TAXONOMY OF THE TRIBE EPILACHNINI (COLEOPTERA: COCCINELLIDAE) OF KERALA

By

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2018-11-117

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KERALA, INDIA
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THESIS

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DEPARTMENT OF AGRICULTURAL ENTOMOLOGY
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VELLANIKKARA, THRISSUR – 680656
KERALA, INDIA
2020

DECLARATION

I hereby declare that the thesis entitled **"Taxonomy of the tribe Epilachnini (Coleoptera: Coccinellidae) of Kerala"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, fellowship or other similar title, of any other university or society.

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CERTIFICATE

Certified that the thesis entitled **"Taxonomy of the tribe Epilachnini (Coleoptera: Coccinellidae) of Kerala"** is a record of research work done independently by **Ms. Beegam Salma M.P.**under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

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We, the undersigned members of the advisory committee of **Ms. Beegam Salma M.P.**, a candidate for the degree of Master of Science in Agriculture, with major field in Agricutural Entomology, agree that the thesis entitled **"Taxonomy of the tribe Epilachnini (Coleoptera: Coccinellidae) of Kerala"** may be submitted by **Ms. Beegam Salma M. P.** in partial fulfilment of the requirement for the degree.

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Beegam Salma M. P.

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Introduction

1. INTRODUCTION

CoccinellidaeLatreille, lady beetle, is the largest family of superfamily Coccinelloidea of order Coleoptera and is species rich with nearly 6000 described species worldwide (Robertson *et al*., 2015). Coccinellids are ecologically and morphologically diverse and exhibit a wide range of food habits spanning kingdoms and trophic levels.

Coccinellids vary in size from minute (less than 1mm) to large (10-17 mm). These beetles can easily be identified by the following characters: body compact, round or short oval to distinctly elongate shape, glabrous or sparse to densely pubescent convex dorsum and flattened venter; clubbed antenna and presence of post coxal line on first abdominal ventrite, tarsal formula usually 4-4-4 and third tarsomere minute and tucked within the broad triangular second segment (cryptotetramerous or pseudotrimerous), a few have more equal tarsomeres (true tetramerous) and some with tarsal formula 3-3-3 (true trimerous) (Vandenberg, 2002).

Traditionally, six or seven subfamilies *viz*., Coccinellinae Latreille, Coccidulinae Mulsant, Scymninae Mulsant, Chilocorinae Mulsant, Epilachninae Mulsant, Sticholotidinae Weise and Ortaliinae Mulsant were recognized under the family Coccinellidae (Sasaji, 1971; Kovar 1996; Vandenberg 2002).Recently, based on the morphological and molecular evidences, Seago *et al*. (2011) revised the classification of Coccinellidae with only two subfamilies *viz*., Coccinellinae and Microweisinae Leng and all other subfamilies were reduced to tribes.

Coccinellids exhibit heterogeneity in feeding behaviour and most of them are predaceous, while some are specialists on plants and some feed on fungi. Phytophagouscoccinellids are recognized under the tribe EpilachniniMulsant and genus *Bulaea*of the tribe Tytthaspidini of Coccinellinae. Tribe Epilachnini is strictly herbivorous, whereas genus *Bulaea* is known to have a mixed diet, which includes partial phytophagy and aphidophagy.

The tribe Epilachnini is a large group of phytophagous lady beetles that contains 27 recognized genera with about 1050 species worldwide, contributing nearly 20 per cent of world coccinellid fauna. Traditionally, members of this tribe were included in the former subfamily Epilachninae, which was divided into four tribes *viz*., Epilachnini, Cynegetini C.G. Thomson, Epivertini Pang & Mao and Eremochilini Gordon & Vandenberg (Jadwiszczak and Wegrzynowicz, 2003; Tomaszewska and Szawaryn, 2016). Seago*et al*. (2011) combined these four tribes and reduced the taxonomic rank of the subfamily Epilachninae to tribe Epilachnini. The molecular and morphology based analysis by Szawaryn*et al*. (2015) confirmed the monophyly of Epilachniniand they proposed a new classification ofEpilachnini.

Epilachna beetles are serious defoliators of cucurbitaceous and solanaceous crops, causing significant damage. Both grubs and adults scrape the soft tissue on the surface of leaves, masticate it and suck the juice (Howard, 1941) resulting in typical ladder like windows on leaves. The grubs usually feed on lower surface of leaves, while adult beetles on upper surface. Females lay hundreds of eggs on the lower surface of the leaves of host plants in clusters of 15-50 and the incubation period is 4 to 14 days. The larval period lasts from 2 to 5 weeks with four instars. They pupate on the lower surface of a leaves and pupal period lasts about one week (Tomaszewska and Szawaryn, 2016).

Epilachna beetles are encountered on a variety of plants belonging to different families*viz*., Solanaceae, Cucurbitaceae, Fabaceae, Poaceae, Urticaceae, Convolvulaceae, Aristolochiaceae and Caryophyllaceae. However, economically important species commonly feed on plants of family Solanaceae and Cucurbitaceae. *Henosepilachnavigintioctopunctata* (Fabricius), one of the important species of epilachna beetles ofeastern parts of Asia and Australia, is a serious pest of solanaceous crops(Tomaszewska and Szawaryn, 2016).

Despite the economic importance, this group was poorly understood taxonomically. Though the Epilachnini fauna of tropical and subtropical zones are diverse, its composition is less known compared to temperate zones of the world.

Kerala, being one of the biodiversity hotspots, fauna of Epilachnini could be diverse. However, no comprehensive studies have been carried out to explore the diversity of epilachna beetles of Kerala.

Considering the above, the present study on "Taxonomy of the tribe Epilachnini (Coleoptera: Coccinellidae) of Kerala" was carried out with the following objectives

1. To study the taxonomy of the tribe Epilachnini in different agricultural ecosystems of Kerala

2. To prepare a key for the identification of the species of Epilachnini

Review of literature

2. REVIEW OF LITERATURE

Family Coccinellidae, though officially called lady beetles, are commonly known as lady bugs (American) or ladybirds (Britain) and includes nearly 6,000 species under 360 genera (Vandenberg, 2002). Coccinellidae is a monophyletic group, placed under the superfamily Coccinelloidea (Robertson *et al*., 2015). Coccinellids exhibit wide trophic diversity ranging from specialized predation on soft bodied insects *viz*., aphids, mealybugs and whiteflies to fungivory, pollenophagy and to strict herbivory. Exploitation of coccinellids as biocontrol agents is well known and recognized worldwide by biocontrol practitioners. Phytophagous coccinellids, grouped under the tribe Epilachnini, are one of the most serious pests of crops causing considerable economic damage.

2. 1 Taxonomic classification of family Coccinellidae

Carl Linnaeus established the genus *Coccinella* in 1758 for 36 species with round and convex body, short clubbed antennae and expanded terminal palpomere. Coccinellidae was recognized as a distinct family under the name 'Tridigites' (referring to apparently 3-segmented tarsi) by Latreille (1807) in his work on classification of beetles and he coined the family name 'Coccinellidae'.

The salient taxonomic publication on Coccinellidae during early years include works by Mulsant (1846), Crotch (1874), Chapuis (1876), Weise (1879), Ganglbauer (1899), Casey (1899), and Korschefsky (1931, 1932). One of the widely accepted classification of Coccinellidae, based on morphological study of adult and larval characters was put forward by Sasaji (1968 and 1971). Accordingly, Coccinellidae was classified into six subfamilies and 19 tribes (Table 1). Many authors modified the classification by addition or rearrangement of one or more subfamilies or tribes. Kovar (1996) established a new subfamily Ortaliinae, which included the tribes Ortaliini and Noviini. Vandenberg (2002) discussed many problems regarding the classification of some of subfamilies and tribes of Coccinellidae.

Table 1. List of subfamilies and tribes under family Coccinellidae

Subfamily	**Tribes**
Sticholotinae Weise, 1901	SukunahikoniniKamiya, 1960; SerangiiniBlackwelder, 1945; Sticholotini Weise, 1901; ShirozuelliniSasaji, 1967
ScymninaeMulsant, 1846	StethoriniDobzhansky, 1924; ScymniniMulsant, 1846; AspidimeriniMulsant, 1850; HyperaspiniMulsant 1846; OrtaliiniMulsant, 1850
ChilocorinaeMulsant, 1846	Telsimiini Casey, 1899; PlatynaspiniMulsant, 1846; ChilocorniniMulsant, 1846
CoccidulinaeMulsant, 1846	Lithophilini; CocciduliniMulsant, 1846; Exoplectrini Crotch, 1874; NoviiniMulsant, 1850
CoccinellinaeLatreille, 1807	CoccinelliniLatreille, 1807; HalyziiniMulsant 1846
EpilachninaeMulsant, 1846	EpilachniniMulsant 1846

Slipinski (2007) suggested a classification, based on the adult and larval morphology, with only two subfamilies *viz*., CoccinellinaeLatreille, 1807 and MicroweisinaeLeng, 1920. Later based on the morphological and molecular evidences, Seago*et al.* (2011) revised the subfamily classification of Coccinellidae with only two subfamilies, Coccinellinae and Microweisinae with all other subfamilies reduced to tribes.

2. 2. Systematic position and phylogeny of family Coccinellidae

Crowson (1955) recognized a group of beetles which includes a cluster of highly derived families within Cucujoideacharacterised by some common features. These beetles were referred as Cerylonid group or Cerylonid Series (C.S.) with around 10,000 species within 660 genera. Thirty seven families were included under Cucujoidea (Leschen*et al*., 2005; Cline *et al*., 2014). The nine families recognized under Cerylonid Series were Alexiidae, Bothrideridae, Cerylonidae, Coccinellidae, Corylophidae, Discolomatidae, Endomychidae, Latridiidae and Akalyptoischiidae (Lord *et al*., 2010; Robertson *et al*., 2015).

According to Slipinski and Pakaluk (1991) Cucujoidea is a presumed artificial assemblage of beetles that have a similar appearance but could not be placed satisfactorily elsewhere. Cucujoidea is regarded as the most problematic cucujiform superfamily with respect to classification and no synapomorphies supporting its monophyly has been identified (Robertson *et al*., 2008).Comprehensive analysis of cucujoid taxa byRobertson *et al*. (2015) using DNA sequence from four nuclear and four mitochondrial genes for 384 coleopteran taxa resulted in the establishment of a new superfamily Coccinelloidea, comprised of 15 families that are monophyletic. Family Coccinellidae is classified in the newly erected superfamily Coccinelloidea.

Coccinellidae is a monophyletic group, but the phylogenetic relationships within the family are poorly known. Morphological studies supported hypotheses that a clade comprising Endomychidae plus Corylophidae (Sasaji, 1971; Crowson, 1981) or that comprising Endomychidae plus Alexiidae (Slipinski and Pakaluk, 1991) was the sister group of Coccinellidae.Kovar (1996) recognized one more subfamily, Ortaliinae and considered Ortaliinae as the sister taxon to the Coccinellinae plus Epilachninae branch.

Recently many publications discussed the phylogenetic relationships within Coccinellidae. Molecular studies by Robertson *et al*.(2008) reported strong support for the monophyly of the Cerylonid Series and Coccinellidae and also supported monophyly of coccinellid subfamilies, Coccinellinae and Epilachninae and

paraphyly of Chilocorinae and Scymninae. Similarly, Giorgi*et al*. (2009) demonstrated the monophyly of family Coccinellinae and Epilachninae and paraphyly of Sticholotidinae, Chilocorinae, Scymninae and Coccidulinae.

Magro *et al*. (2010) studied 61 species of 37 genera of Coccinellidae under several tribes of five subfamilies *viz*., Coccinellinae, Scymninae, Chilocorinae, Epilachninae and Coccidulinae. They concluded that subfamily Coccinellinae was monophyletic, while, Coccidulinae, Epilachninae, Scymninae and Chilocorinae were paraphyletic.

Seago *et al*. (2011) also confirmed the monophyly of family Coccinellidae based on morphological and molecular studies. The apomorphies identified for Coccinellidae wereadult mandibles with well-developed molar part, but without grinding surfaces and tegmen of male genitalia complex, but with a simple, rigid penis. This study did not support the monophyly of subfamilies *viz*., Coccidulinae, Scymninae, Sticholotidinae, or Ortaliinae. Phylogenetic analysis of Coccinellidae by Wang *et al*. (2018) confirmed that subfamilyCoccinellinae, Sticholotidinae and Epilachninae were monophyletic, whereas subfamily Coccidulinae, Chilocorinae and Scymninae were paraphyletic. However, this study could not be able to define the phylogenetic relationships among different subfamilies.

2. 3. Subfamily Coccinellinae

Coccinellinae was considered as a separate group by many earlier authors. This group included some of the larger, more conspicuously coloured members which are primarily predaceous on aphids and other sternorrhynchanHemiptera, but occasionally specializing on other prey groups (Vandenberg, 2002). Many authors suggested Coccinellinae as a subfamily, but with different tribes.

Eventhough, Robertson *et al*. (2008) Giorgi *et al*. (2009) and Magro*et al*. (2010) have confirmed the monophyly of Coccinellidae, these studies could not be able to explain the accepted classification scheme of Coccinellidae. The study of

Seago *et al*. (2011), considering both morphological and molecular evidences, revised the classification of Coccinellidae to two subfamilies: Microweisinae and Coccinellinae. The remaining groups for which monophyly was supported were designated as tribes within Coccinellinae. Coccinellinae is a large subfamily with following characters: tegmen of the male genitalia complex with a large penis guide, symmetrical, primarily articulated parameres and articulated basal strut. Twenty tribes *viz*,.Singhikalini, Hippodamini, Microweisini, Chilocorini, Platynaspini, Shirozullini, Telsimiini, Coccidulini, Exoplectrini, Lithophilini, Noviini, Coccinellini, Psylloborini, Aspidimerini, Hyperaspini, Ortaliini, Scymnini, Stethorini, Sukunahikonini and Epilachnini were categorised under Coccinellinae and some of the earlier tribes were accommodated within these tribes. Comparisons of the tribes under Coccinellinae by different authors are given (Table 2).

2. 4. Tribe EpilachniniMulsant, 1846

The classification of Epilachnini started with classification of the family Coccinellidae, proposed by Mulsant (1846), which he named "Securipalpes". In the world monograph, Mulsant (1850) categorized them as "Epilachniens with *Epilachna*Chevrolat, 1873 as type genus under "Trichosomides" which included hairy coccinellids. Crotch (1874) revised Mulsant's system of classification and treated tribe Epilachnides and Coccinellides as same subfamily Coccinellidae. Chapuis (1876) considered food preference as the base for his classification and the whole Coccinellidae were divided into "Aphidiphages" and "Phytophages". Weise (1879) divided Coccinellidae into two major groups, "Coccinellidaeaphidiphagae and Coccinellidaephytophagae" The system of classification proposed by Ganglbauer (1899) included three subfamilies *viz*., Epilachninae, Lithophilinae and Coccinellinae. Casey studied the world fauna and opined that Epilachnini was not quietly separable from the aphidophagous groups. Sicard (1907, 1909) followed a system similar to that of Weise, in the investigations on Madagascan Coccinellidae, and grouped them to Coccinellidaephytophagae, Coccinellidaeaphidiphgae and Pseudococcinellidae. Korschefsky (1931, 1932) arranged all the Coccinellidae of world into Epilachninae (10 genera), Lithophilinae (1 genus) and Coccinellinae (20 tribes).

Table 2. Comparison of the tribes under Coccinellinae

Sasaji, 1971	**Kovar, 1996**	**Slipinski, 2007**	**Seago*et al*., 2011**
Coccinellini Discotomini Halyziini (as Psylloborini)	Coccinellini Tytthaspidini Discotomini Halyziini (as Psylloborini)	Sticholotidini, Coccidullini, Noviini, Scymnillini, Diomini, Chilocorini, Coccinellini	Argentipilosini Aspidimerini Cephaloscymnini Chilocorini Coccidulini Coccinellini Cryptognathini Diomini Epilachnini Hyperaspini Limnichopharini Monocorynini Noviini Ortaliini Platynaspini Plotinini Shirozuellini Sticholotidini Telsimiini Selvadiini

Epilachninae was identified as one of the subfamily with one tribe, Epilachnini by Sasaji (1968) which was one of the widely accepted coccinellidclassification. Later some modifications were suggested by many authors. Comparisons of the tribes under Epilchninae by different authors are given (Table 3).

Table 3. Comparison of the tribes under Epilchninae by different authors

Sasaji, 1971	**Kovar, 1996**	**Slipinski, 2007**	**Seago*et al*., 2011**
Epilachnini	Epilachnini Epivertini Cynegetini (as Madaiini) Eremochilini	Epilachnini	Subfamily Epilachninae reduced to tribe Epilachniniunder the subfamily Coccinellinae

In earlier works, even though 10 genera were established, most of the Epilachnini species were included in the genus *Epilachna*. Attempts were made to review this group by Dieke (1947), Bielawski (1963), Gordon (1975), and Fursch (1991) on different regional fauna. Li and Cook (1961) studied the Epilachninae of Taiwan and described three genera and 30 species under the subfamily Epilachninae includinggenus *Henosepilachna*. However, some authors questioned the validity of genus*Henosepilachna* and synonymized *Henosepilachna* with *Epilachna* (Richards 1983; Slipinski 2007).

Epilachninae was divided in four tribes: Epilachnini, Cynegetini, Epivertini, and Eremochilini. Tribe Epilachnini was more diverse with 11 genera. Seago*et al*. (2011) reduced taxonomic rank of the subfamily Epilachninae to a tribe Epilachnini within the subfamily Coccinellinae based on simultaneous analysis of molecular and morphological data.

Based on the molecular and morphology characters, Szawaryn *et al*. (2015) studied the phylogenetic relationship of members of Epilachnini and tested the monophyly of different genera. This resulted in the proposal of a modern

classification of Epilachnini. This study recognized 27 genera under Epilachnini and revised many of the present genera. Only14 current generawere found monophyletic.Genus *Epilachna*is now restricted to the New World species, therefore all synonyms at genus and subgenus level based on the type species distributed in Old World, have to be removed from that synonymy and considered as valid names.

Epilachnini is aherbivorous group with well defined morphological characters in developmental stages. Adult beetles are pubescent, mandibles multidentate and lack mola and the mentum is trapezoidal and widest at its base. Eggs are oblong, usually yellow with a distinct microsculpture on the surface of chorion. Grubs have branched processes on dorsal and lateral surfaces of the body, mandibles multidentate apically and without mola (Slipinski and Tomaszewska, 2010).

Sreekala (1997) studied the epilachna beetle complex in vegetables especially on crops belonging to families*viz*., Cucurbitaceae, Fabaceae and Solanaceae in different districts of Kerala (Malappuram, Thrissur and Palakkad). She reported three species, which included *Henosepilachnaseptima* on cucurbitaceous crops, *Afidentamisera*on cowpea and*H. vigintioctopunctata* on solanaceous crops.

2.4.1. Genera under the tribe Epilachnini

World fauna of Epilachnini was categorized into 27 genera (Szawaryn*et al*., 2015). Six genera under the tribe Epilachnini*viz*., *Afidenta*Dieke, *Afidentula*Kapur, *Afissula*Kapur, *Epilachna*Chevrolat, *Henosepilachna* Li and *Macrolasia* Weise were reported from India (Poorani, 2012).

2.4.1.1. Genus *Afidenta* Dieke, 1947

The taxonomy and nomenclatural history of species of *Afidenta* had been confused for decades. Dieke (1947) established the genus *Afidenta*to include species without longitudinally divided sixth abdominal ventrite, in females and having bifid tarsal claws with a sharp basal tooth. Type species was *Epilachnamisera* Weise, 1901.

This genus shows similarity to genus *Afidentula*. Li and Cook (1961) described *Afidentaarisana* from Taiwan, which was later treated as genus*Afissula* by Zeng (1995).Only one species under this genus, *Afidentamisera*(Weise) had been reported from India so far (Poorani, 2012).

2. 4. 1. 2.Genus *Afidentula*Kapur, 1958

Kapur (1958) established the genus *Afidentula* with*Epilachnamanderstjernae*Mulsant as the type species. This genus was established to include species with antenna having a relatively thick and compact club and subtriangular, small mandibles with three teeth and without any additional denticulations or serrations.

The Asian species of *Afidentula* were revised, diagnosed and illustrated by Tomaszewska and Szawaryn (2013). According to the study Szawaryn*et al*. (2015) both *Afidenta* and *Afidentula* could not be recovered as monophyletic groups and each of them had been redefined. Wang *et al*. (2015) contributed two new species of *Afidentula*, *A. dentata* and *A. jinpingensis* and were described from China.

Six species of *Afidentula* were reported from India *viz*., *A. bisquadripunctata*, *A. herbigrada*, *A. himalayana*, *A. manderstjernae*, *A. minima*, *A. stephensi*(Poorani, 2012).

2. 4. 1. 3. Genus *Afissa* Dieke, 1947

Genus *Afissa*was described by Dieke in 1947 and this genus is similar to *Afidentula*, *Afidenta*and some species of *Diekeana* and *Uniparodentata* (both genera derived from former *Epilachna*). Genus *Afissula* was synonymized with *Afissa* by Szawaryn*et al*. (2015). Most of the species formerly classified in *Afissula*and Asian *Epilachna*now belong to the genus *Afissa*.

2. 4. 1. 4. Genus *Afissula*Kapur, 1958

Genus *Afissula*Kapur, a similar genus to *Afidenta* and *Afidentula*, was described by Kapur in 1958 and *Afissularana*Kapur was the type species. The species under the genus so far reported from India are *A. merkli*, *A. mysticoides*, *A. parvula*and *A. sanscrita* (Poorani, 2012). Genus *Afissula* was synonymized with *Afissa* by Szawaryn*et al*. (2015).

2. 4. 1. 5. Genus *Epilachna* Chevrolat, 1837

The genus *Epilachna* was first proposed in 1837 by Chevrolat in the third edition of the Dejean catalog of Coleoptera. Its distribution was more in the tropical parts, although some species penetrated into the temperate regions (Dieke, 1947). Genus *Epilachna*was established *Coccinella borealis* Fabricius as the type species. Many species had been described in this genus and later they were subsequently removed to other genera *Epilachna*is now restricted to the New World species, (Szawaryn*et al*., 2015) and hence the Old World species described under *Epilachna* have to be revised. Forty four species of Indian Epilachnini*viz*., *E.andrewesi, E. atypica, E.bengalica, E.besucheti, E. cherrapunjiensis, E. congener, E. convextata, E. crecentomaculata, E. decemmaculata, E. delessertii, E. dumerili, E. elvina, E. endomycina, E. erinacea, E. fasciolata, E. flavicollis, E. gibbera, E. grayi, E. hendecaspilota, E. hingstoni, E. impicticollis, E. intermixta, E. laesicollis, E. laosana, E. loculosa, E. macularis, E. maculivestis, E. marginicollis, E. mausmaiensis, E. maxima, E. militaris, E. moorii, E. mystica, E. nevilli, E. nilgirica,E. pembertoni, E. probsti, E. septemocellata, E. shilliensis, E. simian, E. subclathrata, E. sureilica, E. suspiciosa*and*E. undecimspilota*had been included under the genus *Epilachna*(Poorani, 2012).

2. 4. 1. 6. Genus *Henosepilachna* Li, 1961

Li and Cook, 1961 described the genus *Henosepilachna* with *Henosepilachna sparsa* Herbst 1786 (=*Henosepilachna vigintioctopunctata* Fabricius

1775) as type species. They established this genus based on two major characters: three-dentate tarsal claw and female abdominal ventrite six divided longitudinally. The genus *Henosepilachna* with about 250 described species (Jadwiszczak and Węgrzynowicz, 2003) is the second largest genus within the tribe Epilachnini. Species of *Henosepilachna* are mostly distributed in tropical and subtropical regions. Characters used for the identification of species were spots on elytra, number and shape of apical tooth of mandible, male genitalia. Dieke (1947) proposed that spots on elytra and pronotum of genus *Henosepilchna* (he referred them as *Epilchna*) could be considered for identification. Spots on elytra consist of two types, persistent spots numbered from one-six and non-persistent spots numbered as a-h. Pronotum consists of spots numbered from one-seven.

Species reported from India under *Henosepilachna*are *H. anita, H. bielawskii, H. boisduvali, H. circellaris, H. circularis, H. dodecastigma, H. dubiosa, H. gangetica, H. implicate, H. indica, H. kaszabi, H. khasiensis, H. manipurensis, H. nana, H. narayana, H. ocellata, H. ornata, H. perplexa, H. pusillanima, H. quarta, H. septima, H. sikkimica, H. vigintioctomaculata, H. vigintioctopunctata* and *H. zebra* (Poorani, 2012). Two species of *Henosepilachna* reported from Kerala are *H. septima*and*H. vigintioctopunctata* (Sreekala, 1997).

2. 4. 1. 7. Genus *Macrolasia* Weise, 1903

Weise (1903) described the genus *Macrolasia*from Pondicherry, India as monotypic genus and the type species was *M. arcula*. *Macrolasia* is most similar to the genus*Subcoccinella*Agassiz and Erichson, in external appearance.

*Macrolasia*can easily distinguished from *Subcoccinella*by the general colour pattern, presence of the apical tibial spurs and a transverse carina near the apices of the mid and the hind tibiae. Species of both genera possess bifid tarsal claws, but in *Macrolasia* the claws bear an additional, weak basal angulation. Basal angulation is absent in *Subcoccinella*. *Macrolasia* also differ significantly in the structure of the mandibles, labium, shape of the mentum, and the structure of male

and female genitalia (Szawaryn and Tomaszewska, 2014). Only one species, *M. arcula* was reported from India.

2. 5. Distribution of Epilachnini

Epilachna beetles are distributed mainly in tropical and subtropical regions of the world compared to temperate zones (Gordon, 1975). The total species composition includes Neotropical fauna about 350 species, African fauna nearly 400 and Asian fauna approximately 300 species. Intersection of tropical forest ecosystems and mountain regions were reported as hotspots for epilachna beetles (Gordon, 1975; Fursch, 1991).

Anand*et al*. (1988) listed Indian Epilachninae with recorded host plants, which included 72 species in five genera. Poorani (2012) reviewed the coccinellid fauna of Indian subcontinent which included 79 species of epilachna beetles under six genera *viz*., *Afidenta*, *Afidentula*, *Afissula*, *Epilachna*, *Henosepilachna* and *Macrolasia*. Epilachnini fauna of south India include 26 species in five genera.

2. 6. Host range

Coccinellids vary in their feeding preference, majority of them are predaceous, some are phytophagous and some mycophagous. The 'true coccinellids' are carnivorous, feeding on other insects. Epilachnini and genus *Bulaea*of the tribe Tytthaspidini are found phytophagous and strictly herbivorous coccinellids are grouped under the tribe Epilachnini. The species of *Epilachna* feed almost exclusively on leaves of plant species belonging to Solanaceae and Cucurbitaceae, with a few species attacking plants of other families, particularly Fabaceae and Compositae. Dieke (1947) opined that as many of important cultivated plants, such as potato, tomato, squash, and bean were subjected to devastating attacks by species of *Epilachna*, the genus might be considered as economically one of the most important among the beetles.

Epilachna beetles are encountered on a variety of plants belonging to different families. The host of Epilachnini includes plants belonging to the family Solanaceae, Cucurbitaceae, Fabaceae, Poaceae, Urticaceae, Convolvulaceae, Aristolochiaceae and Caryophyllaceae (Tomaszewska and Szawaryn, 2016). The larvae usually feed on lower surface of leaves while adult beetles on upper surface.

Epilachnini is the most serious crop pests, causing significant damage to crop plants around the world. For example, *Henosepilachnachrysomelina*(Fabricius) is a serious pest of cucurbitaceous plants (melon, cucumber, and pumpkin) in Central Asia and Southern Europe. *H. vigintioctopunctata* (Fabricius) is distributed throughout the eastern parts of Asia and Australia and is a serious pest of plants of the family Solanaceae (potato, tobacco, tomato, and aubergine). *Epilachnavarivestis* (Mulsant) is a serious pest of peas and beans in America (Tomaszewska and Szawaryn, 2016).

Sreekala (1997) studied epilachna beetle complex in vegetables of Kerala and reported *H. septima* on bittergourd, *H. vigintioctopunctata*on brinjal and *Afidentamisera* on cowpea. Sharma and Pati (2011) first reported *H. vigintioctopunctata* infesting on a medicinal plant, *Withaniasomnifera* from Punjab. Mishra and Yousuf (2019) reported *H. vigintioctopunctata*from forest ecosystem of Uttarakhand, India.

First report of *Bulaealividulabocandei*Mulsant was from Tamil Nadu by Poorani*et al*. (2017) on *Suaeda maritime* (L.) Dumort. (Chenopodiaceae), a common halophytic plant in mangroves and was recorded as a new host plant of *B. lividulabocandei*.

2. 7. Natural enemies of Epilachnini

Jamwal*et al*. (2014) reported egg parasitoid, *Tetrastichus*sp. and pupal parasitoid, *Pediobiusfoveolatus*on *Epilachna vigintioctopunctata*(now *H. vigintioctopunctata*) infesting brinjal. Maximum parasitisation by *Tetrastichus*sp. was

observed during August and the least parasitisation was recorded during November. Same as in case of pupal parasitoid,*P. foveolatus*.

Materials and methods

3. MATERIALS AND METHODS

The study was conducted in the Department of Agricultural Entomology, College of Horticulture, Vellanikkara, Thrissur during 2018-2020 to explore the diversity of Epilachnini in different agricultural ecosystems of Kerala.

3.1 Taxonomic studies of the tribe Epilachnini

Taxonomic study involves specimen collection, followed by preservation, dissection and morphological characterization and finally identification.

3.1.1. Source of specimens

3.1.1.1. Specimen collection

3.1.1.1.1. Survey

Purposive surveys were conducted in different districts of Kerala for the collection of beetles from different agricultural ecosystems (Table 4 and Fig. 3.1).

3.1.1.1.2. Field collection

The beetles were collected by hand picking or sweeping using insect net. Immature stages *viz.*, eggs, grubs and pupae were also collected and reared to adults. Adults were usually collected from the upper surface of leaves whereas eggs and grubs were from the lower surface.

3. 1. 1. 1. 3. Preservation of specimens

The specimens were preserved immediately after collection. Both wet preservation and dry preservation were followed.

3. 1. 1. 1. 3. 1. Wet preservation

Wet preservation was followed for temporary storage. Immediately after collection from the field, specimens were stored in a small vial of 5-10 ml capacity containing 70 per cent of ethyl alcohol.

Table 4. Locations and plants covered

District	Locations	Plants from which the beetles collected
Kasaragod	Kanhanagad	Bittergourd, brinjal
	RARS, Pilicode	-
	COA, Padannakkad	Bittergourd, ridge gourd, stinging nettle, wild bittergourd
Malappuram	Kadampuzha	Cowpea
	KCAET, Thavanur	Brinjal, bittergourd
Thrissur	Nadathara	Cowpea, bittergourd, tomato
	Cherpu	Brinjal
	Avinissery	Stinging nettle, common nettle
	COH, Vellanikkara	Cowpea, bittergourd, ground cherry, brinjal
	Elanad	Bittergourd
	Thiruvillamala	Brinjal
	ARS, Mannuthy	-
Palakkad	Karimbara	Wild coccinia, brinjal
	Nelliyampathy	-
Ernakulam	Muvattupuzha	Salad cucumber
Kottayam	Chingavanam	Brinjal
Idukki	Thangamani	-
	CRS, Pampadumpara	Wild brinjal
Pathanamthitta	Perinjottakkal	Wild coccinia, cowpea, brinjal
	Pathanapuram	-
	Kottarakkara	-
	FSRS,Sadananthapuram	Brinjal

Kollam	DAF, Anchal	Brinjal, bittergourd
Thiruvananthapuram	COA, Vellayani	Brinjal, bittergourd, tomato, wild coccinia
	CRS, Balaramapuram	Brinjal

ARS- Agricultural Research Station, COA- College of Agriculture, COH-College of Horticulture, CRS-Cardamom Research Station, CRS-Coconut Research Station, DAF- District Agricultural Farm, FSRS-Farming System Research Station, KCAET- Kelappaji College of Agricultural Engineering and Technology, RARS- Regional Agricultural Research Station.

3.1.1.1.3.2. Dry preservation

Dry preservation was followed for permanent storage. The specimens preserved in alcohol were spread to tissue papers for the complete evaporation of alcohol from the body of insects. Then the specimens were mounted on triangular card points prepared by cutting white ivory cards. The card points were held by insect pins of size '1' and '2'. Then adult specimens were glued on the pointed end by keeping the insect head forward using Fevicol®. Unique accession numbers were given indicating the location and plants from which it was collected along with the date of collection. Later, proper labeling was made with locality, date, collector's name and associated plant. Then specimens were dried in oven at 50-60ºC for 1-2 weeks and stored in insect cabinet for further study.

3.1.1.2. Other sources of specimens

Specimens in the collection of Department of Agricultural Entomology, College of Horticulture, Vellanikkara and Department of Agricultural Entomology, College of Agriculture, Padannakkad were also studied.

3.1.2. Morphological characterization

3.1.2.1. Grouping of specimens

The specimens were first grouped based on the associated host plants. Further grouping was done based on the spots on elytra. This was followed by separating the specimens as male and female based on the last visible abdominal segment (Sasaji, 1971) (Fig. 2.)

3.1.2.2. Study on spots on elytra and pronotum

The pattern of spots on pronotum and elytra were studied in detail in genus *Henosepilachna*, as described by Dieke (1947). Pronotum has seven spots which are numbered as one-seven (Fig. 3.a). The size and number of spots may vary from

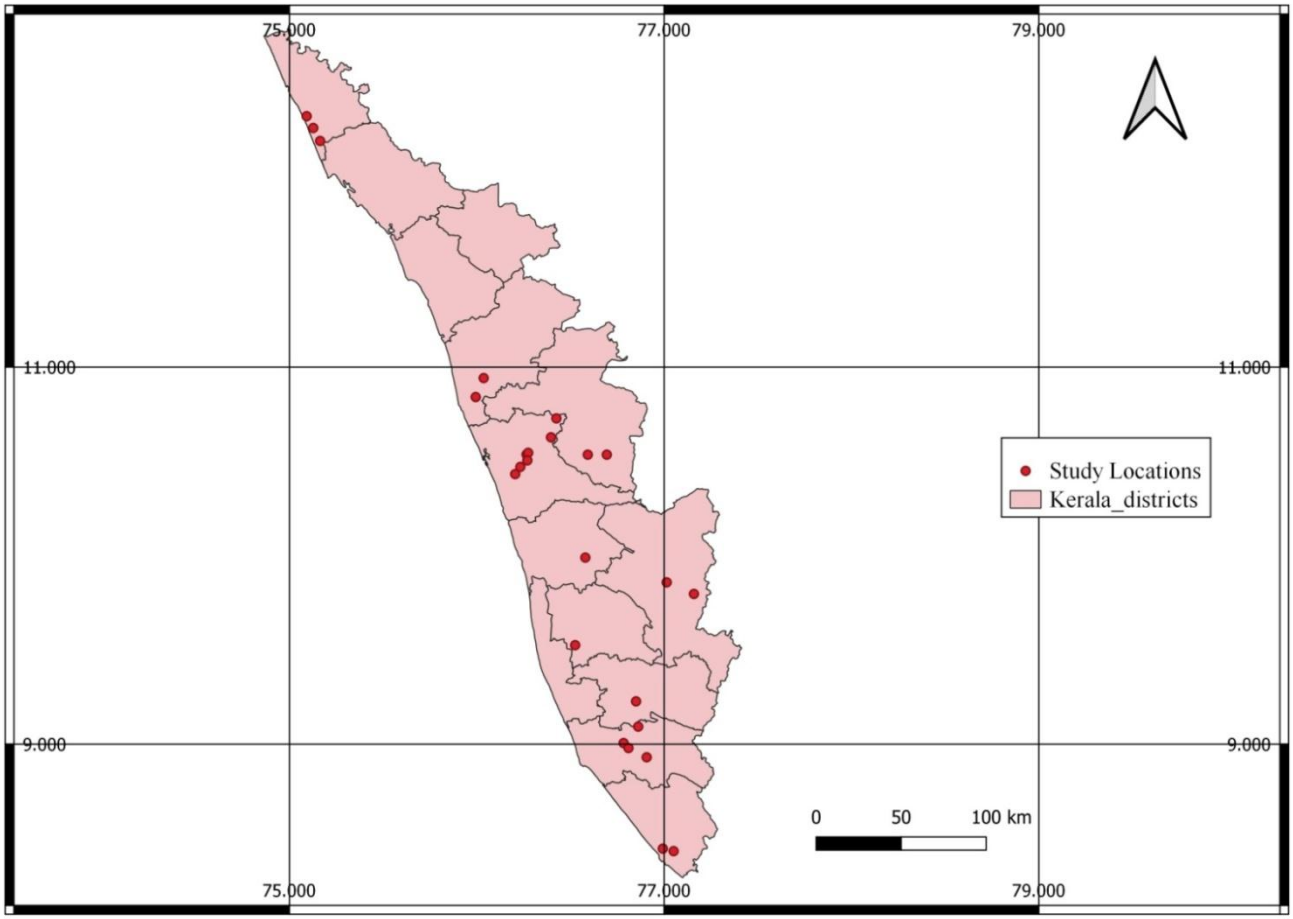


Fig. 1. Study area and location surveyed

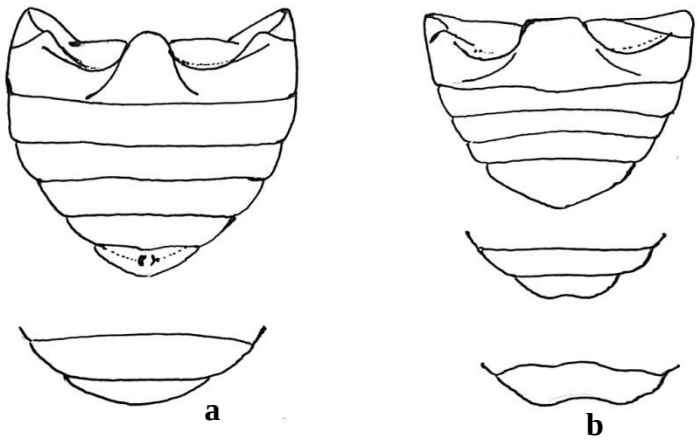


Fig. 2. Last visible abdominal segment a- female, b- male

(Redrawn from Gordon, 1985)

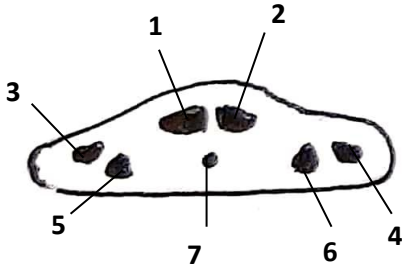


Fig. 3.a.Pronotum

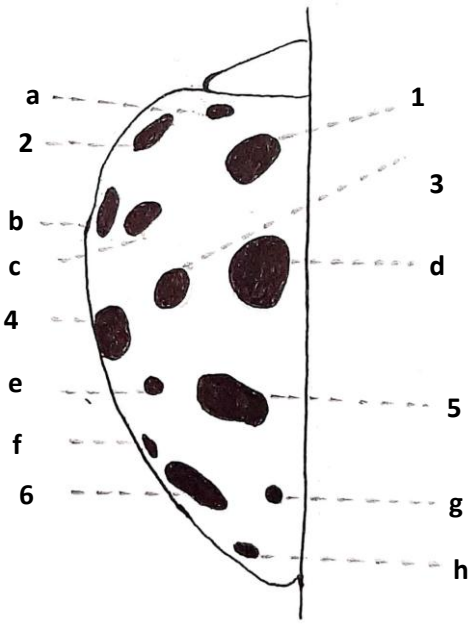


Fig. 3.b. Elytra

Fig. 3. Spots on pronotum and elytra

(Redrawn from Dieke, 1947)

species to species. Elytral spots were of two types, persistent and non-persistent spots. The persistent spots could be relatively large in size and numbered one-six. The non-persistent spots could be relatively small in size represented by a-h (Fig. 3b). Non-persistent spots might present or absent, within the same species number of elytral spots vary.

3.1.2.3. Digestion and dissection of specimens

The method described by Poorani (2012) was followed for the dissection of specimens. The specimen was kept in 10 per cent potassium hydroxide (KOH) over night and then washed with distilled water. This was then soaked in glacial acetic acid for 1-2 min. The specimens were again washed with distilled water to balance pH. Specimen was placed in a slide containing distilled water and abdomen was gently detached by inserting a minute pin between metasternum and first abdominal ventrite. The digested tissues were pressed out with the help of fine needles. Male genitalia were pulled out using a minute pin mounted on spent ball point pen refill. The penis was gently taken out from the penis guide.

Similarly, female genital segments were dissected out under stereomicroscope after digesting the abdomen.Other appendages like antennae, mouth parts, hind legs and tarsal claws were also extracted after dissecting them under a stereomicroscope.

3.1.2.4. Photomicrography

Photographs of habitus were taken by using a camera attached to Stereo Zoom Microscope (Zeiss). The photographs of antenna, labrum, mandible, maxilla, labium, tarsal claw, last abdominal ventrites of male and female,male genital segment and male and female genitalia were taken using Zeiss® image analyser and Leica® stereo microscope. Composite images were generated from image stacks using Combine ZM software.

3.1.2.5. Morphometrics

Measurements of 10 randomly selected male and female were taken separately wherever specimens were available. The measurements were made using ZM software in Zeiss Stereo Zoom Microscope. Measurements like total length, total width, elytral length, elytral width, pronotal length and pronotal width were taken (Fig.4).

Total length (TL)	:	distance from the anterior end to the posterior end of the body
Total width (TW)/ Elytral width (EW)	:	distance across both elytra at their widest point
Pronotal length (PL)	:	distance from the middle of anterior margin to the base of pronotum
Pronotal width (PW)	:	width at the widest point of pronotum
Elytral length (EL)	:	elytral length along suture from apex to base includingscutellum

3.1.2.6. Description

Descriptions of all genera and species were provided in detail. Both male and female genitalia descriptions were provided wherever both sexes were available.

3.1.2.7. Terminology

Abdominal ventrite	:	individual ventrite of the abdomen
Aedeagus	:	penis and tegmen are together referred as aedeagus
Antennal club	:	enlarged distal antennomeres
Antennomere	:	the individual segments of antenna
Base of elytron	:	the area of elytron directly behind the pronotum

Elytral suture	:	elytra touch each other at the median line of the body throughout itslength
Epipleuron	:	the inflexed lateral part of the elytron
Frons	:	a single sclerite on the upper front part of the head capsule
Genital segment of male	:	genital segment of the male consists of the ninth and tenth tergites, the ninth ventrite and a pair of ninth pleurites
Genital segment of female	:	genital segments of female consists of the ninth tergite, pair of the ninth pleurites and a pair of hemisternites and these together form an ovipositor
Hemisternite	:	genital segments of female which are paired
Nodulus	:	part of spermatheca to which the sperm duct is inserted
Palpomeres	:	individual segments of a palp
Parameres	:	paired lateral lobes of tegmen
Penis	:	tubular part of aedeagus, also termed as "sipho" and curved with a T- shaped basal part which is capsular in shape
Penis guide	:	median piece of tegmen, also termed as basal lobe. Penis guide is usually elongate spindle shaped and has a deep groove for the reception of penis at the ventral side
Abdominal post coxal line	:	curved ridges on the lateral part of first abdominal ventrite. They lie behind the metacoxae
Prosternum	:	The central sclerite of the ventral side of the prothorax
Ramus	:	part of spermatheca to which the accessory gland is inserted
Receptaculum	:	Spermatheca

Scape	:	the first segment of the antenna
Scutellum	:	a small shield shaped sclerite lying between the elytral bases
Tarsomeres	:	the individual segments of tarsus
Tarsal claws	:	a pair of sharp, hooked structures at the end of the tarsus
Tegmen	:	part of aedeagus which consists of phallobase, penis guide and parameres
Terminal palpomere	:	an enlarged palpomere at the end of the palp
Trabes	:	a median structure further articulates with the ventral side of tegmen

The parts are illustrated in Fig. 4 and 5.

3.1.2.8. Citation of collectors' name

For citing the collectors' names of the specimens studied, the following abbreviations were used.

AH	:	AmrithaHari, MSc (Ag) Entomology, Department of Agricultural Entomology, College of Agriculture, Vellayani
AKC	:	Arun Kumar C., MSc (Ag) Seed Science and Technology, Department of SeedScience and Technology, College of Agriculture, Vellayani
BMP	:	Beegam Salma M.P., Department of Agricultural Entomology, College of Horticulture, Vellanikkara
HK	:	Harya Krishna V., MSc (Hort) Post Harvest and Technology, Department of Postharvest and Technology, College of Horticulture, Vellanikkara
KS		Kiran S., Msc (Ag), Department of Agricultural Entomology, University of Agricultural Sciences, Raichur

PKK : Pavithra Kumar K., MSc (Ag) Entomology, Department of Agricultural Entomology, College of Horticulture, Vellanikkara

VCV : Dr. Vidya C.V., Department of Agricultural Entomology, College of Agriculture, Padannakkad

3.1.2.9. Identification

The species identification were done based on the available literature and taxonomic keys. Identification of Epilachnini was done based on Dieke (1947), Kapur (1958), Li and Cook (1961), Sreekala (1997), Poorani (2012), Tomaszewska and Szawaryn (2013), and Szawaryn and Tomaszewska (2016).

3.1.2. Depositories

At present, all the specimens used in this study were deposited in the collection of the Department of Agricultural Entomology, College of Horticulture, Vellanikkara.

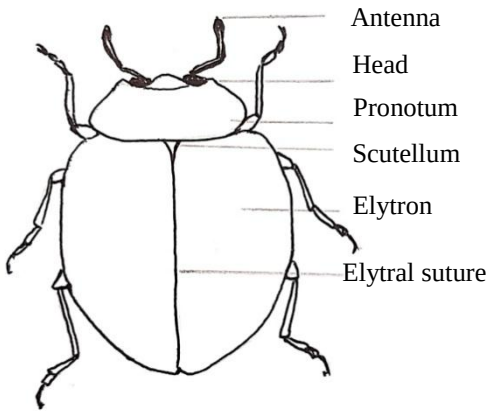
3.1.3. Distribution of species

The locations of collection of species recognized during present study within Kerala were used for the preparation of distribution map. The distribution map was prepared using Quantum GIS software.

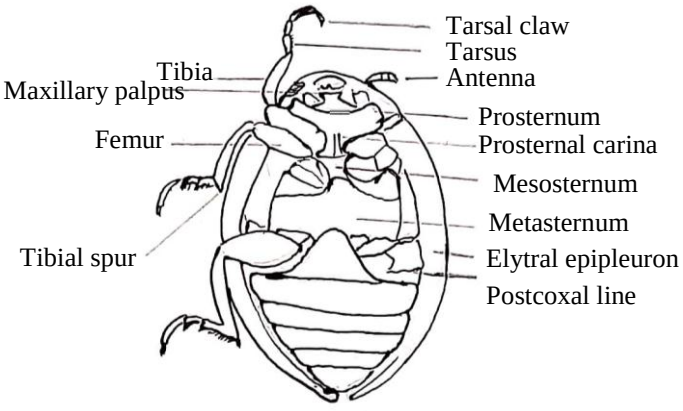
3.1.4. Host range

The host plants from where the beetles collected were recorded. The expertise of scientist from the Department of Agronomy, College of Horticulture, Vellanikkara were utilised.

The parts are illustrated in Fig. 4 and 5.



4a. Habitus - dorsal aspect



4b. Habitus - ventral aspect

Fig.4. Body parts of Coccinellidae

(Redrawn from Gordon, 1985)

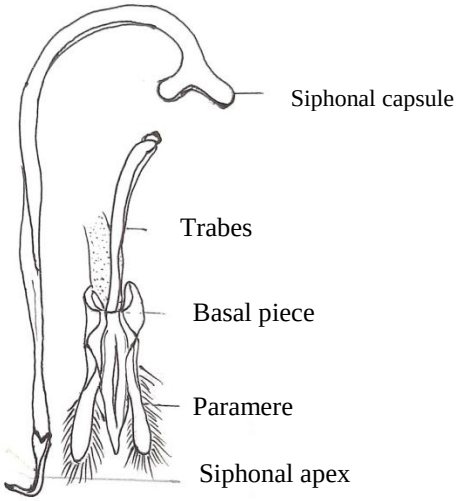


Fig.5a. Male genitalia

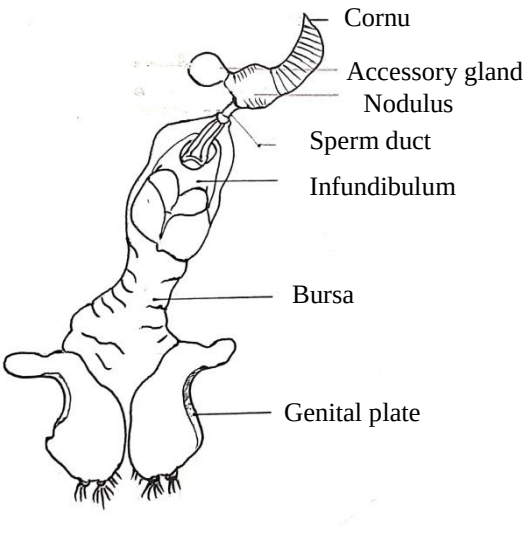


Fig.5b. Female genitalia

Fig.5. Genitalia of Coccinellidae

(Redrawn from Gordon, 1985)

3.3. Taxonomic key for the identification of species

A character table was prepared for different species of Epilachnini based on the characters studied. A dichotomous taxonomic key was then prepared for identification of species of Epilachnini with the help of the character table.

Results

4. RESULTS

The study on "Taxonomy of the tribe Epilachnini (Coleoptera: Coccinellidae) of Kerala" was conducted in the Department of Agricultural Entomology, College of Horticulture, Vellanikkara during 2018-2020. The study recognized seven species belonging to four genera under the tribe Epilachnini. Host range and distribution of the identified species were documented. The major findings of the study are presented below.

4.1. Taxonomy of the tribe Epilachnini

4.1.1. List of species encountered during the study

Family CoccinellidaeLatreille, 1807

Subfamily CoccinellinaeLatreille, 1807

Tribe EpilachniniMulsant, 1846

Genus *Afidenta*Dieke, 1947

Afidenta misera (Weise), 1901

Genus *Afidentula*Kapur, 1958

Afidentulabisquadripunctata (Gyllenhal), 1808

Genus *Afissa* Dieke, 1947

Afissaflavicollis(Thunberg), 1781

Afissanilgirica(Weise), 1908

Genus *Henosepilachna* Li, 1961

Henosepilachnadodecastigma(Wiedemann), 1823

Henosepilachnaseptima(Dieke), 1947

Henosepilachnavigintioctopunctata(Fabricius), 1775

4.1.2. Morphological characters of the tribe Epilachnini

The general morphological characters of the subfamily and tribe studied are described.

4.1.2.1. Subfamily CoccinellinaeLatreille, 1807

Coccinellides Leach, 1815.

Aphidiphages LaPorte, 1840.

Gymnosomides Mulsant, 1846.

Coccinelliti Costa, 1849.

Coccinellidae Crotch, 1873.

Coccinellides Aphidiphages Chapuis, 1876.

Coccinellidae Aphidiphages Weise, 1885.

Type genus: *Coccinella* Linnaeus, 1758.

Body small to medium, convex, dorsum pubescent or glabrous; elytra with or without markings or black spots and round at the tip; scutellum small, triangular; antenna composed of 9-11 antennomeres, antennal club well developed, slightly shorter than head width; mandibles with or without mola, apex bidentate or multidentate; apical segment of maxillary palpisecuriform or elongated; mentum narrow joining submentum; legs rather long, tibiae with or without spurs; tarsi cryptotetramerous or trimerous; abdomen with 5 or 6 visible segments on the ventral side and number of visible segments is usually same in both sexes. Coccinellinae is a large diverse group with complex tegmen with large penis guide, symmetrical, primarily articulated parameres and articulated basal strut.

4.1.2.1. 1. Tribe EpilachniniMulsant, 1846

EpilachniensMulsant 1846: 190.

Type genus: *Epilachna*Chevrolat in Dejean 1837.

Body small to medium, sometimes relatively larger, convex, dorsum pubescent; elytra with varying patterns and black spots or without maculation; inner orbit of eyes emarginated antero-medially, closer to vertex than to mouth parts; antenna with 11 antennomeres; mandibles lack mola and provided with more than two apical teeth (Fig. 6a.); maxilla with last segment of maxillary palpisecuriform or elongate; mentum trapezoidal and widest at its base (Fig. 6b), prementum oval;

pronotum broader than head; legs long, tarsi always cryptotetramerous, claws bifid with or without basal tooth; post coxal line of first visible abdominal ventrite complete or incomplete; apical margin of sixth abdominal segment of male convex or emarginated, apical margin is entire or longitudinally divided in females.

Fig.6a. Mandible

Fig.6b. Labium

Fig. 6. Mandible and labium of Epilachnini

Four genera were identified during the study which could be recognized with the following key.

Key to the genera of the tribe Epilachnini collected during the study

1 Mandibular incisor edge with distinct denticles or teeth; basal knife edge of median lobe of male genitalia well developed; yellowish setae usually present on the inner margin of median lobe; sixth visible abdominal ventrite of female longitudinally split; styli present……..…….... ***Henosepilachna*** **Li**

- Mandibular incisor edge with weak microdenticulation or without denticles; median lobe simple towards the dorsal side without basal knife edge; no yellowish setae on median lobe; sixth visible abdominal ventrite of female entire; styli may be present or absent……..……...……....**2**

2(1) Inner edge or lateral margin of mandibles with small denticles; claws bifid with sharp basal tooth; styli absent…..…….…….....…...***Afidenta*** **Dieke**

- Inner edge or lateral margin of mandibles smooth; claws bifid with wide basal tooth or without basal tooth; styli present…….....**3**

3(2) Mandible long and with microdenticulation on incisor edge;coxites subtriangular or elongate…..…….…….....….***Afissa*** **Dieke**

- Mandibles very small with reduced tooth; coxite wider than long …….. ..……..……..…...…....***Afidentula*** **Kapur**

4. 1. 2. 1. 1. 1. Genus *Afidenta*Dieke, 1947

*Afidenta*Dieke, 1947: 109.

Type species: *Afidentamimetica*Dieke, 1947 (=*Epilachnamisera*Weise, 1901). – Szawaryn *et al*. 2015:558; Tomaszewska and Szawaryn, 2016: 56.

Diagnosis: Genus *Afidenta*can be identified by the following combination of characters: slender mandible with long apical tooth compared to the lateral teeth, galea transversely oval, terminal labial palpomere as long as but narrower than the penultimate one, tibial spur present, sixth abdominal ventrite in females not divided longitudinally, coxites without styli.

Description: Body usually small, orange to reddish brown with black rounded spots on elytra, dorsum pubescent; elytral base not much broader than pronotal base; antenna short with 11 antennomeres, pedicel distinctly narrower than scape; labrum transverse; mandible multidentate, inner edge of mandible with microdenticulation; terminal palpomere of maxillary palp strongly securiform; labium with mentum trapezoidal and widest at the base; prosternum convex, prosternal process smooth without carina; coxa long and not broad, tarsi pseudotrimerous or cryptotetramerous, tarsal claw bifid with a sharp basal tooth; six ventrites in male and female, sixth abdominal segment of female not split longitudinally.

Remarks: Genus *Afidenta* and *Afidentula* are almost similar in body shape and colouration, both having bifid claws with basal tooth and sixth abdominal segment of female not longitudinally split.*Afidenta* can be separated from *Afidentula* by its mandible and male genitalia. Mandible in *Afidenta*is with three teeth with microdenticulation behind inner lateral tooth along inner edge of mandible whereas in *Afidentula*mandibles with three apical teeth and incisor edge without denticulation. *Afidenta* can be separated from *Afissa*and *Henoepilachna*by the characters of mandible, tarsal claw and genitalia of male and female.

4. 1. 2. 1. 1. 1. 1. *Afidenta misera* (Weise), 1901 (Plate 1a, 1b and 1c)
*Epilachna misera*Weise, 1901: 420.
*Afidenta mimetica*Dieke, 1947: 110 -Synonymised by Bielawski, 1961.
Afidenta mimetica simplex Dieke, 1947: 111.

Diagnosis: This species is small having mandible with relatively long apical tooth. Male genitalia small, penis guide wedge shaped, penis stout and narrowing towards apex. Sixth abdominal ventrite of female not divided longitudinally.

Description: Body small, yellowish orange to reddish brown colour, convex, dorsum pubescent; elytra with 12 spots, each elytra consists of six spots arranged as 2-2-2, elytral tips rounded; pronotum broader than head, pronotum with a transverse row of four black rounded spots near the middle or just in front of it, spaced equidistantly; antenna composed of 11 anntenomeres, pedicel distinctly narrower than scape, thirdantennomere elongate; labrum transverse; mandible with three teeth with microdenticulation on incisor edge and along inner edge of mandible behind inner lateral tooth; terminal maxillary palpomere securiform, galea transversely oval; mentum trapezoidal and widest at the base, prementum oval; hind leg with narrow and long femur and tibia, tarsi cryptotetramerous, mid and hind tibia smooth on outer edge without carina, tarsal claw bifid with large basal pointed tooth, tibial spur present; abdominal post coxal line complete; six ventrites in both male and female, in males: apical margin of ventrite 5 truncate; apical margin of ventrite 6 emarginate; in

females: apical margin of ventrite 5 almost rounded; apical margin of ventrite 6 entire, not divided longitudinally.

Male genitalia: Small, tegmen with penis guide wedge-shaped, almost as long as parameres, parameres setose at apex, penis simple, without any process at the apex, penis weakly curved, narrowing towards apex, penis capsule reduced; apodeme (sternite IX) of male genital segment simple, rod like; tergite X subtriangular and rounded towards apex.

Female genitalia: Coxites reniform, diagonally suboval, less than two times longer than wide, styli absent.

Measurements: Total length: 5.06mm, total width: 4.28mm, TL/TW: 1.18, PL/PW: 0.25, EL/EW: 0.16, EW/PW: 1.13.

Material: India: Kerala: 11♂, 6♀ Kadampuzha, 01.viii19 (HR); 1♀, 1♂ Parappa, 15.xi.19 (VCV); 1♂ Perinjottakkal, 28.viii19 (BMP).

Host: Cowpea (*Vignaunguiculata*)

Remarks: *Afidenta* is a monotypic genus. One specimen which is similar to *A. misera* was collected from cowpea during the study. It looks similar to *A. misera* except for the mandible characters. The teeth of mandibles are relatively short with less serration compared to *A. misera*.

4. 1. 2. 1. 1. 2. Genus *Afidentula*Kapur, 1958

Afidentula Kapur, 1958: 324.

Type species: *Epilachna manderstjernae* Mulsant, 1853.

Diagnosis: Genus *Afidentula* could be identified by the following combination of characters: mandible small, short and compact with three apical teeth and only the middle tooth sometimes weakly serrated; tibial spur absent; tarsal claw bifid with wide basal tooth; abdominal ventrite 6 not divided longitudinally in females.

Description: Body small, round to oval, strongly convex, orange-red, with black maculae; antenna with 11 antennomeres, scape large, swollen, pedicel distinctly narrower than scape; mandibles subtriangular narrowing towards apex with three

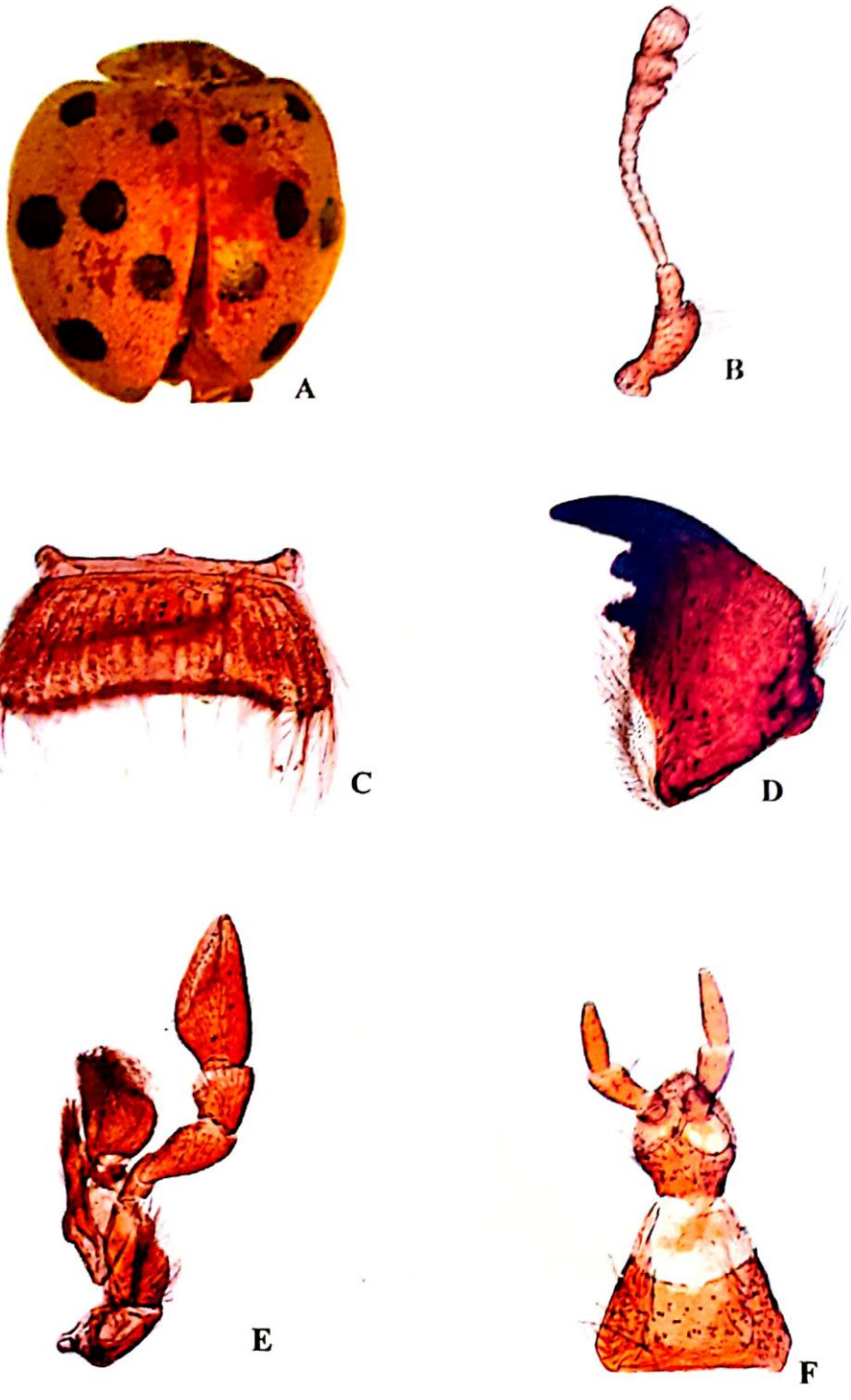


Plate 1a. ***Afidenta misera*** **(Weise)**

A. Habitus; B. Antenna; C. Labrum; D. Mandible; E. Maxilla; F. Labium

G

H

I

J

K

L

Plate 1b. *Afidenta misera* (Weise)

G. Tarsal claw; H. Abdomen- male; I. Abdomen-female; J. Abdominal ventrite 6 – male; K. Abdominal ventrite 6 – female; L. Male genital segment

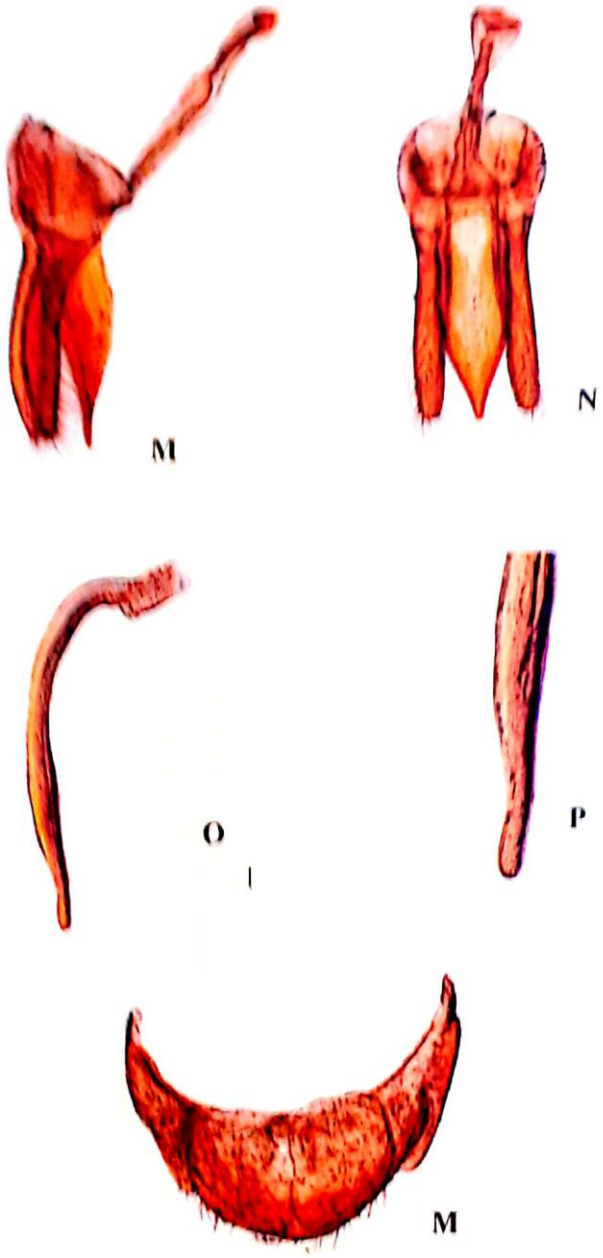


Plate 1e. ***Afidenta misera*** **(Weise)**

M. Tegmen – lateral; N. Tegmen – ventral; O. Penis; P. Penis apex; Q. Female genitalia

apical teeth, sometimes median tooth serrate; labium with mentum trapezoidal, narrowing anteriorly; prosternal process without carina; tibia usually without spurs; tarsi cryptotetramerous or pseudotrimerous; tarsal claw bifid with subtriangular basal tooth; 6 ventrites in males; abdominal post coxal line recurved and complete.

Remarks: Genus *Afidentula* is similar to *Afidenta* and *Afissa* in general body shape, colouration, presence of bifid tarsal claws with a large basal tooth and female abdominal ventrite 6, which is not divided longitudinally. However, it can be easily distinguished from *Afidenta* by small and short mandibles with three apical teeth without much serrations and also by studying male genitalia. *Afidentula* can be easily separated from *Afissa* by mandible and female genitalia. In *Afissa*, mandible is with long apical teeth and female genitalia is of typical 'coccinellid type' with subtriangular, elongate coxites.

One species of *Afidentula* was recognized during the present study, *A. bisquadripunctata* (Gyllenhal)

4. 1. 2. 1. 1. 2. 1. *Afidentula bisquadripunctata* (Gyllenhal), 1808(Plate 2a and 2b)
*Coccinella bisquadripunctata*Gyllenhal, 1808: 186.
Epilachnabisquadripunctata: Crotch, 1874: 89, Korschefsky, 1931: 19.
Afidentabisquadripunctata: Dieke, 1947: 112.
Afidentulabisquadripunctata: Pang & Mao, 1979: 121; Fursch, 1984: 337; Jadwiszczak&Węgrzynowicz, 2003: 22; Poorani, 2004: 38.
Afissulabisquadripunctata: Ren*et al*., 2009: 254.

Diagnosis: The species is distinguished by its small size, convex shape, densely pubescent dorsum, short, differently shaped mandibles, bifid tarsal claw with a basal tooth and male genitalia.

Description: Body small, round-oval, convex; surface distinctlysetose with yellowish hairs; each elytra with four black spots arranged as 1-2-1, first basal spot not touching suture, scutellum or elytral margin; one spot in second row close to elytral suture, and the other near elytral margin; posterior spot in about ¼ of apical length of elytron, all

spots round but vary in size; head and mouthparts orange to light brown; antenna with 11 antennomeres, antennomere third as long as antennomere 4-6 together; mandibles subtriangular, short, small with three apical tooth; maxilla with maxillary palpomere moderately securiform; legs moderately long, hind leg with coxa long and broad, tarsi with bifid claws and a large basal tooth; abdominal postcoxal lines almost complete, reaching posteriorly about ¾ length of first ventrite; apical margin of male fifth abdominal ventrite truncate, sixth abdominal ventrite emarginate.

Male genitalia: Tegmen with parameres narrow and thin, as long as penis guide, of equal width throughout the length; penis guide long with sides parallel and slightly bent or pointed towards apex in the lateral view, apex of penis guide with a shallow notch in the ventral view; penis thin, long, strongly curved, penis apex submembraneous and pointed; apodeme (sternite IX) of male genital segment simple, rod like; tergite X subtruncate apex.

Measurements: Total length: 4.2 mm, total width: 3.7mm, TL/TW: 1.13, PL/PW: 0.3, EL/EW: 1.77, EW/PW: 0.63.

Material: India: 1♂, Raichur (KS).

Host: Sugarcane (*Saccharum officinarum*)

Remarks: This species is similar to *Afidentula thanhsonensis*. But can be separated by having the second labial palpomere less elongate in comparison to apical palpomere and male genitalia with penis guide curved at the top portionandwith sharp tooth in apical fourth and short incision at apex.

4. 1. 2. 1. 1. 3. Genus *Afissa* Dieke, 1947

*Afissa*Dieke, 1947: 113.

Type species: *Coccinellaflavicollis*Thunberg, 1781. Synonymized with*EpilachnaChevrolat* in Dejean 1837, by Li and Cook, 1961.Resurrected from synonymy by Szawaryn*et al*., 2015: 565.

*Afissula*Kapur, 1958.

Type species: *Afissularana*Kapur, 1958 (byoriginal designation).-Jadwiszczak and Wegrzynowicz, 2003:25; Kovar, 2007: 626; Ren *et al*., 2009: 254. Synonymized bySzawaryn*et al*., 2015: 565.

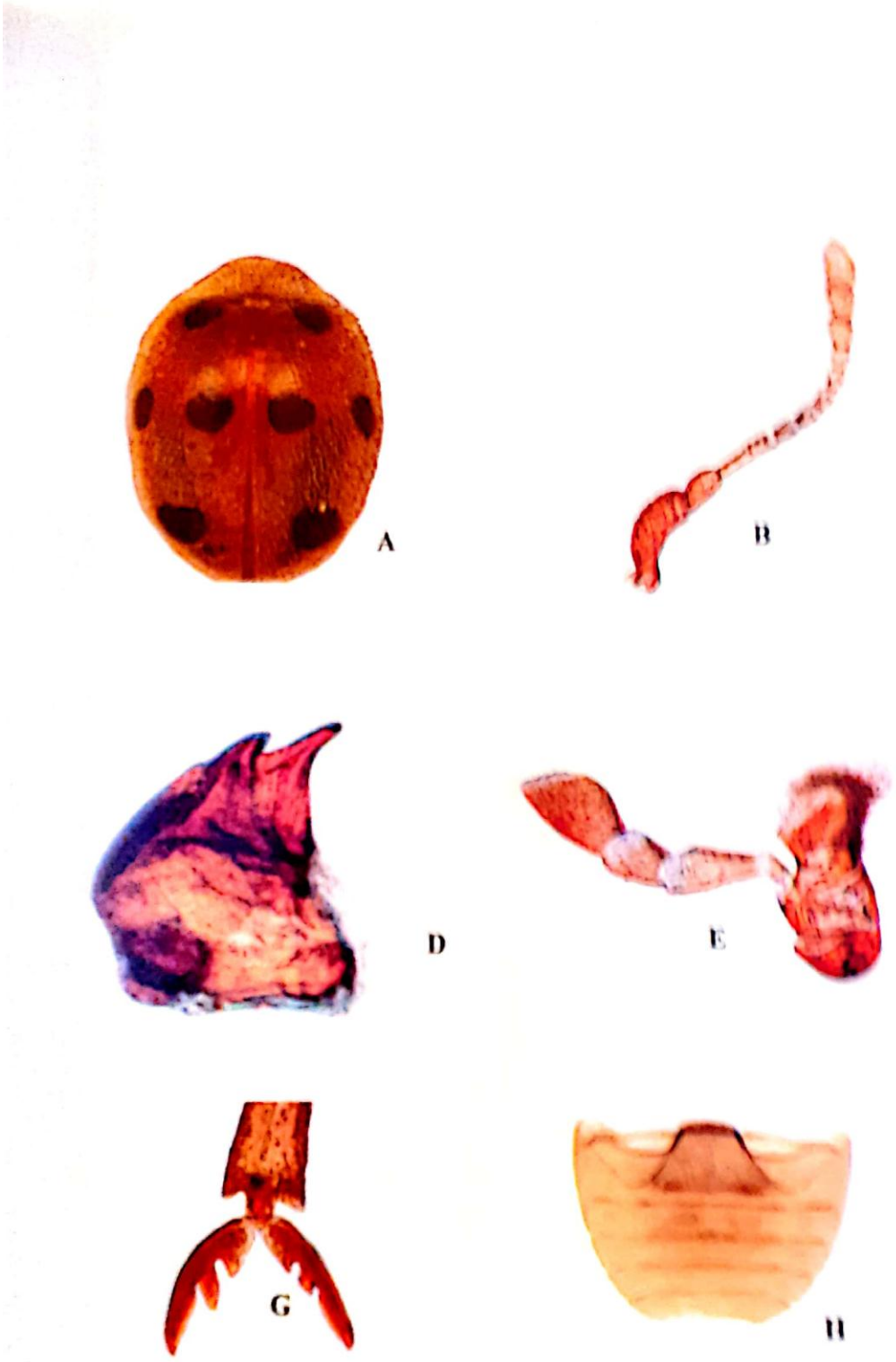


Plate 2a. ***Afidentula bisquadripunctata*** **(Gyllenhal)**

A. Habitus; B. Antenna; D. Mandible; E. Maxilla; G. Tarsal claw; H. Abdomen- male

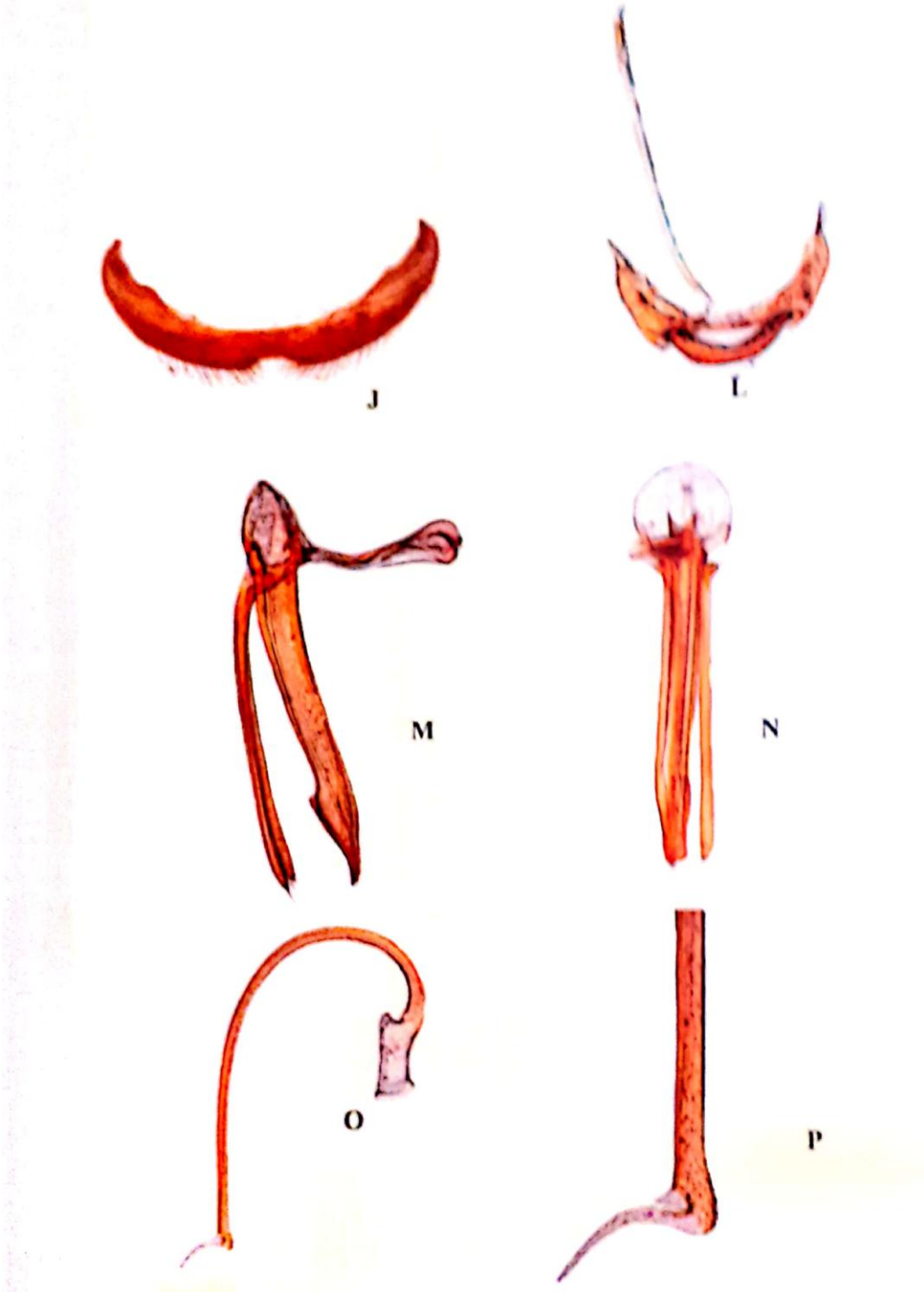


Plate 2b. ***Afidentula bisquadripunctata*** **(Gyllenhal)**

J. Abdominal ventrite 6 – male;L. Male genital segment; M. Tegmen – lateral; N. Tegmen – ventral; O. Penis; P. Penis apex

Diagnosis: Genus *Afissa* could be separated from other genera of tribe Epilchnini by the following combination of characters: antennae distinctly longer than head width, with all antennomeres much longer than wide, mandibles multidentate, dentules are less pronounced or often absent on the lateral edge of mandibles, hind femora not swollen and hemisternites or coxitessubtriangular and elongate i.e. typical 'coccinellid' type.

Description: Small, slightly oval or elongate oval, yellowish red to orange; head without spots; maculation onpronotum and elytra; antenna composed of 11 antennomeres, longer than head width; mandibles with two apical tooth and two lateral ones, dentules usually absent on the lateral edge of mandible; terminal palpomere distinctly securiform; mentum widest near the median part; prosternum usually smooth without carina, tarsi cryptotetramerous or pseudotetramerous, tarsal claw bifid with without basal tooth; abdomen with 6 ventrites in male or 5 or 6 ventrites in females; post coxal line recurved roundly, usually incomplete laterally, sometimes looks complete; male genitalia with long penis and parameres; female genitalia with coxites much longer than wide, triangularly or regularly long oval.

Remarks: Genus *Afissa* looks similar in appearance of genus *Afidentula*, both having the sixth abdominal ventrite of female not divided longitudinally and bifid claws with basal tooth. The main characters to differentiate these two genera are explained in 4.1.2.1.1.2.

Two species of *Afissa*were recognized during the present study,*Afissaflavicollis* (Thunberg) and *Afissanilgirica* (Weise).

Key to the species of the genus *Afissa*collected during the study

1 Mandible with four tooth, penis guide with a cleft towards apex in ventral view, penis very long and penis apex curved……
……..…….*****Afissa flavicollis* (Thunberg)**

- Mandible with more than four tooth; penis guide without cleft towards apex, penis very long and apex broad……..…..***Afissa nilgirica* (Weise)**

4. 1. 2. 1. 1. 3. 1. *Afissa flavicollis* (Thunberg), 1781 (Plate 3a, 3b and 3c)

Epilachna flavicollis Thunberg, 1781: 18.

Epilachna flavicollis: Poorani, 2004: 41; Jadwiszczak & Wagrynowicz, 2003: 65.

Diagnosis: Body small, round oval, mandibles with two apical teeth and two lateral one, genitalia with parameres thin and long hairs on apex, penis guide long and penis apex distinctly curved.

Description: Body small, round oval, yellowish orange or yellowish brown, convex, moderately pubescent, each elytra with five spots arranged as 2-2-1; antenna composed of 11 antennomeres, longer than head width, pedicel distinctly narrower than scape, antennomeres 3-8 elongate, club asymmetrical; labrum transverse, truncate or weakly emarginate at apex; mandibles with two apical and two lateral teeth having small serrations; maxilla with last segment of maxillary palpomere securiform or elongated; legs very long, hind femora longer than broad, claws bifid with basal tooth; abdomen with post coxal line complete; in male: apical margin of ventrite 6 truncate or slightly emarginate, in female: apical margin of ventrite 6 strongly rounded and not divided.

Male genitalia: Penis with penis guide symmetrical, longer than parameres, excised or with a cleft at apex; parameres well developed, simple apically, with long hair in apical part; penis thin and long, curved at apex, penis base sometimes with reduced T-shaped capsule.

Female genitalia: Coxites much longer than wide, triangularly or regularly long-oval; styli present.

Measurements: Total length: 5.97mm, total width: 4.79mm, TL/TW: 1.25, PL/PW: 0.36, EL/EW: 1.44, EW/PW: 1.49.

Material: India: Kerala: 3♂, 3♀, Locality labels were not available.

Host: Speciems available in the Department of Agrl. Entomology, College of Horticulture was used. Host details were not available.

Plate 3a. ***Afissa flavicollis*** **(Thunberg)**

A. Habitus; B. Antenna; C. Labrum; D. Mandible; E. Maxilla; F. Labium

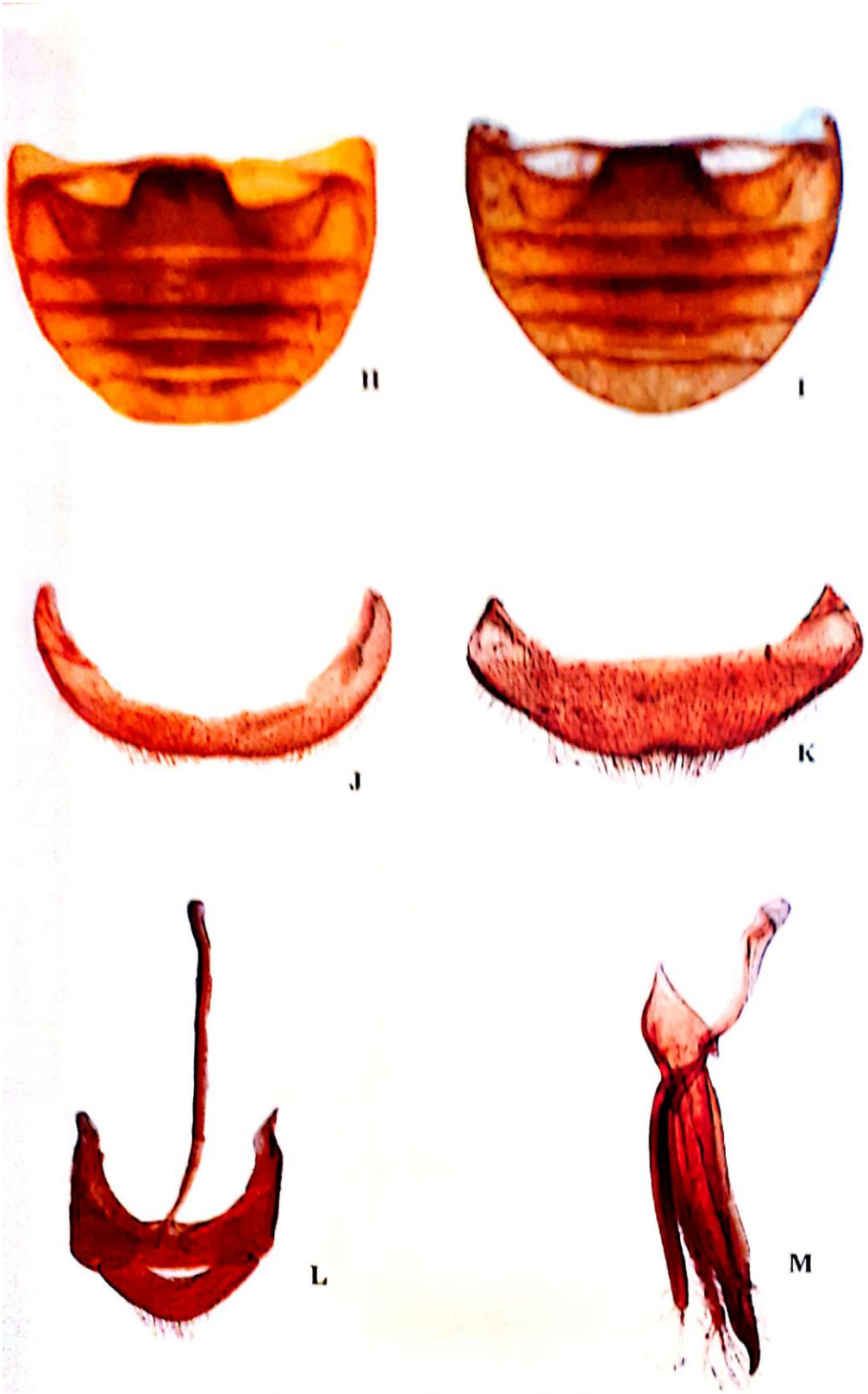


Plate 3b. ***Afissa flavicollis*** **(Thunberg)**

H. Abdomen- male; I. Abdomen-female; J. Abdominal ventrite 6 – male; K. Abdominal ventrite 6 – female; L. Male genital segment; M. Tegmen – lateral;

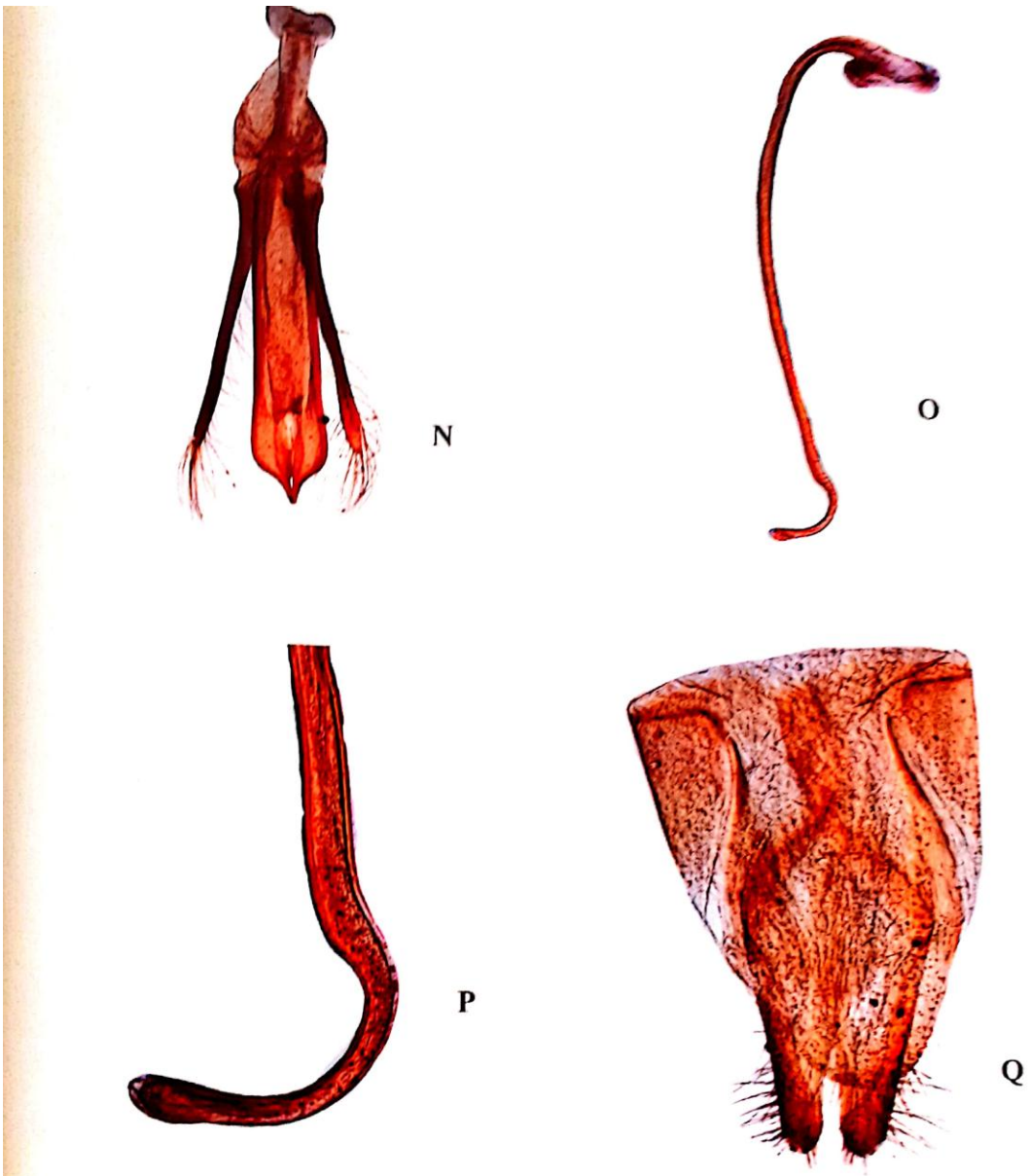


Plate 3c. ***Afissa flavicollis*** **(Thunberg)**

N. Tegmen – ventral; O. Penis;P. Penis apex; Q. Female genitalia

Remarks: This species can be easily separated from *A. nigirica* by its long penis guide and penis which is distinctly curved at apex. Besides, tarsal claw is bifid with a basal tooth in *A. flavicollis* whereas tarsal claw is bifid without basal tooth in *A. nilgirica*.

4. 1. 2. 1. 1. 3. 2. *Afissa nilgirica*(Weise), 1908 (Plate 4a, 4b and 4c)

Solanophila nilgirica Weise, 1908: 219.

Epilachnanilgirica: Poorani 2002: 44; Jadwiszczak&Wegrzynowicz, 2003: 96.

Diagnosis: Small, body strongly convex, mandibles well developed, having more number of long apical tooth with reduced dentation on incisor edge. Male genitalia with broad penis guide which is longer than parameres and penis blunt at its apex.

Description: Small, reddish-brown, pubescent, pronotum without spots and elytra with 12 spots arranged as 2-2-2, first spots on each elytra fused towards the elytral suture forming one black round spot, hence appear as a single spot; antenna with 11 antennomeres, the third antennomere longer than others; labrum transverseand weakly emarginate at apex; mandible very well developed, with more number of apical tooth and are very long and reduced dentation on incisor edge, lateral edge of mandible smooth; terminal maxillary palpomere highly securiform, galea and lacinia highly setose, lacinia relatively large compared to other species; labium with mentum trapezoidal and widest at the base; legs with tarsal claws bifid without basal tooth, tarsi cryptotetramerous or pseudotrimerous; abdominal post coxal line complete, in male: apical margin of ventrite 5 truncate, ventrite six weakly emarginate; in female: apical margin of ventrite 5 truncate, ventrite 6 round and not divided.

Male genitalia: Tegmen with median lobe very broad and long with respect to parameres, parameres thin, apex setose; penis long and penis apex broad.

Female genitalia: Coxiteslonger than wide when compared to other species and shape of coxites slightly elongate oval.

Material: India: Kerala: 1♂, 2♀, Avinissery, 10.ix.2020 (VCV); 1♂, Padannakad, 24.viii2020, (VCV).

Host: Common nettle (*Urticadioica*) and stinging nettle (*Pouzolziazeylanica*).

Remarks: This species similar to *A. flavicollis*. However, this species can be separated by male genitalia, mandible and tarsal claw. Penis guide and penis also varies.

4. 1. 2. 1. 1.4. Genus *Henosepilachna* Li, 1961

*Henosepilachna*Li in Li & Cook, 1961: 35.

Type species:*Coccinellasparsa*Herbst, 1786 (=*Coccinellavigintioctopunctata*Fabricius, 1775).

Henosepilachna (Elateria) Fürsch, 1964: 182.

Type species: *Coccinellaelaterii*P. Rossi, 1794.

*Subafissa*Bielawski 1963.

Type species: *Epilachnapapuensis* Crotch 1874.—Jadwiszczak and Wegrzynowicz 2003: 183.Synonymized by Szawaryn*et al*. 2015: 565.

Diagnosis: This genus could be identified by following combination of characters: Medium sized, mandibular incisor edge with distinct denticles or teeth, basal knife edge of median lobe of male genitalia, yellowish setae on the inner margin of median lobe, sixth visible abdominal ventrite of female which is longitudinally split.

Description: Body oval to hemispherical or convex, pubescent, ground colour yellowish red to brick red; head spotless, pronotum mostly two or seven spotted, elytra mostly with 12 spots; eyes slightly emarginated on inner edge; antenna short, composed of 11 antennomeres, terminal three palpomere forming the club; labrum transverse, mandible multidentate, mandibles with a larger apical tooth and two lateral teeth, apical tooh consists of three parts which is visible from front view, lateral edge of mandibles beyond the lateral teeth with a number of very small teeth (dentules); maxilla with galea dilated with a broad, round apex, terminal palpomere of maxillary palp strongly securiform; labium with mentum trapezoidal, palpus small, short and terminal palpomere tapering to a point distally; pronotum with fine punctures, narrower than base of elytra, anterior margin deeply concave, posterior margin rounded; prosternum narrow and short; elytra with 12-28 spots, persistent and non-

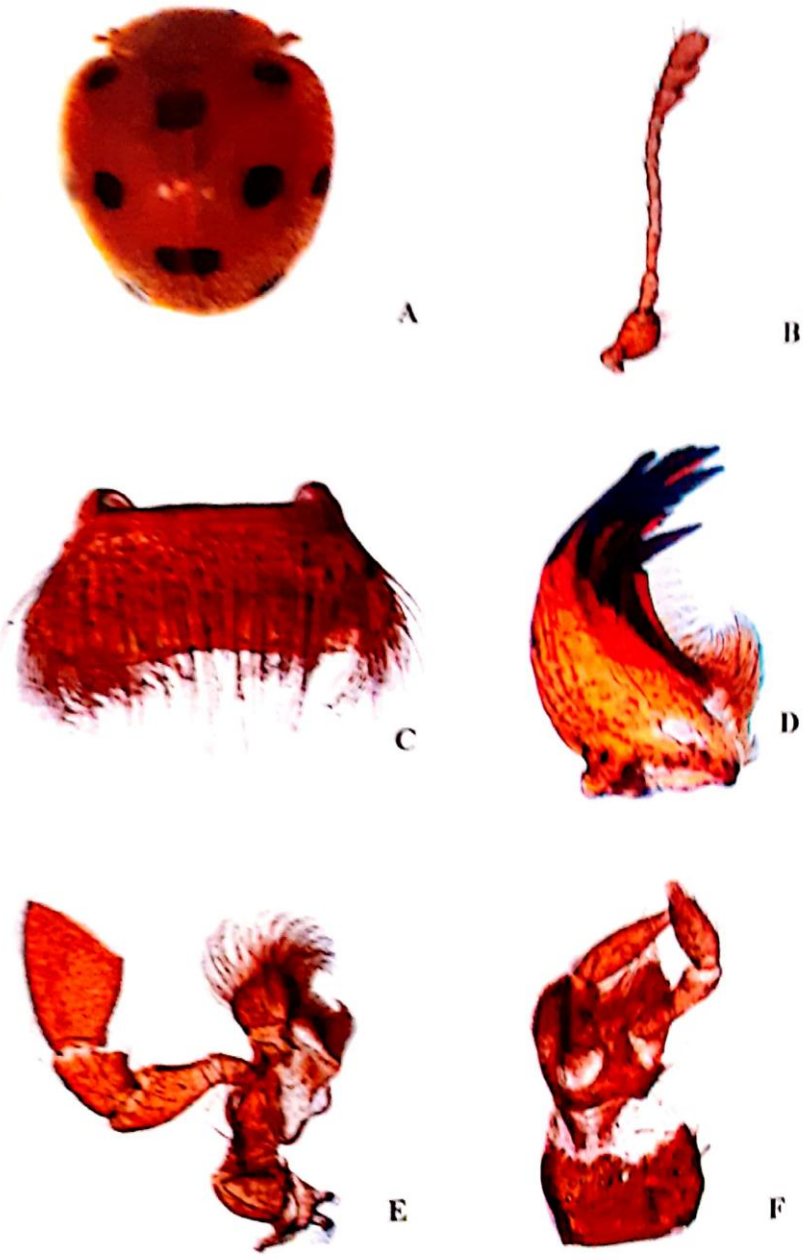


Plate 4a. ***Afissa nilgirica*** **(Weise)**

A. Habitus; B. Antenna; C. Labrum; D. Mandible; E. Maxilla; F. Labium

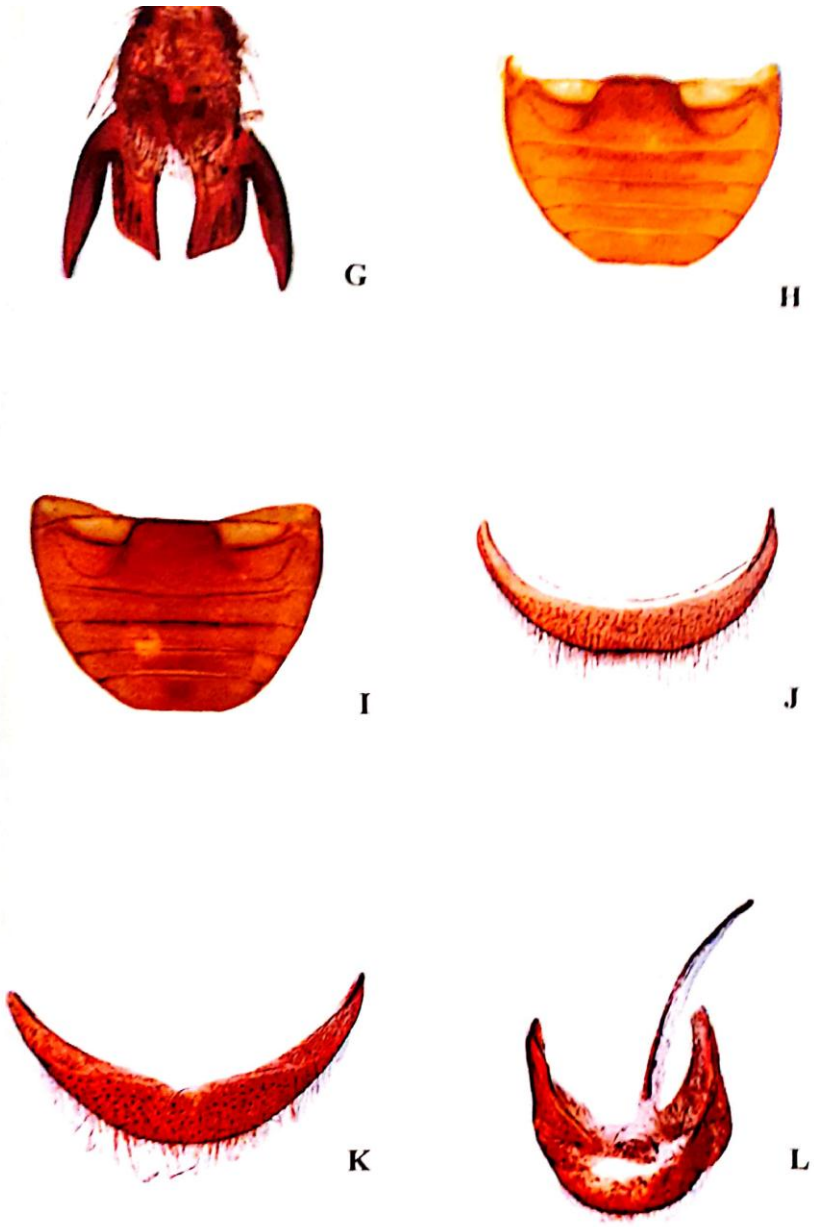


Plate 4b. ***Afissa nilgirica*** **(Weise)**

G. Tarsal claw; H. Abdomen- male; I. Abdomen-female; J. Abdominal ventrite 6 – male; K. Abdominal ventrite 6 – female; L. Male genital segment

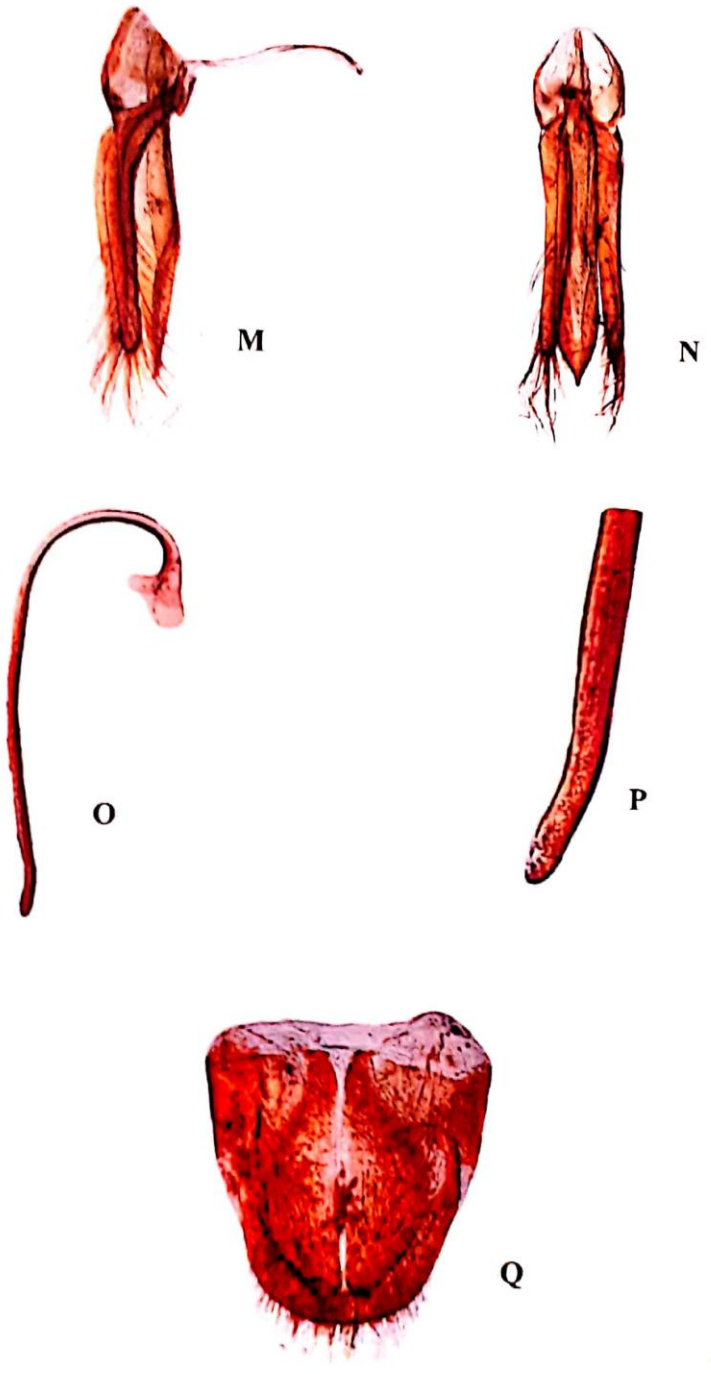


Plate 4c. ***Afissa nilgirica*** **(Weise)**

M. Tegmen – lateral; N. Tegmen – ventral; O. Penis; P. Penis apex; Q. Female genitalia

persistent spots, basic elytral maculation is with six persistent spots always present on each elytron, modification of elytral pattern with one to eight non-persistent spots or enlarged spots or coalesced spots; legs long with long and broad femur, tarsicryptotetramerous or pseudotrimerous, tarsal claws bifid, inner claws are slightly wider than outer claw, with a wide basal tooth; abdomen consists of six visible ventrites, postcoxal line complete, sixth abdominal ventrite of female divided longitudinally; male genitalia with basal knife edge towards the base of median lobe.

Three species of *Henosepilachna*were recognized during the present study, *H. dodecastigma*, *H. septima* and*H. vigintioctopunctata.*

Remarks: Genus*Henosepilachna* is similar to the genus *Epilachna*, but *Henosepilachna* is quite variable in external appearance. *Henosepilachna viginctioctopunctata* has 12-28 spots present on the elytra. In 12 spotted specimens, elytral spot third is never subrectangular; in 28 spotted specimens, elytral spots cb3d lie approximately in a straight line. The apical angles of the elytra are distinct in both sexes.

Key to the species of the genus *Henosepilachna* collected during the study

1 Elytral tip rounded, The persistent spot 4 of the elytra generally touches the external margin of the elytra, male genitalia with median lobe dentulate dorsally; penis nearly straight at the apex…… ……..……..…….....***Henosepilachadodecastigma*(Wiedemann)**

- Elytral tip angular or rounded, spots never touches the external margin of elytra, no dentulation on median lobe of tegmen, penis narrowed towards apex……...**2**

2 Elytral tip angular, penis slightly bent at the apex……...……..***Henosepilachnavigintioctopunctata*(Fabricius)**

- Elytra with 12 or more spots; male genitalia apex of siphon sharply pointed on one side like a nib…….…….……..***Henosepilacha septima* (Dieke)**

4. 1. 2. 1. 1. 4. 1. *Henosepilachna dodecastigma* Wiedemann (Plate 5a, 5b and 5c)

*Coccinelladodecastigma*Wiedemann, 1823: 73.

Henosepilachnadodecastigma: Jadwiszczak&Wegrzynowicz, 2003: 144.

Diagnosis: Medium sized yellowish orange beetles with black maculae, persistent spot 4 of the elytra generally touches the lateral margin, male genitalia with median lobe dentulatedorsally, siphon nearly straight at the apex.

Description: Body convex, dorsum pubescent; elytra usually orange red, elytra having mostly 12 spots, only the persistent spots are present, spot no. 4 usually touches the elytral margin; antenna with 11 antennomeres; mandible with five apical tooth with dentation; maxilla with last segment of maxillary palpomere securiform; labium with mentum trapezoidal and widest and the base: legs long; tarsi cryptotetramerous or pseudotrimerous, tarsi with bifid claws, basal tooth broad; abdominal post coxal line complete, ventrite 6 of female longitudinally divided.

Male genitalia: Median lobe almost equal to the length of paramers, tegmen with inner margin of median lobe having denticles, penis apex blunt, penis capsule thin.

Female genitalia: Coxites suboval, with a deep notch towards inner side, styli present.

Material: India: Kerala: 1♂, Padannakkad, 17. ix.2020 (VCV).

Host: Ridge gourd (*Lufaacutangula*)

Remarks: This species looks similar to other species of *Henosepilachna*, but can be separated by maculation on elytra where spot no.4 touches the lateral margin, male genitalia with dentate median lobe and blunt penis apex.

4. 1. 2. 1. 1. 4. 2. *Henosepilacha septima*Dieke, 1947(Plate 6a, 6b, 6c, 6d and 6e)

*Epilachnaseptima*Dieke, 1947: 58.

*Epilachnakeiseri*Bielawski, 1957a: 73-Synonymised by Kapur, 1967.

Henosepilachnaseptima: Jadwiszczak&Wegrzynowicz, 2003: 170.

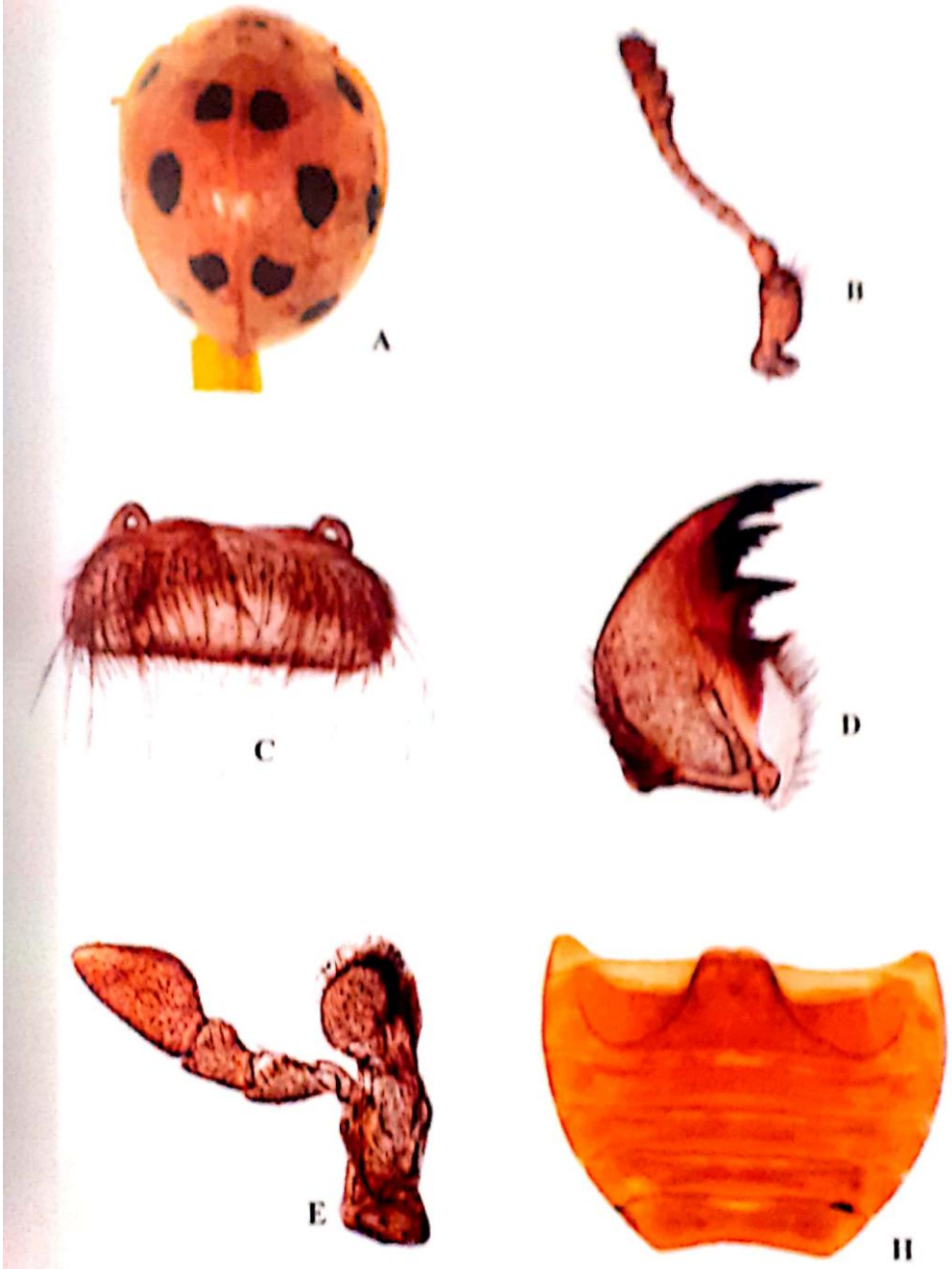
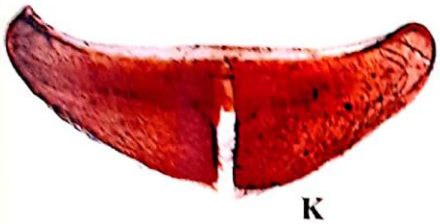


Plate 5a. ***Henosepilachna dodecastigma*** **(Wiedemann)**

A. Habitus; B. Antenna; C.. Labrum; D. Mandible; E. Maxilla; H. Abdomen- male

I

J



K

M

Plate 5b. ***Henosepilachna dodecastigma*** **(Wiedemann)**

I. Abdomen-female; J. Abdominal ventrite 6 – male; K. Abdominal ventrite 6 – female; M. Tegmen – lateral

Plate 5b. ***Hemosepilachna dodecastigma*** **(Wiedemann)**

N. Tegmen – ventral; O. Penis; P. Penis apex; Q. Female genitalia

Diagnosis: This species could be identified by yellowish redcolour with convex shaped body and black spots on elytra, well developed basal knife edge of the median lobe in male genitalia, compressed penis apex which is sharply pointed on one side like a nib.

Description: Relatively large, highly convex, pubescent, ground colour yellowish red; head without spots; pronotum with two to seven black spots arranged in a definite pattern; elytral spots pattern varies from 12-28 numbers, different morphotypes present, morphotype with only persistent spot, with persistent and some of the non-persistent spot, with all persistent and non-persistent spots; antenna with 11 antennomeres, third antennomere longer than others; mandiblemultidentate apically, dentulation on incisor edge; maxilla with ventral surface sparsely pubescent; terminal palpomere elongate, broadened apically or highly securiform; femur and tibia long and broad; tarsi cryptotetramerous; tarsal claws bifid with large basal tooth; abdomen with postcoxal line complete.

Male genitalia: Median lobe with distinct basal knife edge, then straight for most of its length except apex, which gently bent in a hook, parameres long, thick with short hairs on apex; penis tip compressed on one side, tapering like nib.

Female genitalia: Coxites have deep notch on inner side, sparsely pubescent on lower half, styli visible.

Measurements: Total length: 7.23mm, total width: 6.11mm, TL/TW: 1.18mm, PL/PW: 0.255mm, EL/EW: 1.74mm, EW/PW: 0.97mm.

Material: India: Kerala: 5♂, Kanjagad, 11. v.19 (BMP); 4♂,1♀, Padannakkad, 13. v.19, (BMP); 3♂,4♀ Anchal, 29.viii19 (BMP); 6♂, Vellanikkara, 25. vi.19 (BMP); 5♂,4♀, Vellayani, 08.viii19 (BMP&AKC); 1♀,2♂, Karimbara, 01. x.19 (BMP); 1♂, Perinjottakkal, 28.viii19 (BMP); 1♀,2♂, Muvattupuzha, 04.vii.19 (BMP).

Host: Bitter gourd (*Momordicacharantia*), wild coccinia and wild bitter gourd (*Momordicacharantia* var. *muricata*), salad cucumber (*Cucumissativus*) and ivy gourd (*Cocciniagrandis*).

Remarks: Different morphotypes are present. Male genital characters are used for identification. *Henosepilachaseptima*is similar to *H. vigintioctopunctata* in the

external appearance, but adults relatively larger and elytral tip is round and penis tip compressed on one side, tapering like nib.

4. 1. 2. 1. 1. 4. 3. *Henosepilachnavigintioctopunctata*Fabricius, 1775 (Plate 7a, 7b, 7c and 7d)

*Henosepilachnavigintioctopunctata*Fabricius, 1775: 40

Diagnosis: *Henosepilachnavigintioctopunctata*can be identified by following combination of characters: Body convex, yellowish brown in colour with moderately convex body. Elytra with mostly 12 spots arranged in a specific pattern, male genitalia with basal knife edge on the median lobe, siphon slightly bent at the apex.

Description: Body oval, strongly convex, dorsum pubescent; elytra orange to reddish brown with usually 12 spots on the elytra, spots vary in their arrangements, both persistent and non-persistent spots are present, some cases persistent and non-persistent together form large black patches, elytral tip angular, pronotum with seven black spots arranged as 2-2-1-2, spot no.4 not touching the elytral margin; antenna composed of 11 antennomeres, pedicel distinctly narrower than scape, antennomere thrird elongate, antennomeres 4-8 subquadrate or elongate; mandiblemultidentate apically, incisor edge multidentate; maxilla with ventral surface sparsely pubescent, terminal palpomereelongate, broadened apically or highly securiform; hind leg with femur and tibia elongate and pubescent; tarsi cryptotetramerous or pseudotrimerous, tarsal claws bifid with large basal tooth; abdomen with 6 ventrites in both sexes, abdominal postcoxal lines recurved roundly but complete, sixth abdominal ventrite of female fully or almost divided longitudinally in the middle.

Male genitalia: Penisguide almost equal to parameres, penis guide symmetrical usually hooked at apex; penis slightly bent at the apex.

Female genitalia: Coxites with notch towards inner side, styli present.

Measurements: Total length: 5.57mm, total width: 4.79mm, TL/TW: 1.16mm, PL/PW: 0.28, EL/EW: 1.95, EW/PW: 0.88.

Material: India: Kerala: 2♀, 1♂, Thavanur, 04.xii.19 (BMP);2♀, Vellayani, 08.viii.19, (AKC); 1♂,Sadananthapuram, 27.viii.19 (BMP);2♂,Anchal, 29.viii.19

Morphotype 1

Morphotype 2

Morphotype 3

Morphotype 4

Plate 6a. ***Henosepilacha septima*** **(Dieke)**

A. Habitus - different morphotypes

Morphotype 5

Morphotype 6

Morphotype 7

Morphotype 8

Plate 6b. ***Henosepilacha septima*** **(Dieke)**

A. Habitus - different morphotypes

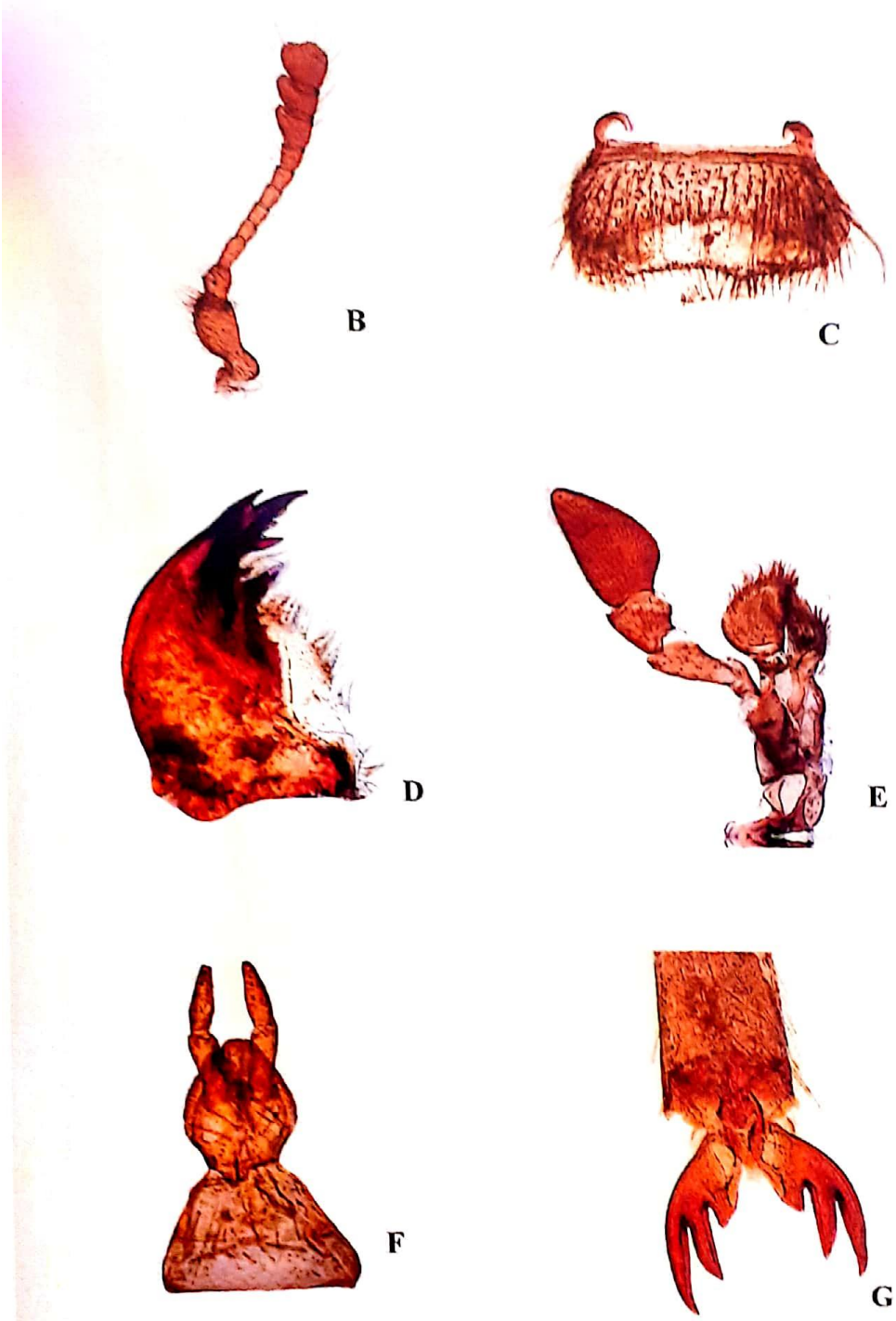


Plate 6c. ***Henosepilacha septima*** **(Dieke)**

B. Antenna; C. Labrum; D. Mandible; E. Maxilla; F. Labium; G Tarsal claw

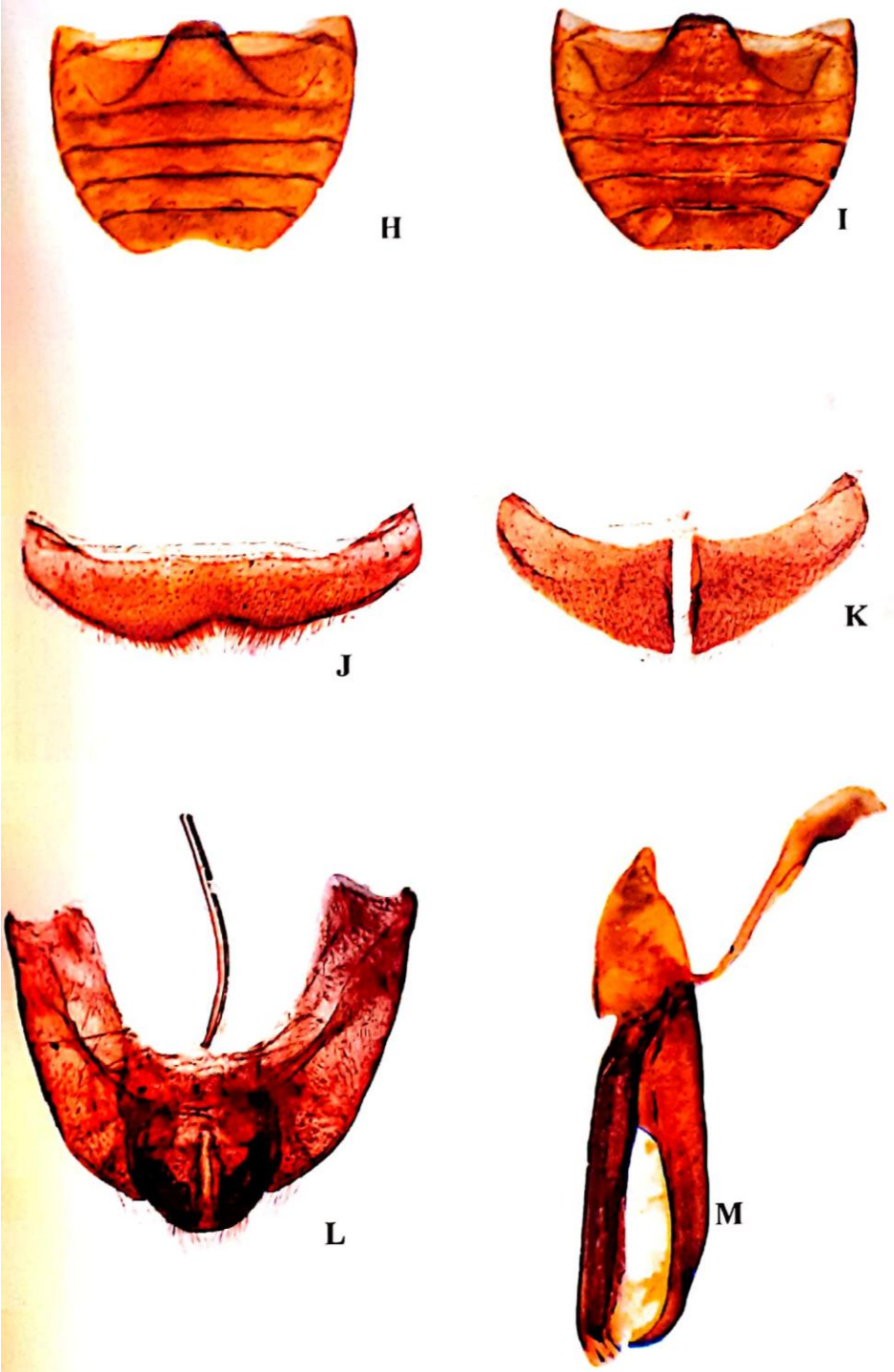


Plate 6d. ***Henosepilacha septima*** **(Dieke)**

H. Abdomen- male; I. Abdomen - female; J. Abdominal ventrite 6 - male; K. Abdominal ventrite 6 - female; L. Male genital segmen; M. Tegmen - lateral

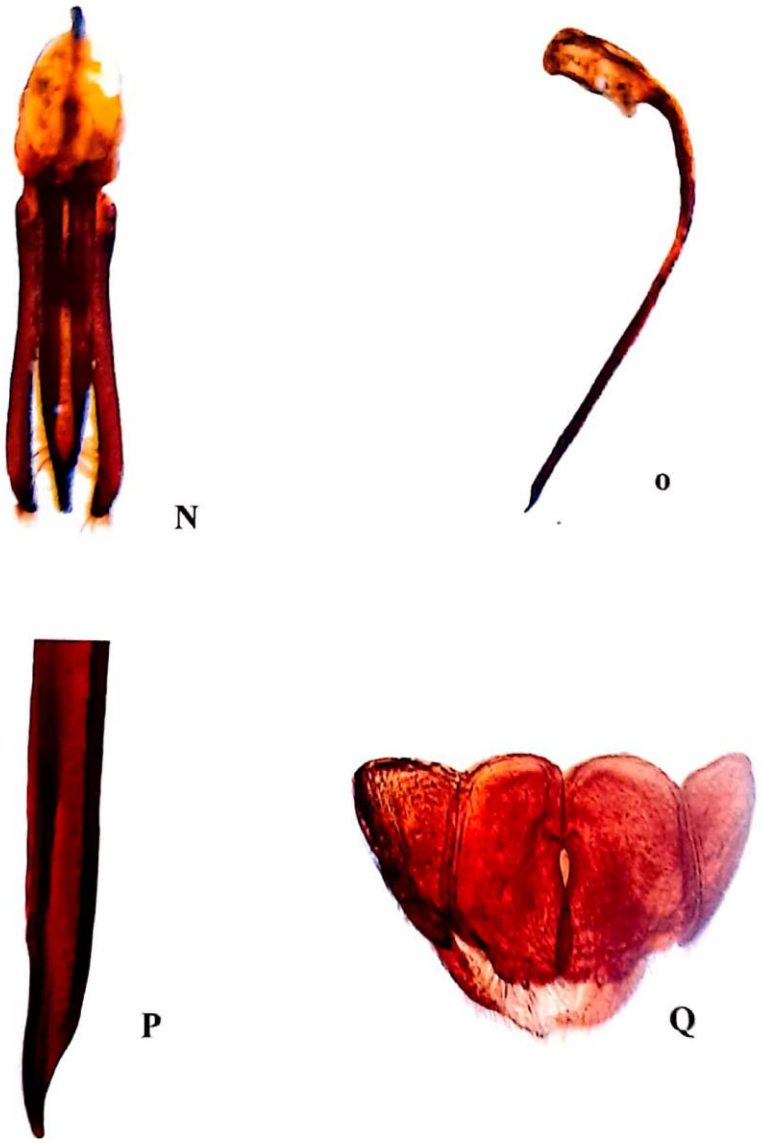
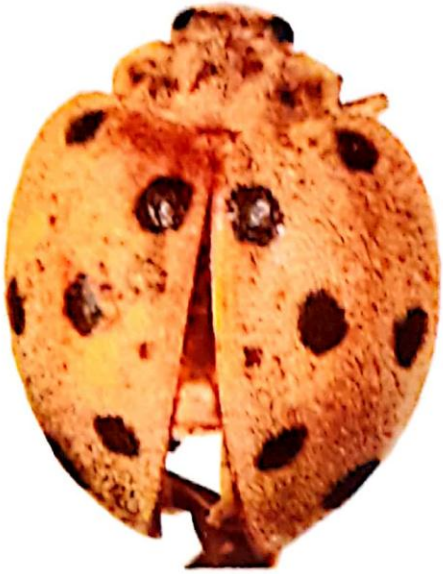


Plate 6e. ***Henosepilacha septima*** **(Dieke)**

N. Tegmen – ventral; O. Penis; P. Penis apex; Q. Female genitalia

Morphotype 1



Morphotype 2

Morphotype 3

Plate 7a. ***Henosepilachna vigintioctopunctata*** **(Fabricius)**

A. Habitus - different morphotypes

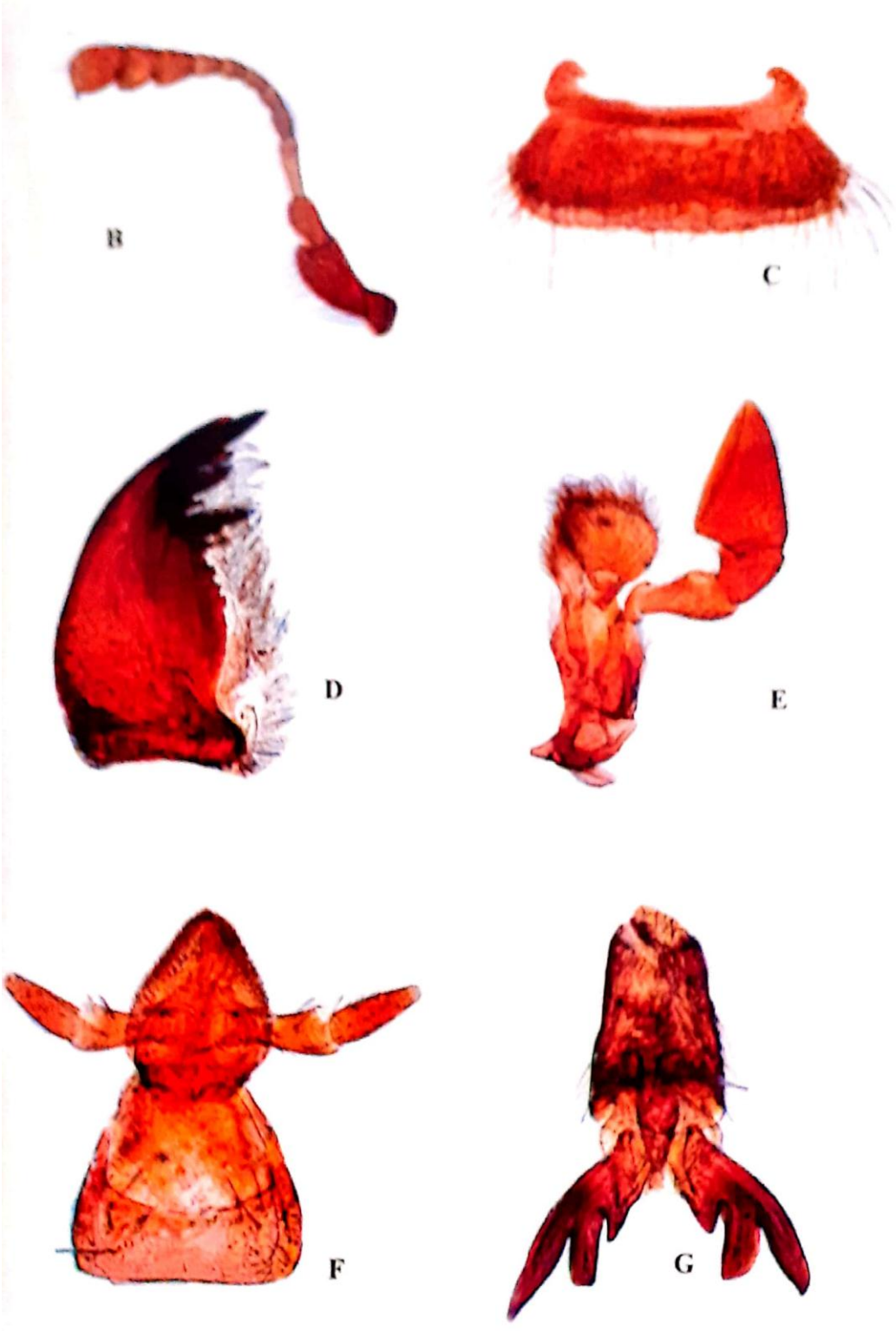


Plate 7b. ***Henosepilachna vigintioctopunctata*** **(Fabricius)**

B. Antenna; C. Labrum; D. Mandible; E. Maxilla; F. Labium; G. Tarsal claw

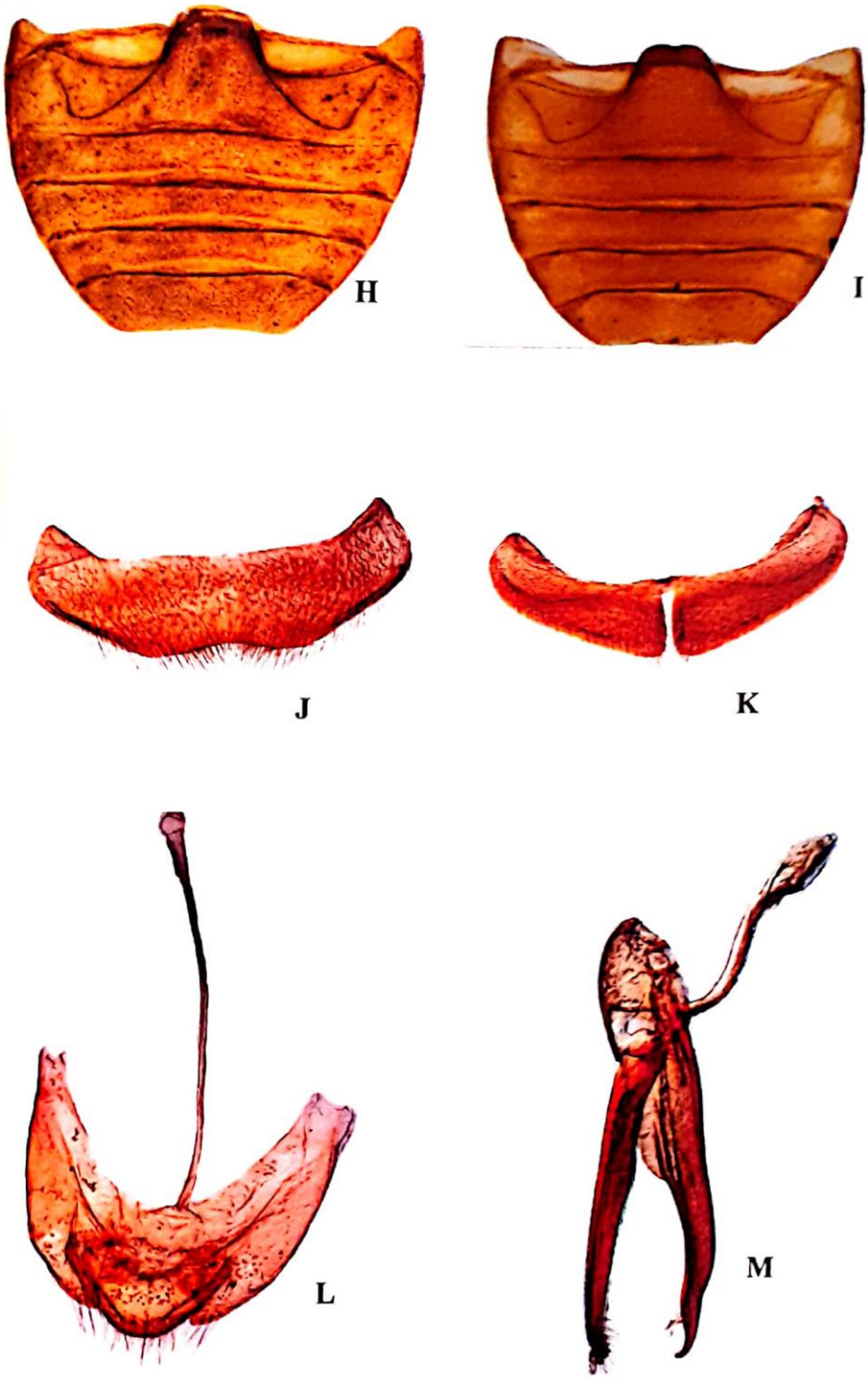
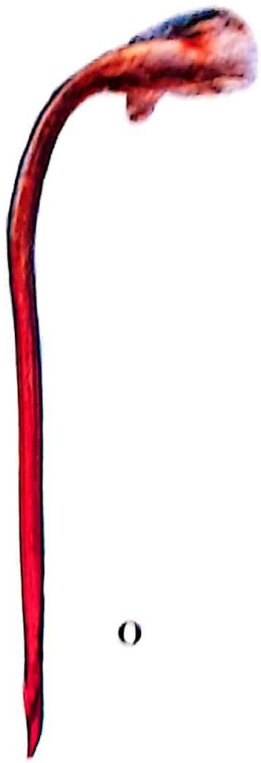


Plate 7c. ***Henosepilachna vigintioctopunctata*** **(Fabricius)**

H. Abdomen- male; I. Abdomen-female; J. Abdominal ventrite 6 – male; K. Abdominal ventrite 6 – female; L. Male genital segment; M. Tegmen – lateral

N



O

Q

Plate 7d. ***Henosepilachna vigintioctopunctata*** **(Fabricius)**

N. Tegmen – ventral; O. Penis; Q. Female genitalia

(BMP);1♂, Chingavanam, 10. x.19 (BMP); 3♂, Balaramapuram, 09.viii19 (BMP);2♂, 1♀, Vellanikkara, 22. vi.19 (BMP); 2♂, 1♀, Pampadampara, 14. v.19 (AH); 1♂, 1♀, Perinottakkal, 28.viii19 (BMP);2♀, Vellanikkara, 25. vi.19 (BMP).

Host: Brinjal (*Solanummelongena*), tomato (*Solanumlycopersicum*), ground cherry (*Physalisangulata*) and ashwaghantha (*Withaniasomnifera*).

Remarks: This species is separated from others species of *Henosepilachna* by male genitalia with penis apex bend and parameres of tegmen setose towards apex. Three different morphotypes of this species were collected in the present study.

4. 1. 3. Host range of species of Epilachnini

The host range and distribution of the species of Epilachnini were studied. In the present study, specimens were collected mainly from solanaceous and cucurbitaceous plants. Both grubs and adults were causing damage by scraping the green matter of leaves resulting in ladder like symptoms. Host plants and the location of collection of each species are given (Table 5). The host of Epilachnini included 14 plants belonging to the families *viz*., Cucurbitaceae, Fabaceae, Solanaceae, Poaceae and Urticaceae.

Species like *H. septima* and *H. vigintioctopunctata* were found to be common in the study area. *H. septima* was collected from bitter gourd (*Momordicacharantia*), wild coccinia, wild bitter gourd (*Momordicacharantia* var. *muricata*), salad cucumber (*Cucumissativus*) and ivy gourd (*Cocciniagrandis*). *Henosepilachnavigintioctopunctata* was found on brinjal (*Solanummelongena*), tomato (*Solanumlycopersicum*), ground cherry (*Physalisangulata*) and ashwaghantha (*Withaniasomnifera*). *Henosepilachnadodecastigma* was collected from ridge gourd (*Luffaacutangula*). *Afidentamisera*were found associated with cowpea (*Vignaunguiculata*), *Afidentulabisquadripunctata*with sugarcane (*Saccharumofficinarum*) and *Afissanilgirica*with common nettle (*Urticadioica*) and stinging nettle (*Pouzolziazeylanica*). *Henosepilachnavigintioctopunctata*and *H. septima*recorded wide host

Table 5. Host plant and geographical distribution of Epilachnini recorded during the study

Species	Host range	Distribution
Afidenta misera (Weise)	Cowpea	Kadampuzha, Parappa, Perinjottakkal, Vellanikkara
Afidentula bisquadripunctata (Gyllenhal)	Sugarcane	Raichur
Afissa flavicollis(Thunberg)	-	Locality labels were not available
Afissanilgirica (Weise)	Stinging nettle, common nettle	Avinissery, padannakad
Henosepilachna dodecastigma (Wiedemann)	Ridge gourd	Padannakad
Henosepilachnaseptima (Dieke)	Bittergourd, coccinia, salad cucumber, wild coccinia and wild bittergourd	Anchal, Kanjagad, Karimbara, Muvattupuzha, Parappa, Perinjottakkal, Sadananthapuram, Thavanur,Vellanikkara, Vellayani.
Henosepilachna vigintioctopunctata (Fabricius)	Aswaghantha, brinjal, ground cherry, tomato	Anchal, Balaramapuram, Chingavanam, Karimbara, Mangalore, Padannakkad, Pampadanpara, Perinjottakkal, Sadananthapuram, Thavanur, Thiruvillamala, Vellanikkara, Vellayan.

range among the species studied. Five hosts were recorded for *H. septima* whereas four hosts for *H. vigintioctopunctata*.

4.1.4. Distribution of species of Epilachnini

The distribution map prepared for the species of Epilachnini studied are given (Fig.7 and 8). *Henosepilachna septima* and *H. vigintioctopunctata* were recorded in almost all the locations of present study area.

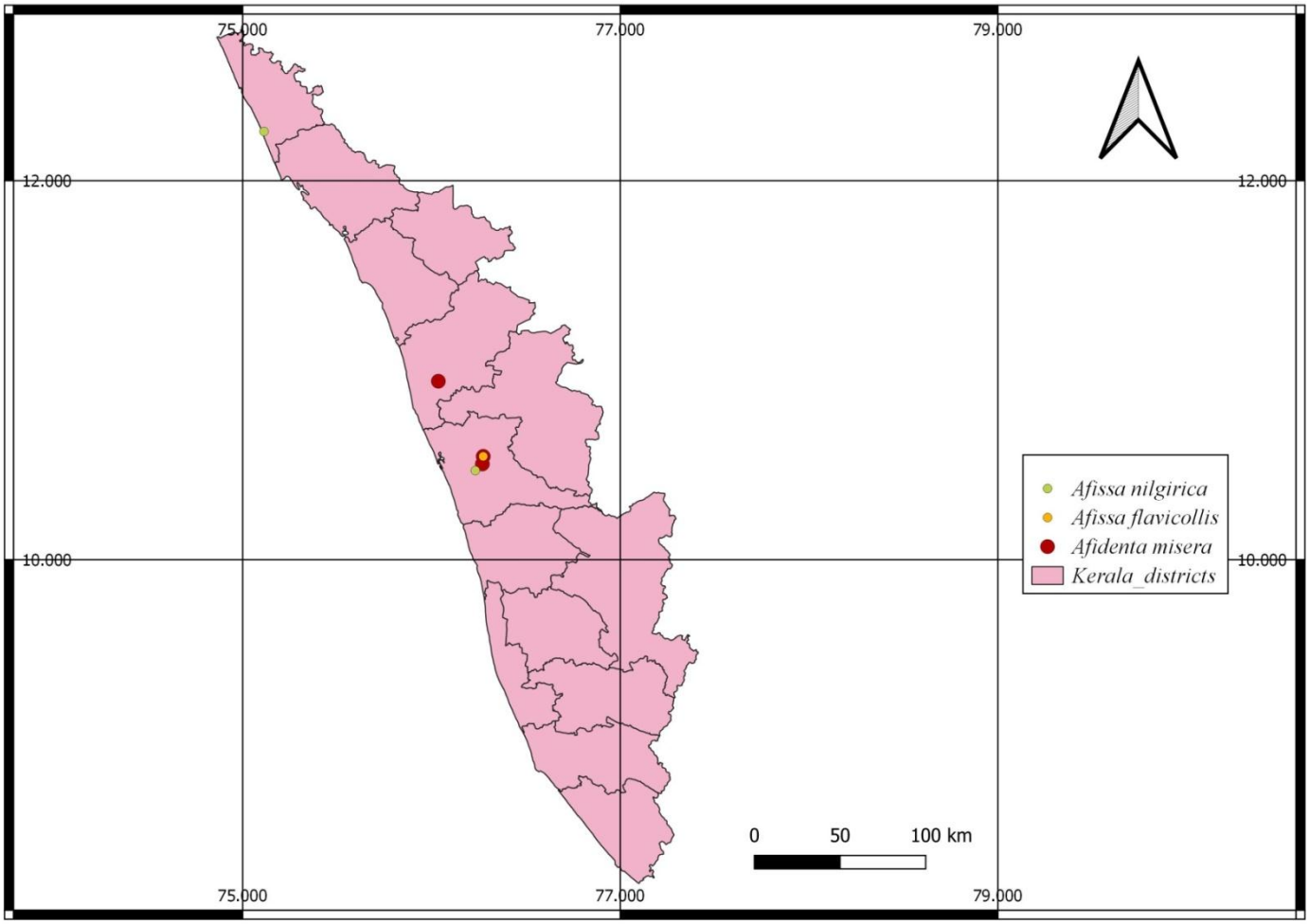


Fig. 7. Species distribution map of species of Epilachnini

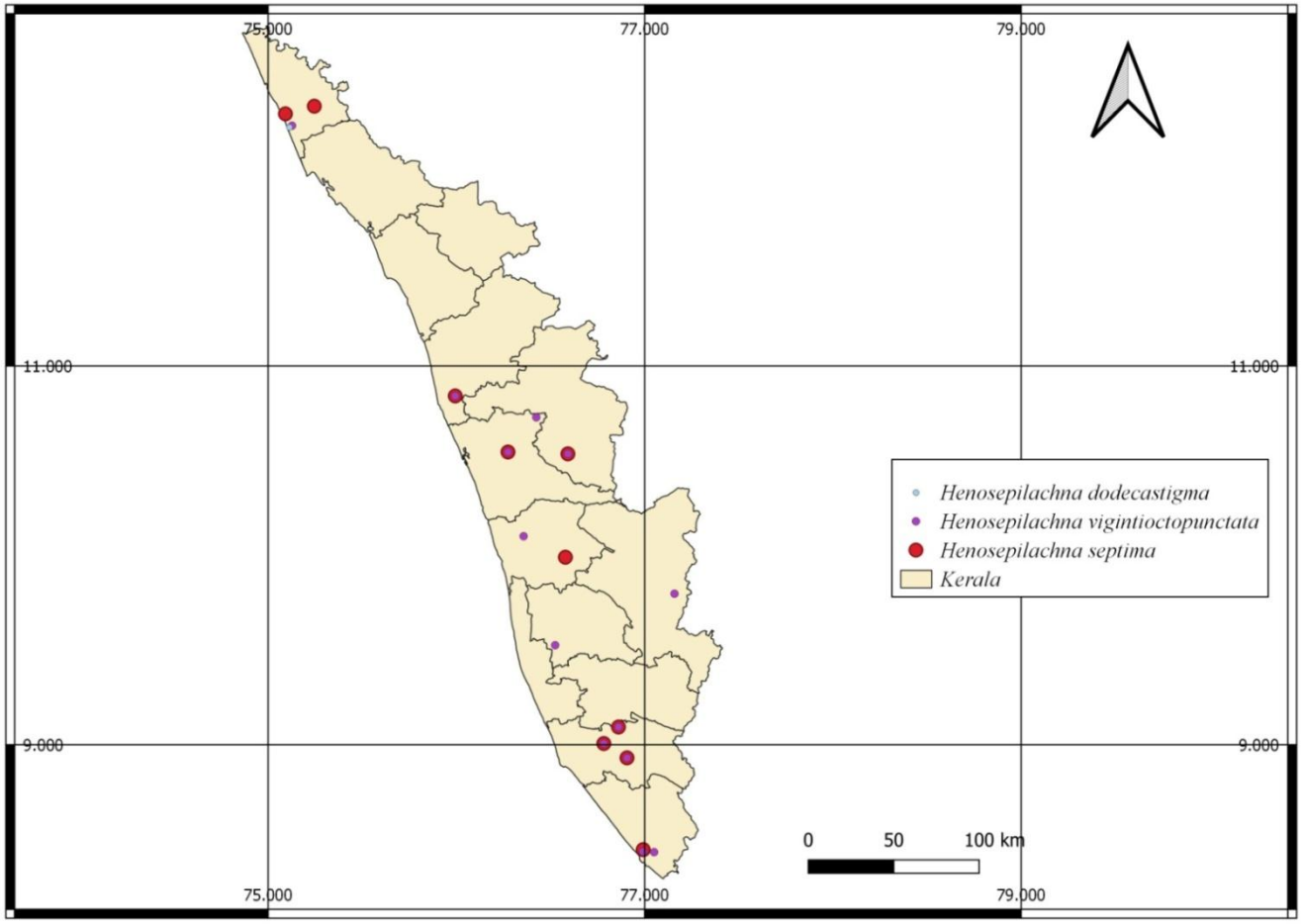


Fig. 8. Species distribution map of species of Epilachnini

Discussion

5. DISCUSSION

The research work on "Taxonomy of tribe Epilachnini (Coleoptera: Coccinellidae) of Kerala" was aimed to study the taxonomy of the tribe Epilachnini and its host range in different agricultural ecosystems of Kerala and to generate taxonomic key for different species of Epilachnini collected during the study. Surveys were carried out in 25 geographical locations, covering major agricultural ecosystems and representing 10 districts of Kerala, Taxonomy, host range and distribution of epilachna beetles collected during the study are discussed here.

5.1. Taxonomy

Epilachnini is a tribe of strictly herbivorous lady beetles (Coccinellidae) belonging to the subfamily Coccinellinae. Family Coccinellidae was classified under Cerylonid group or Cerylonid Series (C.S.), a group of beetle families within Cucujoidea, characterised by some common features (Crowson, 1955). Based on the comprehensive molecular analysis of cucujoid taxa, Robertson *et al*. (2015) erected a new superfamily Coccinelloidea to include former Cerylonid Series of Cucujoidea.

Epilachna beetles were categorized as a distinct group in Coccinellidae by many workers. Sasaji (1971), who put forth one of the most widely accepted classification of Coccinellidae, treated epilachna beetles as subfamily, Epilachninae. Seago*et al.* (2011) revised the classification of Coccinellidae and reduced the subfamily status of Epilachninae to tribe Epilachnini within subfamily Coccinellinae. Accordingly, four tribes*viz*., Epilachnini, Madaini, Epivertini and Eremochilini (Jadwiszczak and Wegrzynowicz, 2003) earlier recognized under Epilachninae were included in the tribe Epilachnini.

Epilachnini is the only phytophagous tribe under Coccinellidae. Both grubs and adults scrape the leaf lamina and the infestation can be identified by unique ladder like skeletonisation symptom. This tribe has well defined morphological characters in all developmental stages. Herbivorous behaviour, pubescent body,

multidentate mandibles without mola and trapezoidal mentum which is widest at its base help to separate epilachna beetle from other coccinellid beetles. Larvae of Epilachnini are easily distinguishable morphologically from other Coccinellidae by branched processes on dorsal and lateral surfaces of the body, head with epicranial stem, and multidentatemandibles without mola (Slipinski and Tomaszewska, 2010).

5.1.1. Tribe Epilachnini

The present study recognized eight species belonging to four genera *viz*., *Afidenta*, *Afidentula*, *Afissa*and *Henosepilachna*.

The characters studied for the separation of genera include mandible, leg, tegmen of male genitalia and sixth abdominal ventrite of female. The sexes were separated by the dimorphic feature of the sixth abdominal ventrite. In male, usually posterior margin of sixth abdominal ventrite is notched or emarginate, whereas it is entire in females.

Among different genera studied, genus *Henosepilachna*could easily be separated from other genera by the typical longitudinal division of sixth visible abdominal ventrite of females. Apart from this, presence of denticulation on the lateral margin of mandible, bifid tarsal claw with broad basal tooth, knife edge towards the base of tegmenwere also used for generic identification. *Afidentula*, *Afidenta*and*Afissa* could be distinguished by characters of mandible, legs and female genital segments. In *Afidentula*, mandibles are short, small with three apical teeth without serration or with weak serration on tooth, whereas in *Afidenta* and *Afissa* the mandibular teeth are with serrations. Denticulations in lateral margin of mandibles also vary in different genera. Lateral margin of mandibles are without denticulations in *Afissa*, whereas denticulations are present in *Afidenta*. In all the three genera, tarsal claw is bifid, but in *Afissa* tarsal claw is with or without basal tooth. In *Afidenta*, the basal tooth is sharp, whereas in *Afidentula* basal tooth is wide. Absence of tibial spur in *Afidentula*, legs without swollen hind femur and subtriangular shape of coxites in *Afissa* are also considered in separating the genera.

World fauna of Epilachnini consists of 1000 species under 27 genera ((Jadwiszczak and Wegrzynowicz 2003; Tomaszewska and Szawaryn, 2013; Tomaszewska and Szawaryn, 2016). Poorani (2012) included 79 species of epilachna beetles under six genera *viz*., *Afidenta*Dieke, *Afidentula*Kapur, *Afissula*Kapur, *Epilachna*Chevrolat, *Henosepilachna* Li and *Macrolasia* Weise from India in the check list of the Coccinellidae of Indian subregion. Recently, six more species were added to the Indian fauna of Epilachnini by Poorani and Thangjam (2019). Fauna of south Indian Epilachnini encompasses 26 species in five genera *viz*., *Afidenta*, *Afidentula*,*Epilachna*, *Henosepilachna* and *Macrolasia*, of which 12 species belonging to four genera *viz*., *Afidenta*, *Afidentula*,*Epilachna* and *Henosepilachna*, were reported from Kerala (Poorani, 2012).

As per the recent generic classification of Epilachnini proposed by Szawaryn*et al*. (2015), genus *Epilachna* is restricted to the New World speciesand does not occur in the Old World. In this study, the genus *Afissula* was synonymized with *Afissa*.According to the recent classification, the genera present in India could be *Afidenta*, *Afidentula*, *Afissa*, *Henosepilachna*and *Macrolasia*. Hence a revision of the tribe Epilachnini in India is suggested.

5.1.1.1. Genus*Afidenta* Dieke, 1947

Genus *Afidenta*is distributed in Asiatic region and this is a monotypic genus with only one species, *A. misera*. This study also identified the species, *A.misera*, which was collected from cowpea (Fabaceae).

Earlier, 39 species were included under the genus *Afidenta*, 37 from Africa and two from Asia. Molecular and morphology based research by Szawaryn*et al*. (2015), revised the African species of *Afidenta*as they formed a monophylectic group with *Afidentula*. The recent study of Wang *et al*. (2015) replaced one of the Asian species of *Afidenta*, *A. siamensis* (Dieke) to the genus *Afidentula*. Therefore *Afidenta*

includes presently only the type species. Study on taxonomy of Epilachna beetles from central Kerala reported *A. misera* on cowpea (Sreekala, 1997).

Male genitalia of *A. misera* is relatively short and stout compared to other species studied. Well-developedparamereswith short setae at apex, weakly curved penis narrowing towards apex and reduced penis capsule are important characters to identify this species. Other characters are reniform coxite, which is distinctly lessthan two times longer than wide and without styli.

5.1.1.2. Genus*Afidentula*Kapur, 1958

Genus *Afidentula*is distributed in South and South-Eastern Asia, Africa and Madagascar. *Afidentula bisquadripunctata* is the only species of *Afidentula* recognized during the present study. The specimen available in the Department of Agricultural Entomology, which was originally collected from Raichur, Karnataka on sugarcane was used for the study.

Until recently, only nine species of *Afidentula* have been reported from Asia (Tomaszewska and Szawaryn, 2013). In molecular studies by Szawaryn*et al*. (2015), four African species of *Afidenta* formed a monophyletic group with *Afidentula* and hence the authors suggested that all African species formerly classified in *Afidenta*could belong to the genus *Afidentula*. Similarly, some of the species of former *Epilachna* and *Henosepilachna* could also belong to the genus *Afidentula*.

Seven species of *Afidentula*have been reportedfrom India, of which only two species are from south India, *A. bisquadripunctata* and *A. minima*. *Afidentula bisquadripunctata* is the only species reported from Kerala (Anand *et al*., 1988).

Afidentulabisquadripunctata can be easily distinguished by its male genitalia. Penis guide is slightly bent or pointed towards apex in the lateral view, whereas apex with a shallow notch in the ventral view. Penis is thin, long, strongly curved and penis apex is submembraneous and pointed.

5. 1. 1. 3. Genus *Afissa* Dieke, 1947

Genus *Afissa* is distributed in South and South-Eastern Asia. Two species of *Afissa* have been recognized during the present study, *A. flavicollis* and *A. nilgirica*. *Afissanilgirica* was collected from plants belonging to Urticaceae *viz*., common nettle (*Urticadioica*) and stinging nettle (*Pouzolziazeylanica*), whereas the host data for *A. flavicollis* was not available.

Genus *Afissula* was recently synonymized with *Afissa* (Szawaryn*et al*., 2015). Most of the species formerly classified in *Afissula*and Asian *Epilachna*, now belong to the genus *Afissa*. Four species of *Afissulaviz*., *A.merkli*, *A. mysticoides*, *A. parvula* and *A. sanscrita* were reported from India (Poorani, 2012). As genus *Afissula* was synonymized with *Afissa*, these species will be now treated under the genus *Afissa*. Recently, three more species of *Afissa*were reported from North East region of India by Poorani and Thangjam (2019).

Poorani (2012) listed *Epilachnaflavicollis* and *E. nilgirica* in the check list of coccinellids of Indian subcontinent. These species may be *A. flavicollis* and *A. nilgirica*, respectively and the type specimens have to be studied to confirm the identity. Hence, revision of genus *Epilachna* is necessary to know more about the species of *Afissa* present in India.

Afissaflavicollis and *A. nilgirica* can be separated by studying the tarsal claw characters and male genitalia. Tarsal claw is bifid with a basal tooth in *A. flavicollis*, whereas tarsal claw is bifid without basal tooth in *A. nilgirica*. Penis guide with an incision at the apex and distinctly curved penis apex are unique for *A. flavicollis*.

5.1.1.4. Genus*Henosepilachna*Li, 1961

Genus *Henosepilachna* is distributed in East Asia, South Asia, Oceania and Australia. Three species of *Henosepilachna* have been recognized during the present study *viz*., *H. dodecastigma*, *H. septima* and *H. vigintioctopunctata*.

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Henosepilachna septima was found on plants belonging to Cucurbitaceae and *H. vigintioctopunctata*on solanaceous crops. In the present study, most of the specimens of *H. septima*were collected from bitter gourd, whereas *H. vigintioctopunctata* from brinjal. *Henosepilachna dodecastigma* was collected from ridge gourd. *Henosepilachnavigintioctopunctata* is a cosmopolitan species and distributed all over the world. *Henosepilachnaseptima*is distributed mainly in India, Sri Lanka and Vietnam, whereas *H. dodecastigma* has been reported from India and Bangladesh.

Many of the world fauna of epilachna beetles were included under the genus *Epilachna* and *Henosepilchna* and these were the two largest genera under Epilachnini. Szawaryn*et al*. (2015) split these two genera into multiple monophyletic clades and they were described as new genera. Hence revision of species under *Epilachna* and *Henosepilachna* is strongly suggested.

As per the earlier classification, ten species of*Henosepilachna*have been reported from south India, of which five species are from Kerala *viz*., *H. dodecastigma, H. nana, H. ornate, H. septima*and *H. vigintioctopunctata* (Poorani, 2012). Two species,*H. nana* and *H. ornate* reported from Nilgiris could not be collected during this study.

The works by Dieke (1947) were followed to study the persistent and non persistent spots on elytra and pronotum of genus *Henosepilachna*. Different morphotypes of *H. septima*and *H. vigintioctopunctata* were identified during the study. Maculation on elytra cannot be considered as a single character for species identification. Many times different species of *Henosepilachna* look identical in external appearance. *Henosepilachnaseptima* was found relatively larger compared to other two species. Male genitalia, especially nature of penis apex is significant in separating the species. In *H. septima* penis apex is sharply pointed on one side like a nib, whereas penis apex is slightly bent in *H. vigintioctopunctata*. The major characters for identifying *H. dodecastigma* are the persistent spot 4 of the elytra, which generally touches the external margin, male genitalia with median lobe dentulate dorsally and penis nearly straight at the apex.

5.2. Distribution and host range of species of Epilachnini

Epilachnini is a cosmopolitan tribe distributed throughout the world. But, species of Epilachnini are predominant in tropical and subtropical regions of the world with a few representatives from temperate zones (Gordon 1975). During this study, epilachna beetles were collected from different locations of study area and *H.septima* and *H. vigintioctopunctata* were the most common species collected. Many of the epilachna beetles of India, especially those species described under the genus *Epilachna* were reported from hilly regions. Most species of Epilachnini occur at the intersection of tropical forest ecosystems and mountain regions such as the Andes, the Himalayas or the region of the Great Rift Valley (Gordon 1975, Fursch 1991).

Many of the epilachna beetles are oligophagous, showing preference to plants belonging to a particular family. During this study, *Henosepilchnaseptima*was found associated withfive host plants belonging to Cucurbitaceae, and were commonly encountered in the study area, whenever the host plants were available. *Henosepilachnavigintioctopunctata* was collected on four plants belonging to Solanaceae, while *A. misera*, *Afidentula* and *Afissa* were collected on Fabaceae, Poaceae and Urticaceae respectively. *Henoepilachnaseptima* is reported from many cucurbitaceous plants like *Momordicacharantia* (Anand*et al*. 1988), *Luffacylendrica* (Naz *et al*., 2013) and *M. subangulata*(Katakura *et al*., 2001) and *H. vigintioctopunctata* from solanaceous crops like brinjal, potato, tobacco, tomato (NBAIR, 2019). However, *H. dodecastigma* feed on both cucurbitaceous and solanaceous plants (NBAIR, 2019). *Afidentamisera*was always collected from cowpea during the present study. Sreekala (1997) also reported *A. misera* from cowpea plants in Kerala. *Afidentulabisquadripunctata* was collected from sugarcane and the species is usually found associated with grasses (NBAIR, 2019). Some of the host plants reported for *A.bisquadripunctata*are *Apludamutica*L. (Poaceae) (Ren*et al*., 2009; Zang& Ou, 2010) and *Arthraxonhispidulus* (Thunb.) Makino (Poaceae) (Zang& Ou, 2010). Members of genus *Afidentula* usually prefer to feed plants belonging to Poaceae. However, *Afidentula decimaculata* Wang ans Cao is reported to feed on

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Colquhouniacoccinea Wall. belonging to Lamiaceae. (Tomaszewska and Szawaryn, 2013). Perusal of literature indicates that host records of *Affisa* are not well documented.

Though host plants of Epilachnini include members of Solanaceae, Cucurbitaceae, Fabaceae, Poaceae, Urticaceae, Convolvulaceae, Aristolochiaceae and Caryophyllaceae (Tomaszewska and Szawaryn 2016), during this study Epilachnini could not be collected on plants belonging toConvolvulaceae, Aristolochiaceaeand Caryophyllaceae.

Among the seven species collected during the study, two species viz., *H. vigintioctopunctata*and *H. septima* are considered as economically important causing significant damage to host plants, brinjal and bittergourd respectively in Kerala. *Henosepilachna vigintioctopunctata* is known throughout the eastern parts of Asia and Australia and is a very serious pest of plants of the family Solanaceae (Tomaszewska and Szawaryn 2016). It is estimated that extensive feeding by *H. vigintioctopunctata* (Fab.) on brinjal results in the reduction in photosynthetic area causing a decline in fruit yield by 60 per cent (Mall *et al*., 1992). The host range of *H. vigintioctopuncatata* recorded in the study suggests that in addition to brinjal, many less economically important plants/weed hosts that occur in crop fields support the pest species for sustaining their population in the absence of the main crop.This information would be helpful in pest management decisions.

Summary

6. SUMMARY

The present study on "Taxonomy of the tribe Epilachnini (Coleoptera: Coccinellidae) of Kerala" was undertaken in the Department of Agricultural Entomology, College of Horticulture, Vellanikkara during 2018-2020. The objectives to study the taxonomy of tribe Epilachnini in different agricultural ecosystems of Kerala and to prepare a key for the identification of the species of Epilachnini.

The works carried out and the salient findings are given.

- An extensive survey was carried out in 10 different districts of Kerala covering 25 locations in different agricultural ecosystems.The beetles were collected by hand picking and sweeping while the immature stages *viz.*, eggs, grubs and pupae were collected along with the associated host plants and reared to adult stage. Specimens were preserved by mounting on triangular card points and labelled with locality, date of collection, collector's name and host plant. The specimens were then dried in oven at 50-60ºC for 1-2 weeks and stored.
- Specimens available in the Department of Agricultural Entomology, College of Horticulture, Vellanikkaraand College of Agriculture, Padannakkad were also used for the study.
- The beetles were first grouped based on their host plant and elytral pattern.
- Measurements of adult specimens *viz*., total length, elytral length,elytral width, pronotal length and pronotal width were taken.
- Pattern of maculation on pronotum and elytra were studied for genus *Henosepilachna*
- The specimens were dissected following the standard procedure.
- Taxonomic characters *viz*., antenna, mouth parts, prosternum, leg, tarsal claw, post coxal line, male and female genitalia were studied and photographs of parts were taken.
- Descriptions and key to genera and species of Epilachnini were prepared.
- The specimens were identified upto species level based on the available literature and taxonomic keys.
- Host range and distribution of species were studied.

- The study recognized seven species belonging to four genera *viz*.,*Afidenta*, *Afidentula*,*Afissa*and *Henosepilachna*. Genus *Afidenta*was represented by one species, *Afidentamisera*. Genus *Afidentula* included *A. bisquadripunctata* and genus *Afissa* with *A. flavicollis* and *A. nilgirica*. *Henosepilachna*was represented by three species, *Henosepilachna dodecastigma, H.septima* and *H.vigintioctopunctata*
- A total of 14 host plants were found during the study. *Henosepilachnaseptima* was collected from cucurbitaceous crops *viz*., bitter gourd, wildcoccinia and wild bitter gourd, salad cucumber and ivy gourd. *Henosepilachnavigintioctopunctata* was found on solanaceous crops *viz*., brinjal, tomato, ground cherry and ashwaghantha. *Henosepilachnadodecastigma* was collected from ridge gourd (Cucurbitaceae). *Afidentamisera*were found associated with cowpea (Fabaceae), *Afidentulabisquadripunctata*with sugarcane (Poaceae) and *Afissanilgirica*with common nettle, and stinging nettle (Urticaceae). Wide host range was recorded for *H. septima*and *H. vigintioctopunctata*.
- Species distribution map was prepared for the species of Epilachnini collectedusing Quantum GIS software.
- *Henosepilachnaseptima* and *H. vigintioctopunctata* were the most widely distributed species.

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Appendix

APPENDIX I

GPS Coordinates of locations surveyed in Kerala

Districts	Location	Latitude (ºN)	Longitude (ºE)
Kasaragod	Kanhanagad	12.3311	75.0915
	Padannakkad	12.2566	75.1169
	Parappa	12.3714	75.2450
	Pilicode	12.1997	75.1633
Malappuram	Kadampuzha	10.9418	76.0363
	Thavanur	10.8526	75.9851
Thrissur	Avinissery	10.4706	76.2320
	Cherpu	10.4324	76.2045
	Elanad	10.6275	76.3956
	Mannuthy	10.5363	76.2651
	Nadathara	10.5052	76.2696
	Thiruvillamala	10.7279	76.4245
	Vellanikkara	10.5452	76.2740
Palakkad	Karimbara	10.5354	76.5921
	Nelliyampathy	10.5354	76.6936
Ernakulam	Muvattupuzha	9.9894	76.5790
Kottayam	Chingavanam	9.5248	76.5247
	Pampadampara	9.7967	77.1586

Idukki	Thankamani	9.8411	77.0349
Pathanamthitta	Pathanapuram	9.0927	76.8612
	Perinjottakkal	9.2267	76.8497
Kollam	Anchal	8.9300	76.9065
	Kottarakkara	9.0056	76.7831
	Sadananthapuram	8.9871	76.7821
Thiruvananthapuram	Balaramapuram	8.4321	77.0503
	Vellayani	8.4453	76.9925

TAXONOMY OF THE TRIBE EPILACHNINI (COLEOPTERA: COCCINELLIDAE) OF KERALA

By

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ABSTRACT OF THE THESIS

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ABSTRACT

Coccinellidae, the lady beetle, is the largest family under the superfamily Coccinelloidea and is rich with nearly 6000 described species worldwide. Coccinellids are ecologically and morphologically diverse and exhibit a wide range of food habits spanning kingdoms and trophic levels. Majority of them are predaceous, while some are phytophagous and some mycophagous. Strictly herbivorous coccinellids are recognized under the tribe Epilachnini.Both the grubs and adults of epilachna beetles scrape the soft tissue on the surface of leaves, masticate it and suck the juice. In spite of its economic importance, no comprehensive studies have been carried out so far to explore the diversity of Epilchnini of Kerala.

The study entitled "Taxonomy of tribe Epilachnini (Coleoptera: Coccinellidae) of Kerala" was carried out inthe Department of Agricultural Entomology, College of Horticulture, Vellanikkaraduring 2018-2020 with the following objectives: (1) taxonomy of the tribe Epilachnini in different agricultural ecosystems of Kerala and (2) prepare an illustrated key for the identification of the species of Epilachnini

Purposive surveys were conducted in different districts of Kerala covering 25 locations in different agricultural ecosystems.The adults were collected by hand picking and sweeping while the immature stages *viz.*, eggs, grubs and pupae were collected along with the associated host plants and reared to adult stage. Adults were usually collected from the upper surface of leaves whereas the immature stages from the lower surface. Wet and dry preservations were followed for temporary and permanent storage, respectively. The specimens were mounted on triangular card points and labelled with details on locality, date of collection, collector's name and host plant. The specimens were then dried in oven at 50-60ºC for 1-2 weeks and stored for further studies.Specimens available in the Department of Agricultural Entomology, College of Horticulture, Vellanikkara and College of Agriculture, Padannakkad were also used for the study.

The beetles were first grouped based on their host plant and elytral pattern. The specimens were then dissected and taxonomic characters *viz*., antenna, mouth

parts, tarsal claw, post coxal line, male and female genitalia were studied. Descriptions, illustrations and key to genera and species of Epilachnini of Kerala were prepared. The specimens were identified upto species levelbased on the available literature and taxonomic keys. Host range and distribution of species were studied and distribution map was prepared using Quantum GIS software.

The study recognized seven species belonging to four genera *viz*., *Afidenta* Dieke, *Affisa* Dieke,*Afidentula* Kapur and *Henosepilachna* Li. Three species under *Henosepilachna* were identified upto species level *viz*., *Henosepilachnadodecastigma* Wiedemann, *H. septima* Dieke and *H. vigintioctopunctata* Fabricius The species identified under *Afidenta* and *Afidentula* included *Afidenta misera* Weise and *Afidentula bisquadripunctata*. Two species studied under *Affisa*are *A. flavicollis* (Thunberg) and *A. nilgirica*(Weise). *Afissa nilgirica* was earlier described under the genus *Epilachna*. As per the new generic classification of Epilachnini this species belongs to *Afissa* and hence transferred to *Afissa* and this is a new combination.

Fourteen host plants were identified for Epilachnini in Kerala which included plants belonging to Fabaceae, Cucurbitaceae, Solanaceae, Poaceae and Urticaceae. Epilachna beetles exhibited oligophagy in their feeding habit, with each species showing preference to plants belonging to a particular family. *Henosepilachnavigintioctopunctata* always preferred solanaceous plants, whereas *H. septima* preferred cucurbitaceous plants. Similarly, *Afidenta misera* preferred plants belonging to Fabaceae and *Affisanilgirica* prefered members of family Urticaceae. *Henosepilachnaseptima* and *H. vigintioctopunctata*were found to be the most widely distributed species in the study area. Apart from crop plants, some of the weeds were also reported as the host plants of epilachna beetles. This study documented the faunal composition of Epilachnini of Kerala, their host range, and geographical distribution. The information generated can be effectively utilized in planning management strategy against epilachna beetles on major crops.