

**TAXONOMIC STUDIES ON
PREDACIOUS COCCINELLIDAE,
ORDER : COLEOPTERA**

By

G. CHANMAMLA

B.Sc., (Ag.)

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DEPARTMENT OF ENTOMOLOGY

**SRI VENKATESWARA AGRICULTURAL COLLEGE
ACHARYA N.G. RANGA AGRICULTURAL UNIVERSITY
TIRUPATI-517 502, (A.P), INDIA.**

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Certificate

Miss.G.CHANMAMLA has satisfactorily prosecuted the course of research and that the thesis entitled "**TAXONOMIC STUDIES ON PREDACIOUS COCCINELLIDAE, ORDER : COLEOPTERA**" submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that the thesis or part thereof has not been previously submitted by her for a degree of any university.

Date :

(Dr.V.RAMASUBBA RAO)
(Major Advisor)

Place :

Declaration

*I, Miss.G.CHANMAMLA hereby declare that the thesis entitled "TAXONOMIC STUDIES ON PREDACIOUS COCCINELLIDAE, ORDER : COLEOPTERA" submitted to Acharya N.G.Ranga Agricultural University, Hyderabad for the degree of **MASTER OF SCIENCE IN AGRICULTURE** majoring in **ENTOMOLOGY** is the result of original research work done by me. I also declare that the materials contained in this thesis have not been published earlier.*

Date :

(G.CHANMAMLA)

CERTIFICATE

This is to certify that the thesis entitled “**TAXONOMIC STUDIES ON PREDACIOUS COCCINELLIDAE, ORDER : COLEOPTERA**” submitted in partial fulfilment of the requirements for the award of degree of **MASTER OF SCIENCE IN AGRICULTURE** to the Acharya N.G.Ranga Agricultural University, Hyderabad, is a record of the bonafide research work carried out by **Miss.G.CHANMAMLA** under our guidance and supervision. The subject of the thesis has been approved by the Student’s Advisory Committee.

No part of the thesis has been submitted by the student for the award of any other degree or diploma. All assistance and help received during the course of the investigations have been duly acknowledged by the author of the thesis.

(Dr.V.RAMASUBBA RAO)
Chairman of the Advisory Committee

Thesis approved by the Student’s Advisory Committee

Chairman : **Dr.V.RAMASUBBA RAO**
Professor
Department of Entomology
S.V. Agricultural College
Tirupati-517 502, A.P.

Member : **Dr.K.MANJULA**
Associate Professor
Department of Entomology
S.V. Agricultural College
Tirupati-517 502, A.P.

Member : **Dr.N.P.ESWARA REDDY**
Professor & Head
Department of Plant Pathology
S.V. Agricultural College
Tirupati-517 502, A.P.

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CONTENTS

Chapter No.	Title	Page No.
I	INTRODUCTION	
II	REVIEW OF LITERATURE	
III	MATERIALS AND METHODS	
IV	RESULTS	
V	DISCUSSION	
VI	SUMMARY	
	LITERATURE CITED	

LIST OF ILLUSTRATIONS

Fig. No.	Title	Page No.
1	<i>Brumoides suturalis</i> (Fabricius)	
2.	<i>Chilocorus nigritus</i> (Fabricius)	
3A&B.	<i>Coccinella septempunctata</i> Linnaeus	
4A,B,C&D	<i>Coccinella transversalis</i> Fabricius	
5.	<i>Harmonia octomaculata</i> (Fabricius)	
6.	<i>Illeis cincta</i> (Fabricius)	
7A & B	<i>Micraspis discolor</i> (Fabricius)	
8A, B,C, D & E	<i>Cheilomenes sexmaculata</i> (Fabricius)	
9.	<i>Propylea sp.nr. japonica</i> (Thunberg)	
10.	<i>Pseudaspidimerus trinotatus</i> (Thunberg)	
11.	<i>Cryptolaemus montrouzieri</i> Mulsant	
12.	<i>Scymnus (Scymnus) nubilus</i> Mulsant	
13.	Species composition of Coccinellid predators in and around Tirupati	
14.	Species composition of Coccinellid predators in groundnut ecosystem	

LIST OF PHOTOS

Photo No.	Title	Page No.
1	<i>Brumoides suturalis</i> (Fabricius)	
2.	<i>Chilocorus nigritus</i> (Fabricius)	
3A&B.	<i>Coccinella septempunctata</i> Linnaeus	
4A,B,C&D	<i>Coccinella transversalis</i> Fabricius	
5.	<i>Harmonia octomaculata</i> (Fabricius)	
6.	<i>Illeis cincta</i> (Fabricius)	
7A & B	<i>Micraspis discolor</i> (Fabricius)	
8A, B,C, D & E	<i>Cheilomenes sexmaculata</i> (Fabricius)	
9.	<i>Propylea sp.nr. japonica</i> (Thunberg)	
10.	<i>Pseudaspidimerus trinotatus</i> (Thunberg)	
11.	<i>Cryptolaemus montrouzieri</i> Mulsant	
12.	<i>Scymnus (Scymnus) nubilus</i> Mulsant	

ABSTRACT

Author	:	G. CHANMAMLA
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“Taxonomic studies on predacious Coccinellidae, Order : Coleoptera” were under taken at the Department of Entomology, S.V. Agricultural College, Tirupati during 2007-2009. In the present study, 12 Coccinellid species belonging to eleven genera, under four tribes of the family Coccinellidae are collected and identified. They, are *Brumoides suturalis* (Fabricius), *Chilocorus nigritus* (Fabricius), *Coccinella septempunctata* Linnaeus, *Coccinella transversalis* Fabricius, *Harmonia octomaculata* (Fabricius), *Illeis cincta* (Fabricius), *Micraspis discolor* (Fabricius), *Cheilomenes sexmaculata* (Fabricius), *Propylea sp. nr. japonica* (Thunberg), *Pseudaspidimerus trinotatus* (Thunberg), *Cryptolaemus montrouzieri* Mulsant and *Scymnus (Scymnus) nubilus* Mulsant.

All the 12 Coccinellid species are described and illustrated. A key for distinguishing all these Coccinellid species with line diagrams and colour photographs are given for easy identification.

Among these 12 species of Coccinellids, *Coccinella transversalis* Fabricius (38%) and *Cheilomenes sexmaculata* (Fabricius) (34%) are the most abundant species in and around Tirupati in different agro-ecosystems followed by *Illeis cincta* (Fabricius) (6%). Five species viz., *Coccinella septempunctata* Linnaeus; *Coccinella transversalis* Fabricius; *Harmonia octomaculata* (Fabricius); *Micraspis discolor* (Fabricius) and *Cheilomenes sexmaculata* (Fabricius) are recorded in groundnut crop ecosystem feeding on aphids, *Aphis craccivora* and leafhoppers, *Empoasca* (*Empoasca*) *motti* Pruthi. Among these species, *Coccinella transversalis* Fabricius is abundant recording 52% of population followed by *Cheilomenes sexmaculata* (Fabricius) (29%).

CHAPTER – I

INTRODUCTION

Coccinellids belong to the family Coccinellidae of the order Coleoptera and are commonly called as ladybird beetles. These are oval to hemispherical in shape with clavate antennae, securiform maxillary palpi and pseudotrimerous tarsi and often brightly coloured with red, orange or yellow elytra frequently spotted black or yellow striped. The Coccinellids are extremely diverse in their feeding habits. The great number of the coccinellid species are predaceous and beneficial from the view point of biological control of pests, feeding during both larval and adult stages upon aphids, scale insects, psyllids, mites etc. Members of a relatively small sub-family Epilachninae are herbivorous and occur as serious pests of agricultural crops.

The predaceous Coccinellids have been successfully employed in the biological control of some herbivorous insects. The spectacular success of the vedalia beetle [*Rodalia cardinalis* (Mulsant)] was in fact the harbinger of classical biological control. Several coccinellids have been successfully introduced in different parts of the world in classical biological control programmes. In 1889, *Rodolia cardinalis* (Mulsant) was introduced to California for combating the cottony cushion scale, *Icerya purchasi* Maskell the destructive pest of citrus and pear (Kapur, 1942). In India also, this scale insect was found notorious in 1929 and it was successfully kept under check with the introduction of *Rodalia cardinalis* from California

(Kapur, 1942). The species, *Cryptolaemus montrouzeri* Mulsant is another coccinellid which was a well known and historically important predator of mealybugs. Since its first introduction into California in 1891 from Sydney, Australia, by Albert Koebele and subsequent introduction in 1893 to Hawaii, it has been imported into over 40 countries throughout the world to combat mealybugs *Planococcus citri* (Risso).

The composition of predacious Coccinellids vary widely among agro ecosystems. The dependence of any species on a given habitat is mainly determined by the occurrence of prey and the abiotic factors. The relationship of many species to habitat can vary in different regions of their distribution and also in different ecosystems. Though, this group of insects has been studied by several workers, no systematic survey to study the fauna of Coccinellids in and around Tirupati of Chittoor district, Andhra Pradesh and their species composition in different crop ecosystems have been made. Hence, the present study was undertaken to fill up this gap with the following objectives:

1. To study the taxonomy of coccinellid predators in and around Tirupati and their identification.
2. Preparation of taxonomic key for the identification of these coccinellid predators.
3. Study the species composition of coccinellid predators associated with groundnut crop eco-system.

CHAPTER – II

REVIEW OF LITERATURE

The literature dealing with the taxonomy of Coccinellid beetles and their classification is briefly reviewed in this chapter.

Mulsant (1846) first time provided the system of classification of the family Coccinellidae under the group securipalpes. In 1850, he divided the family into two major divisions namely Trichosomides and Gymnosomides based on the presence or absence of the dorsal pubescence. Crotch (1874) proposed seven subfamilies of Coccinellidae *viz.*, Rhizobiides, Chilocordies, Exoplectrides, Scymnides, Coccinellides, Thyllhaspides, Hyperaspides. Chapius (1876) subdivided the Coccinellidae into phytophages and aphidophages. He further subdivided the aphidophages into 13 groups as follows: Hippodomiites, Hyperaspites, Chilocorites, Cranophorites, Coccidulites, Coccinellites, Cariites, Discotomites, Poriites, Ortaliites, Bucolites, Scymnites and Chnoodites.

Weise (1879) divided the Coccinellidae into two groups *viz.*, Coccinellidae phytophage and Coccinellidae aphidophage. The Coccinellidae aphidophage further divided into 7 groups as follows : Synonychini, Chilacorini, Coccinellini, Hippodamini, Rhizobiini, Hyperaspini and Scymnini. Weise (1900) also included first time the tribal names Clanini,

Sticholotini and Aspidimerini. Casey (1899) divided the family Coccinellidae into 16 tribes without recognizing any subfamilies. Ganglbauer (1899) proposed an independent subfamily Lithophilinae for *Lithophilus* based on its tetramerous tarsi.

Dobzhansky (1924) separated the tribe Stethorini for the genus *Stethorus* Weise based on the structure of the female genital organs. Korschefsky (1931 and 1932) arranged the Coccinellidae as follows: Coccinellinae : Coccidulini (23 genera), Scymnini (20 genera), Noviini (5 genera), Aspidimerini (5 genera), Hyperaspini (8 genera), Pentiliini (2 genera), Clanini (1 genus), Azyini (2 genera), Exoplectrini (10 genera), Cranophorini (8 genera), Oeneini (9 genera), Pharini (20 genera), Discotomini (5 genera), Patynaspini (2 genera), Synonychini (30 genera), Coccinellini (15 genera), Psylloborini (13 genera), Chilacorini (15 genera); Epilachninae (10 genera); Lithophilinae (one genus). Many authors have followed the Korschefsky's system in their studies on Coccinellidae.

Sasaji (1968) recognized a new system based on phylogeny, comparative morphology of both larvae and adults. He proposed six subfamilies and 19 tribes as detailed below.

Sl. No.	Subfamilies	Tribes
1.	Epilachninae	Epilachnini
2.	Coccidulinae	Noviini, Coccidulini, Lithophilini, Exoplectrini.
3.	Sticholotinae	Shirozuelli, Scrangini, Sukunahikonini, Sticholotini.
4.	Coccinellinae	Coccinellini, Psylloborini.
5.	Chilocorinae	Chilocorini, Telsimiini, Platynaspini
6.	Scymninae	Scymnini, Hyperaspini, Aspidimerini, Ortalinii, Stethorini.

2.1. GENERA AND SPECIES OF PREDACIOUS COCCINELLIDAE WITH SPECIAL REFERENCE TO SOUTH INDIA

Subramaniam (1923) gave a list of some Coccinellids of South India along with their host and distribution. Ayyar (1924) described a new species, *Scymnus coccivora* preying on the neem scale, *Chloropulvinaria maxima* (Green). Kapur (1948a) studied the old world species of the genus *Stethorus* Wise and described 12 new species.

Kapur (1948b) revised Indian species of *Rodolia* Mulsant and added three new species. Puttarudriah and Channabasavanna (1953) studied the beneficial Coccinellids of Mysore-I. They (1955 and 1956) also recorded 53 species in 23 genera grouped in eight tribes and five subfamilies. Usman and Puttarudriah (1955) listed 48 species of predaceous Coccinellidae from the erst while Mysore state.

Kapur (1954) provided notes on systematics and biology of ladybird beetles predaceous on the San Jose scale, *Quadraspidiotus perniciosus* (Comstock) in Kashmir. *Stethorus keralicus* Kapur feeding on areca palm mites was described as a new species by Kapur (1961).

Kapur and Rao (1962) described *Adalia simmondsi* as a new species feeding on *Adelges* spp. in North Western India. Sudha Rao (1962) studied the status of *Coccinella septempunctata* L. and its varieties *Divaricata oliv.* and *Confusa wied* at Bangalore. *Psudoscymnus* was described as a new genus of the tribe Scymnini by Chapin (1962). Monographic treatment of the Coccinellid fauna of Micronesia was given by Chapin (1965b) which includes 48 species under 24 genera.

Bielawski (1964) given a review of the new Guinean species of the genus *Harmonia* Mulsant. Chelliah (1963) described the male genitalia of four species of Coccinellids viz., *Pullus coccindivora* Aiyar, *Pullus quadrillum* Motschulsky, *Pharoscymnus horni* Weise and *Nephus regularis* Sicard. Kapur (1967) provided a check list of Coccinellidae of Andaman Islands. Nagaraja and Hussainy (1967) studied six species of *Chilocorus* predaceous on San Jose and other scale insects.

Kapur and Munshi (1970) described a new species, *Scymnus (Pullus) nymphaeus* predaceous on the aphid, *Rhopalosiphum nymphaeae* (Linnaeus) in Calcutta. Ahmed (1970) described a new species *Pharoscymnus simmondsi* preying on scale insects in Pakistan.

Sasaji (1971) provided keys for the sub-families, tribes, genera and species of the order old Coccinellidae. Kapur (1972) recorded 17 species of Coccinellidae from Goa. Ghorapade (1974) described a new species, *Cryptogonus kapuri* of the tribe Aspidimerini from Bangalore. He provided a key to the known species of *Cryptogonus bilineatus* group. Ghorapade (1976) described a new species of *Illeis* from South India. He also described a new species *Pseudoscymnus devipakalpa* preying on *Aspidiotus destructor* Signoret from Bangalore. Greathead and Pope (1977) studied on the biology and taxonomic problems of some species of *Chilocorus* preying on scales *Aulacaspis* spp. in East Africa.

Gordon (1978) described West Indian Coccinellidae, scale predators representing five tribes, one new genus and four new species were described and also provided key to the genera and species. Natarajan and Mathur (1981) recorded occurrence of predaceous Coccinellid beetles on brown plant-hopper in India. Samal and Misra (1981) described *Coccinellia repanda* Thunb., a predatory coccinellid beetle of rice brown planthopper, *Nilaparvata lugens* (Stal.)

Pajni and Singh (1982) recorded 30 species of Coccinellidae that belong to 18 genera and 2 subfamilies from Chandigarh. Gordon and Chapin (1983) revised the mite feeding coccinellid genus *Stethorus* in Western hemisphere recognizing 21 species of which 11 were new to the science.

Vazirani (1983) described *Sticholotis chittagongi sp. n.* a predator on aphids on *Ziziphus* in Bangalore. Pajani and Verma (1985) studied on the structure of male genitalia in some Indian coccinellid species in Chandigarh. Miyatake (1985) described 46 species of Coccinellids in Nepal. Of these nine species were new. Yoon and Park (1985) revised the sub-family of Coccinellinae from Korea.

Booth and Pope (1986) reviewed the genus *Cryptolaemus*, redefined as two species groups. The first, the *montrouzeri* group, comprising *C. montrouzeri* Mulsant, *C. affinis* Crotch, *C. wallacei* Crotch, *C. simplex* Blackburn, *C. sinestria* Booth and Pope and *C. crotchi* Booth and Pope. The second group comprises of *C. subviolaceus* Crotch and *C. concinnus* Weise and *C. engelhardi* Gorham was transferred to the Chilocrine genus *Brumoides* Chapin. Canepari (1986) studied the type material of 36 species of Coccinellidae from North Indian and Nepal in the Geneva Museum.

Pope (1987) revised species in Coccinellidae treated by Thunberg preserved in the University of Uppsala, Sweden and made several taxonomical changes. In 1988, revised the Coccinellidae in Australia. Booth and Pope (1989) revised the Coccinellidae described by Pope and Mulsant in the Hope Entomological Collections, Oxford.

Booth (1991) described a new genus and species *Aponephus lentiformis* of the tribe Scyminini associated with *Rostrococcus* spp. in Southern India. Tarlok Singh and Phaloura (1990) provided a key to the larvae of four spp. of the genus *Harmonia* Mulsant. It includes *H. sedecimnotata* (Fabricius), *H. eucharis* (Mulsant), *H. dimidiata* (Fabricius) and *H. quadripunctata* Pontoppidan.

Poorani (2001) reviewed the genus *Pseudaspidimerus* Kapur from the Indian sub-region with description of a new species *Pseudaspidimerus infuscatus*. She (2002a) also reviewed the genus *Oenopia* Mulsant of the Indian subcontinent, with description of a new species *Oenopia adelgivora* from Sikkim. She (2002b) also provided the checklist of the Coccinellidae (Coleoptera) of the Indian Subcontinent comprising 400 species (including subspecies) under 79 genera, 22 tribes and five subfamilies. The current combination, original citation, synonyms, distribution and type depository were also given for the included species. Three new specific synonymies

(*Harmonia breiti* Mader = *H. expallida* (Weise) ; *Ortalia yunnanensis* Pang and Mao = *O. horni* Weise; and *scymnus picescens* Gorham = *S. fuscatus* Boheman), one generic synonymy (*Aponephus* Both = *Nephus* Mulsant) and six new combinations (*Coelophora persotteti* Mulsant and *C. unicolor* (Fabricius) with *Phrynocaria* Timberlake, *Platynaspis bimaculata* Pang and Mao with *Platynaspidius* Miyatake, *Aponephus lentiformis* Booth with *Nephus* Mulsant, *Pseudoscymnus luteoniger* Canepari with *Clitostethus* Mulsant and *Sukunahikona popei* Vazirani with *Scotoscymnus* Weise) were proposed.

Sunil Joshi *et al.* (2001) for the first time recorded *Sticholotis cribellata* as a potential predator of sugarcane scales, *Melanaspis glomerata* in Bangalore. Inamulla Khan *et al.* (2003) described 12 different species belonging to nine genera of three tribes and three subfamilies. Eight species belongs to Coccinellinae and 3 species belongs to Chillocorinae, one species belongs to Psyloborini in Pakistan.

Queno-Jose *et al.* (2005) studied diversity of predatory Coccinellids in vegetable fields in Kerala, South India. Mani and Krishnamoorthy (2008) studied *Cryptolaemus montrouzeri* Mulsant preying on mealybugs *Coccidohystrix insolitus* and *Maconellicoccus hirsutus* on *Hibiscus rosasinensis* in Bangalore.

2.2 THE COCCINELLID FAUNA ASSOCIATED WITH GROUNDNUT ECOSYSTEM

Puttarudriah and Channa Basavanna (1953, 1955, 1956) reported several species of Coccinellids from different habitats in Karnataka. He reported 5 species on groundnut *viz.*, *Coccinella transversalis* Fabricius, *Cheilomenes sexmaculata* (Fabricius), *Harmonia octomaculata* (Fabricius), *Micraspis sp. discolor* complex and *Coccinella septempunctata* Linnaeus.

2.3 PREY RECORDS OF PREDACEOUS COCCINELLIDAE

Coccinellids are typically predators of Homoptera such as aphids, scale insects and leafhoppers. Apart from that they also prey on young larvae of Lepidoptera, Hymenoptera, some Diptera, Thysanoptera and Coleoptera.

Andrews (1920) was the first to observe *Cheilomones sexmaculata* preying on mites. Schilder and Schilder (1928) reported a detailed account of prey eaten by many Coccinellids. Ayyar (1924) observed *Scymnus coccivora* Ayyar to feed on *Chloropulvinaria maxima* (Green). Puttarudriah *et al.* (1952) reported occurrence of *Cryptolaemus montrouzeri* Mulsant near Bangalore. Observations showed that this predator was particularly abundant on *Pulvinaria psidii* Maskell and *Pseudococcus spp.* in guava and mango orchards.

Puttarudriah and Channabasavanna (1953 and 1955) reported many coccinellid predators along with their hosts. Kapur (1954) described a new species of Coccinellidae, *Catana chapini* predated on citrus whitefly, *Dialeurodes citri*. During the course of survey of the natural enemies of *Adelges* spp. the coccinellid, *Adalia simmondsi* was reported as new species by Kapur and Sudha Rao (1962) from Himachal Pradesh. Vasantharaj David and Janagarajan (1966) reported a new host *Doctynotus carthami* HRL for the predatory coccinellid *Brumus suturalis* Fabricius from Kovilpatti, Madras.

Kazimi and Ghani (1964) reported *Cheilomenes sexmaculata* (Fabricius) on brinjal, *Hibiscus* sp. and *Cucurbita pepo* attacked by mites at Rawalpindi. Nagaraja and Hussainy (1967) recorded six species of *Chilocorus* feeding on the San Jose scale and other scales from Bangalore. *Chilocorus nigritus* (Fabricius), *C. rubidus* Hope, *C. Kuwanae* Silvestri, *C. bijugus* Mulsant, *C. hauseri* Weise, *C. circumdatus* Schonherr.

Rawat and Modi (1968a) reported *Roddia fumida* Mulsant prey upon *Perissopneumon tamarindus* (Green) from Madhya Pradesh. They (1968b) also revised the coccinellid predators *Nephus regularis* (Sicard), *Hyperaspis maindroni* Sciard and *Scymnus (Pullus), coccivora* Aiyar as natural enemies of *Ferrisia virgata* (Cockerell) in Jabalpur, Madhya Pradesh.

Ahmed (1970) during the course of studies on scale insects and their natural enemies in West Pakistan, *Pharoscymnus simmondsi*. Ahmed was found to be predaceous on *Aonidiella orientalis*. Ghose (1972) observed *Brumoides suturalis* (Fabricius) and *Scymnus sp. nr. nubilis* Mulsant as natural enemies of *Maconellicoccus hirsutus* (Green) in West Bengal.

Ahmed (1973) allied a new tribe Telsimini and Sticholotidini and new genus were erected for *Ghanius karachiensis* predator of *Cerococcus hibisci* Green in Pakistan. Mammen and Nair (1977) recorded the *Harmonia arcuata* feeding on the *Baliothrips biformia* (Bagnall) nymphs and adults on rice from Kerala.

Natarajan and Mathur (1981) recorded predaceous Coccinellids viz., *Coccinella billieti* (Mulsant) and *Oenopia* spp. feeding on rice brown plant hopper *Nilaparvata lugens* (Stal) from CRRI, Cuttack. Samal and Misra (1982) noticed first time the immature stages (grubs) of *Coccinella rependa* feeding on nymphs of brown planthopper, *Nilaparvata lugens* (Stal.). Vazirani (1983) reported *Sticholotis chittagongi* sp. n as feeding on aphids infesting *Ziziphus mauritiana* in Bangladesh.

Thakur *et al.* (1989) recorded the 3 coccinellid predatory beetles viz., *Coccinella septempunctata* Linnaeus, *Hippodamia varigata* Goeze and *Harmonia dimidiata* (Fabricius) prey upon the cabbage aphid *Brevicoryne*

brassicae L. in Kullu Valley, Himachal Pradesh. Booth (1991) described a new genus and species of Coccinellidae *Aponephus lentiformis* as potential predator on *Rastrococcus* spp. from India.

Behera *et al.* (1999) recorded the feeding potential of *Coccinella septempunctata* Linnaeus on the chrysanthemum aphid *Macrosiphoniella sanborni* (Gillette). Sunil Joshi *et al.* (2001) recorded *Sticholotis cribellata* Sicard for the first time as a predator of sugarcane scale, *Melanaspis glomerata* (Green).

Poorani (2002) recorded a new species *Oenopia adelgivora* Poorani predator on *Adelges* spp. from Sikkim. She also recorded *Pseudaspidimerus infuscatus* Poorani as new species and its host as aphids of *Hibiscus rosasinensis*. Omkar and Shefalivastava (2003) reported the comparative prey consumption and searching efficiency of *Coccinella septempunctata* Linnaeus and *Coccinella transversalis* Fabricius on different aphid species *viz.*, *Raphalosiphum maidis* (Fitch), *Myzus persicae* (Sulzer) and *Macrosiphum rosae* (Linnaeus).

CHAPTER – III

MATERIALS AND METHODS

The present investigations on “Taxonomic studies on predaceous Coccinellidae, Order : Coleoptera” were conducted at S.V. Agricultural College, Tirupati, Chittoor district, Andhra Pradesh during 2008-2009. The details of materials and methods used during the present investigations are given in this chapter.

3.1 SOURCES OF MATERIAL STUDIED

The field surveys were carried out at S.V. Agricultural College Farm and farmers fields in and around Tirupati. Intensive collections were made in maize, rice, cowpea, field bean, cucumber, groundnut, brinjal, horsegram, sesamum fields. Coccinellid beetles were collected by sweep netting and hand picking. The collected beetles were killed with the help of cotton swab dipped in ethyl acetate in killing jar, the killed specimens were dried in an hot air oven at 45-50°C for about 6 hours and the dried specimens were stored in small glass vials and labeled.

3.2 METHODS AND STUDY

3.2.1 Mounting of specimens

The oven dried coccinellid specimens were mounted singly on white thick cardboard triangular points which were prepared by using punching machine. The coccinellid specimens were glued in the ventral side of thoracic region in between middle and hind pair of legs on the triangular points which were pinned with entomological pins. These facilitate to study the head, wings, legs and abdomen from all the desired angles. The printed label with the information regarding locality, date of collection, host and name of the collector, was transfixed separately to the entomological pin containing the coccinellid specimen.

The sex of the coccinellid was determined by observing under microscope and indicated on the right hand side of the label by using standard notations ‘♂’ for male and ‘♀’ for female specimens.

3.2.2 Preparation of genitalia and mouthparts

For preparation of both male and female genitalia, the coccinellid specimens were gently supported on a China clay block on its back, and the abdomen was detached from the thoracic region under the binocular microscope with the help of sharp micro needles by pressing at the junction of thorax and abdomen. The detached abdomen was then transferred with the help of camel hair brush carefully to the cavity block containing a few

milliliters of freshly prepared 10 per cent KOH and kept them overnight at room temperature to facilitate digestion of soft tissues. The period varied depending upon the specimen whether freshly collected or old. If necessary the specimens were kept in an hot air oven at 50-60°C for 10-15 minutes for digestion. The abdomen was removed from KOH solution and transferred to a glass cavity dish containing distilled water and gently with the help of blunt needles the digested soft tissues were pressed out. After repeated washings in distilled water, the abdomen was transferred to a glass slide containing one or two drops of glycerine for genitalia dissection, which was made under Stereozoom Binocular Microscope. The above said treatment facilitates the entire abdomen to become completely transparent and permitted to study the genitalia. The mouth parts were also similarly prepared for the study after dissecting them carefully using fine needles and forceps under a Stereozoom Binocular Microscope.

The drawings were made with the help of drawing attachment under Trinocular Research Microscope at 40X and 100X depending on the size of the specimen and these were redrawn on tracing paper with the help of rotaring variant pen. The specimens were identified based on the male and female genitalia structures, besides morphological characters like antennae, mouth parts and elytra. After completion of studies, the dissected parts were finally stored in genetalia vials (microvials) with a drop of glycerine. The vial was stoppered and transfixed to the corresponding specimen under the label.

3.2.3 Identification

All identifications were made using keys published in pertinent literature and also by Dr.J. Poorani, Systematist in Coccinellidae, Project Directorate of Biological Control, Bangalore.

3.2.4 Illustrations

For making illustrations, the mouth parts, antennae, pronotum, hind leg and genitalia parts were kept in position by applying a small pinch of fevistick gum at the bottom of a cavity slide before placing a drop of glycerine on it. The dissected parts were kept immersed completely by gently pressing and after arranging them in desired orientation. The dissected structures were further studied in detail with the help of Olympus Trinocular Research Microscope and Illustrations were also made with the same microscope using drawing attachment. The scales of magnification were indicated on the right hand side of the specimen.

3.2.5 Measurements

Measurements of structures were taken with the help of ocular micrometer placed in one eye piece of the Stereoscopic Trinocular Microscope and this ocular micrometer was calibrated with stage micrometer in millimeters (mm). Five specimens of each of the species were used for taking measurements unless fewer specimens were available. The length of the body from the anterior to the posterior end and also the maximum width were measured.

3.3 SPECIES COMPOSITION OF PREDACEOUS COCCINELLIDS IN GROUNDNUT CROP ECOSYSTEM

To study the incidence of predaceous Coccinellid beetles in groundnut crop ecosystem, the data on beetles, their stages and host insects were recorded at fortnight intervals from January to April, 2009 in bulk groundnut grown in S.V. Agricultural College Farm, Tirupati, Andhra Pradesh. Observations on Coccinellid species and associated prey populations were recorded on ten randomly selected groundnut plants.

CHAPTER – IV

RESULTS

In the present studies the following 12 species belonging to eleven genera, under four tribes of the family Coccinellidae were collected and identified. All these species were described and illustrated along with the keys for identification. The details are furnished hereunder.

4.1 COCCINELLID PREDATOR SPECIES IDENTIFIED

I. **Subfamily** : **Chilocorinae**

Tribe : **Chilocorini**

1. *Brumoides suturalis* (Fabricius)

2. *Chilocorus nigrinus* (Fabricius)

II. **Subfamily** : **Coccinellinae**

Tribe : **Coccinellini**

3. *Coccinella septempunctata* Linnaeus

4. *Coccinella transversalis* Fabricius

5. *Harmonia octomaculata* (Fabricius)

6. *Illeis cincta* (Fabricius)

7. *Micraspis discolor* (Fabricius)

8. *Cheilomenes sexmaculata* (Fabricius)

9. *Propylea sp. nr. japonica* (Thunberg)

III. Subfamily : Scymninae

Tribe : Aspidimerini

10. *Pseudaspidimerus trinotatus* (Thunberg)

Tribe : Scymnini

11. *Cryptolaemus montrouzieri* Mulsant

12. *Scymnus (Scymnus) nubilus* Mulsant

4.2 TAXONOMIC KEY FOR THE IDENTIFICATION OF COCCINELLID PREDATORS

1. Clypeus strongly expanded laterally ; anterior margin of pronotum deeply, trapezoidally concave, lateral portions strongly descending below; elytral base distinctly broader than pronotal base; elytral epipleura broad or its inner carina reaching elytral apex; tibiae angulate externally ----- (Tribe Chilocorini) 2
- Clypeus not strongly expanded laterally, pronotum not as above; elytral base slightly broader than pronotal base; elytral epipleura narrow, inner carina not reaching elytral apex ----- 3
2. Body elongate, oval; each elytron with a sutural and discal broad longitudinal black stripe; elytra without reflexed margin; elytral

epipleura not foveolate (Plate I:1) -----

-----*Brumoides suturalis* (Fabricius).

- Body rounded, subglobose; antennae 8 segmented, elytra black, lateral expansions of pronotum reddish brown; elytra without spots; spermatheca sac-like with finger like projection anteriorly (Plate I:2; Fig.2: a & j) -----

----- *Chilocorus nigrinus* (Fabricius).

3. Eyes usually moderate in size with or without a moderately deep or shallow post antennal emargination; antennae eight to eleven segmented and usually relatively short, at most shorter than two-thirds the head width. Labrum rather short; coxite of female usually elongate, rarely transverse ----- (Tribe Scymnini) 4.

- Eyes covered anteriorly by the expanded head capsule; antennae nine-segmented and very short, less than one-fourth the head width; elytral epipleura very narrow with distinct foveae; trochanters elongate, femora broadly expanded concealing the compressed tibiae, tarsi true trimerous; abdomen composed of six segments, of which first convex posteriorly in an arc; dorsum pubescent and body medium to small

----- (Tribe Aspidimerini) 5.

4. Prosternum produced anteriorly to cover mouth parts; antennae 10 segmented; head, thorax and apices of elytra reddish and rest black (Plate V:11) ----- *Cryptolaemus montrouzieri* Mulsant.
- Pronotum with brown makings; elytra with caudally tapering brown stripe along the commissural line, brown stripe broad at anterior, narrow at posterior looks like ‘V’ shape (Plate V: 12) -----
----- *Scymnus (Scymnus) nubilus* Mulsant.
5. Anterior margin of clypeus with an anterior projection on each side; antennal insertion rather approximating to the eyes; mandible always with a bifid tip (Fig.3A: e; 4A:e and 5:e); anterior margin of pronotum usually deeply emarginate and with angulate anterior corners; maxillary galea conical ----- (Tribe : *Coccinellini*) -----6.
- Anterior margin of clypeus without an anterior projection, prosternal carinae subparallel to slightly divergent towards anterior, enclose an area much longer than broad, subrectangular; male genitalia with median lobe of aedeagus broader than long, U-shaped and posteriorly sinuate in the middle; siphon stout, anteriorly bulbous (Fig.10: j & i; Plate V:10) ----- *Pseudaspidimerus trinotatus* (Thunberg).

6. Antenna with basal segment broader than long, with a strongly convex innerside; lateral side of elytra not margined; inner carina of elytral epipeluron not strongly convergent, reaching apex; elytral epipeluron strongly inclined below; siphon thread like at apex (Fig.8, B, C and D: a & k; Plate IV: A, B, C, D and E) -----
----- *Cheilomenes sexmaculata* (Fabricius).
- Basal segment of antenna elongate and normal; lateral side of elytra margined; inner carina of elytral epipeluron strongly convergent apically or not reaching the apex ----- 7.
7. Anterior margin of meso sternum flat ----- 8.
- Anterior margin of mesosternum weakly emarginate at middle; each elytron with three transverse rows of black spots and an apical spot on a reddish yellow background, the spots frequently coalescing; apex of siphon spoon shaped with membranous projection (Fig.5: a & j; Plate III: 5) ----- *Harmonia octomaculata* (Fabricius).
8. Each elytron with 3+½ roundish spots, spermatheca strongly hooked, nodulus and ramus clearly demarcated (Fig.3A : i; Fig.3B:h; Plate I : 3B) ----- *Coccinella septempunctata* Linnaeus.
- Each elytron without those round spots ----- 9

9. Each elytron with a large trilobed humeral spots (sometimes lacking); elytra with transverse band at apical 0.33, a second usually incomplete band just before apex and black (Fig.4A, B, C and D; Plate II: A, B, C and D) ----- *Coccinella transversalis* Fabricius.
- Elytra without such black stripes ----- 10
10. Siphon curved at basal, apically straight, apex of siphon spatula shaped with hooked process; spermatheca curved and C shaped (Fig.7B: i; 7A:j; Plate III:7) ----- *Micraspis discolor* (Fabricius).
- Apex of siphon spatula shaped without hooked process and corrugated at tip ----- 11
11. Pronotum with a pair of rounded black spots at posterior end; prosternum anteriorly expanded to cover the mouth parts (Plate III:6) ----- *Illeis cincta* (Fabricius).
- Pronotum with black markings at posterior end; hemisternite elongated triangular, nearly round, spermatheca strongly curved, short, stout and C shaped (Fig.9: i & j; Plate V: 9) ----- *Propylea sp. nr. japonica* (Thunberg).

4.3 DESCRIPTION OF DIFFERENT COCCINELLID PREDATORS

Subfamily : Chilacorinae

Tribe : Chilacorini

1. *Brumoides suturalis* (Fabricius) (Plate I :1; Fig.1:a-k)

Coccinella suturalis Fabricius, 1798: 78 (ZMC)

Brumnus suturalis : Mulsant, 1850 : 494.-Korschefsky, 1932:267-Kapur, 1942:56 (boil., early stage figd.).

Brumoides suturalis : Chapin, 1965a:237.

Colour

Head, antennae and pronotum brown; elytra yellowish brown with two longitudinal black stripes on each elytron, legs brown in colour. The ventral side brown to dark brown and varying with age.

External morphology

Body oval, glabrous, moderately convex above. Head with a prominent pair of eyes which, when the head is retracted, are slightly covered by the pronotum. Mouthparts as shown in Fig.1 (b, c, d & e). The antennae 9 segmented with small sensory hairs all over. Frons widened posteriorly, antennal insertions covered by the expanded clypeal margin.

The pronotum with a pair of notches in front of the eyes, scutellum triangular. A median longitudinal black stripe which extends from the scutellum to the apex of the elytra; coxal line complete and legs with a pair of simple claws at the terminal tarsal joint.

Male genitalia

Tegmen with median lobe as long as lateral lobes; lateral lobes sparsely having setae and parallel sided. Apophysis of ninth segment broad at base and caudally bifid. Siphon strongly curved with a T-shaped basal part, broadened apically; siphonal capsule long, quadrate with slender inner process.

Measurements (mm)

Body 3.2 (2.9 – 3.5) long; 2.52 (2.11 – 2.93) wide.

Specimens examined

1 male, on aphids in groundnut, Tirupati : RARS, 24.II.09, G. Chanmamla;

1 male, on leafhoppers in brinjal, Tirupati : Peruru, 4.V.09, G. Chanmamla;

1 female, on aphids in cowpea, Tirupati: Cherlopalli, 6.V.09, G. Chanmamla;

1 female, on aphids in brinjal, Tirupati : Pudipatla; 7.V.09, G. Chanmamla

2. *Chilocorus nigrinus* (Fabricius) (Plate I: 2; Fig.2: a-j)

Coccinella nigrita Fabricius, 1798 : 79 (Type material lost-Booth, 1998).

Chilocorus nigrinus : Mulsant, 1850: 463-Crotch, 1874:184-Korschefsky, 1932 : 240.-Nagaraja & Hussainy, 1967:252 (rev.).

Chilocorus nigrita: Bielawski, 1957 :86 (♂genitalia figs.).-Samways, 1989:345 (world dist.).-Booth, 1998:362 (rev.).

Colour

The body bright black colour, head ochreous brown, eyes black; pronotum black with brown lateral expansions; mouth parts dark brown; scutellum and elytron black, venter of thorax and legs brown, abdominal terga dark brown, underside uniformly ochreous brown, hind wings grey and claws deep brown.

External morphology

Body subglobose, rounded, highly convex, widest in the middle of the body. Head finely punctate with short and yellowish pubescence; genae narrower, frons coarsely punctate and clypeus concave at anterior margin. Mouthparts as shown in Fig.2 (b, c, d and e). Antennae 8 segmented with small sensory hairs, slightly clavate. Pronotum strongly arched, narrower anteriorly with deep emargination; punctuations sparse all over and close, with pubescence at expansions; scutellum triangular with base slightly shorter than side; elytron widest near the middle. Coxal line shallowly curved and reached

anterior margin; femoral line gently curved, extends almost to the lateral margin. Ventral side uniformly punctate and pubescent all over the legs with a pair of claws.

Female genitalia

Hemisternite short, oval and broad and rounded, bears stylus with sparsely pubescent. Spermatheca sac like with a finger like projection anteriorly.

Measurements (mm)

Body 4.2 (3.91 – 4.49) long; 4.4 (4.21 – 4.59) wide.

Specimens examined

1 female, on aphids in maize, Tirupati; S.V. Agril. College Farm, 18.II.09, G.Chanmamla; 2 females, on scales in Mango, Tirupati; S.V. Agricultural College, 8.IV.09, G.Chanmamla; 1 female, on mealybugs in Brinjal, Tirupati: Pudipatla, 7.V.09, G.Chanmamla.

Subfamily : Coccinellinae

Tribe : Coccinellini

3. *Coccinella septempunctata* Linnaeus

(Plate I: 3A, 3B; Figs.3A: a-j, 3B: a-j)

Coccinella 7-punctata Linnaeus, 1758: 365 (?LSL).

Coccinella septempunctata: Korschefsky, 1932: 486 (cat.).-Schaefer & Semyanov, 1992: 125-134 (world parasite list & bibliography).

Coccinella divaricata Olivier, 1808: 1001 (lectotype; UCCC). -Korschefsky, 1932: 457 (cat.).-Mader, 1936: 375 (syn.).-Sudha Rao, 1962: 1341 (status).Gordon, 1987: 13 (lectotype design.).

Coccinella confusa Wiedemann, 1823: n.-Mulsant, 1850: 112 (as a var. of *divaricata*).-Sudha Rao, 1962: 1341 (status rev., morphs figd.).

Cocciliella bruckii Mulsant, 1866: 90.-Crotch, 1874: 46.

Coccinella septempunctata brucki: Korschefsky, 1932: 491.

Colour

Head black, eyes brown, two yellowish spots present near the margin of eyes; mouth parts brown, antennae dark brown in colour, pronotum black with two yellow spots laterally; elytra orange in colour, black spots are present on elytra, these spots are connected to one another and form a broad black maculae on each elytron in some species. Ventral side and legs are black.

External morphology

Body medium sized, oval to round in shape, dorsum highly convex, glabrous. Antennae 11 segmented, last three segments gradually enlarged with setae sparsely. Mouth parts as shown in Fig.3A & 3B (b, c, d and e); maxillary palpi is usually large and hatchet shaped. Frons punctate, pronotum very

densely punctate, scutellum triangular. Elytra sparsely punctate. The black pigmented area on elytra extended upto the first spot, leaving only the posterior structural margin of the elytra orange coloured. The middle orange areas reduced to a crescent shape due to the spreading of black pigment from the side of the original third and second spot and from the side of the fourth spot towards the middle of the elytra. The basal orange coloured area elliptical in shape whose posterior margin emarginated and contiguous upto the narrow apical margin through an elongate costal margin. In Fig.3B Elytra having 7 black spots, each elytra having 3 spots and one spot on commissural line of elytra. Coxal line gently curved, femoral line angulate legs simple, tarsi pseudotrimerous (or) cryptotetramerous, last tarsal segment elongate and ends with a pair of claws.

Female genitalia

Hemisternite bears a stylus. The shape of hemisternite elongate, transverse oval, anterior portion of hemisternite bifid and the basal part of hemisternite sparsely hairy. Spermetheca strongly hooked, nodulus and ramus clearly demarcated and the infudibulum elongated.

Measurements (mm)

Body 7.2 (6.83 – 7.57) long; 5.8 (5.34 – 6.26) wide.

Specimens examined

1 female on mealybug in brinjal, Tirupati; Peruru, 18.XII.08, G.Chanmamla;
1 female, on aphids in groundnut, Tirupati; RARS, 24.11.09, G.Chanmamla;
2 females, on aphids in brinjal, Tirupati; Peruru, 4.V.09, G.Chanmamla;
2 females, on mealybugs in brinjal, Tirupati; Pudipatla, 7.V.09, G.Chanmamla

4. *Coccinella transversalis* Fabricius

(Plate II: Figs.4A & B: a-k and 4C & D : a-j)

Coccinella transversalis Fabricius, 1781: 97 (lectotype ♀; BMNH).-Mulsant, 1850: 126, 1022.-Timberlake, 1943: 14.-Iablokoff-Khnzorian, 1979: 68; 1982: 391.-Pope, 1989: 652 (rev.).

Coccinella repanda Thunberg, 1781: 18 (lectotype ♀; UU). -Mulsant, 1850: 1022 (syn.).-Crotch, 1871: 3; 1874: 117.-Korschefsky, 1932: 483 (cat.).-Pope, 1987: 62 (rev., lectotype design.).

Colour

Colouration variable : dark yellow (Plate II:A) creamy orange (Plate II: B) and pale yellow (Fig.4C) and brick red colour (Plate II:D). Head black with yellow spot, mouthparts black to dark brown, antennae dark brown; eyes black; pronotum black with anterior lateral areas orange to yellow; scutellum black, elytra colouration variable as shown in Plate II: 4A, 4B, 4C and 4D. Elytra with black markings, commissural line black, ventral side and legs fully black.

External morphology

Body larger in females than males. Body oval in shape, strongly convex dorsally. Head wider with a pair of prominent compound eyes. Frons punctate, clypeus straight. Antenna 11 segmented, last segment enlarged and rounded. The scape broad, long twice than pedicel. Mouthparts as shown in Fig.4A - D (b, c, d & e). Pronotum broad and finely punctate. Elytra sparsely punctate, epipleuron well developed. Coxal line curved and complete femoral line angulate. Legs pseudotrimerous end with a pair of claws.

Male genitalia

Tegmen with Y shaped medium lobe long as lateral lobes. Siphon short and curved at base and pointed at apex. Siphonal capsule having inner processes hooked and bifid and external processes broad. Apophysis of ninth abdominal segment caudally bifid, broad and rounded at tip.

Female genitalia

Hemisternite transverse oval to rounded and having stylus with sparsely setaceous. Spermatheca strongly curved and having infundibulum. Nodus, ramus cannot be differentiated.

Measurements (mm)

Body 5.8 (5.19 – 6.41) long; 4.7 (4.39 – 4.81) wide.

Specimens examined

3 males, 2 females on leafhoppers in horsegram, Tirupati: S.V.Agricultural College, 15.XII.08, G.Chanmamla; 2 females, on leafhoppers in rice, Tirupati; Peruru, 16.XII.08, G.Chanmamla; 2 males, 5 females, on aphids maize, Tirupati : S.V. Agricultural College Farm, 17.XII.08, G.Chanmamla; 1 male, 3 females, on aphids in brinjal, Tirupati: Peruru, 18.XII.08, G.Chanmamla; 7 males, 5 females on aphids in groundnut, Tirupati : RARS, 20.I.09, G.Chanmamla; 1 male, 2 females, on leafhoppers in groundnut, Tirupati: S.V. Agricultural College, 26.I.09, G.Chanmamla; 1 male, 3 females, on leafhoppers in groundnut, Tirupati: Ramachandrapuram, 9.II.09, G.Chanmamla; 2 males, 6 females, on aphids in groundnut, Tirupati : Ramachandrapuram, 11.II.09, G.Chanmamla; 2 females, on aphids on groundnut, Tirupati: Ramachandrapuram 16.II.09, G.Chanmamla; 2 females, on leafhoppers in rice, Tirupati : Ramachandrapuram, 16.II.09, G.Chanmamla; 3 males, 2 females, on leafhoppers in groundnut, Tirupati : RARS, 19.II.09, G.Chanmamla; 1 male, 2 females, on leafhoppers in groundnut, Tirupati :Mallavaram, 24.II.09, G.Chanmamla; 2 males, 3 females, on thrips in chrysanthemum, Tirupati : Karkambadi, 5.III.09, G.Chanmamla; 1 male, 1 female, on aphids in groundnut, Tirupati : Mallavaram, 5.IV.09, G.Chanmamla; 2 males, 1 female on aphids in groundnut, Tirupati : RARS, 21.IV.09, G.Chanmamla; 1 male, 3 females on aphids in cowpea, Tirupati : Guttivaripalli, 6.V.09, G.Chanmamla, 3 males, 3 females on coccids in guava, Tirupati: S.V.Agricultural College, 6.V.09, G.Chanmamla; 1 male, on

mealybugs in brinjal, Tirupati : Pudipatla, 7.V.09, G.Chanmamla; 1 male, 3 females, on aphids in fieldbean, Tirupati : Perumalpalli, 8.V.09, G.Chanmamla.

5. *Harmonia octomaculata* (Fabricius) (Plate III: 5; Fig.5: a-k)

Coccinella octomaculata Fabricius, 1781 : 97 (not Thunberg, 1781:13)
(Lectotype ♀; BMNH).

Coccinella arcuata Fabricius, 1787:55 (ZMC).-Crotch, 1874: 110.-
Korschefsky 1932: 440 (cat.)

Harmonia arcuata var. *octomaculata*: Mulsant, 1850: 80.

Harmonia arcuata: Mulsant, 1850: 177; 1866: 59.-Crotch, 1871: 3.-
Timberlake 1943: 18.-Miyatake, 1965: 60.

Harmonia octomaculata: Mader, 1932: 215.-Bielawski, 1957: 93 (male genitalia figd.); 1961c: 6; 1962: 204; 1964: 5 (rev.).-Sasaji, 1971; 280 (desc.); 1977: 14 (larval desc.).-Iablokoff-Khnzorian, 1979: 71; 1982: 475.-Pope, 1989: 685 (rev.).

Harmonia octomaculata var. *arcuata*: Mader, 1932: 217.

Coeinella arcuata var. *octomaculata*: Korschefsky, 1932: 441.

Ptyehanatis octomaculata: Kamiya, 1965: 59.

Colour

Head orange to pale brown with black, eyes; antennae and mouth parts reddish brown in colour. Pronotum reddish brown; elytra reddish brown to brown in colour with black maculae on posterior end of elytra. The commissural line of elytra brown in colour. Ventral side dark brown and the legs reddish brown in colour. Epipleuron also reddish brown and scutellum dark brown.

External morphology

Body oval, longer than broad, dorsally convex and widen at the middle of the body or middle of elytra. Head broad with a pair of prominent compound eyes; frons punctate, intraocular margin divergent apically. Antenna 11 segmented, the last segment bulged, mouth parts as shown in Fig.5 (b, c, d & e). Pronotum strongly and trapezoidally excavated, surface punctate; scutellum triangular and basal margin longer than lateral margin. Elytra sparsely punctate and the epipleuron with an inner carina that may reach the elytral apex or well developed epipleuron. The post coxal line strongly curved and almost reached the anterior margin. Femoral line angulate, legs simple with 4 segmented tarsi ending with a pair of claws.

Male genitalia

Tegmen with short and broad lateral lobes with hairs at apex, median lobe shorter than lateral lobes, shape of median lobe characteristic. Siph strongly curved at base and straight apically and apex of siph spoon shaped with membranous projection; siphonal capsule inner processes hooked and outer processes broadened. Apophysis of ninth abdominal segment broad at caudally, rounded oval tip anteriorly.

Measurements (mm)

Body 6.0 (5.67 – 6.33) long; 4.4 (3.85 - 4.95) wide.

Specimens examined

5 males, 1 female on aphids in cucumber, Tirupati; Cherlopalli, 19.IV.09, G.Chanmamla; 1 male on aphids in groundnut, Tirupati; RARS, 24.II.09, G.Chanmamla.

6. *Illeis cincta* (Fabricius) (Plate III: 6; Fig.6: a-k)

Coccinella cincta Fabricius, 1798: 77 (ZMC)

Psyllobora cincta Mulsant, 1850: 167; 1866 :127.

Thea cincta : Crotch, 1874:135.

Illeis cincta : Korschevsky, 1932: 558 (cat.)- Bielwaski, 1957:95 (male genitalia figd.); 1961:356 (rev.).

Colour

Head yellowish; eyes black, antennae pale yellowish, mouth parts yellowish to brown; pronotum transparent yellow and scutellum yellowish. Pronotum with a pair of black round spots at posterior end. Elytra greyish yellow to pale yellow and shiny. Some times elytra light orange in colour and shiny. Elytral commissural line yellowish. Ventral side brown and legs yellowish to brown.

External morphology

Body elongate oval, dorsally convex, wider at middle of elytra. Head with a pair of prominent black eyes. Eyes mostly covered by the pronotum. Head densely punctate and hairy. Frons flat. Antennae 11 segmented, elongated, last segment of antennae bulged. Mouthparts as shown in Fig.6 (b, c, d and e). Maxillary palpi characteristic, last segment of maxillary palpi enlarged, broad, axe-head shaped. Pronotum strongly excavated, straight, broader than longer and finely punctate. Scutellum triangular. Prosternum anteriorly extended to cover mouthparts. Mesosternum broad and short. Elytra densely punctate than pronotum, apices of elytra rounded. Post coxal line straight not reaching the anterior margin. Femoral line slightly curved and reaching the posterior margin. Legs densely hairy, tarsus 4 segmented and ending with a pair of claws.

Male genitalia

Tegmen with elongated lateral robes and densely hairy at apex, median lobe longer than lateral lobes. Siphon strongly curved basally and apically. Apex of siphon spatula like and inner processes of siphonal capsule short and round, outer processes pointed. Apophysis of ninth abdominal segment elongated and bifid caudally.

Measurements (mm)

Body 4.68 (4.35 – 5.01) long; 3.68 (3.24 – 4.12) wide.

Specimens examined

6 males, 7 females on aphids in sesame, Tirupati: S.V. Agricultural College Farm, 24.XI.08, G.Chanmamla.

7. *Micraspis discolor* (Fabricius)

(Plate III: 7A & B; Figs. 7A: a-j and 7B: a-k)

Coccinella discolor Fabricius, 1798: 77 (Type depository unknown).

Verania discolor: Mulsant, 1850 369-Korschefsky, 1932: 308.-Bielawski, 1957: 92 (♂ genitalia figd.).

Micraspis discolor: Kamiya, 1965a: 60.-Sasaji, 1968: 128.-Sasaji & Tsubokawa, 1983: 47 (larval desc.).-Jiang & Su, 1985: 115 (food habits & syst.).

Coccinella simplex Thunberg, 1820: 363 (lectotype ♀; UU).-Korschefsky, 1932: 582 (as species incerta sedis).-Synonymised and lectotype designated by Pope, 1987: 64.

Colour

Head yellow, compound eyes black, mouth parts and antennae brown; pronotum pale yellow to yellowish white in colour with black spots or patches towards proximal end. Scutellum black, elytra orange in colour with black commissural line. The ventral side yellowish brown, fore legs brownish yellow and hindlegs dark brown.

Females bright orange in colour and highly convex dorsally. Males pale yellowish to orange in colour, pronotum having half moon shaped black marking at posterior end.

External morphology

Body oval, convex dorsally and glabrous. Head with a pair of compound eyes. Eyes sparsely pubescent with very short, erect hairs. Antennae 11 segmented, last 3 segments formed club and enlarged. In male the last antennal segment beak shaped. Mouth parts as shown in Fig.7A & B (b, c, d and e). Elytra slightly pubescent. The post coxal line straight and complete. Femoral line straight but incomplete. The elytral epipleuron

continuation upto the underside or epipleuron is well developed. Legs simple, pseudotrimerous or cryptotetramerous tarsi with apically bifid claw.

Male genitalia

Tegmen having elongated long lateral lobes with densely hairy, median lobe shorter than lateral lobes and the apex of median lobe is pointed. Apophysis of ninth abdominal segment rounded at anterior end. Siphon strongly curved at base, straight at apex; siphonal capsule well developed, apex of siphon with hooked processes.

Female genitalia

Spermatheca curved and C shaped, the spermatheca attached to the inverted Y shaped infundibulum. Hemisternite transverse, oval in shape and stylus absent.

Measurements (mm)

Body 4.0 (3.75 – 4.25) long; 3.48 (3.25 – 3.71) wide.

Specimens examined

6 females, on leafhoppers in rice, Tirupati; S.V. Agricultural College Farm, 24.XI.08, G.Chanmamla; 1 male, on leafhoppers in rice, Tirupati; Peruru, 16.XII.08, G.Chanmamla; 1 female, on aphids in groundnut, Tirupati; RARS, 5.IV.09, G.Chanmamla; 2 females, on leafhoppers in groundnut, Tirupati; RARS, 21.IV.09, G.Chanmamla.

8. *Cheilomenes sexmaculata* (Fabricius)

(Plate IV: 8A-E; Figs:8A-D: a-k; 8E:a-j)

Coccinella sexmaculata Fabricius, 1781: 96 (Lectotype ♀; Banks collection, BMNH).

Coccinella 4-plagiata Swartz in Schönherr, 1808: 195 (Lectotype ♀; NREA).

Synonymised by Nakane & Araki, 1959: 50.-Sasaji&Akamatsu, 1979: 16.

Cheilomenes sexmaculata: Dejean, 1837: 435.-Mulsant, 1850: 444; 1866: 289.Crotch, 1871: 8; 1874: 180 (as *Chilomenes*).-Subramanyam, 1924b: 108, 113 (colour morphs). *Cheilomenes quadriplagiata*: Dejean, 1837: 435.-Mulsant, 1850: 447; 1866: 290.- Crotch, 1871: 8; 1874: 181 (as *Chilomenes*).

Cheilomenes sexmaculata var. *flavofasciata* Mulsant, 1850: 446.-Mader, 1935:352.

Orcus mollipes Olliff, 1895: 30 (Type material lost).-Synonymised by Pope, 1989: 646.

Cheilomenes sexmaculata var. *australis* Weise, 1908: 12 (as *Chilomenes*); Mader, 1935: 352.

Menochilus sexmaculatus: Timberlake, 1943: 40.-Nakane & Araki, 1959:
50.Sasaji & Akamatsu, 1979: 2.-Iablokoff-Khnzorian, 1979: 58; 1982:
146 (rev.).Pope, 1989: 646 (rev.).

Menochilus quadriplagiatus: Timberlake, 1943: 41.

Chilomenes hiugaensis Takizawa, 1917: 221. -Sasaji, 1971: 285.

Menochilus sexmaculatus: Timberlake, 1943: 40.-Nakane & Araki, 1959:
50.Sasaji, 1971: 285 (desc.).-Sasaji & Akamatsu, 1979: 2.-Iablokoff-
Khnzorian, 1979: 58.- 1982: 146.-Pope, 1989: 646 (rev.).

Cydonia triangulifera var. *inops* Mulsant, 1866: 286 (Holotype; UCCC).-
Crotch, 1874: 180 (as *Chilomenes*).-Bielawski & Chujo, 1964: 228 (as
Verania).

Micraspis inops: Chunram & Sasaji, 1980: 488.-Iablokoff-Khnzorian, 1982.

Colour

Colour variable, creamy orange to bright orange (Plate IV: 8A and 8D).
Pale yellow (Plate IV: 8B), bricked (Plate IV:8E) and yellow in colour
(Plate IV: 8C). Head pale yellow to yellowish, eyes black, antennae and mouth
parts brown. Pronotum colour also variable : yellow to orange with black
markings. Scutellum black, elytra colouration and black maculae variable;

elytra having the black zigzag markings two on each elytra, black spot at posterior end of elytra and these markings may not be present in some beetles (Plate IV: 8B and 8E). The commissural line of elytra black. Ventral side brown in colour and legs brown to black.

External morphology

Body large to medium sized. Females larger than males. Elongated oval beetles, glabrous and the dorsum highly convex. Head narrower than half of pronotum and punctate. Antennae 11 segmented, clavate, scape larger than pedicel. Mouth parts as shown in Fig.8A-E (b, c, d & e). Pronotum trapezoidally excavated and densely punctate. Scutellum wider and triangular. Elytra sparsely punctate epipleuron well developed. Coxal line straight and reaching the anterior margin. Femoral line strongly curved reaching the posterior margin of sternum. Legs having pseudotrimerous tarsi and tarsal segments densely hairy, end with a pair of claws.

Male genitalia

Sipho strongly curved at base and thread like apically; the siphonal capsule well developed, the inner processes rounded and external processes pointed. Tegmen with broad long median lobe, lateral lobes equal to median lobe and hairy. Apophysis of ninth abdominal segment broad and bifid caudally.

Female genitalia

Spermatheca short, stout and curved; in ventral view spermatheca kidney shaped, broadened at base, and attached to the infundibulum with the help of thread or spring like processes. Hemisterinite cone shaped with stylus slightly hairy at base.

Measurements (mm)

Body 4.4 (3.12 – 5.68) long; 3.56 (3.19 – 3.93) wide.

Specimens examined

1 female, on leafhoppers in rice, Tirupati; S.V. Agricultural College Farm, 24.XI.08, G.Chanmamla; 1 male, on aphids in horsegram, Tirupati; S.V.Agricultural College Farm, 15.XII.08, G.Chanmamla; 1 male, 1 female, on aphids in maize, Tirupati; Peruru, 15.XII.08, G.Chanmamla; 3 males, 3 females, on aphids in maize, Tirupati; RARS, 17.XV.08, G.Chanmamla; 2 males, on leafhoppers in brinjal, Tirupati; Perumalpalli, 18.XII.08, G.Chanmamla; 6 males, 6 females, on aphids in maize, Tirupati; Peruru, 26.I.09, G.Chanmamla, 7 males, 11 females on aphids in maize, Tirupati; S.V.Agricultural College, 18.II.09, G.Chanmamla. 3 females, on mealybugs in cucumber, Tirupati; Cherlopalli, 19.IV.09, G.Chanmamla; 2 male, 3 females on leafhoppers in bhendi, Tirupati; Vedullacheruvu, 4.V.09, G.Chanmamla; 4 males, 6 females on aphids in cowpea, Tirupati: Cherlopalli, 6.V.09,

G.Chanmamla; 1 male, 1 female on mealybugs in brinjal, Tirupati: Pudipatla, 7.V.09, G.Chanmamla; 2 males, 3 females on aphids in fieldbean, Tirupati: Perumalpalli, 8.V.09, G.Chanmamla; 2 males, 3 females on leafhoppers in fieldbean, Tirupati: Pudipatla, 8.V.09, G.Chanmamla.

9. *Propylea sp. nr. japonica* (Thunberg) (Plate V: 9; Fig.9: a-j)

Coccinella japonica Thunberg, 1781: 12 (lectotype ♂; UU).-Pope, 1987: 58 (lectotype design.).

Coccinella tetraspilota Hope, 1843: 64 (not Hope, 1831) (Lectotype; B:MNH).Synonymised and lectotype designated by Booth & Pope, 1989: 366.

Propylea japonica: Lewis, 1896: 30.

Propylaea japonica: Mader, 1933: 262-263.-Kamiya,1965: 44-46.

Propylea quatuordecimpullctata japonica: Timberlake, 1943: 28.

Colour

Head brown, eyes black, antennae and mouthparts dark brown; pronotum golden yellowish with markings, scutellum black; elytra pale yellow to light orange in colour with black commissural lines, ventral side dark brown with dark brown, legs.

External morphology

Body short, oval, glabrous, dorsally strongly convex. Head broader than long with a pair of prominent eyes and finely punctate. Frons weakly convex. Antennae 11 segmented, last 3 segments gradually enlarged, scape twice larger than pedicel and sparsely setaceous all over the antennae. Mouthparts as shown in Fig.9 (b, c, d & e). Pronotum finely punctate broader than long, trapezoidally excavated; scutellum smaller, triangular in shape. Elytra densely punctate than pronotum and elytral epipleuron very well developed. Post coxal line slightly curved, incomplete. Femoral line curved and reaching the posterior margin.

Female genitalia

Hemisternite elongated triangular, nearly round. Stylus present, finely setaceous. Spermatheca strongly curved, short, stout, C shaped and characteristic in this species.

Measurements (mm)

Body 3.75 (3.46 – 4.04) long; 2.61 (2.13 – 3.09) wide.

Specimens examined

1 male on aphids in groundnut, Tirupati : Ramachandrapuram, 11.II.09, G.Chanmamla; 1 female on aphids in groundnut, Tirupati : RARS, 5.IV.09, G.Chanmamla; 1 female on aphids in cowpea, Tirupati : Cherlopalli, 6.V.09, G.Chanmamla.

Subfamily : Scymninae

Tribe : Aspidimerini

10. *Pseudaspidimerus trinotatus* (Thunberg) (Plate V: 10i: Fig.10: a-k)

Caccinella trinotata Thunberg, 1781: 11 (lectotype ♂; UU).-Korschefsky, 1932: 582 (as species incerta sedis).-Pope, 1987: 64 (lectotype design.).

Pseudaspidimerus trinotatus: Pope, 1987: 64.

Platynaspis circumflexa Motschulsky, 1858: 118 (Lectotype; UM).-Korschefsky, 1931: 172 (cat.).-Iablokoff-Khnzorian, 1972: 167.

Pseudaspidimerus circumflexa: Kapur, 1948b: 117 (rev.).-Poddar & Ghosh, 1984: 67 (bioL., larva figd.).-Synonymised by Pope, 1987: 64.

Pseudaspidimerus circumflexa var. *testaceus* Weise, 1900a: 423. -Korschefsky, 1931: 172 (cat.).-Kapur, 1948b: 117 (rev.).

Colour

Very small beetle with bright golden yellow colour to reddish brown, rarely dark brown. Head brown, eyes black; antennae dark brown in colour, pronotum yellowish, elytra bright yellowish brown. Ventral side and legs pale yellowish to dark yellowish in colour.

External morphology

Body oval to rounded, pubescent, highly convex above. Head with a pair of prominent eyes. Mouth parts as shown in Fig.10 (b, c, d & e). Maxillary palpi barrel shaped, cylindrical with an obliquely truncated apex. Antennae 9 segmented with sparsely setaceous. The genae very narrowly expanded just above the eyes. Frons weakly convex, the antennal insertions usually lateral in front of the eyes and broadly separated. Pronotum or pronotal and subscutellar spots absent and scutellum triangular. Prosternal carinae subparallel to slightly divergent anteriorly and the enclosed presternal carinae always much longer and narrower. Elytra hard and convex dorsally. In the middle of elytra dark brown spots present. The epipleura deeply impressed or foveate on level with middle pair of legs. The femur plate-like, greatly enlarged and retracted into deep impressions on the ventral side of the body tarsi 4 segmented with a pair of claws.

Male genitalia

The median lobe of tegmen very broad and U-shaped, with a medially sinuate posterior margin. The lateral lobes parallel sided and sparsely hairy at their apex, siphon stout, anteriorly bulbous.

Measurements (mm)

Body 2.5 (2.21 – 2.79) long; 1.9 (1.68 – 2.12) wide.

Specimens examined

1 male, on aphids in maize, Tirupati : S.V. Agricultural College Farm, 18.II.09, G.Chanmamla; 1 male, on aphids in cowpea, Tirupati : Cherlopalli, 6.V.09, G.Chanmamla.

Tribe : Scymnini

11. *Cryptolaemus montrouzieri* Mulsant (Plate V:11; Fig.11 : a-k)

Cryptolaemus montrouzieri Mulsant, 1853a: 268 (lectotype; PM).

Cryptolaemus montrouzieri : Crotch, 1874: 204 (emend.).-Korschefsky, 1931: 169 (cat.).-Puttarudriah *et al.*, 1952: 377 (introduction into India).

Cryptolaemus montrouzieri montrouzieri: Booth & Pope, 1986: 706 (rev. and lectotype design.).

Colour

Head, antennae reddish yellow, eyes black; mouth parts yellowish brown; scutellum black; elytra shining black with apices reddish yellow; prosternum yellowish brown, meso and metasternum slightly black in colour, ventral side yellowish brown to dark brown and legs dark brown in colour with pale tarsi.

External morphology

Body strongly oval in shape, convex with strongly setaceous. Head finely punctate relatively large, deep and close punctures, half of their diameter or less nearer to eyes and clypeus. Punctures finer on vertex behind eyes. Antennae 10 segmented with last 3 segments forming a club. Mouth parts as shown in Fig.11 (b, c, d & e). Pronotum pubescent more at side margins. Scutellum closely punctured. Prosternum has semicircular lobe anteriorly. Elytra more pubescent than pronotum and forming shaggy appearance to elytra, elytra more pubescent but less punctured. Post coxal lines shallowly curved and rounded, reached to anterior margin and femoral line strongly curved. Legs with 4 tarsal segments and end with a pair of claws.

Male genitalia

Apophysis of 9th abdominal segment expanded anteriorly in M shape and caudally bifid. Siphon strongly curved with developed siphonal capsule and apex of siphon truncated. Tegmen with ruminant median lobe shorter than lateral lobes and lateral lobes hairy.

Measurements (mm)

Body 3.84 (3.46 – 4.22) long; 2.7 (2.36 – 3.04) wide.

Specimens examined

3 males, 1 female on mealybugs in brinjal, Tirupati : Pudipatla, 7.V.09,
G.Chanmamla.

12. *Scymnus (Scymnus) nubilus* Mulsant (Plate V: 12; Fig.12: a-l)

Scymnus nubilus Mulsant, 1850: 972 (lectotype; BEC, OU).-Bielawski, 1972:
293 (♂ genit. figd.).-Booth & Pope, 1989: 359 (lectotype design.).

Scymnus (Scymnus) nubilus: Korschefsky, 1931: 143 (cat).

Scymnus curtisii Mulsant, 1850: 973 (original syntype lost).-Synonymised by
Booth & Pope, 1989: 351.

Scymnus suturalis Motschulsky, 1858: 120.-Crotch, 1874: 253.-Korschefsky,
1931: 144.-Iablokoff-Khnzorian, 1972: 166.

Scymnus stabilis Motschulsky, 1866: 426 (Holotype; UM).-Crotch, 1874:
257.Weise, 1900: 439.-Korschefsky, 1931: 144 (cat).

Scymnus lateralis Sicard, 1913: 502 (Holotype ♀; BMNH)-Korschefsky,
1931: 143 (cat).-Pang and Gordon, 1984: 133 (redesc.).-Synonymised
by Booth & Pope, 1989: 360.

Colour

Very small beetles. Head dark brown, eyes black, mouth parts antennae
brown in colour; pronotum dark brown with small spot or patch, scutellum
black; elytra dark brown to brown in colour having the black line or patch
along with commissural line of elytra broad at anterior and narrow posteriorly

and it forms V shaped patch; ventral side dark brown to black in colour with brown legs.

External morphology

Small sized body oval, elongated and highly pubescent. Head densely punctate with a pair of compound eyes. Antennae 9 segmented, last 2 segments are enlarged gradually and scape elongated twice than pedicel. Mouth parts as shown in Fig.12 (b, c, d, e & f). Antennal scape elongated twice than pedicel. Pronotum densely punctate and pubescent; posterior margin of pronotum is W shaped and broad; scutellum triangular, elytra heavily pubescent with yellowish hairs, epipleuron not well developed. Coxal line curved, complete and femoral line straightly curved.

Male genitalia

Tegmen with short median lobe, lateral lobes elongate, slender and sparsely hairy. Apophysis of the 9th abdominal segment expanded broadly at distal end. Siphon strongly curved at base with pointed apex and thread like; the inner processes of siphonal capsule narrow and longer and outer processes broad and short.

Measurement (mm)

Body 1.85 (1.53 – 2.17) long; 1.7 (1.08 – 1.26) wide.

Specimen examined

2 males, 3 females on aphids in brinjal, Tirupati : S.V. Agricultural College Farm, 18.II.09, G.Chanmamla; 1 male, on leafhoppers in groundnut, Tirupati : RARS, 24.II.09, G.Chanmamla.

4.4 SPECIES COMPOSITION OF COCCINELLID PREDATORS

Among these 12 species of Coccinellids, *Coccinella transversalis* Fabricius (38%) and *Cheilomenes sexmaculata* (Fabricius) (34%) are the most abundant species in and around Tirupati in different agro-ecosystems followed by *Illeis cincta* (Fabricius) (6%) (Fig.13).

4.4.1 Species composition of predaceous Coccinellids associated with groundnut crop ecosystem

Five species viz., *Coccinella septempunctata* Linnaeus; *Coccinella transversalis* Fabricius; *Harmonia octomaculata* (Fabricius); *Micraspis discolor* (Fabricius) and *Cheilomenes sexmaculata* (Fabricius) were recorded in groundnut crop ecosystem feeding on aphids, *Aphis craccivora* Koch and leafhoppers, *Empoasca* (*Empoasca*) *motti* Pruthi. Among these species, *Coccinella transversalis* Fabricius was the most abundant coccinellid recording 52% of population followed by *Cheilomenes sexmaculata* (Fabricius) which recorded 29% of population (Fig.14).

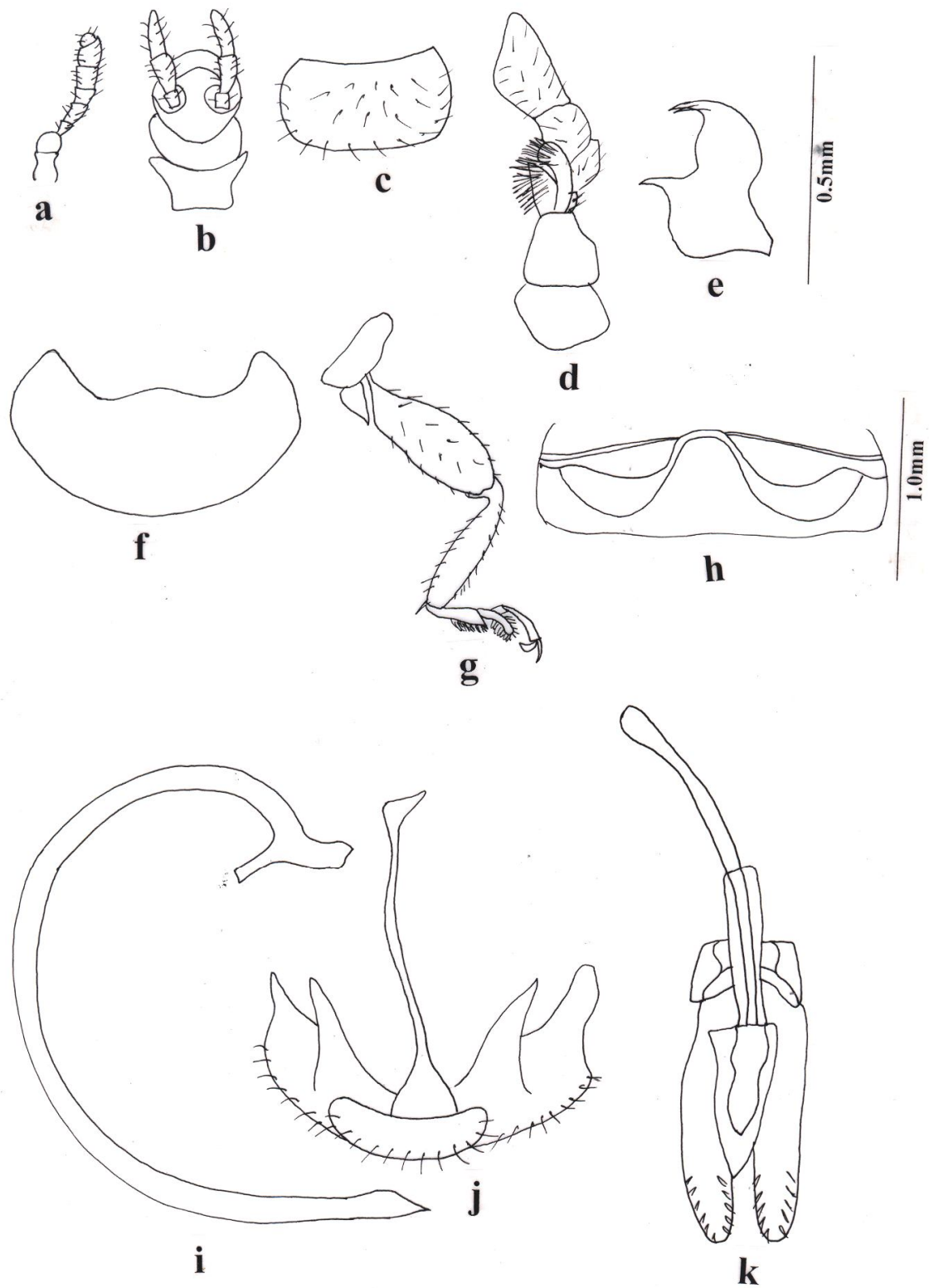


Fig. 1 : *Brumoides suturalis* (Fabricius): (a) Antenna; (b) Labium; (c) Labrum; (d) Maxilla; (e) Mandible; (f) Pronotum; (g) Hindleg; (h) First abdominal sternite; (i) Siphon; (j) Ninth abdominal segment of male; (k) Male tegmen, ventral view.

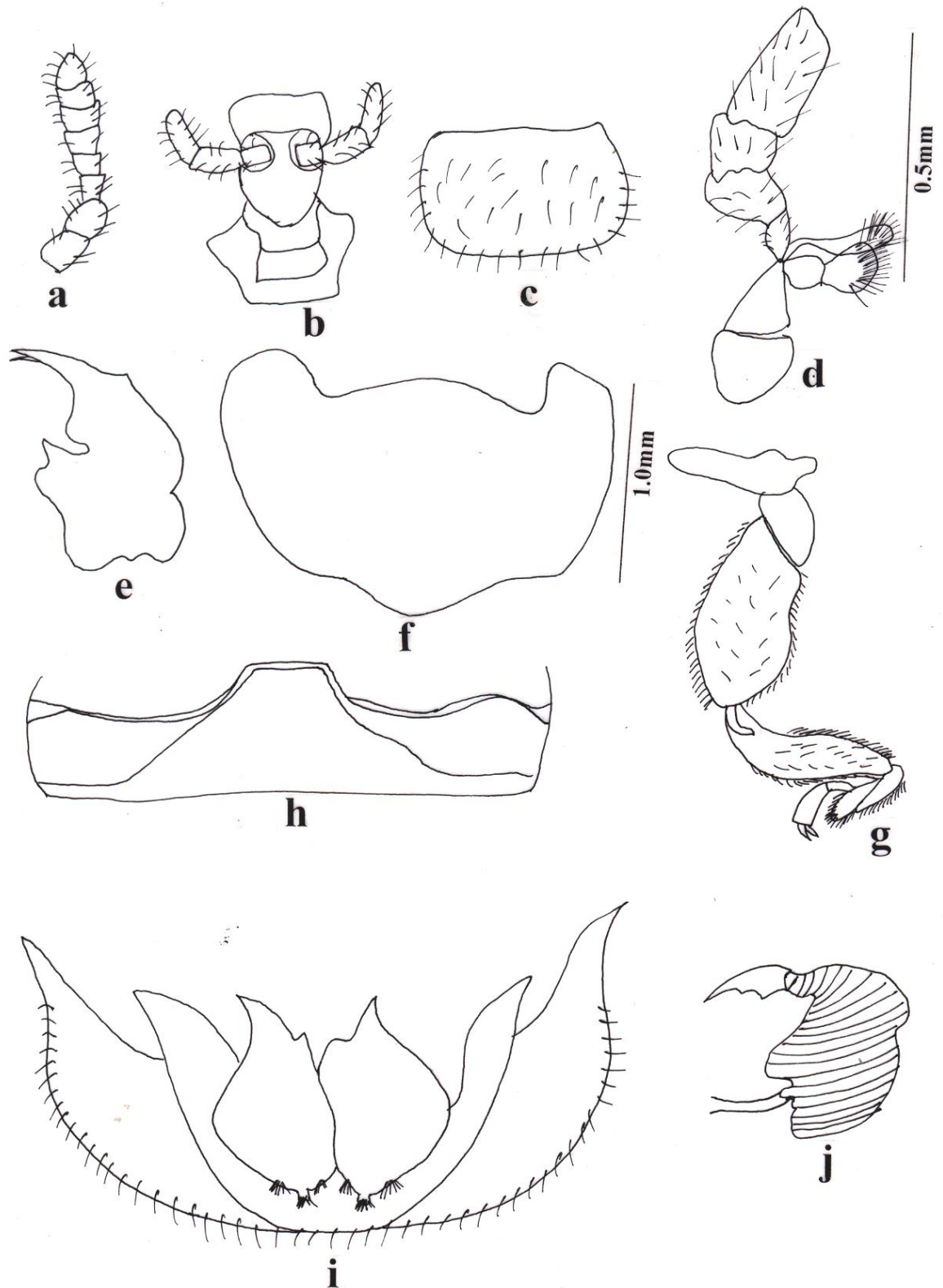


Fig. 2 : *Chilocorus nigratus* (Fabricius): (a) Antenna; (b) Labium; (c) Labrum; (d) Maxilla; (e) Mandible; (f) Pronotum; (g) Hindleg; (h) First abdominal sternite; (i) Hemisternite of female; (j) Spermatheca of female.

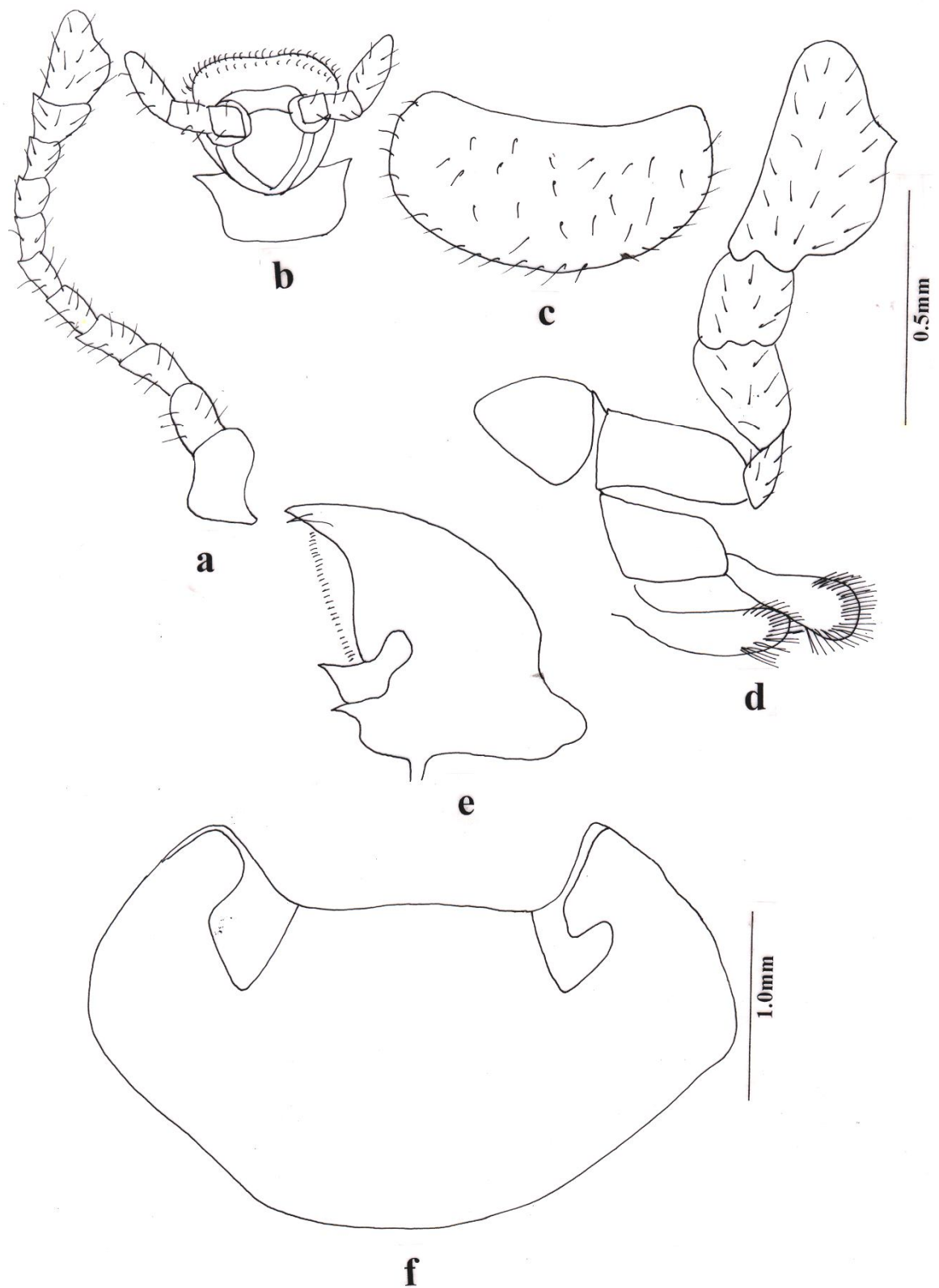


Fig. 3A: *Coccinella septempunctata* Linnaeus: (a) Antenna; (b) Labium ; (c) Labrum; (d) Maxilla; (e) Mandible; (f). Pronotum.

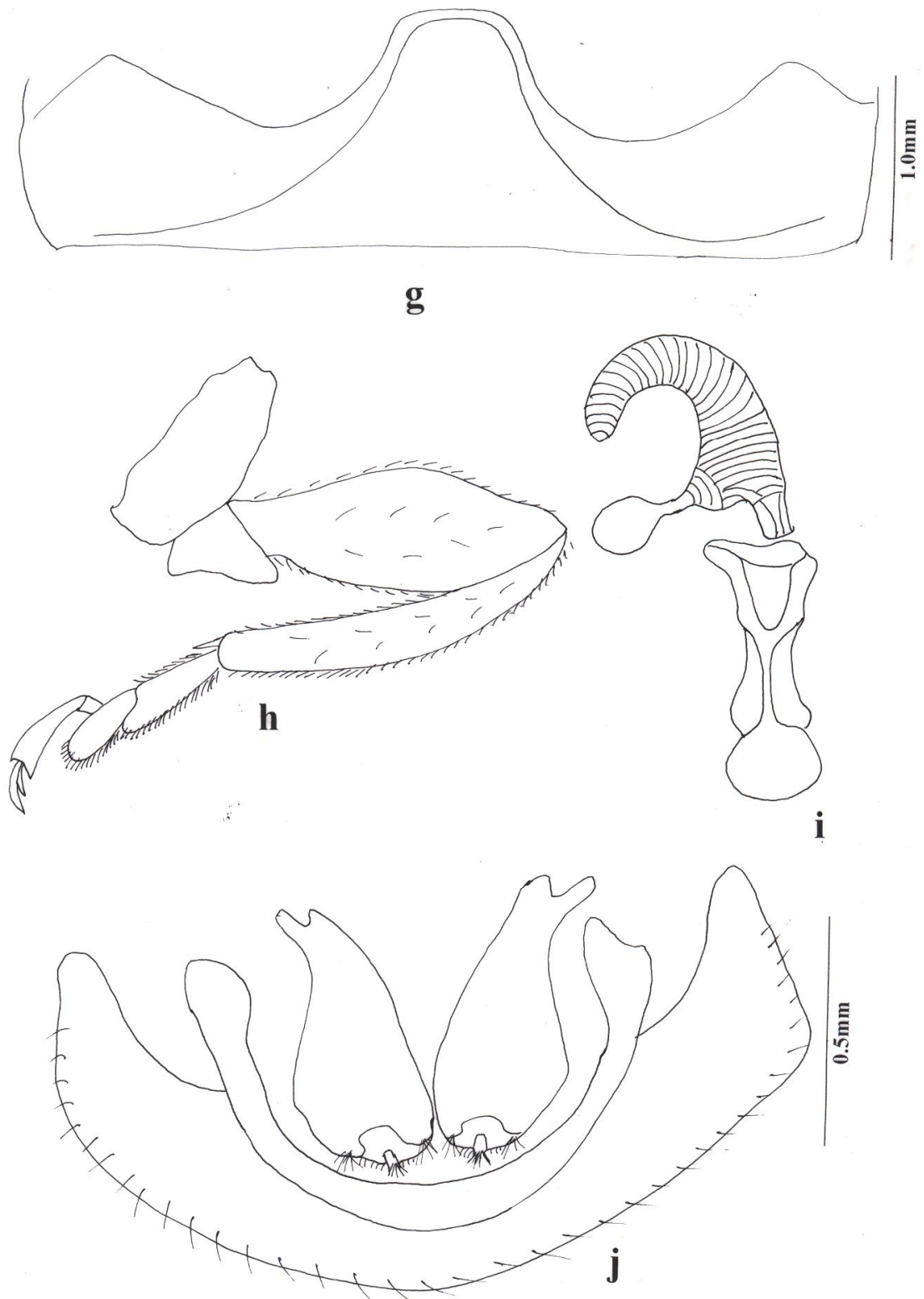


Fig. 3A: *Coccinella septempunctata* Linnaeus: (g) First abdominal sternite; (h) Hindleg; (i) Spermatheca of female; (j) Hemisternite of female.

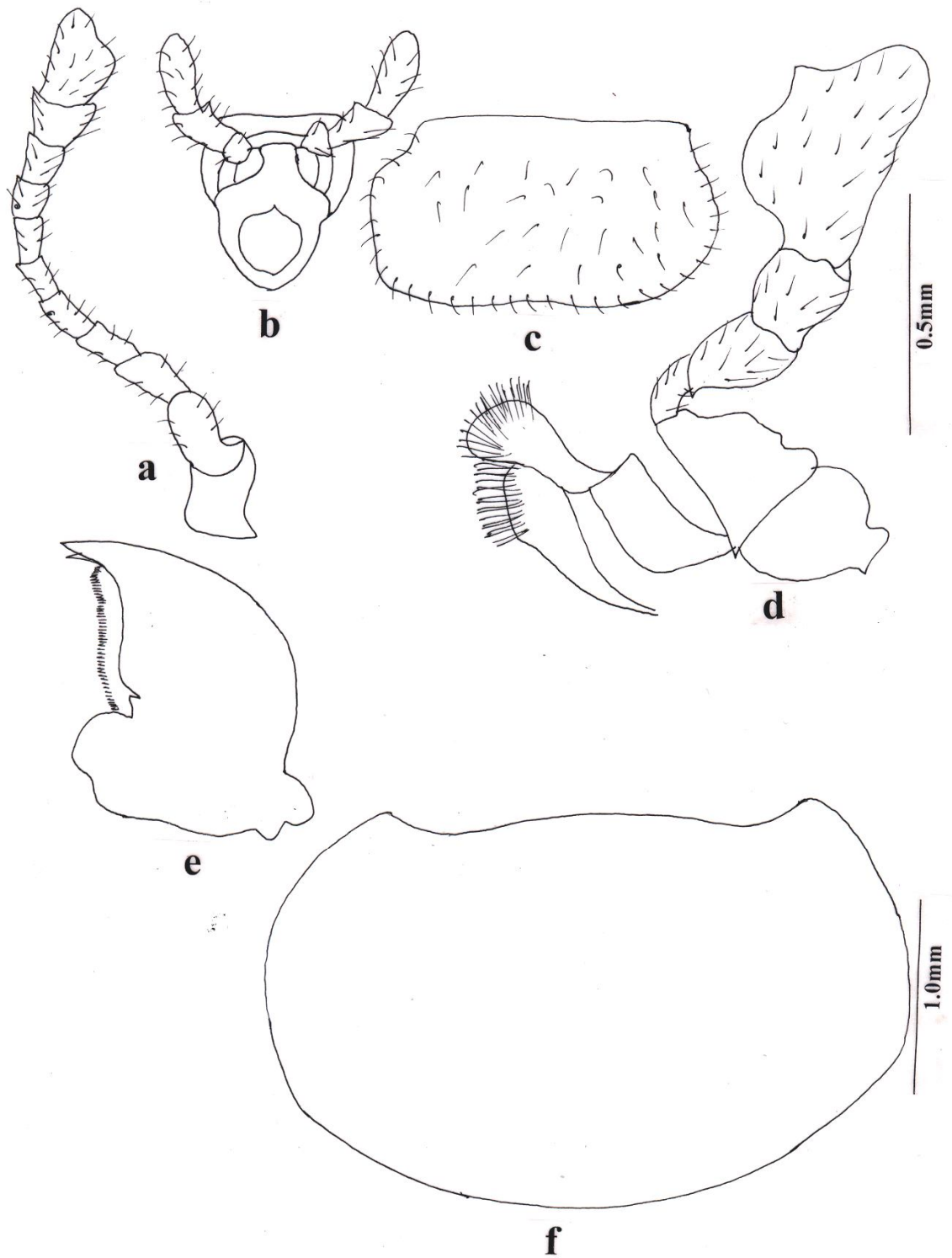


Fig. 3B: *Coccinella septempunctata* Linnaeus: (a) Antenna; (b) Labium; (c) Labrum; (d) Maxilla; (e) Mandible; (f) Pronotum.

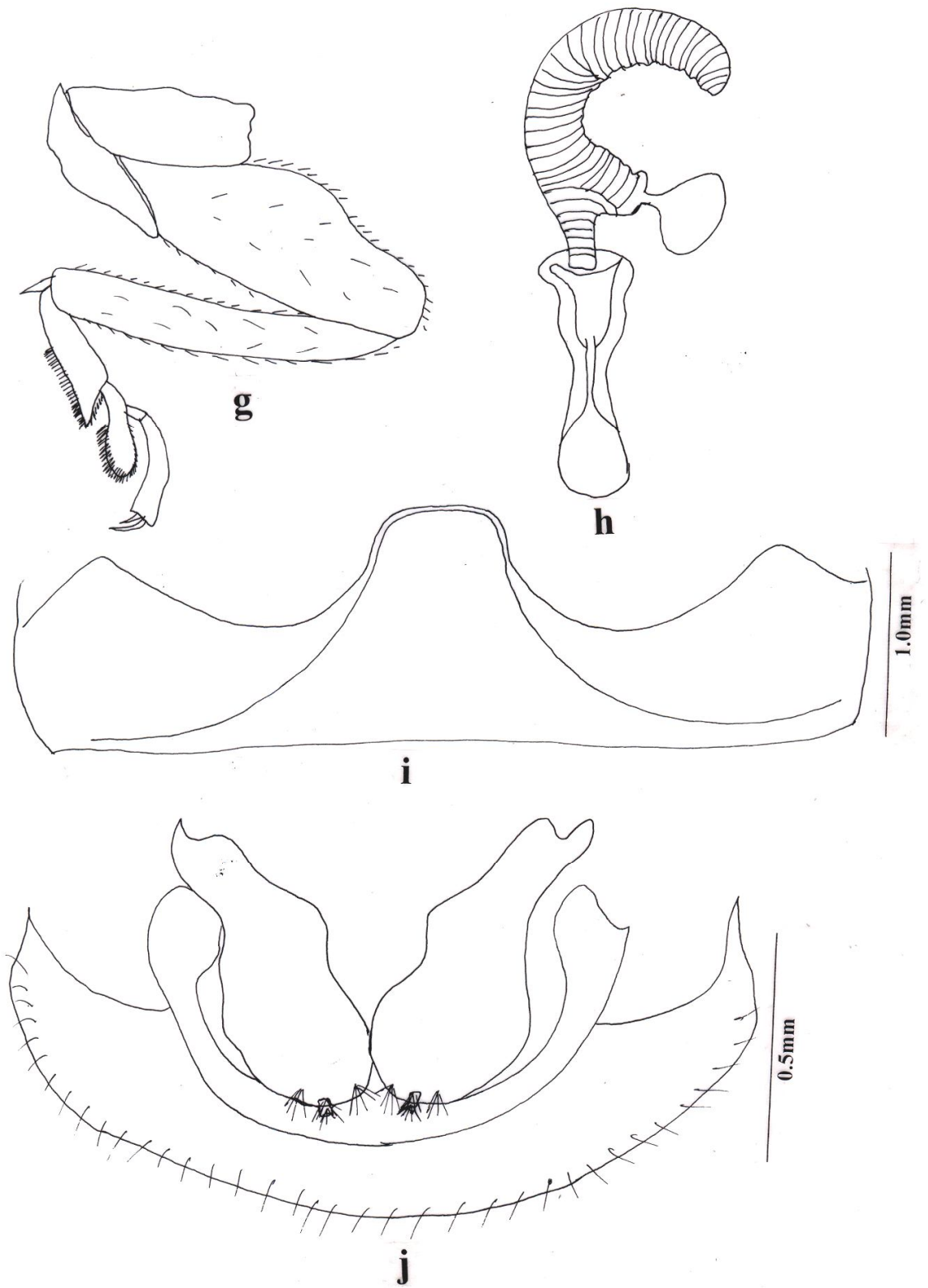


Fig. 3B: *Coccinella septempunctata* Linnaeus: (g) Hindleg; (h) Spermatheca of female; (i) First abdominal sternite; (j). Hemisternite of female.

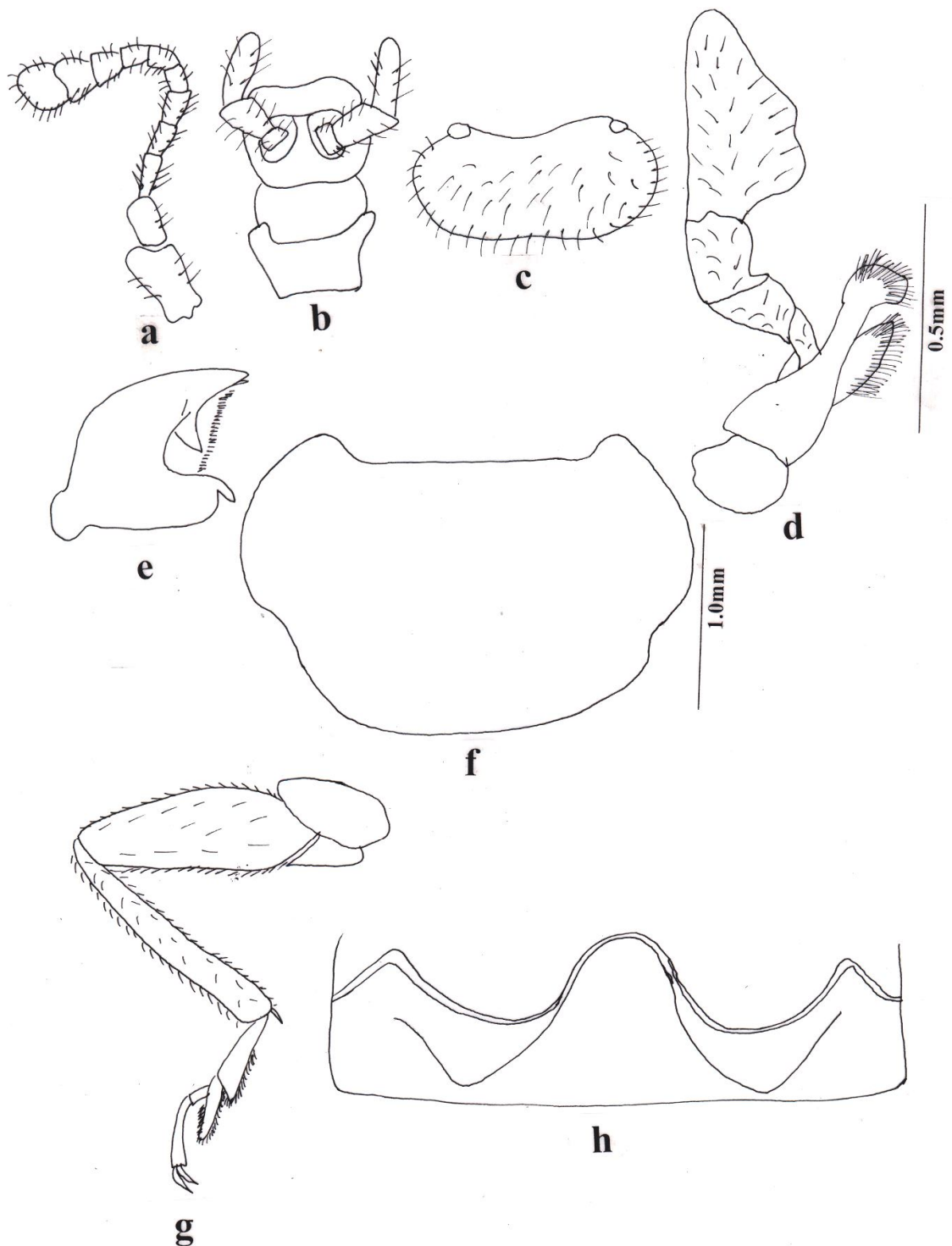


Fig. 4A: *Coccinella transversalis* Fabricius : (a) Antenna; (b) Labium ;
(c) Labrum; (d) Maxilla; (e) Mandible; (f) Pronotum;
(g) Hindleg; (h) First abdominal sternite.

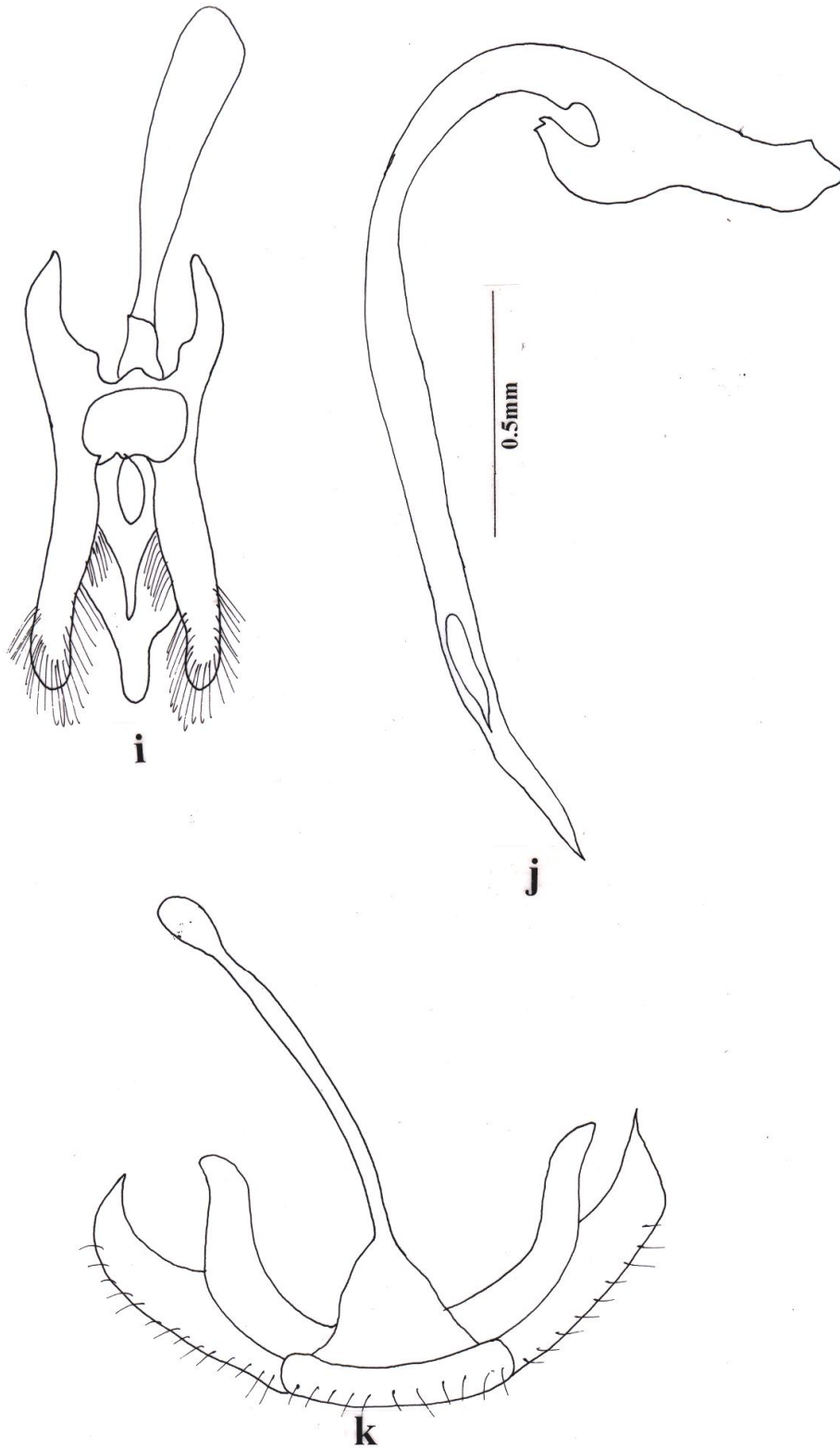


Fig. 4A: *Coccinella transversalis* Fabricius : (i) Male tegmen, ventral view; (j) Siphon; (k) Ninth abdominal segment of male.

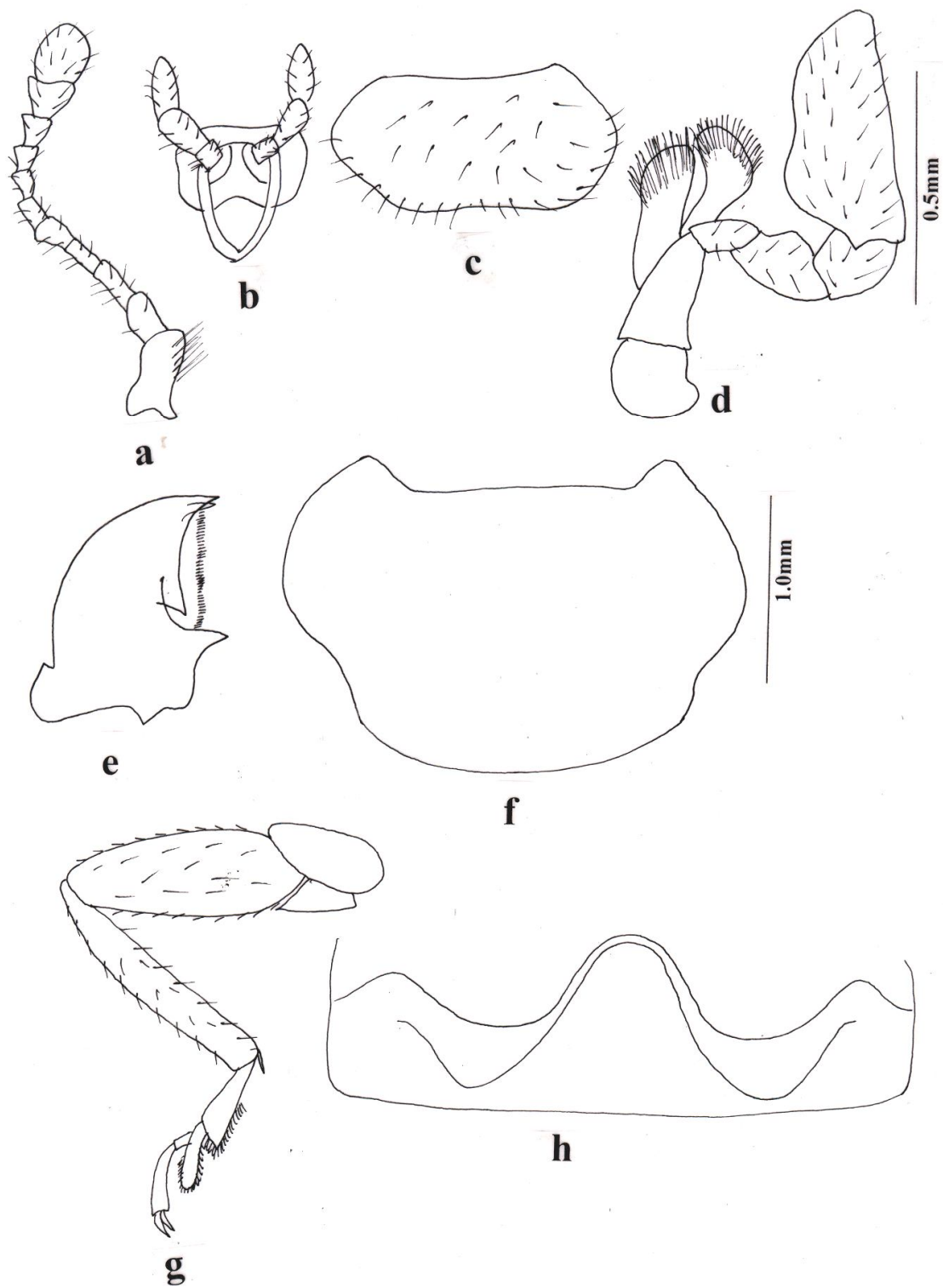


Fig. 4B: *Coccinella transversalis* Fabricius : (a) Antenna; (b) Labium; (c) Labrum; (d) Maxilla; (e) Mandible; (f) Pronotum; (g) Hindleg; (h) First abdominal sternite.

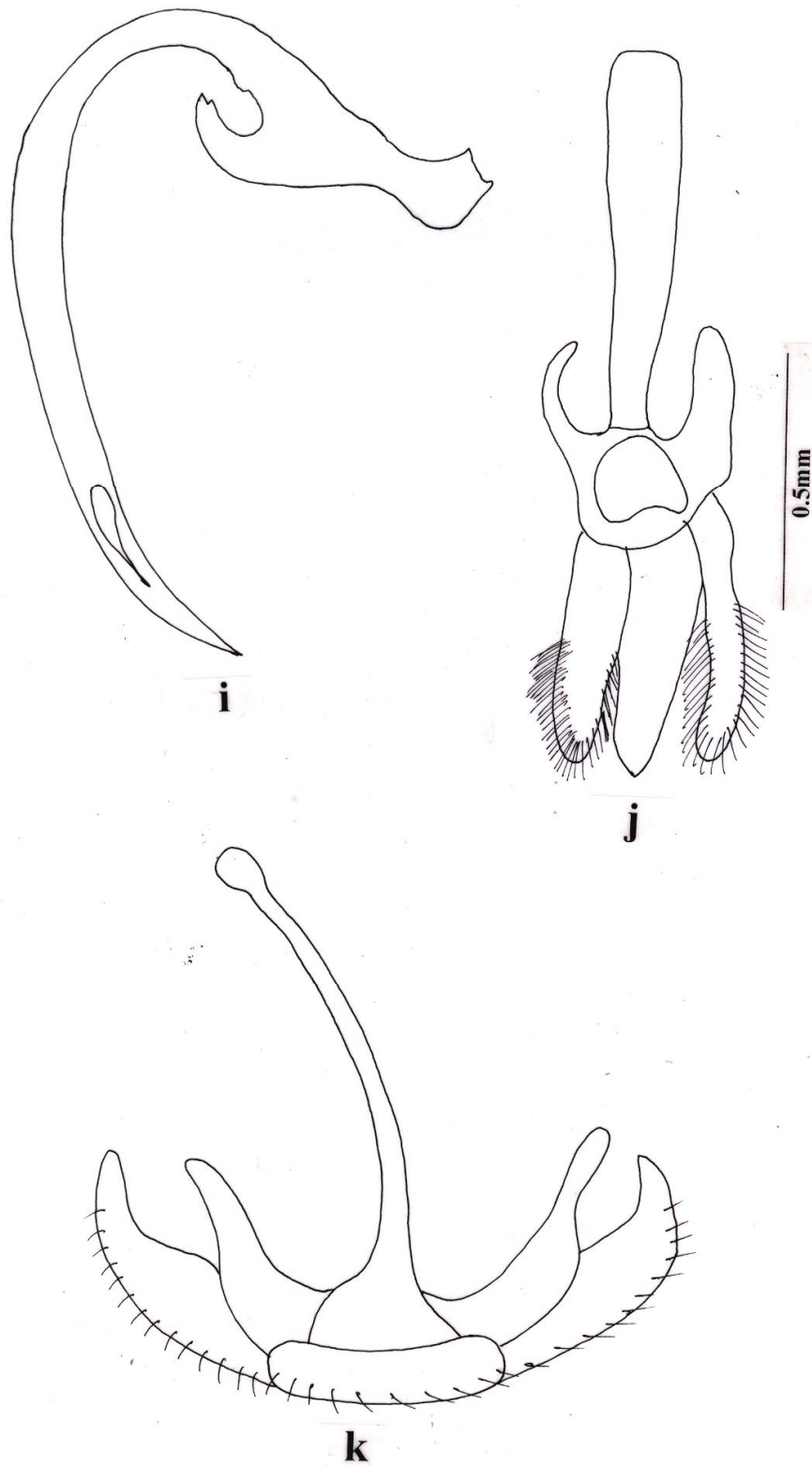


Fig. 4B: *Coccinella transversalis* Fabricius : (i) Siphon; (j) Male tegmen, dorsal view; (k) Ninth abdominal segment of male.

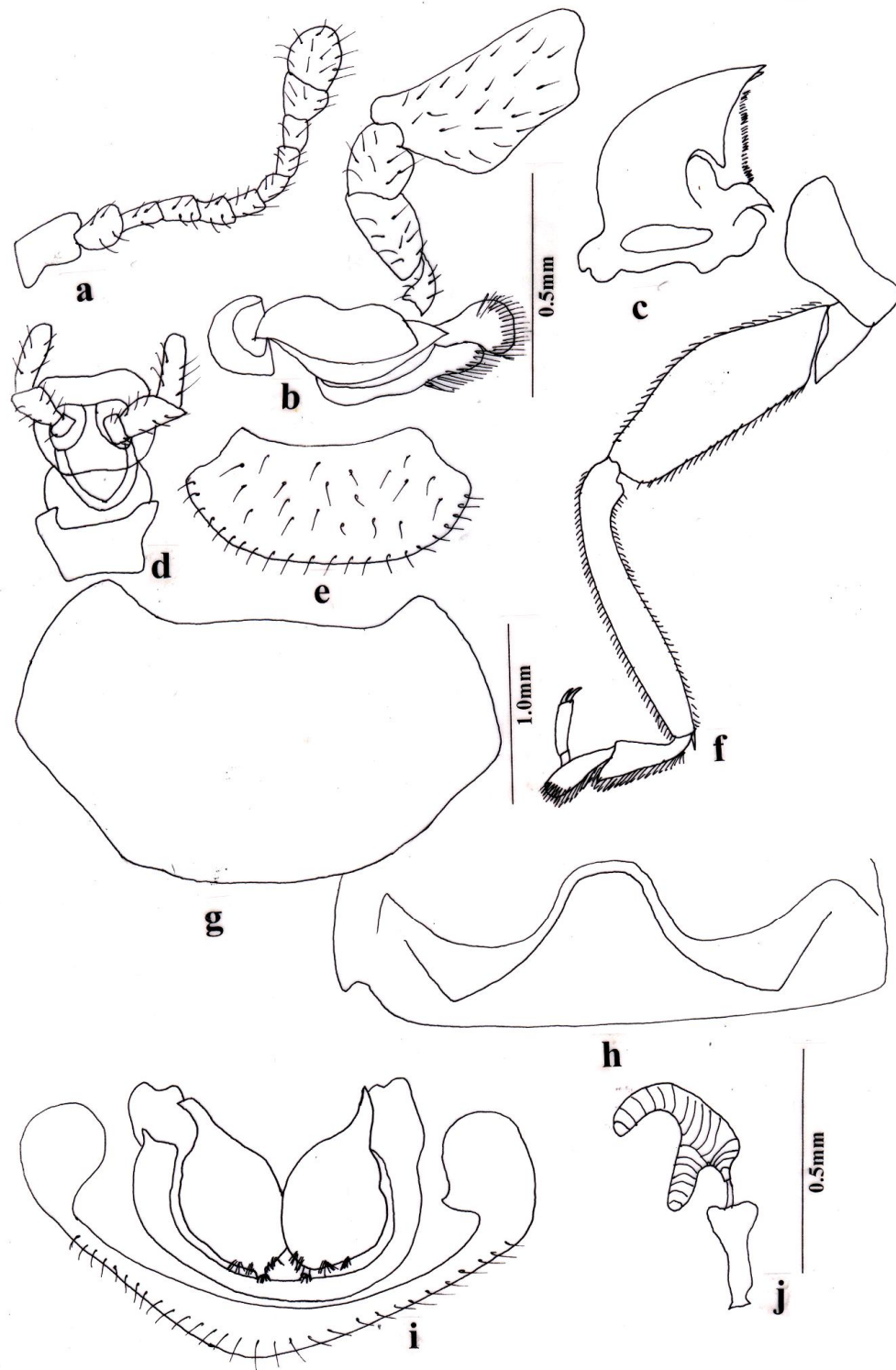


Fig. 4C: *Coccinella transversalis* Fabricius : (a) Antenna; (b) Maxilla; (c) Mandible; (d) Labium; (e) Labrum; (f) Hindleg; (g) Pronotum; (h) First abdominal sternite; (i) Hemisternite of female; (j) Spermatheca of female.

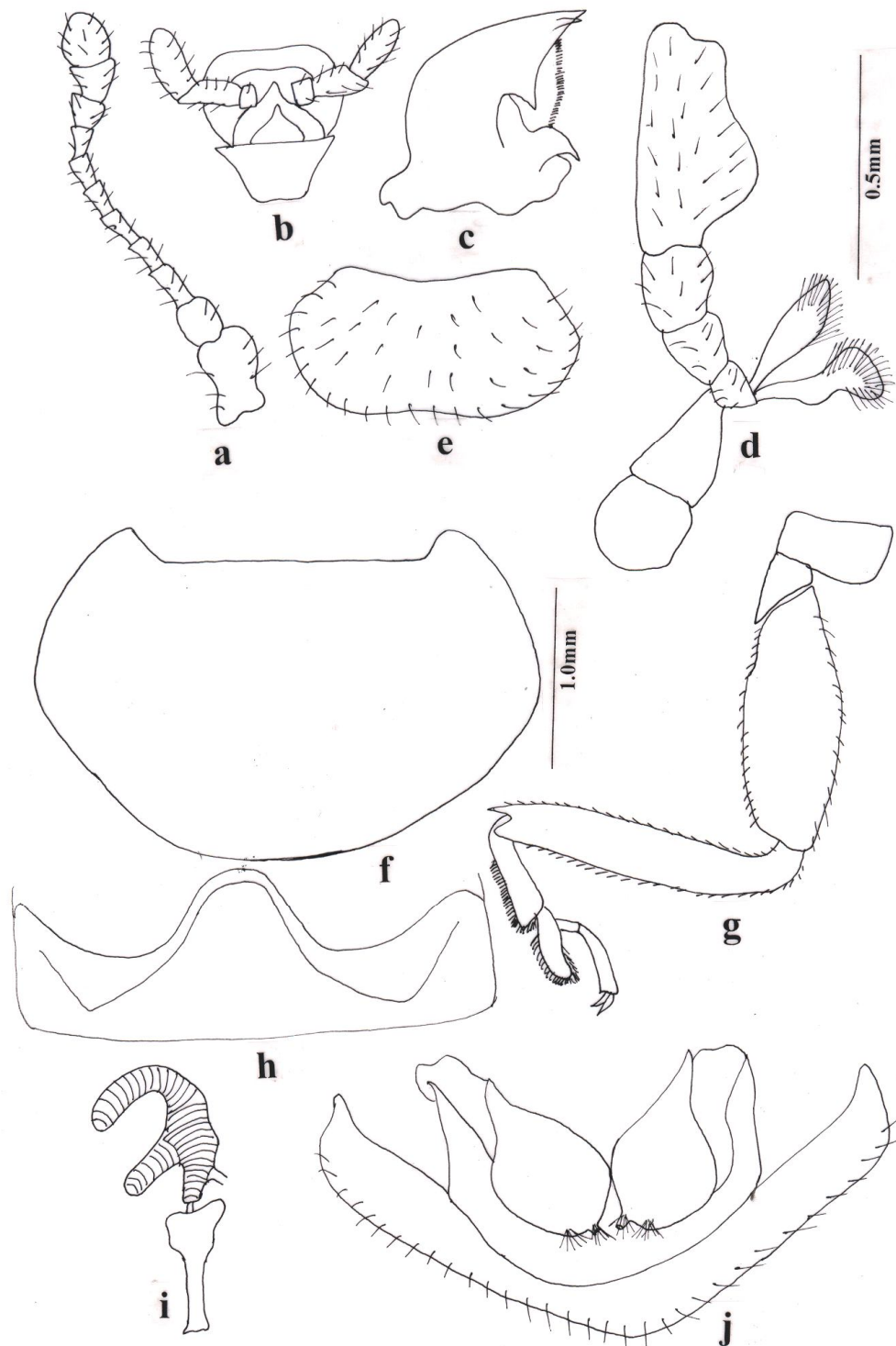


Fig. 4D: *Coccinella transversalis* Fabricius : (a) Antenna; (b) Labium; (c) Mandible; (d) Maxilla; (e) Labrum; (f) Pronotum; (g) Hindleg; (h) First abdominal sternite; (i) Spermatheca of female; (j) Hemisternite of female.

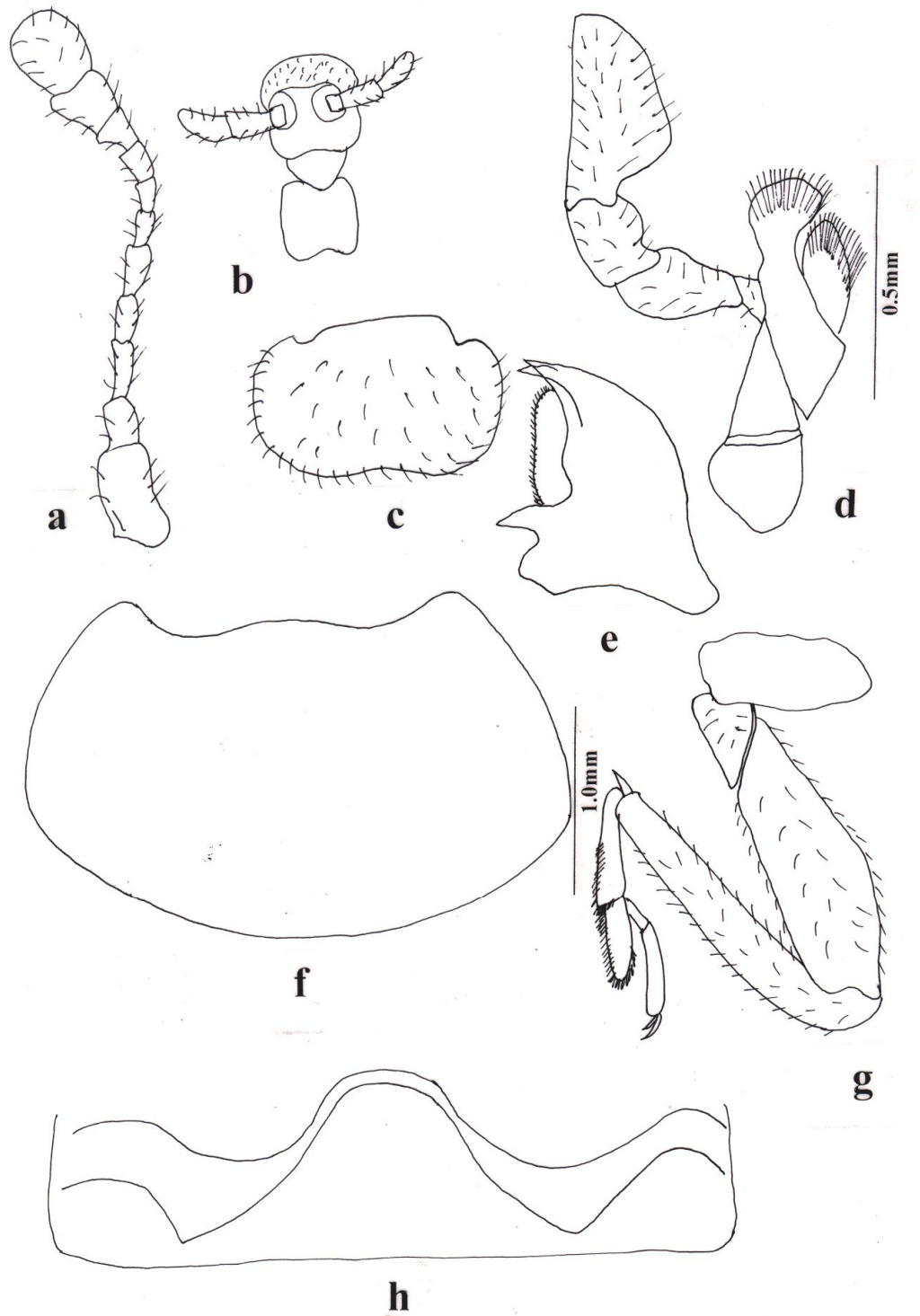


Fig. 5: *Harmonia octomaculata* (Fabricius) : (a) Antenna; (b) Labium; (c) Labrum; (d) Maxilla; (e) Mandible; (f) Pronotum; (g) Hindleg; (h) First abdominal sternite.

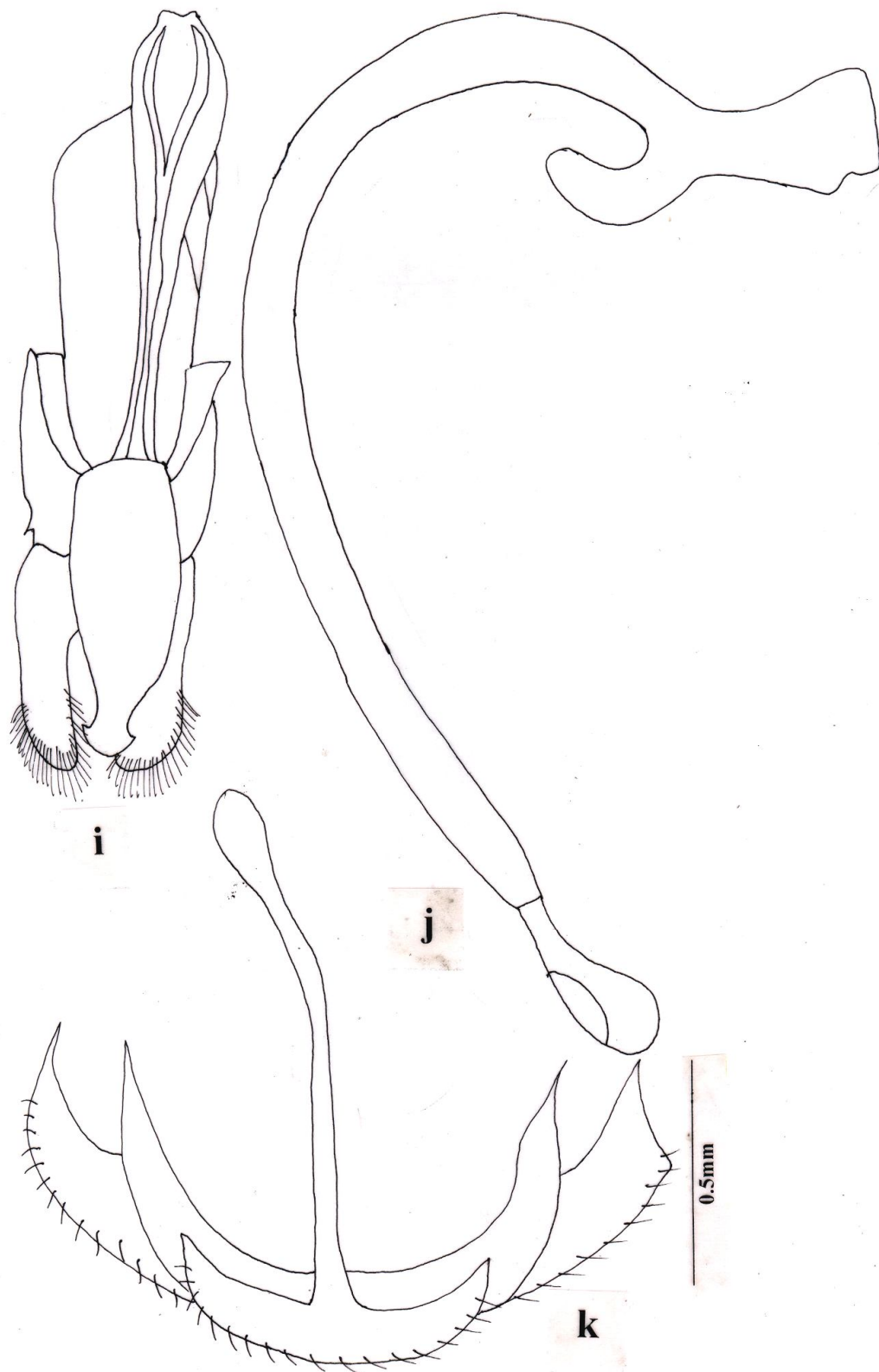


Fig. 5: *Harmonia octomaculata* (Fabricius) : (i) Male tegmen, dorsal view; (j) Siphon; (k) Ninth abdominal segment of male.

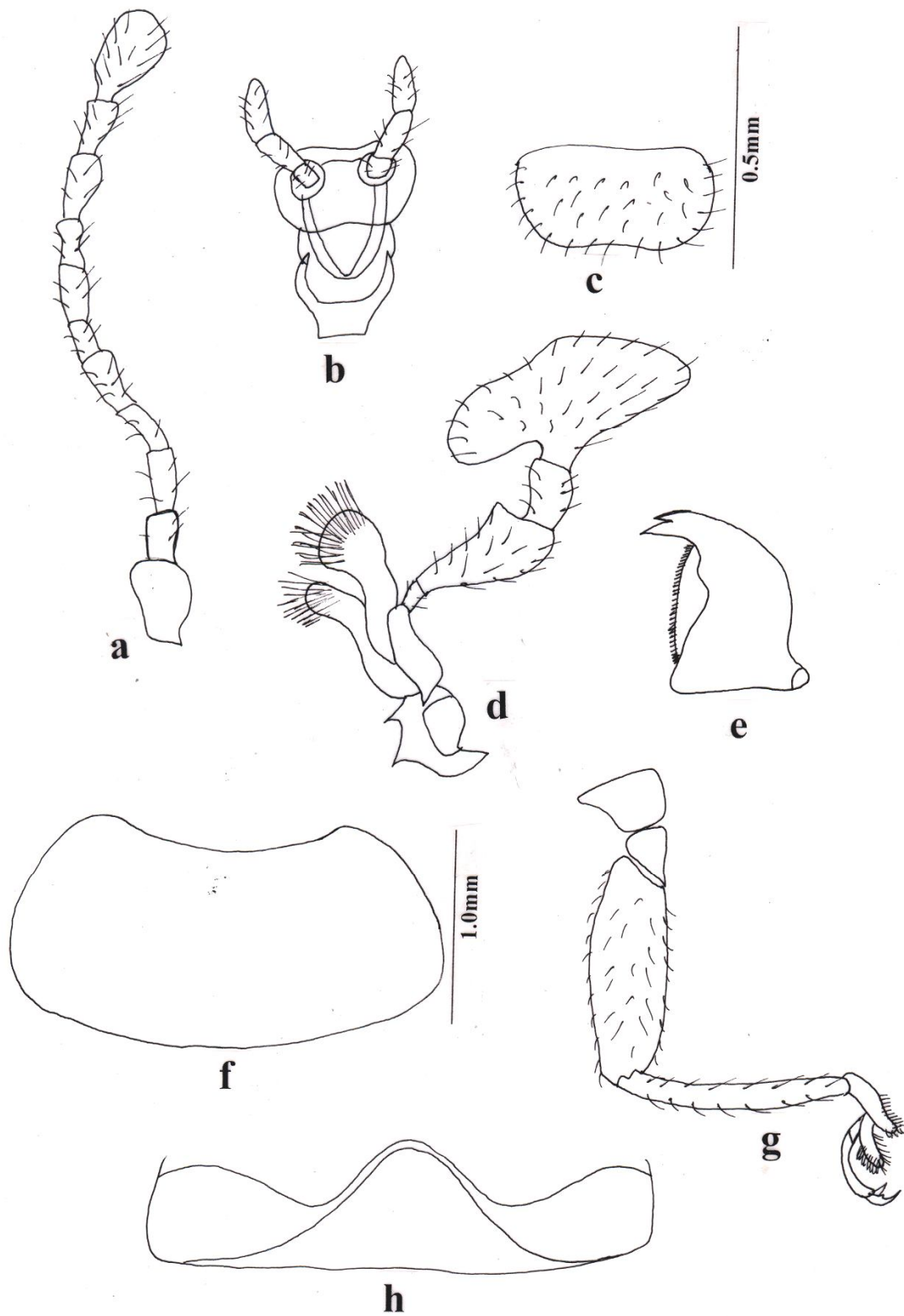


Fig. 6: *Illeis cincta* (Fabricius) : (a) Antenna; (b) Labium; (c) Labrum; (d) Maxilla; (e) Mandible; (f) Pronotum; (g) Hindleg; (h) First abdominal sternite.

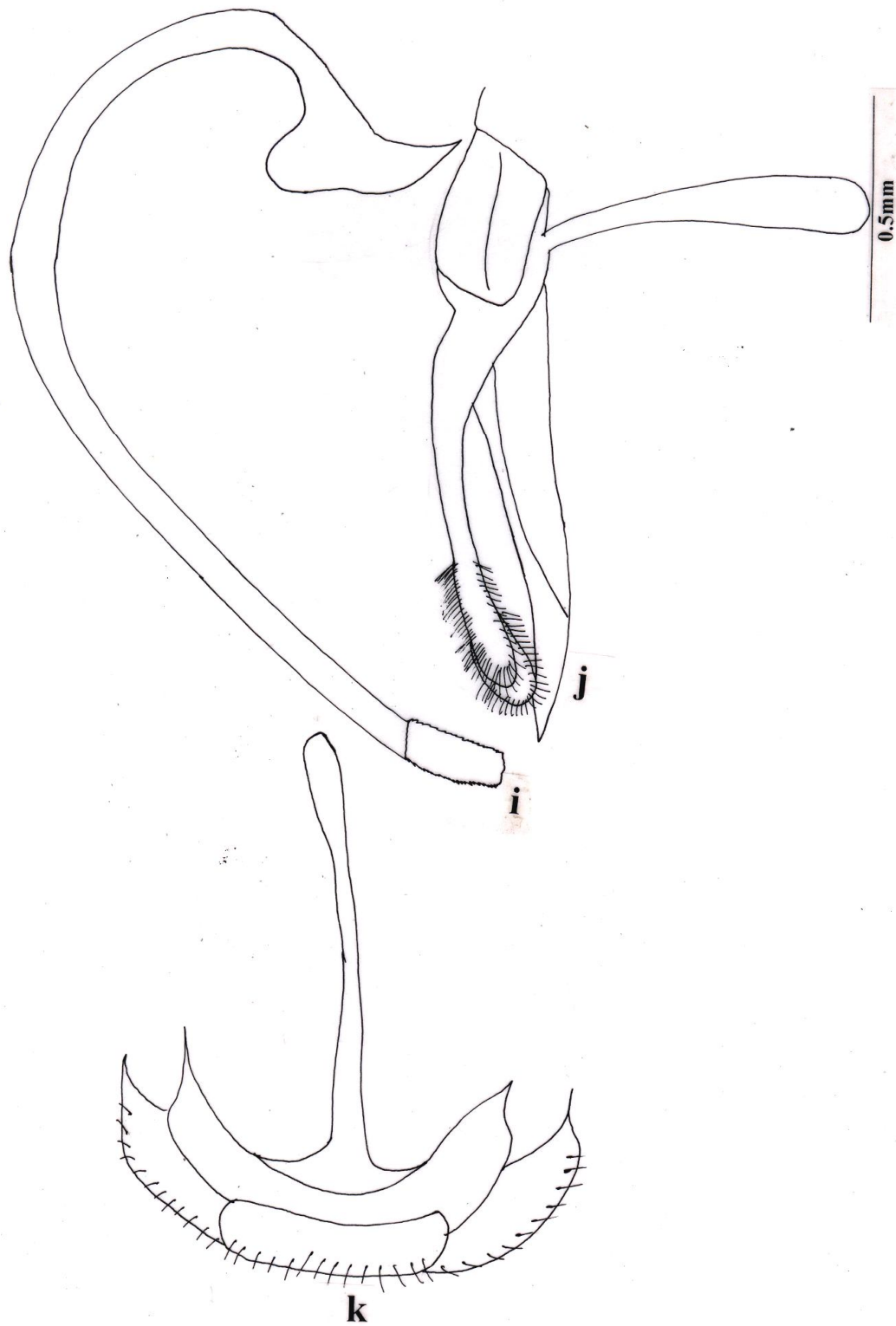


Fig. 6: *Illeis cincta* (Fabricius) : (i) Siphon; (j) Male tegmen, lateral view; (k) Ninth abdominal segment of male.

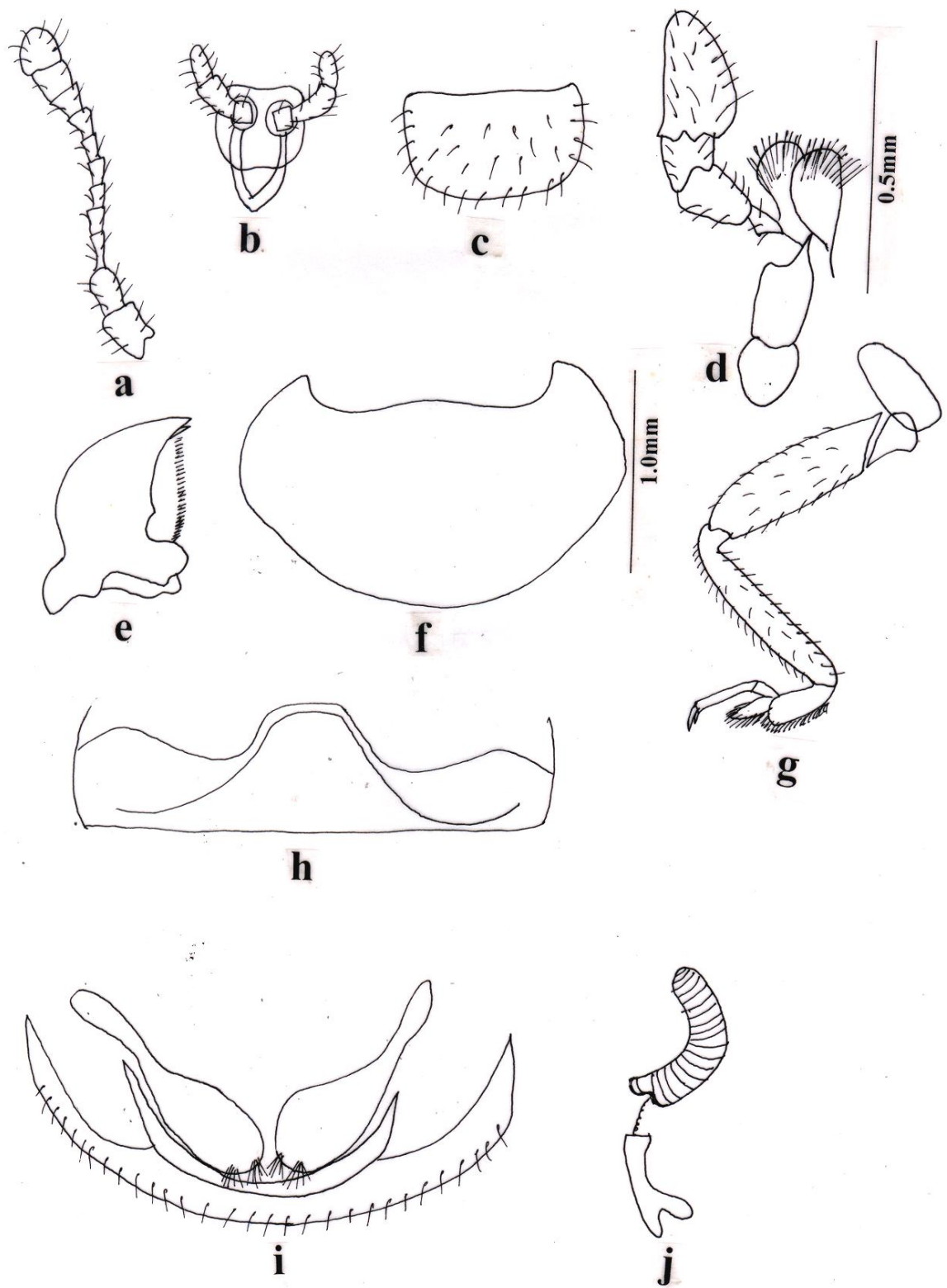


Fig. 7A: *Micraspis discolor* (Fabricius) : (a) Antenna; (b) Labium; (c) Labrum; (d) Maxilla; (e) Mandible; (f) Pronotum (g) Hindleg; (h) First abdominal sternite (i) Hemisterinite of female; (j) Spermatheca of female.

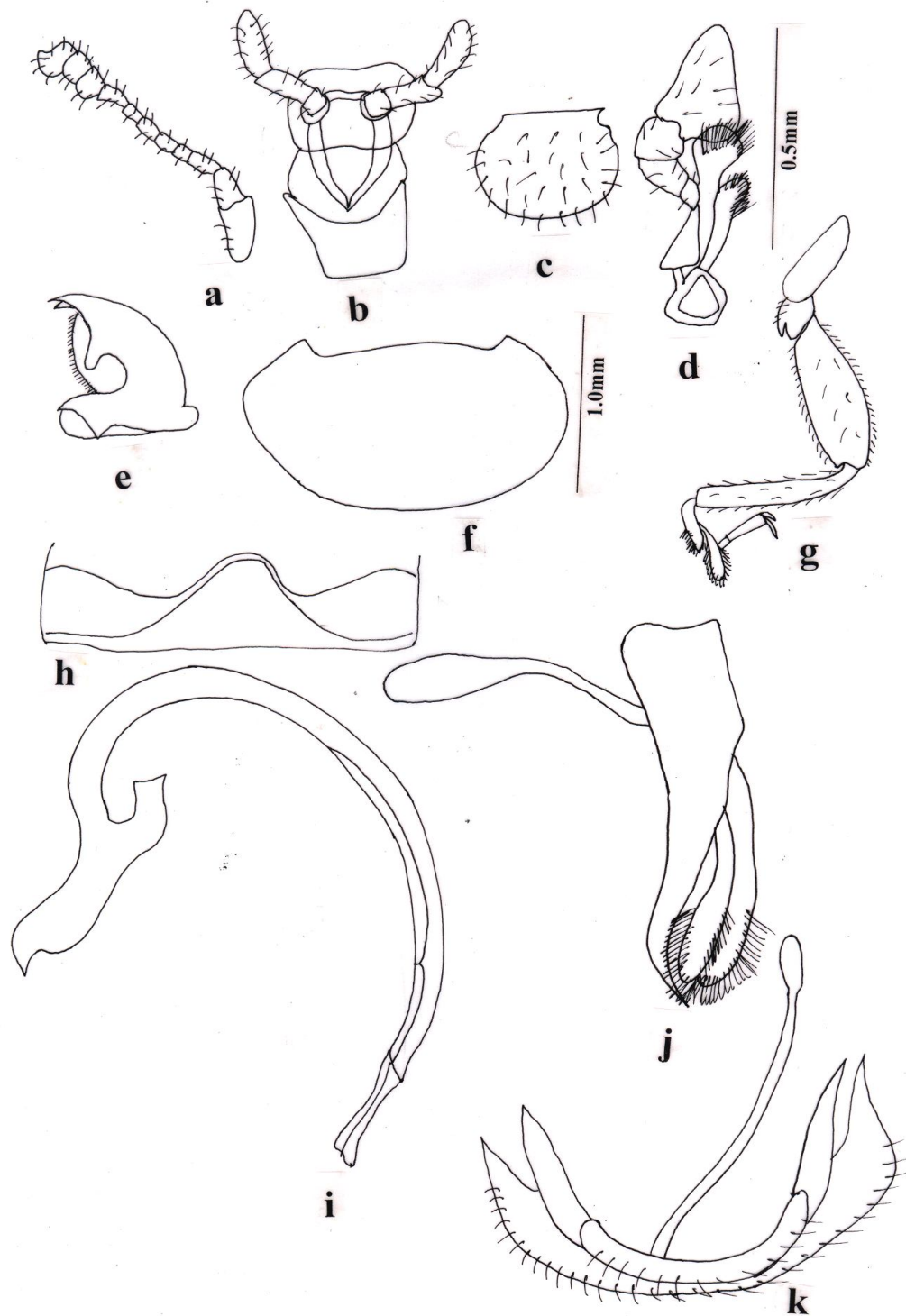


Fig. 7B: *Micraspis discolor* (Fabricius) : (a) Antenna; (b) Labium; (c) Labrum; (d) Maxilla; (e) Mandible; (f) Pronotum; (g) Hindleg; (h) First abdominal sternite; (i) Siphus; (j) Male tegmen, lateral view; (k) Ninth abdominal segment of male.

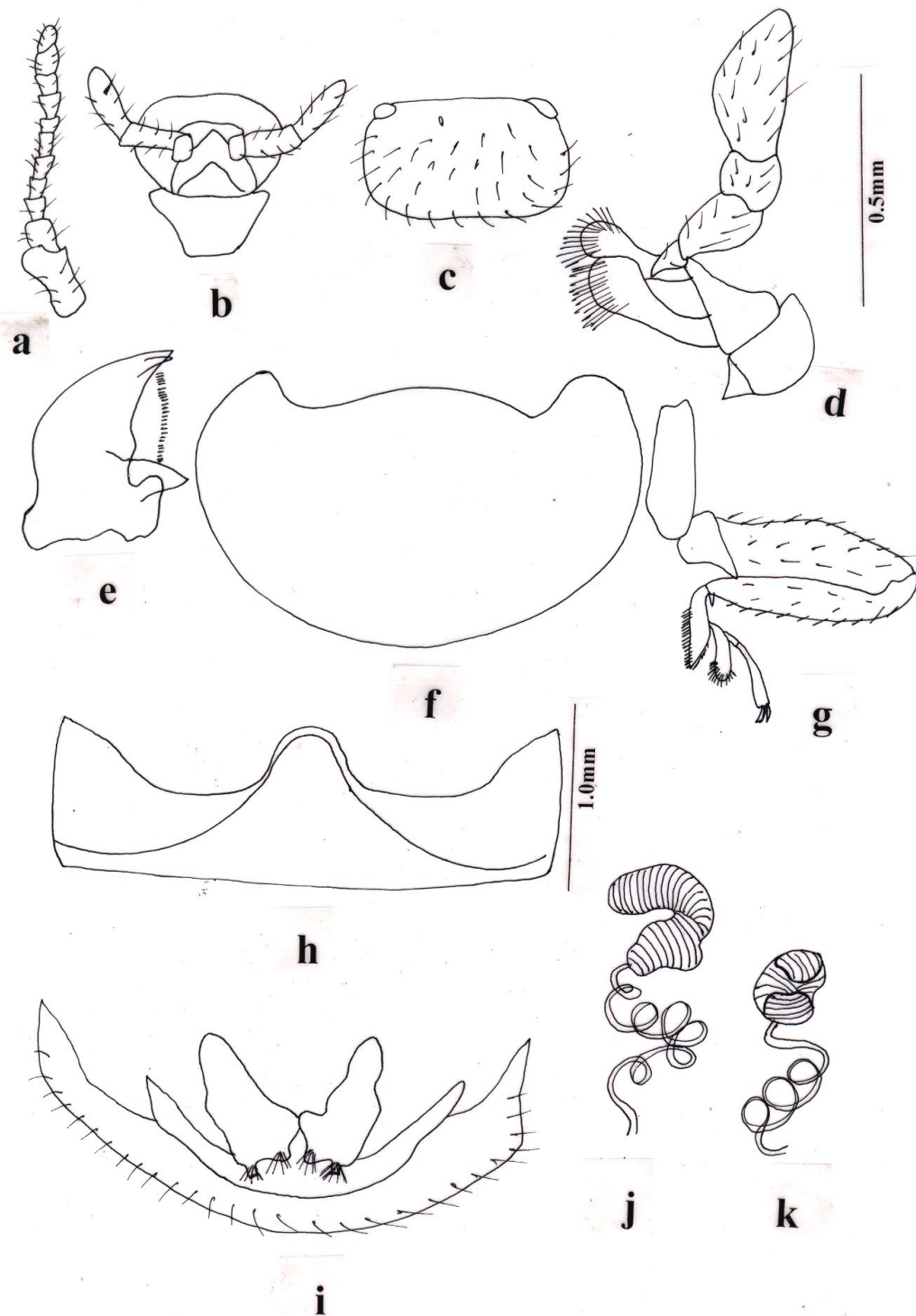


Fig. 8A: *Cheilomenes sexmaculata* (Fabricius) : (a) Antenna; (b) Labium; (c) Labrum; (d) Maxilla; (e) Mandible; (f) Pronotum; (g) Hindleg; (h) First abdominal sternite; (i) Hemisternite of female; (j) Spermatheca of female, dorsal view; (k) Spermatheca of female, ventral view.

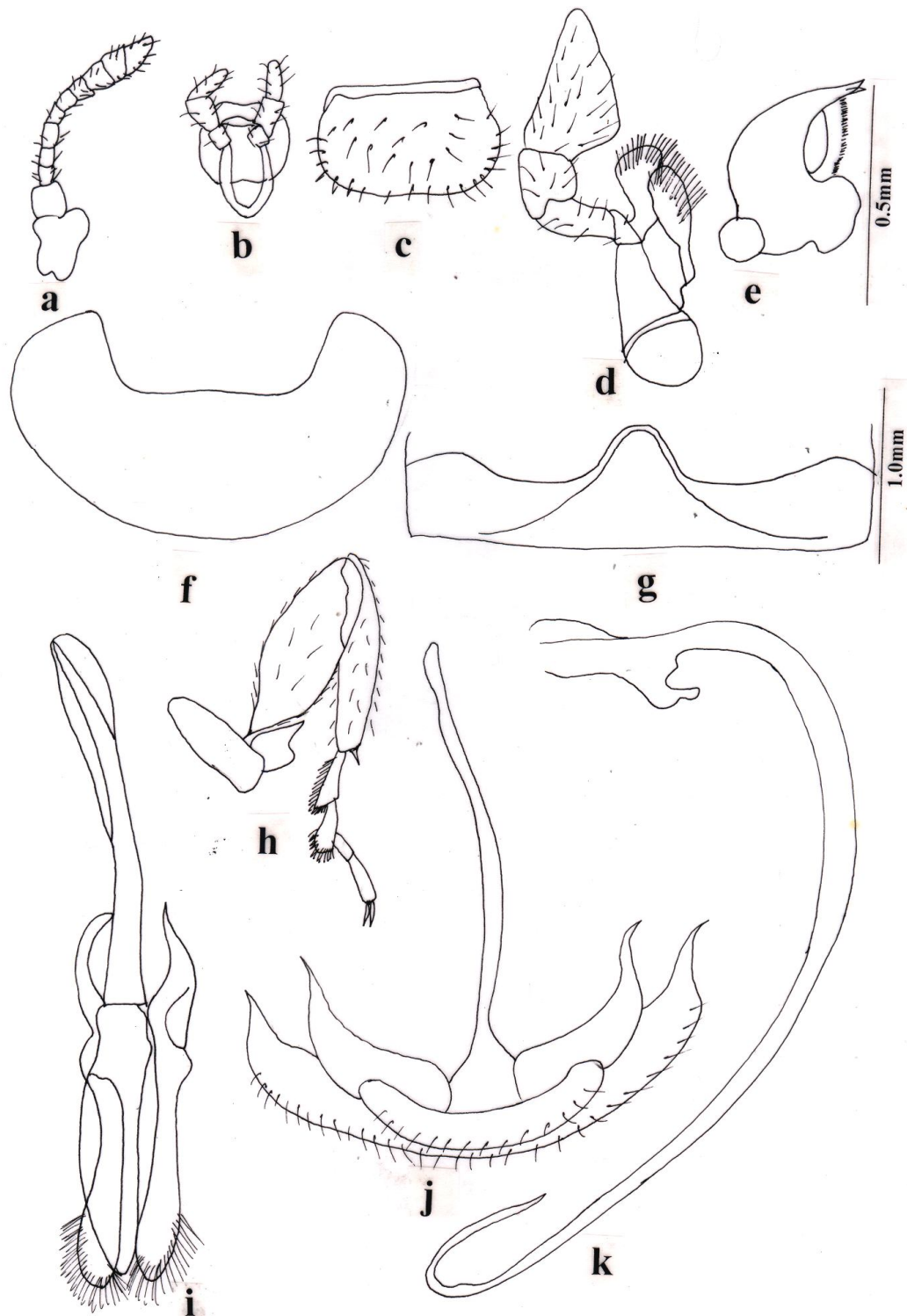


Fig. 8B: *Cheilomenes sexmaculata* (Fabricius) : (a) Antenna; (b) Labium; (c) Labrum ; (d) Maxilla; (e) Mandible; (f) Pronotum; (g) First abdominal sternite; (h) Hindleg; (i) Male tegmen, dorsal view; (j) Ninth abdominal segment of male; (k) Siphon.

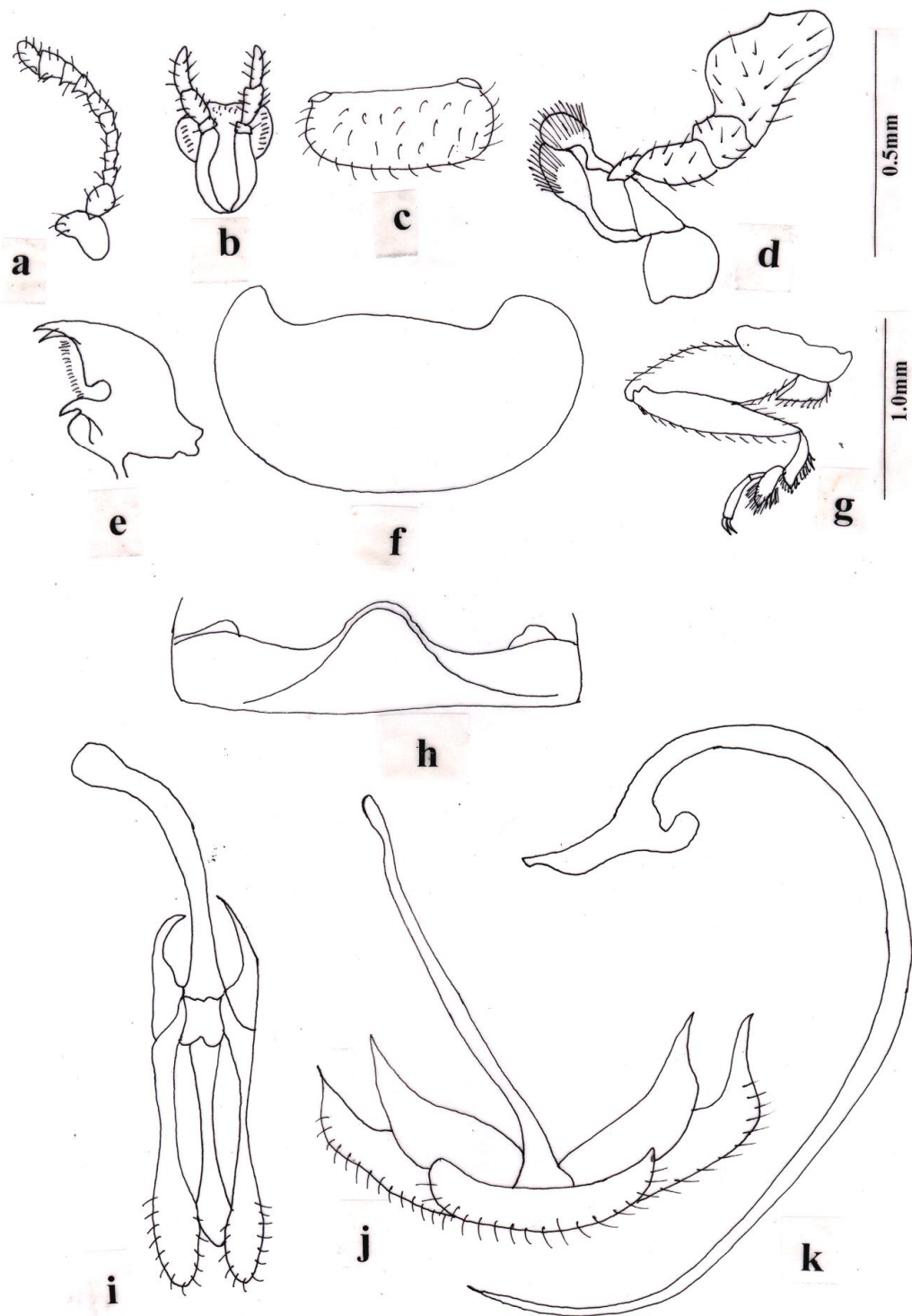


Fig. 8C: *Cheilomenes sexmaculata* (Fabricius) : (a) Antenna; (b) Labium; (c) Labrum ; (d) Maxilla; (e) Mandible; (f) Pronotum; (g) Hindleg; (h) First abdominal sternite; (i) Male tegmen, dorsal view; (j) Ninth abdominal segment of male; (k) Siphon.

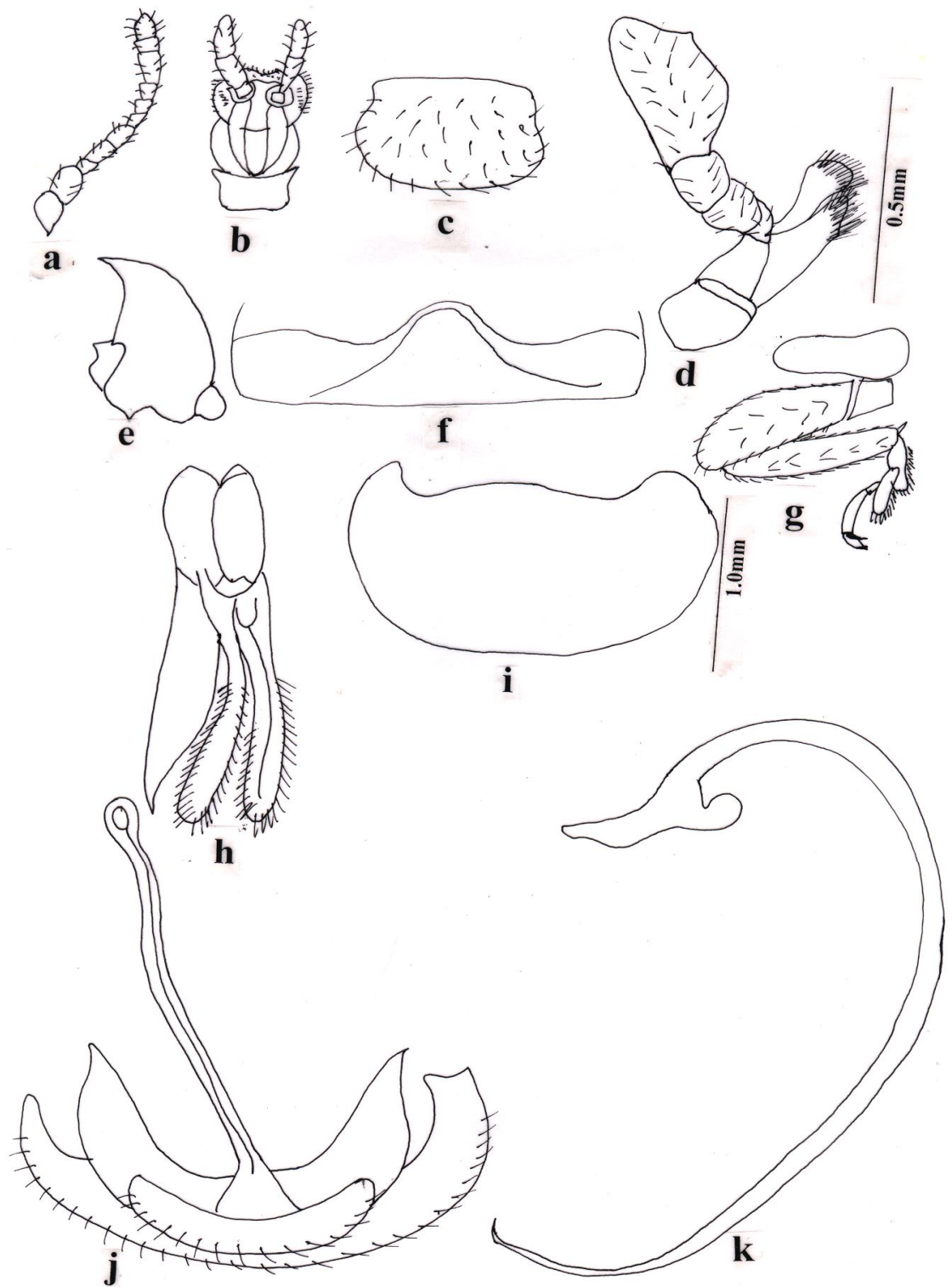


Fig. 8D: *Cheilomenes sexmaculata* (Fabricius) : (a) Antenna; (b) Labium; (c) Labrum; (d) Maxilla; (e) Mandible; (f) First abdominal sternite; (g) Hindleg; (h) Male tegmen, lateral view; (i) Pronotum; (j) Ninth abdominal segment of male; (k) Siphon.

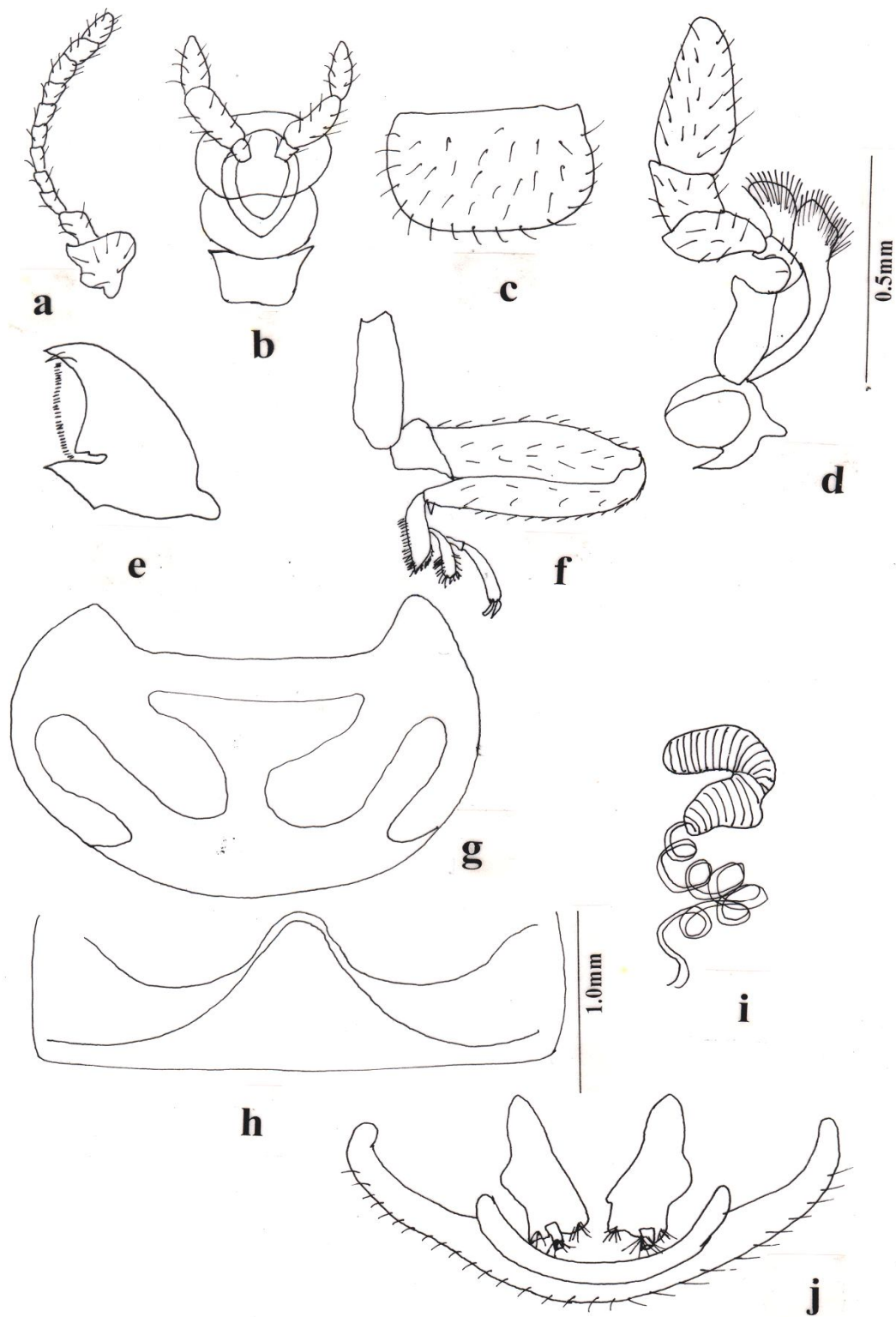


Fig. 8E: *Cheilomenes sexmaculata* (Fabricius) : (a) Antenna; (b) Labium; (c) Labrum; (d) Maxilla; (e) Mandible; (f) Hindleg; (g) Pronotum; (h) First abdominal sternite; (i) Spermatheca of female; (j) Hemisternite of female.

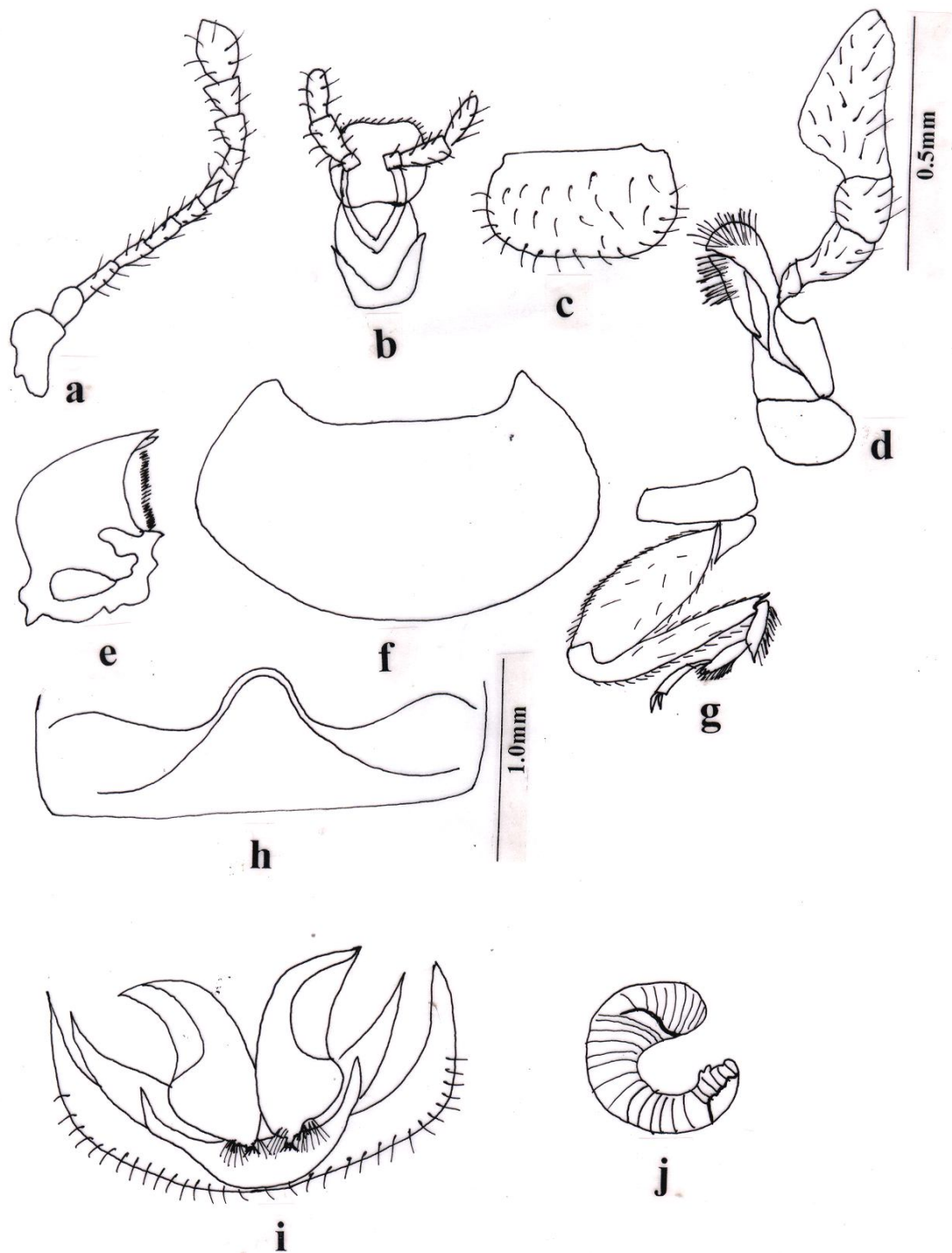


Fig. 9: *Propylea sp.nr. japonica* (Thunberg) : (a) Antenna; (b) Labium; (c) Labrum; (d) Maxilla; (e) Mandible; (f) Pronotum; (g) Hindleg; (h) First abdominal sternite; (i) Hemisternite of female; (j) Spermatheca of female.

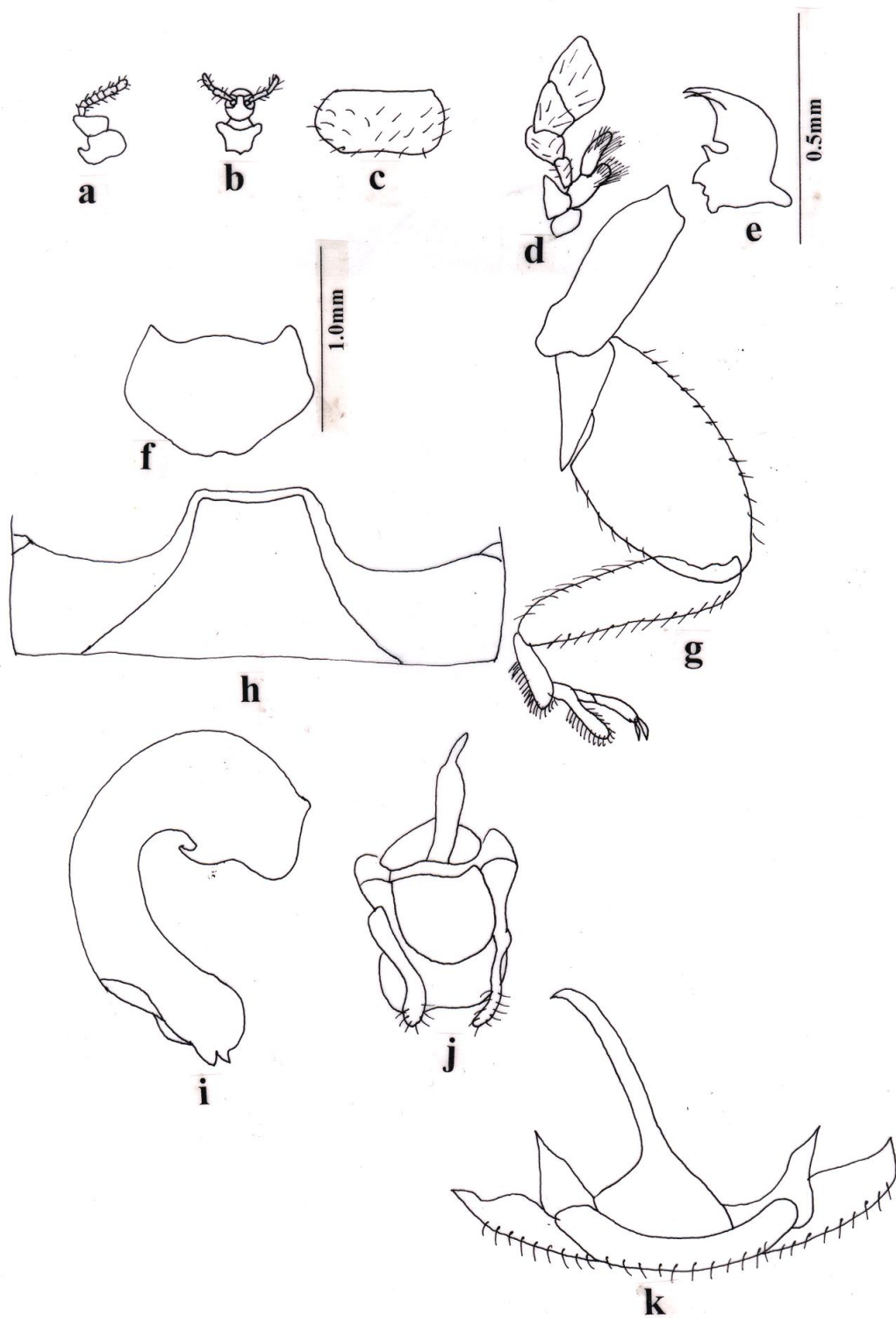


Fig.10: *Pseudaspidimerus trinotatus* (Thunberg) : (a) Antenna; (b) Labium; (c) Labrum ; (d) Maxilla; (e) Mandible; (f) Pronotum; (g) Hindleg; (h) First abdominal sternite; (i) Siphus; (j) Male tegmen, dorsal view; (k). Ninth abdominal segment of male.

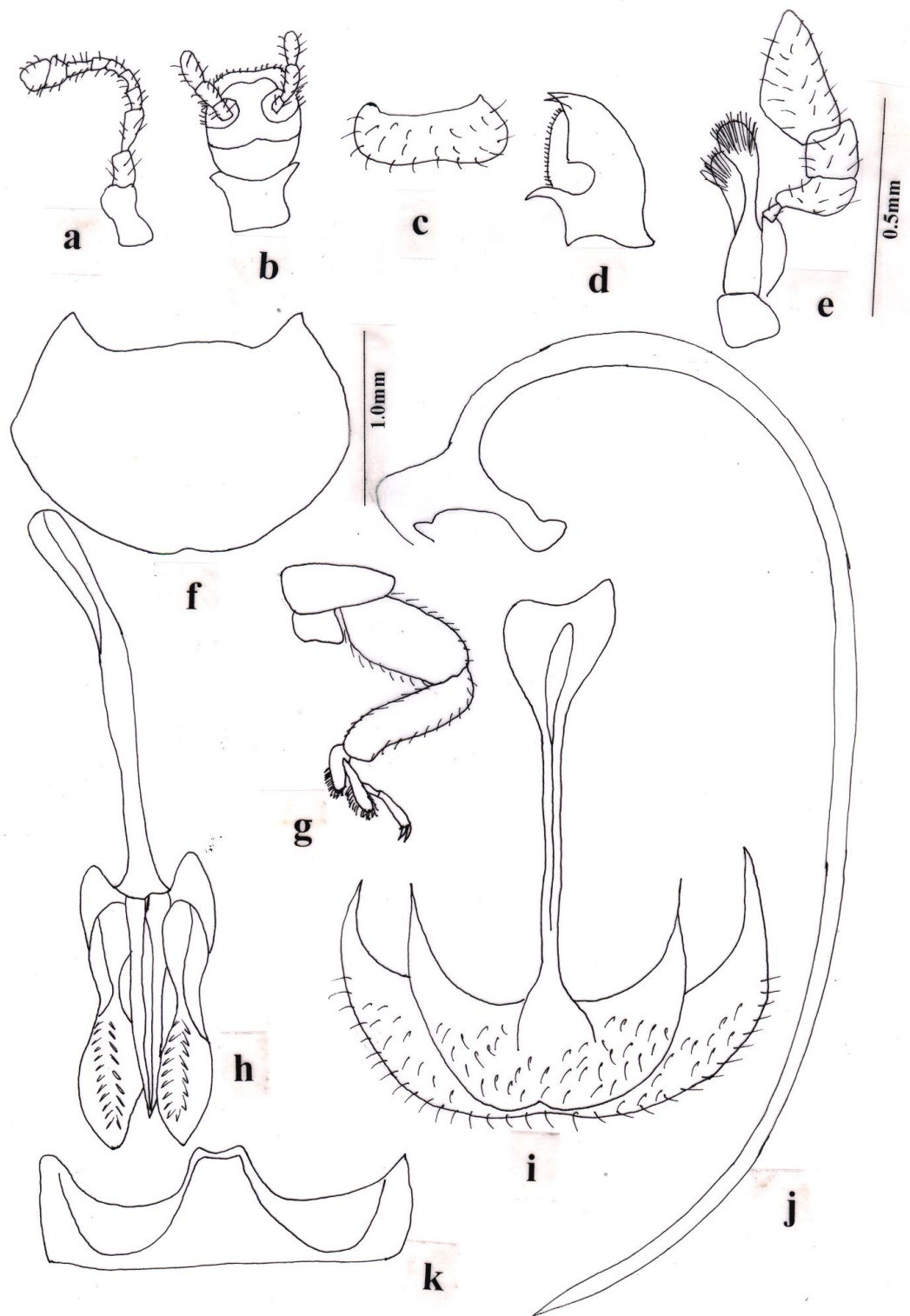


Fig.11: *Cryptolaemus montrouzieri* Mulsant : (a) Antenna; (b) Labium; (c) Labrum ; (d) Mandible; (e) Maxilla; (f) Pronotum; (g) Hindleg; (h) Male tegmen, ventral view; (i) Ninth abdominal segment of male; (j) Siphon; (k) First abdominal sternite.

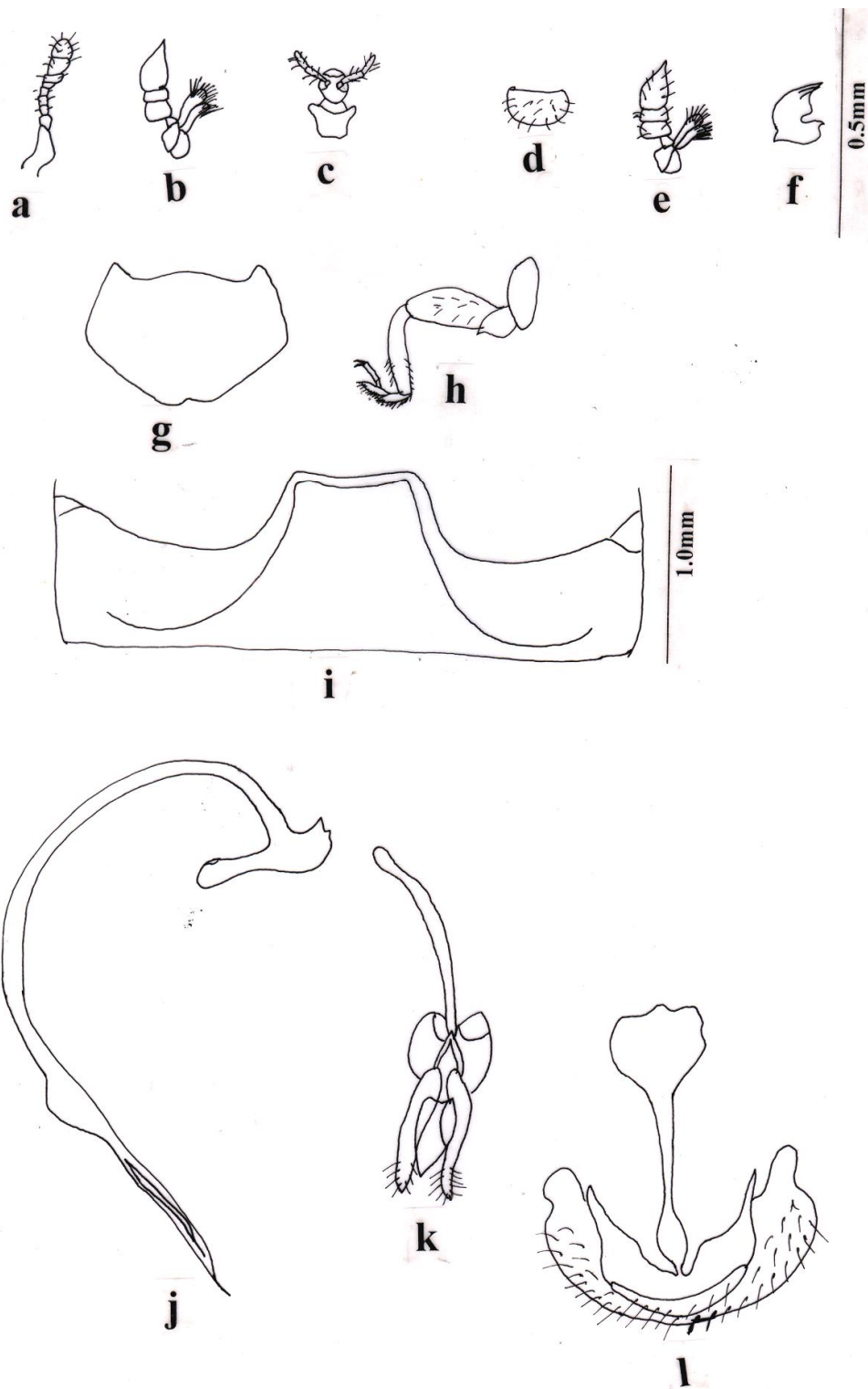


Fig.12: *Scymnus (Scymnus) nubilus* Mulsant : (a) Antenna; (b) Maxilla; (c) Labium; (d) Labrum; (e) Maxilla; (f) Mandible; (g) Pronotum; (h) Hindleg; (i) First abdominal sternite; (j) Siphus; (k) Male tegmen, ventral view; (l) Ninth abdominal segment of male.

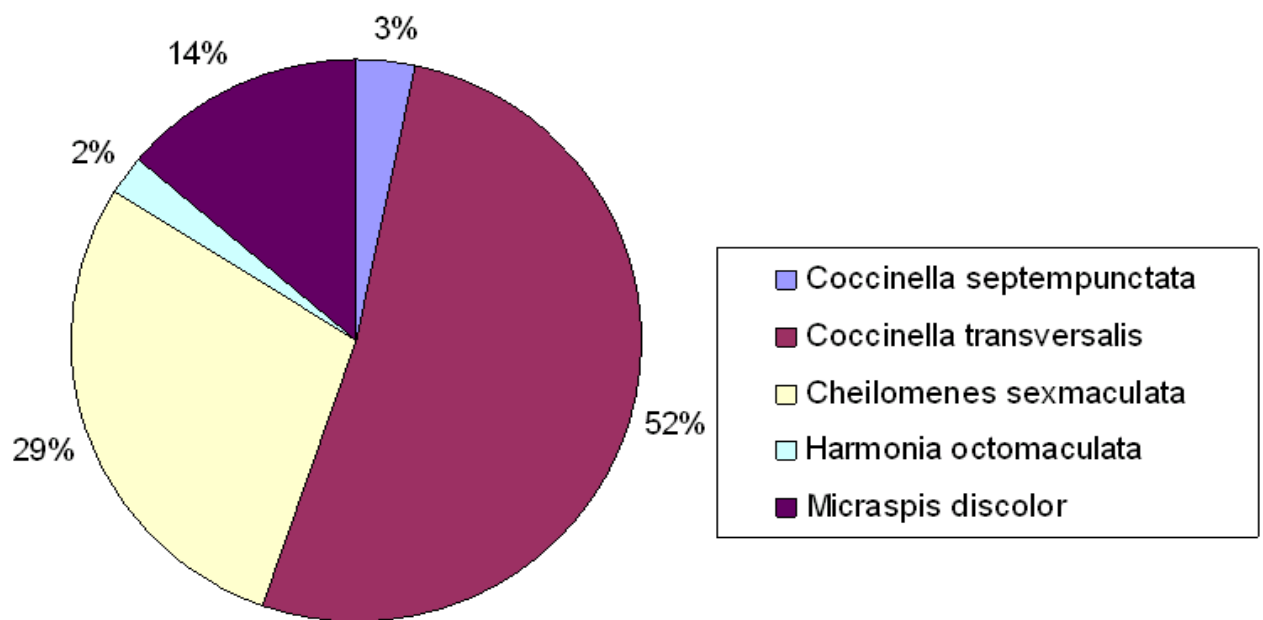
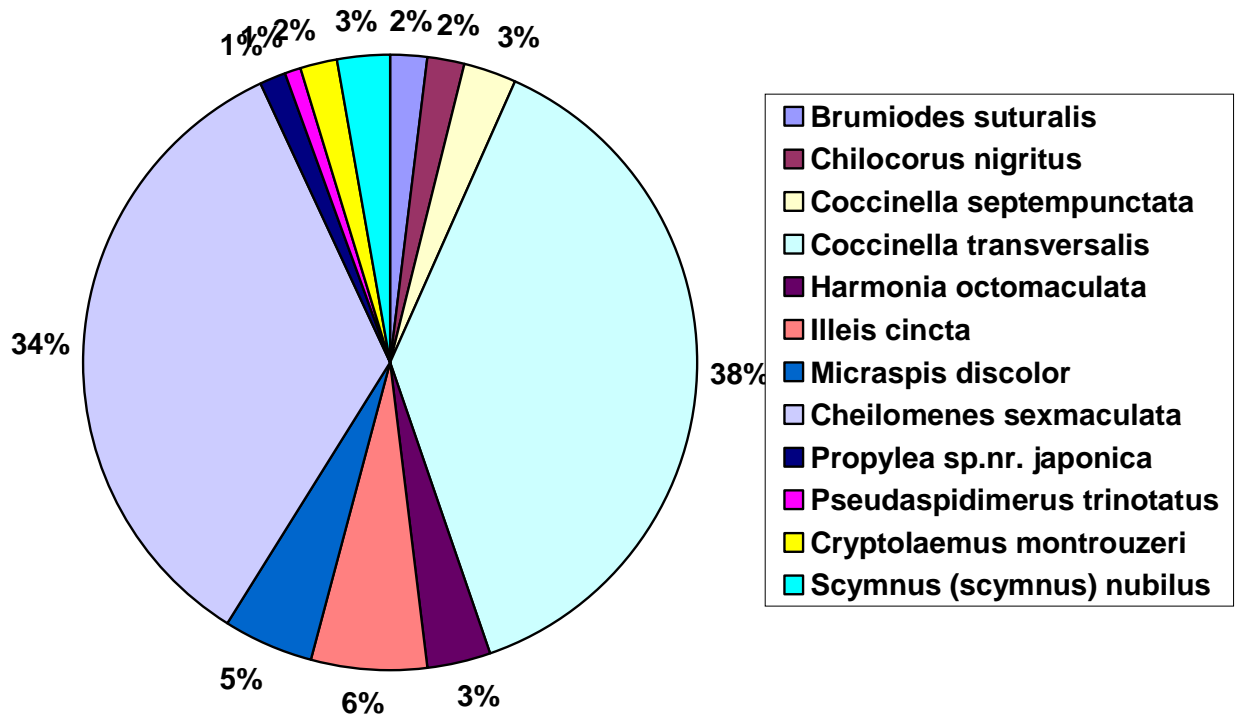
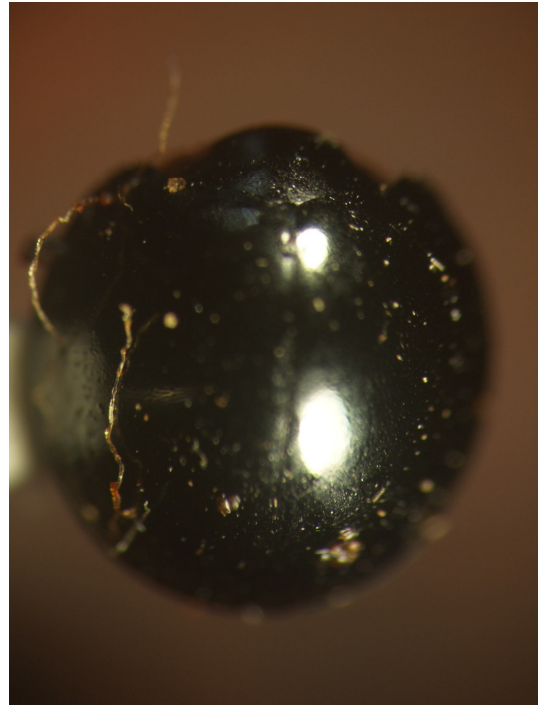


Fig.14: Species composition of Coccinellid predators in groundnut ecosystem





1. Male (50x)



2. Female (32x)



3A. Female (25x)



3B. Female (20x)

Plate I: 1. *Brumoides suturalis* (Fabricius); 2. *Chilocorus nigrinus* (Fabricius);
3. *Coccinella septempunctata* Linnaeus : A and B are colour variations



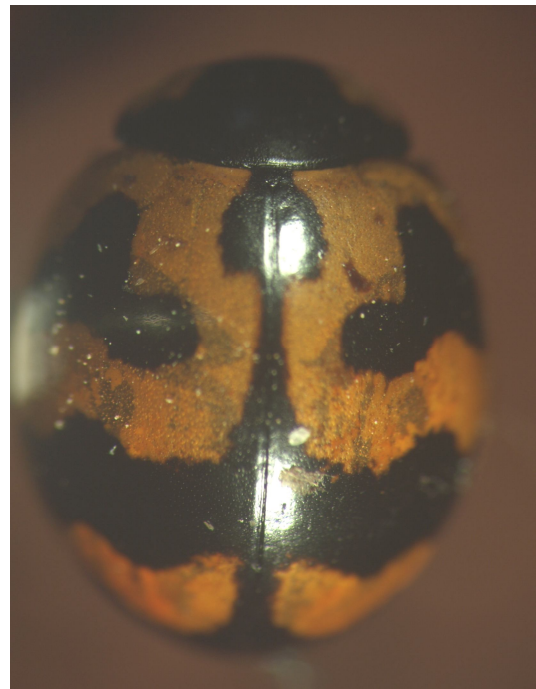
4A. Male (32x)



4B. Male (25x)



4C. Female (25x)



4D. Female (25x)

Plate II:4.*Coccinella transversalis* Fabricius : A, B, C and D are colour variations



5. Male (25x)



6. Male (25x)



7A. Female (32x)



7B. Male (32x)

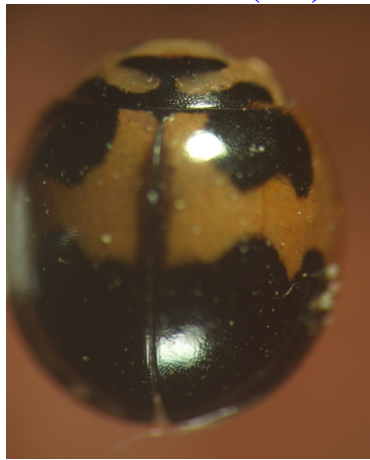
**Plate III: 5. *Harmonia octomaculata* (Fabricius); 6. *Illeis cincta* (Fabricius);
7. *Micraspis discolor* (Fabricius): A and B are colour variations.**



8A. Female (32x)



8B. Male (32x)



8C. Male (40x)



8D. Male (25x)



8E. Female (25x)

Plate IV: 8. *Cheilomenes sexmaculata* (Fabricius) : A, B, C, D and E are colours variatoinis



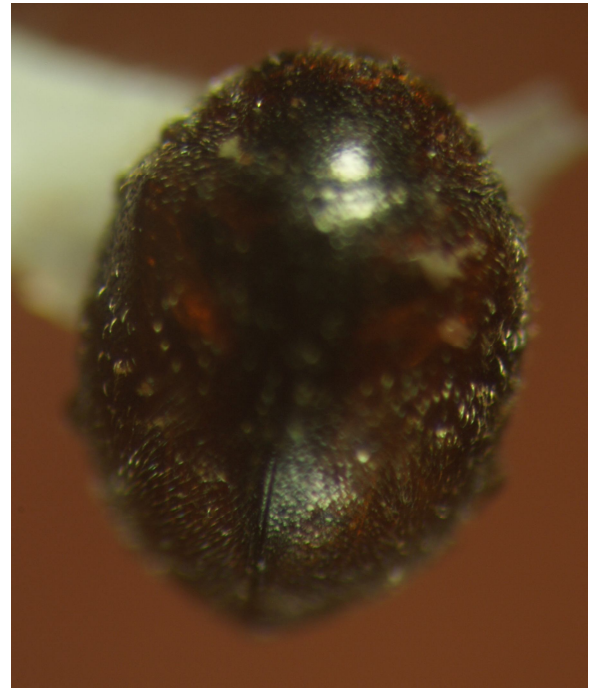
9. Female (40x)



10. Male (57x)



11. Male (40x)



12. Male (57x)

Plate V: **9. *Propylea sp. nr. japonica* (Thunberg);**
 10. *Pseudaspidimerus trinotatus* (Thunberg);
 11. *Cryptolaemus montrouzieri* Mulsant;
 12. *Scymnus (Scymnus) nubilus* Mulsant

CHAPTER – V

DISCUSSION

The Coccinellids, which are commonly called as lady bird beetles belong to the family Coccinellidae of the order Coleoptera. These are often brightly coloured with red, orange or yellow elytra frequently spotted black or yellow stripes. The great number of Coccinellid species are predaceous, beneficial from the viewpoint of biological control of pests, feeding during both larval and adult stages of aphids, scale insects, mites etc. The species composition under the relationship of many species to habitat can vary in different regions of their distribution and also in different ecosystems. In view of their importance in biological control of crop pests the accurate identification of Coccinellid fauna associated with a particular crop ecosystem and particular region is very much essential. Hence, the present investigation was undertaken with an objective to identify the Coccinellid species that are present in and around Tirupati, Andhra Pradesh associated with different crop ecosystems.

In the present investigation, the following 12 Coccinellid species belonging to eleven genera, under four tribes of the family Coccinellidae were collected and identified.

1. *Brumoides suturalis* (Fabricius)
2. *Chilocorus nigrinus* (Fabricius)
3. *Coccinella septempunctata* Linnaeus
4. *Coccinella transversalis* Fabricius
5. *Harmonia octomaculata* (Fabricius)
6. *Illeis cincta* (Fabricius)
7. *Micraspis discolor* (Fabricius)
8. *Cheilomenes sexmaculata* (Fabricius)
9. *Propylea sp. nr. japonica* (Thunberg)
10. *Pseudaspidimerus trinotatus* (Thunberg)
11. *Cryptolaemus montrouzieri* Mulsant
12. *Scymnus (Scymnus) nubilus* Mulsant

Two species of the Chilacorinae belonging to two genera of the tribe Chilacorini were collected and described in this study. One of these, *Brumoides suturalis* (Fabricius) was reported by Puttarudriah and Channabasavanna (1953) under the genus *Brumus*. Chapin (1965a) described a new genus, *Brumoides* for inclusion of this species. This species is yellowish brown, black stripe on outside of each elytron starting from the humeral angle and ending before reaching the reddish area at the tip of the elytron. Siphon strongly curved with T-shaped basal part. Another species, described in the study is *Chilocorus nigrinus* (Fabricius) which is agreed with the

descriptions provided by Nagaraja and Hussainy (1967). This species is small, bright black colour beetle, antennae 8 segmented, elytra without spots, spermatheca sac-like with finger like projection anteriorly.

Seven species of the Coccinellidae belonging to 6 genera of the tribe Coccinellini were collected in this study. Among these two species encountered under the genus *Coccinella* were *Coccinella septempunctata* Linnaeus and *C. transversalis* Fabricius, which were redescribed by Chapin (1956b) and Sasaji (1971). In the present study, two different colour variants were observed in *Coccinella septempunctata* among which one type have the clear black spots and in another type these spots coalescing. Varma (1953) also reported the different colour variants in this species. In the species *Coccinella transversalis* Fabricius also observed four different colour variants; which are shown in Plate II.

The species, *Harmonia octomaculata* (Fabricius) was reported from Karnataka as *Coccinella arcuata* Fabricius (Puttarudriah and Channabasavanna, 1953, 1955). Chapin (1965b) and Sasaji (1971) provided redescription of this species based on males and females. This species is having 3 transverse rows of black spots on each elytron and an apical spot on a reddish yellow background, the spots frequently coalescing, apex of siphon is spoon shaped with membranous projection.

The species *Illeis cincta* (Fabricius) can be identified by pronotum with a pair of rounded black spots at posterior end. Apex of siphon spatula shape without hooked process and corrugated besides at tip. This species was also described by Ghorpade (1976). *Illeis cincta* (Fabricius) is found in large number on mildew – affected mulberry, cowpea and balsams. Subramaniam (1923) has given brief notes on the life-cycle of the species and Beeson (1941) has figured and described the life stage under the name *Thea cincta*.

The species, *Cheilomenes sexmaculata* (Fabricius) is the most common and widely distributed species. In the present study, five different colour types were observed. All the different distinct colour types reported by Subramaniam (1923) were encountered during this study. The male and female genitalia structure of all the species are similar and hence there are more colour variants. *Cheilomenes sexmaculata* was redescribed by Chapin (1965b) and Sasaji (1971). This species is having antennae with basal segment broader than long, elytral epipleuron strongly inclined below, siphon strongly curved at base and thread like at apex.

Micraspis discolor (Fabricius) has been reported by Kapur (1972) from Goa. Sasaji (1971) redescribed this species based on morphological characters. This species has been identified by lateral and anterior margin of elytra without black stripe, siphonal tip spatulate with hooked process, spermatheca

curved and 'C' shaped. *Propylea* sp. nr. *japonica* (Thunberg) has been identified by pronotum with black markings at posterior end, spermatheca strongly curved, short, stout and C shaped.

Three species of Scymninae belonging to three genera of 2 tribes were collected during this study. Under the tribe Aspidimerini, *Pseudoaspidimerus trinotatus* (Thunberg) was described. Poorani (2001) revised the genus *Pseudoaspidimerus* Kapur and redescribed the *P. trinotatus*. This species has been identified by prosternal carinae subparallel to slightly divergent towards anterior, male genitalia with U-shaped median lobe, siphon stout, anteriorly bulbous.

Two species of tribe scymnini were described in the present study. *Cryptolaemus montrouzieri* Mulsant was described by Sasaji (1971) and Chapin (1965b). Sexes can be distinguished by the colour of the first pair of legs. In females, the first pair of legs are black, while in males, orange. Booth and Pope (1986) reviewed the genus *Cryptolaemus* with particular reference to the species resembling *C. montrouzieri* Mulsant. This species is identified by prosternum produced anteriorly to cover mouthparts. Head, thorax and apices of elytra are reddish and the rest of the body is black. The second species *Scymnus (Scymnus) nubilus* described in the present investigation which was also reported by Puttarudriah and Channabasavanna (1953). Chatterjee and Bose (1934) have recorded this species from various places in South India. This

species was identified by pronotum with brown markings, elytra with caudally tapering brown stripe along with commissural line. Brown stripe broad at anterior, narrow at posterior. Siphon apex is pointed and thread like.

Among these 12 species of Coccinellids, *Coccinella transversalis* Fabricius (38%) and *Cheilomenes sexmaculata* (Fabricius) (34%) are the most abundant species in and around Tirupati in different agro-ecosystems followed by *Illeis cincta* (Fabricius) (6%) (Fig.13). Five species viz., *Coccinella septempunctata* Linnaeus; *Coccinella transversalis* Fabricius; *Harmonia octomaculata* (Fabricius); *Micraspis discolor* (Fabricius) and *Cheilomenes sexmaculata* (Fabricius) were recorded in groundnut crop ecosystem feeding on aphids, *Aphis craccivora* and leafhoppers, *Empoasca* (*Empoasca*) *motti* Pruthi. Among these species *Coccinella transversalis* Fabricius abundant recording 52% of population followed by *Cheilomenes sexmaculata* (Fabricius) recording 29% of population as shown in Fig.14. Puttarudriah and Channabasavanna (1953, 1955, 1956) also reported these five species on groundnut crop.

CHAPTER – VI

SUMMARY

In the present investigation on “Taxonomic studies on predaceous Coccinellidae, order : Coleoptera” was under taken at S.V. Agricultural College, Tirupati during 2007-09. The following 12 Coccinellid species belonging to eleven genera under four tribes of the family *Coccinellidae* were identified.

1. *Brumoides suturalis* (Fabricius)
2. *Chilocorus nigrinus* (Fabricius)
3. *Coccinella septempunctata* Linnaeus
4. *Coccinella transversalis* Fabricius
5. *Harmonia octomaculata* (Fabricius)
6. *Illeis cincta* (Fabricius)
7. *Micraspis discolor* (Fabricius)
8. *Cheilomenes sexmaculata* (Fabricius)
9. *Propylea sp. nr. japonica* (Thunberg)
10. *Pseudaspidimerus trinotatus* (Thunberg)
11. *Cryptolaemus montrouzieri* Mulsant
12. *Scymnus (Scymnus) nubilus* Mulsant

These Coccinellids were described in respect of their external morphology and male and female genitalia structures along with the line drawings, drawn originally under Trinocular Research Microscope with drawing attachment. A key for distinguishing all these Coccinellid species were given in results Chapter-IV and also quoted the line diagrams and colour photographs wherever necessary for clear understanding and for easy identification of these species. All these Coccinellid species along with their key characters were discussed in discussion chapter.

Among these 12 species of Coccinellids, *Coccinella transversalis* Fabricius (38%) and *Cheilomenes sexmaculata* (Fabricius) (34%) are the most abundant species in and around Tirupati in different agro-ecosystems followed by *Illeis cincta* (Fabricius) (6%). Five species viz., *Coccinella septempunctata* Linnaeus; *Coccinella transversalis* Fabricius; *Harmonia octomaculata* (Fabricius); *Micraspis discolor* (Fabricius) and *Cheilomenes sexmaculata* (Fabricius) were recorded in groundnut crop ecosystem feeding on aphids, *Aphis craccivora* and leafhoppers, *Empoasca* (*Empoasca*) *motti* Pruthi. Among these species *Coccinella transversalis* Fabricius is abundant recording 52% of population followed by *Cheilomenes sexmaculata* (Fabricius) recording 29% of population.

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***Originals not seen**

Note: The literature is cited in accordance with the thesis guidelines prescribed by Acharya N.G.Ranga Agricultural University, Rajendranagar, Hyderabad-500 030.

KEY FOR THE IDENTIFICATION OF COCCINELLID PREDATORS

1. Clypeus strongly expanded laterally ; anterior margin of pronotum deeply, trapezoidally concave, lateral portions strongly descending below; elytral base distinctly broader than pronotal base; elytral epipelura broad or its inner carina reaching elytral apex; tibiae angulata externally ----- (Tribe Chilocorini) 2
 - Clypeus not strongly expanded laterally, pronotum not as above; elytral base slightly broader than pronotal base; elytral epipelura narrow, inner carina not reaching elytral apex ----- 3
2. Body elongate oval; each elytron with a sutural and discal broad longitudinal black stripe; elytra without reflexed margin; elytral epipleura not foveolate (Plate I:1) ----- --
-----*Brumoides suturalis* (Fabricius).
- Body rounded, subglobose; antennae 8 segmented, elytra black, lateral expansions of pronotum reddish brown; elytra without spots; spermatheca sac-like with finger like projection anteriorly (Plate I:2; Fig.2: a & j) -----
----- *Chilocorus nigrinus* (Fabricius).
3. Eyes usually moderate in size with or without a moderately deep or shallow post antennal emargination; antennae eight to eleven segmented and usually relatively short, at most shorter than two-thirds the head width. Labrum rather short; coxite of female usually elongate, rarely transverse ----- (Tribe Scymnini) 4.

- Eyes covered anteriorly by the expanded head capsule; antennae nine-segmented and very short, less than one-fourth the head width; elytral epipluera very narrow with distinct foveae; trochanters elongate, femora broadly expanded concealing the compressed tibiae, tarsi true trimerous; abdomen composed of six segments, of which first convex posteriorly in an arc; dorsum pubescent and body medium to small ----- (Tribe Aspidimerini) 5.
- 4. Prosternum produced anteriorly to cover mouth parts; antennae 10 segmented; head, thorax and apices of elytra reddish and rest black (Plate V:11) ----- *Cryptolacemus montrouzeri* Mulsant.
- Pronotum with brown makings; elytra with caudally tapering brown stripe along the commissural line, brown stripe broad at anterior, narrow at posterior looks like ‘V’ shape (Plate V: 12) -----
----- *Scymnus (Scymnus) nubilus* Mulsant.
- 5. Anterior margin of clypeus with an anterior projection on each side; antennal insertion rather approximating to the eyes; mandible always with a bifid tip (Fig.3A: e; 4A:e and 5:e); anterior margin of pronotum usually deeply emarginate and with angulate anterior corners; maxillary galea conical ----- (Tribe : *Coccinellini*) -----6.
- Anterior margin of clypeus without an anterior projection, prosetrnl carinae subparallel to slightly divergent towards anterior, enclose an area much longer than broad, subrectangular; male genitalia with median lobe of aedeagus broader than long, U-shaped and posteriorly sinuate in the middle; siphon stout, anteriorly bulbous (Fig.10: j & i; Plate V:10) ----- *Pseudaspidimerus trinotatus* (Thunberg).

6. Antenna with basal segment broader than long, with a strongly convex innerside; lateral side of elytra not margined; inner carina of elytral epipeluron not strongly convergent, reaching apex; elytral epipeluron strongly inclined below; siphon thread like at apex (Fig.8, B, C and D: a & k; Plate IV: A, B, C, D and E) -----
----- *Cheilomenes sexmaculata* (Fabricius).
- Basal segment of antenna elongate and normal; lateral side of elytra margined; inner carina of elytral epipeluron strongly convergent apically or not reaching the apex ----- 7.
7. Anterior margin of meso sternum flat ----- 8.
- Anterior margin of mesosternum weakly emarginate at middle; each elytron with three transverse rows of black spots and an apical spot on a reddish yellow background, the spots frequently coalescing; apex of siphon spoon shaped with membranous projection (Fig.5: a & j; Plate III: 5) ----- *Harmonia octomaculata* (Fabricius).
8. Each elytron with 3+½ roundish spots spermatheca strongly hooked, nodulus and ramus clearly demarcated (Fig.3A : I; Fig.3B:h; Plate I : 3B) ----- *Coccinella septempunctata* Linnaeus.
- Each elytron without those round spots ----- 9
9. Each elytron with a large trilobed humeral spots (sometimes lacking); elytra with transverse band at apical 0.33, a second usually incomplete band just before apex and black (Fig.4A, B, C and D; Plate II: A, B, C and D) ----- *Coccinella transversalis* Fabricius.
- Elytra without such black stripes ----- 10

10. Siphon curved at basal, apically straight, apex of siphon spatula shaped with hooked process; spermatheca curved and C shaped (Fig.7B: i; 7A:j; Plate III:7) ----- *Micraspsis discolor* (Fabricius).
- Apex of siphon spatula shaped without hooked process and corrugated at tip ----- 11
11. Pronotum with a pair of rounded black spots at posterior end; prosterum anteriorly expanded to cover the mouth parts (Plate III:6) -----
----- *Illeis cincta* (Fabricius).
- Pronotum with black markings at posterior end; hemisternite elongated triangular, nearly round, spermatheca strongly curved, short, stout and C shaped (Fig.9: i & j; Plate V: 9) -----
----- *Propylea sp. nr. japonica* (Thunberg).