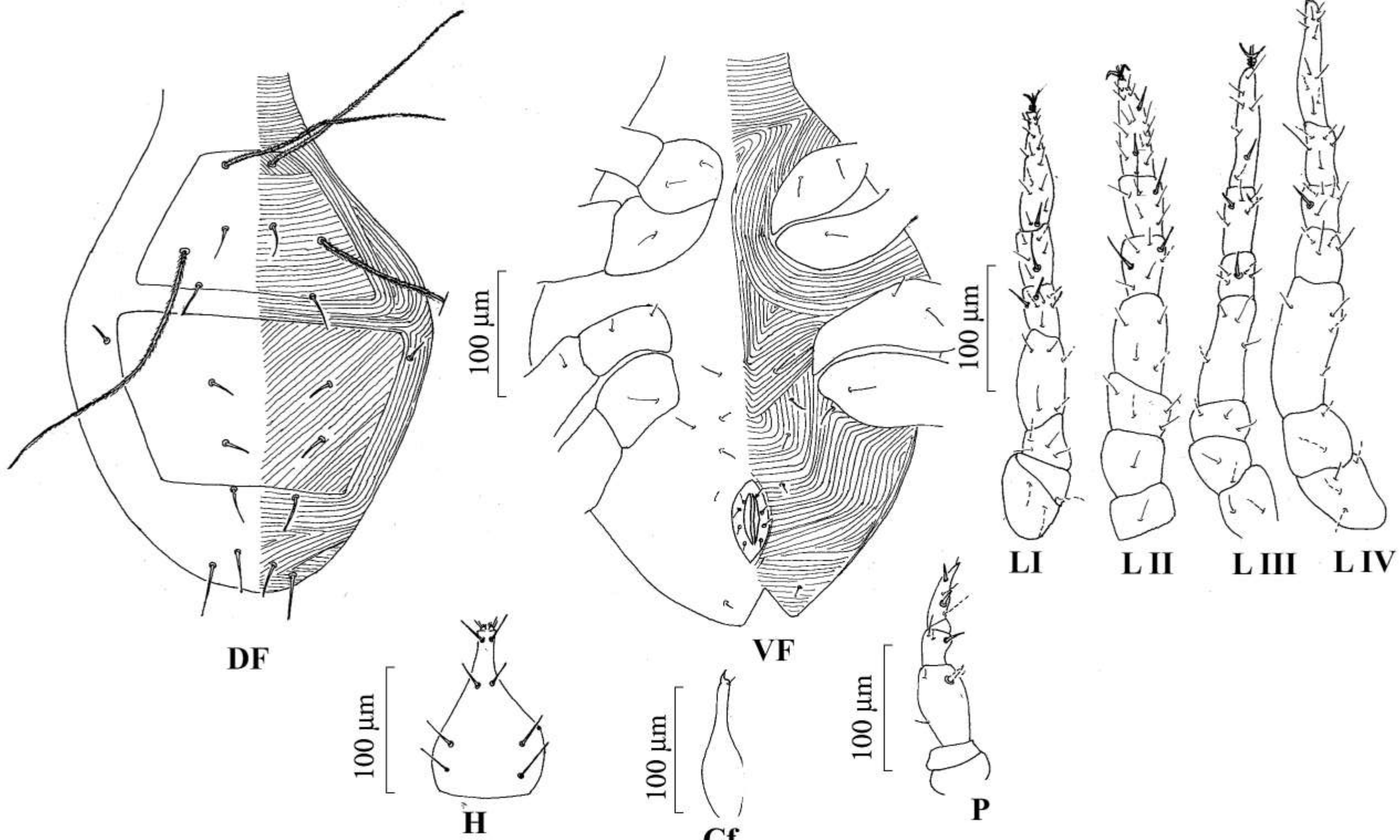
Morphological and Taxonomical Characters of the Family Cunaxidae B

PLATE 69



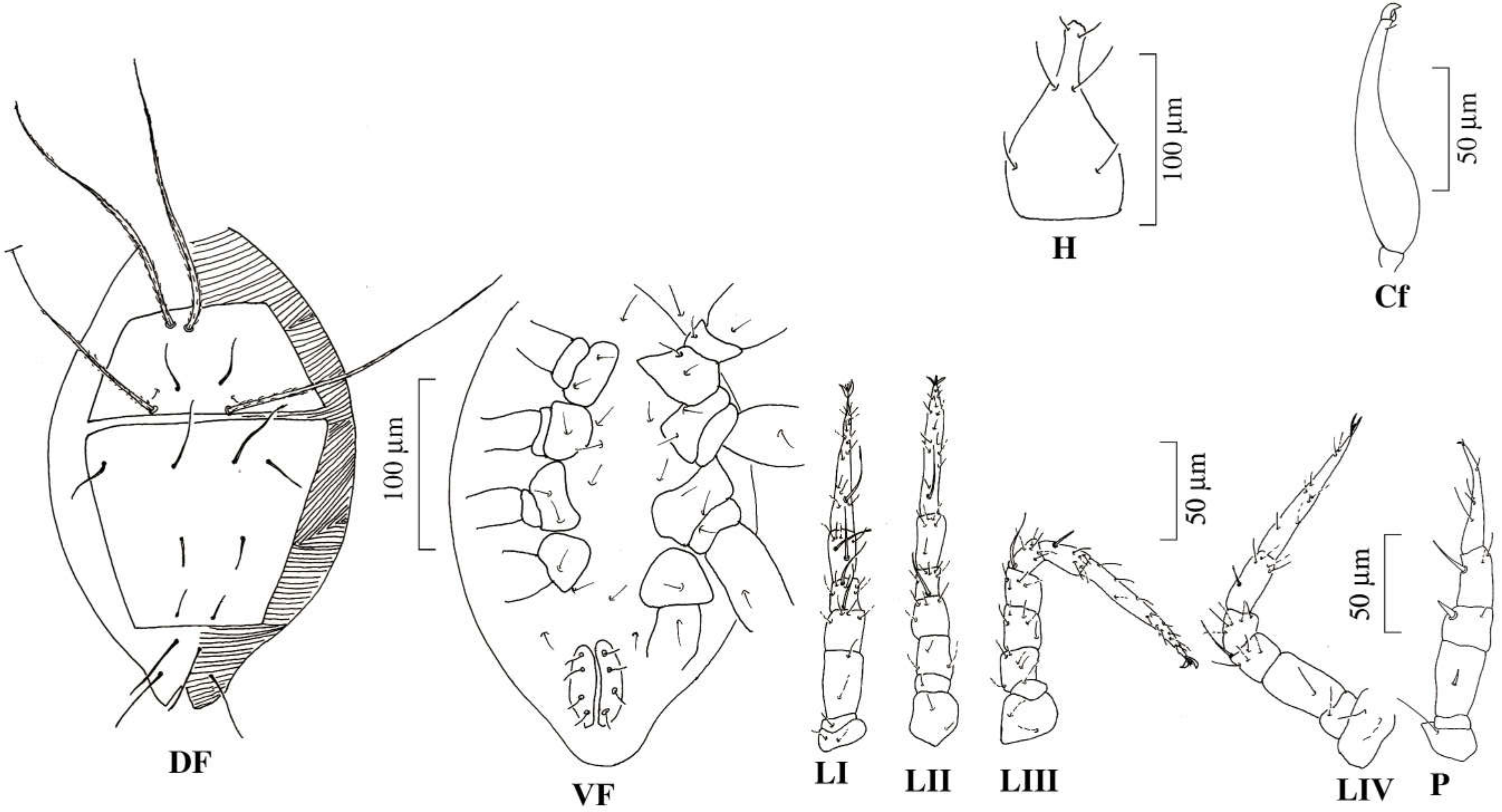
Cunaxa pushpae sp. nov.

PLATE 70



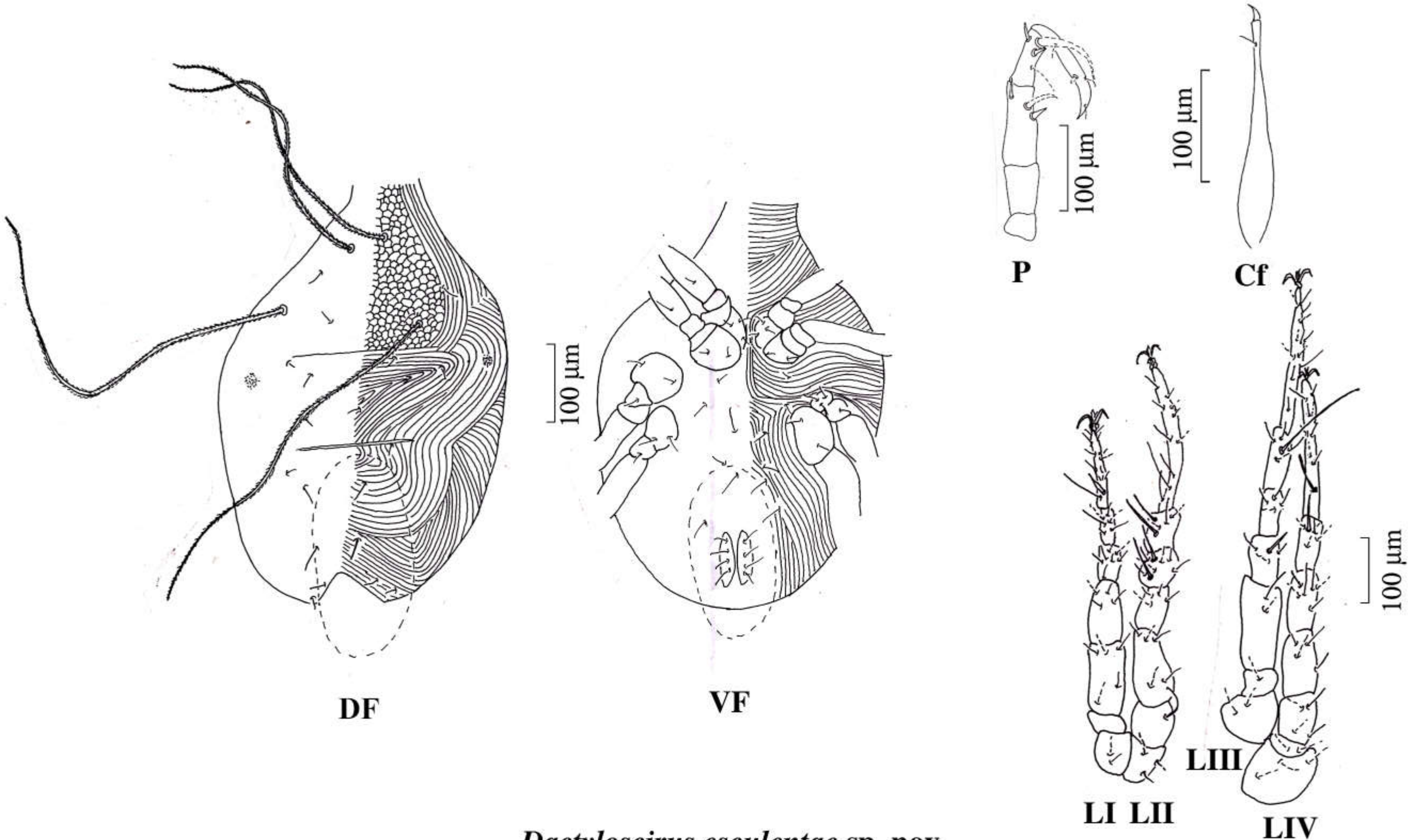
Cunaxa soansi Rahul *et al.*, 2017

PLATE 71



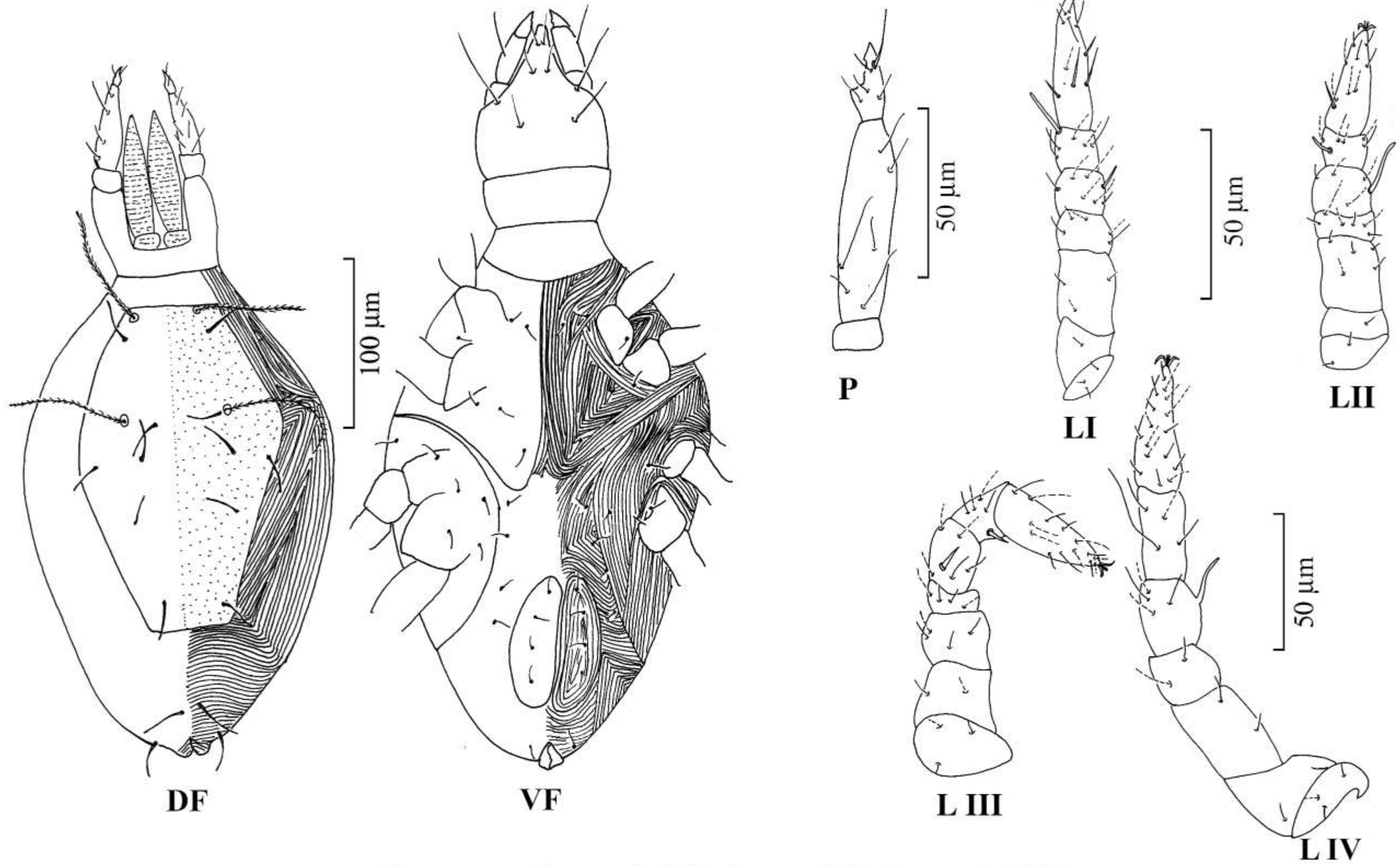
Cunaxa womersleyi Baker and Hoffmann, 1948

PLATE 72



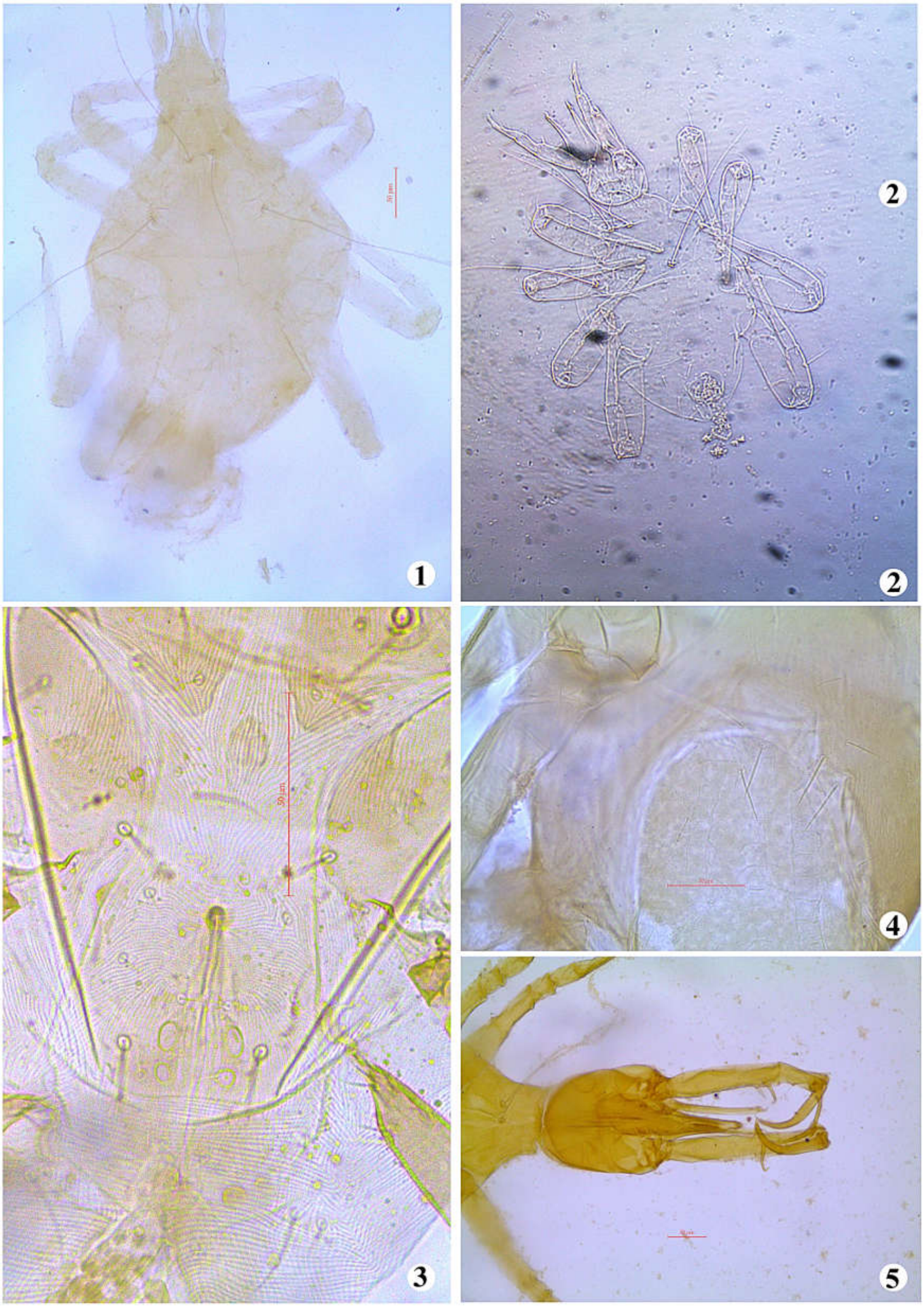
Dactyloscirus esculentae sp. nov.

PLATE 73



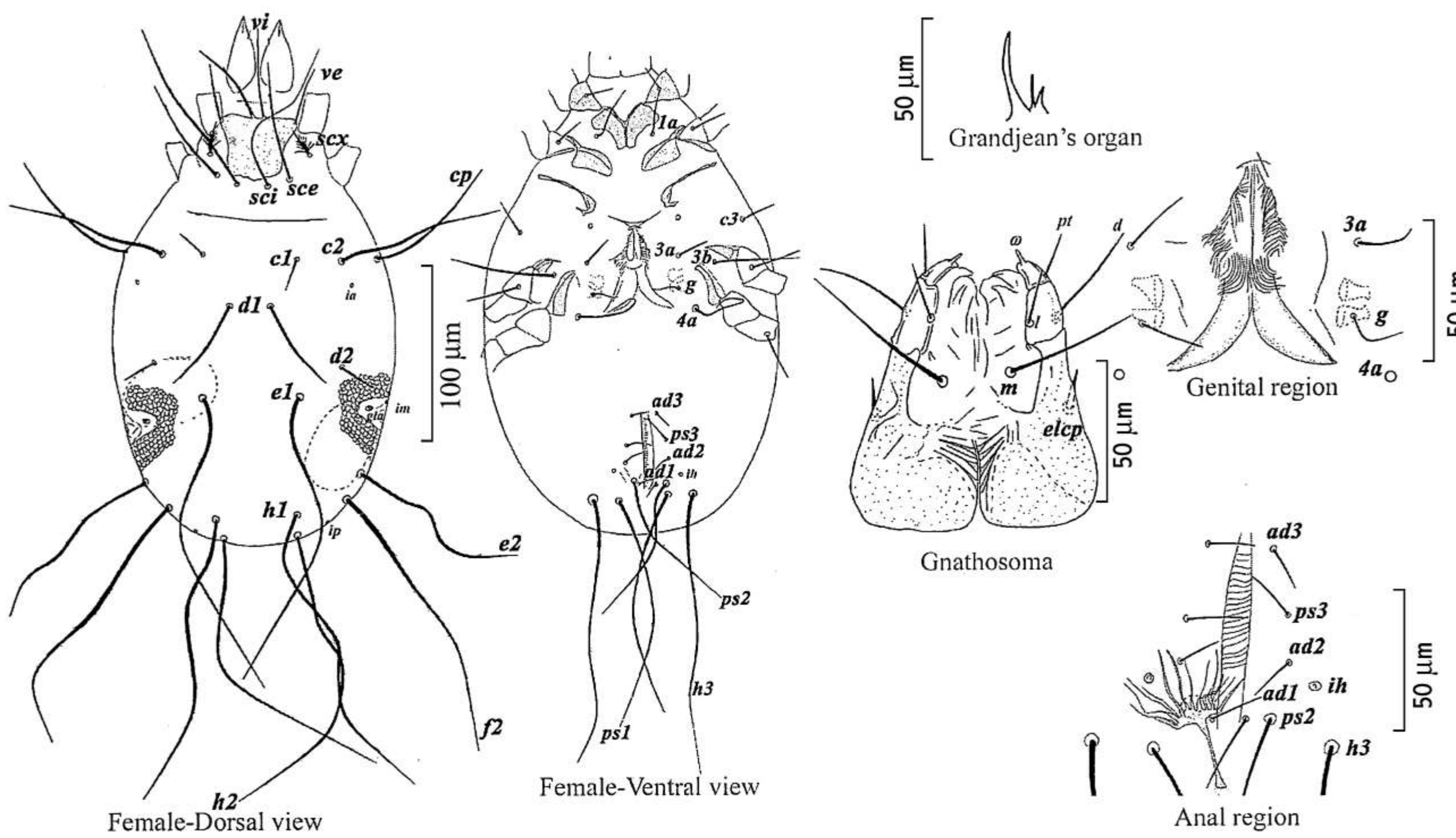
Neocunaxoides andrei (Baker and Hoffmann), 1975

PLATE 74



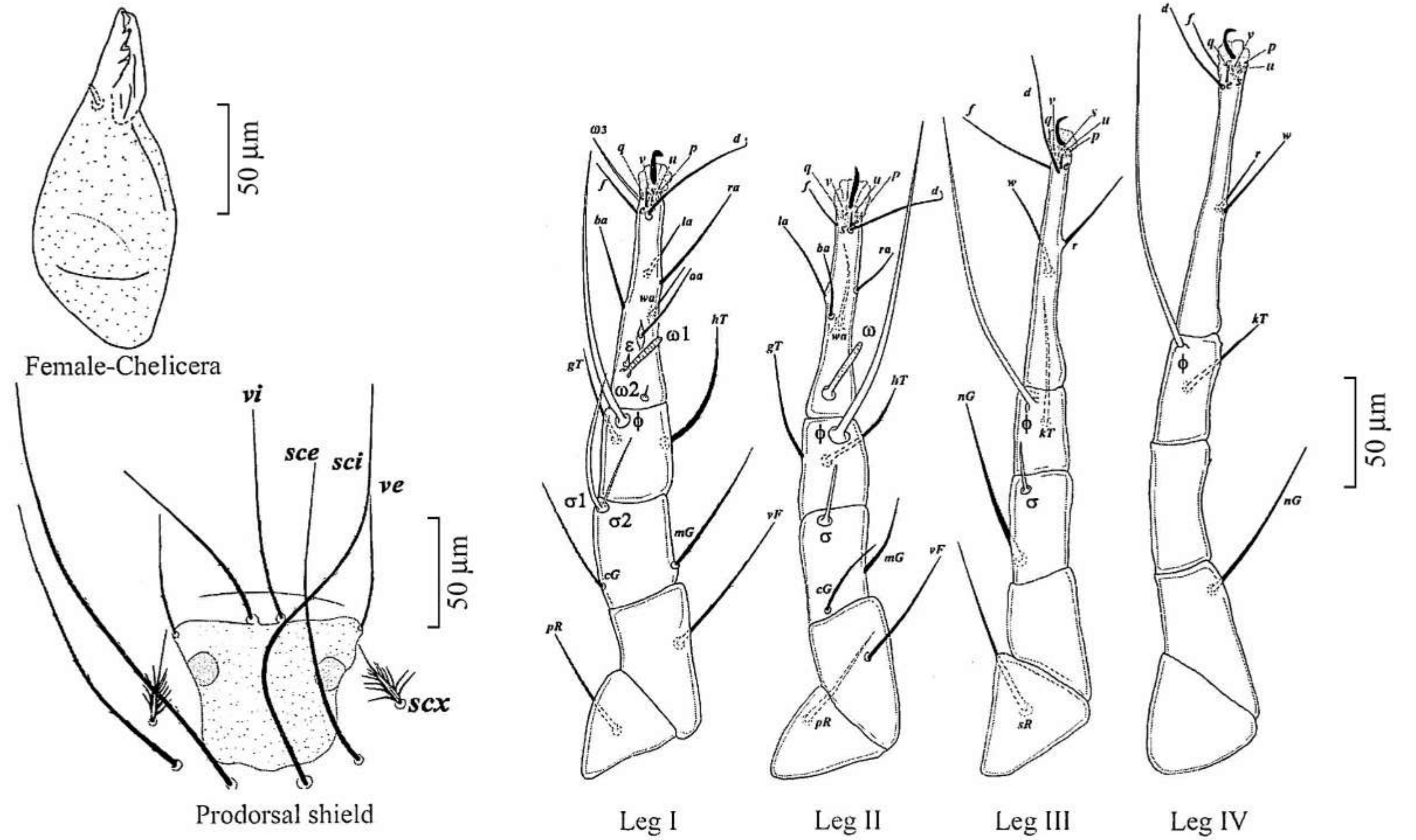
Family Cunaxidae: **1.** Adult DV; **2.** Adult VV; **3.** Sclerotisation on dorsal shield; **4.** Genital pore with genital setae; **5.** Hypostome.

PLATE 75A



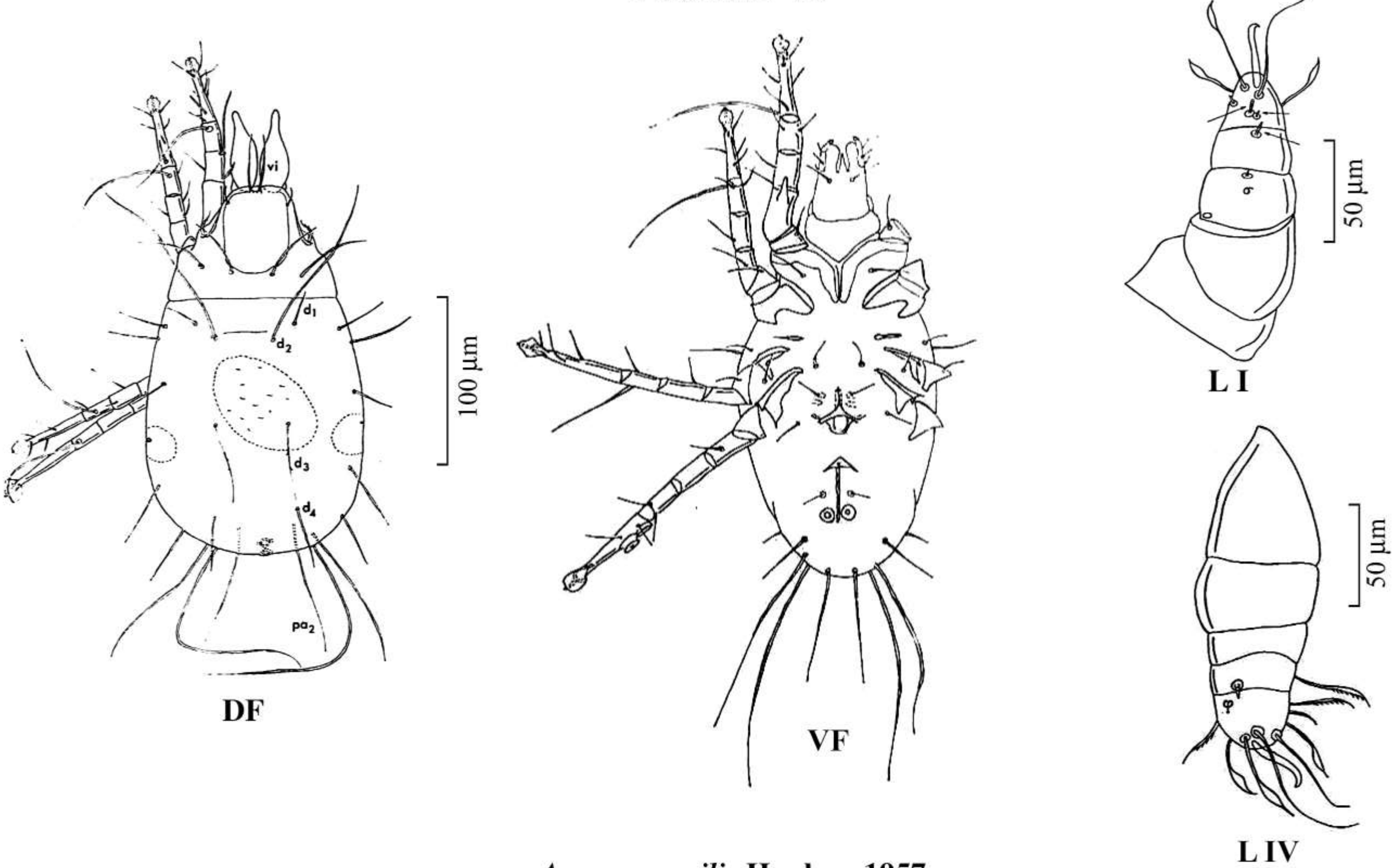
Morphological and Taxonomical characters of the Family Acaridae A

PLATE 75B



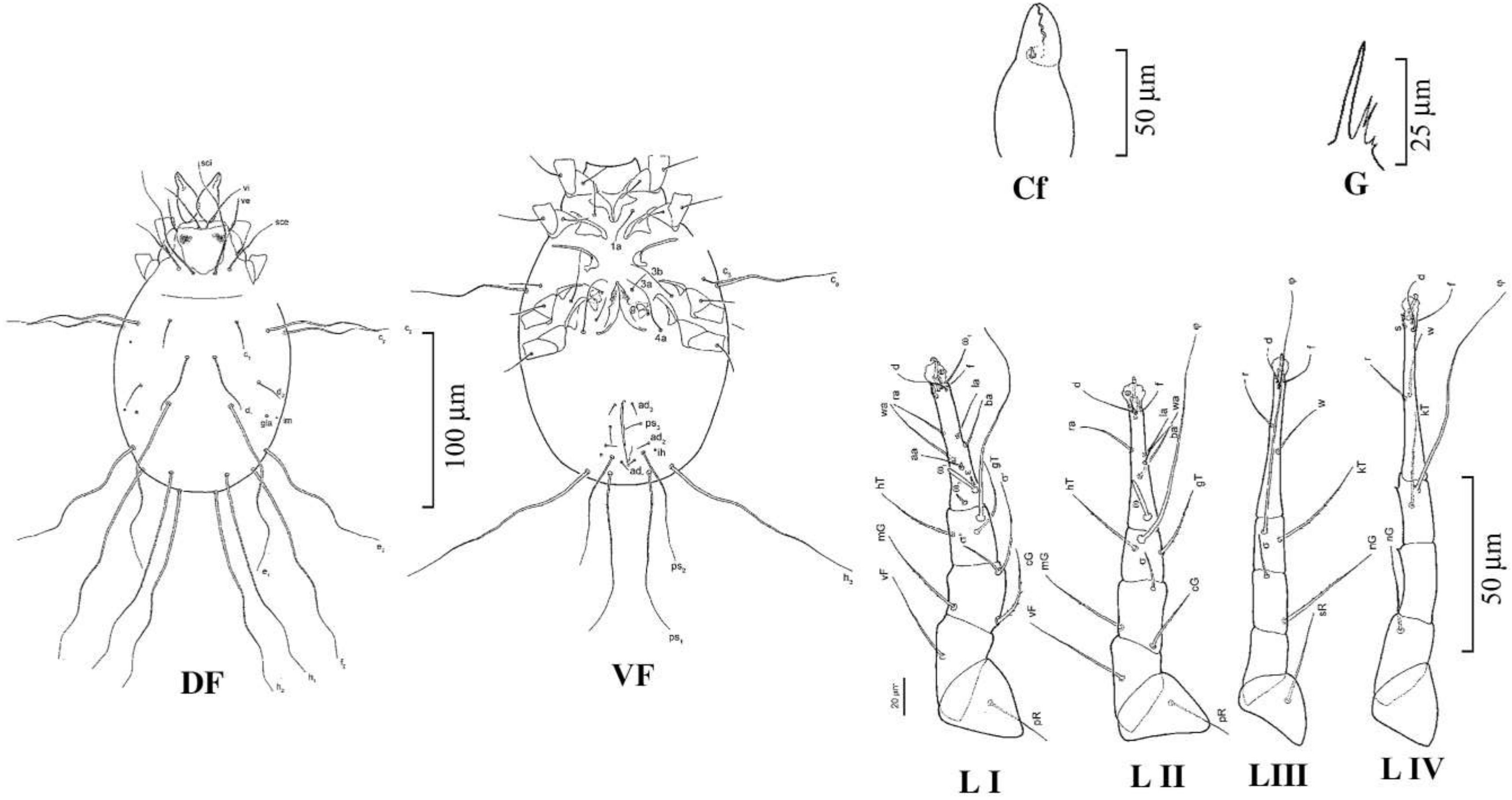
Morphological and Taxonomical characters of the Family Acaridae B

PLATE 76



Acarus gracilis Hughes, 1957

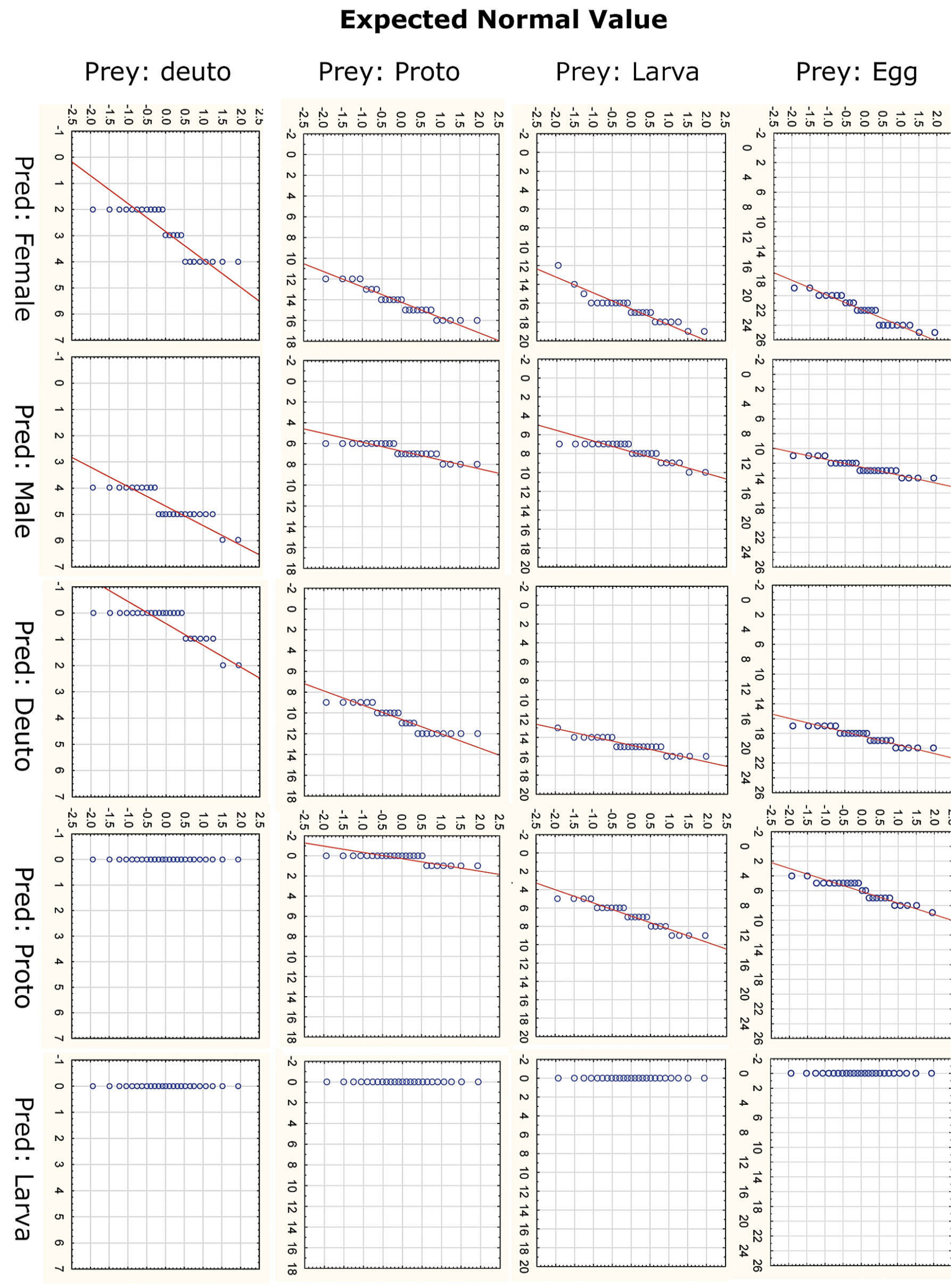
PLATE 77

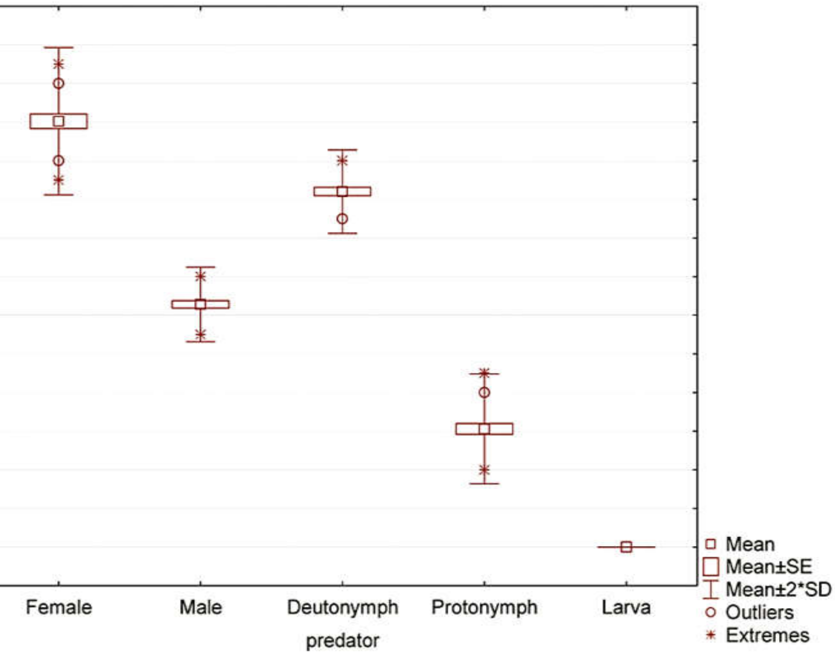


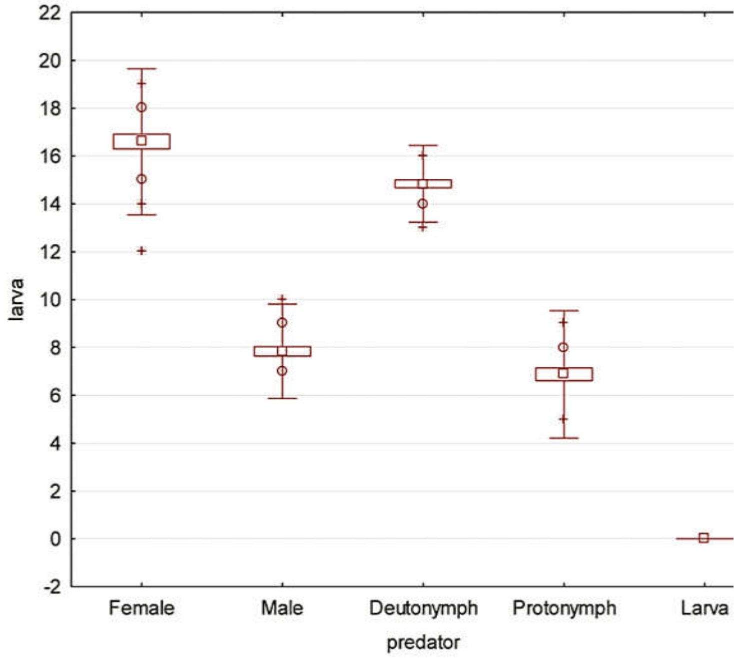
Tyrophagus putrescentiae Schrank, 1781

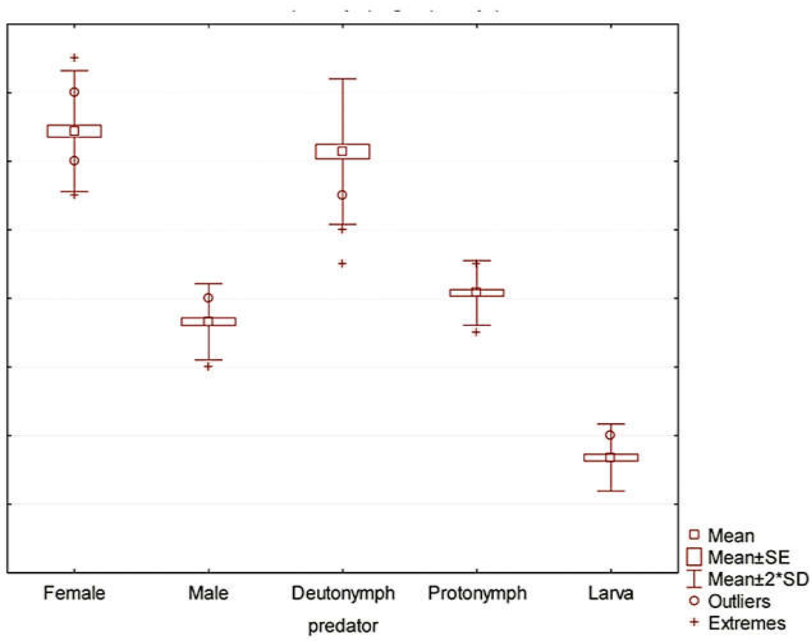
PLATE 78

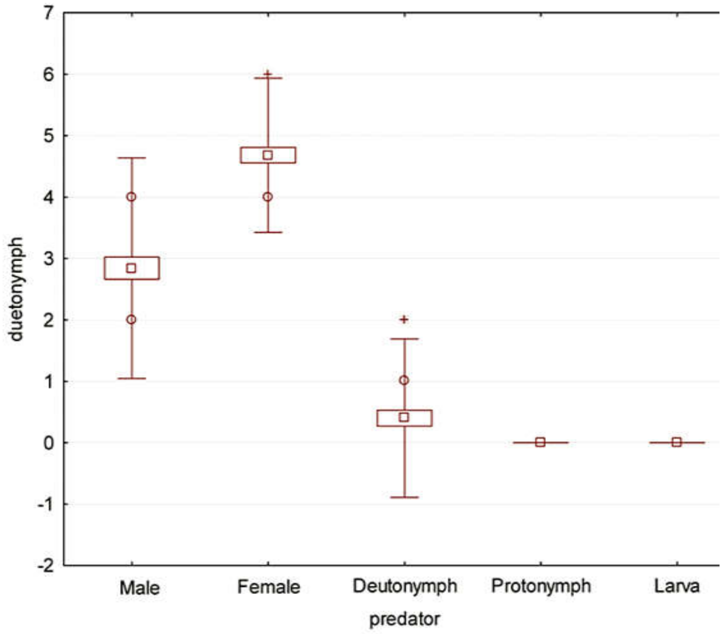
Family Acaridae: **1 & 2.** Dorsal view of adult female; **3.** Adult female gnathosoma with chelicera; **4.** Anal region with genital pore.

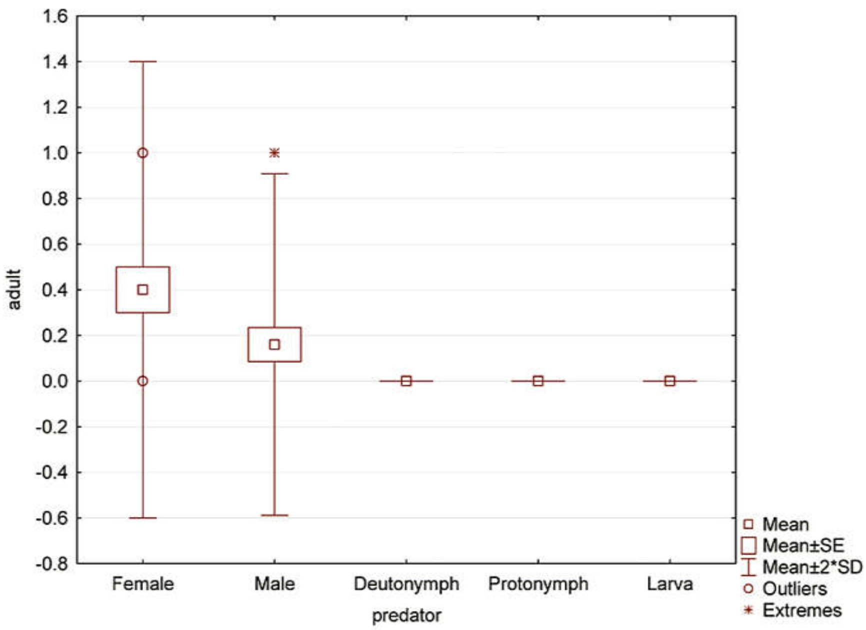

Expected Normal Value
Prey: deuto
Prey: Proto
Prey: Larva
Prey: Egg
Pred: Female
Pred: Male
Pred: Deuto
Pred: Proto
Pred: Larva

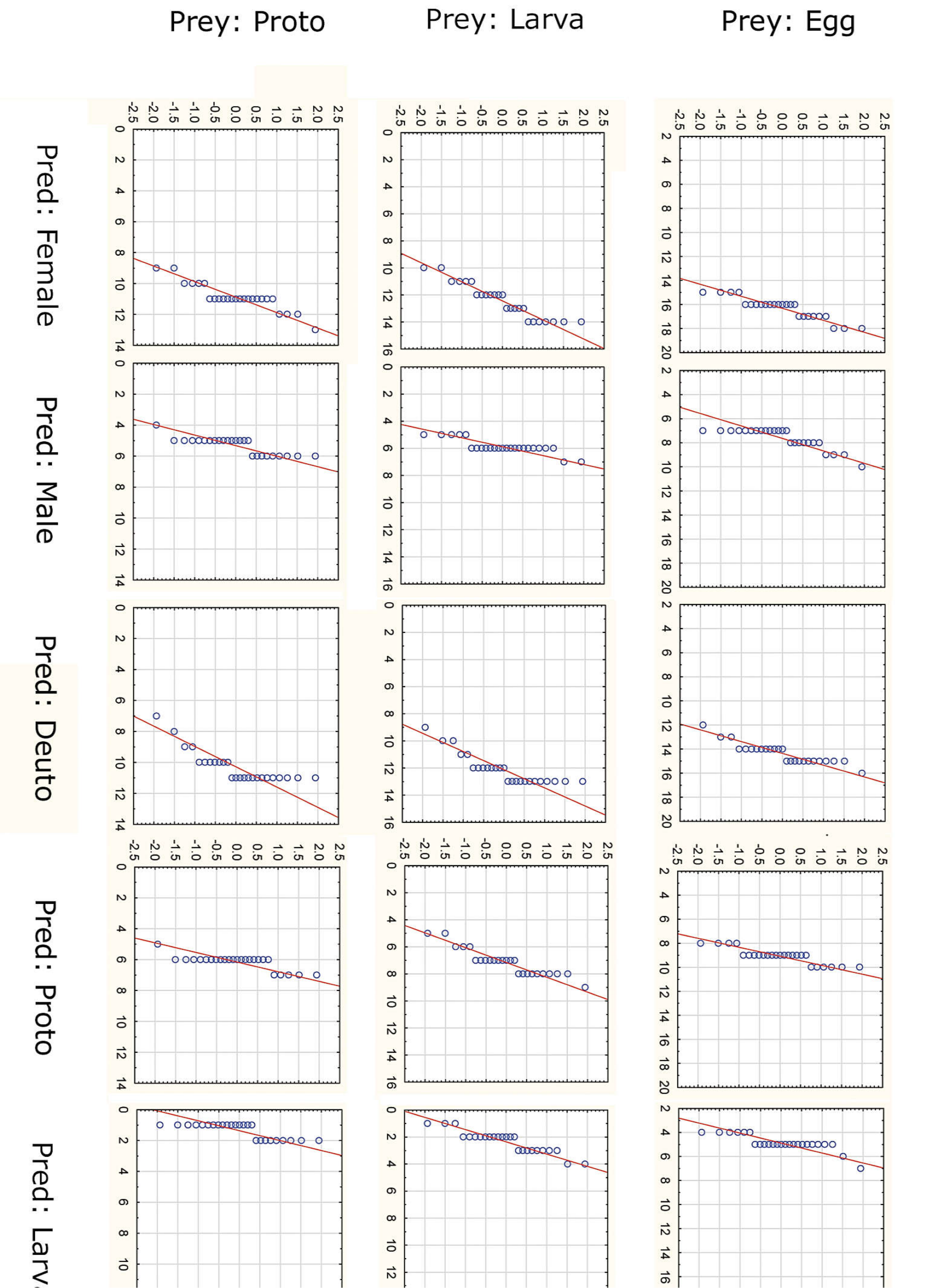

Female
Male
Deutonymph
Protonymph
Larva
predator
Mean
Mean±SE
Mean±2*SD
Outliers
Extremes


22
20
18
16
14
12
10
8
6
4
2
0
-2
larva
Female
Male
Deutonymph
Protonymph
Larva
predator

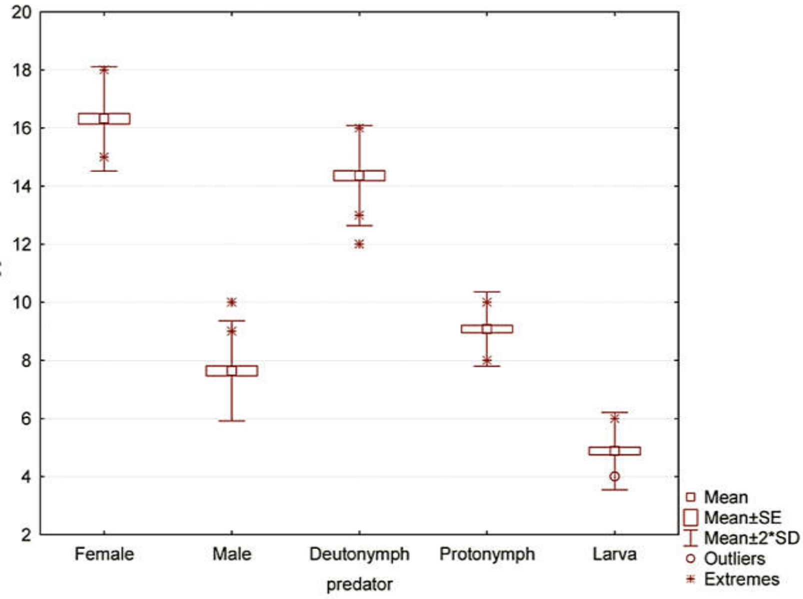

Female
Male
Deutonymph
Protonymph
Larva
predator
Mean
Mean±SE
Mean±2*SD
Outliers
Extremes

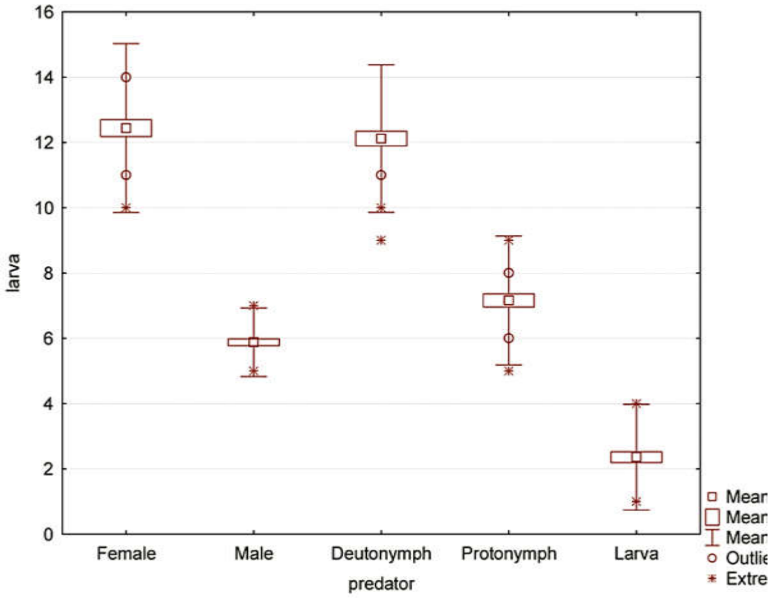

7
6
5
4
3
2
1
0
-1
-2
duetonymph
Male
Female
Deutonymph
Protonymph
Larva
predator

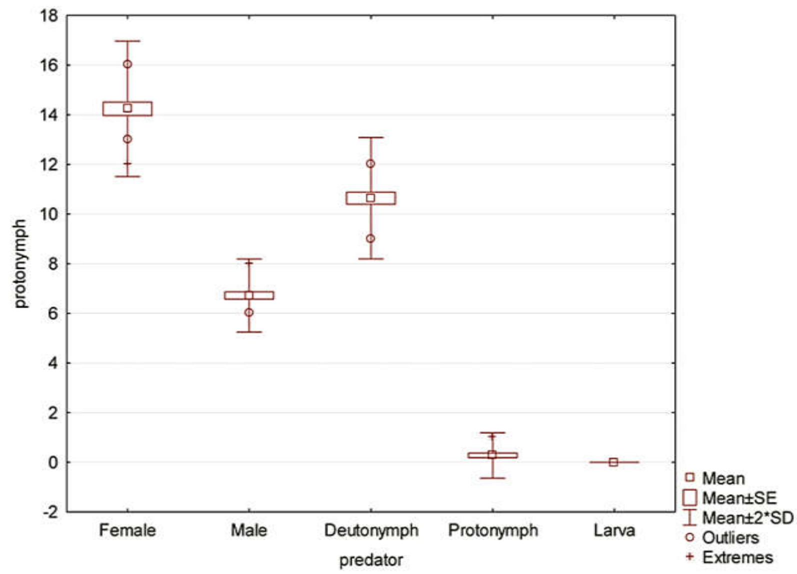

1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
adult
Female
Male
Deutonymph
Protonymph
Larva
predator
Mean
Mean±SE
Mean±2*SD
Outliers
Extremes

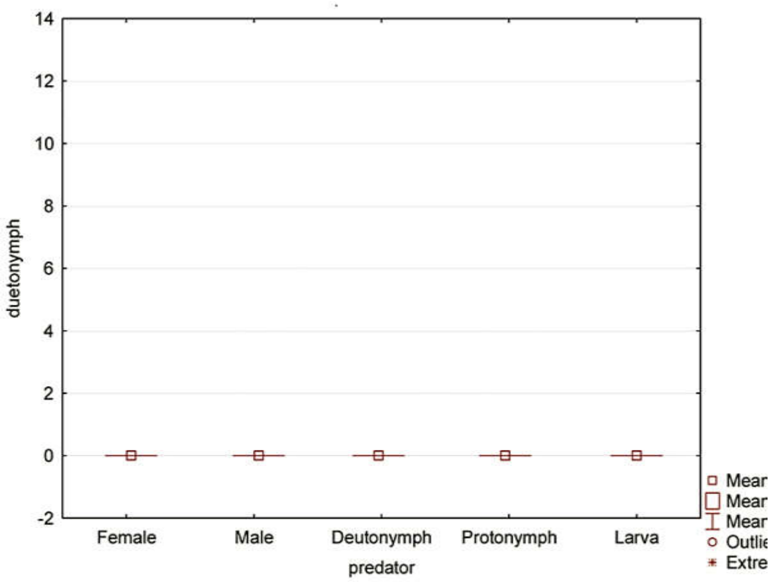


Prey: Proto
Prey: Larva
Prey: Egg
Pred: Female
Pred: Male
Pred: Deuto
Pred: Proto
Pred: Larv


20
18
16
14
12
10
8
6
4
2
Female
Male
Deutonymph
Protonymph
Larva
predator
Mean
Mean±SE
Mean±2*SD
Outliers
Extremes


16
14
12
10
8
6
4
2
0
larva
Female
Male
Deutonymph
Protonymph
Larva
predator
Mear
Mear
Mear
Outlie
Extre


18
16
14
12
10
8
6
4
2
0
-2
protonymph
Female
Male
Deutonymph
Protonymph
Larva
predator
Mean
Mean±SE
Mean±2*SD
Outliers
Extremes


14
12
10
8
6
4
2
0
-2
duetonymph
Female
Male
Deutonymph
Protonymph
Larva
predator
Mear
Mear
Mear
Outlie
Extre

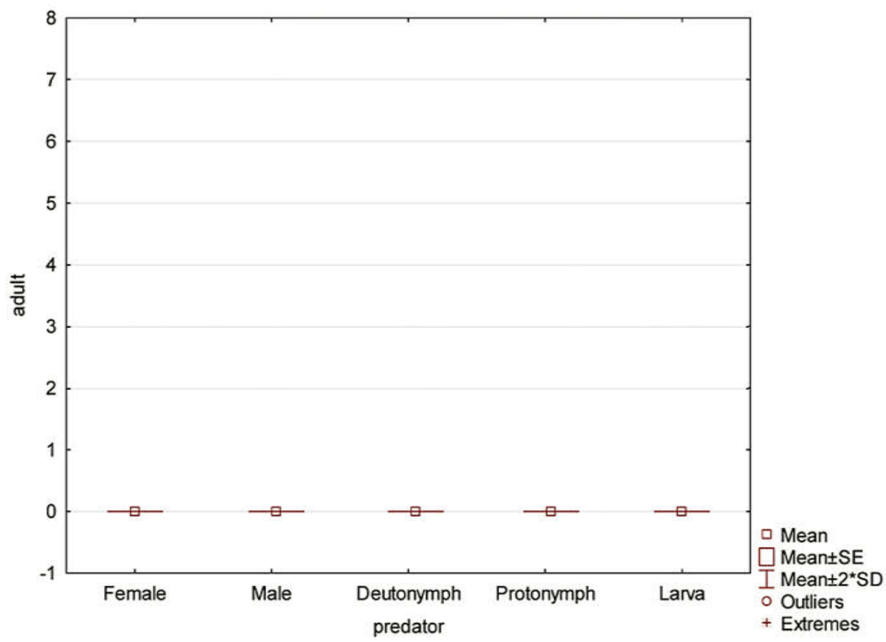
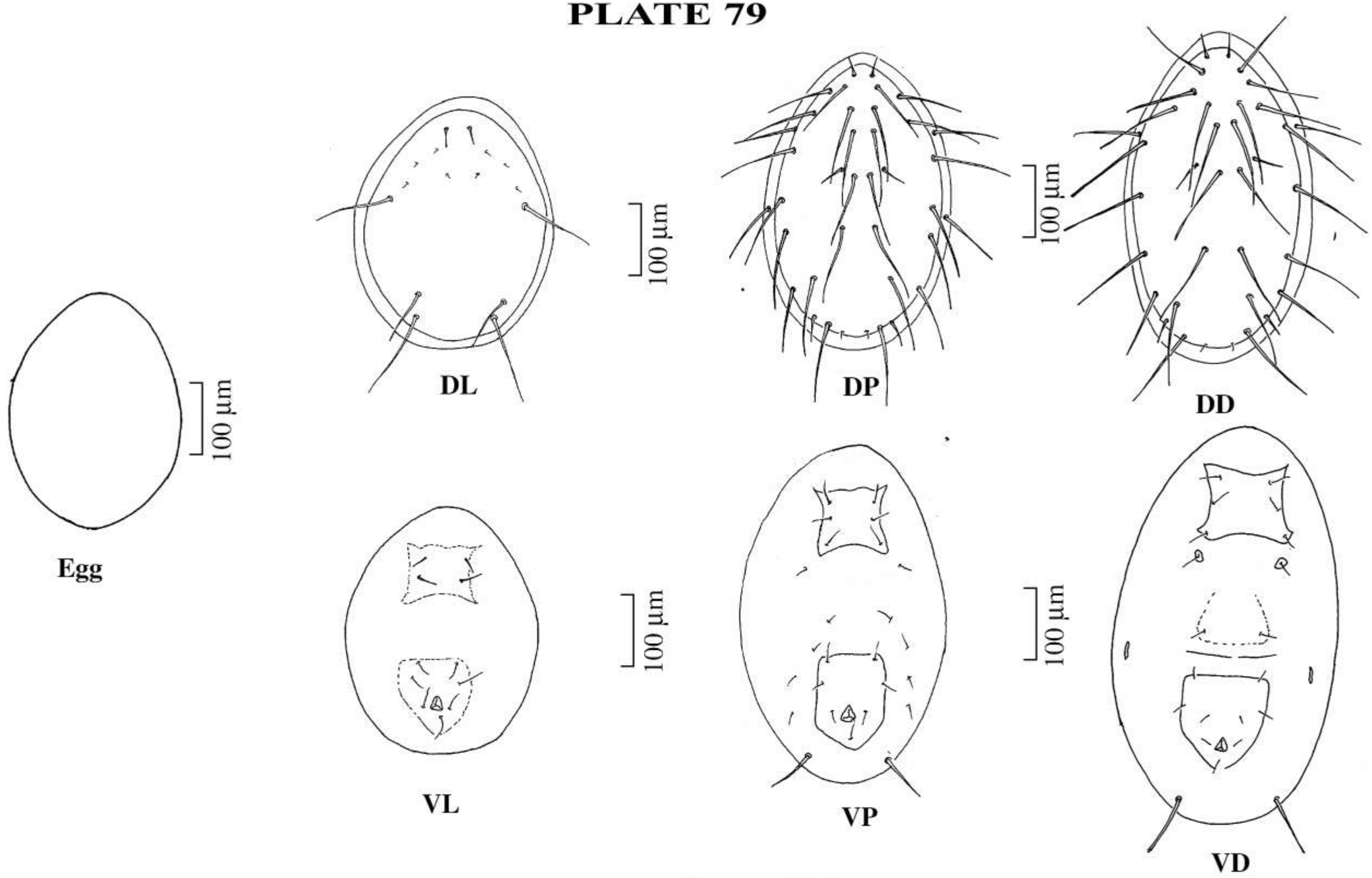
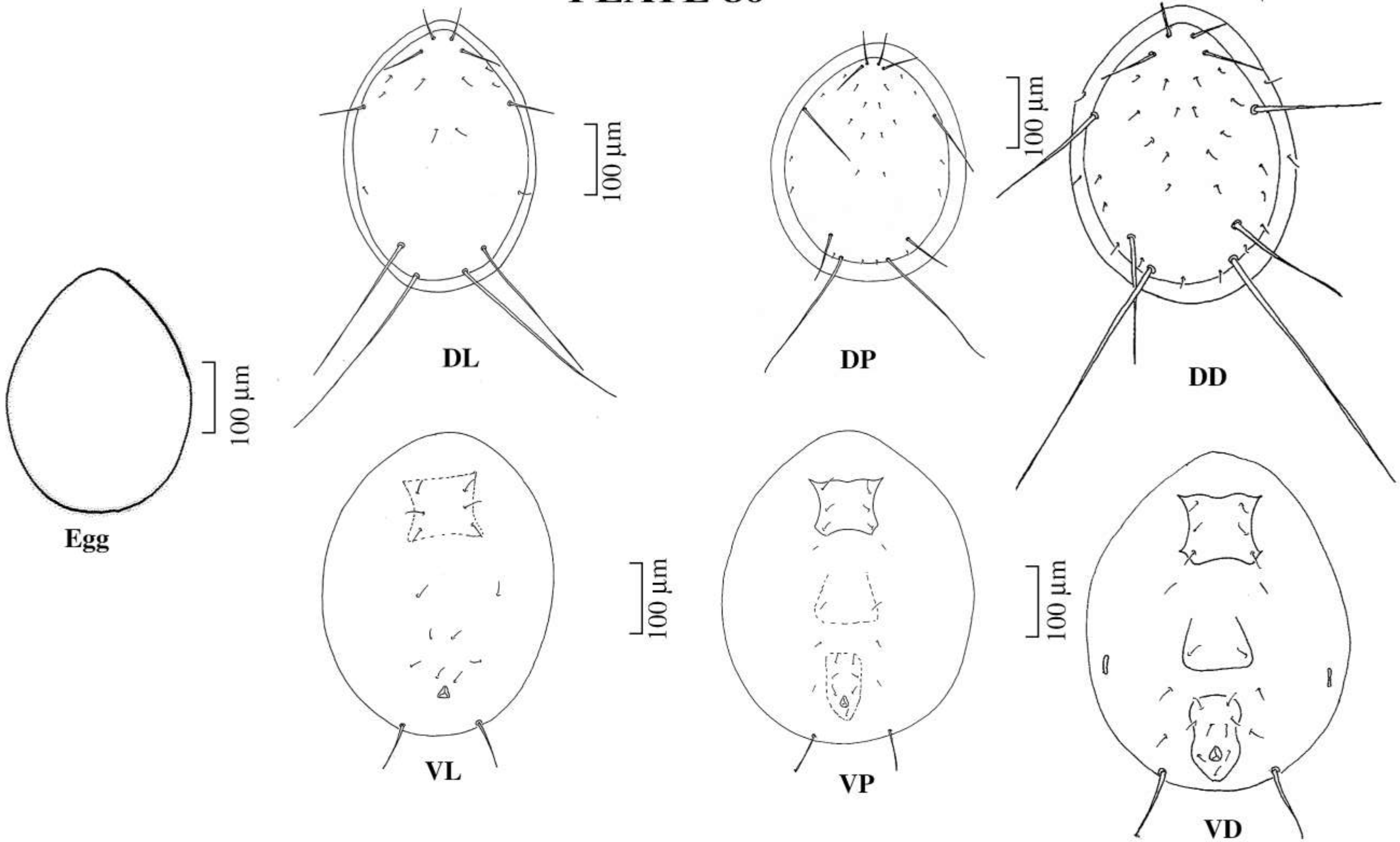

8
7
6
5
4
3
2
1
0
-1
adult
Female
Male
Deutonymph
Protonymph
Larva
predator
Mean
Mean±SE
Mean±2*SD
Outliers
Extremes

PLATE 79



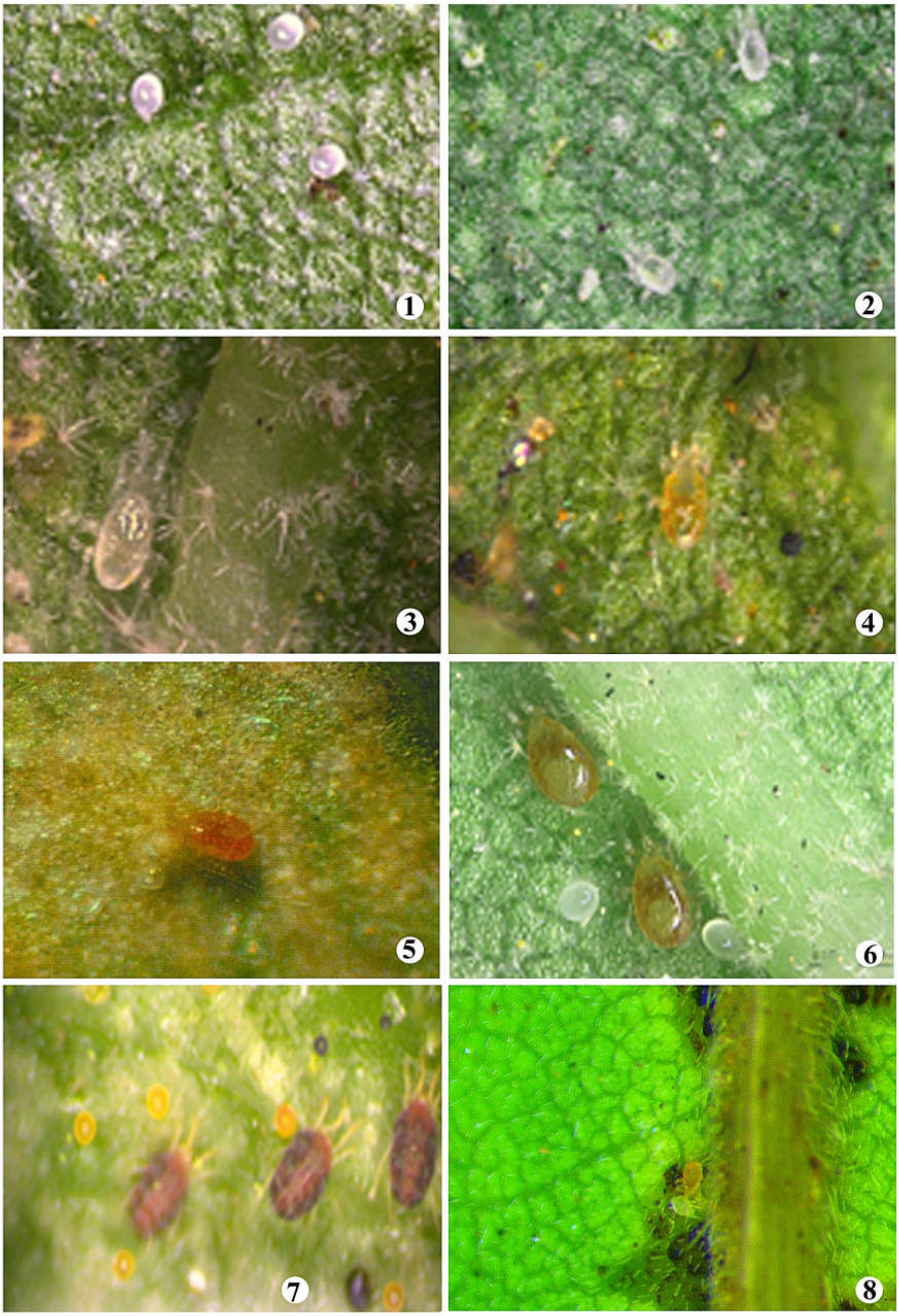
Developmental stages of *N. sasikalae* sp. nov.

PLATE 80



Developmental stages of *A. dioscoreae* Rahul *et al.*, 2016

PLATE 81



Figs. 1-8. Breeding and feeding biology of *N. sasikalae* on *T. urticae* ; **1.** Egg **2.** Larva; **3.** Protonymph; **4.** Deutonymph; **5.** Adult female; **6.** Adult colony; **7.** Pest colony; **8.** Adult female feeding on larva of the prey.