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# CONTENTS

# Taxonomic survey of stink bugs (Heteroptera: Pentatomidae) of India

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## Abstract

**A taxonomic survey has been conducted to observe the diversity of pentatomid bugs in India. The species collected have been systematically arranged in their respective subfamilies and tribes. The study is based on the personal collection and on the basis of collection deposited in the museum of Indian Agricultural Research Institute, New Delhi.**

**Keywords:** *Taxonomic survey, Stink bugs, India.*

## Introduction

The members of the family Pentatomidae are commonly called as stink bugs. They constitute an economically important group of hemipterous pests as most of the species are phytophagous. Both nymphs and adults have piercing and sucking type of mouthparts. They suck the sap by piercing their rostrum into the plant tissues and lowers its vitality. The infested plants remain stunted in growth and present a sickly appearance. The injury caused by them is usually overlooked as they have a colouration which is more or less harmonious to their surroundings. Besides sucking the sap from the plant, some of them transmit a number of viral, bacterial and fungal diseases.

The members of the subfamily Asopinae are predaceous in nature and feed upon other insects, especially on lepidopterous larvae.

In the present study four subfamilies under the family Pentatomidae have been recognized viz., Pentatominae, Phyllocephalinae, Podopinae and Asopinae on the basis of length of rostrum, bucculae, frena and scutellum; presence and absence of tuft of setae on the inner margin of fore tibia. Further, the subfamilies Pentatominae and Asopinae are divided into fourteen and two tribes respectively.

In India, important contributions on the taxonomy of the family Pentatomidae have been made by Atkinson (1887,1888,1889), Bergroth (1915a and1915b), Distant (1902,1908 and 1918), Menon and Ghai (1959), Sen (1965), Mathew(1969,1977 and 1980), Pawar (1971), Chopra (1972 and 1974), Ghauri (1975a, 1975b and1977), Azim and Shafee (1978, 1980, 1982, 1983a, 1983b, 1984a, 1984b, 1985a, 1985b1987a and1987b), Shafee and Azim (1984), Azim and Gami (1999), Azim (2000, 2002) and Azim *et al.*(2008).

## Subfamily: Pentatominae Leach

### Tribe: Gynenicini Shafee and Azim

Genus *Gynenica* Dallas
Type-species: *Gynenica marginella* Dallas
Neogynenica Yang
Type-species: *Neogynenica izzardi* Yang

*Gynenica affinis* Distant
Material examined: 1 ♀, 6 ♂, India; Andhra Pradesh, Tenali on *Crossandra undulifolia* Salisb., 3.i.1980 (S. Adam Shafee). IARI, New Delhi Collection: 1♂, Delhi on grass, 25.iv.1939 (Rang coll., R-8102), *Gynenica* sp. Det M. Bose.

*Gynenica alami* Shafee & Azim
Material examined: 1♀, India; Andhra Pradesh, Guntur on *Crossandra undulifolia* Salisb., 5.ii.1980 (M. N. Azim).

### Tribe: Mecideini Distant

Genus *Mecidea* Dallas
Type-species: *Mecidea indica* Dallas

*Mecidea indica* Dallas
Material examined: IARI, New Delhi collection: 1 ♂, Punjab, Lyalpur (R-1898).

*Mecidea pallidissima* Jansen-Haarup
Material examined: IARI, New Delhi collection; 1 ♂, South India, Coimbatore, 7.iv.1913 (Fletcher coll., R-1899); 1 ♂, South India, Coimbatore,7.iv.1913 (Fletcher coll., R-1900).

**Tribe: Strachiini Mulsant and Rey**
Genus *Strachia* Hahn
Type-species: *Strachia crucigera* Hahn

*Strachia crucigera* Hahn
Material examined: IARI, New Delhi collection; 1♀, Bengal, Dacca, 15.i.1906 (R-2103).

Genus *Eurydema* Laporte
Type-species: *Cimex oleraceum* Linnaeus

*Eurydema pulchrum* (Westwood)
Material examined: 8♀, 8♂, India; Uttar Pradesh, Aligarh, University Botanical Garden on *Raphanus sativus* L., 20.vi.1976 (M.N.Azim); 5 ♀, 5 ♂, Jammu & Kashmir, Srinagar, Naseem Bagh on *Raphanus oleracea* L., IARI, New Delhi collection: 1♀, Uttar Pradesh, Mussoorie on turnip leaves, 24.vi.1940 (H.S.Pruthi coll., R-8111); 1 ♀, Bihar, Pusa on weed, 27.iii.1933 (W.K.Wesley coll.); 1♀, Trichinopolly on Paddy (Baldev coll.); 1 ♂, Peshawer on Taru, April, 1916 (Fletcher coll., R-2090).

*Eurydema lituriferum* (Walker)
Material examined: IARI New Delhi collection; 1 ♀, Uttar Pradesh, Mussoorie on turnip leaves, 24.vi.1940 (H.S.Pruthi coll., R-8115).

Genus: *Stenozygum* Fieber
Type-species: *Stenozygum variegatum* Fieber, 1861 (=*Stenozygum coloratum* Fieber)
Material examined: 1♀, India; Uttar Pradesh, Aligarh, University Botanical Garden on *Brassica compestris* L.,20.vii.1977 (M. N. Azim).

Genus: *Bagrada* Stal
Type-species: *Cimex picta* Fabricius

*Bagrada picta* (Fabricius)
Material examined:10 ♀, 8 ♂, India; Uttar Pradesh, Aligarh, University Botanical Garden on *Brassica compestris*, 27.vii.1977 (M.N.Azim); IARI, New Delhi collection: 1 ♀, U.P., Saharanpur, Botanical Garden on Mustard and Cabbage, 30.ix.1917 (R-139).

**Tribe: Sciocorini Amyot and Serville**
Genus: *Scicoris* Fallen
Type-species: *Sciocoris terreus* Schrank

*Sciocoris indicus* Dallas
Material examined: 8♀, 5♂, India; Uttar Pradesh, Aligarh, University Botanical Garden on grass,30.vi.1978 (M.N.Azim); 6 ♀, Tamil Nadu, Madras on Croton sp., 11.xi.1979 (M.N.Azim).

*Sciocoris tamilnadensis* Azim& Shafee
Material examined: 1 ♀, India; Tamil Nadu, Madras on grass, 12.xi.1979 (M.N.Azim).

*Sciocoris rufus* Azim & Shafee
Material examined: 1 ♀, India; Uttar Pradesh, Aligarh, University Botanical Garden on Croton,28.vi.1978 (M.N.Azim).

Genus: *Menedemus* Distant
Type-species:*Menedemus vittatus* Dallas

*Menedemus hieroglyphicus* Distant
Material examined: IARI, New Delhi collection; 1♂, India: Coorg, 5.vi.1917(T.R.N. Coll.,R-1877).

**Tribe: Dorpiini Distant**
Genus: *Dorpius* Distant
Type-species: *Dorpius typicus* Distant

*Dorpius indicus* Distant
Material examined: IARI, New Delhi collection; 1♂, Delhi, at light, 18.vi.1939 (R-8096).

Genus *Laprius* Stal
Type-species: *Cimex gastricus* Thunberg

*Laprius varicornis* (Dallas)
Material examined: 1 ♂, India; Uttar Pradesh, Aligarh, University campus at light, 23.vii.1977 (M.N.Azim). IARI, New Delhi collection:1♂, Bombay at light, 1.viii.1904 (R-1882); 1♀, Bengal, Chapra (Mackenzie coll., R-1881).

**Tribe: Eysarcorini Mulsant and Rey**
Genus: *Eysarcoris* Hahn
Type-species: *Eysarcoris aeneus* (Scop.)

*Eysarcoris ventralis* (Westwood)
Material examined: 9 ♀, 8 ♂, India; Uttar Pradesh, University campus at light, 15.vii.1977 (M.N.Azim).

Genus: *Carbula* Stal
Type-species: *Carbula decorata* (Signoret)

*Carbula scutellata* Distant
Material examined: 2 ♀,India; Tamil Nadu, Coimbatore, Forest Research Institute on Croton sp., 23.xi.1979 (M.N.Azim); IARI, New Delhi collection; 1 ♂, Bombay, Bassein fort, September, 1909 (A.M.coll.,R-2003).

*Carbula biguttata* (Fabricius)
Material examined: IARI, New delhi collection; 1 ♀, Lebong, Phoobsering, October, 1910 (R-2004).

*Carbula indica* (Westwood)
Material examined: IARI, New Delhi collection; 1 ♀, Lebong, September, 1908 (M.M.L. coll., R-2002); 1 ♂, Bombay, Bassein fort, September, 1909 (A.M. coll., R-2001).

Genus: *Stollia* Ellenrieder
Type-species: *Cimex guttiger* Thunberg

*Bainbriggeanus* Distant
Type-species: *Bainbriggeanus fletcheri* Distant

*Stollia guttiger* (Thunberg)
Material examined: 5 ♀, 5 ♂, India; Uttar Pradesh, Aligarh, University Botanical garden on Croton sp., 5.vii.1978 (M.N.Azim); 5 ♀, 6 ♂, Tamil Nadu, Madras, Myalapore on grass, 15.xi.1979 (M.N.Azim).

Genus: *Hermolaus* Distant
Type-species: *Hermolaus typicus* Distant

*Hermolaus typicus* Distant
Material examined: 1 ♀, India; Uttar Pradesh, Aligarh, University campus at light, 3.vi.1979 (M.N.Azim).

*Hermolaus ernakulensis* Azim & Shafee
Material examined: 1 ♀, India; Kerala, Ernakulum on grass, 28.iii.1979 (M.N.Azim).

*Hermolaus brevis* Azim & Shafee
Material examined: 1♀, 2 ♂, India; Uttar Pradesh, Aligarh, University campus at light, 14.viii.1979 (M.N.Azim).

**Tribe: Halyini Dallas**
Genus: *Halys* Fabricius
Type-species: *Cimex dentatus* Fabricius

*Halys dentatus* (Fabricius)
Material examined: 5 ♀, 5 ♂, India; Uttar Pradesh, Jawahar Park on *Azadirachta indica*, 5.iv.1980 (M.N.Azim); IARI, New Delhi collection: 1♂, Gwalior, Dinara, Karera, 12.v.1944 (H.L.Rattan coll.), *H. dentatus* det. C.K. Samuel.

*Halys magnus* Chopra
Material examined: 12 ♀, 8 ♂, India; Uttar Pradesh, Aligarh, Jawahar Park on *Azadirachta indica* L., 4.iii.1979 (M.N.Azim); 5 ♀, 5 ♂, Tamil Nadu, Coimbatore, Veda Medurai on *Acacia Arabica*, 28.iii.1979 (M.N.Azim).

*Halys parvus* Chopra
Material examined: 5 ♀, 5 ♂, India; Uttar Pradesh, Jawahar Park on Azadirachta indica, 23.iii.1997 (M.N.Azim).

Genus: *Erthesina* Spinola
Type-species: *Cimex fullo* Thunberg

*Erthesina fullo* (Thunberg)
Material examined: IARI, New Delhi collection; 1 ♀, Assam, Jorhat, September (Gupta coll., R-1843); 1♂, Assam, Baroma, 3.iii.1907 (R-1840).

*Erthesina guttata* (Fabricius)
Material examined: 2 ♂, India; Rajasthan, Ajmer, 18.xi.1978 on *Acacia* sp. (M.N.Azim).

Genus: *Dalpada* Amyot & Serville
Type-species: *Dalpada aspersa* Amyot & Serville

*Dalpada mcdonaldi* Azim & Shafee
Material examined: 5 ♀, India; Tamil Nadu, Coimbatore, Forest Research Institute on *Ceiba pentandra* (Linn.), 27.iii.1979 (M.N.Azim); 5 ♀, 4 ♂, Jammu & Kashmir, Srinagar on apple tree, 27.vii.1994 (Ajaz Rasool Gami); 6 ♀, 4 ♂, University of Kashmir campus on apple tree, 16.vi.2002 (M. Shafi Bhat).

*Dalpada oculata* (Fabricius)
Material examined: IARI, New Delhi collection; 1 ♀, India; Uttar Pradesh, Dehradun on Arhar

(M.Bose coll.), *Dalpada oculata* det. Sucheta

*Dalpada jugatoria* Lethierry
Material examined: IARI, New Delhi collection; 1 ♀, Bombay, Bassein (V.N.S. coll., R-1829).

*Dalpada affinis* Dallas
Material examined: IARI, New Delhi collection; 1 ♂, Lebong, September, 1908 (M.M.L.coll.).

*Dalpada clavata* (Fabricius)
Material examined: IARI, New Delhi collection; 1 ♀, Nainital, May 1843 (Lucknow Museum); 1 ♀, Bhowali 6000ft on apple leaf, 13.vi.1929 (R-8133).

*Dalpada confusa* Distant
Material examined: IARI, New Delhi collection; 1 ♀, Nainital District, 4.vii.1937 (T.Ahmad coll.); 1 ♀ (R-7388), *Dalpada confusa* Distant det., B. Uvarov 1938.

Genus: *Paranevisanus* Distant
Type-species: (*Paranevisanus subgenericus* Distant)=*Paranevisanus melania* Distant
*Asylana* Distant
Type-species: *Asylana punjabensis* Distant

*Paranevisanus melania* (Distant)
Material examined: 5♀, India; Jammu & Kashmir, Srinagar, Habak on apple tree, 5.viii.2001 (Anjum Aziz Mir).

Genus: *Apodiphus* Spinola
Type-species (*Halys hellenica* Lefebvre)= *Halys amygdali* Germ.

*Neonevisanus* Distant
Type-species: *Neonevisanus rugosus* Distant

*Apodiphus integriceps* Horvath
Material examined: 5 ♀, 5 ♂, India; Jammu & Kashmir, Srinagar, Raj Bagh on apple tree, 15.viii.2001 (Nakeer Razak); IARI, New Delhi collection; 1 ♀, Kashmir, Yasimarg, 15.viii.1923 (Fletcher coll., R-8070).

*Apodiphus pilipes* Horvath
Material examined: 6 ♀, 3 ♂, India; Jammu & Kashmir, Srinagar, Habak on apple tree (Malus sp.), 15.vii.2002 (M.S.Bhat).

Genus: *Phricodus* Spinola
Type-species: *Aradus hystrix* Germar
Material examined: IARI, New Delhi collection; 1 ♂, Coimbatore on Gingelly, 31.v.1912 (K.P.S. coll, R-1869); 1 ♂, South India, Coimbatore, 11.i.1913 (Fletcher coll., R-1868); 1 ♀, South India, Coimbatore at light, 4.xii.1912 (Fletcher coll., R-1861).

**Tribe: Carpocorini Mulsant and Rey**
Genus *Carpocoris* Kolenati
Type-species: *Cimex lynx* Fabricius

*Carpocoris nigricornis* (Fabricius)
Material examined: 1 ♀, India; Uttar Pradesh, Moradabad, Pipalsana on *Phaseolus mungo*, 21.iii.1977 (M. N. Azim); 2 ♀, 1 ♂, Jammu & Kashmir, Anantnag, Pahalgam on wild plant, 12.viii.2004 (M.S.Bhat).

*Carpocoris pallidus* (Dallas)
Material examined: 1 ♀, India; Jammu & Kashmir, Baramulla on wild plant, 3.ix.2004 (M.S.Bhat). IARI, New Delhi collection: 1 ♀, Himachal Pradesh, Simla on hedge, 13.iv.1966 (A. Pawar coll.)

Genus: *Dolycoris* Mulsant & Rey
Type-species: *Cimex baccarum* Linnaeus

*Dolycoris indicus* Stal
Material examined: 7 ♀, 5 ♂, India; Uttar Pradesh, Aligarh, University agricultural farm on *Trifolium alexandrinum* Linn., 20.iv.1977 (M.N.Azim); 4 ♀, Moradabad on *Phaseolus mungo*, 2.vi.1979 (M.N.Azim); 7 ♀, 3 ♂, Tamil Nadu, Coimbatore, Mettupalayam on Trifolium alexandrinum Linn., 1.iv.1979 (M.N.Azim); 8 ♀, 4♂, Jammu & Kashmir, Srinagar on *Brassica* sp. 5.vii.2002 (M.S.Bhat).

Genus: *Codophila* Mulsant & Rey
Type-species: *Cimex varia* Fabricius

*Codophila maculicollis* (Dallas)
Material examined: 1♀, India; Uttar Pradesh, Aligarh, University agricultural farm on *Raphanus sativus*, 15.iv.1980 (M.N.Azim); IARI, New Delhi collection; 1 ♀, Poona on Linseed, 19.ix.1941 (Ghulamullah coll.,R-8141) *Codophila maculicollis* Dallas, det. M. Bose.

Genus: *Agonoscelis* Spinola

Type-species: *Cimex nubila* Fabricius

*Agonoscelis nubila* (Fabricius)
Material examined: 8 ♀, 5 ♂, India; Uttar Pradesh, Aligarh, University Botanical Garden on *Foeniculum vulgare*, 16.iii.1978 (M.N.Azim); 5 ♀, 3 ♂, Tamil Nadu, Coimbatore, Mettupalayam, Nanjangarh on *Trifolium alexandrinum* L., 15.vi.1979 (M.N.Azim).

*Agonoscelis femoralis* Walker
Material examined: IARI, New Delhi collection; 1 ♀, Assam, 3.iii.1907 (R-2063); 1 ♂, Delhi, on Linseed, 28.xi.1940 (P.Mukherjee coll.) *Agonoscelis femoralis* Walker det. Sucheta.

*Agonoscelis tamilnadensis* Mathew
Material examined: 2 ♀, India; Tamil Nadu, Coimbatore, Mettupalayam on Trifolium alexandrinum L., 26.iii.1979 (M.N.Azim)

Genus *Halyomorpha* Mayr
Type-species: *Cimex picus* Fabricius)

*Halyomorpha picus* (Fabricius)
Material examined: IARI, New Delhi collection; 1 ♀, Bellary, Ramandrug, 28.viii.1918 (Roy coll.).

Genus *Cappaea* Ellenrieder
Type-species: *Pentatoma taprobanensis* Dallas

*Cappaea taprobanensis* (Dallas)
Material examined: IARI, New Delhi collection; 1 ♀, Nilgiris on Orange, 25.i.1917 (Y.R. coll., R-1929).

**Tribe: Antestiini Distant**
Type-species: *Antestia anchora* Thunberg

*Antestiopsis anchora* (Thunberg)
Material examined: IARI, New Delhi collection; 1 ♀, Burma, Zashis, 5.vi.1918 (A.G.R. coll., R-2012); 1 ♀, Ceylon, Alutnuwara, 17.xii.1908 (R-2013).

*Antestiopsis cruciata* (Fabricius)
Material examined: IARI, New Delhi collection; 1 ♂, India; Uttar Pradesh, Gonda on *Mangifera indica* L., 28.ii.1980 (M.N.Azim). IARI, New Delhi collection: 1 ♂, South India, Khondala on Coffee (C.R. coll.,R-1924) *Antestia cruciata* Fabricius det Baldev Pradshad, 1956.

**Tribe: Degonetini Azim and Shafee**

Type-species: *Degonetus serratus* Distant
*Degonetus serratus* Distant
Material examined: 8 ♀, 8 ♂, India; Tamil Nadu, Coimbatore, Forest Research Institute campus on *Tectona grandis*, 27.iii.1979 (M.N.Azim); IARI, New Delhi collection: 1 ♂, Bihar, Pusa, 9.iii.1936 (M.Bose coll., R-8086).

**Tribe: Rhyncochorini Stal**
Genus: *Ryncochoris* Stal
Type-species: *Cimex humeralis* Thunberg

*Rhynchocoris humeralis* (Thunberg)
Material examined: 1♀, India; Assam, Guwahati on citrus fruits, 21.iii.1980 (K.M.Das); IARI, New delhi collection: 1 ♀, Assam, Guwahati on orange (H.C. Javaraya coll.).

**Tribe: Pentatomini Leach**
Genus: *Nezara* Amyot & Serville
Type-species: *Cimex smaragdula Fabricius*= *Cimex viridula* L. fixed by Kirkaldy

*Nezara viridula* (Linn.)
Material examined: 8♀, 9 ♂, India; Uttar Pradesh, Aligarh, University Botanical garden on *Trifolium alexandrinum* L., 10.iii.1976 (M.N.Azim); 2 ♀, Andhra Pradesh, Guntur, Ponnur on *Lycopersicum esculentum*, 6.iv.1979 (M.N.Azim); 1♂, Tamil Nadu, Coimbatore, Mettupalayam on Sorghum vulgare, 26.iii.1979 (M.N.Azim); 2 ♀, Jammu & Kashmir, Srinagar on Cowpea, 17.viii.2002 (M.Shafi); IARI, New Delhi collection: 1 ♂, Bihar, Pusa, 1.vii.1929 (Samuel coll., R-2194).

Genus: *Acrosternum* Fieber
Type-species: *Cimex heegri* Fabricius

*Acrosternum graminea* (Fabricius)
Material examined: 8 ♀, 5 ♂, India; Uttar Pradesh, Aligarh, University Botanical garden on *Trifolium alexandrinum* L., 5.iv.1977 (M.N.Azim); 4 ♀, 2 ♂, Andhra Pradesh, Guntur, Ponnur on wild plant, 20.iv.1979 (M.N.Azim); IARI, New Delhi collection: 1 ♀, Bihar, Pusa on grass, 27.vii.1915 (U. Bahadur coll., R-1250).

Genus *Plautia* Stal
Type-species: *Cimex fimbriata* Fabricius

*Plautia fimbriata* (Fabricius)
Material examined: 5 ♀, 4 ♂, India; Uttar Pradesh, Aligarh, University Botanical garden on *Solenum*

*melongena*, 28.vii.1977 (M.N.Azim); 5 ♀, 2 ♂, Karnataka, Mysore, Nanjangarh on *Croton* sp., 21.xi.1979 (M.N.Azim); IARI, New Delhi collection: 1 ♂, Bengal, Durbhanga, Daulatpur, 30.vii.1908 (H.M.Z. coll., R-787); 1 ♀, Pusa, Pomegranate fruits (Ghosh coll., R-725); 1♀, Punjab, Gurdaspur on Lantana, 19.x.1918 (A.G.R. coll., R-786); 1 ♂ Assam, Baroma on Petals, 2.iii.1907 (R-705).

*Plautia viridicollis* (Westwood)
Material examined: IARI, New Delhi collection; 1 ♂, Guwahati, Barnihat, Nov. 1944 (S.Dutt coll., R-703) *Plautia viridicollis* (Westwood) named by Distant.

Genus: *Placosternum* Amyot & Serville
Type-species: *Cimex taurus* Fabricius

*Placosternum taurus* (Fabricius)
Material examined: IARI, New Delhi collection; 1 ♂, Assam, Shillong, 12.vi.1918 (Boy coll., R-2123).

*Placosternum obtusum* Montandon
Material examined: IARI, New Delhi collection; 1 ♀, South India, Bangalore (R-2127).

*Placosternum dama* (Fabricius)
Material examined: IARI, New Delhi collection; 1 ♀, Coimbatore, Kollegal on *Ficus*, 13.i.1917, (Rama Krishna coll., R-2129).

*Placosternum urus* Stal
Material examined: IARI, New Delhi collection; 1 ♀, Assam, Shillong, June, 1918 (Fletcher coll., R-2128).

*Placosternum alces* Stal
Material examined: IARI, New Delhi collection; 1 ♀, South India, Mettupalayam, January, 1915 (C.K.S. coll, R-2119).

**Tribe: Tropicorini Distant**
Genus: *Tropicoris* Hahn
Type-species: *Tropicoris rufipes* Linn.

*Tropicoris laeviventris* Stal
Material examined: 5 ♀, 4 ♂, India: Jammu & Kashmir, Anantnag, Pahalgam on wild plant, 21.vii.2003 (M.S. Bhat).

Genus: *Menida* Motschulsky
Type-species: *Menida violacea* Motschulsky

*Menida histrio* (Fabricius)
Material examined: 5 ♀, 5 ♂, India: Karnataka, Mysore, Nanjangarh on Oryza sativa L., 21.xi.1979 (M.N.Azim); 4 ♀, 3 ♂, Andhra Pradesh, Prakasaran, Chirala on grass, 7.i.1980 (M.N.Azim); IARI, New Delhi collection: 1 ♀, South India, Coimbatore on cholan, 24.iv.1913 (A.G.R. coll, R-2275); 1 ♀, Bengal, Charra on rice, 30.x.1904 (R-2276).

*Menida apicalis* (Dallas)
Material examined: IARI, New Delhi collection: 1 ♂, Bihar, Pusa on *Tamarix dioca*, 19.iii.1936 (M.Bose coll.).

*Menida varipennis* (Westwood)
Material examined: IARI, New Delhi collection: 1 ♂, Bengal, Palamow (R-2264); 1 ♂, Bihar, pusa, 1.ix.1915 (Boy cool, R-8104).

Genus: *Cresphontes* Stal
Type-species: *Rhaphigaster monsoni* Westwood

*Cresphontes fulvus* Azim & Shafee
Material examined: 2 ♀, 2 ♂, India: Uttar Pradesh, Aligarh, University Botanical garden on inflorescence of *Mangifera indica* Linn., 5.iii.1979 (M.N.Azim).

Genus: *Piezodorus* Fieber
Type-species: *Cimex lituratus* Fabricius

*Piezodorus rubrofasciatus* (Fabricius)
Material examined: 5 ♀, 4 ♂, India: Uttar Pradesh, Aligarh, University Botanical garden on *Trifolium alexandrinum* Linn., 21.iv.1976 (M.N.Azim); 2 ♀, Andhra Pradesh, Guntur on Solanum nigrum, 3.iv.1979 (M.N.Azim); IARI, New Delhi collection: 1 ♀, Bombay, 15.iii.1967 (G.R.Dutt coll., R-2236); 1 ♀, Bengal, Pusa, 2.iii.1907 (D.N. coll., R-1224); 1 ♀, Bihar, Pusa, 24.iv.1913 (C.B.S. coll., R-1246).

Genus: *Priassus* Stal
Type-species: *Priassus spiniger* Haglund

*Priassus exemptus* (Walker)
Material examined: IARI, New Delhi collection: 1 ♂, India: Meghalaya, shillong, Forest area (P.K.Vatsuliya coll.).
Genus: *Palomena* Mulsant & Rey
Type-species: *Palomena viridissima* Poda

*Palomena reuteri* Distant
Material examined: 2 ♀, India: Jammu & Kashmir, Anantnag, Pahalgam at light, 21.viii.2003 (M.S.Bhat).

Genus: *Catacanthus* Spinola
Type-species: *Cimex incarnatus* Drury

Catacanthus *incarnatus* (Drury)
Material examined: 2 ♀, India: Tamil Nadu, Tenkashi on *Croton* sp., 1.xii.1979 (M.N.Azim); IARI, New Delhi collection: 1 ♀, Poona on *Ixova*, 21.x.1904 (R-2187).

*Catacanthus mirabilis* Distant
Material examined: IARI, New Delhi collection: 1 ♀, Nilgiris, Noduvatum, august, 1904 (R-2191).

**Tribe: Aeliini Douglas and Scott**
Genus: *Aeliomorpha* Stal
Type-species: *Aeliomorpha simulans* Stal

*Aeliomorpha coimbatorensis* Azim & Shafee
Material examined: 2 ♀, 1 ♂, India: Tamil Nadu, Coimbatore, Mettupalayam on *Trifolium alexandrinum* L., 22.xi.1979 (M.N.Azim).

*Aeliomorpha viridis* Azim & Shafee

Material examined: 2 ♂, India: Uttar Pradesh, Aligarh, University Botanical garden on wild plant, 12.iv.1977 (M.N.Azim).

Genus: *Adria* Stal
Type-species: *Pentatoma parva* Dallas

Material examined: 5 ♀, 5 ♂ India: Uttar Pradesh, Aligarh, University campus at light, 22.vii.1977 (M.N.Azim).

**Subfamily: Podopinae Amyot and Serville**

Genus: *Storthecoris* Horvath
Type-species: *Storthecoris nigriceps* Horvath

*Storthecoris nigriceps* Horvath
Material examined: IARI, New Delhi collection: 1 ♀, Bengal, Pusa, 1.ii.1905 (P.C.P. coll., R-1683).

*Storthecoris aligarhensis* Azim & Shafee
Material examined: 3 ♀, India: Uttar Pradesh, University campus on grass, 18.iii.1979 (M.N.Azim).
*Storthecoris singularis* Azim & Shafee
Material examined: 4 ♀, India: Uttar Pradesh, Aligarh, University Agricultural farm on wild plant, 10.iii.1979 (M.N.Azim).

Genus: *Brachycerocoris* Costa
Type-species: *Brachycerocoris camelus* Costa

*Brachycerocoris camelus* Costa
Material examined: IARI, New Delhi collection: 1 ♀, Bangalore, Malleswaram on Lantana fruits, 25.iii.1917 (Y.R. coll.).

Genus: *Podops* Laporte
Type-species: *Podops inuncta* Fabricius

*Podops coarctata* Fabricius
Material examined: IARI, New Delhi collection: 1 ♂, Madras, Salem, 14.viii.1907 (I.R.No.396;R-1126).

Genus: *Amauropepla* Stal
Type-species: *Amauropepla denticulata* Haglund

*Amauropepla denticulata* Haglund
Material examined: IARI, New Delhi collection: 1 ♂, Bengal, Pusa under leaves (A.S.K. coll., R-1689).

Genus: *Melanophara* Stal
Type-species:*Melanophara dentata* Haglund

*Melanophara dentata* Haglund
Material examined: IARI, New Delhi collection: 1 ♂, Bengal, Pusa under soil, 3.ii.1905 (1148,R-1692).

**Subfamily: Phyllocephalinae Amyot and Serville**

Genus: *Schyzops* Spinola
Type-species: *Pentatoma aegyptiaca* Lefebvre

*Schyzops insignis* (Walker)
Material examined: IARI, New Delhi collection: 1 ♀, Chapra (Mackenzie coll.,R-2447); 1 ♀, Siripur, 31.vii.1911 (Mackenzie coll., R-2446).

Genus: *Dalsira* Amyot & Serville
Type-species: *Dalsira affinis* Amyot & Serville

*Dalsira glandulosa* (Wolff)
Material examined: IARI, New Delhi collection: 1 ♂, Assam, Halem, August, 1908 (Mitchel coll., R-2443).

Genus: *Tetroda* Amyot & Serville
Type-species: *Acanthia histeroides* Fabricius

*Tetroda histeroides* (Fabricius)
Material examined: IARI, New Delhi collection: 1 ♂, Madras, Salem, 14.viii.1907 (R-2459); 1 ♀, Kamrup farm on grass, 13.v.1919 (Ghosh coll.,R-2461).

Genus: *Diplorhinus* Amyot & Serville
Type-species: *Diplorhynus furcatus* (Westwood)

*Diplorhinus quadricornis* Stal
Material examined: IARI, New Delhi collection: 1 ♀, (Saran & Mackenzie coll.,R-2457); 1♀, (Saran & Mackenzie coll.,R- 2455).

Genus: *Gellia* Stal
Type-species: *Gellia albivittis* (Dallas)

*Gellia nigripennis* (Dallas)
Material examined: IARI, New Delhi collection: 1 ♀, Bilaspur, November, 1907 (R-2463); 1 ♂, Nasik, 1907 (R-2462).

Genus: *Megarhynchus* Laporte
Type-species: *Aelia rostratus* Fabricius

*Megarhynchus rostratus* Westwood
Material examined: IARI, New Delhi collection: ♂, Bihar, Pusa, 30.iii.1906 (R-2482); 1 ♂, Bihar, Pusa, March, 1907 (R-2483).

## Subfamily: Asopinae Amyot and Serville

### Tribe: Asopini Amyot and Serville

Genus: *Asopus* Burmeister
Type-species: *Cimex malabaricus* Fabricius

*Amyotea* Ellenrieder
Type-species: *Amyotea dystercoides* Ellenrider

*Asopus malabaricus* (Fabricius)
Material examined: 2 ♀, India: Karnataka, Mysore, Nanjangarh on Paddy, 21.xi.1979 (M.N.Azim); IARI, New Delhi collection: 1 ♀, Bihar, Pusa, on wild plant, 21.viii.1908 (R-2343); 1 ♀, Orissa, Ganjam, Aska, 9.iv.1910 (T.V.R. coll., R-2346).

*Asopus rufus* Azim & Shafee
Material examined: 1 ♀, India: Uttar Pradesh, Agra on grass, 15.xi.1979 (M.N.Azim).

Genus: *Andrallus* Bergroth
Type-species: *Cimex spinidens* Fabricius

*Andrallus spinidens* (Fabricius)
Material examined: 1 ♂, India: Uttar Pradesh, Moradabad, Pipalsana on *Mangifera indica,* 23.xii.1979 (M.N.Azim); IARI, New Delhi collection: 1 ♀, India, Delhi on Maize, 18.v.1946 (S.N.Chatterjee coll.) *Andrallus spinidens* det. Sucheta; 1 ♀, Yedu Arabia on jawar, 31.i.1943 (S.Khan coll.) *Andrallus spinidens* det. Sucheta.

Genus: *Zicrona* Amyot & Serville
Type-species: *Cimex caerulea* Linn.

*Zicrona caerulea* (Linn.)
Material examined: 1 ♀, India: Uttar Pradesh, Moradabad, Pipalsana on *Phaseolus mungo* L., 29.v.1979 (M.N.Azim), 2 ♀, Jammu & Kashmir, Srinagar, Dachigam National Park on wild plant, 27.ix.2004 (M.S.Bhat); IARI, New Delhi collection: 1 ♀, Nainital, 4.vii.1937 (R.Swarup coll., R-7008), 1 ♂, Assam, Chandpur, January, 1908 (R-2348).

### Tribe: Jallini Mulsant and Rey

Genus: *Cazira* amyot & Serville
Type-species: *Pentatoma verrucosa* Westwood

*Cazira ulcerata* (Herrich-Schaeffer)
Material examined: 1 ♂, India: Kerala, Trivandrum, Chiryankil on grass, 28.xi.1979 (M.N.Azim); IARI, New Delhi collection: 1 ♂, Bengal, Pusa (R-2294), 1 ♂, Bihar, Pusa (R-2295).

*Cazira friwaldskyi* Horvath
Material examined: IARI, New Delhi collection: 1 ♀, Lebong 5000ft, June, 1909 (H.M.L. coll., R-2291).

*Cazira verrucosa* (Westwood)
Material examined: IARI, New Delhi collection: 1 ♀, Bihar, Pusa, 29.vi.1906 (R-2290), 1 ♀, Nilgiris, Naduvatum, May, 1906 (R-2289).

Genus: *Blachia* Walker
Type-species: *Blachia ducalis* Walker

*Sesha* Distant
Type-species: *Sesha manifesta* Distant

*Blachia ducalis* Walker

Material examined: IARI, New delhi collection: 1 ♀, Khasi hills, Nongpoh, 7.1907 (D.Nowrojee coll., R-2298).

Genus: *Canthecona* Amyot & Serville
Type-species: *Canthecona discolor* Palisot de Beauvois

*Canthecona tibialis* Distant
Material examined: 2 ♀, India: Uttar Pradesh, Aligarh, *Mangifera indica* L., 21.x.1979 (M.N.Azim).

*Canthecona furcellata* (Wolff)

Material examined: IARI, New Delhi collection: 1 ♀, Bengal, 27.iv.1905 (T.V.R.A.coll., R-1276), 1 ♀, Chapra (Mackenzie coll.,R-1282), 1 ♀, Bihar, pusa, 8.vii.1939 (C.K.Samuel coll.).

*Canthecona parva* Distant
Material examined: 1 ♀, India: Uttar Pradesh, Aligarh, on *Mangifera indica* L., 14.viii.1978 (M.N.Azim); IARI, New delhi collection: 1 ♀, Bengal, Pusa, Daltonganj (C.S.M. coll., R-1341).

Genus: *Picromerus* Amyot & Serville
Type-species: *Cimex bidens* Linn.

*Picromerus obtusus* Walker
Material examined: 1 ♀, India: Uttar Pradesh, aligarh on *Mangifera indica* L., 25.iii.1978 (M.N.Azim).

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# Addition of two new species to genus *Chimarra* Stephens (Trichoptera: Philopotamidae) from Sikkim (India)

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## Abstract

**Two new species of genus *Chimarra* Stephens from Sikkim are described and illustrated. Newly described species are *C. imperfecta* from Dikchu and *C. indentata* from Gangtok.**

**Keywords:** *Chimarra, C. imperfecta, C. indentata, Sikkim, India.*

## Introduction

Of the 665 species of *Chimarra* known from the World (Morse, 2011), 260 species are recorded from the Oriental region. The vast majority of these have been described just in the last 21 years. This genus is the largest genus of family Philopotamidae Stephens. It is divided into 4 subgenera; *Chimarra* Stephens, *Chimarrita* Blahnik, *Curgia* Walker and *Otarrha* Blahnik (Blahnik, 1998). The last 3 of these subgenera occur only in the Neotropical region, whereas subgenus *Chimarra* Stephens occurs in all biogeographic regions except Antarctic. Though this genus is cosmopolitan yet it is especially abundant in tropical regions. From India, this is the only subgenus represented under subfamily Chimarrinae Rambur. Blahnik (1998) revised the Neotropical species of this genus and discussed its phylogeny. Blahnik *et al.* (2009) described 30 new species of *Chimarra* from Borneo. Wichard (2007) described a new fossil species of this genus in Dominican amber. Immature stages of this genus were described by Hoang and Bae (2008) from Vietnam. Cartwright (2002) described Australian species of *Chimarra*. As far as Oriental region is concerned Malicky (1979, 1989, 1993, 1994, 1995, 1997, 1998, 2000, 2006, 2007, 2008, 2009, 2010 and 2011) is the main contributor with approximately 130 species to his credit from Nepal, China, Thailand, Indonesia, Vietnam, Bhutan, Myanmar, Malaysia, Java, Sumatra, Philippines, Borneo and India. Many other workers like Schmid (1958 and 1960), Kimmins (1957 and 1964), Mey (1990 1995, 1998a, 1998b, 2003 and 2006), Hwang (1957), Olah (1993), Hsu and Chen (1996) also contributed to the systematics of this genus from Oriental region. So far, 21 species of this genus are on the record from the faunistic limits of India. Out of this 14 have been reported from Himalayan region alone. Contributors to these 14 species include: Kimmins 1957 (5), Martynov 1935 (4), Ghosh and Chaudhary 1999 (2) and Saini *et al.* 2010 (3). Adult males of this genus are remarkable for their extreme variation in genital morphology particularly in the structure of inferior appendages, tergite X and phallic apparatus of males.

## Materials and Methods

The caddisflies belonging to this genus were collected with light traps (ultraviolet mercury vapour bulbs) put near high altitude water streams in the Himalayan belt of India. The collected specimens were preserved in 70% ethyl alcohol with a drop of glycerol and labeled with pertinent information. The examination of various morphological characters such as labial palp, antenna, setal warts, legs, wing maculation, venation and genitalic attributes was done with the help of relevant literature. For studying the genitalic characters, the genitalia was removed from the specimen and put in 10% KOH solution overnight. After this, the genitalia was repeatedly washed with glacial acetic acid and then put in a solution of 80% ethyl alcohol with a drop of glycerol for observation. The drawings were prepared with the aid of a zoom stereoscopic binocular (Kyowa Getner DVZ-555 with maximum magnification of 90 X) fitted with an ocular grid. The inking of the final drawings was done with the Rottering black ink. Terminology for genitalia and wings follows Blahnik (1998, 2009). The types of the new species have been deposited in the

Museum of PUPM, Department of Zoology, Punjabi University, Patiala, India.

**Genus: *Chimarra* Stephens, 1829**
**Type species:** *Phryganea marginata* Linnaeus, 1767 (monobasic)
**Diagnostic Features:** The important diagnostic characteristics of genus *Chimarra* Stephens include: the foretibial spur formula 1, 4, 4; occipital portion of head well developed and extended in a wide curve behind eyes; ocelli present; maxillary palps 5-segmented, with second segment twice the length of first and fourth almost half the length of long annulated and flexible fifth segment; each forewing lacks fork IV (fork of M3+4); costal and anal margins are nearly parallel; vein $R_s$ strongly sinuous before discoidal cell, and forks I-III and V present. Hind wing only slightly wider than fore wing; vein $R_1$ narrowly parallel to subcosta, sometimes apparently fused; fork I- III and V present; anal vein $A_2$ is narrowly looped to join anal vein $A_1$ (Blahnik, 1998). Inferior appendages in the male genitalia are each 1-segmented while in the other members of family Philopotamidae these are 2-segmented.

***Chimarra imperfecta* sp. nov.**
(Figs. 1)
**Material examined:** Holotype: ♂, India: Sikkim, Dikchu, 1,550m, 22.v.1999, Ref. no.TRC/P/C42, (PUPM)
**Distribution:** India; Sikkim.
**Etymology:** The species name pertains to imperfect outer margin of lateral lobe of segment X.
**Description:** Adult male; length of fore wing 4.5mm. Body uniformly fulvous except fuscous head and thorax and entirely covered with thick, short and fuscous pubescence.
**Male genitalia**: Abdominal segment IX with anteroventral margin moderately, triangularly expanded; posteroventral process merely indicated, broadly sub-triangular, very wide basally, apex scarcely projecting, obtuse. Inferior appendage single segmented, slightly longer than tergum X, slender at base but broad at middle and roundly pointed at apex. Tergum X with sclerotized lateral and mesal lobes; each lateral lobe broad at base and its outer margin serrate and apically narrow in dorsal view, with numerous sensilla; median lobe digitate, slender, finger like, smaller than lateral lobe of tergum X. Preanal appendage short, globose, slightly flattened. Aedeagus with long median spine and two short basal spines.

**Remarks:** *Chimarra imperfecta* sp. nov. though resembling *C.fusca* Kimmins1957, can be easily distinguished from the latter by the structure of inferior appendage which is narrow basally, broad and rounded apically (digitate in *C.fusca*); preanal appendage wart like (elongate in *C. fusca*); aedeagus with one long median and two short lateral spines (aedeagus enclosing mass of black spinules at apex in *C.fusca*).

***Chimarra indentata* sp. nov.**
(Figs.2)
**Material examined:** Holotype: ♂, India: Sikkim, Gangtok 1,700m, 25.v.1999, Ref. no. TRC/P/C50, (PUPM).
**Distribution:** India; Sikkim.
**Etymology:** The species name is after peculiar indentation at apex of inferior appendage.

**Description:** Adult male; length of fore wing 6 mm. Body uniformly fuscous except the lower side of abdomen creamish and entirely covered with thick, short and fuscous setae. Head is covered with thick, long and nigrescent pubescence.
**Male genitalia**: Abdominal segment IX with anteroventral margin sub triangularly roundly pointed; posterolateral side truncate; posteroventral process short, broadly triangular. Inferior appendage single segmented, shorter than tergum X, with superior and inferior margins parallel, apically with shallow excision and in ventral view with mesoapically directed tooth. Tergum X with sclerotized lateral and mesal lobes; lateral lobe broad at base and narrow towards apex in lateral view, with an infold at middle, rounded apically, convergent in dorsal view; mesal lobe digitate, spoon like, twisted in dorsal view. Preanal appendage short, globose and spinifere. Aedeagus long, apically bifid, with a pair of sickle-like spines at base.
**Remarks:** *C.indentata* sp.nov deserves the status of species novum as the apex of its inferior appendage is indented; sclerotized lateral lobe of tergum X large and convergent, with infold at middle and mesal lobe twisted at apex.
**Abbreviations:** PUPM= Punjabi University Patiala Museum.

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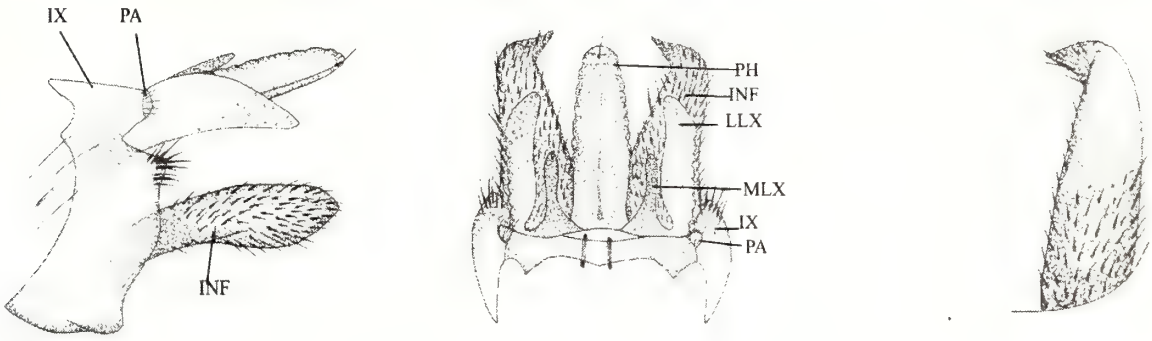
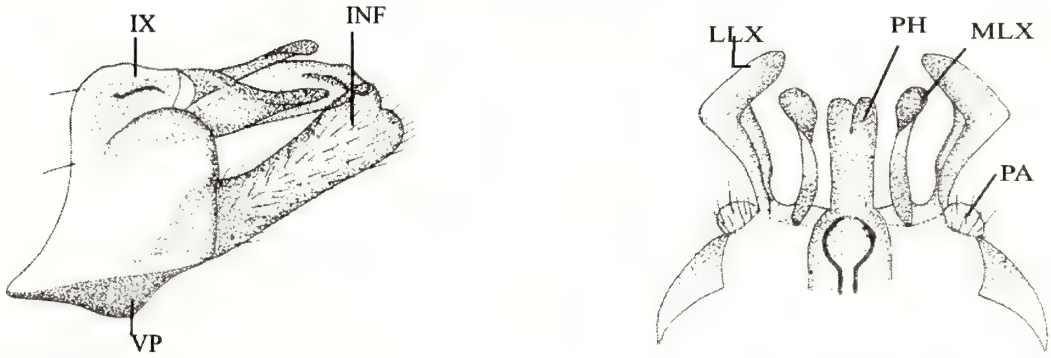



Lateral view Dorsal view Ventral view of inferior appendage

**Figs.1: Male genitalia of *Chimarra imperfecta* sp. nov.**




Lateral view Dorsal view

Dorsal view of inferior appendage Ventral view of inferior appendage

**Figs.2: Male genitalia of *Chimarra indentata* sp.nov.**

INF- Inferior appendage; LLX- Sclerotized lateral lobe of tergum X; MLX- Sclerotized mesal lobe of tergum X; PA- Preanal appendage; PH- Phallus; VP- Post ventral process; IX- Abdominal segment IX.

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# SEM studies on immature stages of weaver ant *Oecophylla smaragdina* (Fabricius, 1775 ) (Hymenoptera: Formicidae) from India

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## Abstract

**The present study has been designed to focus on scanning electron microscopy of immature stages of weaver ant *Oecophylla smaragdina* and this work would provide an insight to employ larval diagnostic features as a supplement to remove confusion in very closely related species with better resolution and more precision. Presence of a prepupal stage in *O. smaragdina* has been indicated by present study, which was not reported earlier (Fig. 4).**

**Keywords:** *SEM, Immature stages, Oecophylla smaragdina, India.*

## Introduction

Ants are social insects which belong to family Formicidae, and along with wasps and bees, they constitute order Hymenoptera, one of the advanced orders. Evidence for the success of ants is provided by the estimates of their total biomass which is nearly 15% of the entire terrestrial animal biomass. The species under consideration *Oecophylla smaragdina* (Fabricius, 1775) distributed in India, Australia and South-east Asia is in use as effective biological control agent. Immature stages of this species are also used as food supplement in various regions of South–east Asia. As the larvae are important for the well being of the colony, the physiology and behavior of the colony with reference to the larvae must be learnt. Wheeler and Wheeler (1953, 1960a, 1960b, 1964a, 1964b, 1964c, 1966, 1970, 1976, 1980, 1982, 1986a, 1986b, 1986c, 1986d, 1989a, 1989b, 1989c and 1991) described the larvae of over 700 ant species and explained morphology of the generalized ant larva using simple optical microscope. They emphasized the importance of larval descriptions to myrmecology and concluded that certain larval characters can be applied to species level taxonomy and systematics in various ant genera

As their study included a single mature larva and moreover, the work was based on optical microscopy, hence they were not able to elucidate minute details. More recently, few workers (e.g. Fox *et al.*, 2007) paid more attention to minute larval structures and carried out scanning electron microscopy. But the case of all important weaver ant *Oecophylla* could not get recognition. With this back drop, the present study was designed to focus on scanning electron microscopy of immature stages of weaver ant *Oecophylla smaragdina.* It is hoped that this work would provide an insight to employ larval diagnostic features as a supplement to remove confusion in very closely related species with better resolution and more precision.

## Materials and Methods

1. Immature stages of *Oecophylla smaragdina* were collected from mango, citrus and guava trees in Horticulture Department, Punjabi University, Patiala and also from surrounding areas (Ropar, Hoshiarpur and Anandpur Sahib).

2. The larvae were fixed in Dietrich's Solution for 24 hours.

3. After fixing in Dietrich Solution these were preserved in 80% alcohol.

4. Then the larvae were separated into three instars according to their maximum head capsule width.

5. Measurements were made with a compound microscope equipped with an ocular micrometer.

6. Body lengths from 50 larvae from each instar were measured for more accuracy.

7. After separation and measurements, larvae (N=10) from each instar were prepared for Scanning Electron

microscopy analysis with following protocol;
(i) Samples were post-fixed in 1% Osmium Tetraoxide.
(ii) These were dehydrated in graded acetone series.
(iii)Then the specimens were vacuum dried in desiccator.
(iv) Specimens adhered to the double-face adhesive carbon tape were coated with gold in a gold ion sputter coater (HITACHI E-1010).
(v) Then the samples were analyzed under a HITACHI S -3400 N Scanning Microscope.

8. The terminology used for the description of the larvae of *Oecophylla smaragdina* follows Wheeler and Wheeler (1976) and Fox *et al.* (2007). Body hairs were measured at full length and body length is presented both in straight length (N=50 for each instar) and length through spiracles, which was taken from only one larva of each instar still in good body shape after being mounted on glass slide.

Pupae lengths were measured on a straight line from the top of the head capsule to the tip of the abdomen. Concerning other measurements (of head capsule, mouthparts, hairs, etc.) only of one individual per instar are presented in the description. All body measurements are presented as mean ± standard error.

## Results and Discussion

The larvae of *O. smaragdina* have been previously described by Wheeler and Wheeler (1976, 1986b), although without the knowledge of the number of larval instars and that too based on five specimens only.

According to Wheeler and Wheeler (1976) a generalized ant larva possesses the following features: "an ant larva is soft, whitish, legless grub with a distinct, soft and hypognathous head on the anterior end of body, followed by 13 distinct somites posteriorly. Body profile is pogonomyrmecoid i.e. diameter greater near the middle of the abdomen, decreasing gradually towards the posterior end, which is rounded. Thorax is more slender than abdomen and form a ventrally curved neck. Leg vestiges are present as pairs of short transverse lines near the posterior borders of each thoracic somite. Gonopod vestiges are present as a pair of short transverse lines on the ventral surface of one or more abdominal somites VII, VIII and IX. Anus is a transverse slit on the abdominal somite X, slightly ventral to the most posterior point on the somite. Ten pairs of minute and uniform spiracles, a pair each on mesothorax, metathorax and abdominal somite I to VIII are present. Integument of body is spinulose and body is furnished with unbranched hairs. Cranium is subhexagonal in anterior view. Integument of the cranium is smooth with a few sensilla. Antennae bear three sensilla, each of which bear a minute spinule. Clypeus is marked off by grooves. Mandibles, palps, galea and pleurostoma are sclerotized. Labrum is bilobed thick flap. Maxillae are with the conoidal lacinia. Palps are paxilliform each with 5 sensilla. Labrum is hemispheroidal. Hypopharynx is densely spinulose".

In tribe Oecophyllini the body profile is Oecophylloid type. Very few, minute, smooth, unbranched and acute body hairs are present. Antennae are minute. Head hairs are few in number, very short and spike-like. Labrum is small and bilobed. Only two hair are present on anterior surface. Chiloscleres are lacking. Mandibles are very small and dolichoderoid. Maxillae are broad and apparently adnate. Palps and galea are very small. In the present SEM studies on *Oecophylla smaragdina* the number of larval instars were established by measuring maximum head capsule widths of the larvae (Solis, 2007) and it has been observed that the number of larval instars for *Oecophylla smaragdina* is three, which are discussed in detail as follows:

### First larval instar

**Body-** The first larval instars of *Oecophylla smaragdina* are whitish in colour. Wheeler and Wheeler (1976) has divided the body profiles into 12 types namely Pogonomyrmecoid, Pheidoloid, Dolichoderoid, Attoid, Myrmecoid, Crematogastroid, Aphaenogasteroid, Platytheroid, Leptanilloid, Leptomyrmecoid, Oecophylloid and Rhopalomastigoid. Body profile of *O. smaragdina* is oecophylloid i.e. body is plump, sausage-shaped and slightly curved. Diameter of the body is nearly uniform. No neck is formed (Fig. 1a and 1b). Head is on the anterior end. Anus is slightly sub-terminal in position with no differentiation of lips perhaps due to the preservation of the specimens. Head capsule is proportionally small in relation to the body size (Fig.1a). There are only few, unbranched, sparsely distributed body hairs measuring approximately 5.27µm in length (Fig. 1c). Hairs are abundantly distributed near the anterior surface of thorax measuring 57.34µm in length (Fig. 1d). Body protuberances are divided into three groups by Wheeler and Wheeler (1976); the leptaenilline protuberances; welts which are low, elongate and narrow protuberances and tubercles include all other shapes like bosses if they are low, convex and subcircular. Body protuberances in case of *O. smaragdina* are in the form of spike like structures measuring 18.3µm in length and boss which is an elevated structure with a rounded

terminus measuring 18.3µm (Fig.1e). The integument of the whole body is densely covered with small, about 5.98µm long spike like protuberances (Fig. 1f). Ten pairs of spiracles, a pair each on the mesothorax, metathorax and eight anterior abdominal somites are present with the diameter of 1.81µm (Fig. 1b and 1g). Length of a straight stiff larva is not comparable to the length of the curved flexible larva. So, two lengths are measured on straight larva *viz.*, straight length and length through spiracles. Straight length is measured from the dorsum of the prothorax to the posterior end of the body and length through spiracles from the front of the head through all the spiracles to the anus. Straight body length is 951.5µm; range 883-1020µm and length through spiracles is 1514µm.

**Head Capsule-** Cranium 306µm high X 340µm wide and is roughly sub heptagonal. A single cephalic seta present, measuring 36.6µm in length on the tip of the cranium (Fig.1h). Antennae are observed as slight elevations from the head measuring 5.3µm in width, with three sensilla on them (Fig. 1i). Head surface is smooth with simple hairs measuring 19.4µm in length on it. Very few, short and spike like hairs observed. Distribution of hairs is not symmetrical.

**Mouthparts-** Clypeus not clearly delimited from the cranium, upper surface of clypeus smooth, without sensilla. A distinct row of simple hairs with 42.06µm in length is present lining the distal clypeal border. Labrum small, measuring 62.1µm in length, bilobed and with only two simple hairs on the anterior surface (Fig. 1j).

**Second Larval Instar**

**Body-**Body profile is Oecophylloid type as observed in the first instar, but head is slightly terminal in position, neck becomes more curved, body becomes cylindrical and narrow (Fig. 2a). Anus is clearly sub-terminal in position measuring 22.8µm in transverse length (Fig. 2b). Body hairs are minute, smooth, unbranched and acute measuring in 46.6µm in length. Integument of the body is covered with small spike like protuberances (Fig. 2c and 2d). Ten pairs of spiracles are present with 2.41µm diameter (Fig. 2e). Body length is 1815µm; range 1700-1930µm and length through spiracles is 1821.5µm.

**Head Capsule-** Cranium 332µm high X 433µm wide (Fig. 2f). Antennae are distinct, 12.0µm in diameter (Fig. 2g). Head hairs are smooth, simple straight, curved and measure about 47.6µm in length (Fig. 2f and 2h).

**Mouthparts-** Labrum bilobed, 88.2µm wide with two simple hairs on its anterior surface (Fig. 2h and 2i). Mandibles are small, simple, sharp-pointed, 39.4µm long and 9.2µm wide at the base and dolichoderoid in shape without any medial teeth (Fig. 2i, and 2j). Maxillae are broad, adnate type and measure 25.7µm in length and 20.8µm in width at the base. Maxillary palpus 10.65µm long. Galea is simple 6.68µm long (Fig. 2i and 2j). Labium is 88.2µm wide (Fig. 2h and 2i).

**Third Larval Instar**

**Body-** Body profile is as in the second instar (Fig. 3a). Anus is sub-terminal in position (Fig. 3b). Body hairs very sparsely distributed, about 24.02µm long. Spike like body protuberances measuring 3.43µm in length are present on the whole body surface (Fig. 3c). Spiracles are 5.93µm in diameter (Fig. 3d). Body length is 2320µm; range 2070-2570µm. Length through spiracles is 3010µm.

**Head Capsule-** Cranium 431µm high X 495µm wide. All head hairs are simple, unbranched, acute and measure about 53.06µm in length (Fig. 3e and 3h). Cephalic seta is 43.7µm long and 31.8µm wide (Fig. 3e). Antennae are 14.2µm wide with three sensilla (Fig. 3f).

**Mouthparts-** Clypeus is not clearly delimited from the cranium. Labrum 125µm wide with two hairs, which are 13.7µm long on its anterior surface (Fig. 3g and 3h). Mandibles are small, dolichoderoid in shape, 23.9µm long (Fig. 3g and 3h).

To sum up, the description of the larva confirms the general morphological aspects originally observed by Wheeler and Wheeler (1976) with some marked differences. It has been observed during the present study that the profile of the larva remains Oecophylloid in all the three instars and size of body increases as the larva grows (Fig. 1a, 2a and 3a). Straight body length of the first instar was 951.5µm which increases upto 1815µm in second instar and 2320µm in third instar. Length through spiracles also increases. Position of anus shifts from slightly ventral in first instar to subterminal in second instar which remains the same in the third instar (Fig. 2b and 3b). Wheeler and Wheeler (1976) observed the body protuberances in the form of welts and bosses, but small spike like protuberances on the whole body surface of all the three instars has been observed which are already known to be useful to the larva in following manners (Fig. 1f, 2c, 2d and 3c):

1. They provide support to the body by creating an airspace between body and substrate.
2. Some of the hairy tubercles afford protection against cannibalism.
3. They help larvae in the process of attachment.
4. Tubercles act as exudate organs which secrete onto their surfaces substances to which workers are very fond, thus help in trophallaxis.
5. They help in holding food.

Variation in hair distribution on the body between

Fig.1a

Fig.1d

Fig.1b

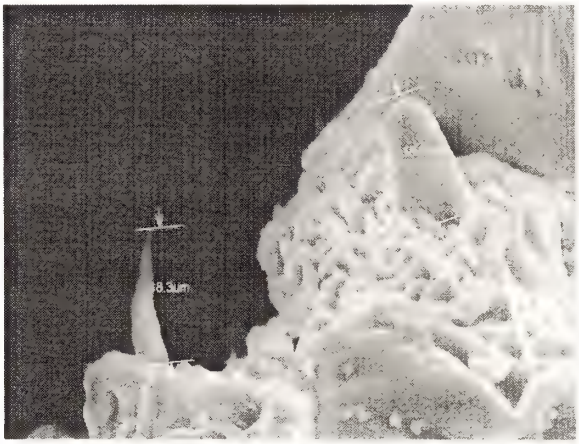


Fig.1e

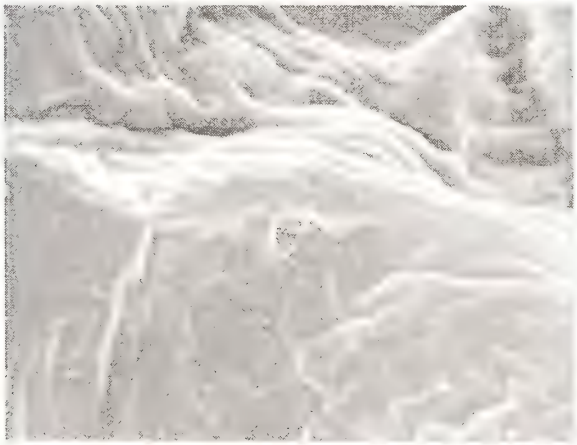

Fig.1c

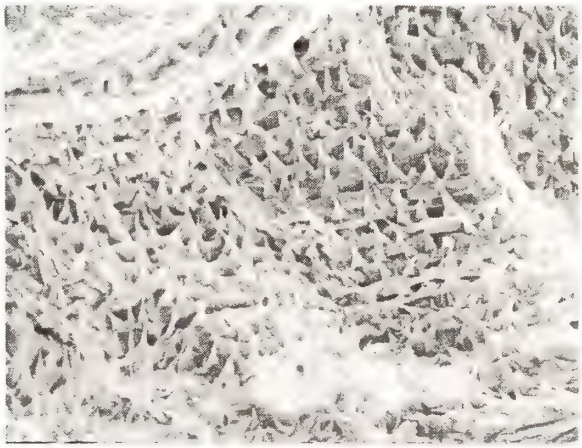

Fig.1f

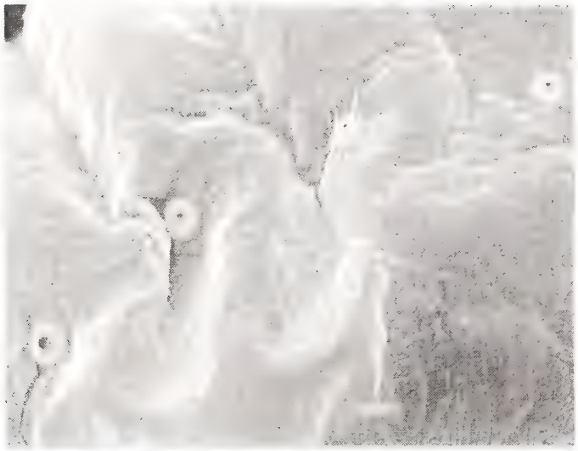

Fig.1g

Fig.1j

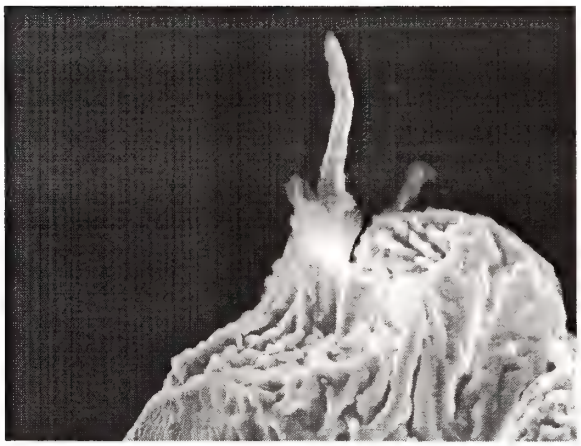

Fig.1h

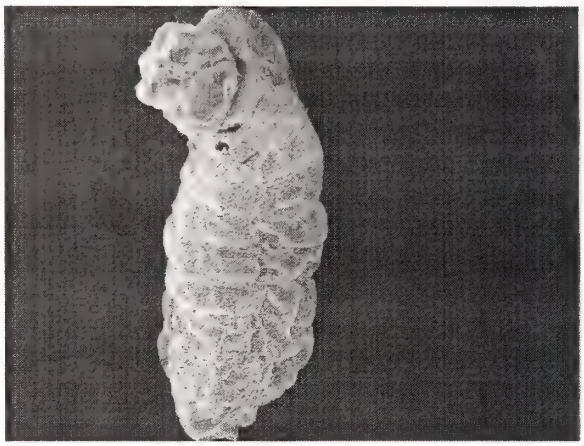

Fig.2a

Fig.1i

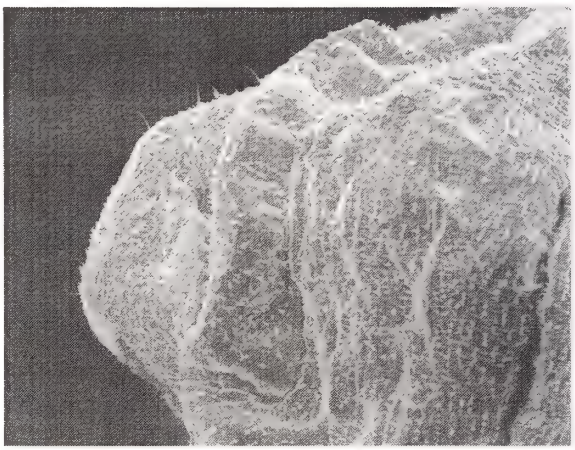

Fig.2b

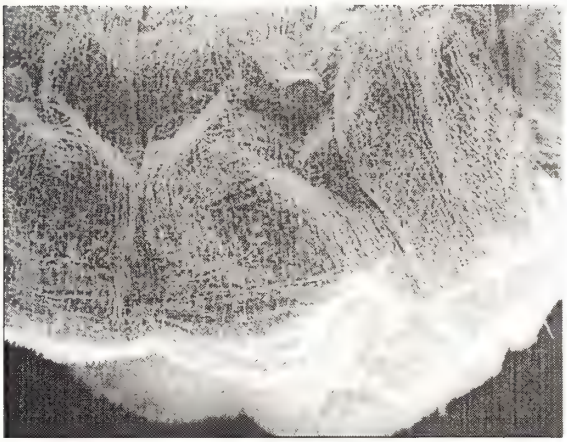

Fig.2c

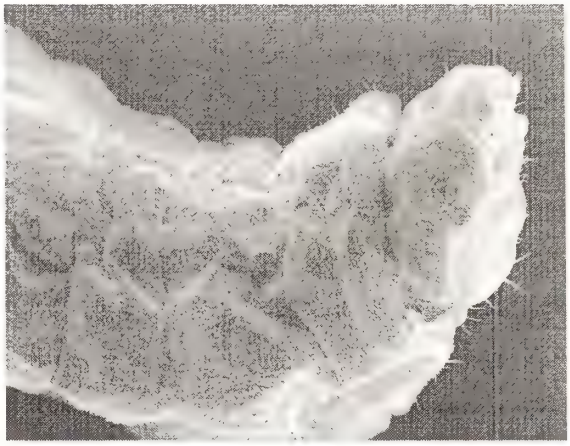

Fig.2f

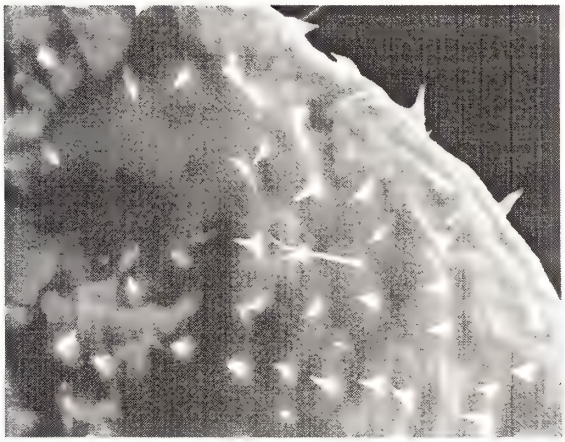

Fig.2d

Fig.2g

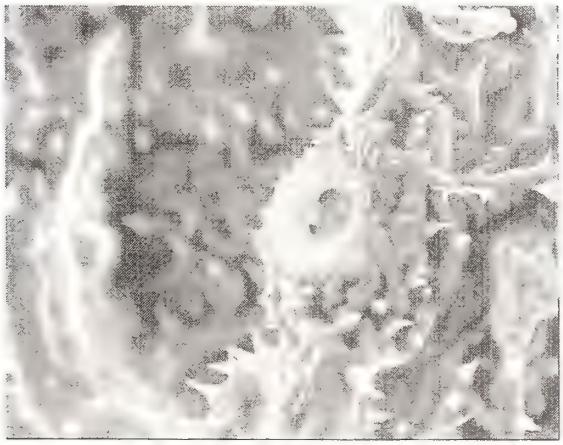

Fig.2e

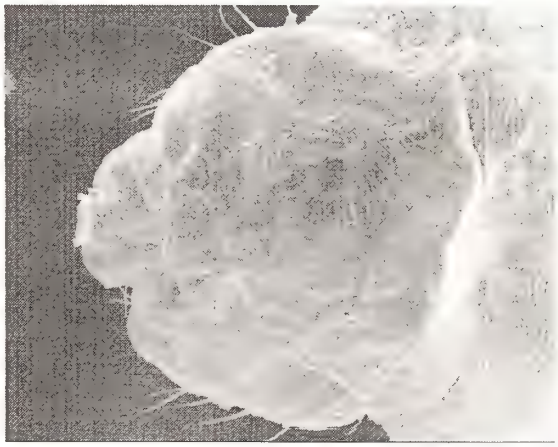

Fig.2h

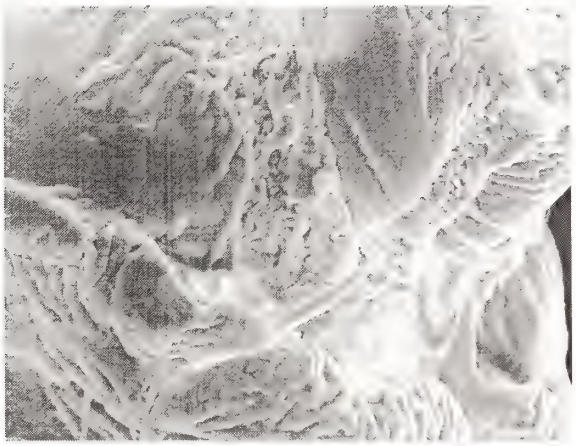

Fig.2i

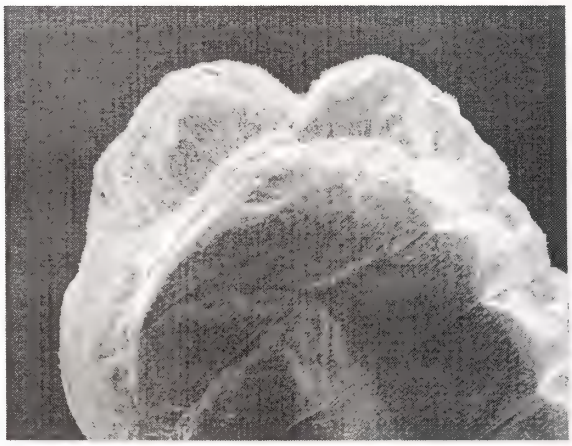

Fig.3b

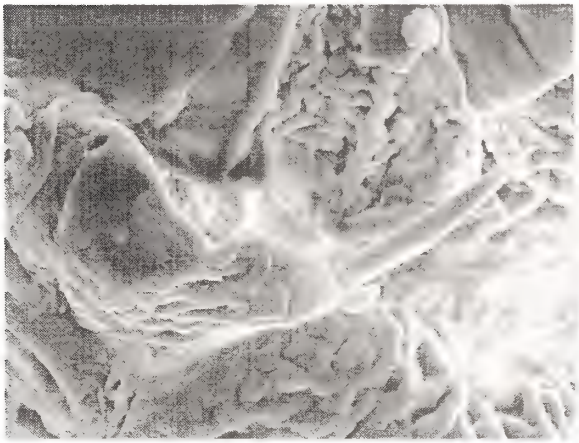

Fig.2j

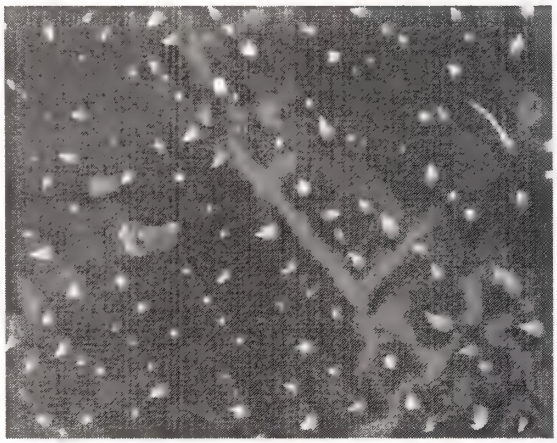

Fig.3c

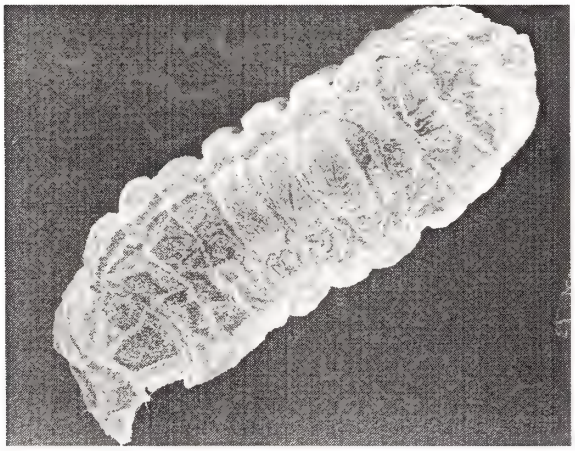

Fig.3a

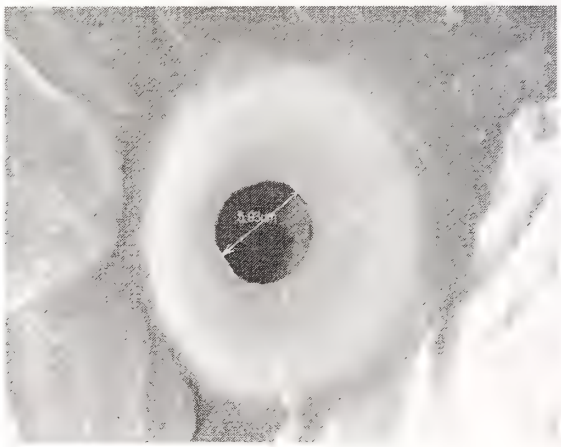

Fig.3d

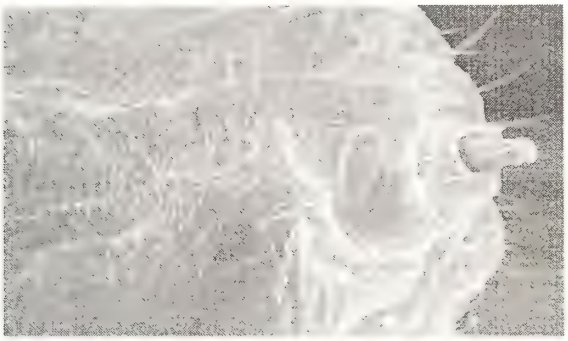

Fig.3e

Fig.4

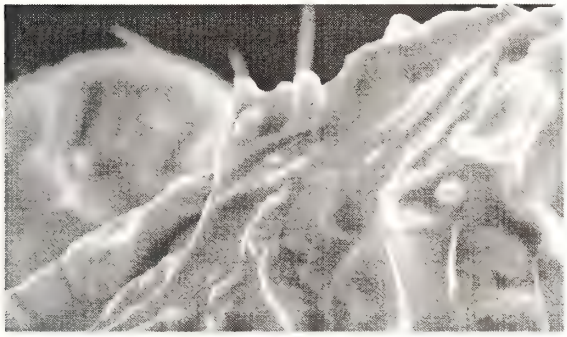

Fig.3f

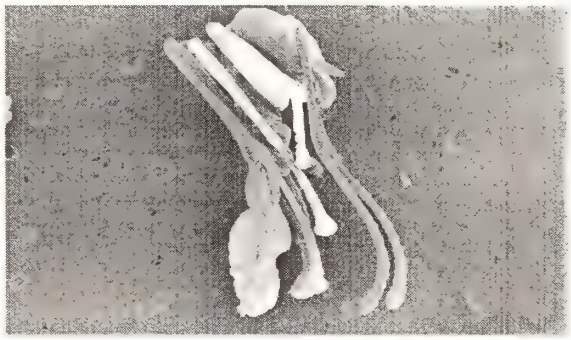

Fig.5

Fig.3g

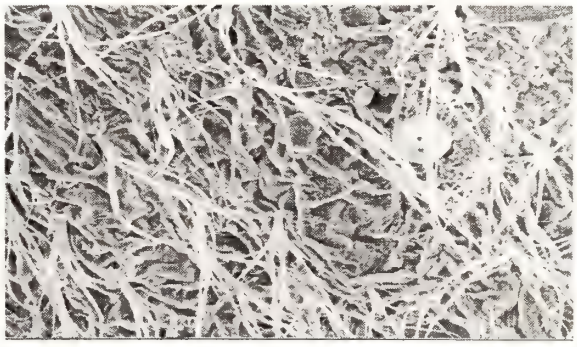

Fig.6a

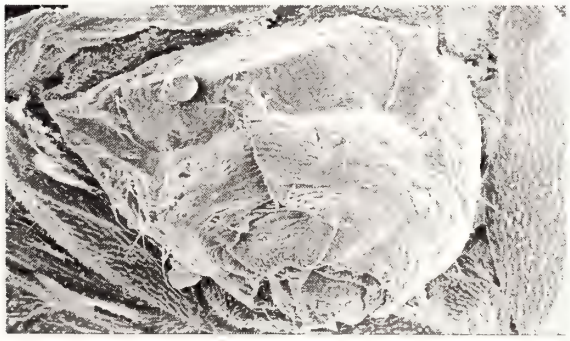

Fig.3h

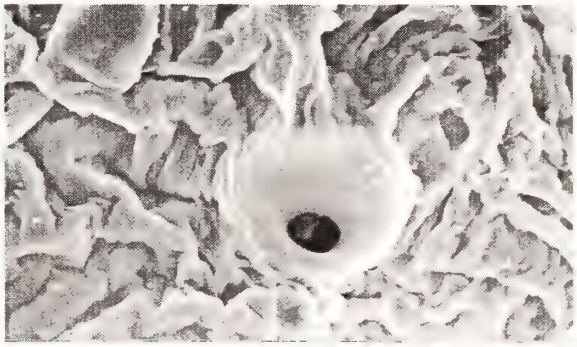

Fig.6b

different specimens within an instar has been observed. This variation was not reported earlier. Hairs are very sparsely distributed on the body. Length of the hair is very small. Longer and densely distributed hairs are present on the ventrally curved neck region of the thorax. There is no specific pattern of hairs on the head. Presence of cephalic seta on the tip of the cranium has been observed (Fig. 1h). Size of the seta decreases as the larva grows. Diana Wheeler (1982) considered the cephalic seta a feasible morphological character in establishment of number of instars. This character has been used during present study for confirming the number of instars for this species which were already established with the help of maximum head capsule width under optical microscope. Number of spiracles are 10 in all instars but diameter increases as the larva grows. Openings are unornamented in all spiracles in each instar. Width of the labrum increases in each instar (Fig. 1j, 2h, 2i, 3g and 3h). Arcila *et al.* (2002) described the larvae of *Paratrechina fulva* and observed considerable differentiation of mandible morphology between each larval instar. They considered mandible morphology a feasible character for identification of the larval instars. But in *O. smaragdina*, there is no noticeable difference between the mandibles in all instars. Length and width of the mandible increases (Fig. 2i, 2j, 3g and 3h). Presence of a prepupal stage in *O. smaragdina* has been indicated, which was not reported earlier (Fig. 4). Cuticular layer covers the larva completely and no internal structures were visible. Few head hairs in some specimens come out of the cuticle. Usually pupae of formicinae have a cocoon (e.g. *Camponotus*), but pupae in this species have no cocoon, like other exceptions in the subfamily (Wheeler and Wheeler, 1976) (Fig. 5). The female larvae (Fig. 6a and 6b) have a pattern of the body which is very different from all other larvae. Size of this larva is comparable to that of third instar larva. This larva is different from worker larva in terms of body hair coverage. As the worker larva has a very few, sparsely distributed hairs on its body, but the female larva is densely covered with bunches of multifid hairs.

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# Revised phylogenetic analysis of Indian species of genus *Himalopsyche* Banks (Trichoptera: Spicipalpia: Rhyacophilidae)

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## Abstract

**Revised phylogenetic analysis was conducted for both the groups of the genus *Himalopsyche* (Trichoptera: Rhyacophilidae) based on characters of male genitalia. 17 characters representing 37 character states were used in the analysis. The results are discussed in terms of remarkable diversity of genitalic types in the males.**

**Keywords:** *Phylogenetic Analysis, Trichoptera, Himalopsyche, Genitalic types.*

## Introduction

The genus *Himalopsyche* originated in the Oriental region (Schmid, 1989). Over the globe this genus is represented by 48 species with 1 reported from Nearctic; 7 from East Palearctic and 40 from Oriental region (Morse, 2010). Based on *Rhyacophila tibetana* Martynov as its type species from Tibet, genus *Himalopsyche* was established and described by Banks (1940). On the basis of so many morphological affinities this genus is closely related to *Rhyacophila*, of which it seems to be a specialized off shoots. The diagnostic feature of genus *Himalopsyche* Banks include: metascutellum with spinifere warts and strongly spotted; venation similar to *Rhyacophila* except, veins R and M curve backward so that in forewings $R_4$ and $R_5$ are on each side of the apical wing point; discoidal cell open in both wings and the ventral abdominal process is absent. From the 40 species of Oriental region, around 18 species are from India and its adjoining areas (Morse, 2010) which are mainly contributed by Kimmins (1952), Martynov (1930, 1935, 1936), Morton (1900) and Schmid (1963, 1966) to the tune of 1, 3, 1 and 13 species respectively. Schmid (1966) divided genus *Himalopsyche* into two distinct groups i.e. Kuldschensis group and Tibetana group and to infer phylogeny of species of both groups some different characters were used.

When viewed from the economic point of view, larvae of this group are important and beneficial components of the trophic dynamics and energy flow in the lakes, rivers and streams they inhabit (Resh and Rosenberg, 1984). This group is considered the most useful and important aquatic organisms for monitoring climatic changes effects, and are widely used in bio-monitoring surveys, many of which are now mandated by federal and municipal statutes in developed countries (Dohet 2002, Lenat 1993, Resh 1993, Resh and Unzicker 1975).

## Materials and Methods

Species descriptions were derived primarily from literature contributed by Morton (1900), Martynov (1930,1935,1936), Kimmins (1952) and Schmid (1963,1966). Revised phylogenetic analysis was carried with a computer program PAUP version 4.0, with more characters as compared to earlier study (Saini and Kaur, 2010), has been used to infer the phylogeny (Swofford, 2000). The characters used to infer phylogeny of groups of genus *Himalopsyche* Banks, 1940 were:

**For Kuldschensis group**

**1. Preanal appendage:**(0-absent, 1-present)
**2. Terminal part of inferior appendage:** (0-not globose, 1–globose)
**3. Anal sclerite in dorsal view:** (0-apically bifid, 1-apically entire)
**4. Median lobes of segment X:** (0-partly fused, 1-completely fused)
**5. Segment IX:** (0-does not form a roof over segment X; 1-forms a roof over segment X)
**6. Paramere:** (0-absent; 1-present)
**7. Paramere:** (0-without spines; 1-with strong spines, 2-absent)
**8. In side view anal sclerite:** (0-not pointed apically, 1-pointed apically)
**9. Paramere:** (0-simple, 1-trifid, 2-absent)
**10. Inferior appendage:** (0-uniarticulated, 1-biarticulated)

**Table 1: Presence or absence data for ten characters for 10 species of the Kuldschensis group of genus *Himalopsyche* as used in the phylogeneticanalysis ; *H. digitata* (Martynov,1935) is included as an outgroup.**

| Characters → | | | | | | | | | | 1 |
|---|---|---|---|---|---|---|---|---|---|---|
| Species ↓ | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 0 |
| *H.todma* Schmid,1963 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 |
| *H. dolmasampa* Schmid,1963 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 |
| *H. malenanda* Schmid,1963 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| *H. bhagirathi* Schmid,1963 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 0 |
| *H. yongma* Schmid,1963 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 |
| *H. yatrawalla* Schmid,1966 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 0 |
| *H. lungma* Schmid,1963 | 1 | 1 | 1 | 0 | 0 | 0 | 2 | 1 | 2 | 0 |
| *H. gyamo* Schmid,1963 | 1 | 1 | 1 | 0 | 0 | 0 | 2 | 0 | 2 | 0 |
| *H. amitabha* Schmid,1966 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| *H. angnorbui* Schmid,1963 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 |
| *H. digitata* (Martynov,1935) (outgroup) | 1 | 0 | 1 | 0 | 0 | - | - | 1 | - | 1 |

**For Tibetana group**

**1. Basal segment or basal part of inferior appendage:** (0-not constricted to a slender finger about midway, 1-constricted to a slender finger about midway)

**2. Length of terminal segment or terminal part of inferior appendage:** (0-less as compared to basal, 1-almost equal to or longer than basal)

**3. Terminal segment or terminal part of inferior appendage in side view:** (0-not visible, 1-visible)

**4. Outer branch of lateral lobe of tergite X:** (0-not foliate, 1-foliate)

**5. Preanal appendage:** (0-not bifid, 1-bifid)

**6. Segment X in dorsal view:** (0-with pointed lobes, 1-with rounded lobes, 2-no distinction of lobes)

**7. Inferior appendage:** (0-uniarticulated; 1-biarticulated)

**Table 2: Presence or absence data for seven characters for 8 species of the Tibetana group of genus *Himalopsyche* as used in the phylogenetic analysis; *H. lungma* Schmid,1963 is included as an outgroup.**

| Species | Characters | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| *H. lepcha* Schmid, 1963 | 0 | 1 | 1 | 0 | 0 | 2 | 1 |
| *H.horai* (Martynov,1936) | 0 | 0 | 0 | 0 | 0 | 2 | 1 |
| *H.lanceolata*(Morton,1900) | 0 | 0 | 1 | 0 | 0 | 2 | 1 |
| *H. tibetana* (Martynov,1930) | 1 | 0 | 1 | 1 | 0 | 2 | 1 |
| *H.biansata* Kimmins,1952 | 1 | 0 | 1 | 0 | 0 | 2 | 1 |
| *H.maitreya* Schmid,1963 | 0 | - | 1 | 0 | 0 | 2 | 1 |
| *H. digitata* (Martynov,1935) | 0 | 1 | 1 | 0 | 1 | 0 | 1 |
| *H.hierophylax* Schmid,1966 | 0 | 1 | 1 | 0 | 1 | 1 | 1 |
| *H. lungma* Schmid,1963 (Outgroup) | 0 | 1 | 1 | 0 | 0 | 1 | 0 |

## Results

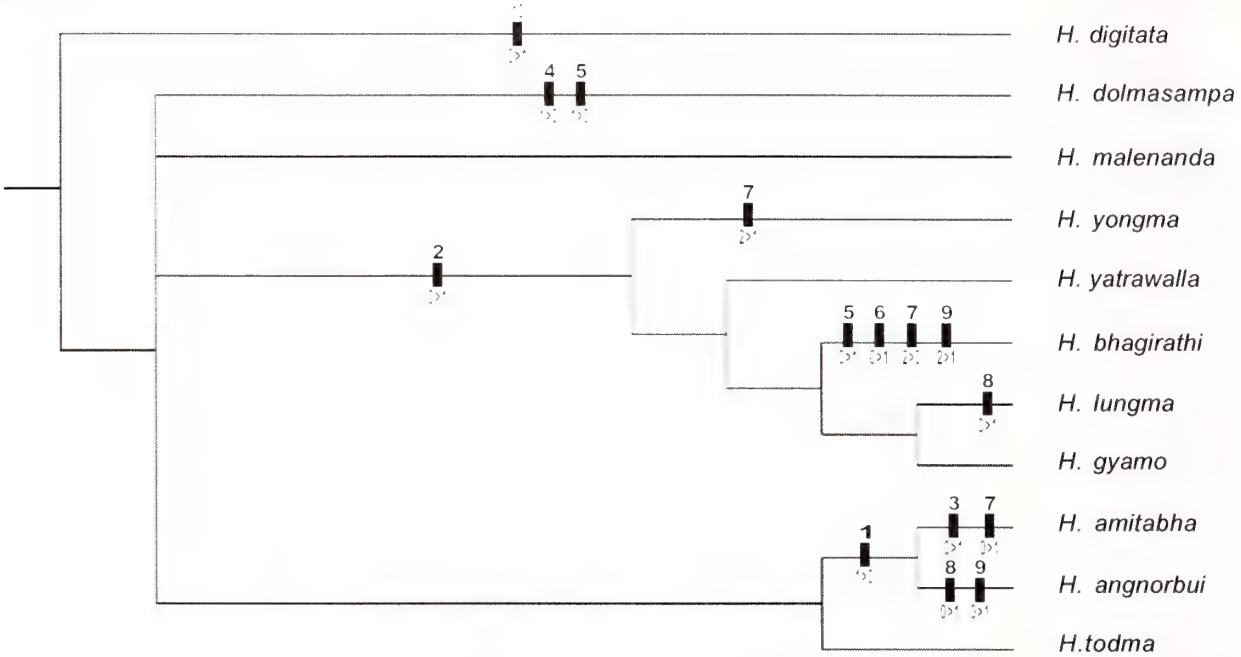


**Fig. 1: Phylogenetic cladogram of 10 species of the Kuldschensis group of genus *Himalopsyche*. Character numbers are above the hashmarks; state changes are shown below with the respective primitive and derived conditions reported by a '>'. 28 trees were found using the computer program PAUP version 4.0, with consistency index (CI) of 0.66, a retention index (RI) of 0.60 and rescaled consistency index (RC) of 0.40.**

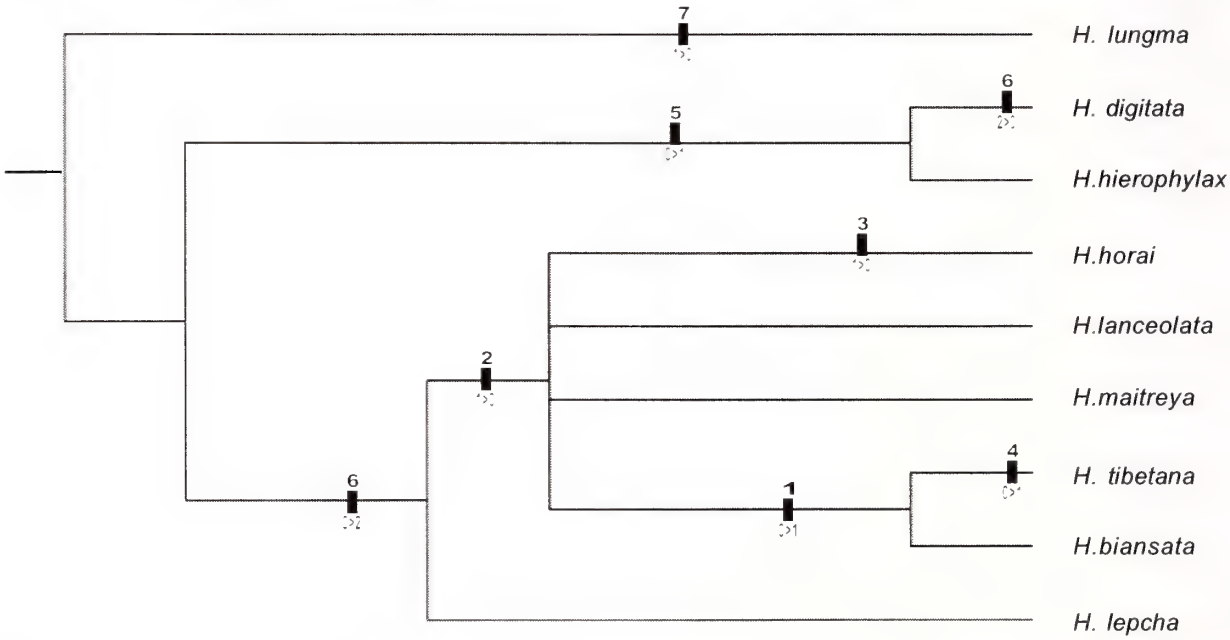


**Fig. 2: Phylogenetic cladogram of 8 species of the Tibetana group of genus *Himalopsyche*. Character numbers are above the hashmarks; state changes are shown below with the respective primitive and derived conditions reported by a '>'. 3 trees were found using the computer program PAUP version 4.0, with consistency index (CI) of 1.00, a retention index (RI) of 1.00 and rescaled consistency index (RC) of 1.00.**

## Discussion

To analyze the phylogeny of both groups of genus *Himalopsyche* Banks 17 characters representing 37 character states were used. In fig. 1: outgroup taxon (*H. digitata*) got isolated from all species of Kuldschensis group on basis of biarticulation of inferior appendage ( Character 10, state 1). *H. yongma*, *H. yatrawalla*, *H. bhagirathi*, *H. lungma* and *H. gyamo* showed synapomorphy due to (Character 2, state 1) terminal part of inferior appendage globose. *H. bhagirathi* can be distinguished from sister species *H. lungma* and *H. gyamo* on basis of characters 5, 6, 7 and 9. *H. amitabha*, *H. angnorbui* and *H. todma* formed cluster at the base of cladogram and sister species *H. amitabha* and *H. angnorbui* got isolated from *H. todma* on basis of absence of preanal appendage (Character 1, state 0).

In fig. 2 the outgroup (*H. lungma*) used to infer phylogeny in Tibetana group got separated from all species of Tibetana group by Character 7, state 0 i.e. uniarticulated inferior appendage. *H. digitata* and *H. hierophylax* got isolated from all other species of this group on basis of bifidation of preanal appendage (Character 5, state 1) and all other species shared character 6. *H. lepcha* got separated from *H. horai*, *H. lanceolata*, *H. maitreya*, *H. tibetana* and *H. biansata* due to character 2 and sister species *H. tibetana* and *H. biansata* can be distinguished from each other on basis of outer branch of lateral lobe of tergite X foliate in *H. tibetana*. To conclude, this can be said that species of genus *Himalopsyche* Banks exhibit a remarkable diversity of genitalic types in the males.

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# Taxonomic studies on the genus *Zemeros* Boisduval from Indian Himalayas (Lepidoptera: Riodinidae)

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## Abstract

**World over the genus *Zemeros* Boisduval contains two species i.e., *Z. emesoides* Felder and Felder and *Z. flegyas* Fruhstorfer. Whereas in India, this genus is represented by only one species *Z. flegyas* which is also its type species. The male and female genitalia of this type species are studied for the first time and accordingly the generic diagnosis has been updated by incorporating these characters. Besides some variations in wing maculation and venation have also been recorded in this species.**

**Keywords:** *Lycaenidae, Riodinidae, Zemeros, Male genitalia and Female genitalia.*

## Introduction

The genus *Zemeros* Boisduval is known by only two species i.e., *Z. emesoides* Felder and Felder and *Z. flegyas* Fruhstorfer worldover (Bridges, 1988). Out of these, the former is confined to Peninsular Malaya, Singapore, Borneo and Neomalaya (d' Abrera, 1986; Eliot, 1992). The latter species *Z. flegyas* which is also the type species of the genus besides India (ranges from Mussoorie to Assam), also occurs in Sumatra, Nias, Java, Bali, Borneo, Lombok, Sumbawa, Sumba, Hainaan, Siam, Tannasserim, Shan-States, Mergui, Burma, South China, Philippines, Malaya and Celebes and is separated into twelve subspecies (Shirozu, 1955; Forster, 1961; Fujioka, 1970; Shields, 1985; Varshney, 1994). In view of the distribution, the present sample has been identified as *Zemeros flegyas indicus* Fruhstorfer (Evans, 1932; Shields, loc. cit.; Haribal, 1992).

## Observations

### Genus *Zemeros* Boisduval

Common name: The Punchinello

Boisduval, [1836], (Roret's Suite a Buffon), Hist. nat., Ins. spec. gen. Lepid. 1 : pl. 21 (=pl. 5 C); Bingham, 1905, Fauna Brit. Ind., Butts I : Evans, 1932, Ident. Indian Butts (2nd ed.) : 194; Eliot, 1992, Butts Mlay Penin. (4th ed.): 205.

*Zimeros* Ehrlich, 1958, Univ. Kansas Sci. Bull. 39 : 359.

**Type-species: *Papilio allica* Fabricius**

Fabricius, 1787, Manitissa Ins. 2 : 52.

The nominal species *Papilio allica* Fabricius is currently treated as being the same as that represented by the older established nominal species *Papilio flegyas* Cramer.

**Generic diagnosis:** Frontoclypeal area dressed with equal ochraceous hair; eyes smooth; labial palpi porrect, not extending beyond head, second segment cylindrical, third segment gradually tapering into acute apex; antenna with well defined lanceolate club, nudum limited to apex; terminal tibial spurs absent; wings spotted and not striped, hindwing tornus neither produced nor tailed; forewing with 12 veins, vein Sc and vein $R_1$ approximating, vein 1A+2A weakly bifurcated at base, hindwing with vein $R_S$ and $M_1$ connate at origin, precostal vein present; male genitalia with uncal tip acute, not hooked, brachia long, V-shaped, apices acute, tegumen broad, vinculum laterally much reduced, deeply U-shaped, a large spade-like central sclerotized plate

present, valvae open fish-mouth shaped, juxta absent, aedeagus large, slender, slightly curvate, extending well beyond central sclerotized plate, coecum well developed and rounded, ductus ejaculatorius enters dorsad; female genitalia with genital plate weakly sclerotized, ductus seminalis enters ventrad near base of ductus bursae, basal portion of ductus bursae striped and sclerotized, corpus bursae subovate, not clearly differentiated, a pair of pustule-shaped signa present, apophyses anteriores and apophyses posteriores absent.

***Zemeros flegyas* Cramer**

Common name: The Punchinello Cramer, [1780], Uitl. Kapellen 3 (24) : 158 (*Papilio*); Bingham, 1905, Fauna Brit. Ind., Butts I: 499 (*Zemeros*); Evans, 1932, Ident. Indian Butts (2nd ed.): 194 (*Zemeros*); Shields, 1984, J. Bombay nat. Hist. Soc. 81 (3): 547 (*Zemeros*); Eliot, 1992, Butts Malay Penin. (4th ed.): 205 (*Zemeros*).
*esla* Fruhstorfer, 1912, Ent. Rundsch. 29 (3): 23 (*Zemeros*).

***Zemeros flegyas indicus* Fruhstorfer**

Fruhstorfer, (1904), Berl. ent. Z. 48 (4): 282 (*Zemeros*).
*confucius* Moore, 1878, Proc. Zool. Soc. Lond. (3): 701 (*Zemeros*).

**Male Genitalia**: Symmetrical; uncus large, bilobate, each lobe pentagonal in shape, apex acute, pilose; brachia long, V-shaped, basal portion broad and flat, distal portion cylindrical, tapering to acute slightly reflexed apices; subscaphium lens shaped, strongly developed; tegumen large, triangular dorsally, anterior margin more or less rounded, laterally produced into blunt processes; lateral windows large, well developed; vinculum thin, narrow, deep U-shaped, slightly oblique; saccus inconspicuous; a broad, large, spade-like, well sclerotized central plate present; valvae large, open fish-mouth like, broader than longer, costa ridge-like, sacculus with a digitus process below, ampulla large, arched, triangular, lobe-like, harpe large and triangular, pilose; juxta absent; aedeagus large, slender, bicurvate, ankylosed at zone, suprazone and subzone subequal, suprazone slightly narrower with a lanceolate elongated sclerotized plate in centre, apex broad, the latter extending beyond central sclerotized plate, opening of vesica terminal, subzone with coecum large, broad and rounded, bulbus ejaculatorius expanded dorsally, ductus ejaculatorius enters dorsad.

**Female Genitalia**: Lodix not developed; genital plate weakly sclerotized, with both lamella antevaginalis and lamella postvaginalis arcuate, the latter relatively less sclerotized, followed by a broad sclerotized area and a patelliform sclerotized region comprising two reniform halves; ductus seminalis tubular, opening ventrally into basal portion of ductus bursae; the latter longer than corpus bursae, sclerotized, depressed distal portion more broader and striped, reception at corpus bursae imperceptible; corpus bursae subovate, semi-membranous, a pair of pustule-like atomarius signa present; apophyses anteriores and apophyses posteriores absent; papilla analis auriculate, large, apposed, outer margin more sclerotized, pilose.
Forewing length; Male: 16-20 mm, Female: 19-20 mm.

## Material examined

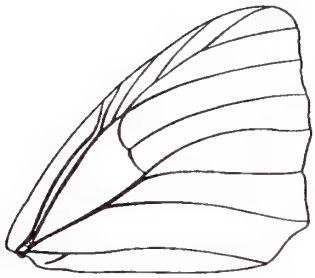
Sikkim: 1 ♂, 25.IX.1995, Pakyong, 1650 m ASL, East District; 1 ♂, 24.V.1997, Temi, 1110 m ASL, East District; 1 ♂, 1 ♀, 2.X.1995, 1 ♂, 3.X.95, Namchi, 1350 m ASL, South District; 1 ♂, 14.IX.1996. Mangan, 1200 m ASL, North District.
Assam: 3 ♂, 25.IX.1996, 4 ♂, 26.IX.1996, 1 ♂, 27.IX.1996, 2 ♀, 29.IX.1996, 1 ♂, 13.X.1996, 2 ♂, 14.X.1996, 1 ♂, 1 ♀, 16.X.1996, Bashistha, 250 m ASL, Kamrup; 2 ♂, 30.IX.1996, Bhalukpong, 213 m ASL, Sonitpur.
Arunachal Pradesh: 2 ♂, 4 ♀, 1.V.1995, Naharlagun, 500 m ASL, Papum Pare; 2 ♂, 2.V.1995, Jollang Village, 560 m ASL, Papum Pare; 4 ♂, 1 ♀, 10.X.1996, Itanagar, 550 m ASL, Papum Pare.
Range: 213-1650 m ASL.

**Old distribution :** Mussoorie to Assam and Burma.

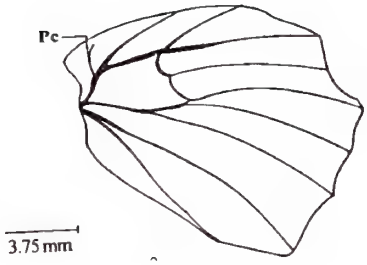
**Larval food plants**: *Maesa montana* DC. and *M. chisia* D. Don (Myrsinaceae) (Wynter-Blyth, 1957).

## Remarks

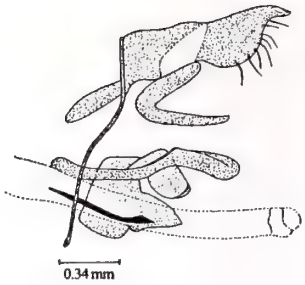
Having examined a large sample comprising twenty eight males and twelve females, some variations in terms of maculation, size and wing venation have been recorded as follows. The males collected from Namchi and Pakyong in Sikkim Himalaya are darker with less prominent markings on uppersurface of their wings. Regarding wing venation, the veins Sc and $R_1$ of the forewing may be very closely approximated and almost touching to each other (three males and two females) or moderately approximated (twenty five males and ten females). Owing to variations, mentioned above, a series of five males and three females were dissected and found to be conspecific genitalically in either case. While dealing with butterflies of the Malay Peninsula, Eliot (1992) has not mentioned any type of such variations



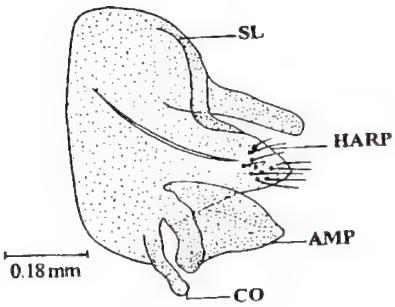
Venation of forewing



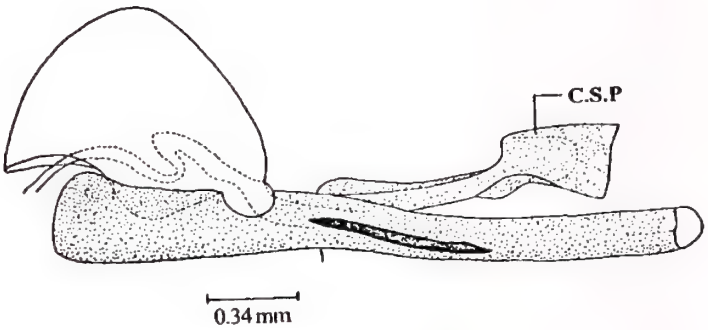

Venation of hindwing



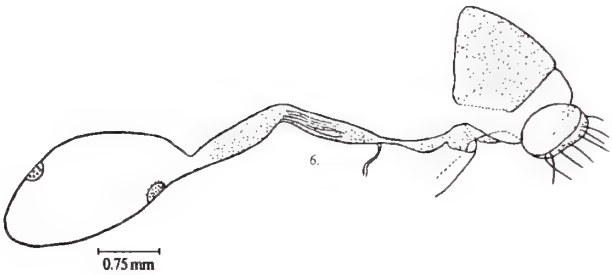

Male genitalia (lateral view)



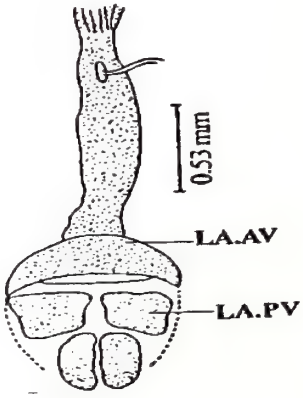

Left valva (inner view)



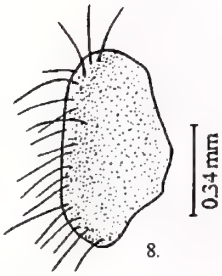

Aedeagus (lateral view)




Female genitalia (lateral view)




Genital plate




Papilla analis

Fig: *Zemeros flegyas indicus* Fruhstorfer

wing venation and maculation. The genitalia too have not been studied. Accordingly, both the male and female genitalia of this type-species are reported for the first time. About collection, inspite of repeated surveys, no specimen of this species could be collected from Mussoorie and adjoining areas which has otherwise been mentioned as a part of its range (Bingham, 1905; Evans, 1932; Peile, 1937; Wynter-Blyth, 1957; Shields, 1985; d'Abrera, 1986; Mani, 1986 and Smith, 1989).

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# An updated checklist of blowflies (Diptera: Calliphoridae) from India

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## Abstract

**An updated checklist of blowflies (Diptera: Calliphoridae) is provided herewith. This has been carried due to some recent shufflings, new records, new species and erroneous placement of taxa in earlier reported lists. Now, the family Calliphoridae is represented by 9 subfamilies, 30 genera and 119 species from India.**

**Keywords:** *Blowflies, Calliphoridae, Diptera, India.*

## Introduction

Since Senior-White's fauna of British India and Oriental Region (Diptera: Calliphoridae, Vol-VI) nothing much has been contributed on this family from India in terms of streamlining the taxonomy of this complicated group. Isolated inputs in the form of new species/records have appeared from national and international workers from time to time, but no data in term of number of species appeared since checklists by Nandi, 2004; Bharti, 2008 and Mitra and Sinha (published online). Unfortunately, the authors of online checklist have not consulted the literature pertaining to current status of various taxa, which have undergone shuffling in recent times thus leading to errors. Moreover, data needs to be updated due to recent shufflings/publications (Bharti and Kurahashi, 2009; Rognes, 2009 and Bharti and Kurahashi, 2010) and on the basis of recommendations by Rognes, 2010 (personal communication). For instance, as per Rognes, 2009 *Bengalia emarginatoides* is a new edition to India and Srilanka and *Bengalia pallidoxa* Seguy, 1946; *Bengalia chromatella* Seguy,1946 and *Bengalia bezzi* Senior White,1924 as junior synonyms of *Bengalia varicolor* (Fabricius,1805). Rognes, 2010 (personal communication) also amended the status of species belonging to genus *Bengalia* which were erected by Lehrer, 2005. These include *Bengalia krishna* Lehrer, 2005 (=*B. martinleakei*), *Bengalia evanfoneae* Lehrer, 2005 (=*B. jejuna)*, *Bengalia gandhiana* Lehrer, 2005 (=*B. martinleakei*), *Bengalia indipyga* Lehrer, 2005 (=*B.kanoi?)*.

In the wake of above mentioned discussion the updated list is as follows:

**Family: Calliphoridae**

**Subfamily: Ameniinae**

**Tribe: Catapicephalini**
**Genus: *Catapicephala* Macquart,1850**
*Catapicephala ingens* (Walker,1860)
*Catapicephala pattoni* Senior-White, Aubertin & Smart,1940
*Catapicephala micans* (Fabricius,1805)
*Catapicephala splendens* Macquart,1851

**Tribe: Ameniini**
**Genus: *Silbomyia* Macquart,1843**
*Silbomyia asiatica* Crosskey,1965
*Silbomyia parvula* Baranov,1938

**Subfamily: Helicoboscinae**

**Genus: *Gulmargia* Rognes,1992**
*Gulmargia angustisquama* Rognes,1993

**Subfamily: Calliphorinae**

**Tribe: Calliphorini**
**Genus: *Aldrichina* Townsend,1934**
*Aldrichina grahmni* (Aldrich,1930)

**Genus: *Calliphora* Robineau-Desvoidy,1830**
*Calliphora vicina* Robineau-Desvoidy,1830
*Calliphora pattoni* Aubertin,1931
*Callipora vomitoria* (Linneaus,1758)

*Calliphora loewi* Enderlein,1903

**Tribe: Phumosiini**
**Genus: *Phumosia* Robineau-Desvoidy,1830**
*Phumosia indica* (Surcouf,1914)
*Phumosia testacea* (Senior-White,1923)

**Subfamily: Bengaliinae**

**Tribe: Bengaliini**
**Genus: *Bengalia* Robineau-Desvoidy,1830**
*Bengalia emarginatoides*Rognes,2009
*Bengalia labiata* Robineau-Desvoidy,1830
*Bengalia hastativentris* Senior-White,1923
*Bengalia jejuna* (Fabricius,1787) (=*B. evanfoneae,* Lehrer, 2005)
*Bengalia jejuna* var.*quadrinotata* (Bigot,1887)
*Bengalia lateralis* Macquart,1843
*Bengalia martin-leakei* Senior-White,1930 (=*B. Krishna* Lehrer, 2005, *B. gandhiana* Lehrer, 2005)
*Bengalia escheri* Bezzi,1913
*Bengalia xanthopyga* Senior-White,1924
*Bengalia surcoufi* Senior-White,1923
*Bengalia varicolor* (Fabricius,1805) (= *B. bezzi* Senior-White,1923, *B. pallidicoxa* Seguy,1946, *B. chromatella* Seguy,1946) Rognes, 2009
*Bengalia torosa* (Wiedemann,1819)

**Subfamily: Melanomyinae**

**Genus: *Melinda* Robineau- Desvoidy, 1830**
*Melinda abdominalis* (Malloch,1931)
*Melinda bengalensis* Nandi,1994
*Melinda chambensis* Singh and Sidhu, 2007
*Melinda chandigarhensis* Singh and Sidhu, 2007
*Melinda pusilla* (Villeneuve,1927) (=*Pollenia townsendi* Senior-White, Aubertin & Smart,1940)
*Melinda pusilla indica* Kurahashi,1970
*Melinda scutellata* (Senior-White,1923)

**Subfamily: Luciliinae**

**Tribe: Luciliini**
**Genus: *Hemipyrellia* Townsend,1917**
*Hemipyrellia ligurriens* (Wiedemann,1830)
*Hemipyrellia pulchra* (Wiedemann,1830)

**Genus: *Hypopygiopsis* Townsend,1916**
*Hypopygiopsis infumata* (Bigot,1877)
*Hypopygiopsis tumrasvini* Kurahashi,1977

**Genus: *Lucilia* Robineau-Desvoidy,1830**
*Lucilia ampullacea* Villeneuve,1922
*Lucilia bazini* Seguy,1934
*Lucilia calviceps* Bezzi,1927 (**New record**, Bharti & Kurahashi, 2010)
*Lucilia cuprina* (Wiedemann,1830)
*Lucilia illustris* (Meigen,1826)
*Lucilia porphyrina* (Walker,1856)
*Lucilia papuensis* Macquart,1843
*Lucilia sericata* (Meigen,1826)

**Subfamily: Polleniinae**

**Tribe: Polleniini**
**Genus: *Pollenia* Robineau- Desvoidy,1830**
*Pollenia hazarae* (Senior-White,1923)
*Pollenia rudis* (Fabricius,1794)

**Tribe: Melanodexiini**
**Genus: *Morinia* Robineau-Desvoidy,1830**
*Morinia argenticincta* (Senior-White,1923)

**Genus: *Wilhelmina* Schmidtz & Villeneuve,1932**
*Wilhelmina indica* Sidhu & Singh, 2005

**Genus: *Polleniopsis* Townsend,1917**
*Polleniopsis asiatica* (Senior-White,1923) new comb. (Kurahashi,1972)
*Polleniopsis kashmirensis* Kurahashi & Okadome,1976
*Polleniopsis pilosa* (Townsend,1917)

**Genus: *Tainanina* Villeneuve,1926**
*Tainanina pilisquama* (Senior-White,1925)
*Tainanina sarcophagoides* (Malloch,1931)

**Genus: *Onesia* Robineau-Desvoidy,1830**
*Onesia khasiensis* (Senior-White,1922)

**Genus: *Dexopollenia* Townsend,1917**
*Dexopollenia flava* Aldrich,1930
*Dexopollenia testacea* (Townsend,1917)

**Subfamily: Chrysomyinae**

**Tribe: Chrysomyini**
**Genus: *Chrysomya* Robineau-Desvoidy,1830**
*Chrysomya albiceps* (Wiedemann,1819)
*Chrysomya bezziana* Villeneuve,1914
*Chrysomya defixa* (Walker, 1857)
*Chrysomya indica* Sinha and Nandi, 2004

*Chrysomya megacephala* (Fabricius,1794) (fdf/sdf, two forms in India, Bharti & Kurahashi, 2009)
*Chrysomya nigripes* Aubertin,1932
*Chrysomya pinguis* (Walker,1858)
*Chrysomya phaonis* (Seguy,1928)
*Chrysomya rufifacies* (Macquart,1843)
*Chrysomya villeneuvi* Patton,1922

**Subfamily: Rhiniinae**

**Tribe: Rhiniini**
**Genus: *Chlororhinia* Townsend,1917**
*Chlororhinia exempta* (Walker,1856)
*Chlororhinia tamenensis* Joseph & Rao,1972

**Genus: *Idiella* Braeuer & Berensteamn,1889**
*Idiella divisa* (Walker, 1861)
*Idiella euidielloides* Senior-White,1923
*Idiella mandarina* (Wiedemann,1830)
*Idiella tripartia* (Bigot,1874)

**Genus: *Idiellopsis* Townsend,1917**
*Idiellopsis xanthogaster* (Wiedemann,1820)

**Genus: *Rhinia* Robineau-Desvoidy,1830**
*Rhinia mallochi* (Senior-White, Aubertin & Smart,1940)
*Rhinia apicalis* (Wiedemann,1830)

**Genus: *Stomorhina*Rondani,1861**
*Stomorhina discolor* (Fabricius,1794)
*Stomorhina lunata* (Fabricius,1805)
*Stomorhina melastoma* (Wiedemann,1830)
*Stomorhina procula* (Walker,1849)
*Stomorhina simplex* (Walker,1857)
*Stomorhina townsendi* Kurahashi,1997
*Stomorhina unicolor* (Macquart,1851)
*Stomorhina xanthogaster* (Wiedemann,1820)

**Tribe: Cosminini**
**Genus: *Cosmina* Robineau-Desvoidy,1830**
*Cosmina bicolor* (Walker,1856)
*Cosmina limbipennis* (Macquart,1848)
*Cosmina prasina* (Brauer& Bergenstamm,1889)
*Cosmina viridis* Townsend,1917
*Cosmina simplex* (Walker,1858)

**Genus: *Thoracites* Brauer& Bergenstamm,1891**
*Thoracites abdominalis* (Fabricius,1805)

**Tribe: Isomyiini**
**Genus: *Isomyia* Walker,1860**
*Isomyia aurifacies* James,1970
*Isomyia delectans* Walker,1860
*Isomyia electa* Villeneuve,1927
*Isomyia fulvicornis*(Bigot,1887)
*Isomyia fuscocincta* Bigot,1877
*Isomyia gomezmenori* (Peris,1951)
*Isomyia nebulosa* (Townsend,1917)
*Isomyia nigrofasciata* (Peris,1951)
*Isomyia oestracea* (Seguy,1934)
*Isomyia perisi* James,1970
*Isomyia phryxea* Seguy,1949
*Isomyia pseudonepalana* (Senior-White, Aubertin & Smart,1940)
*Isomyia pseudoviridana* (Peris,1952)
*Isomyia sivah* (Bigot,1878)
*Isomyia versicolor* (Bigot,1877)
*Isomyia viridaurea*(Wiedemann,1819)
*Isomyia zeylanica* Senior-White, Aubertin & Smart,1940

**Genus: *Strongyloneura* Bigot,1886**
*Strongyloneura nudus* Ghezta and Kumar,1991
*Strongyloneura prolata* (Walker,1860)

**Tribe: Rhyncomyiini**
**Genus: *Borbororhinia* Townsend,1917**
*Borbororhinia bivittata* (Walker,1856)

**Genus: *Metallea* van der Wulp,1880**
*Metallea notata* van der Wulp,1880
*Metallea flavibasis* Senior-White,1922
*Metallea setosa* (Townsend,1917)

**Genus: *Rhyncomya* Robineau-Desvoidy,1830**
*Rhychomya callopis* Loew,1856
*Rhyncomya catalypsa* Seguy,1946
*Rhyncomya divisa* (Walker,1856)
*Rhyncomya flavipes* Robineau-Desvoidy,1830
*Rhyncomya pollinosa* (Townsend,1917)
*Rhyncomya sarotes* Seguy,1928
*Rhyncomya viridaurea* Wiedemann,1824

**Doubtful Species**
*Bengalia rivanella* Lehrer, 2005
*Bengalia shivanella* Lehrer, 2005

To sum up, family Calliphoridae is represented by 120 species from India, out of which 22 species are endemic to this region.

## Acknowledgements

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# SEM studies on immature stages of *Pheidole indica* Mayr, 1879 (Hymenoptera: Formicidae) from India

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## Abstract

**The present work gains significance in the light of use of certain larval characters to species level taxonomy and systematics in various ant genera. Due to widespread distribution of some ant taxa it becomes mandatory to elucidate any interspecific and geographic variations. Keeping in view, the significance of immature stages in ant taxonomy, SEM studies on immature stages of *Phediole indica* Mayr, has been carried out to provide an insight into minute morphological details.**

**Keywords:** *SEM, Immature stages, Pheidole indica, India.*

## Introduction

With more than 12,000 species known, ants have emerged as a major insect group in terms of their significance in ecology, biology, natural history and evolution. With such diversity, immature stages of only few ant species have been described. The significant contributions have been by Wheeler and Wheeler (1976, 1986), who synthesized their previous works on immature stages covering about more than 700 ant species. Thus they paved the way for usage of larval characters in discriminating allied species. But unfortunately their work was not based or targeted at a particular species or species complexes; rather they provided a holistic view of immature morphology of various subfamilies of ants. Recent advances have been by Fox *et.al.* (2007) who carried SEM on larvae of *Paratraechina longicornis* and provided significant characterization of immatures.

As evident from previous works, the larvae of myrmicinae are so heterogenous that no characterization can be given for the subfamily as a whole. Genus *Pheidole* with more than 1,000 species worldwide considered hyper diverse has been poorly studied in terms of immature stages. However, some contributions have been made by Wheeler and Wheeler on subfamily Myrmicinae (1960a and b, 1980, 1989a,b and c, and 1991). As far as genus *Pheidole* is concerned Diana Wheeler (Personal communication) and Passera (1974) has worked on *Pheidole vinelandica* and *Pheidole pallidula*.

Keeping in view, the significance of immature stages in ant taxonomy, SEM studies on immature stages of *Pheidole indica* Mayr (distributed widely in countries like India, Japan and China) have been carried to provide an insight into minute morphological details, which could be used in future interspecific diagnosis.

## Materials and Methods

The colonies of *Pheidole indica* Mayr were collected from Shivalik range of North-West Himalaya. The immatures were fixed in Dietrich's solution for 24-48 hrs and preserved in 80% alcohol. The larvae were separated into three instars according to their maximum head capsule widths. Measurements were made with compound microscope equipped with an ocular micrometer. After separation, larvae (N=10) from each instar were prepared for scanning electronic microscopy analysis with following steps;

a) Samples were post-fixed in 1% osmium tetraoxide, after which they were dehydrated in a graded acetone series.

b) Then the specimens were vacuum dried in desiccator.

c) Specimens adhered to the double-face-adhesive carbon tape were coated with gold in a gold ion sputter coater (HITACHI-E-1010).

d) Samples were analyzed under a HITACHI-S-3400N Scanning microscope.

For larval description, the terminology given in Wheeler and Wheeler (1976) and Fox *et al.* (2007) was followed.

Body hairs were measured at full length and body length as straight length. Measurements of the head capsule, mouthparts, hairs etc. were taken of one individual per instar on which the descriptions were based.

## Results and Discussion

During present study based on SEM, three larval instars have been recognized in case of *Pheidole indica*, which are discussed here in detail.

### First larval instar

**Body-**Whitish, Pheidoloid in shape due to the presence of short, stout and straight abdomen. Head ventral near anterior end, mounted on short stout neck, which is the prothorax (Fig. 1a). Hairs present on the entire body surface, but more abundant on the dorsal side than on the ventral side. Two types of hairs present on the body, anchor tipped hairs, measuring about 159 µm in length present mostly on the dorsal side of the body; and deeply bifid hairs, tips curling in opposite directions measuring about 49.07 µm in length; (Fig. 1c, 1d). Body length-1310µm (Fig. 1b).

**Head capsule-** Cranium 205 µm high x 222 µm wide; roughly sub-circular (Fig. 1e). Head surface smooth, two types of hairs present on the head which were distributed symmetrically; slightly curved or straight hairs, about 37.6 µm long; deeply bifid hairs about 40.1 µm long (Fig. 1e, 1f, 1g).

**Mouthparts-**Clypeus clearly delimited from the cranium, about 76.7 µm long, upper surface of clypeus smooth with two types of hairs; simple hairs about 27.1 µm long and tip bifid hairs about 26.2µm long (Fig. 1e, 1h). Labrum bilobed, 59.9 µm wide (Fig. 1g, 1h). Mandibles subtriangular pheidoloid in shape; with three subapical teeth, not all in the same plane; apex curved medially to form a tooth, about 87.7 µm long x 18.5 µm wide (Fig. 1g). The rounded fleshy maxillae protrude ventrolaterally from each side of the head. Maxilla paraboloidal in shape. The only sharply defined parts of the maxilla are the palp and galea, which are on the stipes. Galea about 23.8 µm long is longer than maxillary palp about 20.6 µm long x 13.6 um wide (Fig. 1i).

### Second larval instar

**Body-** Change in the body shape has been observed in the second instar i.e shape found to be Attoid (stout and more curved; diameter approximately equal to the distance from labium to anus (Fig. 2a, 2b); anus clearly subterminal in position with lower lip bigger than the upper lip about 116 µm in diameter (Fig. 2a, 2c, 2d). Body hairs denser over the dorsal side of the body and of one type only i.e. bifid hairs about 58.55 µm in length (Fig. 2b, 2e). Body length-2100 µm (Fig. 2b).

**Head capsule-** Cranium 232 µm high x 262 µm wide. Hairs on the cranium are of two types, a distinct row of 4-5 simple slightly curved or straight hairs line the distal cranial border, and hairs bifid at the tip, about 43.7 µm long (Fig. 2f).

**Mouthparts-** Clypeus clearly delimited from the cranium, 79.3 µm long (Fig. 2f). Labrum bilobed 76.4 µm wide. Mandibles Pheidoloid in shape with two visible teeth, and measure about 81.3 µm long x 25.2 µm wide. Protuberances on the mandibles clearly visible (Fig. 2g). Maxilla paraboloidal in shape. Galea 24.1 µm long x 12.9 µm wide. Maxillary palpus 25.7 µm long x 16.1 µm wide (Fig. 2g).

### Third larval instar

**Body-** Body profile same as in the second larval instar i.e attoid (Fig. 3a). Anus subterminal in position about 268 µm in diameter (Fig. 3b). Body hairs of three types; long bifid hairs about 47.17 µm long on the dorsolateral side; short bifid hairs about 13.3 µm long on the ventral side; tip denticulate hairs about 133 µm long (Fig. 3c, 3d). Body length-3020 µm.

**Head capsule-** Cranium 312 µm high x 236 µm wide (Fig. 3e). Hairs on the head are of two types (1) simple, slightly curved or straight hairs about 42.7 µm long; (2) bifid hairs about 27.75 µm long (Fig. 3e).

**Mouthparts-** Clypeus 84.3 µm long clearly delimited from the cranium; A distinct row of two simple slightly curved or straight hairs about 16.8 µm long lining the distal clypeal border (Fig. 3f, 3g). Labrum markedly bilobed 98.8 µm wide (Fig. 3f). Mandibles 70.5 µm long (Fig. 3h). Maxillae paraboloidal in shape. Galea 29 µm long x 10.9 µm wide. Maxillary palp 28.1 µm long x 14.7 µm wide (Fig. 3h).

The present study confirms the general aspects originally observed by Wheeler and Wheeler (1976, 1986) in case of genus *Pheidole* but some significant differences have been observed. First, variation in the type of hair especially over the head capsule between different larval stages has been observed (Fig. 1d, 1e, 2f, 3e). This variation was not noticed by Wheeler and Wheeler (1976), because their work was based on a single mature worker larva only. Hair type is one of the characters considered in calculating the "specialization indices" proposed by Wheeler and Wheeler (1986). Furthermore, the presence of bifurcations in the head hairs has been recently proposed as a character of considerable importance for separating species in the genus *Solenopsis* Westwood (Pitts *et al.*, 2005).

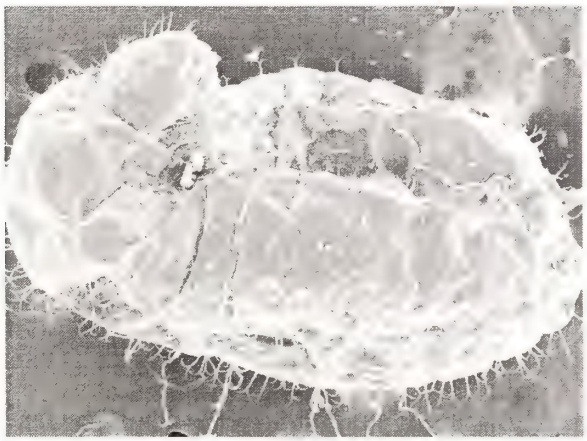

Fig.1a

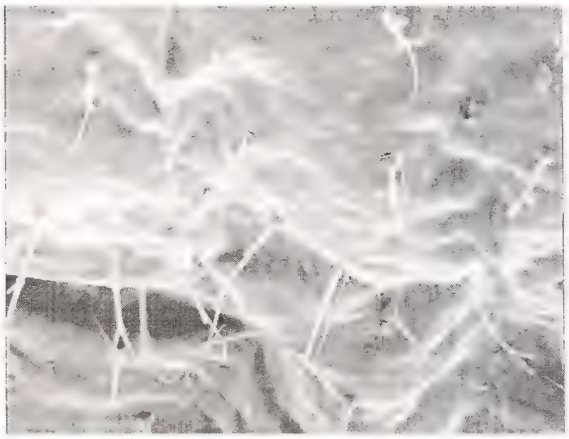

Fig.1d

Fig.1b

Fig.1e

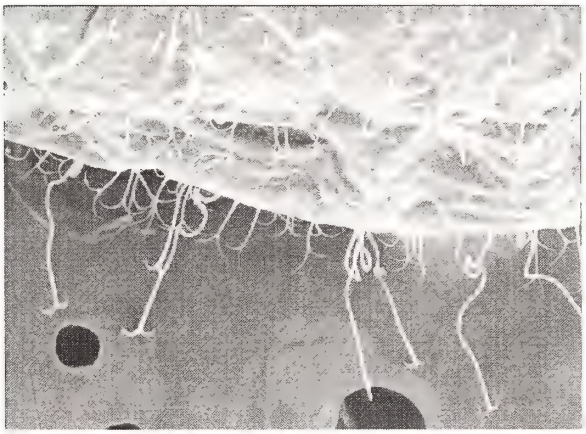

Fig.1c

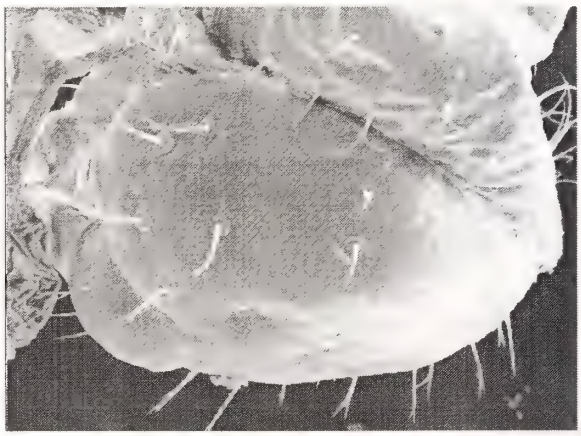

Fig.1f

Fig.1g

Fig.2a

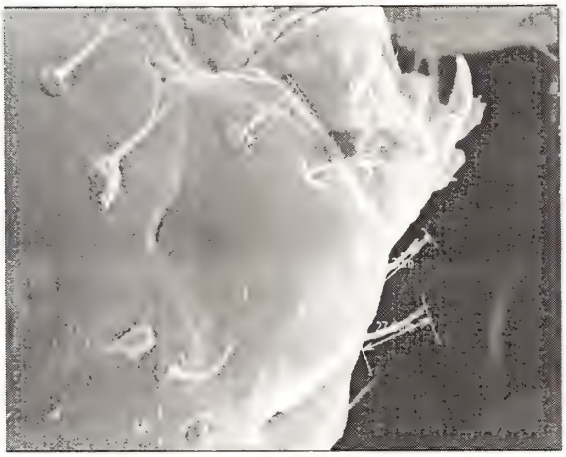

Fig.1h

Fig.2b

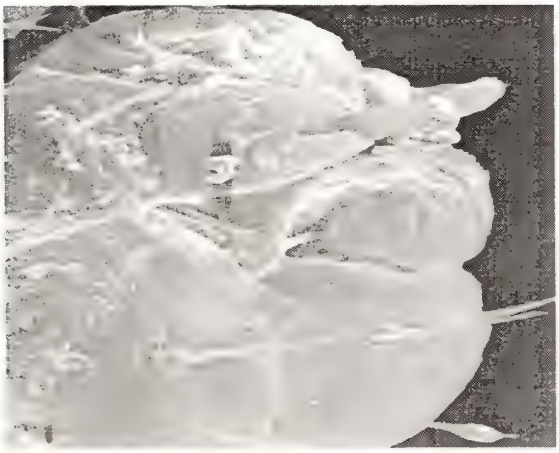

Fig.1i

Fig.2c

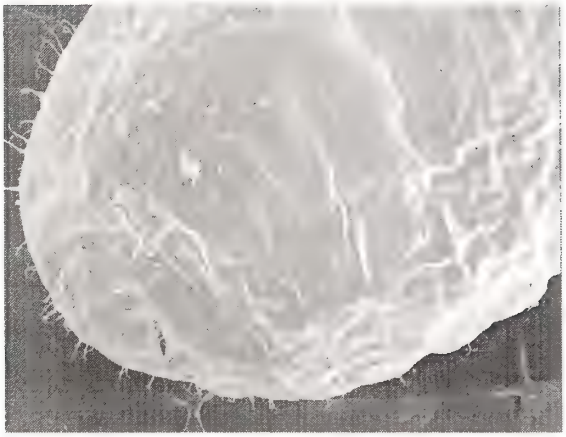

Fig.2d

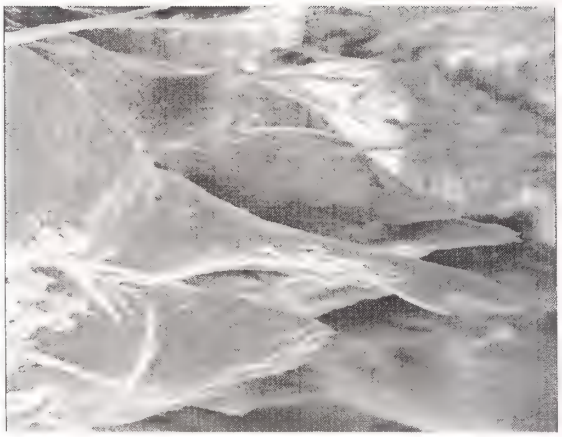

Fig.2g

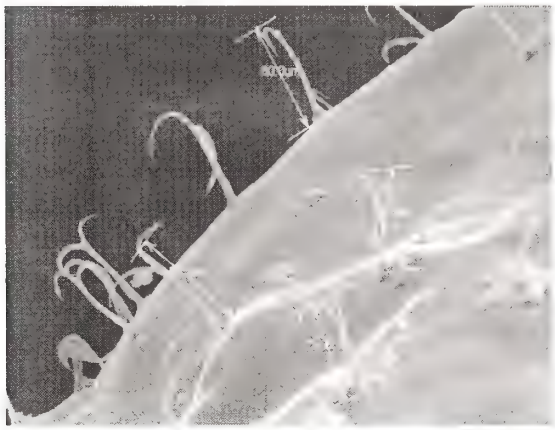

Fig.2e

Fig.3a

Fig.2f

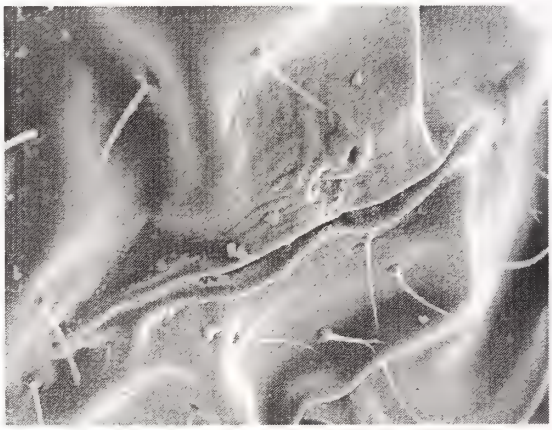

Fig.3b

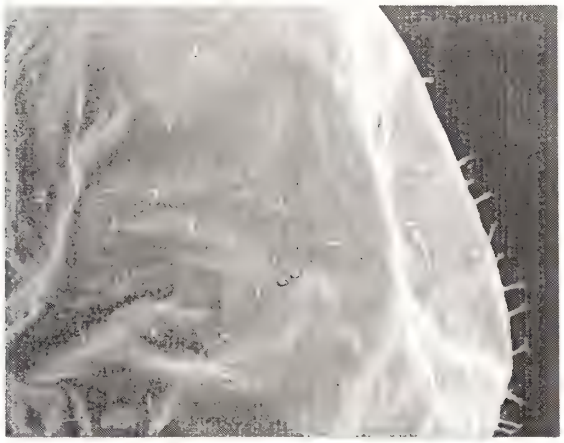

Fig.3c

Fig.3f

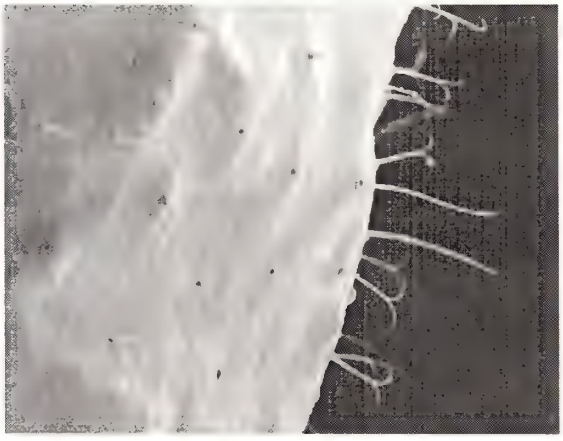

Fig.3d

Fig.3g

Fig.3e

Fig.3h

Fox *et al.* (2007) pointed out that intraspecific variation in types of head hairs might occur in other ant species as well. Therefore, Fox *et al.* (2007) and the results of the present study clearly suggest the revision of previously described ant larvae in the light of present work. Two types of hairs has been observed on the cranium. Clear variation in the head capsule width between the three instars has been observed. It is noticed that the head capsule width considerably increases as the larvae matures. Clear variation in the distribution and as well as type of body hairs has been observed in the three instars. Two types of body hairs have been observed (anchor tipped hairs and deeply bifid hairs) in case of first instar. Anchor tipped hairs have been observed only on the dorsal surface of first instar (Fig. 1b, 1c). In the second larval instar only one type of hair are present i.e deeply bifid hairs (Fig 2e). In case of the third larval instar three types of hairs are present; long bifid hairs, short bifid hairs and tip denticulate hairs (Fig. 3c, 3d).

A clear variation in the body shape has been observed among the three larval instars. First, larva was found to be of pheidoloid in shape (Fig. 1a) as compared to the attoid type of body shape found in second and third larval instar (Fig. 2a, 2b and 3a). Body length of first, second and third instars is found to be 1310 µm, 2100 µm, 3020 µm respectively (Fig. 1b, 2b and 3a). Position of anus was sub-terminal in case of second and third larval instar with diameter 116 µm and 268 µm respectively (Fig. 2c and 3b).

Size of the cranium of first, second and third instars was 205 µm high x 222 µm wide, 232 µm high x 262 µm wide and 312 µm high x 236 µm wide respectively (Fig. 1e, 2f and 3e). Clypeus is found to be clearly delimited from the cranium in all the three instars and is 76.7 µm long, 79.3 µm long and 84.3 µm long in first, second and third instars respectively (Fig. 1e, 2f and 3e).

Labrum has been markedly bilobed and is 59.9 µm wide in first instar, 76.4 µm wide in second instar and 98.8 µm wide in third instar respectively (Fig. 1g, 2f and 3e). Mandibles subtriangular, pheidoloid in shape with two to three subapical teeth, apex curved medially to form a tooth (87.7 µm long x 18.5 µm wide) in case of first instar (Fig. 1e), whereas in case of second instar the number reduces to two and in third instar single apical tooth has been present (Fig. 2f).

Maxillae found to be paraboloidal in shape in all the three instars. Maxillary palps and galeae of all the three instars have been found to be very distinct. (Fig. 1i, 2g and 3h).

To conclude, further details to the description of the larvae of *Pheidole indica* have been added, which would help in future inferences in ant systematics and phylogeny.

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# Influence of *Varroa* parasitization on some biomolecules in *Apis mellifera* L. worker brood

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## Abstract

**The present study includes investigation on biochemical parameters i.e. total protein, glucose, glycogen and cholesterol content in *Varroa* infested and non infested worker brood of *Apis mellifera* L. *A.mellifera* worker pupa (brown eyed stage) was taken from the colonies maintained by Department of Zoology, Panjab University, Chandigarh. *Varroa* infested worker pupae of *A.mellifera* showed a decline in glucose and glycogen content as compared to the uninfested control. This is suggestive of greater utilization of body energy reserves as a result of parasitic stress. Fall in the level of cholesterol in the infested pupae observed during the present study was probably due to its incidental intake alongwith proteins while feeding on the haemolymph.**

**Keywords:** *Varroa, Apis mellifera*, protein, glucose, glycogen, cholesterol.

## Introduction

A honey bee colony is vulnerable to predator and parasite attack because it provides rich and concentrated food sources in the form of brood, wax, honey and pollen. Therefore honey bee colonies often fall prey to various enemies including large hairy mammals like bear, badger, martens and tiny parasites including protozoans and mites The mite, *Varroa destructor* (Anderson and Trueman, 2000) is a major pest of honey bees in most parts of the world. This external parasite feeds on haemolymph (blood) of adult bees, larvae and pupae. Heavy parasitism results in high bee mortality and subsequent weakening of the colony which leads to colony death. The mite was originally found parasitizing the Indian honey bee, *Apis cerana* (Oudemans, 1904), but with time the mite extended its host range to *A. mellifera*. On *A. mellifera* it parasitizes worker brood as well as drone brood and thus has become a serious mortality factor. Honey bee parastization by *Varroa* is capable of illiciting biological, behavioural, morphological and physiological pathogenesis. The present investigation was conducted to understand physiological interference due to mite infestation through biochemical assays.

## Materials and Methods

**Study Area and Material**: A random sample of *Varroa destructor* infested (harbouring two mites) and non infested worker pupae (brown eye stage) of *A. mellifera* were drawn from the infested and healthy colonies maintained by Department of Zoology, Panjab University, Chandigarh.

**Sample preparation**: Each pupa was taken in 1 ml of saline and electrically homogenized. The homogenate was used for further experiments.

**Biochemical estimation**: The quantitative estimation of total protein, glucose, glycogen and cholesterol was done following standard methods (Sawhney and Singh, 2000). OD's were taken on colorimeter. Each estimation was repeated three times with three replicates per estimation.

## Results

The consequences of parasitisation by *Varroa* on biochemical parameters in infested worker brood of the European honey bee *A. mellifera* were examined and compared with healthy worker brood. Results are presented Table1.

## Discussion

*Varroa* mother mite produces wounds on the host cuticle with its saw toothed chelicerae during feeding (Martin, 1997). The development of the infested worker

**Table-1: Protein, Carbohydrate and Lipid content of non-infested and *Varroa* infested *Apis mellifera* L. worker pupa.**

| S.No. | Biomolecules | Non- Infested (mg/ml) Mean ± S.D. | Infested (mg/ml) Mean ± S.D. |
|---|---|---|---|
| 1. | Protein | 0.279±0.002 | 0.194±0.001 |
| 2. | Glucose | 0.411±0.003 | 0.399±0.003 |
| 3. | Glycogen | 0.027±0.002 | 0.010±0.002 |
| 4. | Cholesterol | 0.122±0.003 | 0.049±0.005 |

brood is impaired leading to the formation of malformed adults. The infested adult worker bees have been reported to exhibit reduction in haemolymph volume (Weinberg and Madel, 1985). Bowen-Walker and Gunn (2001) studied the biochemical effects of *Varroa* parasitisation on adult worker *A. mellifera*. According to them, wet weight, dry weight and water contents of emerging worker infested with the mite were all negatively correlated with increasing numbers of mites. Parasitized bees also emerged with lower head and abdomen concentration of proteins. Sugars are known to be important energy source, small amounts of glycogen, glucose, fructose and trehalose serve as essential energy material in foragers (Leta *et al.*, 1996; Panzenbock and Crailshein, 1997; Blatt and Roces, 2001, 2002; Woodring *et al.*, 2003). Decline in carbohydrates content during the present studies is suggestive of greater utilization of body energy reserves as a results parasitic stress.

Lipid levels in *Varroa* infested adult worker were studied by Bowen-Walker and Gunn (2001). However they did not observe any detectable change in the levels of this molecule because lipid levels are naturally extremely low in adult bees at emergence as compared to brood (20-30%) (Hepburn *et al.*, 1979). Reduced cholesterol content observed during the present study can be explained on the basis of the fact that selective uptake of haemolymph devoid of fats is not possible. Hence some amount of cholesterol is also lost due to feeding on the larva. It can therefore safely be concluded that parasitisation by *Varroa* on worker brood causes significant losses of metabolic reserves leading to weakened individuals often unable to open the caps to emerge as also observed by Boecking and Drescher (1992).

## Acknowledgements

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# Weaver ant (*Oecophylla smaragdina*), huntsman spider (*Heteropoda venatoria*) and house gecko (*Hemidactylus frenatus*) as potential biocontrol agents of the nuisance pest, *Luprops tristis*

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## Abstract

**Massive seasonal invasion of huge aggregations of rubber litter beetle, *Luprops tristis*, into residential buildings prior to the onset of monsoon rains, and their prolonged stay in a state of dormancy for 8-9 months, is a regular event in rubber plantation tracts. Odoriferous defensive gland secretions released by the beetles are suggested as repelling the potential natural enemies of *Luprops* and a key reason for their unabated massive population build up. In the present study the influence of defensive glands of *Luprops* in determining the feeding preference of the huntsman spider (*Heteropoda venatoria*), weaver ant (*Oecophylla smaragdina*) and house gecko (*Hemidactylus frenatus*) on *Luprops* and the feeding preference of the predators are tested. Results revealed that the tested predators fall under two categories with one group (house geckos and spiders) deterred by the presence of defensive gland and the other group (weaver ants) not deterred by the gland. Higher consumption of *Luprops* by weaver ants establishes that among the three predators tested, weaver ants is the most efficient predator of the *Luprops* and has potential in the biocontrol of *Luprops* in rubber plantations.**

**Keywords:** *Rubber litter beetle, Mupli, Biocontrol, Natural enemies.*

## Introduction

Massive seasonal invasion of huge aggregations of *Luprops tristis* (Fabricius, 1801), into residential buildings prior to the onset of monsoon rains, and their prolonged stay in dormancy for 8-9 months, is a regular event in rubber plantation tracts in South India. Their high abundance in the range of 0.5 to over 4 million per residential building, illustrates the regional importance of *L. tristis* as a nuisance species. Clusters of several hundred to thousands attracted to light crawl inside the living rooms and fall off into beds and food from ceilings making them the most dreaded beetles to farming communities in rubber plantation belts. They do not sting or bite, but when disturbed, they release an irritating odoriferous secretion that burns the skin (Sabu *et al.*, 2008; Sabu and Vinod, 2009 ). Since the invasion and the nocturnal activities of the beetle takes place during rainy season and lasts for weeks, affected people are left with little choice but to kill the invaded beetles by indoor spraying of insecticides in living rooms. There is no data on the magnitude of environmental pollution it causes or the health impairment arising from the indoor application of insecticides. Despite three decades of their widespread presence in the region, no efficient strategies for controlling the population build up of *L. tristis* have been developed and there is a critical need to develop environmentally benign control tactics. Identification of natural enemies and their introduction would be a right step in this direction. Search for the natural predators in rubber plantations and residential buildings revealed that huntsman spider (*Heteropoda venatoria*), weaver ant (*Oecophylla smaragdina*) and house gecko (*Hemidactylus frenatus*) occasionally prey upon these beetles. Odoriferous defensive gland secretions released by the beetles are suggested as repelling the predators and could be a key reason for their unabated massive population build up (Abitha *et al.*, 2010). Nevertheless, there have been no empirical observations to confirm that defensive glands deter the natural predators. In the present study, feeding preference of the huntsman spider (*Heteropoda venatoria*), weaver ant (*Oecophylla smaragdina*) and house gecko

(*Hemidactylus frenatus*) on *Luprops* and the influence of defensive glands in determining the feeding preference of the natural predators were evaluated. It is hypothesized that when offered a choice of normal beetles and gland removed beetles (hereafter referred as glandless beetles), predators will show feeding preferences towards glandless beetles.

## Materials and Methods

The present investigation was carried out during March, 2009 to May, 2010. The laboratory experiments were conducted at the Dept. of Zoology, Devagiri College campus, Calicut and the studies in residential buildings were conducted in a residential building located at East Hill, Calicut.

Beetles (*Luprops tristis*) were collected from a rubber plantation in the Devagiri college campus by sifting rubber litter. Defensive glands of the beetles were removed by holding the beetles between left thumb and index finger and placing on the stage of stereo zoom microscope with ventral surface of the insect facing up (Vinod *et al.*, 2009). When pressed with modest pressure, the glands were extruded and the extruded glands were cut off using a pair of fine scissor or forceps. The glandless beetles were washed in distilled water and in 10% alcohol to remove the defensive gland secretions and the beetles were blotted dry and transferred to insect cages.

Ten huntsman spiders (*Heteropoda venatoria*) of similar size and undetermined age and sex, were collected live from a residential building with sweep net and were confined to individual cylindrical plastic container (8.5 cm diameter and 15 cm height) topped with mesh net and were starved for seven days. Damp cotton ball was placed in a small dish in the container as source of water. Feeding preferences of spiders were analysed by releasing ten glandless beetles into five cylindrical plastic containers and ten normal beetles into the remaining five cylindrical plastic containers for a 12 hour period starting from 18 hours to 6 hours. After the 12 hour exposure, unfed beetles were collected and numbers were recorded. Spiders were kept unfed for seven days and the same experiment was repeated. Each plastic container comprised one replicate and total of 10 replicates each for glandless and normal beetle was available for data analysis.

Attempts to analyze the feeding preferences of weaver ants (*Oecophylla smaragdina*) and house gecko (*Hemidactylus frenatus*) by rearing in laboratory set up failed as both the predators did not attempt to feed upon the offered prey. Hence, the feeding preference was analysed by placing beetles close to their foraging area in a residential building. Individual beetles tied to 30 cms long cotton thread and with the free end of the thread glued to the wall of the residential building were placed close to wall mounted lamp shades selected as hiding place by house gecko in residential buildings for a 12 hour period starting from 18 hours to 6 hours. Similarly, beetles tied to a cotton thread were placed on the branches of a mango tree with nesting colonies of weaver ants for a 12 hour period starting from 6 hours to18 hours. To prevent the possibility of wall lizards feeding on other light attracted insects and entry of other arthropod pests in to the room, windows and ventilators of the room were covered with five mm nylon nets and also by manually clearing the room free of common house hold arthropod pests ten days prior to the initiation of the study. Experiments with house gecko were done using five house geckos spotted in the building and each trial was repeated at five days intervals. During each feeding trial, a set of five beetles (normal and glandless beetles separately) were made available to each predator for a 12 hour period and the number of fed and unfed beetles were recorded.

Distribution of data sets was analysed with Jarquebera test (Weiss, 2007). Predation on different prey items (beetles with gland and without gland for each type of predators (huntsman spider, house gecko and weaver ants) was analyzed as a one-way ANOVA on numbers of prey eaten. Variation in the quantity of prey items consumed by each predator was analysed with one-way ANOVA followed by Tukey-kramer test. All statistical data analyses were performed with MegaStat Version 10.0 (Orris 2005).

## Results

Preference of weaver ants, house gecko and huntsman spiders towards normal and glandless beetles: House gecko consumed 3.7 ± 0.95 glandless beetles and 2.6 ± 0.70 beetles with gland, and huntsman spiders consumed 0.9 ± 0.74 glandless beetles and 0.3 ± 0.48 beetles with gland during the 12 hour study period (Fig. 1). Significant variation was recorded in the feeding preference with spider and gecko preferring beetles without glands than those with glands ($p \leq 0.05$). Weaver ants consumed 4.9 ± 0.32 glandless beetles and 4.8 ± 0.42 beetles with gland during the 12 hour study period. No significant variation was recorded in the feeding preference of weaver ants towards beetles with and without defensive glands ($p \geq 0.05$).

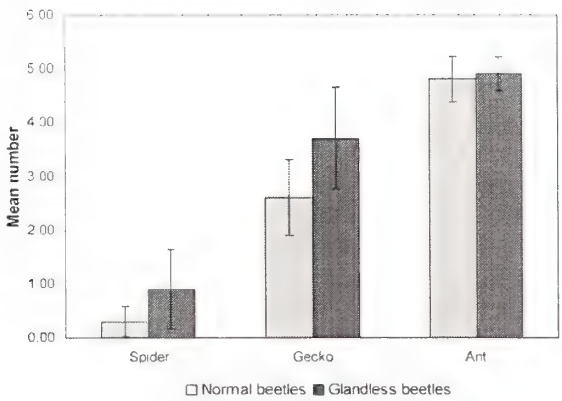


Fig. 1: Bar diagram of the feeding preference of spiders (*Heteropoda venatoria*), weaver ants (*Oecophylla smaragdina*) and wall lizard (*Hemidactylus frenatus*) on *Luprops tristis* with and without defensive glands.

Significant variation in the number of beetles fed by huntsman spider, house gecko and weaver ants was distinct. Pair wise analysis of the feeding preference (spider/gecko; spider/weaver ant; gecko/weaver ant) revealed that among the three predators, weaver ants consumed the highest (4.8 ± 0.42) and spiders consumed the lowest number (0.3 ± 0.48) of beetles during the 12 hour study period ($p \leq 0.05$). Feeding preference of gecko (2.6 ± 0.70) was intermediate between weaver ants and spiders.

## Discussion

Higher consumption rate by weaver ants and the non-deterrence by the glands establish clearly that among the three predators tested weaver ants are the most efficient predator of *Luprops* and hence likely to be the most potential biological control agent of *Luprops*. High variation in the quantity of beetles consumed between ants and other predators must be influenced by involvement of many individuals as weaver ants are social insects. Since, among the three predators ants are social insects and the others are solitary feeders, estimating the feeding preference of ants with a single individual was not possible and we took into consideration the number of beetles consumed by a spider, a gecko and the colony of ants during a fixed time duration. Recent research has demonstrated the effectiveness of weaver ants in controlling several pests in mango orchards (Peng and Christian, 2004, 2005, 2006 and 2007), cashew plantations (Peng *et al.*,1999 and 2005), citrus and sapodilla orchards (Van Mele and Cuc, 2000; Van Mele *et al.*, 2002; Van Mele and Chien, 2004), coconut plantations (Kumaresan, 1996) and cocoa plantations (Way and Khoo, 1989). Although generally regarded as beneficial, the economic value of using weaver ants have been tested with rigorous scientific methods, even then weaver ants are still often regarded as a nuisance pest during harvesting of crops (Sinzogan *et al.*, 2008). Hence, the proposal of introducing weaver ants as a natural enemy is less likely to be welcomed by the planters and rubber tappers in the rubber belts, as their bites and uncontrollable aggressiveness may make rubber tapping a difficult task. We propose that, since rubber tappers do not have to reach the canopy and disturb the nests in rubber plantations and tapping and latex collection is done in the early morning hours when weaver ants are less active, weaver ants may not be a serious threat to rubber tappers. Further disturbance to the tappers from ants can be solved by the use of ash as a deterrent as done in Australian mango and Chinese citrus orchards. Hence, in view of the absence of no other control measures, absence of natural enemies and the alarming rate of population build up of *Luprops* in the rubber belts, reluctance to deploy weaver ants in biological control should be overlooked. Since rubber trees are not widely selected as host plant by weaver ants and ants nest generally on the tree tops the introduction of canopy dwelling ants to the litter floor of the rubber plantations requires introduction of short statured varieties of the preferred host plants of weaver ants that can grow under the shades of rubber plantations and introduction of colonies of ants by bringing ant's queen as practiced in other parts of the world is suggested.

The tested predators fall under two categories with one group deterred by the presence of defensive gland and the other group with not deterred by the glands. Results show that, the defensive gland secretions deters and apparently functions as a protection against house geckos and spiders but not against weaver ants. Absence of variation in the quantity of glanded and glandless beetles fed by weaver ants and the observed biting of weaver ants on the vicinity of defensive glands indicate that defensive gland secretions have no deterring effect on ants. It is likely that the weaver ants themselves who produces a vast array of pheromones (Crozier *et al.*, 2009; Dejean *et al.*, 2005; Beugnon and Dejean, 1992) are insensitive to the gland secretions of *Luprops*. Inactivity and the peculiar behaviour of holding on to objects shown by *Luprops* in response to the arrival of ants, we consider as a defensive action. We propose that since weaver ants produce some of the most persistent ant pheromones and mark their entire

territories and trails with pheromones (Dejean *et al.*, 2005; Beugnon and Dejean, 1992; Dejean and Beugnon, 1991), and these pheromones warn all organisms with a fitness related to the presence of weaver ants (The pheromone avoidance hypothesis, Offenberg, 2007; Offenberg *et al.*, 2004), *Luprops* beetles must be taking a defensive posture in response to the trail pheromones left by the ants in its territory where the experimental animals have been placed.

## Conclusions

i). Defensive gland secretions of *Luprops* deterred house gecko (*Hemidactylus frenatus*) and spider (*Heteropoda venatoria*) and not deterred the weaver ants (*Oecophylla smaragdina)*.

ii). In an applied biological control context, weaver ants (*Oecophylla smaragdina)* are most likely to be an effective biocontrol against *Luprops* present in rubber plantations.

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# Revised phylogenetic analysis of Indian species of genus *Macrophya* Dahlbom (Hymenoptera: Symphyta; Tenthredinidae: Tenthredininae)

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## Abstract

**Revised phylogenetic analysis was performed for 14 species of the genus *Macrophya* (Hymenoptera: Tenthredinidae) using the phylogenetic analysis package PAUP, based on 15 of the morphological characters most commonly used for *Macrophya* species identification. Species descriptions were derived primarily from "Indian Sawflies Biodiversity" vol. II Saini (2007), Saini and Bharti (1996), Saini *et al.* (1996), and Saini and Vasu (1997). The results are discussed in terms of evolutionary trends or biological maxim that "nature prefer to modify the already existing structures so as to cope with new needs."**

**Keywords:** *Phylogenetic analysis, Macrophya, Evolutionary trends.*

## Introduction

The genus *Macrophya* (Hymenoptera: Tenthredinidae) is widely distributed genus with its representatives available in almost all main regions of the globe. With regard to its affinities, it shares most of its characters with *Pachyprotasis* Hartig. Even within *Macrophya* the range of characters is so wide that time to time many of its subgenera were proposed (Malaise, 1945) and because of no distinct boundaries they all got merged (Ross, 1937; Gibson, 1980). Today none of its subgenus is considered to be valid (Abe and Smith,1991). The genus *Macrophya* was first described by Dahlbom (1835) as a subgenus of *Tenthredo* Linnaeus, on the basis of body shape, length and form of antenna. He divided this subgenus into two subsections "A" and "B". Hartig (1837) applied names to these two subsections using *T. (Macrophya)* for subsection "B" and *T.(M.) (Pachyprotasis)* for subsection "A". Both of these were later recognised as valid genera by Westwood (1840).

The genus is characterized by venation as in *Pachyprotasis,* but the anal cell may have a cross vein. Malar space mostly shorter than the diameter of an ocellus. The hind legs are strongly built, and the knees reaching and mostly exceeding the apex of the abdomen (Saini, 2007). The larval stages feed on variety of wild herbs, shrubs and trees. Generally adults feed on pollens, flower nectar or leaf juice exuding from wounds caused by strong mandibles. However, many robust species indulge in zoophagy (Cameron,1882; Rohwer,1913; Benson,1938; Malaise,1945; Naito,1988 and Goulet,1996).

The purpose of present study is to trace the long evolutionary history which modified generalizations into specializations of extreme form to suit the circumstances in which subsequently insects dwelled. Parsimony analysis is used to investigate phylogenetic relationships among *Macrophya* species, using data based on morphological characters most commonly used for *Macrophya* identification. With the help of literature contributed by Saini *et al.* (1996) and Saini and Vasu (1997) some different characters were used to trace phylogeny of genus *Macrophya*.

## Materials and Methods

Species descriptions were derived primarily from "Indian Sawflies Biodiversity" vol. II Saini (2007), Saini and Bharti (1996), Saini *et al.* (1996), and Saini and Vasu (1997) and the characters used in the analysis were those given comparably for all, or almost all, species. *Tenthredo rufipodus* Saini and Bharti, 1996 was also included in the analysis as the outgroup. Revised phylogenetic analysis was carried with a computer program PAUP version 4.0, with more characters as compared to earlier study (Saini and Kaur, 2010), has been used to infer the phylogeny (Swofford, 2000). In total 15 morphological characters were used in the phylogenetic analysis. These were:

**1.Forewing:** (0-without infuscated band, 1-with infuscated band)

**2.Body colour:** (0-not metallic blue, 1-metallic blue)

**3.Clypeus:** (0-not triangularly incised up to 1/4 of its length, 1- triangularly incised up to 1/4 of its length)
**4. Frontal area:** (0-not below level of eyes, 1-below level of eyes)
**5. Average length of body of female:** (0-10 mm, 1-above 10mm, 2-below 10mm)
**6. Subapical teeth of tarsal claw:** (0-smaller than apical teeth, 1-longer or equal to apical teeth)
**7. Labrum:** (0-with rounded anterior margin, 1-with truncate or subtruncate anterior margin, 2-with slightly emarginate anterior margin)
**8. Median fovea:** (0-absent, 1-distinct, 2-indistinct)
**9. Supraantennal tubercles:** (0-insignificant, indistinct or not raised, 1-raised or significant)
**10. Circumocellar furrow:** (0-fine or clear, 1-distinct, 2-indistinct, 3-sharp)
**11. Postocellar area:** (0-flat, 1-subconvex, 2-slightly raised, 3-fine )
**12. Mesoscutellum:** (0-slightly or roundly raised or elevated, 1-subconvex, 2-prismatic, 3- flat)
**13. Mesepisternum:** (0-roundly raised, 1-obtusely raised, 2-depressed not obtusely raised)
**14. Antenna length:** ( 0-2 times or more than 2 times of head width;1-less than 2 times of head width)
**15. Hind femora:** (0-hardly reaching apex of abdomen, 1-exceeding apex of abdomen)

**Table-1: Presence or absence data for fifteen characters for 14 species of the genus *Macrophya* as used in the phylogenetic analysis; *T. rufipodus* Saini and Bharti, 1996 is included as an outgroup.**

| Character → / Species ↓ | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *M. andreasi* Saini and Vasu, 1997 | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 1 | 0 | 3 | 1 | 0 | - | 1 | 1 |
| *M. brancuccii* Muche, 1983 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| *M. formosana* Rohwer, 1916 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 2 | 1 | 3 | 1 | 0 | 0 | 1 | 1 |
| *M. gopeshwari* Saini *et al.*, 1986 | 0 | 0 | 0 | 1 | 2 | 1 | 1 | 1 | 1 | 0 | 0 | 2 | 1 | 0 | 1 |
| *M. khasiana* Saini *et al.*, 1996 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 |
| *M. maculicornis* Cameron, 1899 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| *M. manganensis* Saini *et al.*, 1996 | 0 | 0 | 1 | 0 | 0 | 1 | 2 | 2 | 1 | 3 | 0 | 0 | 1 | 1 | 1 |
| *M. naga* Saini and Vasu, 1997 | 1 | 0 | 0 | 0 | 2 | 1 | 1 | 2 | 0 | 1 | 1 | 1 | - | 0 | 1 |
| *M. planata* (Mocsary, 1909) | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 2 | 1 | 2 | 1 | 2 | 1 | 0 | 1 |
| *M. pompilina* Malaise, 1945 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 2 | 1 | 3 | 1 | 1 | 0 | 0 | 1 |
| *M. pseudoplanata* Saini *et al.*, 1996 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 3 | 1 | 0 | 1 |
| *M. regia* Forsius, 1930 | 0 | 1 | 0 | 1 | 2 | 1 | 1 | 0 | 0 | 3 | 2 | 0 | 0 | 1 | 1 |
| *M. rufipodus* Saini *et al.*, 1996 | 0 | 0 | 0 | 0 | 2 | 1 | 1 | 2 | 1 | 1 | 0 | 1 | 0 | 0 | 1 |
| *M. verticalis* Konow, 1998 | 0 | 0 | 0 | 1 | 2 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 |
| *T. rufipodus* Saini and Bharti,1996 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 1 | 1 | 3 | 0 | 2 | 1 | 0 |

## Discussion

The outgroup taxon *T. rufipodus* got separated from all species of genus *Macrophya* on the basis of postocellar area fine (Character 11, state 3), mesepisternum depressed not obtusely raised (Character 13, state 2) and hind femora hardly reaching apex of abdomen (Character 15, state 0). The derived consensus tree identified two groupings to be present in the cladogram. In the first group *M. khasiana* got isolated from *M. verticalis*, *M. brancuccii*, *M. regia*, *M. gopeshwari*, *M. planata*, *M. maculicornis* and

## Results

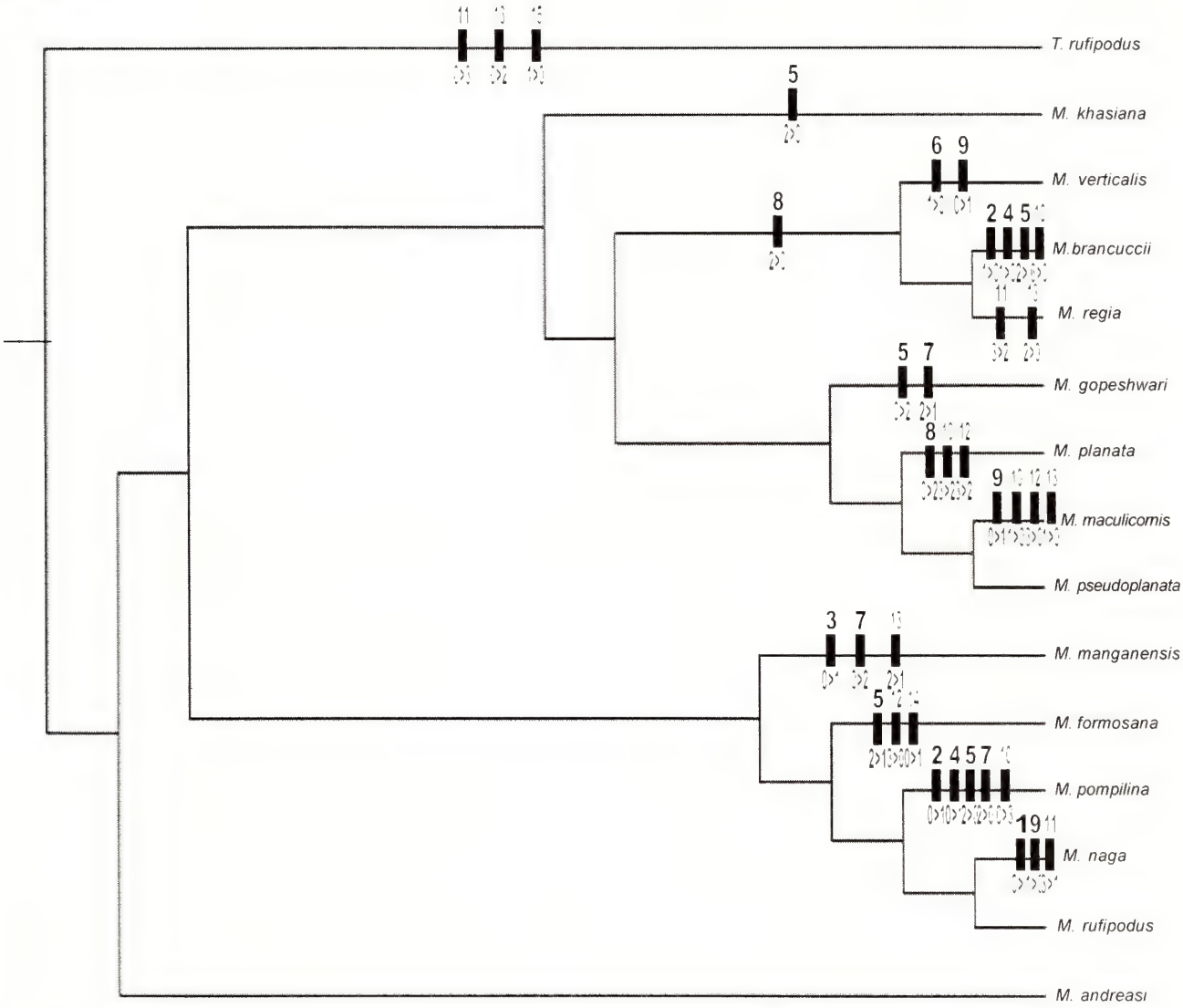


Fig. 1. Strict consensus tree for 14 species of *Macrophya* derived from the 7 most parsimonious trees calculated from the data in Table 1 ; outgroup = *Tenthredo rufipodus* Saini and Bharti,1996 . Character of the ingroup have been optimized by fast transformation as implemented in PAUP. Character numbers are above the hashmarks; state changes are shown below with the respective primitive and derived conditions reported by a '>'. 7 trees were found using the computer program PAUP version 4.0, with the shortest tree requiring 28 steps, a consistency index ( CI ) of 0.50, a retention index ( RI) of 0.55 and rescaled consistency index ( RC) of 0.28.

*M. pseudoplanata* on the basis of average length of body of female is 10mm ( Character5, state 0). *M. verticalis*, *M. brancuccii* and *M. regia* due to absence of median fovea got separated from *M. gopeshwari*, *M. planata*, *M. maculicornis* and *M. pseudoplanata*. *M. brancuccii* and *M. regia* are sister species and got isolated from *M. verticalis* due to characters 6 and 9. *M. gopeshwari* can be distinguished from *M. planata*, *M. maculicornis* and *M. pseudoplanata* due to average length of body below 10mm (Character 5, state 2) and labrum with subtruncate anterior margin (Character 7, state 1). *M. planata* on basis of characters 8, 10 and 12 got isolated from sister species *M. maculicornis* and *M. pseudoplanata*. Due to triangularly incision in clypeus, labrum with slightly emarginated anterior margin and mesepisternum obtusely raised *M. manganensis* got separated from *M. formosana*, *M. pompilina*, *M. naga* and *M. rufipodus* and all these species showed monophyly as indicated by homologue 6. *M. naga* and *M. rufipodus* at the base of cladogram got separated from closely related species *M. pompilina* due to characters 2, 4, 5, 7 and 10. *M. naga* and *M. rufipodus* on basis of characters 1, 9 and 11 got separated from each other. So, extremely specialized forms descended by gradual changes leads to accumulation of certain appropriate features which represents body organization acquired to become complex so as to meet requirements which also underlies the biological maxim.

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# Notes on life history of *Oecophylla smaragdina* (Fabricius) and its potential as biological control agent

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## Abstract

**Studies on life history of weaver ant *Oecophylla smaragdina* and its potential as biological control agent were carried out in Horticulture Department, Punjabi University, Patiala. Parameters such as life history, nest building behavior, caste composition, and potential of *Oecophylla smargadina* as biological control agent were studied.To study the effect of weaver ant as pest control agent, 127 Mango trees and 38 Citrus trees were observed for nests of weaver ant. Out of these, 80 mango trees and 25 citrus trees were found with *Oecophylla* nests, number of nests per tree was also taken into account. Average yield per tree with and without ant nests was calculated.**

**Keywords:** *Oecophylla smaragdina, Life history, Biological control, India.*

## Introduction

Among the thousands of social insects a few deserve to be called classic, because of certain remarkable features in their behavior have prompted unusually careful and thorough studies. The honey bees, the bumble bees, the driver ants, the army ants, the leafcutter ants, the slave-maker ants, and the fungus growing termites are all examples of classic social insects. *Oecophylla* belongs to the subfamily Formicinae, provisionally placed in a tribe of their own, Oecophyllini. *Oecophylla* is a relatively old genus with 11 fossil species being reported from the Oligocene and Miocene deposits (Azuma *et al.*,2002). The species of *Oecophylla* lack a functional sting. But these industrious animals inflict a painful bite which is aggravated by irritating chemicals secreted from their abdomen. The construction of communal silk nests has clearly contributed to the success of *Oecophylla* weaver ants. With their huge colonies and their ability to construct nests almost anywhere, the *Oecophylla* weaver ants have achieved a close control of their environment.

Two closely related living species of the genus *Oecophylla* are; *Oecophylla longinoda* found in Sub-Saharan Africa and *Oecophylla smaragdina* found in India, South-East Asia and Australia. *Oecophylla smaragdina*, also known as the yellow citrus ant, has been used in China for almost 1700 years to protect citrus fruit against damage by insect pests. Use of ants as biological control of insects was widespread in the citrus orchards of Sihui, Qingyuan, and Panyu districts around Canton, as well as in Caoching and Gaozhou.

They feed on various insects that attack the orange, tangerine, lemon, and pomelo trees and their fruit, supplement their diet with carbohydrate rich honey dew excreted by small insects (Hemiptera). Whole orchards can be colonized by securing a nest on one tree and then connecting it to adjacent trees with bamboo strips. The strips serve as bridges for the ants to build new nests in nearby trees.

The weaver ants evidently combat the diseases by attacking the bugs. The *Oecophylla* workers are also particularly effective in hunting insects that feed on the tissue and sap of trees.

Although the weaver ant *Oecophylla* is the first written record of biological control, dating from 304 A.D, there have been fewer than 70 publications on this predator as a biological control agent in Asia. Classical biological control has achieved some tremendous successes over the past century, yet scientists recognize that the opportunities are limited and that greater attention is needed to increase the impact of native natural enemies (Greathead, 1991). A review of manipulative field studies showed that, in 75% of cases, generalist predators, whether single species or species assemblages, reduced pest numbers significantly

(Symondson *et al.*, 2002). Other useful criteria for ants as biological control agents include broad habitat range and choice of species that are unlikely to be out-competed by other ants (Majer, 1986).

Holldobler and Wilson (1977) studied the social establishment and maintenance of territory by African weaver ant *Oecophylla longinoda*. They explained that odour trails laid from rectal gland of worker ants were used to recruit nest mates to previously unoccupied space in the nests. Begg (1977) studied the effect of cyclone "Tracy" on the *Oecophylla smaragdina* in deciduous vine thickets near Darwin.

Keeping in view the above mentioned facts, the present study was designed to acquire more knowledge about the weaver ant *Oecophylla smaragdina* and its potential as biological control agent in our country.

## Materials and Methods

1. For this study related to weaver ant *Oecophylla smaragdina,* Horticulture Department of Punjabi University, Patiala was selected.
2. Nests of *Oecophylla smaragdina* were located on Mango and Citrus trees and observations related to study were carried from September, 2007 to August, 2008.
3. Parameters such as life history, nest building behavior, caste composition, and potential of *Oecophylla smargadina* as biological control agent were studied.
4. Data pertaining to fruit yield, w.r.t. number of trees with ant nests etc. have been compared with trees without weaver ant nests.
5. Pests infecting selected trees were identified to get a broader view of the effect of weaver ant.
6. For better correlation, the data pertaining to pesticides sprayed have also been taken into consideration.
7. Meteorological data (average temperature, relative humidity) during the period of study was procured from Meteorological Department of Punjabi University, Patiala.

## Results and Discussion

Study on life history of *Oecophylla smaragdina* and its role as biological control agent was carried out at Horticulture Department, Punjabi University, Patiala from September, 07 to August, 08.

For clarity, the results and discussion are dealt here in two parts, i.) covering the life history and nesting behavior of *Oecophylla smaragdina* and ii.) its role as biological control agent.

**1. Life history and Nesting Behavior of *Oecophylla smaragdina***

**Castes of *Oecophylla smaragdina***

The castes of this species are easily differentiated into small and large workers, males and females (Table-3). Major workers (adults) were found to be 8mm in length compared to 5mm in case of minor workers. Pupae of major workers and minor workers measured 4mm and 3mm in length respectively. The small workers are seldom found outside the immediate proximity of the nests; they may solicit honey-dew producing Homoptera within the nests, but their main function was found to attend the developing brood and the sexual forms. The large workers attend honey-dew producing Homoptera outside the nests, forage on the ground, kill other insects for food and defend the colony. They are the only form that builds the nests and shelters over clusters of Homoptera, they also attend the brood and carry it from nest to nest within the colony. The virgin sexual form posses wings, but the gravid queen is dealated (wingless) and has an abdomen greatly distended with developing ova.

**Nesting habits of *Oecophylla smaragdina***

*Oecophylla smaragdina* builds arboreal nests and has never been observed to nest or forage beneath the soil surface. During present study, the colonies of *Oecophylla smaragdina* were observed on citrus and mango trees. Generally the choice of host plant appears to depend partly on the ease with which the leaves can be used to form nests and partly on the ability of the host plant to support suitable Homoptera from which the ant can obtain honey-dew for food. During the study *Amritodus atkinsoni* (Lethiery) was found associated with ant nests on citrus and mango trees.

It was observed that day before nest building, the large workers crawled slowly over the nest areas in order to assess the number of leaves to form nest. For building nests, larger workers draw individual leaves together, forming chains of up to twelve workers to bridge the gaps. The chains are formed by each ant gripping with its mandibles the very long petiole of the ant in front and leaves are gripped by the mandibles and by the well developed tarsal claws. About two hundred workers in chains of up to nine individuals were observed drawing a pair of leaflets together and the manner in which all chains coordinated in pulling together was most striking. After the leaves were drawn together, they were held in position by workers, while other larger workers, carrying larvae in their mandibles, proceeded to secure the edges together with silk secreted by the larvae.

Nests were observed for five months on 5 trees of citrus. It was seen that there were total of 20 nests at the start of the season and 40 at the end. Average of 5-6 nests were built per tree/season. Each nest was

occupied for an average of eighty-five days and deserted when most of the leaves of which it was built, died.

**Composition of *Oecophylla smaragdina* nests**

Eighteen nests, 9 each from mango and citrus trees were examined for their contents. It consisted of egg, larvae and pupae (brood), major and minor workers and sometimes depending upon season

**Table-1: Showing average temperature and percentage of relative humidity (R.H.) recorded during months of the year (2007-2008)**

| Months | Temperature (°C) | | Relative Humidity % |
|---|---|---|---|
| | Maximum | Minimum | |
| September,07 | 31.9 | 20.3 | 91.86 |
| October,07 | 33.21 | 16.60 | 81.83 |
| November,07 | 28.29 | 9.6 | 89.56 |
| December,07 | 18.3 | 1.08 | 93.09 |
| January, 08 | 17.26 | 2.6 | 86.19 |
| February,08 | 23.4 | 3.1 | 89.51 |
| March,08 | 31.0 | 25.86 | 80.29 |
| April,08 | 22.72 | 14.56 | 60.96 |
| May,08 | 38.28 | 24.32 | 57.80 |
| June,08 | 36.06 | 22.3 | 85.50 |
| July,08 | 34.09 | 25.2 | 89.32 |
| August,08 | 32.7 | 24.0 | 90.16 |

**Table-2: Mean number of workers and brood of Oecophylla smaragdina within nests built on Mango and Citrus trees**

| Tree | No. of nests examined | Mean number of workers per nest | Mean number of brood per nest |
|---|---|---|---|
| Mango | (3 Small) | 707 | 245 |
| | 9 (3 Medium) | 4994 | 4336 |
| | (3 Large) | 13,383 | 8981 |
| Citrus | 9 | 719 | 298 |

**Table-3: Average length of Major and Minor worker adults and pupae of *Oecophylla smaragdina***

| Caste | Average length (mm) |
|---|---|
| Major worker (adult) | 8 mm |
| Minor worker (adult) | 5 mm |
| Major worker (pupae) | 4 mm |
| Minor worker (pupae) | 3 mm |

**Table-4: Pests of Mango and Citrus trees**

| Pest of Mango | Insect order | Family | Species Common name |
|---|---|---|---|
| 1. *Amritodus atkinsoni* (Lethiery) | Hemiptera | Cicadellidae | Mango-hopper |
| 2. *Drosicha mangiferae* (Green) | Hemiptera | Margarodidae | Mango Mealy-bug |
| 3. *Batocera rufomaculata* DeGeer | Coleoptera | Cerambycidae | Mango Stem-borer |
| 4. *Sternochetus mangiferae* (Fabricus) | Coleoptera | Curculionidae | Mango-stone Weevil |
| 5. *Bactrocera dorsalis* (Hendel) | Diptera | Tephritidae | Mango Fruit-fly |
| 6. *Aceria mangiferae* Sayed | Acari | Eriophidae | Mango-bud Mite |
| **Pest of Citrus** | | | |
| 1. *Diaphorina citri* Kuwayana | Hemiptera | Aphalaridae | Citrus Psylla |
| 2. *Phyllocnistis citrella* Stainton | Lepidoptera | Phyllocnistidae | Citrus Leaf-miner |
| 3. *Dialeurodes citri* (Ashmead) | Hemiptera | Aleyrodidae | Citrus Whitefly |
| 4. *Aleurocanthus woglumi* Ashby | Hemiptera | Aleyrodidae | Citrus Blackfly |
| 5. *Papilio demoleus* Linnaeus | Lepidoptera | Papilionidae | Citrus caterpillar |
| 6. *Ophideres* sp. | Lepidoptera | Noctuidae | Fruit-sucking Moths |
| 7. *Desineura citri* Grover | Diptera | Cecidomyiidae | Citrus Blossom Midge |

**Table-5: Pests of Mango**

| Name of Pest | Period of Occurrence | Parts attacked and damage caused | Insecticides used |
|---|---|---|---|
| 1. *Amritodus atkinsoni* (Lethiery) Mango-hopper | Active throughout the year. Maximum damage caused during Feb.-April | Nymph and adults are found clustering on the inflorescence and suck the sap during spring. Infested flowers shrivel, turn brown and fall off | Malathion or Endosulfan |
| 2. *Drosicha mangiferae* (Green) Mango Mealy-bug | This pest is active from December to May and spend rest of the year in egg stage | Damage is caused by nymphs and wingless females. They suck plant juice, causing tender shoots and flower to dry up. | 500 ml of Methyl parathion 50 EC in 250 lt. of water/ha. |
| 3. *Batocera rufomaculata* DeGeer Mango Stem-borer | Spring season | Not very common, Damage is caused by the grubs killing branch or sometimes entire tree | Stems are injected with 4 ml of methyl parathion 50 EC mixed in 1 lt. of water into the hole and plugged with mud. |
| 4. *Sternochetus mangiferae* (Fabricius) Mango-stone Weevil | Life cycle starts with formation of mango fruits. Weevil lay eggs in fruits (May) | Not a serious pest, the injury is caused by the larvae feeding on the pulp. | The Weevil being an internal feeder throughout its life cycle cannot be controlled by pesticides |
| 5. *Bactrocera dorsalis* (Handel) Mango Fruit-fly | Active during summer months | Damage is caused by grubs which feed on pulp making the fruit unfit for human consumption | 1.25 lt. of Malathion 50 EC + 12.5 Kg Sugar in 1250 lt. of water per ha. |
| 6. *Aceria mangiferae* Sayed Mango-bud Mite | Peak in population has been observed in months of February, June and July | The bud mite sucks the sap from inside the buds and causes necrosis of tender tissues | Spray of 1 lt. of dimethoate 30 EC in 250 lt. of water/ha. during summer |

**Table-6: Pests of Citrus**

| Name of Pest | Period of Occurrence | Parts attacked and damage caused | Insecticides used |
|---|---|---|---|
| 1. *Diaphornia citri* Kuwayana Citrus Psylla | Throughout the year. Nymph occur during months of April to September | Most destructive pest of citrus. Nymph are harmful they possess sharp, piercing mouth parts; suck the cell-sap in millions. The leaf-bud, flowers and leaves may wilt and die. | 1.70 lt. of dimethoate 30 EC or 1.25 lt. of malathion 50 EC or 500 ml of fenitrothion 50 EC in 250 lt. of water/ha during Feb.-March (Springflush) May-June (before rainy season) and July-August (after rainy season) |
| 2. *Phyllocsnistis citrella* Stainton Citrus Leaf-miner | Active during late spring or summer season | Larvae cause damage to young leaves by making zigzag slivery mines. The injured epidermis takes the shape of twisted silvery galleries. | 125 ml of fenvalerate 20 EC or 250 ml cypermethrin 10 EC or 875 ml of decamethrin 2.8 EC or 370 ml of monocrotophos 40 EC in 250 lt. of water/ha at fortnightly intervals |
| 3. *Dialeurodes citri* (Ashmead) Citrus Whitefly | Active during March-April and again in August-Sept. | The damage is caused by adults as well as nymphs. | 1140ml of Thiodon 35EC (endosulfan) in 500 lt. of water/acre during April-may and again September - October. |
| 4. *Aleurocanthus woglumi* Ashby Citrus Blackfly | Active during March-April and July-October. | Both adult and nymphs suck plant sap resulting in curling of leaves and premature fall of flower buds and developing fruits | 1140ml of Thiodon 35EC (endosulfan) in 500 lt. of water/acre during April-may and again September- October. |
| 5. *Papilio demoleus* Linnaeus Citrus Caterpillar | Activity synchronizes with the growth of citrus plants in April and Aug-Sept. | Damage is caused by young larvae which feed on fresh leaves and terminal shoots | 750ml Thiodon 35EC (endosulfan) in 500lt.of water/acre. |
| 6. *Ophideres* sp. Fruit-sucking Moths | Minor pest during Spring and July-October. | Cause damage in adult stage. Punctures fruit for sucking juice. | 2.5 kg of Carbaryl 50 WP in 500 lt. of water/ha at time of maturity of fruits |
| 7. *Dasineura citri* Grover Citrus Blossom Midge | Feb.-March (2-3) generations are completed during flower period | The attack of this orange fly pest is heavy during Feb.-March and the infested blossom looks abnormal in shape. The attacked buds and flowers when Shaken drop off easily, reducing the fruit bearing capacity of the trees | 1.70 lt. of dimethoate 30 EC or 1.4 lt. of Phosalone 35 EC in 1250 lt. of water per ha. |

* EC = Emulsifiable Concentrate, ** WP = Wettable Powder

**Table-7: Types of Insecticides Used**

| Insecticides | WHO Classification | Trees | Total Exp. (Rs.)/year |
|---|---|---|---|
| **Organophosphates** | | | |
| Methyl parathion | Extremely hazardous (Ia) | Mango | Rs. 559 |
| Melathion | Moderately hazardous (II) | Citrus<br>Mango | Rs.125<br>Rs. 691 |
| Dimethoate | Moderately hazardous (II) | Citrus<br>Mango | Rs.384<br>Rs. 2143 |
| Phosalone | Moderately hazardous | Citrus | Rs. 241 |
| Monocrotophos | Moderately hazardous | Citrus | Rs.171 |
| **Organo chlorine** | | | |
| Endosulfan | Highly hazardous (Ib) | Citrus, Mango | Rs. 525 |
| **Carbamate** | | | |
| Carbamyl | Highly hazardous (Ib) | Citrus<br>Mango | Rs.186<br>Rs.1067 |
| **Pyrethroids** | | | |
| Cypermethrin | Moderately hazardous | Citrus | Rs.126 |
| Decamethrin | Moderately hazardous | Citrus | Rs.187 |
| Fenitrothion | Moderately hazardous | Citrus | Rs.246 |
| Fenvalerate | Moderately hazardous | Citrus | Rs.181 |
| | | | **Total: Rs. 6832** |

**WHO Classification**

Ia. Extremely hazardous
Ib. Highly hazardous
II. Modertately hazardous

**Table-8: Categorization of trees with or without ant nests**

| No. of Mango trees | No. of Trees with Ant Nest | No. of Nests per tree (Average) | No. of Trees without nest. |
|---|---|---|---|
| 127 | 80 | 20 | 47 |
| **No. of Citrus trees** | | | |
| Malta (30) | 20 | 8 | 10 |
| Kinnow (8) | 5 | 8 | 3 |

**Table-9: Total yield pertaining to 2007-2008 at Horticulture Department**

| Fruit | Average Yield/Tree/Year | Total Yield at Horticulture Department, Punjabi University, Patiala pertaining to year 2007-2008 |
|---|---|---|
| Mango (127) | 75.4 Kg | 9579.5 Kg |
| **Citrus** | | |
| Malta (30) | 17 Kg | 510Kg |
| Kinnow (8) | 40.3 Kg | 323Kg |

**Table-10: Average yield per tree with and without ant nests**

| Trees | Average Yield/Tree (With ant nests) | Average Yield/Tree (Without ant nests) | Total Yield/ Year |
|---|---|---|---|
| Mango (127) | 79.5Kg (6360 Kg) | 67.5Kg (3219.5 Kg) | 9579Kg |
| Kinnow (8) | 43Kg (215 Kg) | 36 Kg (108Kg) | 323 Kg |
| Malta (30) | 18 kg (360 Kg) | 15 Kg (150 Kg) | 510 Kg |

dealate queens. The population was roughly estimated by counting the number of workers and brood in 9 nests each of citrus and mango trees. It has been observed that in medium sized nests the proportion of brood to the number of workers is almost same, but in case of small and large size nests, number of brood per nest is comparatively low (Table-2).

Nests were also examined at intervals for the presence of sexual forms. It was observed that during August and September, 07, winged male and female adults were found not more than 2-3 per nest. Most nests contained only worker adults and brood. In October, queen larvae and pupae, male pupae and small number of male and female adults were observed. Immature and adult sexual forms were found in large numbers during November, December, January and February. During February and March, dealated females (after nuptial flight) were found on vegetation. From March up to August, the process of nest building starts all over again and the nest during this period largely comprises of brood, immature adults of sexual forms, major and minor workers and dealate queen.

**2. *Oecophylla smaragdina* as pest control agent**

In Horticulture Department, Punjabi University Patiala, the main insect pests of Citrus and Mango trees were: Mango-hopper *Amritodus atkinsoni* (Lethiery) (Hemiptera: Cicadellidae), Mango Mealy-bug *Dorsicha mangiferae* (Green) (Hemiptera: Margarodidae), Mango Stem-borer *Batocera rufomaculata* DeGeer (Coleoptera: Cerambycidae), Mango-stone Weevil *Sternochetus mangiferae* (Fabricius) (Coleoptera: Curculionadae), Mango Fruit-fly *Bactrocera dorsalis* (Hendel) (Diptera: Tephritidae), Mango–bud Mite *Aceria mangiferae* Sayed (Acari: Eriophidae) [Mango] (Table 4, 5); Citrus Psylla *Diaphornia citri* Kuwayana (Hemiptera: Aphalaridae), Citrus Leaf-miner *Phyllocnistis citrella* Stainton (Lepidoptera: Phyllocnistidae), Citrus Whitefly *Dialeurodes citri* (Ashmead) (Hemiptera: Aleyrodidae), Citrus Blackfly *Aleurocanthus woglumi* Ashby (Hemiptera: Aleyrodidae), Citrus Caterpillar *Papilio demoleus* Linnaeus (Lepidoptera: Papilionidae), Fruit-sucking Moths *Ophideres* sp. (Lepidoptera: Noctuidae) and Citrus Blossom Midge *Desineura citri* Grover (Diptera : Cecidomyiidae) [Citrus] (Table 4 and 6).

The life history of these pests coincided with the fruit bearing period of the mango and citrus trees (Table 5 and 6). To control the pests of both trees various pesticides are in use in the experimental site. The pesticide treatment is generally carried out in the months of March and August respectively. The pesticides used by the Horticulture Department were found to be Organophosphates, Organochlorines, Carbamates and Pyrethroids. It has been observed that the above mentioned insecticides come under the extremely hazardous to moderately hazardous category of World Health Organization (WHO) (Table-7).

Keeping in mind the hazardous effects of these pesticides, an attempt was made to study the effect of weaver ant as pest control agent. For this purpose, number of mango and citrus trees were counted in the Horticulture Department and then the trees with ant nests and also number of nests per tree were identified (Table- 8). It was found that average yield/mango tree with ant nest was 79.5Kg compared to 67.5Kg/mango tree without ant nests. Similar results were found in case of Kinnow trees, 43Kg/tree with ant nests and 36Kg/tree without ant nests and Malta trees obeyed the same yielding 18Kg/tree with ant nests as compared to 15Kg/tree in the absence of ant nests. Insecticides were sprayed irrespective of the presence or absence of ant nests. But during present study, it was found that the incidence of these pest species was almost negligible on the trees occupied by weaver ants. Thus it was observed that these trees dominated in terms of quality and quantity of fruits.

These preliminary observations carried over a limited period of time indicate that weaver ant has a lot of potential as biological control agent in our country. Ant husbandry holds a lot of promise and its potential as biological control agent could be harnessed in India as well.

Still, we need to work on nest establishment/nest shifting of this peculiar ant so as to use it as an effective biological control resource. Finally, we need to generate awareness amongst horticulturists regarding its use so as to avoid hazardous effects of pesticides.

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# Diversity and distribution of social apocrites of Vadodara, Gujarat, Western India

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## Abstract

**Three year survey of bees and wasps carried out in the city of Vadodara and its surroundings at four sites having specific habitat types highlighted the effect of habitat on the presence and abundance of the bees. The study was based on the hourly counts made twice every month in four selected habitats; agricultural fields, community gardens, fragmented habitats and residential sites situated at different locations in and around Vadodara ranging from 25-30 kms. The study recorded a total of 47 species of bees and wasps belonging to 29 genera from 15 families. Out of which11 species are social belonging to 7 genera under 3 families. Shannon diversity showed highest score of social bee diversity in fragmented habitats, followed by agricultural fields and community gardens. Least diverse were residential sites .The underlying reason for the success of fragmented habitats is that they provide ideal multiple microhabitats for nurturing insect species. Numbers of bees were more in community gardens where exotic and indigenous species of plants were cultivated, followed by fragmented habitats and agricultural fields. Minimum number was obtained from residential sites.**

**Keywords**: *Apocrita, food plants, varied habitats, diversity and numbers.*

## Introduction

Hymenoptera is a large order of insect class with more than 1,20,000 known species on the globe (Gordon,2009) out of which more than 5000 species are identified in India (Alfred,1998).

This study involves Vespidae, Halictidae and Apidae families of the suborder Apocrita available in and around Vadodara. Ants, bees and wasps are best known members of this suborder probably the most beneficial of the entire insect class. It contains a great many species that are of value as pollinators e.g. *Apis dorsata, A.indica* or predators like *Polistes stigma, Icaria ferruginea* of injurious insect pests e.g. *Helicoverpa armigera* and *Spodoptera litura.* Also has parasites like *Evania appendigaster*, *Brachymeria hearseyi, Xanthopimpla stemmator.*

Hymenoptera especially the Apoidea group, are the most important plant pollinators of the natural and agricultural ecosystems (Roubik ,1989, Neff and Simpson, 1993) and are strongly related to the evolution and diversification of the angiosperms (Bawa, 1990). Generally, the bees are totally dependent on the floral resources for the maintenance of adults and nests.

Although wasps present less effective participation as pollinators in natural ecosystems, their adults (males and females) are regular flower visitors and nectar consumers, especially social wasps, which also collect nectar for energy supply of their colonies (Gadagkar, 1991).

Asia has a poorer bee fauna compared to other biogeographical regions (Michener, 1979) and lower diversity compared to the Neotropics, but in terms of abundance the social apid bees are the most numerous in the pollinator spectrum (Roubik *et al.*, 2005).

Among the several hundred northwestern species of bees, it is estimated that 10 percent are either social or semisocial, 10 percent parasitic and the remaining 80 percent solitary.

As there is no such study from Vadodara a city of gardens (62 in number) this study was undertaken to know the diversity and abundance of social bees and wasps; the decreasing availability of their food plants; clues which are responsible in reducing their population in agricultural and residential areas to recognize them as biocontrol agents or as components of Integrated Pest management.

## Materials and Methods

**Study area:** Vadodara District is in the eastern part of the state of Gujarat , western India. It is located at 22°11' N latitude and 73°07' E longitude. The diversity of social bees was assessed across 4 habitats of the Vadodara and its surroundings from January 2006 to December 2008. Survey sites were chosen based on accessibility and location within an ecoregion. Four different types of habitats; Agricultural fields in and around Vadodara, fragmented areas within Vadodara, community gardens and the old and new residential areas of the Vadodara city were selected on the basis of ecological factors, flora, type of soil, surrounding environment and anthropogenic activities.

**Sampling method:** Each study area was visited twice per month from morning 7 a.m.to 9 a.m. and evening 5 p.m. to 7 p.m. of the same day, which included collection for one hour and labeling for the other., At all the sites plots of 10x10 m were laid. The number of individuals in a given species collected during 2 hours, from each site were recorded. Bees on vegetation were collected by sweeping the above ground vegetation. Those on flowers and in flight were individually collected using the sweep net. Of the bees collected in this manner, the easily identifiable common bees were released on site after making a count and recording their identity. Collected bees were identified up to species level.

**Identification of bees:** Bees collected were identified up to family and generic levels using keys of Imms' general textbook of Entomology (1997) and Borror (1992), Species level identification was based on keys and descriptions of Bingham (1897), Leffroy (1909) and Ananthkrishnan (2004). Reference collections of bees and wasps in the museum of Indian Agricultural Research Institute, PUSA, and New Delhi were also used to confirm the identity of certain species.

**Data analysis:** Based on the number of bee species and their abundance in each site, bee diversity in each of the study sites was calculated using the Shannon Weiner Diversity Index (Henderson, 2003).

## Results and Discussion

**Species composition**: A total of 1776 bee specimens were collected from the 10 sites during the 3 years .The study recorded a total of 47 bee species belonging to 29 genera in 15 families out of which 11 species, 7 genera and 3 families were social (Table-1). Family Vespidae and Sphecidae included the largest number of genera. Family Sphecidae included the largest number of species followed by Vespidae and Xylocopidae. Maximum genera and species of social apocrits are also included in Vespidae. 7 species of wasps belonging to Vespidae family and three species of honeybees from Apidae were recorded. Whereas from Halictidae only one species of *Nomia westwoodii* was found.

**Percentage composition:** 11 species of social apocrits formed 23% of total species of hymenoptera found in Vadodara. (Fig. 1).

**Distribution and Diversity of Bees:** Social bees and wasp abundance was found maximally in community gardens where different floral plants were grown followed by fragmented habitats, agricultural fields and least number was in residential sites (Fig. 2).

**Bee Diversity Indices:** Shannon diversity index gave the highest score for the bee diversity in fragmented habitats, followed by agricultural fields, community gardens and lowest score was for residential areas (Table-2). The finding of this study highlights the fact that the highest diversity of bees is in the area where anthropogenic pressure is comparatively less. Furthermore, in these habitats, the vegetation comprises a mixture of flowering herbs and patches of natural vegetation providing a ready source of pollen and nectar for bees throughout the year.

In the city of Vadodara even though the 4 habitats are located at different distances ranging from 25-30 Km, social bees and wasps diversity was nearly same. Some of these social hymenopterans are predators *viz., Polistes* spp. and *Vespa* spp. (Table 3a); as they prey upon the pupae and caterpillars of lepidopteran pests like *Helicoverpa armigera, Spodoptera litura* and can be useful components of Integrated pest management. Some are pollinators *viz., Apis indica* and *A. dorsata* (Table 3b), which are important for improving the quality and quantity of agricultural crop plants.

Since hymenopterans are highly beneficial, their nests should not be destroyed, unless and until they become annoyance near house. Establishment of their nests should be encouraged by creating more favorable environmental conditions for them in the gardens as well as in agricultural fields .The vegetation and sites where these bees and wasps make their nests should be preserved (Table 4). Due to building of malls and multiplexes as well as urbanization in the city many green spaces with the type of vegetations where bees and wasps thrive upon are lost leading to decrease in their population.

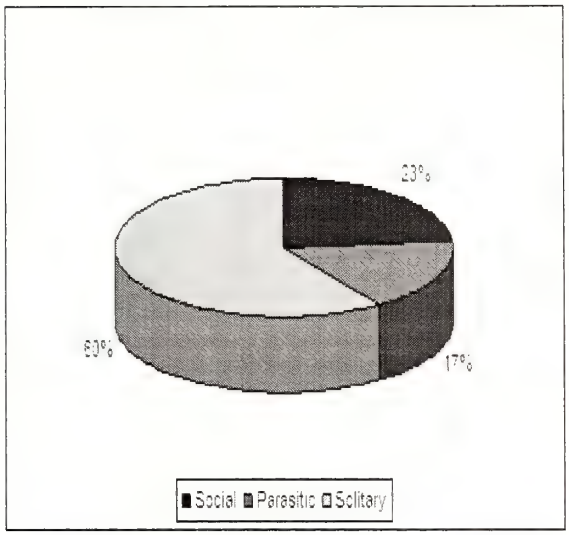


Fig. 1: Percentage of Apocrita in Vadodara

Table 1: Taxonomic composition of bees and wasps in the 4 study sites of Vadodara and its surroundings.

| S. No. | Family | Genus No. | Species No. |
|---|---|---|---|
| 1. | Ichneumonidae | 2 | 2 |
| 2. | Evaniidae | 1 | 1 |
| 3. | Chalcididae | 1 | 1 |
| 4. | Chrysididae | 1 | 1 |
| 5. | Scoliidae | 1 | 2 |
| 6. | Pompilidae | 1 | 1 |
| 7. | Eumenidae | 2 | 5 |
| 8. | Vespidae | 5 | 7 |
| 9. | Sphecidae | 5 | 9 |
| 10. | Halictidae | 1 | 1 |
| 11. | Andrenidae | 2 | 2 |
| 12. | Megachilidae | 2 | 3 |
| 13. | Anthophoridae | 2 | 2 |
| 14. | Xylocopidae | 2 | 7 |
| 15. | Apidae | 1 | 3 |
| | **Total** | **29** | **47** |

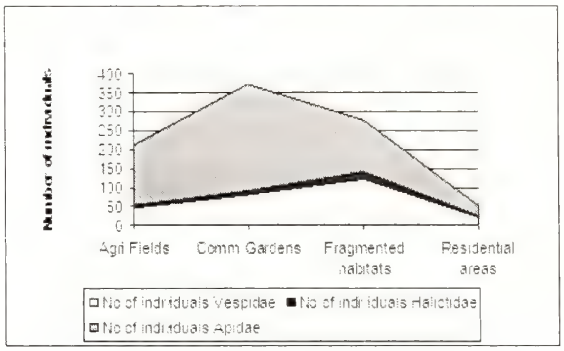


Fig. 2: Social Apocrits in various habitats of Vadodara

Table 2: Shannon Weiner Diversity Index for bees sampled at the 4 study sites of the Vadodara and its surroundings.

| Habitat | Shannon-Weiner index H |
|---|---|
| Agricultural Fields (AF) | 2.2591 |
| Community Gardens (CG) | 2.2127 |
| Fragmented Habitats (FH) | 2.2673 |
| Residential Areas (RA) | 2.1984 |

Table 3a: Food of social Apocrits.

| S. No. | Family: Vespidae | |
|---|---|---|
| 1. | *Icaria ferruginea* Fabricius | Predators of Noctuid caterpillars and grubs of Chrysomelid beetles. |
| 2. | *Polistes fuscatus* Fabricius1793 | |
| 3. | *P.stigma* bernardii Le Guillou | |
| 4. | *Parapssamophila erythrocephala* Menke | |
| 5. | *Rhynehium abdominate* | |
| 6. | *R. cubzeipenne* | |
| 7. | *Vespa cincta* Fabricius, 1775 | Adults of Vespa predates on *Apis indica*. |
| | Family: Halictidae | |
| 8. | *Nomia westwoodii* | Parasitic on other Halictids. |

**Table 3b: Food of social Apocrits.**

| S. No. | Family: Apidae | Food plants and pollen sources | | | |
|---|---|---|---|---|---|
| | | Crop plants | Floral plants | Herbs/Shrubs | Trees |
| 1. | *Apis indica* | Paddy, Pigeon pea, Maize, Wheat, Cotton, Castor | *Hibiscus lobatus*, *Ixora*, *Canna indica*, *Rosa chinensis Gaillardia*, *Helianthus annuus*, *Gerbera* sp., *Phlox paniculata*, *Calendula officinalis*, *Dianthus* sp., *Cosmos* sp. | *Lawsonia inermis*, *Zizyphus mauritiana*, *Caeselpenia crista*, *Portulaca oleracea* | *Mangifera indica*, *Moringa oleifera*, *Butea monosperma* |
| 2. | *A. dorsata* | Cotton, Castor | *Hibiscus lobatus* , *Helianthus annuus* | *Zizyphus mauritiana*, *Calotropis procera* *Ficus bengalensis* | *Mangifera indica*, *Annona squamosa*, |
| 3. | *A. florea* | Paddy, Pigeon pea | *Ixora*, *Canna indica* *Lantana camara*, *Gerbera* sp., *Phlox drumondi*, *Calendula officinalis*, *Dianthus* sp., *Cosmos* sp. | *Lawsonia inermis*, *Zizyphus mauritiana*, *Ipomea obscura*, *Portulaca oleracea* | *Mangifera indica*, *Moringa oleifera*, *Annona squamosa* |

**Table 4: Nests and their sites**

| S.No. | Species | Type of nest | Site of nest | |
|---|---|---|---|---|
| | | | Non Vegetatative | Vegetative |
| 1. | *Polistes* sp. *and Icaria* sp. | Single horizontal series of cells, not enclosed in an envelope and supported by a short stout peduncle. Nest composed of paper like material made from withered fibers of wood collected from dead trees, fences and posts, chewed by mandibles into a paste with the addition of salivary fluid. | Hanging under eaves of buildings | In shades and branches of *Zizyphus, Ixora, Mangifera indica.* |
| 2. | *Vespa* sp. | Number of circular combs attached one over the other and each comb contains numerous hexagonal paper cells. The whole nest is enclosed in a paper envelop. | Hanging under eaves of buildings | Branches of *Butea monosperma, Annona squamosa, Ficus bengalensis.* |
| 3. | *Apis dorsata* | Very large single comb, arrange their wax cells on layers which may be vertical with nearly horizontal cells | Vertical structures such as eaves and walls of buildings | Inaccessible branches of tall trees like *Mangifera indica, Ficus bengalensis.* |
| 4. | *Apis florae* | Tiny single combs, vertical and horizontal cells. | Crevices in buildings | Bushes of dense vegetation |
| 5. | *Apis indica* | Series of parallel combs | Eaves of rocks, walls and safe places of buildings | Hollowed out tree trunks |
| 6. | *Nomia* sp. | Main burrow is usually vertical with lateral branches | Burrows in the ground | |

Thus there is a strong need of conserving their biodiversity and focussing their importance as pollinators and biocontrol agents.

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# Some notes on Rhopaloceran diversity (Lepidoptera) of Himachal Pardesh

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## Abstract

**Twenty-eight species of nineteen genera belonging to three families of butterfly from fifteen localities were collected and identified. The collection record, old distribution alongwith host plants were given.**

**Keyword:** *Diversity, Family, Genera, Lepidoptera.*

## Introduction

Moths, butterflies and skippers belong to the order Lepidoptera generally with two pairs of membranous wings which, together with the body, are more or less clothed with tiny scales, often brightly colored. It is the second largest order after Coleoptera in the class Insecta, whose number is roughly equivalent to that of known flowering plant species (Holloway *et. al* 1992). There are about 2, 00,000 species of Lepidoptera world over and out of these, only 15,000 species belong to the butterflies (Rhopalocera) and the remaining being moths (Herterocera). Collection, preservation and studying of Lepidoptera are a tedious work due to their fast flying nature and due to this the same has been neglected from India for the last many years. District Una is selected for the present research work which is situated in shivalik range of Himalaya. It lies within North Latitude 31° 21' and 31° 50' and East Longitudes 71° 55' and 76° 28', altitude 750 metres and South-Western part of Himachal Pradesh. The hill ranges are covered by scanty vegetation comprising mostly of shrubs. The authors have undertaken survey-cum-collection tour to the 15 localities such as Dehlan, Bangana, Gagret, Raipur, Mubarkpur, Bharwain, Haroli, Una, Amb, Chintpurni, Daulatpur, Basoli, Santokhgarh, Chauki Maniar, and Lathiani of the Una district of Himachal Pradesh were visited between during different seasons from March to August, 2008. The survey led to the collection of 28 species, out of which 02 belong to family Papilionidae and 13 each to family Nymphalidae and Pieridae were identified and studied in detail.

## Materials and Methods

The adults of butterflies were collected with the help of insect collection net (circumference 93 cm, handle length 87 cm, bag depth 77 cm) by sweeping method. These methods were quite suitable for collection of butterflies over the leaves and flowers (Arora, 1990). Rhopalocerans collected were killed in killing bottle by using liquid chemicals like ethyl acetate, carbon tetrachloride etc. The specimens collected from various localities were pinned with different sizes entomological pins (38mm x 40mm; 38mm x 55mm) and stretching in spreading board boxes (40cm x 30cm x 10cm) or on plastazote pasted/fixed at the bottom of a slide box. The stretched specimens were stored in well fumigated (naphthalene balls) air tight wooden show cases. The label carrying information such as locality, date of collection, altitude and name of the collector etc. was tagged with each specimen. The preparation of wings slide were undertaken as per Common (1970) and Zimmerman (1978). The taxonomic procedure involves an examination of various morphological characters such as head, labial palpus, legs, wing shape, wing maculation and wing venation. Except wing venation, the rest of the characters have been directly examined from the dried specimens. For naming of each vein Comstock-Needham system (Miller, 1970) has been followed. The photographs of the adults of different species were taken with the help of digital camera (Nikon D200).

## Observation

Preliminary sorting and taxonomic segregation was done with the help of literature Moore, 1865, 1866-68, 1880-87, 1890, 1896- 1899; de. Niceville, 1881; de Niceville and Marshall, 1882, 1886, 1890; Hampson, 1892, 1895, 1918; Bingham, 1905, 1907; Bell, 1911; Talbot, 1939; Wynter-Blyth, 1957; Common, 1970; D'Abrerra, 1980-86, 1998; Arora, 1990; Holloway, *et al.*

1992; Varshney, 1993, 1994,1997, 1998; Rose and Sidhu, 1994, 1996, 1997a, 1997b, 1999, 2001; Rose and Sharma, 1995a, 1995b, 1998a, 1998b, 1998c, 1998d, 1999, 2000a, 2000b, 2000c; Gunatheraj *et al.*, 1998; Trigunayat, 1999;Yakovlev and Nakonechnyi, 2001; Rose and Walia, 2003; Bhaskaran and Eswaran, 2005; Thakur *et al,* 2006; Uniyal, 2007 and Withrington and Veronik 2008 and after comparison of adults from our national Museum at FRI, Dehradun and IARI, New Delhi. In all, twenty-eight species belonging to nineteen genera i.e., *Aglais* Dalman, *Anosia* Hübner, *Ariadne* Horsifield, *Hypolimnas* Hübner, *Junonia* Hübner, *Lethe* Hübner, *Morpho* Fabricius, *Neptis* Fabricius, *Pyronia* Hübner, *Satyrus* Westwood of family Nymphalidae, *Papilio* Linnaeus of family Papilionidae and *Atella* Doubleday, *Catopsilia* Hübner, *Cepora* Billberg, *Colias* Fabricius, *Delias* Hübner, *Eurema* Hübner, *Ixias* Hübner, *Pieris* Schrank of family Pieridae were identified. All the collected species have been deposited in the Taxonomy Laboratory, Department of Entomology, Punjab Agricultural University, Ludhiana. Taxonomic segregation of butterflies recorded in this study was based on the morphological details as presented below.

## Superfamily Papilionoidea

### Family: Nymphalidae

**Diagnosis:** Head vertex very smooth, labial palpi three segmented, upcurved, maxillary palpi one segmented, haustellum naked, antennae filliform, clubbed, antennal pecten absent, ocelli absent, chaetosemata present, tympana absent, venation variable, wing coupling absent, forewing pterostigma absent, forewing chorda absent, forewing anal veins $A_{1+2}$ forewing cell vein absent, hindwing pterostigma
absent, hindwing anal veins $A_{1+2}$ $A_3$, hindwing cell vein absent, epiphysis absent, tibial spurs zero in forelegs and two each in midlegs and hindlegs.

### I. Genus: *Aglais* Dalman

*Aglais* Dalman, 1816, *K.Vet.Acad.Handl. Stockh.,* (1): 56.

***Aglais urticae rizana* (Moore)**

*Vanessa urticae rizana* Moore, 1872, *Proc. Zool Soc. Lond.*: 559.

**Material examined**: Himachal Pradesh: Distt.Una; Raipur, 545m, 2.viii. 2008, 2 ♀, 1♂, Bharwain, 708m, 17.viii.2008, 1 ♀, 2 ♂, coll. Anita Kumari.

**Distribution:** Sikkim, Himalayas (www.nhm.ac.uk); Himalayas from Kashmir to Sikhim (Bingam, 1905); Bharwain, Raipur (H.P.) (present study).

**Larval host Plant:** Unknown.

### II. Genus: *Anosia* Hübner

*Anosia* Hübner, 1816, *Verz. bekantt. Schmett.* (1):15-16.

***Anosia chryssipus* Linnaeus**

*Anosia chrysippus* Linneaus, 1758, *Syst.Nat. (Edn.x)*: 471.

**Material examined:** Himachal Pradesh: Distt. Una; Chauki Maniar, 530m, 5.vii. 2008, 1 ♂, Haroli, 375m, 1.viii.2008, 2 ♀, coll. Anita Kumari.

**Distribution:** Griechenlan (Inseln) (www.nhm. ac.uk.); Southern Europe, Syria, Ethiopian Region, Arabia, Persia and Afghanistan (Bingham, 1905); Chauki maniar,Haroli (H.P.), (present study).

**Larval host Plant:** *Calotropis gigantean* (Bingham, 1905).

### III. Genus: *Ariadne* Horsifield

*Ariadne* Horsifield, 1829,*Cat.Lep.Ins.Mus.E. India.Co.*: 3.

***Ariadne merione tapestrina* (Moore)**

*Ergolis merione tapestrina* Moore, 1884 *J.A.S.B.* Liii.: 19.

**Material examined:** Himachal Pradesh: Distt. Una; Dehlan, 374m, 4.viii. 2008, 1 ♀, 1 ♂, coll. Anita Kumari.

**Distribution:** India (www.nhm.ac.uk.); the northern half of continental India, Shimla to Sikhim in the Himalayas, Rajputana, Bengal, Assam, Burma, Tenasserim, Malayan subregion (Bingham, 1905); Dehlan, (H.P.), (present study).

**Larval host Plant:** *Tragia cannabina* and *T. involucrata* (Bingham, 1905).

### IV. Genus: *Hypolimnas* Hübner

*Hypolimnas* Hübner, 1819, *Verz. bekantt. Schmett.*: 45.

***Hypolimnas missipus misippus* Linnaeus**

*Hypolimnas misippus misippus* Linnaeus, 1764, *Mus. Ulr.*: 264.

**Material examined:** Himachal Pradesh: Distt. Una; Haroli, 375m, 1.viii. 2008, 2 ♂, coll. Anita Kumari.

**Distribution:** Regio Indica, Africa, Australia, Guiana (www.nhm.ac.uk.); in Himalayas upto 6000 feet; extending to the Malayan subregion and China, (Bingham, 1905); Haroli (H.P.), (present study).

**Larval host Plant:** *Portulaco oleracea* (Bingham, 1905).

### V. Genus: *Junonia* Hübner

*Junonia* Hübner, 1819, *Verz. bekantt. Schmett*: 34, 35.

***Junonia almana almana* (Linnaeus)**

*Junonia almana almana* Linnaeus, 1758, *Syst. Nat.*: 472, n.89.

**Material examined:** Himachal Pradesh: Distt. Una; Una, 370m, 21.v. 2008, 1 ♀, 2 ♂; Santokhgarh, 378m, 1.iv. 2008, 1 ♀, coll. Anita Kumari.
**Distribution:** India, China (www.nhm.ac.uk); Una, Santokhgarh (H.P.), (present study).
**Larval host Plant:** *Mimulis gracilis*, Rice crop (Bingham, 1905).

***Junonia atlites atlites* (Linnaeus)**
*Precis atlites atlites* Linneaus, 1763, *Amoen. Acad.*6: 407, n.72.
**Material examined:** Himachal Pradesh: Distt. Una; Gagret, 472m, 1.vi. 2008, 2 ♂, coll. Anita Kumari.
**Distribution:** India, China, Java (www.nhm.ac.uk); Gagret (H.P.), (present study).
**Larval host Plant:** Unknown.

***Junonia lemonias lemonias* (Linnaeus)**
*Precis lemonias lemonias* Linnaeus, 1758, *Syst. Nat.*: 473.
**Material examined:** Himachal Pradesh: Distt. Una; Bangana, 573m, 17.v. 2008, 1 ♀, 1 ♂; Chauki maniar, 530m, 5.viii. 2008, 3 ♀; Dehlan, 374m, 4.viii. 2008, 2♀, coll. Anita Kumari.
**Distribution:** Regio Indica. (www.nhm.ac.uk); Bangana, Chauki maniar, Dehlan (H.P.), (present study).
**Larval host Plant:** Unknown.

***Junonia orithya* Linnaeus**
*Junonia orithya* Linnaeus, 1764, *Mus. Ulr.* :278. **Material examined:** Himachal Pradesh: Distt. Una; Daulatpur, 436m, 24.iii. 2008, 1 ♀, 2 ♂; Amb, 484m, 5.iv.2008, 3 ♀, 1 ♂; Bangana, 573m, 17.v.2008, 1 ♀, 4 ♂, coll. Anita Kumari.
**Distribution:** Regio, Indica, Africa, (www.nhm.ac.uk.) India, Ceylon, Assam, Burma, Tenasserim, China and the Malayan Subregion (Bingham, 1905); Daulatpur, Amb, Bangana (H.P.), (present study).
**Larval host plant:** Amaranthus, Sweet Potato (Bingham, 1905).

**VI. Genus: *Lethe* Hübner**
*Lethe* Hübner,1819, *Verz. bekantt. Schmett.*: 56.

***Lethe europa nudgara* Fabricius**
*Lethe europa nudgra* Fabricius, 1775, *Syst. Ent.*: 500.
**Material examined:** Himachal Pradesh: Distt. Una; Bharwain, 708m, 17.viii. 2008, 3 ♂, coll. Anita Kumari.
**Distribution:** Jawa, Bawean, Kagean, Nias, Philippinen (www.nhm.ac.uk.); the plains of northern India, lower hill of the Himalayas, Assam, Burma, Tenasserin, extending to China and the Malay Peninsula (Bingham, 1907); Bharwain (H.P.), (present study).
**Larval host Plant:** Unknown.

**VII. Genus: *Morpho* Fabricius**
*Morpho* Fabricius, 1807, *Ill. Mag.* 6:280.

***Morpho perseus perseus (Crammer)***
*Mycalesis perseus perseus* Cra mmer, 1779,*Pap. Ex.1*:71.
**Material examined:** Himachal Pradesh: Distt. Una; Amb, 484m, 5.iv. 2008, 1 ♀; Bangana, 573m, 17.v.2008, 1 ♀; Haroli, 375m, 1.viii.2008, 2 ♀, coll. Anita Kumari.
**Distribution:** Himalayas, Kangra to Sikhim, Bhutan, Bengal, Southern India, Ceylon, China and Malayan Subregion (Bingham, 1905); Amb, Bangana, Haroli (H.P.), (present study).
**Larval host Plant:** Grasses (Bingham, 1905).

**VIII. Genus: *Neptis* Fabricius**
*Neptis* Fabricius, 1807, *Ill.Mag.* 6 :282.

***Neptis hylas astola* Linnaeus**
*Neptis hylas astola* Linnaeus, 1758, *Syst. Nat. (Edn.x.)*: 486.
**Material examined:** Himachal Pradesh: Distt. Una; Daulatpur, 436m, 24.iii. 2008, 1 ♀, 1 ♂; Chintpurni, 710m, 7.v.2008, 1 ♀, coll. Anita Kumari.
**Distribution:** India (www.nhm.ac.uk.); Western and east Himalayas, Khasis Hills, and Upper Burma (Moore, 1890); Daulatpur, Chintpurni (H.P.), (present study).
**Larval host Plant:** Large flower Mexican clover (Moore, 1890).

**IX. Genus: *Pyronia* Hübner**
*Pyronia* Hübner,1816, *Verz. bekannt. Schmett.*: 59.

***Pyronia kashmirensis* (Ruhl)**
*Vanessa kasmirensis* Ruhl, 1894, *Pal Grosschmett.*: 596.
**Material examined:** Himachal Pradesh: Distt. Una; Mubarakpur, 490m, 15.iii. 2008, 2 ♀, 3 ♂; Daulatpur, 436m, 24.iii.2008, 4 ♀, 1 ♂, coll. Anita Kumari.
**Distribution:** The Himalayas from Kashmir to Sikhim (Bingham, 1905); Mubarkpur, Daulatpur (H.P.), (present study).
**Larval host Plant:** Unknown.

**X. Genus: *Satyrus* Westwood**
*Satyrus* Westwood, 1851, *Cen.diurn.Lep.* 2: 72.

***Satyrus swaha* (Kollar)**
*Aulocera swaha* Kollar, 1844, *Hugel's Kashmir*, 4: 444.

**Material examined:** Himachal Pradesh: Distt. Una; Mubarkpur, 490m, 15.iii. 2008, 2 ♀; Bangana, 573m, 17.v. 2008, 3 ♀, coll. Anita Kumari.
**Distribution:** Sikkim, Tschitral (www.nhm.ac.uk) Himalayas from Kashmir to east Kumaun (Bingham, 1905); Mubarkpur, Bangana (H.P), (present study).
**Larval host Plant:** Wild blue Iris (different grasses), (Bingham, 1905).

## Family: Papilionidae

**Diagnosis:** Head vertex very smooth, labial palpi three segmented, upcurved, maxillary palpi one segmented, haustellum naked, antennae filliform, clubbed, antennal pecten absent, ocelli absent, chaetosemata present, tympana absent, venation variable, wing coupling absent, forewing pterostigma absent, forewing chorda absent, forewing anal veins $A_1A_2$, forewing cell vein absent, hindwing pterostigma
absent, hindwing anal veins $A_{1+2}$, hindwing cell vein absent, epiphysis present, tibial spurs zero in forelegs and midlegs and two in hindlegs.

### XI. Genus: *Papilio* Linnaeus

*Papilio* Linnaeus, 1758, *Syst. Nat., (Edn.x)*1: 458.

#### *Papilio demoleus demoleus* Linnaeus

*Papillio demoleus* Linnaeus ,1758, *Sept. Nat. (Edn.x)*: 464, n.35.
**Material examined:** Himachal Pradesh: Distt.Una; Dehlan, 374m, 4.viii. 2008, 5 ♂; Bangana, 573m, 17.v. 2008, 3 ♀, 5 ♂, coll. Anita Kumari.
**Distribution:** China, Eainan, Tonkin, N.S.India, Ceylon, Perain (www.nhm.ac.uk); Ceylon, India, Northern Burma, Persia, Arabia (Bingham, 1907); Dehlan, Bangana (H.P.), (present study).
**Larval host Plant:** Citrus (Bingham, 1907).

#### *Papilio polytes nikobarus* Linnaeus

*Papilio polytes* Linnaeus, 1758, *Syst. Nat. (Edn. x)*: 460, n 7.
**Material examined:** Himachal Pradesh: Distt. Una; Gagret, 472m, 1.vi. 2008, 1 ♀, 1 ♂; Raipur, 545m, 2.viii. 2008, 2 ♀, 4 ♂, coll. Anita Kumari.
**Distribution:** Liu-Kiu, Formosa, China, Eainan, Tonkin, Ceylon, Perain (www.nhm.ac.uk) Andamans (Bingham, 1907); Gagret, Raipur (H.P), (present study).
**Larval host Plant:** Citrus, Murraya, Triphasia, Xanthoxylon (Talbot, 1939).

## Family: Pieridae

**Diagnosis:** Head vertex very smooth, labial palpi three segmented, upcurved, maxillary palpi absent, haustellum naked, antennae filliform, clubbed, antennal pecten absent, ocelli absent, chaetosemata present, tympana absent, venation variable, wing coupling absent, forewing pterostigma absent, forewing chorda absent, forewing anal veins $A_{1+2}$, forewing cell vein absent, hindwing pterostigma absent, hindwing anal veins $A_{1+2}A_3$, hindwing cell vein
absent, epiphysis present, tibial spurs zero in forelegs and two each in midlegs hindlegs.

### XII. Genus: *Atella* Doubleday

*Atella* Doubleday, 1847, *Gen. D. Lep.* (1). 165.

#### *Atella phlantha phlantha* Horsifield

*Atella phalantha phalantha* Horsifield, 1829, *Cat Lep. E. Ind. Comp.*: 7.
**Material examined:** Himachal Pradesh: Distt. Una; Basoli, 398m, 31.vii. 2008, 5 ♀, 2 ♂; Raipur, 545m, 2.viii. 2008, 2 ♀, 1 ♂, coll. Anita Kumari.
**Distribution:** Throughout Continental India, Ceylon, Assam, Burma, Tenasserin, China, Japan and the Malayan Subregion (Bingham, 1905); Basoli, Raipur (H.P.), (present study).
**Larval host Plant:** *Flacourtia* species (Bingham, 1905).

### XIII. Genus: *Catopsillia* Hübner

*Catopsilia* Hübner, 1823,*Verz.bekantt. Schmett.*: 98.

#### *Catopsilia pomona catilla* Fabricius

*Catopsilia pomona catilla* Crammer, 1779, *Pap. Exot.* 3: 63, pl. 229.
**Material examined:** Himachal Pradesh: Distt. Una; Santokhgarh, 368m, 1.iv. 2008, 1 ♀, 1 ♂; Basoli, 398m, 31.vii.2008, 4 ♀, 2 ♂, coll. Anita Kumari.
**Distribution:** Ceylon, India, Burma, Andaman and Nicobar Islands, South China to Solomon Islands and Australia (Talbot, 1939); Santokhgarh, Basoli (H.P.), (present study).
**Larval host Plant:** *Cassia fistula* (Talbot, 1939).

#### *Catopsilia pomona hilaria* Fabricius

*Catopsilia pomona hilaria* Crammer, 1781 *Pap.Exot.* 4: 95, pl. 339.
**Material examined:** Himachal Pradesh: Distt. Una; Gagret, 472m, 1.vi. 2008, 2 ♀, 2 ♂; Basoli, 398m, 31.vii.2008, 3 ♀, 1 ♂, coll. Anita Kumari.
**Distribution:** Ceylon, India, Burma Andaman and Nicobar Islands; South China to Solomon Islands and Australia (Talbot 1939); Gagret, Basoli (H.P.), (present study).

**Larval host Plant:** *Cassia fistula* (Talbot,1939).

***Catopsilia pyranthe minna* Linnaeus**
*Catopsilia pyranthe minna* Linnaeus, 1758. *Syst.Nat. (Edn.x)* 1: 469.
**Material examined:** Himachal Pradesh: Distt. Una; Daulatpur, 436m, 24.iii. 2008, 1 ♀, 6 ♂; Bangana, 573m, 17.v.2008, 3 ♂, coll. Anita Kumari.
**Distribution:** Celebes, Baluchistan to Malay Penninsula, Borneo, Sumatra, Java, South China, Formosa, Haonan to Philippines, India. (www.nhm.ac.uk.); Ceylon, India, Burma and Andaman Islands extending to Hainan, Formosa and South China, South and East to Borneo, Java, Celebes and the Philippines. (Talbot, 1939); Daulatpur, Bangana (H.P.), (present study).
**Larval host Plant:** *Cassia tora, Cassia auriculata* (Talbot, 1939).

**XIV. Genus: *Cepora* Billberg**
*Cepora* Billberg, 1820, *Enumer.Ins.*: 76.

***Cepora nerissa phryne* Fabricius**
*Cepora nerissa phryne* Fabricius, 1775, *Syst. Ent.*: 473.
**Material examined:** Himachal Pradesh: Distt. Una; Amb, 484m, 5.iv. 2008, 6 ♀,1 ♂, coll. Anita Kumari.
**Distribution:** N.W. Himalayas (to 4000ft) (www.nhm.ac.uk.); Nepal, Sikhim, Bhutan, Bengal, Assam, upper and lower Burma, Tenasserim, Siam and China (Bingham, 1907); Amb (H.P.), (present study).
**Larval host Plant:** Capparis (Bingham, 1907).

**XV. Genus: *Colias* Fabricius**
*Colias* Fabricius, 1807, *Ill.Mag.* 6: 284.

***Colias fieldi edusina* Leech***Colias fieldi edusina* Leech, 1893, *Butt. China*, 2: 438, pl.35, f: 6,7.
**Material examined:** Himachal Pradesh: Distt. Una; Haroli, 375m, 1.viii. 2008, 1 ♀, 5 ♂; Dehlan, 374m, 4.viii.2008, 3 ♀, 6 ♂, coll. Anita Kumari.
**Distribution:** Sikkim to North Burma (2500-14000 ft.) and North Yunnan (www.nhm.ac.uk.); Baluchistan to North Punjab, Sikkim and northern Burma, Western Himalayas (Bingham, 1907); Haroli, Dehlan (H.P.), (present study).
**Larval host Plant:** Feed on leguminosae, *Trifolium* (Bingham,1907).

***Colias hyale glicia* Linnaeus**
*Colias hyale glicia* Linnaeus, 1758, *Syst. Nat. (Edn.x)*, I: 71.
**Material examined:** Himachal Pradesh: Distt. Una; Bangana, 573m, 17.v.2008, 1 ♀, 2 ♂, coll. Anita Kumari.
**Distribution:** North (except South Russia), North Africa. (www.nhm.ac.uk.); Baluchistan, the Himalayas from Chitral, Kashmir to Bhutan and Palaearctic region (Bingham, 1907); Bangana (H.P.), (present study).
**Larval host Plant:** *Trifolium* (Bingham, 1907).

**XVI. Genus: *Delias* Hübner**
*Delias* Hübner, 1820, *Verz. bek. Schmett.*, p.91.

***Delias eucharis* Drury**
*Delias eucharis* Drury, 1773, Ill. *Ex. Ent.*2, pl. 10 f.5.
**Material examined:** Himachal Pradesh: Distt. Una; Chintpurni, 710mm, 7.vi. 2008, 2 ♂; Chauki Maniar, 530mm, 5.vii.2008, 1 ♀, 1 ♂, coll. Anita Kumari.
**Distribution:** India, Ceylon (Talbot, 1939); Chintpurni, Chauki Maniar (H.P.),(present study).
**Larval host Plant:** *Loranthus, Sisoo, Ficus glomerata* (Talbot, 1939).

**XVII. Genus: *Eurema* Hübner**
*Eurema* Hübner, 1819, *Verz. bek. Schmett.*: 96.

***Eurema hecabe merguiana* Linnaeus**
*Eurema hecabe merguiana* Linnaeus, 1758, *Syst. Nat.(Edn.x)* : 470.
**Material examined:** Himachal Pradesh: Distt. Una; Amb, 484m, 5.iv.2008, 2 ♀, 4 ♂, Basoli 398m.31.vii.2008, 4 ♀, 5 ♂, coll. Anita Kumari.
**Distribution:** South China, Bengal, Sikkim, Burma, Siam, Lankawi Island, Malay Pensula (www.nhm.ac.uk.); Spread eastwards to Siam and China, South far into the Malayan Subregion, and to west into parts of Ethiopian Region (Bingham, 1907); Amb, Basoli (H.P.), (present study).
**Larval host Plant:** *Sesbania aculeate* (a monsoon annual) and *Cassia tora* (Bingham, 1907).

**XVIII. Genus: *Ixias* Hübner**
*Ixias* Hübner, 1820, *Verz. bek. Schmett.*,: 95.

***Ixias marianne* Crammer**
*Ixias marianne* Crammer, 1779, *Exot. III*: 41: 217.
**Material examined:** Himachal Pradesh: Distt. Una; Daulatpur, 436m, 24.iii. 2008, 1 ♀, 1 ♂; Amb, 484m, 5.vii.2008, 1 ♂, coll. Anita Kumari.
**Distribution:** S. India, Ceylon. (www.nhm.ac.uk.); Ceylon to Peninsular, India, Punjab, Kumaon (Talbot,1939); Daulatpur, Amb (H.P.), (present study).
**Larval host Plant:** *Capparis sepiaria, C. divaricata, C.aphylla* and *C. grandis* (Talbot,1939).

***Ixias pyrene cingalensis* Linnaeus**

*Ixias pyrene cingalensis* Linneaus, 1764, *Mus. Ulr.* 241.

**Material examined:** Himachal Pradesh: Distt. Una; Santokhgarh, 368m, 1.viii. 2008, 3 ♂; Chauki Maniar, 530m, 5.vii.2008, 2 ♂; Haroli, 375m, 1.viii.2008, 4 ♂, coll. Anita Kumari.

**Distribution:** China (www.nhm.ac.uk.); Ceylon (Talbot, 1939); Santokhgarh, Chauki Maniar, Haroli (H.P.), (present study).

**Larval host Plant:** *Capparis sepiara* (Talbot, 1939).

**XIX. Genus: *Pieris* Schrank**

*Pieris* Schrank, 1801, *Fauna Boica*, 2, (1):152, 164.

***Pieris brassicae* Linnaeus**

*Pieris brassicae* Linnaeus, 1758, *Syst.Nat. (Edn.x)*, 467.

**Material examined:** Himachal Pradesh: Distt. Una; Mubarakpur, 490m, 15.iii.2008, 1 ♀, 3 ♂; Santokhgarh, 368m, 1.iv.2008, 4 ♀, 2 ♂; Bangana, 573m, 17.v.2008, 2 ♀, 3 ♂, coll. Anita Kumari.

**Distribution:** Europe to Asia Minor (www.nhm.ac.uk.); Europe, Northern Asia Central Asia, Himalayas from Chitral to Bhutan (upto 10,000 feet), North-west India Umballa (Bingham, 1907); Mubarkpur, Santokhgarh, Bangana (H.P.), (present study).

**Larval host Plant:** *Brassica* plants (Bingham, 1907).

***Pieris mesentima lordaca* Walker**

*Pieris mesentima lordaca* Walker, 1870, *Entom.*, 5: 48.

**Material examined:** Himachal Pradesh: Distt. Una; Bangana, 573m, 17.v. 2008, 2 ♂; Bharwain, 708m, 17.viii.2008, 2 ♂, coll. Anita Kumari.

**Distribution:** Himalayas from Kashmir to Sikhim, plains to southern India (Bingham, 1907); Bangana, Bharwain (H.P.)(presentstudy).

**Larval host Plant:** *Capparis aphylla, Caparris sepiaria, Capparis heyneana, Cadaba indica, Maerua arenaria* (Talbot, 1939).

## Discussion

Twenty-eight species belonging to nineteen genera *i.e., Aglais* Dalman, *Anosia* Hübner, *Ariadne* Horsifield, *Hypolimnas* Hübner, *Junonia* Hübner, *Lethe* Hübner, *Morpho* Fabricius, *Neptis* Fabricius, *Pyronia* Hübner, *Satyrus* Westwood, *Papilio* Linnaeus, *Atella* Doubleday, *Catopsilia* Hübner, *Cepora* Billberg, *Colias* Fabricius, *Delias* Hübner, *Eurema* Hübner, *Ixias* Hübner, *Pieris* Schrank belonging to three families i.e., Nymphalidae, Papilionidae and Pieridae of the superfamily Papilionoidea. Four species such as *Pieris brassicae* Linnaeus, *Papilio demoleus demoleus* Linnaeus, *Catopsilia pomona catilla* Fabricius and *Junonia orithya* Linnaeus are very common in these area.

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# List of Indian Ants (Hymenoptera: Formicidae)

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**Abstract**

**Ants of India are enlisted herewith. This has been carried due to major changes in terms of synonymies, addition of new taxa, recent shufflings etc. Currently, Indian ants are represented by 652 valid species/subspecies falling under 87 genera grouped into 12 subfamilies.**

**Keywords:** *Ants, India, Hymenoptera, Formicidae.*

## Introduction

The following 652 valid species/subspecies of ants are known to occur in India. Since Bingham's Fauna of 1903, ant taxonomy has undergone major changes in terms of synonymies, discovery of new taxa, shuffling of taxa etc. This has lead to chaotic state of affairs in Indian scenario, many lists appeared on web without looking into voluminous literature which has surfaced in last many years and currently the pace at which new publications are appearing in myrmecology. This species list is based upon the effort of many ant collectors as well as myrmecologists who have published on the taxonomy of Indian ants and from inputs provided by myrmecologists from other parts of world. However, the other running/dynamic list continues to appear on http://www.antweb.org/india.jsp, which is periodically updated and contains information about new/unconfirmed taxa, still to be published or verified.

| Subfamily | Genus | Species and subspecies |
|---|---|---|
| Aenictinae | *Aenictus* | 28 |
| Amblyoponinae | *Amblyopone* | 3 |
| | *Myopopone* | 1 |
| | *Mystrium* | 1 |
| Cerapachyinae | *Cerapachys* | 6 |
| | *Sphinctomyrmex* | 1 |
| Dolichoderinae | *Bothriomyrmex* | 3 |
| | *Chronoxenus* | 1 |
| | *Dolichoderus* | 10 |
| | *Iridomyrmex* | 2 |
| | *Liometopum* | 1 |
| | *Philidris* | 1 |
| | *Tapinoma* | 6 |
| | *Technomyrmex* | 8 |

| | | |
|---|---|---|
| Dorylinae | *Dorylus* | 3 |
| Ectatomminae | *Gnamptogenys* | 4 |
| Formicinae | *Acropyga* | 2 |
| | *Anoplolepis* | 1 |
| | *Camponotus* | 62 |
| | *Cataglyphis* | 3 |
| | *Echinopla* | 1 |
| | *Formica* | 8 |
| | *Gesomyrmex* | 1 |
| | *Lasius* | 16 |
| | *Lepisiota* | 12 |
| | *Myrmoteras* | 3 |
| | *Nylanderia* | 7 |
| | *Oecophylla* | 1 |
| | *Paratrechina* | 1 |
| | *Plagiolepis* | 7 |
| | *Polyrhachis* | 48 |
| | *Prenolepis* | 1 |
| | *Pseudolasius* | 1 |
| Leptanillinae | *Leptanilla* | 1 |
| | *Yavnella* | 1 |
| Myrmicinae | *Anillomyrma* | 1 |
| | *Aphaenogaster* | 13 |
| | *Cardiocondyla* | 11 |
| | *Carebara* | 11 |
| | *Cataulacus* | 5 |
| | *Crematogaster* | 41 |
| | *Dilobocondyla* | 1 |
| | *Gauromyrmex* | 1 |
| | *Indomyrma* | 1 |
| | *Kartidris* | 1 |
| | *Leptothorax* | 1 |
| | *Liomyrmex* | 1 |
| | *Lophomyrmex* | 6 |
| | *Mayriella* | 2 |
| | *Meranoplus* | 5 |

| | | |
|---|---|---|
| | *Messor* | 2 |
| | *Metapone* | 1 |
| | *Monomorium* | 25 |
| | *Myrmecina* | 4 |
| | *Myrmica* | 32 |
| | *Myrmicaria* | 2 |
| | *Paratopula* | 3 |
| | *Perissomyrmex* | 1 |
| | *Pheidole* | 54 |
| | *Pheidologeton* | 2 |
| | *Pyramica* | 3 |
| | *Recurvidris* | 1 |
| | *Rhopalomastix* | 1 |
| | *Rhoptromyrmex* | 2 |
| | *Solenopsis* | 1 |
| | *Stenamma* | 1 |
| | *Strumigenys* | 14 |
| | *Temnothorax* | 9 |
| | *Tetramorium* | 30 |
| | *Tyrannomyrmex* | 1 |
| | *Vollenhovia* | 1 |
| | *Vombisidris* | 2 |
| Ponerinae | *Anochetus* | 9 |
| | *Centromyrmex* | 1 |
| | *Diacamma* | 12 |
| | *Emeryopone* | 1 |
| | *Harpegnathos* | 2 |
| | *Hypoponera* | 5 |
| | *Leptogenys* | 29 |
| | *Odontomachus* | 4 |
| | *Odontoponera* | 1 |
| | *Pachycondyla* | 22 |
| | *Platythyrea* | 3 |
| Proceratiinae | *Discothyrea* | 1 |
| | *Probolomyrmex* | 2 |
| | *Proceratium* | 2 |
| Pseudomyrmecinae | *Tetraponera* | 9 |

1 ***Acropyga*** *acutiventris* Roger, 1862
2 *Acropyga rubescens* Forel, 1894
3 ***Aenictus*** *aitkenii* Forel, 1901
4 *Aenictus ambiguus* Shuckard, 1840
5 *Aenictus arya* Forel, 1901
6 *Aenictus binghami* Forel, 1900
7 *Aenictus brevicornis* (Mayr, 1879)
8 *Aenictus certus* Westwood, 1842
9 *Aenictus ceylonicus* (Mayr, 1866)
10 *Aenictus clavatus* Forel, 1901
11 *Aenictus clavatus kanariensis* Forel, 1901
12 *Aenictus clavitibia* Forel, 1901
13 *Aenictus dentatus* Forel, 1911
14 *Aenictus doryloides* Wilson, 1964
15 *Aenictus fergusoni* Forel, 1901
16 *Aenictus gleadowii* Forel, 1901
17 *Aenictus gracilis* Emery, 1893
18 *Aenictus laeviceps* Smith, F.,1857
19 *Aenictus latiscapus* Forel, 1901
20 *Aenictus longi* Forel, 1901
21 *Aenictus pachycerus* (Smith, F., 1858)
22 *Aenictus peguensis* Emery, 1895
23 *Aenictus piercei* Wheeler, W. M. & Chapman, 1930
24 *Aenictus pubescens* Smith, F., 1859
25 *Aenictus punensis* Forel, 1901
26 *Aenictus sagei* Forel, 1901
27 *Aenictus shillongensis* Tiwari, 2000
28 *Aenictus shuckardi* Forel, 1901
29 *Aenictus westwoodi* Forel, 1901
30 *Aenictus wroughtonii* Forel, 1890
31 ***Amblyopone*** *bellii* Forel, 1900
32 *Amblyopone pertinax* Baroni Urbani, 1978
33 *Amblyopone rothneyi* Forel, 1900
34 ***Anillomyrma*** *decamera* (Emery, 1901)
35 ***Anochetus*** *graeffei* Mayr, 1870
36 *Anochetus kanariensis* Forel, 1900
37 *Anochetus madaraszi* Mayr, 1897
38 *Anochetus myops* Emery, 1893
39 *Anochetus obscurior* Brown, 1978
40 *Anochetus pupulatus* Brown, 1978
41 *Anochetus rufus* (Jerdon, 1851)
42 *Anochetus sedilloti* Emery, 1884
43 *Anochetus yerburyi* Forel, 1900
44 ***Anoplolepis*** *gracilipes* (Smith, F., 1857)
45 ***Aphaenogaster*** *annandalei* Mukerjee, 1930
46 *Aphaenogaster beccarii* Emery, 1887
47 *Aphaenogaster beesoni* Donisthorpe, 1933
48 *Aphaenogaster cavernicola* Donisthorpe, 1938
49 *Aphaenogaster cristata* (Forel, 1902)
50 *Aphaenogaster feae* Emery, 1899
51 *Aphaenogaster longiceps* (Smith, F., 1858)
52 *Aphaenogaster rothneyi* (Forel, 1902)
53 *Aphaenogaster sagei* (Forel, 1902)
54 *Aphaenogaster sagei pachei* (Forel, 1906)
55 *Aphaenogaster schurri* (Forel, 1902)
56 *Aphaenogaster smythiesii* (Forel, 1902)
57 *Aphaenogaster smythiesii prudens* (Forel, 1902)
58 ***Bothriomyrmex*** *dalyi* Forel, 1895
59 *Bothriomyrmex walshi* Forel, 1895
60 *Bothriomyrmex wroughtonii* Forel, 1895
61 ***Camponotus*** *aethiops cachmiriensis* Emery, 1925
62 *Camponotus albosparsus* Bingham, 1903
63 *Camponotus angusticollis* (Jerdon, 1851)
64 *Camponotus angusticollis sanguinolentus* Forel, 1895
65 *Camponotus arrogans* (Smith, F., 1858)
66 *Camponotus ashokai* Karmaly & Narendran, 2006
67 *Camponotus badius* (Smith, F., 1857)
68 *Camponotus barbatus taylori* Forel, 1892
69 *Camponotus buddhae* Forel, 1892
70 *Camponotus camelinus* (Smith, F., 1857)
71 *Camponotus cinerascens* (Fabricius, 1787)
72 *Camponotus compressus* (Fabricius, 1787)
73 *Camponotus confucii* Forel, 1894
74 *Camponotus cotesii* Forel, 1893
75 *Camponotus crassisquamis* Forel, 1902
76 *Camponotus dolendus* Forel, 1892
77 *Camponotus exiguoguttatus* Forel, 1886
78 *Camponotus gretae* Forel, 1902
79 *Camponotus himalayanus* Forel, 1893
80 *Camponotus holosericeus* Emery, 1889
81 *Camponotus horseshoetus* Datta & Raychaudhuri, 1985
82 *Camponotus invidus* Forel, 1892
83 *Camponotus irritans* (Smith, F., 1857)
84 *Camponotus kattensis* Bingham, 1903
85 *Camponotus keralensis* Karmaly & Narendran, 2006
86 *Camponotus lamarckii* Forel, 1892
87 *Camponotus leonardi* Emery, 1889
88 *Camponotus longi* Forel, 1902
89 *Camponotus luteus* (Smith, F., 1858)
90 *Camponotus megalonyx* Wheeler, W. M., 1919
91 *Camponotus mendax* Forel, 1895
92 *Camponotus misturus fornaronis* Forel, 1892
93 *Camponotus mitis* (Smith, F., 1858)
94 *Camponotus nicobarensis* Mayr, 1865
95 *Camponotus nirvanae* Forel, 1893
96 *Camponotus oblongus binominatus* Forel, 1916
97 *Camponotus opaciventris* Mayr, 1879
98 *Camponotus parius* Emery, 1889
99 *Camponotus phragmaticola* Donisthorpe, 1943
100 *Camponotus puniceps* Donisthorpe, 1942
101 *Camponotus radiatus* Forel, 1892
102 *Camponotus reticulatus latitans* Forel, 1893
103 *Camponotus rothneyi* Forel, 1893
104 *Camponotus rufifemur* Emery, 1900
105 *Camponotus rufoglaucus* (Jerdon, 1851)
106 *Camponotus rufoglaucus tenuis* Forel, 1907
107 *Camponotus selene* (Emery, 1889)
108 *Camponotus sericeus* (Fabricius, 1798)
109 *Camponotus siemsseni* Forel, 1901
110 *Camponotus socrates* Forel, 1904
111 *Camponotus strictus* (Jerdon, 1851)
112 *Camponotus sylvaticus basalis* Smith, F., 1878
113 *Camponotus sylvaticus paradichrous* Emery, 1925
114 *Camponotus timidus* (Jerdon, 1851)
115 *Camponotus varians* Roger, 1863
116 *Camponotus variegatus fuscithorax* Dalla Torre, 1893
117 *Camponotus variegatus somnificus* Forel, 1902
118 *Camponotus varius* Donisthorpe, 1943
119 *Camponotus velox* (Jerdon, 1851)
120 *Camponotus vitreus* (Smith, F., 1860)
121 *Camponotus wasmanni* Emery, 1893
122 *Camponotus wroughtonii* Forel, 1893
123 ***Cardiocondyla*** *breviscapa* Seifert, 2003
124 *Cardiocondyla carbonaria* Forel, 1907
125 *Cardiocondyla goa* Seifert, 2003
126 *Cardiocondyla kagutsuchi* Terayama, 1999

127 *Cardiocondyla mauritanica* Forel, 1890
128 *Cardiocondyla nuda* (Mayr, 1866)
129 *Cardiocondyla opaca* Seifert, 2003
130 *Cardiocondyla parvinoda* Forel, 1902
131 *Cardiocondyla shagrinata* Seifert, 2003
132 *Cardiocondyla tiwarii* Gosh, Sheela & Kundu, 2005
133 *Cardiocondyla wroughtonii* (Forel, 1890)
**134** **Carebara** *aborensis* (Wheeler, W.M., 1913)
135 *Carebara asina* (Forel, 1902)
136 *Carebara bengalensis* (Forel, 1902)
137 *Carebara lamellifrons* (Forel, 1902)
138 *Carebara leei* (Forel, 1902)
139 *Carebara lignata* Westwood, 1840
140 *Carebara nayana* (Sheela & Narendran, 1997)
141 *Carebara raja* (Forel, 1902)
142 *Carebara rothneyi* (Forel, 1902)
143 *Carebara similis* (Mayr, 1862)
144 *Carebara wroughtonii* (Forel, 1902)
**145** **Cataglyphis** *cugiai* Menozzi, 1939
146 *Cataglyphis indicus* Pisarski, 1961
147 *Cataglyphis longipedem* (Eichwald, 1841)
**148** **Cataulacus** *granulatus* (Latreille, 1802)
149 *Cataulacus latus* Forel, 1891
150 *Cataulacus muticus* Emery, 1889
151 *Cataulacus simoni* Emery, 1893
152 *Cataulacus taprobanae* Smith, F., 1853
**153** **Centromyrmex** *feae* (Emery, 1889)
**154** **Cerapachys** *aitkenii* Forel, 1900
155 *Cerapachys besucheti* Brown, 1975
156 *Cerapachys biroi* Forel, 1907
157 *Cerapachys indicus* Brown, 1975
158 *Cerapachys longitarsus* (Mayr, 1879)
159 *Cerapachys sulcinodis* Emery, 1889
**160** **Chronoxenus** *myops* (Forel, 1895)
**161** **Crematogaster** *abdominalis* Motschoulsky, 1863
162 *Crematogaster aberrans* Forel, 1892
163 *Crematogaster aberrans assmuthi* Forel, 1913
164 *Crematogaster aberrans inglebyi* Forel, 1902
165 *Crematogaster aitkenii* Forel, 1902
166 *Crematogaster anthracina* Smith, F., 1857
167 *Crematogaster betapicalis* Bolton, 1995
168 *Crematogaster binghamii* Forel, 1904
169 *Crematogaster biroi* Mayr, 1897
170 *Crematogaster biroi smythiesii* Forel, 1902
171 *Crematogaster brunnea contemta* Mayr, 1879
172 *Crematogaster brunnea nicevillei* Emery, 1922
173 *Crematogaster brunnea nilgirica* Emery, 1922
174 *Crematogaster brunnea rabula* Forel, 1902
175 *Crematogaster brunnea ruginota* Santschi, 1928
176 *Crematogaster buddhae* Forel, 1902
177 *Crematogaster dalyi* Forel, 1902
178 *Crematogaster dalyi sikkimensis* Forel, 1904
179 *Crematogaster diffusa* (Jerdon, 1851)
180 *Crematogaster dohrni artifex* Mayr, 1879
181 *Crematogaster ebenina* Forel, 1902
182 *Crematogaster flava* Forel, 1886
183 *Crematogaster himalayana* Forel, 1902
184 *Crematogaster hogsoni* Forel, 1902
185 *Crematogaster kirbii* (Sykes, 1835)
186 *Crematogaster perelegans* Forel, 1902
187 *Crematogaster politula* Forel, 1902
188 *Crematogaster pradipi* Tiwari, 1999
189 *Crematogaster ransonneti* Mayr, 1868
190 *Crematogaster rogenhoferi* Mayr, 1879
191 *Crematogaster rothneyi* Mayr, 1879
192 *Crematogaster rothneyi civa* Forel, 1902
193 *Crematogaster rufa* (Jerdon, 1851)
194 *Crematogaster sagei* Forel, 1902
195 *Crematogaster sagei laevinota* Forel, 1902
196 *Crematogaster soror* Forel, 1902
197 *Crematogaster subnuda* Mayr, 1879
198 *Crematogaster travancorensis* Forel, 1902
199 *Crematogaster urvijae* Bharti, 2003
200 *Crematogaster walshi* Forel, 1902
201 *Crematogaster wroughtonii* Forel, 1902
**202** **Diacamma** *assamense* Forel, 1897
203 *Diacamma ceylonense* Emery, 1897
204 *Diacamma cyaneiventre* André, 1887
205 *Diacamma indicum* Santschi, 1920
206 *Diacamma rugosum* (Le Guillou, 1842)
207 *Diacamma rugosum doveri* Mukerjee, 1934
208 *Diacamma rugosum jerdoni* Forel, 1903
209 *Diacamma rugosum rothneyi* Forel, 1900
210 *Diacamma rugosum sculptum* (Jerdon, 1851)
211 *Diacamma rugosum sikkimense* Forel, 1903
212 *Diacamma rugosum viridipurpureum* Emery, 1893
213 *Diacamma scalpratum* (Smith, F., 1858)
**214** **Dilobocondyla** *bangalorica* Varghese, 2006
**215** **Discothyrea** *sringerensis* Zacharias & Rajan, 2004
**216** **Dolichoderus** *affinis glabripes* Forel, 1895
217 *Dolichoderus feae* Emery, 1889
218 *Dolichoderus feae fuscus* Emery, 1889
219 *Dolichoderus moggridgei* Forel, 1886
220 *Dolichoderus moggridgei bicolor* Santschi, 1920
221 *Dolichoderus moggridgei lugubris* Santschi, 1920
222 *Dolichoderus sundari* Tiwari, 2000
223 *Dolichoderus taprobanae* (Smith, F., 1858)
224 *Dolichoderus taprobanae gracilipes* (Mayr, 1879)
225 *Dolichoderus thoracius* (Smith, F., 1860)
**226** **Dorylus** *labiatus* Shuckard, 1840
227 *Dorylus orientalis* Westwood, 1835
228 *Dorylus orientalis obscuriceps* Santschi, 1920
**229** **Echinopla** *lineata* Mayr, 1862
**230** **Emeryopone** *narendrani* Varghese, 2006
**231** **Formica** *clara* Forel, 1886
232 *Formica fusca* Linnaeus, 1758
233 *Formica gagates* Latreille, 1798
234 *Formica gravelyi* Mukerjee, 1930
235 *Formica kashmirica* Starcke, 1935
236 *Formica rufibarbis* Fabricius, 1793
237 *Formica sanguinea* Latreille, 1798
238 *Formica truncorum* Fabricius, 1804
**239** **Gauromyrmex** *acanthinus* (Karavaiev, 1935)
**240** **Gesomyrmex** *spatulatus* Cole, 1949
**241** **Gnamptogenys** *bicolor* (Emery, 1889)
242 *Gnamptogenys binghamii* (Forel, 1900)
243 *Gnamptogenys coxalis* (Roger, 1860)
244 *Gnamptogenys meghalaya* Lattke, 2004
**245** **Harpegnathos** *saltator* Jerdon, 1851
246 *Harpegnathos venator* (Smith, F., 1858)
**247** **Hypoponera** *assmuthi* (Forel, 1905)
248 *Hypoponera confinis* (Roger, 1860)
249 *Hypoponera confinis aitkenii* (Forel, 1900)
250 *Hypoponera confinis wroughtonii* (Forel, 1900)
251 *Hypoponera ragusai* (Emery,1894)
**252** **Indomyrma** *dasypyx* Brown, 1986

**253** ***Iridomyrmex*** *anceps* (Roger, 1863)
254 *Iridomyrmex anceps sikkimensis* Forel, 1904
**255** ***Kartidris*** *nyos* Bolton, 1991
**256** ***Lasius*** *alienoflavus* Bingham, 1903
257 *Lasius alienus* (Foerster, 1850)
258 *Lasius bicornis* (Foerster, 1850)
259 *Lasius breviscapus* Seifert, 1992
260 *Lasius brunneus* (Latreille, 1798)
261 *Lasius crinitus* (Smith, F., 1858)
262 *Lasius draco* Collingwood, 1982
263 *Lasius fuliginosus* (Latreille, 1798)
264 *Lasius himalayanus* Bingham, 1903
265 *Lasius hirsutus* Seifert, 1992
266 *Lasius lawarai* Seifert, 1992
267 *Lasius magnus* Seifert, 1992
268 *Lasius mikir* Collingwood, 1982
269 *Lasius niger* (Linnaeus, 1758)
270 *Lasius talpa* Wilson, 1955
271 *Lasius wittmeri* Seifert, 1992
**272** ***Lepisiota*** *annandalei* (Mukerjee, 1930)
273 *Lepisiota bipartita* (Smith, F., 1861)
274 *Lepisiota capensis* (Mayr, 1862)
275 *Lepisiota capensis simplex* (Forel, 1892)
276 *Lepisiota fergusoni* (Forel, 1895)
277 *Lepisiota frauenfeldi integra* (Forel, 1894)
278 *Lepisiota modesta* (Forel, 1894)
279 *Lepisiota opaca* (Forel, 1892)
280 *Lepisiota opaca pulchella* (Forel, 1892)
281 *Lepisiota rothneyi* (Forel, 1894)
282 *Lepisiota rothneyi wroughtonii* (Forel, 1902)
283 *Lepisiota sericea* (Forel, 1892)
**284** ***Leptanilla*** *escheri* (Kutter, 1948)
**285** ***Leptogenys*** *assamensis* Forel, 1900
286 *Leptogenys binghamii* Forel, 1900
287 *Leptogenys birmana* Forel, 1900
288 *Leptogenys carinata* Donisthorpe, 1943
289 *Leptogenys chinensis* (Mayr, 1870)
290 *Leptogenys dalyi* Forel, 1900
291 *Leptogenys dentilobis* Forel, 1900
292 *Leptogenys diminuta* (Smith, F., 1857)
293 *Leptogenys diminuta deceptrix* Forel, 1901
294 *Leptogenys diminuta diminutolaeviceps* Forel, 1900
295 *Leptogenys diminuta laeviceps* (Smith, F., 1857)
296 *Leptogenys diminuta palliseri* Forel, 1900
297 *Leptogenys diminuta woodmasoni* (Forel, 1886)
298 *Leptogenys emiliae* Forel, 1902
299 *Leptogenys hysterica* Forel, 1900
300 *Leptogenys iridipennis* (Smith, F., 1858)
301 *Leptogenys jeanettei* Tiwari, 2000
302 *Leptogenys kitteli* (Mayr, 1870)
303 *Leptogenys kitteli minor* Forel, 1900
304 *Leptogenys longiscapa* Donisthorpe, 1943
305 *Leptogenys lucidula* Emery, 1895
306 *Leptogenys minchinii* Forel, 1900
307 *Leptogenys moelleri* (Bingham, 1903)
308 *Leptogenys peuqueti* (André, 1887)
309 *Leptogenys processionalis* (Jerdon, 1851)
310 *Leptogenys punctiventris* (Mayr, 1879)
311 *Leptogenys roberti* Forel, 1900
312 *Leptogenys roberti coonoorensis* Forel, 1900
313 *Leptogenys stenocheilos* (Jerdon, 1851)
**314** ***Leptothorax*** *acervorum* (Fabricius, 1793)
**315** ***Liometopum*** *lindgreeni* Forel, 1902
**316** ***Liomyrmex*** *gestroi* (Emery, 1887)
**317** ***Lophomyrmex*** *ambiguus* Rigato, 1994
318 *Lophomyrmex bedoti* Emery, 1893
319 *Lophomyrmex birmanus* Emery, 1893
320 *Lophomyrmex changlangensis* Sheela & Ghosh, 2008
321 *Lophomyrmex kali* Rigato, 1994
322 *Lophomyrmex quadrispinosus* (Jerdon, 1851)
**323** ***Mayriella*** *transfuga* Baroni Urbani, 1977
324 *Mayriella warchalowskii* Borowiec, 2007
**325** ***Meranoplus*** *bellii* Forel, 1902
326 *Meranoplus bicolor* (Guerin-Meneville,1844)
327 *Meranoplus laeviventris* Emery, 1889
328 *Meranoplus levis* Donisthorpe, 1942
329 *Meranoplus rothneyi* Forel, 1902
**330** ***Messor*** *himalayanus* (Forel, 1902)
331 *Messor instabilis* (Smith, F., 1858)
**332** ***Metapone*** *nicobarensis* Tiwari & Jonathan, 1986
**333** ***Monomorium*** *aberrans* Forel, 1902
334 *Monomorium atomum* Forel, 1902
335 *Monomorium atomum integrium* Forel, 1902
336 *Monomorium biroi* Forel, 1907
337 *Monomorium criniceps* (Mayr, 1879)
338 *Monomorium destructor* (Jerdon, 1851)
339 *Monomorium dichroum* Forel, 1902
340 *Monomorium effractor* Bolton, 1987
341 *Monomorium floricola* (Jerdon, 1851)
342 *Monomorium glabrum* (Andre, 1883)
343 *Monomorium indicum* Forel, 1902
344 *Monomorium kempi* Mukerjee, 1930
345 *Monomorium latinode* Mayr, 1872
346 *Monomorium longi* Forel, 1902
347 *Monomorium luisae* Forel, 1904
348 *Monomorium mayri* Forel, 1902
349 *Monomorium monomorium* Bolton, 1987
350 *Monomorium orientale* Mayr, 1879
351 *Monomorium pharaonis* (Linnaeus, 1758)
352 *Monomorium rugifrons* (Smith, F., 1858)
353 *Monomorium sagei* Forel, 1902
354 *Monomorium scabriceps* (Mayr, 1879)
355 *Monomorium schurri* Forel, 1902
356 *Monomorium wroughtoni* Forel, 1902
357 *Monomorium wroughtonianum* Ettershank, 1966
**358** ***Myopopone*** *castanea* (Smith, F., 1860)
**359** ***Myrmecina*** *pilicornis* Smith, F., 1858
360 *Myrmecina striata* Emery, 1889
361 *Myrmecina urbanii* Tiwari, 1994
362 *Myrmecina vidyae* Tiwari, 1994
**363** ***Myrmica*** *afghanica* Radchenko & Elmes, 2003
364 *Myrmica aimonissabaudiae* Menozzi, 1939
365 *Myrmica boltoni* Radchenko & Elmes, 1998
366 *Myrmica brancuccii* Radchenko & Elmes, 1999
367 *Myrmica cachmiriensis* Forel, 1904
368 *Myrmica collingwoodi* Radchenko & Elmes, 1998
369 *Myrmica ereptrix* Bolton, 1988
370 *Myrmica foreliana* Radchenko & Elmes, 2001
371 *Myrmica fortior* Forel, 1904
372 *Myrmica hecate* Weber, 1947
373 *Myrmica indica* Weber, 1950
374 *Myrmica inezae* Forel, 1902
375 *Myrmica kozlovi* Ruzsky, 1915
376 *Myrmica martensi* Radchenko & Elmes, 1998
377 *Myrmica nitida* Radchenko & Elmes, 1999
378 *Myrmica ordinaria* Radchenko & Elmes, 1999

379 *Myrmica pachei* Forel, 1906
380 *Myrmica petita* Radchenko & Elmes, 1999
381 *Myrmica rhytida* Radchenko & Elmes, 1999
382 *Myrmica rigatoi* Radchenko & Elmes, 1998
383 *Myrmica rugosa* Mayr, 1865
384 *Myrmica rupestris* Forel, 1902
385 *Myrmica smythiesii* Forel, 1902
386 *Myrmica tenuispina* Ruzsky, 1905
387 *Myrmica urbanii* Radchenko & Elmes, 1998
388 *Myrmica varisculpta* Radchenko & Rigato, 2009
389 *Myrmica villosa* Radchenko & Elmes, 1999
390 *Myrmica vittata* Radchenko & Elmes, 1999
391 *Myrmica wardi* Radchenko & Elmes, 1999
392 *Myrmica weberi* Elmes & Radchenko, 2009
393 *Myrmica williamsi* Radchenko & Elmes, 1999
394 *Myrmica wittmeri* Radchenko & Elmes, 1999
**395** ***Myrmicaria*** *brunnea* Saunders, 1842
396 *Myrmicaria fodica* (Jerdon, 1851)
**397** ***Myrmoteras*** *brachygnathum* Moffett, 1985
398 *Myrmoteras indicum* Moffett, 1985
399 *Myrmoteras scabrum* Moffett, 1985
**400** ***Mystrium*** *camillae* Emery, 1889
**401** ***Nylanderia*** *aseta* (Forel, 1902)
402 *Nylanderia assimilis* (Jerdon, 1851)
403 *Nylanderia bourbonica* (Forel, 1886)
404 *Nylanderia indica* (Forel, 1894)
405 *Nylanderia smythiesii* (Forel, 1894)
406 *Nylanderia taylori* (Forel, 1894)
407 *Nylanderia yerburyi* (Forel, 1894)
**408** ***Odontomachus*** *haematodus* (Linnaeus, 1758)
409 *Odontomachus monticola* Emery, 1892
410 *Odontomachus rixosus* Smith, F., 1857
411 *Odontomachus simillimus* Smith, F., 1858
**412** ***Odontoponera*** *transversa* (Smith, F.,1857)
**413** ***Oecophylla*** *smaragdina* (Fabricius, 1775)
**414** ***Pachycondyla*** *amblyops* (Emery, 1887)
415 *Pachycondyla annamita arcuata* (Forel, 1900)
416 *Pachycondyla astuta* Smith, F., 1858
417 *Pachycondyla bispinosa* Smith, F., 1858
418 *Pachycondyla darwinii* (Forel, 1893)
419 *Pachycondyla darwinii indica* (Emery, 1899)
420 *Pachycondyla henryi* Donisthorpe, 1942
421 *Pachycondyla javana* (Mayr, 1867)
422 *Pachycondyla jerdonii* (Forel, 1900)
423 *Pachycondyla leeuwenhoeki* (Forel, 1886)
424 *Pachycondyla luteipes* (Mayr, 1862)
425 *Pachycondyla luteipes continentalis* (Karavaiev, 1925)
426 *Pachycondyla melanaria* (Emery, 1893)
427 *Pachycondyla nicobarensis* Forel, 1905
428 *Pachycondyla nigrita* (Emery, 1895)
429 *Pachycondyla rubiginosa* (Emery, 1889)
430 *Pachycondyla rufipes* (Jerdon, 1851)
431 *Pachycondyla striolata* Donisthorpe, 1933
432 *Pachycondyla sulcata* (Mayr, 1867)
433 *Pachycondyla sulcata fossulata* (Forel, 1900)
434 *Pachycondyla sulcata sulcatotesserinoda* (Forel, 1900)
435 *Pachycondyla tesseronoda* (Emery, 1877)
**436** ***Paratopula*** *andamensis* (Forel, 1903)
437 *Paratopula ceylonica* (Emery, 1901)
438 *Paratopula intermedia* Sheela & Narendran, 1998
**439** ***Paratrechina*** *longicornis* (Latreille, 1802)
**440** ***Perissomyrmex*** *nepalensis* Radchenko, 2003
**441** ***Pheidole*** *allani* Bingham, 1903
442 *Pheidole bandata* Bharti, 2004
443 *Pheidole binghamii* Forel, 1902
444 *Pheidole capellinii* Emery, 1887
445 *Pheidole constanciae* Forel, 1902
446 *Pheidole constanciae nigra* Forel, 1902
447 *Pheidole coonoorensis* Forel, 1902
448 *Pheidole diffusa* (Jerdon, 1851)
449 *Pheidole duneraensis* Bharti, 2001
450 *Pheidole feae* Emery, 1895
451 *Pheidole fergusoni* Forel, 1902
452 *Pheidole fervens* Smith, F., 1858
453 *Pheidole ghatica* Forel, 1902
454 *Pheidole grayi* Forel, 1902
455 *Pheidole hospita* Bingham, 1903
456 *Pheidole indica* Mayr, 1879
457 *Pheidole jucunda* Forel, 1885
458 *Pheidole jucunda fossulata* Forel, 1902
459 *Pheidole lamellinoda* Forel, 1902
460 *Pheidole lanuginosa* Wilson, 1984
461 *Pheidole latinoda angustior* Forel, 1902
462 *Pheidole latinoda major* Forel, 1885
463 *Pheidole longipes* (Latreille, 1802)
464 *Pheidole malabarica* (Jerdon, 1851)
465 *Pheidole malinsii* Forel, 1902
466 *Pheidole megacephala* (Fabricius, 1793)
467 *Pheidole minor* (Jerdon, 1851)
468 *Pheidole multidens* Forel, 1902
469 *Pheidole mus* Forel, 1902
470 *Pheidole naoroji* Forel, 1902
471 *Pheidole noda* Smith, F., 1874
472 *Pheidole parasitica* Wilson, 1984
473 *Pheidole parva decanica* Forel, 1902
474 *Pheidole phipsoni* Forel, 1902
475 *Pheidole pronotalis* Forel, 1902
476 *Pheidole providens* (Sykes, 1835)
477 *Pheidole roberti* Forel, 1902
478 *Pheidole rogersi* Forel, 1902
479 *Pheidole rogersi taylori* Forel, 1902
480 *Pheidole sagei* Forel, 1902
481 *Pheidole sepulchralis* Bingham, 1903
482 *Pheidole sharpi* Forel, 1902
483 *Pheidole sharpi hoogwerfi* Forel, 1902
484 *Pheidole smythiesii bengalensis* Forel, 1902
485 *Pheidole smythiesii* Forel, 1902
486 *Pheidole spathifera* Forel, 1902
487 *Pheidole spathifera aspatha* Forel, 1902
488 *Pheidole sulcaticeps punensis* Forel, 1902
489 *Pheidole sykesii* Forel, 1902
490 *Pheidole templaria* Forel, 1902
491 *Pheidole terraceensis* Bharti, 2001
492 *Pheidole watsoni* Forel, 1902
493 *Pheidole woodmasoni* Forel, 1885
494 *Pheidole wroughtonii* Forel, 1902
**495** ***Pheidologeton*** *affinis* (Jerdon, 1851)
496 *Pheidologeton diversus* (Jerdon, 1851)
**497** ***Philidris*** *myrmecodiae andamanensis* (Forel, 1903)
**498** ***Plagiolepis*** *balestrierii* Menozzi, 1939
499 *Plagiolepis dichroa* Forel, 1902
500 *Plagiolepis exigua* Forel, 1894
501 *Plagiolepis jerdonii* Forel, 1894
502 *Plagiolepis moelleri* Bingham, 1903

503 *Plagiolepis pontii* Menozzi, 1939
504 *Plagiolepis rogeri* Forel, 1894
**505** ***Platythyrea*** *nicobarensis* Forel, 1905
506 *Platythyrea parallela* (Smith, F., 1859)
507 *Platythyrea sagei* Forel, 1900
**508** ***Polyrhachis*** *abdominalis* Smith, F., 1858
509 *Polyrhachis aculeata* Mayr, 1879
510 *Polyrhachis armata* (Le Guillou, 1842)
511 *Polyrhachis armata defensa* Smith, F., 1857
512 *Polyrhachis bicolor* Smith, F., 1858
513 *Polyrhachis bihamata* (Drury, 1773)
514 *Polyrhachis binghamii* Forel, 1893
515 *Polyrhachis convexa* Roger, 1863
516 *Polyrhachis dives* Smith, F., 1857
517 *Polyrhachis dives belli* Forel, 1912
518 *Polyrhachis exercita* (Walker, 1859)
519 *Polyrhachis exercita lucidiventris* Forel, 1907
520 *Polyrhachis exercita obtusisquama* Forel, 1902
521 *Polyrhachis furcata* Smith, F., 1858
522 *Polyrhachis gracilior* Forel, 1893
523 *Polyrhachis hauxwelli* Bingham, 1903
524 *Polyrhachis hector* Smith, F., 1857
525 *Polyrhachis hemiopticoides* Mukerjee, 1930
526 *Polyrhachis hippomanes* Smith, F., 1861
527 *Polyrhachis horni* Emery, 1901
528 *Polyrhachis illaudata* Walker, 1859
529 *Polyrhachis illaudata intermedia* Forel, 1886
530 *Polyrhachis indificans* (Jerdon, 1851)
531 *Polyrhachis lacteipennis* Smith, F.,1858
532 *Polyrhachis lacteipennis obsoleta* Forel, 1893
533 *Polyrhachis laevissima dichroa* Forel, 1893
534 *Polyrhachis menelas* Forel, 1904
535 *Polyrhachis mutata* Smith, F., 1858
536 *Polyrhachis narendrani* Karmaly, 2004
537 *Polyrhachis pagana* Santschi, 1928
538 *Polyrhachis proxima* Roger, 1863
539 *Polyrhachis pubescens* Mayr, 1879
540 *Polyrhachis punctillata fergusoni* Forel, 1902
541 *Polyrhachis punctillata smythiesii* Forel, 1895
542 *Polyrhachis punjabi* Bharti, 2003
543 *Polyrhachis rastellata* (Latreille, 1802)
544 *Polyrhachis relucens* (Latreille, 1802)
545 *Polyrhachis rupicapra* Roger, 1863
546 *Polyrhachis spinigera* Mayr, 1879
547 *Polyrhachis striata* Mayr, 1862
548 *Polyrhachis sylvicola* (Jerdon, 1851)
549 *Polyrhachis thrinax* Roger, 1863
550 *Polyrhachis thrinax lancearia* Forel, 1893
551 *Polyrhachis tibialis parsis* Emery, 1900
552 *Polyrhachis travencoricus* Karmaly, 2004
553 *Polyrhachis tubericeps* Forel, 1893
554 *Polyrhachis villipes* Smith, F., 1857
555 *Polyrhachis wroughtonii* Forel, 1894
**556** ***Prenolepis*** *naoroji* Forel, 1902
**557** ***Probolomyrmex*** *bidens* Brown, 1975
558 *Probolomyrmex procne* Brown, 1975
**559** ***Proceratium*** *bhutanense* De Andrade, 2003
560 *Proceratium williamsi* Tiwari, 2000
**561** ***Pseudolasius*** *familiaris* (Smith, F., 1860)
**562** ***Pyramica*** *assamensis* (De Andrade, 1994)
563 *Pyramica nepalensis* (De Andrade, 1994)
564 *Pyramica podarge* Bolton, 2000
**565** ***Recurvidris*** *recurvispinosa* (Forel, 1890)
**566** ***Rhopalomastix*** *rothneyi* Forel, 1900
**567** ***Rhoptromyrmex*** *mayri* Forel, 1912
568 *Rhoptromyrmex wroughtonii* Forel, 1902
**569** ***Solenopsis*** *geminata* (Fabricius, 1804)
**570** ***Sphinctomyrmex*** *taylori* Forel, 1900
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**572** ***Strumigenys*** *aduncomala* De Andrade, 2007
573 *Strumigenys emmae* (Emery, 1890)
574 *Strumigenys exilirhina* Bolton, 2000
575 *Strumigenys fixata* Bolton, 2000
576 *Strumigenys godeffroyi* Mayr, 1866
577 *Strumigenys habropilosa* Bolton, 2000
578 *Strumigenys hostilis* Bolton, 2000
579 *Strumigenys hypoturba* Bolton, 2000
580 *Strumigenys lewisi* Cameron,1866
581 *Strumigenys lyroessa* (Roger, 1859)
582 *Strumigenys nanzanensis* Lin & Wu, 1996
583 *Strumigenys peraucta* Bolton, 2000
584 *Strumigenys smythiesii* Forel, 1902
585 *Strumigenys virgila* Bolton, 2000
**586** ***Tapinoma*** *andamanense* Forel, 1903
587 *Tapinoma annandalei* (Wheeler, W.M., 1928)
588 *Tapinoma indicum* Forel, 1895
589 *Tapinoma luffae* (Kurian, 1955)
590 *Tapinoma melanocephalum* (Fabricius, 1793)
591 *Tapinoma wroughtonii* Forel, 1904
**592** ***Technomyrmex*** *albipes* (Smith, F., 1861)
593 *Technomyrmex brunneus* Forel, 1895
594 *Technomyrmex elatior* Forel, 1902
595 *Technomyrmex horni* Forel, 1912
596 *Technomyrmex indicus* Bolton, 2007
597 *Technomyrmex pratensis* (Smith, F., 1860)
598 *Technomyrmex rector* Bolton, 2007
599 *Technomyrmex vitiensis* Mann, 1921
**600** ***Temnothorax*** *desioi* (Menozzi, 1939)
601 *Temnothorax desioi melanicus* (Menozzi, 1939)
602 *Temnothorax fultonii* (Forel, 1902)
603 *Temnothorax inermis* (Forel, 1902)
604 *Temnothorax nordmeyeri* (Schulz, 1997)
605 *Temnothorax rothneyi* (Forel, 1902)
606 *Temnothorax rothneyi simlensis* (Forel, 1904)
607 *Temnothorax schurri* (Forel, 1902)
608 *Temnothorax wroughtonii* (Forel, 1904)
**609** ***Tetramorium*** *barryi* Mathew, 1981
610 *Tetramorium beesoni* (Mukerjee, 1934)
611 *Tetramorium belgaense* Forel, 1902
612 *Tetramorium bicarinatum* (Nylander, 1846)
613 *Tetramorium browni* Tiwari, 2000
(Since *Tetramorium browni* Tiwari, 2000 is unresolved junior primary homonym of *Tetramorium browni* Bolton, 1980, so *Tetramorium meghalayense* is proposed here as replacement name).
614 *Tetramorium caespitum* (Linnaeus, 1758)
615 *Tetramorium christiei* Forel, 1902
616 *Tetramorium coonoorense* Forel, 1902
617 *Tetramorium cordatum* Sheela & Narendran, 1998
618 *Tetramorium decamerum* (Forel, 1902)
619 *Tetramorium elisabethae* Forel, 1904
620 *Tetramorium fergusoni* Forel, 1902
621 *Tetramorium indicum* Forel, 1913
622 *Tetramorium inglebyi* Forel, 1902
623 *Tetramorium keralense* Sheela & Narendran, 1998
624 *Tetramorium lanuginosum* Mayr, 1870
625 *Tetramorium malabarense* Sheela & Narendran, 1998

626 *Tetramorium mixtum* Forel, 1902
627 *Tetramorium myops* Bolton, 1977
628 *Tetramorium obesum* André, 1887
629 *Tetramorium pacificum* Mayr, 1870
630 *Tetramorium petiolatum* Sheela & Narendran, 1998
631 *Tetramorium rossi* (Bolton, 1976)
632 *Tetramorium rugigaster* Bolton, 1977
633 *Tetramorium salvatum* Forel, 1902
634 *Tetramorium sentosum* Sheela & Narendran, 1998
635 *Tetramorium simillimum* (Smith, F., 1851)
636 *Tetramorium smithi* Mayr, 1879
637 *Tetramorium tortuosum* Roger, 1863
638 *Tetramorium walshi* (Forel, 1890)
**639** ***Tetraponera*** *aitkenii* (Forel, 1902)
640 *Tetraponera allaborans* (Walker, 1859)
641 *Tetraponera attenuata* Smith, F., 1877
642 *Tetraponera binghami* (Forel, 1902)
643 *Tetraponera modesta* (Smith, F., 1860)
644 *Tetraponera nigra* (Jerdon, 1851)
645 *Tetraponera nitida* (Smith, F., 1860)
646 *Tetraponera pilosa* (Smith, F., 1858)
647 *Tetraponera rufonigra* (Jerdon, 1851)
**648** ***Tyrannomyrmex*** *dux* Borowiec, 2007
**649** ***Vollenhovia*** *oblonga* (Smith, F., 1860)
**650** ***Vombisidris*** *humboldticola* Zacharias & Rajan, 2004
651 *Vombisidris occidua* Bolton, 1991
**652** ***Yavnella*** *indica* Kugler, 1987

**Unidentifiable names and other exclusions**
**Incertae sedis**
*Atta dissimilis* Jerdon,1851
*Atta domicola* Jerdon,1851
*Formica malabarica* Schrank, 1837
*Formica phyllophila* Jerdon, 1851
*Monomotium bidentatum* (Smith, F., 1858)
*Myrmica breviceps* Smith, F., 1878
*Myrmica caeca* Jerdon, 1851
*Myrmica humilis* Smith, F., 1858
*Myrmica luctuosa* Smith, F., 1878
*Ponera affinis* Jerdon,1851
*Ponera pumila* Jerdon,1851

**Species inquirenda**
*Technomyrmex incises* (Mukerjee, 1930)

**Other doubtful exclusions, whose presence in India couldn't be verified**
*Hypoponera truncata* (Smith, F., 1860)
*Myrmica margaritae* Emery, 1889
*Camponotus thraso* Forel, 1893
*Polyrhachis scissa* Roger, 1862
*Camponotus singularis* (Smith, F., 1858)
*Polyrhachis exercita rastrata* Emery, 1889
*Polyrhachis sexspinosa* (Latreille, 1802)
*Polyrhachis carinata* (Fabricius, 1804)
*Polyrhachis ammon* (Fabricius, 1775)

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# Natural parasitisation of *Spodoptera litura* F. (Lepidoptera: Noctuidae) by *Zele chloropthalma* Nees (Hymenoptera: Braconidae) in vegetable ecosystems of Kashmir Valley, India

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## Abstract

**The present paper reports the occurrence of *Zele chloropthalma* Nees as a parasitoid of lepidopteran pest *Spodoptera litura* F. for the first time from Kashmir Valley. Observations have been made on the seasonal abundance and the extent of paraitisation of *S. litura* by *Z. choloropthalma* in various vegetable ecosytsms of Kahmir. The highest extent of parasitisation was observed to be 9.75%.**

**Keywords:** Parasitoid, *Spodoptera, Zele chloropthalma*, Kashmir

## Introduction

Some species of genus *Spodoptera* (Lepidoptera: Noctuidae) such as *Spodoptera exigua* (Hubner) and *S. litura* (Fabricius) are reported as minor pests of vegetable crops in India (Nair, 1970; Butani and Jotwani, 1984; Capinera, 2001). Several parasitoids have been reported to parasitize *S. litura* on various host plants in different regions of the world (Rao and Satyanarayana, 1984 in India and Hassanein *et al.*, 1985 in Egypt). However, there is no systematic report of any parasitoid of *S. litura* from Kashmir Valley. In the present investigation natural parasitisation of *S. litura* has been reported and the extent of parasitisation recorded.

## Materials and Methods

To record the parasitoids of *S. litura* and other pests, field surveys were undertaken in the prevailing agroclimatic conditions, during the years from 2005 to 2008, covering various vegetable ecosystems across 6 districts of Kashmir Valley *viz.*, Anantnag, Badgam, Baramulla, Ganderbal, Pulwama and Srinagar. Weekly collection of the larvae of *S. litura* was made from several sites selected in these districts. The larvae were reared in the laboratory until the emergence of parasites or adult pest. The parasites emerged were properly preserved and the identification of parasitoid, *Zele choloropthalma* (Hymenoptera: Braconidae) was done according to Achterberg (1979) and Wharton *et al.* (1997).

## Results and Discussion

In the present survey, the larvae of *S. litura* were found attacking several vegetable cole crops *viz.* cabbage, cauliflower, knoll-khol and kale. In general, the attack of lepidopteron pest, *S. litura* was witnessed during the months from May to August in each study year. Given the maximum number of larvae recorded (Table 1), the highest extent of infestation was observed during the months of June and July. Kale and knoll-khol were most severely attacked. The larvae after rearing were found to be parasitized by a hymenopteran parasitod, *Zele chloropthalma* Nees (Hymenoptera: Braconidae). The present reporting of *Z. chloropthalma* Nees as a parasite of *S. litura* is the first record from Kashmir (India).

Obtained data indicate that, the parasitisation of *S. litura* by *Z. chloropthalma* is mostly observed during the months of June and July. In the year 2005, a total of 174 larvae were collected from the selected sites, out of which, 7 larvae were found parasitized, and hence, the percentage of parasitism was 4.02%. The highest extent of parsitisation in this year was recorded to be 8.33% in the last week of June.

In the year 2006, a total of 184 larvae were collected from the selected sites, out of which, 7 larvae were found parasitized, and hence, the percentage of parasitism was 3.80%. The highest extent of parsitisation in this year was recorded to be 7.69% % in the last

week of June.

In the year 2007, a total of 167 larvae were collected from the selected sites, out of which, 10 larvae were found parasitized, and hence, the percentage of parasitism was 5.98%. The highest extent of parsitisation in this year was recorded to be 9.09% in the in the 3rd and 4th week of June.

In the year 2008, a total of 177 larvae were collected from the selected sites, out of which, 9 larvae were found parasitized, and hence, the percentage of parasitism was 5.08%. The highest extent of parsitisation in this year was recorded to be 9.75% in the last week of June.

**Table-1: Weekly number of *S. litura* and its Hymenopteran parasitoid, *Z. chloropthalma* recorded in vegetable ecosystems during 2005-2006 survey in Kashmir (India).**

| Month /Week | No. of *S. litura* collected | | | | No. of larvae parasitized by *Z. chloropthalma* | | | | %age parasitism | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2005 | 2006 | 2007 | 2008 | 2005 | 2006 | 2007 | 2008 | 2005 | 2006 | 2007 | 2008 |
| May | | | | | | | | | | | | |
| I week | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| II week | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| III | 2 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| IV | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| June | | | | | | | | | | | | |
| I | 9 | 6 | 5 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| II | 8 | 16 | 10 | 14 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 7.14 |
| III | 26 | 24 | 22 | 20 | 1 | 0 | 2 | 1 | 3.84 | 0 | 9.09 | 5.0 |
| IV | 36 | 39 | 44 | 41 | 3 | 3 | 4 | 4 | 8.33 | 7.69 | 9.09 | 9.75 |
| July | | | | | | | | | | | | |
| I | 32 | 35 | 34 | 29 | 2 | 2 | 3 | 2 | 6.25 | 5.71 | 8.82 | 6.89 |
| II | 22 | 24 | 15 | 20 | 1 | 1 | 0 | 1 | 4.54 | 4.16 | 0 | 5.0 |
| III | 12 | 15 | 20 | 14 | 0 | 0 | 1 | 0 | 0 | 0 | 5.0 | 0 |
| IV | 13 | 9 | 11 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| August | | | | | | | | | | | | |
| I | 9 | 7 | 5 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| II | 2 | 4 | 1 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| III | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| IV | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 174 | 184 | 167 | 177 | 7 | 7 | 10 | 9 | 5.17% | 3.80% | 5.98% | 5.08% |

This work gives an opportunity to further extend the present study to explore the possibility of utilizing the recorded parasite for biological control after standardization of rearing techniques in Kashmir valley.

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