

**SYSTEMATIC STUDIES ON INDIAN HALICTIDAE  
(APOIDEA: HYMENOPTERA)**

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## CHAPTER -1

### INTRODUCTION

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Hymenoptera with approximately 115,000 described species constitutes nearly 10 percent of the species diversity of our planet. However, Gaston *et al.* (1991) estimated the number to be between 300,000 and 3,000,000. Hymenoptera is economically vital as its members comprise of parasitoids, predators, pollinators and herbivores. A large group of insects in the superfamily Apoidea commonly known as bees are well equipped for gathering pollen and nectar from plants and are the most important group of pollinators of more than 118 crops including agricultural crops, fruits, flowers etc. (McGregor, 1976; Anonymous, 2000). Bees are distributed worldwide may be due to the high floral diversity of tropical and subtropical ecosystems. They are most diverse in arid and semi-arid regions of the world such as the Mediterranean basin, Central Asia, the south western deserts of North America, arid regions of Chile and Argentina, temperate parts of Australia, and southern Africa (Linsley, 1958; Michener, 1979a).

Worldwide 17,000 species have been described under superfamily Apoidea (Michener 2000). Bees can be classified into two main informal groups, short-tongued (ST) and long-tongued (LT) bees based on their mouthparts (Kirby 1802). Recently the total bee taxa have been grouped into seven families under super family Apoidea *viz.*, Stenotritidae, Colletidae, Andrenidae, Halictidae, Melittidae, Megachilidae and Apidae comprising of 1,234 genera and subgenera. Among them family Apidae are well renowned group for their abundance and eusocial life. The bees other than Apidae, are often called as wild bees and are poorly known from India and other countries. Unlike honey bees, they lead a quasisocial and solitary life. One such family amongst them is Halictidae, commonly known as sweat bees are also one of the largest groups (Michener, 2007). They contribute significantly in pollination of several tropical crop species although they are not as abundant as Apidae in terms of number of individuals.

The halictids are generally small bees, often bright metallic coloured, feed on pollen and nest underground or in wood. They are morphologically diverse bees distributed on all continents except Antarctica. The members of this family can be recognized by the

following set of characters *viz.*, a collar like pronotum not reaching tegulae, branched or plumose body hairs, first segment of metatarsus often enlarged and flattened, single subantennal suture, basal vein in forewing strongly arched and jugal lobe of hind wing longer than the submedian cell. Family Halictidae currently includes four sub families *viz.*, Rhophitinae, Nominae, Nomioioidinae, Halictinae and 75 genera worldwide (Alexander and Michener 1995).

Bees of family Halictidae are difficult to characterize taxonomically and little is known about many species outside of their original descriptions. Perusal of literature on this group reveals that extensive work has been done on this family from various parts of the world, *viz.*, Westwood (1875) Smith (1875a) Cameron (1902a) Bluthgen (1926) and Sakagami & Ebmer (1987). However, majority of the systematic work on Indian bees are contributions made by specialists located outside India, but most attempts restricted to mere description of new species (Pauly, 1990; Batra, 1966; Baker, 2002; Sakagami, 1968; Astafuravo, 2008). Only a few genera and few species of these bees have been studied from India. The only work on Indian bees worth mention is that of Bingham (1903) who included all the different types, *viz.*, social/ non social bees under a single family Apidae and used characters like shape of the tongue and nature and colour of pubescence on the body for their segregation. His studies included 24 species under genus *Halictus* and 13 species under genus *Nomia* belonging to the present day Halictidae from India but many of them have either been synonymized or transferred to other genera. The nesting habits, social behavior, pollination and flower relationships and their behaviour management has been studied in some Indian halictines (Batra 1966;#1967;#1977; Solomon and Puranachandra, 2004). Apart from this, work on this family has been restricted to publication of a first record of Genus *Conanthalictus* bee from Amritsar, India (Tomar and Suniti 2002) and genitalic studies of a few halictid genera ( Tomar and Tomar, 2005).

Although most species under genera *Lasioglossum*, *Nomia*, *Pseudapis*, *Halictus* and *Sphecodes* belonging to family Halictidae are economically very important but the taxonomy of most Indian species is inadequately worked out as the descriptions of most of the known species are obsolete, lack illustrations and inadequate for quick and

authentic identification. Pertinent literature reveals that this group of bees had been deserted sporadically with no comprehensive work undertaken on them. Thus serious gap exists in the present taxonomic knowledge of Indian Halictidae. Establishing accurate taxonomic identities of species belonging not only of these important genera but also those of relatively unknown ones will aid studies involving pollination biology.

Hence, keeping this in view, present study aims to address the gaps in our existing knowledge through improving the descriptions by including standard and novel characters relevant to bee taxonomy along with illustrations and coloured photographs, all of which will facilitate quick and authentic identification of species and will not only bridge the gaps in our existing knowledge but will also place the taxonomy of the group on a strong base. Therefore the present study aims at the following objectives.

1. To survey and collect members of family Halictidae.
2. To evaluate various taxonomic characters with a view to establishing accurate identities of various genera and species of family Halictidae.
3. Description/Redescription of various genera and species belonging to family Halictidae.
4. Preparation of diagnostic keys for identification of species by modifying the existing ones.

## CHAPTER - 2

### REVIEW OF LITERATURE

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Members of family “Halictidae” (Hymenoptera: Apoidea) commonly known as sweat bees are widely distributed in the tropical and subtropical regions of the world. All the pertinent literature has been reviewed under the following subheadings.

#### 2.1 Systematic history and taxonomic position of family Halictidae

Bees have been segregated in many ways during the past centuries by several workers. The present day members of Halictidae were earlier included under different genera in a much broader sense than the present family Halictidae (Thomson, 1872) *viz.*, under *Andrena*, *Apis* in ‘*Systema Naturae*’ by Linnaeus (1758); under *Sphex* and *Tenthredo* by Fabricius (1775) in his ‘*System Entomologiae*’. The composition of family Halictidae has kept changing since long and finally transformed into the current classification.

The first attempt on bee classification was made by Kirby (1802) who divided bees into two generic group *viz.*, *Melitta* and *Apis*, and kept all blunt tongued bees under *Melitta* and point tongued bees under *Apis*. In the same year Latreille (1802a) separated bees into family groups, Andrenetes and Apiaries, and included the present day halictids under division I of Andrenetes. These studies formed the basis for bee workers and led to the establishment of several genera. Klug (1807) listed 32 bee genera in his revisionary work. Thereafter Lepeletier (1841) proposed a new classification which reflected the social and nesting behavior of bees. He included genus *Sphecodes* (tribe Rhathymites) under parasitic bee group and other genera like *Halictus*, *Nomia* and *Dufourea* under solitary nesting bees (tribe Andrenites and Penurgites).

Schenk (1861, 1869), named all the subfamilies based on their generic roots and included genera *Halictus* and *Nomia* under subfamily Andrenidae while genera like *Dufourea*, *Rophites*, and *Systropha* were placed under different subfamilies. Thomson (1872) proposed the most modern classification of bees wherein for the first time genus *Halictus* was raised to tribe Halictina and was separated from *Andrena*. He grouped close relatives together and included *Dufourea*, *Rophites*, *Sphecodes* under Halictina. In spite

of Thomson's (1872) findings, Schmiedeknecht (1882) proposed a classification of bees which was similar to that of Lepeletier (1841).

Ashmead (1899) studied bee genera from all parts of the world and modified Schmiedeknecht's (1882) system. He again reunited halictines with Andrenidae and raised the status of tribe Halictina to subfamily Halictinae. A striking classification was proposed by Robertson (1904) with two large groups, Pygidialia and Apygidialia. He was the first to propose the name of family Halictidae and he separated *Nomia* and *Dufourea* into different families under Pygidialia. Börner (1919) also assembled bees to in appropriate family groups. He raised two subfamilies Halictinae and Halictoidinae under Halictidae and included three tribes Nominii, Halictini and Nomioidini under Halictinae.

Bischoff (1934) stressed on characters like subantennal sutures, episternal groove and jugal lobe of hindwing in bee classification which was followed by Michener (1944, 1965) who added three subfamilies Dufoureae, Nomiinae and Halictinae under Halictidae in his classification of bees of the world. Warncke (1977a) divided bees into two broad families and included subfamily Halictinae under Andrenidae, however no tribae names were used. The subfamily Halictinae was again divided by Michener (1979a) into three tribes Augochlorini, Halictini and Nomioidini.

Recently Michener (2007) classified the total bee taxa into seven family groups *viz.*, Stenotritidae, Colletidae, Andrenidae, Halictidae, Melittidae, Megachilidae and Apidae comprising of 1,234 genera and subgenera. Further the family "Halictidae" was divided into four subfamilies, *viz.*, Rhophitinae, Nomiinae, Nomioidinae and Halictinae and subfamily Halictinae was subdivided into two tribes Halictini and Augochlorini with 24 and 25 generic groups, respectively while the subfamilies Nomiinae, Rophitinae, Nomioidinae included 11, 13 and three generic groups, respectively. Currently subfamily Halictinae is the most diverse group of Halictidae with 2,711 valid species recorded worldwide.

### **2.1.1 On subfamily Halictinae**

Curtis (1833) was the first to recognize the heterogeneity of genus *Halictus* Latreille 1804 and erected a new genus *Lasioglossum* with type species *L. tricingulam* which had characteristic basal hair bands on metasomal terga and a hairy lacinia. Sichel

(1866) in his monograph, described fifteen species of genus *Sphecodes* and gave them new names, *Sphecodes ruficornis*, *S. punctulatus* from Algeria; *S. scariosus* sub var *gibbus*, *S. subpunctulatus* from Morocco; *S. abyssinicus* sub var *hispanicus*, *S. senegalensis*, *S. punctatus* from Cape of good hope; *S. subconfertus*, *S. metathoracicus*, *S. aspericollis*, *S. puncticollis*, *S. metanotiaeus*, *S. basalis* from Mexico and *S. rugulosus* and *S. granulatus* from Chili. Smith (1867) revised characters and synonyms of British bee fauna and reviewed Sichel's results. He accepted five species viz., *Sphecodes gibbus*, *S. rufiventris* (= *Tiphia rufiventris*, *Dichroa analis*, *S. rufescens*), *S. subquadratus*, *S. ephippius* (= *S. maculatus*) and *S. fuscipennis*.

Among the earlier workers, Schenck (1870) studied genus *Halictus* and described seven species viz., *Halictus laticeps*, *H. appropinquans*, *H. clypeatus*, *H. striatus*, *H. similimmus*, *H. ferrugeneipes*, *H. parumpunctatus* from Nassao; eight species viz., *H. fasciatus*, *H. linearis*, *H. megacephalus*, *H. semipunctatulus*, *H. intermedius*, *H. transitorius*, *H. lucidus*, *H. tarsatus* from Austria; three species viz., *H. 6-strigatus*, *H. brevicornis*, *H. 6-signatus* from West Phalia and one new species *H. hirtellus* from Lethmathe mark.

Thomson (1872) was the first to elevate tribe Halictini based on generic name *Halictus*, while wanting to separate it from genus *Andrena*. Smith (1873) described several new species of genus *Halictus*, viz., *Halictus costulatus*, *H. morbillosus*, *H. gribodi*, *H. occidentis*, *H. scitulus*, *H. tarsatus* and *H. aerarius* from various locations of Japan. During the same year, Cresson (1873) in his treatise on 'Hymenoptera Texana' described twelve new species of genus *Halictus* viz., *H. occidentalis*, *H. armaticeps*, *H. texanus*, *H. bardus*, *H. ornatipes*, *H. impurus*, *H. lusorius*, *H. connexus*, *H. disparilis*, *H. coactus*, *H. stultus* and *H. albitarsis* from Texas. Schenck (1873) also reported a new species *Halictus griseus* from Lowenzahn.

Ten new species of genus *Halictus* occurring in Derbent, Russia viz., *H. patellatus*, *H. fallax*, *H. caspicus*, *H. riparius*, *H. bicallosus*, *H. coloratus*, *H. pulverous*, *H. meridionalis*, *H. semitectus* and *H. cephalictus* and synonymized several existing Russian species viz., *Halictus quadricinctus* = *H. tomentosus*; *H. rubicundus* = *Apis flavipes* ♀, *H. nidulans*; *H. maculatus* = *interruptus*; *H. fulvicornis* = *albipes*; *H.*

*cylindricus* = *H. abdominalis*, *H. fulvocinctus*, *H. malachurus*, *H. terebrator*, *H. elegans*, *H. rubellus*, *H. rufiventris*, *H. obovatus*; *H. tumulorum* = *H. fasciatus* and *H. flavipes* = *H. seladonia* were described by Morawitz (1869, 1874).

Saussure (1891) erected a remarkable new genus *Thrinchostoma* from Madagascar in Africa with type species *Thrinchostoma renitantely* with peculiar, unique patches of hairs on wings of male. In 1905, Cameron described ten new species of genus *Halictus* viz., *H. robertianis*, *H. rubricaudis*, *H. pearstonensis*, *H. lampronotus*, *H. thesis*, *H. despositus*, *H. aethiopicus*, *H. interstitinervis*, *H. lippani*, and *H. capicola* from Cape.

Tribe Halictini was upgraded by Ashmead (1899) to subfamily Halictinae during his attempt to reunite the Halictines again with family Andrenidae. Robertson (1902) erected two new genera *Evylaeus* and *Chloralictus* based on the sclerotisation of cross veins 1r-m and 2r-m. Cockerel (1909) described eight species viz., *Augochlora jamaicana*, *Nomioides muiri* and *Nomia (Meganomia) binghami*, *Halictus afripyga*, *H. distinctus*, *Nomia testacea*, *N. aratina* and *Nomioides appendiculata* in his catalogue. He also proposed a key for identification of eight species of genus *Halictus* from Japan and China viz., *H. (Chloralictus) acra*, *H. tarsatus*, *H. occidentis*, *H. affinis*, *H. subopacus*, *H. scitulus*, *H. proximatus* and *H. familiaris*.

A new subgenus *Nesohalictus* under genus *Halictus* was erected by Crawford (1910) with type species *Halictus (Nesohalictus) robbi* from Manila, Phillipines. This subgenus was characterized by elongated tongue, few long teeth on inner hind tibial spur, transverse cubital veins, cubitus extending beyond the second transverse cubital and upper 2/3<sup>rd</sup> of second recurrent vein, obsolescent. Cockerell (1912b) recorded four new species of genus *Sphcodes* viz., *S. scotti*, *S. patruelis*, *S. trentonensis* and *S. manni* from North America and one species *S. hudsoni* from Canada. Cockerell (1913a) studied some oriental bees and described two new species of *Nomia*, *N. parciformis* and *N. leucoptera* from India, three new species viz., *H. (Evylaeus) kandiensis* from Sri Lanka, *H. purnongensis* and *H. musicus* from Australia.

Strand (1913c) studied bee fauna of oriental region and described eight new species from Sri Lanka namely *Halictus horni*, *H. aulocophorus*, *H. paraduanus*, *H. horianus*, *H. kandycola*, *H. nelandicus*, *H. centrophorus* and *H. amblyplygus*; and one

new species *H. blepharophorus* from Taiwan. Cockerell (1913a) reported the occurrence of genus *Thrinchostoma* from Asia for the first time with the description of a new species *T. sladeni* from Nepal.

Bluthgen (1923a) revised genus *Halictus* from Spain and described nine new species viz., *Halictus fumatipennis*, *H. jaramielicus*, *H. crenicornis*, *H. tridivisus*, *H. quadripartitus*, *H. pseudoplanulus*, *H. coelebs* and *H. dusmeti*. He also recorded, ♀ *H. vergilianus* and ♂ *H. carneiventris* first the time from Spain. Further he also erected *Halictus rubicundus* var. n. *laticinctus*. In his notes on *Halictus* of Palaearctic region, described one new species *H. dichrous* from Tunis, for the first time described ♂ of *H. strictifrons* and synonymised *H. angustifrons* with *rubescens*. During the same year, Bluthgen (1923b) again described nine new species from Hungary and surrounding regions viz., *Halictus sexinctus*, *H. crenicornis*, *H. colliciatius*, *H. sajoi* from Hungary; *H. siculus* from Sicily; *H. nicosiae* from Cyprus; *H. pentheri* from Asia minor; *H. adjikenticus* from Caucasus and *H. brachyceros* from an unknown locality. He formulated a key to the species of genus *Halictus*. Again in 1923c he described seven new species viz., *H. epigyialis*, *H. sociorum* from Caucasus; *H. foveolatus* from South France; *H. ilicus* from Turkestan; *H. tripolitanus* from Cyrenaica; *H. dichrous* from Tunisia and *H. shulthessi* from Morocco. Two new varieties were also erected, *H. albipes* var. n. *rubelloids* and *H. leucopygmatius* var n. *numidus* from Tunisia.

In a revisionary work on oriental *Halictus*, Bluthgen (1926) described numerous new species viz., *H. albescens insulates*, *H. xystronotus* var *inversa*, *H. propinquus* var *sylvatica*, *H. buruanus*, *H. burmanus* from Burma and Java; *H. negriticus*, *H. dapanensis*, *H. baguionellus*, *H. samarensis*, *H. sibuyanensis*, *H. subnaganensis*, *H. mimulus* from Philippines; *H. bedanus*, *H. tamulicus*, *H. singhalensis* from Srilanka; *H. javanus*, *H. vanajus*, *H. getasanus*, *H. bataviae* from Java; *H. abnormis*, *H. kintonensis*, *H. fruhstorferi* from Tomkin; *H. amboinensis* from Amboina; *H. nicobaricus* from Nicobar; *H. matanganus* from Borneo; *H. tibetanus* from Tibet; *H. singaporellus*, *H. penangensis*, *H. physocephalus*, *H. puloensis* from Penang; *H. laraticus*, *H. laratellus* from Tenimber; *H. pseudothoracicus*, *H. muaranus*, *H. sirambeanus*, *H. sumatranus* from Sumatra; and *H. behamatus*, *H. maymyonicus*, *H. burmensis*, *H. goluratus*, *H. rugifrons*, *H. bumanicus*, *H. tenasserimus* from Myanmar.

Mitchell (1956) described fifteen new species of *Sphecodes* from the North America viz., *Sphecodes S. autumnalis*, *S. townesi*, *S. australis*, *S. coronus*, *S. carolinus* and *S. atlantis* from Michigan; *S. brachycephalus*, *S. wheeleri*, *S. hydrangea*, *S. exaltus*, *S. crawfordi* from North Carolina; *S. morsei* from Minnesota; *S. packardi* from New Hampshire; *S. canadensis* from Quebec; *S. nigricorpus* from Connecticut and *S. fattigi* from Florida. Mitchell (1960) reviewed the genus *Dialictus* of Eastern United States and transferred seven species belonging to genus *Halictus* to *Dialictus* viz., *ashmeadii* to *creberrimus*, *rugosus* to *hartii*, *stultus* to *incospicuus*, *smilacinate* to *laevissimus*, *euryceps* to *laevissimus*, *brycinci* to *perpunctatus*, *graenichori* to *pictus*, *subconnexus* to *ronweri*, *consonus* to *versans* and *Lasioglossum (Chloralictus)* to *D. coreopsis*.

Benoist (1964) reviewed the species of genus *Halictus* from Madagascar viz., *H. inelegans*, *H. badius*, *H. scalaris*, *H. ambustus*, *H. umbrinus*, *H. delphinensis*, *H. dolosur*, *H. johannae*, *H. pubens*, *H. erythropus*, *H. trivialis*, *H. seyrigi*, *H. speculum*, *H. antanimorensis*, *H. lasereanus* and *H. oppidanus* and grouped them based on specific characters. Matsumura and Sakagami, (1971) for the first time recorded a species of subgenus *L. (Ctenonomia)* from Nepal viz., *L. (E.) albescens* and provided a bionomic account of the same.

Ebmer (1978a) in his study on halictid bee fauna of Iran, described 19 new species, four subspecies and determined congeners of twelve species viz., *Halictus (H.) icarus*, *Halictus (H.) grossellus*, *H. lobatus*, *H. (Vestitohalictus) aesturans*, *H. (V.) surabadensis*, *Lasioglossum (L.) equinum*, *L. (L.) fahringeri* (♂ new), *L. (L.) phoebos*, *L. (L.) subequestre* (♂ new), *L. (L.) tugusicum*, *L. (L.) cilicium* (♂ new), *L. (E.) salutatrix* (♀ new), *L. (E.) acherontion*, *L. (E.) exulans*, *L. (E.) nitidulum* *L. (E.) sardinium* *L. (E.) viriderostratum*, *L. (E.) talyschense* (♂ new), *L. (E.) asteria*, *L. (E.) andromeda*, *L. (E.) hyrkanium*, *limbelloides*, *L. (E.) eurydikae* (♂ new), *L. (E.) faustum*, *L. (E.) opaconitens*, *L. (E.) daphna*, *L. (E.) makedonicum* (♂ new), *L. (E.) betomarium* (♀ new), *Rophites quinquespinosus montanus*, *R. mandibulansis* (♀ new), *Systropha villosa*, *H. (S.) paropamisos* and established several new subspecies viz., *L. (L.) zonulum xylopedis*, *L. (E.) tirolense panagaeum*, *L. (Evyllaeus) calceatum reinigi* and *L. (E.) pseudolepto rhynchum*.

Two years later in 1980, Ebmer in his revision of Asiatic Halictidae, described three species viz., *Lasioglossum (Evyllaes) cerambyx* from Pakistan, *L. (E.) melan*, and *L. (E.) quadrinotatiforme* from Tadzhikistan. He further described two new subspecies viz., *L. (E.) matianense pluto* from Kirgizia and *L. (L.) fallax rhadiourgon* from Pakistan.

During the same year Pauly (1980) in his studies of Indonesian bees, reported six new species viz., *Homalictus declivis*, *H. kongeani*, *H. moearae*, *H. ranacus*, *H. subdeclivis*, *H. vechtin* spp. redescribed fourteen species of genus *Homalictus*, and formulated a key to *H. adonidiae*, *H. babakanensis*, *H. bataviae*, *H. getasanus*, *H. laraticus*, *H. nusaensis*, *H. redivivus*, *H. testaceips* and transferred six species from genus *Halictus* to *Homalictus* viz., *babakanensis*, *bataviae*, *getasanus*, *laraticus*, *nusaensis*, *redivivus* and *testaceips*. He also provided diagnostic characters to identify the genus *Indohalictus* of Indonesia. Michener (1980) described a new species of genus *Homalictus* with an unusual wing venation, viz., *Homalictus silvestris* from Mindanao, Philippines.

Ebmer (1983) in his second series of revisionary work on Asiatic Halictidae described three new species viz., *Lasioglossum (Evyllaes) acanthum* from Uzbekistan and *L. (E.) suppressum*, *L. (E.) fulvopacum* from Afganistan. Michener (1984) analysed the gross morphology of mentum and lorum of a wide variety of bees to understand the implications of the said structures in Apoidea phylogeny. In this study, he found that the desclerotization of mentum and lorum were the characteristic features of Halictidae and Oxaeidae while the other family groups evolved the V or Y shaped lorum characteristic of Melittidae, Ctenoplectridae and long-tongued bees. Pauly (1984c) erected a new genus *Paradialictus* consisting of the cleptoparasitic genera of Halictidae based on a single type species ♀ *Paradialictus synavei* from Virungas. Michener (1986) described a new species *L. kinabaluense* during his study on affinities of Australasian species from Malaysia. Ebmer (1986) described a new species of genus *Lasioglossum* from Pakistan, *L. (Evyllaes) osiris* along with diagnostic characters for its identification.

Revisionary studies on the new world species of genus *Lasioglossum* Curtis by McGinley (1986) led to the description of twenty new species viz., *L. acarophilum*, *L. acuminatum*, *L. anhypops*, *L. argutum*, *L. asaphes*, *L. bajaense*, *L. cercothrix*, *L.*

*channelense*, *L. eickworti*, *L. katyae*, *L. lampronotum*, *L. orphnaeum*, *L. paraforbesii*, *L. parkeri*, *L. perscabrum*, *L. rupticristum*, *L. sandrae*, *L. timberlakei*, *L. tropidonotum*, and *L. xyriotropis*; synonymisation and transfer from genus *Halictus* to *Lasioglossum* viz., *Halictus supercretus* to *L. circinatum*; *H. ripariellus* to *L. colatum*; *H. matensis* comb. n. to *L. costale*; *H. sericeus* to *L. crocoturum*; *H. cyaneiceps* to *L. desertum* and *H. olympiae subangustus* to *L. sisymbrii*; Designation of a neotype for *H. trizonatus* and lectotypes for eight species viz., *H. costalis*, *H. matensis*, *H. crocoturus*, *H. desertus*, *H. fuscipennis*, *H. manitouellus*, *H. pacificus* and *H. sisymbrii*. In all McGinley, 1986 described 51 species and formulated illustrated keys for identification and added data on floral associations.

Ebmer (1988) catalogued non parasitic bees of genera *Halictus*, *Lasioglossum*, *Nomioides*, *Pseudapis*, *Dufourea*, *Rhophitoides*, *Rophites* and *Systropha* of middle Europe. In his synoptic catalogue, he listed species along with their complete citation, valid synonyms, type details and also information on any lectotypes or neotypes. He also described a new subspecies, *Lasioglossum (Evylaeus) fulvicorne melanocorne*. He compiled all his previous work (1971, 1974) and formulated an illustrated key to species of genera *Halictus* and *Lasioglossum*. He also mapped the geographical distribution of species from west to east based on his studies of the entire old collections from Austria and correlated distribution with climatic factors.

A new species *Lasioglossum pavo* with decorative sternal hair fringes in males from Mentawai Island near Sumatra was described by Sakagami (1989). Further he redescribed the type species of an important subgenera of Malaysian bee fauna, *L. (Ctenonomia) carinatum*. He compared *L. pavo* sp. n. and *L. carinatum* with closely associated species *L. xystonotum*, *L. vagans* and *L. cire* based on the distinguishing characters of dorsal propodeum.

Warncke (1992) proposed major revisions of genus *Halictus* and *Sphecodes* during 1990's. He described six new species of genus *Sphecodes* viz., *S. saxicolus*, *S. haladai* from Tajikistan; *S. crassanus* from Spain; *S. anatolicus*, *S. armeniacus* from Turkey and *S. atlanticus* from Algeria; seven new subspecies were reported from various locations of Turkey and Morocco viz., *S. ruficrus gomerensis*, *S. marginatus larochei*, *S.*

*hirtellus canariensis* subsp. n. from Canary Islands, *S. monilicornis berberus*, *S. geoffrellus atlassa*, *S. geoffrellus hakkariensis*, *S. dusmeti maroccanus* from Morocco; *S. marginatus creticus* from Crete; *S. rufiventris hethiticus* from Turkey and *S. dusmeti nurekensis* from Tajikistan. He also provided an illustrated key for identification of the species occurring in Spain.

Sakagami and Tadauchi (1995) described three new halictine species from Japan viz., *Lasioglossum (Lasioglossum) nipponicola*, *L. (L.) ebmerianum*, *L. (Evylaeus) sphecodicolor* spp. n. and also compiled an illustrated key to identification of species. Engel (2001) described three new species, *Habralictellus rufopanticis*, *H. eickwortellus*, *Habralictellus eleutherensis* from Puerto Rico, Mona Island, British Virgin Islands, Bahamas and Cuba. He provided illustrations for all the species and established floral records for *H. rufopanticis*.

Pauly (1999) classified tribe Halictini and augmented it with many new genera and subgenera; compiled a complete list of species from Afrotropical region. Two new subgenera were also established under genus *Lasioglossum* viz., *Ipomalictus* with type species *Halictus nudatus* and *Rubricaudis* with type species *Halictus rubricaudis*. Further, he synonymised subgenus *Oxyhalictus* with *Labrohalictus*. Regional keys were formulated for identification of genus and subgenus level with illustrations and also a total of 726 species names were included under tribe Halictini.

McGinley (2003) revised the entire genus *Sphexodogastra* Ashmead of subfamily Halictinae from the New world. He described eight species including three new species viz., *S. antiochensis* (endangered species), *S. danforthi*, and *S. potosi*, added an illustrated key for identification of all the species and reviewed nesting biology of four species viz., *S. antiochensis*, *S. lusoria*, *S. oenotherae*, *S. texana*. He also proposed new combinations and elevated *S. lusoria* from junior synonymy under *S. aberrans* and synonymised *Halictus galpinisae* with *S. lusoria*.

Niu *et al.* (2004) reported five new species under subgenus *Seladonia* viz., *Halictus multicarinatus*, *H. (S.) confusus alpinus*, *H. (S.) confusus perkinsi*, *H. (S.) semitectus* and *H. (S.) varentzowi* from China. A total of 17 species were described and a key to all the species viz., *H. (S.) aerarius*, *H. (S.) confusus alpines*, *H. (S.) confusus*

*perkinsi*, *H. (S.) dorni*, *H. (S.) leucaheneus leucaheneus*, *H. (S.) magnus*, *H. (S.) mongolicus*, *H. (S.) pjalmensis pjalmensis*, *H. (S.) placidulus*, *H. (S.) propinquus*, *H. (S.) seladonius*, *H. (S.) semitectus*, *H. (S.) subauratus subauratus*, *H. (S.) tumulorum higashi*, *H. (S.) varentzowi*, *H. (S.) multicarinatus* and *H. (S.) vicinus* was compiled. Again in 2007, Niu *et al.* reported two species new to China *viz.*, *Halictus (Vestitohalictus) mucoreus* and *H. (V.) pulvereus* and redescribed eight species, *H. (V.) pollinosus pollinosus*, *H. (V.) pseudomucoreus*, *H. (V.) pseudovestitus pseudovestitus*, *H. (V.) vestitus*, *H. (V.) tectus* and *H. (V.) ferreotus* and formulated an illustrated key for identification of all the known species of China.

Engel (2009) described a new species under tribe Augochlorini, *Chlerogas aterrimus* from Bolivia and commented on the misassociation of sex of *Chlerogas boliviensis*. He described the new species from two males and a female and therefore distinguished it from *C. boliviensis*, known only from females. He revised the key for the species of *Chlerogas* along with new locality record for *C. boliviensis*. Gonzalez *et al.* (2010) recognized two subgenera of nocturnal bees of *Megalopta*, *viz.*, *M. (Noctoraptor)* with two new species *viz.*, *Megalopta (Megalopta) tetewana* from Mexico and *M. (Noctoraptor) huaoranii* from Ecuador of Neotropical region. He placed nearly 30 species in the nominated subgenus and formulated a key for identification of the species from Central America.

Rasmussen and Michener (2011) described a congener of type species ♂ *Sphecodes ralunensis* belonging to subgenus *Callosphecodes* Friese, for the first time from New Britain. The ♀ *S. ralunensis* was compared with ♀ *Sphecodes manskii* for first time with illustrations. Engel (2011) described a new species, *Microsphecodes xaymacensis* of the cleptoparasitic bee genus *Microsphecodes* Eickwort and Stage. He illustrated key features of male and female collected from Jamaica and distinguished it from congeners on the basis of color, sculptures, pygidial plate and male genitalia.

Gibbs (2011) revised challenging metallic forms of *Lasioglossum* Curtis in his monograph and described eleven new species belonging to subgenus *Dialictus* *viz.*, *Lasioglossum arantium*, *L. ascheri*, *L. batya*, *L. curculum*, *L. furunculum*, *L. georgeickworti*, *L. gotham*, *L. izawsum*, *L. katherineae*, *L. rozeni* and *L. trigeminum*.

He described totally 97 species, illustrated 40 species and proposed keys for both males and females. He resurrected some species from synonymy, *L. (D.) smilacinae* from *L. laevissimum* and *L. (D.) nymphaeorum* from *L. albipenne*; transferred *L. rufulipes* and *L. testaceum* from *Evylaeus* to *Dialictus*; Designated lectotypes for *Halictus albipennis*, *H. albitarsis*, *H. cressonii*, *H. disparilis*, *H. hortensis*, *H. nubilis*, *H. pilosusleucocomus*, *H. planatus*, *H. stultus*, *H. subconnexus rohweri*, *H. tegularis*, *H. versans* and *H. viridatus*; and proposed several new synonymies viz., *L. (D.) flaveriae* = *Dialictus tahitensis*; *L. (D.) leucocomum* = *Dialictus otsegoensis*; *L. (D.) lionotum* = *Paralictusasteris*; *L. (D.) longifrons* = *L. (Chloralictus) robertsonellum*; *L. (D.) nigroviride* = *Evylaeus pineolensis*; *L. (D.) simplex* = *Halictus (Chloralictus) malinus*; *L. smilacinae* = *Halictus zophops* = *D. philanthanus*; *L. (D.) testaceum* = *Halictus (Chloralictus) scrophulariae* = *Lasioglossum (Chloralictus) sandhouseae*; *L. (D.) versans* = *Evylaeus divergenoides*.

### 2.1.2 On subfamily Nomiinae

A new species *Nomia opulenta* from Moroty and later during the same year again another new species, *N. kirbii* was described from Brazil by Smith (1865). Walker (1871) described nine new species, *Nomia zonaria*, *N. vespoidea*, *N. bicoloripes*, *N. rufiventris*, *N. femoralis*, *N. ampla*, *N. scriptifrons*, *N. eburnefrons* and *N. pallicornis* collected from Red Sea and Arabia. Ritsema (1873) erected a new genus *Steganomus* with typical compresso-dilate antennae, large tegulae which was close to genus *Nomia*, but had only two submarginal cells on the forewing. He also described a new species *Steganomus javanus* collected from Java and designated it as the type species.

During his studies on the collections at British Museum, Smith (1875) described several species under genus *Nomia* viz., *N. terminata*, *N. carinata*, *N. albofasciata*, and *N. fuscipennis* from Myanmar, Sri Lanka, Java and Sumatra respectively. Westwood (1875) added one more new species *N. rustica* from Sri Lanka.

Strand (1912) reviewed old world bees and described eleven new species viz., *Nomia tetraloniformis*, *N. cjeesmanni*, *N. nellebugensis*, *N. russuloides*, *N. andrenimorpha*, *N. mia*, *N. aliniana*, *N. garu*, *N. benitoana* from West Africa. Again in 1913c, Strand reviewed oriental bees and described five new species viz., *Nomia puttalama*, *N. matalea*, from Sri Lanka, and another four new species *N. parcana*, *N.*

*kankauna*, *N. pilamica*, and *N. horni* from Formosa along with a new variety *N. megasoma nitidai*.

During his studies of bee fauna of Sri Lanka Friese (1913), described five new species of genus *Nomia* viz., *N. ceylonica*, *N. biroi*, *N. butteli*, *N. elegantula*, *N. crassiuscula*. Again in 1914 Friese, reported eight new species of genus *Nomia* viz., *N. testacea*, *N. gratiosa*, *N. mangniventris*, *N. rubripes*, *N. brevipes*, *N. burorum*, *N. nudiventris* and *N. fluvipes* from Africa. Cockerel (1918) studied bees of Malay Peninsula and described two new species viz., *N. notha* from Philippines and *N. anthracoptera* from Singapore.

Five new species of *Nomia* viz., *N. chopardi*, *N. lividocincta*, *N. villiersi*, *N. inamoena*, *N. impressiventris* were reported from Sudan by Benoist (1950). Hirashima (1955) erected a new subgenus *Dinomia* under genus *Nomia* with a new type species *N. taiwana* from Formosa. Again in 1956 Benoist, reported a new species *Nomia lamottei* from West Africa. Later in 1964, he again described twenty new species from South East coast of Africa viz., *Nomia seyrigi*, *N. flaviventris*, *N. podagra*, *N. obscura*, *N. castaeneiceps*, *N. erythropyga*, *N. inconspicua*, *N. luridipes*, *N. media*, *N. nigella*, *N. cingulata*, *N. minuta*, *N. subnitide*, *N. nudula*, *N. analis*, *N. ivondrensis*, *N. melanosoma*, *N. rudiusscula*, *N. dichroa*, and *N. bipartita* from Madagascar.

In his studies on Australian bee fauna during (1966-67) Michener erected two new subgenera viz., *Nomia (Austronomia)* based on type species *N. australica* Smith, and *N. (Ptilinomia)* based on new type species *N. plumosa* from Nondugl, New Guinea; described three new species viz., *N. (Melittida) gressetti* from Daulo Pass, *N. (Austronomia) maai* from Ming and *N. (Melittida) simplicinotum* from Nenguag in New Guinea; provided a key for identification of subgenera of genus *Nomia* Latreille occurring in the Australian region. This key was later on refined by the same author and widely adopted worldwide. The subgenera *N. (Curvinomia)*, *N. (Hoplonomia)*, *N. (Melittida)*, *N. (Reepenia)* and *N. (Rhopalomelissa)* were included in the Australian fauna. A new synonymy was also proposed for *N. (Reepenia) bituberculata* = *Tetralonia testacea* = *N. (Reepenia) eboracina*.

Hirashima (1966) redescribed the subgenus *Nomia* (*Ptilonomia*) and reported two new species *N. (P.) micheneri* and *N. (P.) laevisoma* from New Guinea. He also provided distinguishing characters of *N. (P.) plumosa* and compared it with the current new species. Again in 1968, he formulated a key for identification of metallic forms of genus *Nomia* (*Mellitidia*) and described six new species viz., *N. (M.) aeraria*, *N. (M.) nigrescens*, *N. (M.) nigricrus*, *N. (M.) plumosiscopa*, *N. (M.) viridiaenea*, *N. (M.) viridissima* from various locations of New Guinea. Later on in 1980, reported three new species from Sri Lanka viz., *N. (A.) austellata*, *N. (A.) krombeini*, and *N. (A.) notiomorpha* out of five species are studied. He also formulated a key for identification of four species groups viz., *N. (A.) fruhstorferi*, *N. (A.) takaoensis*, *N. (A.) ustula* and *N. (A.) krombeini*.

Michener and Greenberg (1985) analysed the morphological characters of rophitines and found them to possess several derived features of Halictidae like elongated prepalpi of galea, slender and hairy lacinia high above rest of the maxilla, membranous mentum and lorum. Further Michener (1985) added more features to differentiate rophitines like, antenna usually arising below midlength of eyes and antennal sockets separated from upper clypeal margin more than the diameter of socket; apex of labrum of female truncate or rounded not produced into a process, without penicillus; trochanteral and femoral scopa reduced; longest hairs ordinarily shorter than those of tibial scopa; In 1995, Alexander and Michener did parsimony analysis of adult characters with a sample of genera and found Rophitinae to be paraphyletic, from which Nomiinae and Halictinae evolved and grouped the present day Nomioidina under Rophitinae.

Pauly (1990) classified the genera of subfamily Nomiinae, having large tegulae, viz., *Pseudapis*, *Stictonomia*, *Nomiapis*, *Ruginomia*, *Steganomus*, *Pachynomia* and other genera with moderately large tegula like *Lipotriches*, *Macronomia* and *Austronomia* from Africa. He described five new species namely, *Pseudapis guichardi*, *P. usambarae*, *P. kenyensis*, *P. riftensis* and *P. ocracea* and formulated a key for identification of males of 21 species viz., *P. cinerea*, *P. algerinensis*, *P. anomala*, *P. sudanica*, *P. usakoa*, *P. pandeana*, *P. patellata*, *P. anthidioides*, *P. kingi*, *P. interstitinervis*, *P. edentata*, *P. duplocincta*, *P. innesi*, *P. dixica*, *P. armata* and *P. nubica*. The females of twelve species of genus *Pseudapis* which he could not differentiated were clustered into two unidentified

groups. In his next series Pauly (1990) revised genus *Steganomus* and described two new species, *Steganomus tessmanni* and *S. ennediensis* and formulated a key for identification of four species including *S. ogliviae* and *S. junodi* occurring in tropical Africa.

Pauly (1990) upgraded several subgenera of *Lipotriches* to genera viz., *Afronomia*, *Macronomia* and *Trinomia* and revised seven species of genus *Afronomia* Pauly occurring in Africa. He tentatively placed three unidentified species from Asia in the same subgenus which was smaller than African species (7mm) and lacked teeth on hind femora of male. He also revised 42 species of genus *Lipotriches*, among them 14, 8 and 20 species were from Africa, Malagasy and Asia, respectively.

In his revisionary studies of African Nomiinae Pauly (2000) compiled the distribution of 25 species of the genus *Leuconomia*, refined the key to identify species and described 14 new species viz., *Leuconomia alluaudi*, *L. bongo*, *L. brothersi*, *L. clypeonitida*, *L. ethiopica*, *L. garambensis*, *L. microlutea*, *L. mlanjensis*, *L. omanica*, *L. rozeni*, *L. stageri*, *L. starkei*, *L. tibiaplumosa*, *L. vassei* and proposed twelve new synonyms viz., *L. atripes* = *Nomia gorytoids* var *tangana*; *L. brevipes* = *N. leucophora* = *Nomia coelura*; *L. candida* = *Nomia candida coloratipes* = *N. distinctula*; *L. granulata* = *N. braunsiana* = *Nomia braunsiana* var *nigripes*; *L. rufitarsis* = *Nomia pulchra* = *N. pulcherrima* = *N. niveocincta*.

Baker (2002) described four new species from the Palearctic and Oriental region viz., *Pseudapis fayumensis*, *P. stenotarsus* and *Nomiapis kophenes* *N. carcharodonta*; proposed several new combinations for subgenera viz., *Nomia (Paranomia) lutea* to *N. (Leuconomia)* and *Nomia (Clavinomia) clavicornis* to *N. (Austronomia)*. He also established new synonyms for the following species *Pseudapis siamensis* (Cockerell, 1929) = *Nomia umesoi* = *Nomia megalobata*. He compiled a synoptic catalogue and proposed keys for identification of males of Palearctic and Oriental species. He also provided some information on nesting behavior of *Nomiapis divesipes*.

Four new species were added by Astafurova and Pesenko (2005) to Mongolian fauna of Nomiinae viz., *Lipotriches fruhstorferi*, *Nomiapis diversipes*, *N. femoralis*, and *N. mandschurica*; and two species new to Vietnam, viz., *Lipotriches esakii* and *L. yasumatsui*. They also designated lectotypes for two nominal species *Andrena brevitarsis*

and *Nomia fugax*. The authors compiled an annotated list and a key for identification of males of nine species of subfamily Nomiinae from Eastern Palaearctic region viz., *Lipotriches fruhstorferi*, *L. esakii*, *L. yasumatsui*, *Nomia chalybeata*, *N. punctulata*, *Nomiapis diversipes*, *N. femoralis*, *N. fugax* and *N. mandschurica*. Niu *et al.* (2005) reported two new records in China viz., *Rhophitoides canus* and *Rophites quinquespinosus* and redescribed five species of rophitine group viz., *Systropha curvicornis*, *Morawitzella nana*, *Rhophitoides canus*, *Rophites quinquespinosus* and *R. gruenwaldti* from China and provided a key to identify the species.

Michener (2007) refined the characters of subgenus *Austronomia* Michener, with addition of several new characters viz., basitibial plate of female completely carinated either rounded or pointed, lack of continuous carina across the pronotum, lack of teeth on hind femora of male, subhorizontal basal propodeum and hind tibial spur of male minutely serrate to ciliate. He downgraded all the new genera erected by Pauly (1990) to subgenera under genus *Lipotriches*.

Astafurova (2008) illustrated the genitalia and key features of four genera and 25 species of subfamily Nomiinae from Russia and adjacent countries. He reported nine species of *Nomiapis* Cockerell, eleven species of *Pseudapis* Kirby, two species of *Nomia* Latreille and three species of *Lipotriches* Gerstäcker. He provided identification keys for both ♂ and ♀ of Russian fauna for the following species viz., *Nomiapis equestris*, *N. divesipes*, *N. armata*, *N. valga*, *N. mandschurica*, *N. femoralis*, *N. squamata*, *N. fugax*, *Pseudapis tobiasi*, *P. anatolica*, *P. tadzhica*, *P. edentate*, *P. inermis inermis*, *P. rufescence*, *p. bytinski*, *P. elegantissima*, *P. lobata*, *P. nilotica latipes*, *P. platula*, *Nomia punctulata*, *N. chalybeate*, *Lipotriches fruhstorferi*, *L. yasumatsui*, *L. esakii*, *L. yasumatsui yasumatsui* and *L. yasumatsui koreana*.

Pauly (2009), in his striking compilation of oriental Nomiinae described 50 new species from the Oriental region viz., *Gnathonomia boyolali*, *G. cambodiana*, *G. mayoyaoensis*, *G. radiata*, *G. timorensis*, *G. wahisi*, *Maculonomia sanguinea*, *M. soekaboemiensis*, *M. tigeri*, *Curvinomia submirifica*, *Pachynomia nathani*, *Steganomus lieftincki*, *Lipotriches aurodigitata*, *L. gracilis*, *L. notoxantha*, *L. postcarinata*, *L. tubuliseta*, *L. vietnamensis*, *Macronomia anamalaiensis*, *M. angkorensis*, *M. dilatata*, *M.*

*karnatakaensis*, *M. madrasensis*, *M. nilgiriensis*, *M. orbitarsis*, *M. savannakheti*, *M. walayarensis*, *Maynenomia chayaphumensis*, *M. ghatensis*, *M. indochinensis*, *M. keralaensis*, *M. lonavlaensis*, *M. nathani*, *M. packeri*, *M. poonaensis*, *Austronomia arcuata*, *A. atromellea*, *A. bismarcki*, *A. browni*, *A. djampangi*, *A. gressitti*, *A. guadalcanalensis*, *A. hollandiae*, *A. laminatrochanter*, *A. nivea*, *A. pilitrochanter*, *A. pseudoscutellata*, *A. sancristobali*, *A. solomonensis* and *A. tapinensis*. He provided regional keys for the identification of African genera and subgenera. He sorted 282 names of species and recognized 136 valid species from Oriental region and 49 species from New Guinea and Pacific islands.

### 2.1.3 On subfamily Nomioidinae

Schenck (1866) erected a new genus *Nomioides* with the type species *Andrena pulchella* which was close to *Nomia* but differed in wing scales, hindlegs of male and the habitat. Pesenko (1983) reported new records of ten species under genera *Ceylalictus* and *Nomioides* from Mongolia and northern China viz., *Ceylalictus variegatus*, *Nomioides pulverosus* (= *N. gussakovskiji*), *N. minutissimus*, *N. modestus*, *N. bluethgeni*, *N. gussakovskiji*, *N. minutissimus*, *N. modestus*, *N. monticola*, and *N. ornatus*. Later in 2005 Pesenko recorded nine species in subfamily Nomioidinae from the Eastern Palaearctic Region, viz., *Ceylalictus variegatus*, *Nomioides bluethgeni*, *N. gussakovskiji*, *N. ino*, *N. minutissimus*, *N. modestus*, *N. monticola*, *N. ornatus*, and *N. pulverosus*. He provided an annotated list of species with complete data and key to the identification of species.

In 2009, Pesenko and Pauly reviewed the fauna of subfamily Nomioidinae of Arabian peninsula and reported five new species viz., *Nomioides abudhabiensis*, *N. riyadhensis*, *N. scaramozzinoi*, *N. serotinus*, and *N. tricinctus*. A total of twenty species were described with illustrations and a key was formulated for identification of species. Seven species viz., *Ceylalictus karachensis*, *Nomioides deceptor*, *N. elbanus*, *N. kenyensis*, *N. klausii*, *N. ornatus*, and *N. squamiger* were recorded for the first time from Arabian Peninsula.

Pesenko and Pauly (2009) in their monograph on subfamily Nomioidinae of African region excluding Madagascar. 33 species belonging to three genera of Nomioidinae from Africa. All of the species were redescribed with 267 illustrations; a

key for the identification of species was formulated; Seven new species and one new subspecies were described viz., *Cellariella inexpectata*, *C. schwarzi*, *Ceylalicthus congoensis*, *Nomioides deceptor capverdensis*, *N. griswoldi*, *N. kenyensis*, *N. micheneri* and *N. paulyi*; new status were established for *Nomioides maculiventris* var. *fulviventris* and *N. somalicus* subsp. *kalaharicus* were considered separate species under genus *Cellariella*; *Nomioides karachensis* var. *desertorum*, a separate species under genus *Ceylalicthus*; *Nomioides canariensis*, an insular subspecies of *N. deceptor*; *Nomioides maurus* an African subspecies of *N. minutissimus*; resurrected a few names *Nomioides elbanus* and *N. squamiger*; new synonymies were established: *Nomioides somalica* subsp. *kalaharica* = *Cellariella brooksi*; *Nomioides somalicus* = *N. somalicus* var. *completus* = *N. atomellus*; *Nomioides deceptor* = *N. minutissimus* var. *deserticola*; *Ceratina maculiventris* = *Nomioides maculiventris* var. *convergens* = *N. callonotus* = *N. maculiventris* var. *cyaneonotus*; *Nomioides minutissimus* subsp. *maurus* = *N. senecionis* = *N. maurus* var. *tingitanus*; Lectotypes were designated for the nominal taxa, *Ceratina maculiventris*; *Nomioides callonotus*; *N. maculiventris* var. *cyaneonotus*, *N. somalicus* subsp. *kalaharicus*; distributional maps were provided for all the species. Further, morphological evolution, phylogeny and geographical history of subfamily Nomioidinae also discussed in this monograph.

#### 2.1.4 On subfamily Rophitinae

Lepelletier (1841) erected a new genus *Dufourea* and designated a type species *Dufourea minuta*. Friese (1913) described a new species *Systropha butteli* from Sri Lanka. Structure of leg, antennae, male sternum were used for the recognition of genera and subgenera. Timberlake (1939) separated most of the species of rophitines by male sterna S6. Popov (1957) erected a new genus *Morawitzella* and designated the type species *Epimetha nana* from Central Asia.

Revisionary studies on this subfamily for the West palaeartic region was conducted by Warncke (1979a) placed all the species under the genus *Rophites* except genus *Systropha*. He erected five new subgenera under genus *Rophites*, viz., *Carinorophites* with type species, *Dufourea rufiventris* Friese; *Cypriophites* with type species *Rophites cyprius* (Mavromoustakis); *Dentirophites* with type species *Dufourea*

*gaullei* Vachal; *Merrophites*, with type species, *Dufourea merceti* Vachal, and *Microrophites* with type species *R. (M.) quadridentatus*. He downgraded the genera *Dufourea* Lepeletier, *Halictoides* Nylander, *Morawitzella* Popov and *Morawitzia* Friese to subgenera under genus *Rophites*. He described ten new species under genus *Rophites*, viz., *Rophites (D.) atratus*, *R. (D.) brachycephalus*, *R. (D.) chagrinus*, *R. (D.) maroccanus*, *R. (D.) nodicornis*, *R. (D.) tunesius*, *R. (Halictoides) dubiosus* *R. (H.) inermis ponticus*, *R. (Microrophites) quadridentatus*, *R. bidentatus*. Along with several new combinations and transfers to genus *Rophites*. Alexander and Michener (1995) analysed the characters of adult halictid genera and concluded that Rophitinae was a paraphyletic group from which Nomiinae and Halictinae were derived.

However, Michener (2007) disagreed with the downgrading of genus *Dufourea*, *Morawitzella*, *Morawitzia* by Warncke's segregation (1979) and revised the characters, listed 13 genera viz., *Ceblurgus*, *Conanthalictus*, *Dufourea*, *Goeletapis*, *Microlictoides*, *Morawitzella*, *Morawitzia*, *Penapis*, *Protodufourea*, *Rophites*, *Sphecodosoma*, *Systropha* and *Xeralictus*. with separate keys for identification of genera of Eastern and Western Hemispheres

### 2.2.0 On Indian halictidae

Regional work on halictid bee fauna from India, is limited to those of Smith (1875a, 1879) and Bingham (1897, 1898). During his studies on the collections of British Museum, Smith (1875a) established a new genus *Cyathocera* based on a new type species *C. nodicornis* from Lucknow and Barrackpore. Although the genus was closely allied to *Nomia* but differed from it by the presence of only two submarginal cells in forewings and males with two jointed club of the antenna. He also described ten species viz., *N. oxybeloides*, *N. aurifrons*, *N. ellioti*, *N. similima* *N. capitata*, *N. clypeata*, *N. basalis*, *N. fervida*, *N. combusta*, *N. pilipes* from India and *N. scutellata*, *N. antennata*, *N. thoracica* from India and China.

Westwood (1875) described three new species from Eastern India, *Nomia buddha*, *N. sykesiana* and *N. iridescens*. He supplemented some of the Smith's species with descriptions of males of *N. silhetica*, *N. combusta*, *N. tridentata* and also added illustrations for them. Cockerell (1912b) reported a new species *Nomia comperta* from

India. Smith (1879) in his studies on collections of British Museum, described seven new species from India viz., *Sphecodes albifrons*, *S. crassicornis* from Bombay; *S. montanus*, *S. irridipennis*, from North India; *S. sodalis* from Calcutta; two new species of genus *Halictus* viz., *H. senescens* from Bombay and *H. albozonatus* from Punjab.

Bingham (1897) in his “*Fauna of British India*” described about 88 species of aculeate hymenopterans, which included halictids viz., *Nomia aurata*, *Halictus amaenus*, *Halictus cameronii*, *Halictus vachalii*. Further he proposed *Halictus ducalis* as a new name for *Halictus amaenus*. In his notes on aculeate Hymenoptera (1898), described five new species from India viz., *Sphecodes indicus*, *Halictus asperatus*, *H. dynastes*, *H. nireus* and *H. himalayansis* and also included description of seven species viz., *Halictus jucundus*, *H. senescens*, *Nomia tridentata*, *N. zonaria* walker, *N. lamellate*, *N. tegulata* and *N. oxybeloides*. During (1908-09), in his notes on records of Indian museum he described three new forms *H. polycator*, *H. deiphobus* and *H. paris* collected from Himalayas. He also provided taxonomic notes on nine species viz., *H. albescens*, *H. subopacus*, *H. lucidipennis*, *H. senescens*, *Nomia ellioti*, *N. westwoodi*, *N. punctulata*, *N. clypeata* and *N. floralis*.

Cameron (1907a) studied the collections made by Nurse and described three new species viz., *Halictus simlaensis*, *H. matheransis* and *Nomia fulvinerva* from North India. Cockerell (1913) studied some oriental bees and described two new species, *Nomia parciformis* and *N. leucoptera* from India. Bluthgen (1926) in his faunal work on Indomalaysian halictids, described two new species *T. flaviscapus* and *T. tokinense* based on males. He also described both ♂ and ♀ of *T. sladeni*, *T. assamense*, and ♂ *T. bryanti* and ♂ *T. macrognathum* var *brunnea* and formulated a key for identification of all the studied species.

Bluthgen (1926) in his revisionary work on oriental *Halictus*, described thirty six new species from the Indian region viz., *Halictus assamicus*, *H. subglobosus*, *H. hydrocephalus*, *H. villosulopsis*, *H. turneri*, *H. shillongensis*, *H. pheidolopsis*, *H. margheritanus*, *H. subauratoides* spp. n. from assam; *H. acrocephalus* sp. n. from *H. bengal*, *H. plasunicus* spp. n. from India, *H. pseudocidens*, *H. notoxyustus*, *H. tunguensis*, *H. pseudopalmeri*, *H. sikimensis*, *H. sikimicus* spp. n. from sikkim; *H.*

*reflexus*, *H. kodialicus*, *H. matianicus*, *H. reliquus*, *H. fuscus*, *H. catileps*, *H. massuriensis*, *H. araxanellus*, *H. sanitarius*, *H. nursei*, *H. compressus*, *H. pashokensis*, *H. kangranus*, *H. matianensis*, *H. cavernifrons*, *H. reflexoides* *H. massuricus* and one new variety *H. massuricus chaprensis* from North India.

The first Indian publication by Batra and Michener (1966) included description of new species for the first time under genus *Systropha* i.e., *S. punjabensis* from Punjab, India and it was compared with *S. (Systrophidia) glabriventris*. It was Warncke (1979a) who recorded the genus *Rophites* for the first time from Jammu and Kashmir, India. He described two new species viz., *Rophites gkuruensis* and *R. kashmirensis* from Kashmir, and another species *R. nigrohirtus* from Khumbu, Nepal with illustrations and proposed a key for all the new species.

Batra (1966) published his observations on the nesting habits and social structure of twelve bee species from Punjab and Mysore, India. In the same year, Sakagami and Wain (1966) reported the queen-worker differentiation for an Indian species, *Halictus (Halictus) latisignatus*. Sakagami (1968) described new subspecies viz., *Lasioglossum albescens iwazii* and studied nesting habits of Indomalayan bees.

Ebmer (1980) in his first of revision any work on Asiatic Halictidae, described two new species, *L. (E.) didomenon*, *L. (E.) hypsiston* from Ladakh, India. Few new combinations and synonyms were proposed viz., *L. (E.) skorikovi* = *L. harputicum*; *L. (L.) subopacum* = *Halictus horishensis*; *Halictus pekingense* downgraded to *L. (E.) politum pekingense*. Ebmer (1983) in his second revisionary studies on Asiatic Halictidae described one new species, *Lasioglossum (Evylaeus) melachloran* from Kashmir and also described the males of *L. (L.) melan* and *Halictus (H.) modernus* from India.

Taxonomic notes on genus *Halictus (Seladonia)* from oriental region by Sakagami and Ebmer (1987) included redescription of four oriental species from India viz., *H. (S.) lucidipennis*, *H. (S.) propinquus*, *H. (S.) subauratoides* and *H. (S.) vicinus*. They also provided a key for identification of species of *H. (Seladonia)* of oriental region and proposed the following synonyms *H. (S.) lucidipennis* = *H. varipes*; *H. (Pauphalictus)* = *Lasioglossum (Evylaeus) Robertson*; *H. (Puncthalictus)* = *Lasioglossum (Evylaeus) Robertson*.

Pauly (1990) classified the genera of subfamily Nomiinae, having large tegulae, viz., *Pseudapis*, *Stictonomia*, *Nomiapis*, *Ruginomia*, *Steganomus*, *Pachynomia* and other genera with moderately large tegula like *Lipotriches*, *Macronomia* and *Austronomia* from African region including some Indian species. He formulated a key for identification of males of 21 species including four species from India viz., *P. anomala*, *P. patellata*, *P. edentata* and *P. armata*.

Baker (2002) described a new species of genus *Nomiapis* viz., *N. carcharodonta* from India and supported the differentiation of two genera *Nomiapis* Cockerell and *Pseudapis* Kirby. He also established new synonyms for the following Indian species viz., *Nomiapis bispinosa* = *Nomia basalis*; *Pseudapis oxybeloides* = *Nomia latispina* = *Nomia lepidota* = *Nomia biroi*; *Pseudapis edentata* = *Nomia orientana* = *Nomia orientana negevensis* = *pseudapis gunchard* and *Steganomus nodicornis* = *Nomia matalea*, compiled a synoptic catalogue and formulated a key for identification based on males. Lectotypes were designated for three species viz., *Nomia oxybeloides*, *Cyathocera nodicornis*, *Nomia latispina*, *Nomia biroi*, and *Nomia matalea*. In addition to that, he corrected the misidentified names, *P. armata* and *N. unidentata* as *Pseudapis nilotica* and *Nomiapis bispinosa*, respectively and provided information on nesting behavior of *Pseudapis nilotica*.

Astafurova (2008) illustrated the genitalia and key features of four genera and 25 species of subfamily Nomiinae from Russia and adjacent countries which also included few Indian species viz., *Nomiapis armata*, *Pseudapis edentata*, *P. flavolobata*, *P. nilotica latipes* and *Nomia chalybeata*. He also formulated a key for the identification of both ♂ and ♀. Pauly (2009) in his striking compilation on oriental Nomiinae, described 12 new species from India viz., *Pachynomia nathani*, *Steganomus lieftincki*, *Macronomia anamalaiensis*, *M. karnatakaensis*, *M. madrasensis*, *M. nilgiriensis*, *M. walayarensis*, *M. ghatensis*, *M. keralaensis*, *M. lonavlaensis*, *M. nathani*, *M. poonaensis*; formulated a key for identification of genera and subgenera from African region including the above Indian species.

Pesenko and Pauly (2009) in their monograph on subfamily Nomioidinae of Africa excluding Madagascar rediscovered a few Indian species viz., *Ceylalicetus*

*punjabensis*, *C. variegatus* and *Nomioides minutissimus*, gave illustrations of the genitalia and formulated a key for identification of the species. A new species *Lasioglossum* (*Mediocralictus*) *orchidodeceptum* was described by Pauly and Banziger (2011) from Thailand and India. This subgenus was new to the oriental region. Further, this species was recorded as an important pollinator of rare orchid *Ophrys* sp.

## CHAPTER - 3

### MATERIALS AND METHODS

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#### 3.1 MATERIALS

The present study on family Halictidae were based on the specimens acquired from the following sources.

**a) National Pusa Collection (NPC) of the Division of Entomology, Indian Agricultural Research Institute, New Delhi**

The identified specimens and those sorted from the unidentified collections of NPC formed the base material for the present study.

**b) Personal collection**

Specimens were collected periodically from various states of India and IARI, New Delhi. Some specimens were also received from pollination biology workers from different parts of the country.

#### 3.2 METHODS

##### 3.2.1 Collection, killing, drying, mounting and preservation

The bees collected from the flowers of various plants using sweep net were killed using ethyl acetate. Subsequently the specimens were stretched, pinned, labeled, segregated and stored in the insect boxes for further studies.

##### 3.2.2 Method of study

The preserved and identified specimens were examined and the specimens apparently resembling each other were grouped together. They were identified based on the keys available (Pesenko, 2005; Michener, 2007; Pauly, 2009) and further confirmed by comparing with the identified specimens in NPC.

The standard terminology of Michener (2007) was used for the description of pilosity, sculptures and genitalia etc. The term 'pilosity' used in the description referred to type and arrangement of hairs and 'sculptures' referred to punctures, depressions and patterns on the cuticle. The measurements of morphological features were taken with an ocular and a stage micrometer and converted to millimeter or indicated as ratio's in the descriptions (Table 1). The antennal

flagellomeres were referred to as F1, F2, F3 etc., following the scape and pedicel. The term apical bands or transverse fascia was used for abdominal tergal bands. The metasomal terga and sterna were referred to with the alphabets T and S respectively and their numbers given along with the alphabets *viz.*, T1, T2, S1, S2 etc. The term basal propodeum or propodeal triangle was used for the mid dorsum of propodeum. The term outer or inner gonostylus have also been used in place of dorsal or ventral gonostylus.

The freshly collected bees were usually loaded with pollens or spills of nectar on their body, which obscured the morphological characters. In order to clean the specimens, the bee wash method of the bee working group was followed. The bees were washed with tap water followed by mixture of warm water with dish washer liquid (a drop in 100ml), then blotted in tissue paper. After that 95% alcohol was added to dehydrate the specimens and the specimens were again blotted. The specimens were then placed on to a paper towel for 45 minutes and the paper was gently folded to remove any moisture left on the specimens. Finally the specimens were dried under an air blower at low speed. Old or dry specimens were relaxed in a moist chamber between moist filter papers.

The relaxed specimens were taken for genitalia dissection. The apical segment of the abdomen S5 onwards was removed. Subsequently it was boiled in 10% potassium hydroxide for 1-2 minutes, washed repeatedly with distilled water, neutralized and dehydrated with glacial acetic acid. The processed genitalia was then kept in a cavity block containing glycerol and studied. Thereafter it was stored in a small glass vial with glycerol for future reference and pinned under the specimen from which it was removed. The illustrations and photographs of processed specimens were made using Camera Lucida (Leica 10308700, Leica DFC 425 C), Leica LZ 205 FA and processed further using Adobe Photoshop version 7.1.

### **3.2.3 Preparation of checklist**

The status of already known species was reviewed and a check list was compiled for the Indian region mainly based on the available literature, with the

aid of Zoological records, catalogues, original descriptions wherever available and online resources. The geographical distribution were based on literature available and new distribution records within the country were also reported based on the data labels of specimens actually examined and collections made during the course of study from different places of India. The new distribution records of the species were asterisked (\*) in the checklist.

**Table 1:** List of morphological characters used for measurements

<b>S. No</b>	<b>Morphological characters</b>	<b>Type</b>
1.	Body length	Meristematic
2.	Head length	Meristematic
3.	Head width	Meristematic
4.	Upper interocular	Meristematic
5.	Lower interocular	Meristematic
6.	Clypeus length	Meristematic
7.	clypeoantennal distance	Meristematic
8.	Eye length	Meristematic
9.	Interocellar and ocellocular distance	Meristematic
10.	Alveolar distance	Meristematic
11.	Antennocellar distance	Meristematic
12.	Cylpeoantennal distance	Meristematic
13.	Scape and pedicel length	Meristematic
14.	Pedicel length	Meristematic
15.	Flagellomere 1	Meristematic
16.	Flagellum	Meristematic
17.	Tegula length and width	Meristematic

18.	Scutum length	Meristematic
19.	Scutellum length	Meristematic
20.	Metantoum length	Meristematic
21.	Basal propodeum length	Meristematic
22.	Propodeum posterior surface width	Meristematic
23.	Forewing length and width	Meristematic
24.	Hind wing length and width	Meristematic
25.	Stigma length and width	Meristematic
26.	Prestigma length and width	Meristematic
27.	Free length of Marginal cell	Meristematic
28.	Marginal cell beyond stigma	Meristematic
29.	Hind femur and tibia length	Meristematic
30.	Hind tibia and basitarsi length	Meristematic
31.	Head length and width	Ratio
32.	Upper and lower interocular	Ratio
33.	Clypeus length and clypeoantennal distance	Ratio
34.	Eye length and head length	Ratio
35.	Interocellar and ocellocular distance	Ratio
36.	Alveolar and antennocellar distance	Ratio
37.	Cylpeoantennal distance	Ratio
38.	Scape and pedicel length	Ratio
39.	Flagellomere 1 and pedicel	Ratio
40.	Flagellum and scape	Ratio

41.	Tegula Length and width	Ratio
42.	Scutum and scutellum Length	Ratio
43.	Scutellum and metantoum Length	Ratio
44.	Metanotum and basal propodeum length	Ratio
45.	Forewing length width	Ratio
46.	Hind wing length width	Ratio
47.	Stigma length and width	Ratio
48.	Prestigma length and width	Ratio
49.	Free length of Marginal cell	Ratio
50.	Marginal cell beyond stigma	Ratio
51.	Hind femur and tibia length	Ratio
52.	Hind tibia and basitarsi length	Ratio
53.	Gonobase Length and width ratio	Ratio
54.	Gonocoxite width and total length ratio	Ratio
55.	Penis valve length and width ratio	Ratio
56.	Dorsal gonostylus length width and ratio	Ratio
57.	Lower gonostylus length width and ratio	Ratio
58.	Width ratio of dorsal and ventral gonostylus	Ratio
59.	Volsella length width ratio	Ratio
60.	Genitalia length and height ratio	Ratio

## CHAPTER -4

## RESULTS

## 4.1.1. GENERAL MORPHOLOGY OF HALICTIDAE

The halictid bees generally comprises of both metallic and non metallic forms, variable in size 4 to 17 mm (*Nomioides*, female *Sphcodes* and *Nomia*) with diverse morphological features. The body is divided into three parts viz., head, mesosoma and metasoma or abdomen. Although propodeum is considered to be a part of mesosoma yet it is treated separately. Color of integument varies from black (*Halictus*), brown (*Sphcodes*) and red (eg. abdomen of *Sphcodes*, some *Nomia*, *Lasioglossum*), and yellow (eg. integumental patterns of *Nomioides*). The color of pubescence is white (*Halictus*) to bright yellow (*Nomia*).

The **head** is hypognathus (all halictids); subconical (*Nomia*, *Lipotriches*) or subquadrangular (*Halictus*), consists of a pair of compound eyes, antennae, three ocelli and mouthparts. The compound eyes are equally long (*Lipotriches*, *Nomia*) or much shorter than the head (*Sphcodes*). Eyes surrounded by margins called inner and outer or posterior orbit. Ocelli are round, prominent, sometimes with carina between ocelli (*Lipotriches*). Clypeus broad, convex slightly and occupying lower part of head. Head is divided into four major regions for descriptive purpose viz., paraocular area, supraclypeal area, frons or supra-antennal area and vertex. The paraocular area limited between lateral to the inner orbit of eye and margin of clypeus. The supraclypeal area is defined as the area between the antennal sockets above clypeus. Frons delimited by an imaginary line drawn between the antennal sockets along their upper margin and below mid ocelli. Area nearby and around ocelli is vertex. Area behind the compound eyes is called as gena and separated by preoccipital carina (*Pseudapis*) with occiput next to it. The post occiput is around foramen magnum and separated by postoccipital suture. The proboscidal fossa is a groove which holds the proboscis when at rest and is surrounded by hypostoma.

The mouthparts are chewing and lapping type consisting of labrum, mandible, maxilla and labium. Labrum small, with a distal process (in females) usually concealed

below the clypeus at repose. Mandible is bidentate with a preapical tooth and a small (*Nomia*) or long (*Sphecodes*) apical tooth. The labium and maxilla combines to form proboscis. The maxilla of proboscis consists of basal cardo, stipes, small hairy lacinia (prepalpal parts), maxillary palpi and short galea with elongated prepalpi. The labium consists of lorum or submentum, mentum, long prementum, labial palpi, glossa and paraglossa. Labial palpi is cylindrical shorter with the first two segments similar to distal segments. The glossa is short (*Sphecodes*) or long (*Lasioglossum*).

Antenna filiform, arises from alveoli or antennal sockets. The antenna consists of scape, pedicel and flagellomeres. The scape is long and the pedicel is usually shorter than the flagellomeres. Twelve flagellomeres are present in males and eleven in females. The flagellum of male is dorsoventrally flattened (eg. *Halictus*) or the apical segments flat and enlarged (*Steganomus*). A single subantennal suture arises from antennal socket reaching epistomal suture.

**Mesosoma** includes thorax and propodeum, the former consists of pro, meso and metathorax each with a pair of legs and two pairs of wings on meso and metathorax. The prothorax is represented by pronotum with pronotal lobes laterally. Pronotum extends ventrally and meets near fore coxa. The pronotal carina or lamella may also be present at anterior margin in some genera (*Lipotriches*, *Pseudapis* and *Steganomus*). The dorsolateral angle of pronotum extended along posterior margin and forms the pronotal collar. Mesothorax divided into two major sclerites viz., scutum and scutellum. Axilla, a small sclerite is found at base of wings separated by an axillar suture. Scutum large, anteriorly broad with a median sulcus and parapsidal sulc on it, surface of scutum is with or without punctures; scutellum small, with or without posterior spines. Two grooves viz., vertical episternal groove and horizontal scrobal groove are present on mesepisternum. The episternal groove extends down beyond the scrobal groove. The scrobe is a small pit on the scrobal groove. The area behind the episternal groove is called as hypoepimeral area and is convex. Tegula is small (*Halictus*, *Sphecodes*, *Nomia*, *Lasioglossum*) or large (*Lipotriches*, *Pseudapis*, *Steganomus*) and oval (*Sphecodes*, *Halictus*, *Lasioglossum*) or auriform (*Nomia*). Metathorax includes a metanotum, lateral metepisternum, a pair of

hindlegs and hindwings. The metanotum with (*Nomia*) or without (*Halictus Lasioglossum*) lateral spines is delimited by transmetanotal suture.

Leg consists of a long coxa, small trochanter, almost equally long femur and tibia, flattened longer basitarsi equal to tibia and pretarsi. In females, strong (*Lipotriches*, *Nomia*) or weak (*Sphcodes*) scopa is present on outer surface of hind femur. In male, hind femur enlarged but scopa absent. In females, a hard basitibial plate is present at base of outer hind tibia. Hind tibia apically extended in male. Spurs are present at apex of hind tibia with their lower margin serrate (*Nomia*, *Patellapis*, *Lasioglossum*) or with coarse tooth (*Halictinae*, *Lasioglossum*, *Halictus*). Hind tibial spurs are reduced in males (*Lipotriches*, *Nomia*) which possess enlarged tibia.

Wings hyaline (*Halictus*, *Lasioglossum*) or fuscous (some *Sphcodes*). The median vein of forewing strongly arched at middle. Forewing includes one marginal cell (2<sup>nd</sup> R1), submarginal cells (1<sup>st</sup> R1, 1<sup>st</sup> Rs, 2<sup>nd</sup> Rs), stigma and a prestigma. The marginal cell is large, rounded (*Nomia*) or with pointed apex (*Nomioides*). The third submarginal cell is shorter than the first (*Halictus*, *Lasioglossum*) or the third SMC same as first or twice as long as second (*Nomia*) and or with only two SMC (*Dufourea*, *Steganomus*). Hind wing jugal lobe is longer than the submedian cell.

Propodeum divided into three parts, the dorsal, lateral and posterior propodeum. The dorsal or basal propodeum is short (*Nomia*) or long (*Halictus*, *Nomioides*) with weak (*Nomia*) or strong (*Sphcodes*) carina along the margins. Sometime basal propodeum is very narrow or declivous (some *Nomia* species). The posterior surface is broad, heart shaped with median depression called propodeal pit. The propodeum variously sculptured across the genera and species viz., *Sphcodes*, *Pseudapis* and *Nomia*.

**Metasoma** or gaster is cylindrical (*Halictus*) to subconical (*Nomioides*). It consists of tergum and sternum. The tergal sclerites referred to as T1, T2 and T3 etc. The tergum dorsolaterally curved with an undefined mid area called as disc. The anterior margin of tergum is marked by the antecostal suture and the impression or line below which is gradulus. A pregradular area is found above the gradulus. Marginal zone is

defined between the premarginal line and posterior margin of tergum. Lateral apodemes are present at anterior lateral ends. The prepygidium or pygidial fimbriae present (*Lasioglossum*) or absent (*Halictus*) on apical terga of female. The morphological terms are similar for sternum but their apex modified variously in S5 to S8 of male with hairs or spicules (*Nomia*). The **genitalia** consist of gonobase, volsella, gonocoxite, gonostylus, penis and penis valve. The gonobase is rectangular (*Lipotriches capitata*) to conical (*Nomia buddha*) with an opening at middle known as genital foramen which is narrow, oval (*Lipotriches fervid*) to broad (*Sphcodes crassicornis*). The volsella is small or reduced and divided into digitus and cuspis. Gonocoxite is the base of gonostylus. The gonostylus variously modified across the species which is narrow (*Nomioides*) or broad (*Nomia curvipes*), may be single (*Nomioides*) or paired (*Nomia curvipes*) overlapped as dorsal and ventral lobes with simple (*Halictus*) or ornamented hairs (*Nomia ellioti*). The penis valve is a long, hard structure and the apex curved downwards into a long apodeme. The penis is a fleshy lobe found between the penis valve (Figure.1, 2 & 3).

#### 4.1.2. A CHECK LIST OF INDIAN HALICTIDAE

##### Subfamily HALICTINAE Thomson 1872

##### Tribe Halictini Thomson 1872

##### I. Genus *Eupetersia* Blüthgen, 1928

*Eupetersia* Blüthgen, 1928a: 49

*Calleupetersia* Cockerell, 1938a: 329

*Eupetersia* (*Nesoeupetersia*) Blüthgen, 1936: 182

Type species: *Eupetersia neavei* Blüthgen, 1928b: 165; Michener, 1997: 23

S.No	Species	Distribution
1.	<i>nathani</i> Baker, 1974 <i>Eupetersia</i> ( <i>Nesoeupetersia</i> ) <i>nathani</i> Baker, 1974: 59-63	Tamil Nadu: Nilgiris, Cherangode

##### II. Genus *Halictus* Latreille, 1804

*Halictus* Latreille, 1804: 182

*Seladonia* Robertson, 1918: 91

*Odontalictus* Robertson, 1918: 91

*Halictus* (*Monilapis*) Cockerell, 1931: 529

Type species: *Apis quadricincta* Fabricius, 1777: 247; Michener, 1991: 232

1.	<i>acrocephalus</i> Blüthgen, 1926: 597	West Bengal
2.	<i>brunnescens</i> (Eversmann, 1852) <i>Hylaeus brunnescens</i> Eversmann, 1852: 34 <i>Halictus brunnescens</i> Eversmann, 1852: 23; Pesenko, 1984a: 23 <i>Halictus quadricinctus</i> var <i>maximus</i> Friese, 1916: 23; Pesenko, 1984a: 23 <i>Halictus</i> ( <i>Halictus</i> ) <i>brunnescens</i> (Eversmann, 1852: 34); Pesenko, 1984a: 346 <i>Halictus quadricinctus</i> var <i>aegyptiacus</i> Friese, 1916: 346; Pesenko, 1984b: 346	Jammu & Kashmir, Himachal Pradesh: Kulu
3.	<i>constrictus</i> Smith, 1853 <i>Halictus paris</i> Bingham, 1908: 361 <i>Halictus matsurai</i> Matsum; Hirashima, 1957: 12	Himachal Pradesh: Shimla, Jammu & Kashmir; Uttarakand: Mussoorie, Swarghat
4.	<i>duplocinctus</i> Vachal, 1902 <i>H. duplocinctus</i> Vachal, 1902: 225 <i>H. magnificus</i> Nurse, 1903: 541; Blüthgen, 1922: 63	Jammu & Kashmir
5.	<i>fimbriatus</i> Smith, 1853 <i>Halictus fimbriatus</i> Smith, 1853: 63; <i>Halictus asperatus</i> Bingham, 1898: 123; Pesenko, 1984: 19	Jammu & Kashmir: *Srinagar; Himachal Pradesh: Shimla, Dungagali
6.	<i>latisignatus</i> Cameron, 1908 <i>Halictus latisignatus</i> Cameron, 1908: 310	*Maharashtra: Mumbai *Karnataka: Coorg
7.	<i>lucidipennis</i> Smith, 1853 <i>Halictus</i> ( <i>Seladonia</i> ) <i>lucidipennis</i> Smith, 1853: 362; Ebmer, 1980: 483	Haryana: Hissar; Karnataka: Bangalore; Maharashtra;

- H. varipes* Morawitz, 1876: 223-224; Sakagami and Ebmer, 1987: 326; Pauly, 1999: 146  
*H. vernalis* Smith, 1879: 30; Ebmer, 1980: 483  
*H. niloticus* Smith, 1879: 32  
*H. magretti* Vachal, 1892: 137  
*H. dives* Pérez, 1895: 52  
*H. (S) sudanicus* Cockerell, 1945: 352  
*H. (S) tokarensis* Cockerell, 1945: 352-353  
*H. (S) dissensis* Cockerell, 1945: 353  
*H. omanicus* Pérez, 1907: 489  
*H. variipes* var *koptica* Blüthgen, 1933a: 16-17  
*H. (Seladonia) medanicus* Cockerell, 1945: 354  
*H. (Seladonia) mogrensis* Cockerell, 1945: 355  
*H. (Seladonia) tokariellus* Cockerell, 1945: 355  
*H. (Seladonia) medaniellus* Cockerell, 1945: 356  
*H. (Seladonia) morinellus hyemalus* Warncke, 1982: 134; Ebmer, 1988: 356  
*H. (Seladonia) lucidipennis* (Smith, 1853: 62); Sakagami and Ebmer, 1987: 321; Pesenko, 2004: 101
8. **minor** Morawitz, 1876  
*Halictus minor* Morawitz, 1876b: 233  
*Halictus altaicus* Pérez, 1903: 208; Ebmer, 1980: 472  
*Halictus jarkandensis* Strand, 1909b: 36; Blüthgen, 1931 (1930): 211; Michener, 1978: 534  
*Halictus yarkandensis* Michener, 1978: 534  
*Halictus rudolphi* Pesenko, 1984a: 45; Lelei, 2007: 783
9. **paropamisos** Ebmer, 1978  
*Seladonia (Seladonia) paropamisos* (Ebmer, 1978a: 91); Pesenko, 2004: 101
10. **propinquus** Smith, 1853  
*Halictus grandiceps* Friese, 1925: 161; Blüthgen, 1931b: 325  
*Halictus alexis* Cameron, 1896: 99; Bingham, 1897: 430  
*Halictus pinguis* Vachal, 1902: 230; Blüthgen, 1931b: 325  
*Halictus (Seladonia) propinquus* Smith, 1853: 61; Michener, 1978: 528
11. **resurgens** Nurse, 1903  
*Halictus resurgens* Nurse, 1903: 542  
*Halictus frontalis turkomannus* Pérez, 1903: ccvii; Warncke, 1975: 111  
*Halictus (Leusius) holtzi* Schulz, 1906: 49  
*Halictus asiaeminoris* Strand, 1921: 311, 312
12. **subauratoides** Blüthgen, 1926  
*Halictus subauratoides* Blüthgen, 1926: 680
- \*Madhya Pradesh: Indore  
Rajasthan: Bharatpur;  
\*Tamil Nadu: Madurai
- Maharashtra;  
Uttarakhand: Dehradun;  
Jharkhand; Himachal Pradesh;
- Maharashtra
- Karnataka: Bengaluru  
Orissa: Jeypore  
Uttaranchal: Dehradun  
Uttarakhand: Mussoorie,\*Pantnagar  
West Bengal: Barrackpore  
\*Andhra Pradesh: Vijayarai
- Jammu & Kashmir;  
Maharashtra
- Meghalaya: Shillong  
Assam;

- Halictus (Seladonia) subauratoides* Blüthgen, 1926; Michener, 1978: 528; Sakagami and Ebmer, 1987: 349
13. **subauratus** Blüthgen 1926  
*Apis subaurata* Rossi, 1792:144  
*Halictus virescens*, Lepeletier, 1841:279  
*Halictus gramineus* Smith, 1849: 58  
*Halictus meridionalis* Morawitz, 1873 (1874): 170  
*Halictus subauratus meridionalis* Morawitz, 1873:  
*Halictus subauratus* Blüthgen 1926: 680  
*Halictus subauratus syrius* Blüthgen, 1933: 72  
*Halictus subauratus var corsa* Blüthgen, 1933:  
*Halictus (Seladonia) subauratus corsa* Blüthgen, 1933  
*Halictus (Seladonia) subauratus* Ebmer 1983: 322  
*Halictus (Seladonia) subauratus subauratus* Ebmer 1983: 341  
*Seladonia (Seladonia) subaurata* (Rossi, 1792)
14. **vicinus** Vachal, 1895  
*Halictus vicinus* Vachal, 1895: 431  
*Halictus abuensis* Cameron, 1908a: 310  
*Halictus propinquus silvatica* Blüthgen, 1926: 677  
*Halictus daturae* Cockerell, 1929c: 584  
*Halictus daturae var laosina* Cockerell, 1929c: 585  
*Halictus umbrosus* Cockerell, 1929c: 588  
*Halictus speculiferus* Cockerell, 1929c: 588  
*Halictus (Seladonia) vicinus*, Sakagami & Ebmer, 1987: 345
- Uttarakand: Lal Tibba, Mussoorie  
Uttar Pradesh;  
Uttarakhand: Mussoorie, Lal Tibba  
Rajasthan: Mount Abu

### III. Genus *Lasioglossum* Curtis, 1833: 448

- Hemihalictus* Cockerell, 1897: 288  
*Halictus (Lucasius)* Dours, 1872: 350; Sandhouse, 1943: 566  
*Halictus (Lucasiellus)* Cockerell, 1905: 272  
*Halictus (Lucasellus)* Schulz, 1911: 202  
*Halictus (Pallhalictus)* Warncke, 1975: 92  
*Halictus (Fahrhalictus)* Warncke, 1975: 95  
*Halictus (Leuchalictus)* Warncke, 1975: 98  
*Sphecodogastra* Ashmead, 1899: 92  
*Paralictus* Robertson, 1901: 229  
*Dialictus* Robertson, 1902: 48  
*Evylaeus* Robertson, 1902: 247  
*Chloralictus* Robertson, 1902: 248  
*Curtisapis* Robertson, 1918: 91  
Type species: *Lasioglossum triangulum* Curtis, 1833: 448; = *Melitta xanthopus* Kirby, 1802, by original designation

1. **albenum** (Blüthgen, 1934)

Rajasthan: Mount Abu

- Halictus ablenus* Blüthgen, 1934: 198; Ebmer, 1975: 103  
*Lasioglossum albenum* (Blüthgen); Ebmer, 1975: 103
2. ***albescens*** (Smith, 1853) \*Madhya Pradesh: Indore  
 \*New Delhi  
 Maharashtra;  
 Punjab;  
 Uttar Pradesh;  
 West Bengal,  
 Uttarakhand;  
*Halictus albescens* Smith, 1853: 61; Blüthgen, 1926: 491  
*Halictus albozonatus* Smith, 1879: 32; Bingham, 1897: 423  
*Halictus senescens* (Smith, 1879: 30); Vachal, 1895: 430  
*Halictus albicinctus* Dalla Torre, 1896: 52  
*Halictus picipes* Cameron, 1897: 102  
*Halictus minikoiensis* Cameron, 1902a: 58  
*Halictus bengalensis* Cameron, 1903: 131  
*Halictus manilae* Ashmead, 1904b: 281  
*Halictus luzonicus* Strand, 1910: 208  
*Halictus javanensis* Strand, 1910: 198  
*Halictus amblypygus* Strand, 1913: 141; Blüthgen, 1926:  
 492  
*Halictus javanicus* Friese, 1914: 23; Blüthgen, 1926: 492  
*Lasioglossum (L.) albescens* (Smith); Michener, 1965: 173
3. ***algirum*** (Blüthgen, 1923) Uttarakhand  
*Halictus algirus* Blüthgen, 1923: 252
4. ***alphenum*** (Cameron, 1897: 108) Uttarakhand  
*Halictus alphenus* Cameron, 1897: 108; Blüthgen, 1931b:  
 301  
*Halictus ceylonicus* Cameron, 1902b: 254; Blüthgen,  
 1931b: 301  
*Halictus strandiellus* n.n. for *H. ceylonicus* Strand, 1910:  
 187  
*Ceylonicola submicans* Friese, 1918: 504; Blüthgen, 1926:  
 546  
*Lasioglossum (Sudila) alphenum* Cameron, 1897 (1896);  
 Sakagami, Ebmer and Tadauchi, 1996: 164
5. ***bispinosum*** Blüthgen 1926 India  
*Halictus bispinosus* Blüthgen, 1926:621
6. ***buccinum*** (Vachal, 1985) India  
*Halictus buccinus* Vachal, 1985: 443
7. ***cameronellum*** (Cockerell, 1911) Northern India  
*Halictus himalayensis* Cameron, 1904: 210  
*Halictus cameronellus* Cockerell, 1911a; 192  
*Halictus matianicus* Blüthgen, 1926: 552
8. ***catileps*** (Blüthgen, 1926) India  
*Halictus catileps* Blüthgen, 1926: 577
9. ***cavernifrons*** (Blüthgen, 1926) India  
*Halictus cavernifrons* Blüthgen, 1926: 658
10. ***cavillosum*** (Vachal, 1894) India  
*Halictus cavillosum* Vachal, 1894

11. **cire** (Cameron, 1897) West Bengal  
*Halictus ciris* Cameron, 1897: 105; Blüthgen, 1931b: 300  
*Halictus kandycola* Strand, 1913: 139; Blüthgen, 1926: 537  
*Lasioglossum (Ctenonomia) cire* Cameron, 1897: Sakagami  
and Munakata, 1990: 985; Wijesekara, 2001: 148
12. **clarum** (Nurse, 1902) Gujarat  
*Halictus clarus* Nurse, 1902: 146
13. **compressum** (Blüthgen, 1926) Uttar Pradesh;  
Himachal Pradesh;  
Kumaon, Almora, Raniket,  
Chanbattia;  
India  
*Halictus compressus* Blüthgen, 1926: 619; Warncke, 1973:  
281
14. **cuniculum** (Vachal, 1895) India  
*Halictus cuniculus* Vachal, 1895: 437
15. **delience** (Strand, 1910) India  
*Halictus delience* Strand, 1910: 188  
*Halictus roepkei* Friese, 1914: 21  
*Halictus eschscholtzi* Cockerell, 1919c: 275  
*Halictus latebralis* Cockerell, 1921:
16. **didomenon** Ebmer, 1980: 484 Jammu & Kashmir:  
Ladakh  
*L. (Evyllaesus) didomenon* Ebmer, 1980: 484
17. **discursus** (Cameron, 1897) Uttarakhand  
*Halictus discursus* Cameron, 1897: 100
18. **dolus** Ebmer, 1974 India  
*L. (Evyllaesus) dolus* Ebmer, 1974: 203
19. **dynastes** (Bingham, 1898) India  
*Halictus dynastes* Bingham, 1898: 124
20. **eduardi** (Blüthgen, 1931) North India  
*Halictus eduardi* Blüthgen, 1931b: 306
21. **epipygiale** (Blüthgen, 1923) Uttarakhand: Kumaon  
*Halictus epipygialis* Blüthgen, 1923c: 276  
*Halictus massuriensis* Blüthgen, 1926: 579  
*Halictus quettensis* Blüthgen, 1929: 58-61  
*Halictus bentoni* Cockerell, 1919c: 177  
*Halictus malachuropsis* Blüthgen, 1931b: 314  
*Lasioglossum (Evyllaesus) massuriense* (Blüthgen, 1926:  
579); Ebmer, 1978a: 47  
*Lasioglossum (Evyllaesus) epipygiale quettense* Blüthgen,  
1929: 58
22. **excisum** Ebmer 1998 Sikkim
23. **feai** (Vachal, 1895) Sumatra, India, Burma  
*Halictus feae* Vachal, 1895: 440
24. **fulgens** (Nurse, 1902) Himachal Pradesh  
*Halictus fulgens* Nurse, 1902: 147
25. **funebre** (Cameron, 1897) Uttarakhand  
*Halictus funebris* Cameron, 1897: 104  
*Halictus fuscus* Blüthgen, 1926: 570
26. **himalayense** (Bingham, 1898) India  
*Halictus himalayensis* Bingham, 1898: 124; Cameron,

- 1904b: 210
27. **hydrocephalum** (Blüthgen, 1926) India  
*Halictus hydrocephalus* Blüthgen, 1926: 535
28. **hypsisiton** Ebmer, 1980 India  
*Lasioglossum (Evyllaesus) hypsisiton* Ebmer, 1980: 488
29. **inoum** (Cameron, 1904) India  
*Lasioglossum inoum* Cameron, 1904b:  
*Halictus maymyonicus* Blüthgen, 1926: 499
30. **krishna** (Nurse, 1902) Himachal Pradesh  
*Halictus krishna* Nurse, 1902: 146
31. **lakhnauense** (Bluthgen 1928) Uttar Pradesh  
*Halictus lakhnauensis* Bluthgen 1928:
32. **leucozonium** (Schrank, 1781) Himachal Pradesh  
*Apis leucozonias* Schrank, 1781:  
*Halictus similis* Smith, 1853:69  
*Halictus bifasciatellus* Schenck, 1875:  
*Halictus leucozonius* var *nigrotibialis* Dalla Torre, 1877;  
*Halictus deiphobus* Bingham, 1908:  
*Halictus satschauensis* Blüthgen, 1934:  
*Halictus leucozonius clusium* Warnecke, 1975:  
*Lasioglossum leucozonium cedri* Ebmer, 1976:  
*Lasioglossum (Lasioglossum) satschauense* (Blüthgen,  
1934)  
*Lasioglossum (Lasioglossum) satschauense*  
*mandschuricum* Ebmer, 1978:  
*Lasioglossum (Lasioglossum) leucozonium* (Schrank, 1781)
33. **margheritanum** (Bluthgen 1926) Assam  
*Halictus margheritanus* Bluthgen 1926: 591
34. **marginatum** (Brullé, 1832) India, Southern Asia;  
*Halictus marginatus* Brullé, 1832: 351  
*Halictus marginatus* Vasic, 1979: 219
35. **massuricum** (Blüthgen, 1926) Bihar,  
*Halictus massuricus* Blüthgen, 1926: 594 West Bengal
36. **matianense** (Blüthgen, 1926) Himalaya, Gharwal  
*Halictus matianensis* Blüthgen, 1926: 635  
*Lasioglossum (Evyllaesus) matianense pluto* Ebmer, 1980:  
497
37. **melachloron** Ebmer 1983 Jammu & Kashmir
38. **nathanae** Pauly, 2001 Kerala: Trivandrum,  
*Lasioglossum (Ipomalictus) nathanae* Pauly, 2001: 145 Ponmudi Range
39. **nicobaricum** Bluthgen 1926 Andaman & Nicobar  
*Halictus nicobaricus* Bluthgen 1926: 663 Islands
40. **nursei** (Blüthgen, 1926) India, Nepal  
*Halictus nursei* Blüthgen, 1926: 614
41. **oppositum** (Smith, 1875) India  
*Nomia opposita* Smith, 1875: 59
42. **orchidodeceptum** Pauly and Banziger, 2011: 17 South India: Madras,  
*Lasioglossum (Mediocralictus) orchidodeceptum* Pauly and Anamalai hills, Nilgiri  
Banziger, 2011: 17 hills, Naduvatam;
43. **orpheum** (Nurse, 1904) Himachal Pradesh

- Halictus orphans* Nurse, 1904a: 26
44. **paralphenum** Sakagami, Ebmer and Tadauchi, 1996 India  
*Lasioglossum paralphenum* Sakagami, Ebmer and Tadauchi, 1996: 143-189
45. **pashokense** (Bluthgen 1926) West Bengal  
*Halictus pashokense* Bluthgen 1926:625
46. **perihirtulum** (Cockerell, 1937) India  
*Halictus (Evylyaeus) perihirtulus* Cockerell, 1937: 8
47. **pheidolopse** (Blüthgen, 1926) North India  
*Halictus pheidolopsis* Blüthgen, 1926: 573
48. **plasunicum** (Blüthgen, 1926) North India, Nepal  
*Halictus plasunicus* Blüthgen, 1926: 639
49. **polyctor** (Bingham, 1908) India  
*Halictus polyctor* Bingham, 1908: 360
50. **poonaense** (Cockerell 1919) Maharashtra: Pune  
*Halictus poonaensis* Cockerell, 1919:
51. **pseudoccidens** (Blüthgen, 1926) North India  
*Halictus pseudoccidens* Blüthgen, 1926: 500
52. **pseudopalmeri** (Blüthgen, 1926) North India  
*Halictus pseudopalmeri* Blüthgen, 1926: 565
53. **reliquum** (Bluthgen, 1926) Himachal Pradesh  
*Halictus reliquus* Bluthgen 1926: 561
54. **rugifrons** (Blüthgen, 1926) North India  
*Halictus rugifrons* Blüthgen, 1926: 550
55. **rugolatum** (Smith, 1853) India  
*Halictus rugolatus* Smith, 1853:
56. **salutatrix** (Cameron, 1896) Uttarakhand, India  
*Halictus salutator* Cameron, 1897: 107  
*Halictus niveus* Bingham, 1898 : 124  
*Halictus zonatulus* Cameron, 1902b: 255
57. **sanitarium** (Blüthgen, 1926) West Bengal: Darjeeling  
*Halictus sanitarius* Blüthgen, 1926: 612
58. **serenum**(Cameron, 1897) Gujarat  
*Halictus serenus* Cameron, 1897: 97  
*Halictus deesanus* Cameron, 1908a: 309  
*Halictus ceylonicus* Strand, 1910: 187  
*Halictus strandiellus* Cockerell, 1911: 179  
*Halictus hornianus* Strand, 1913c: 138
59. **serratatum** (Bluthgen 1926) Kerala  
*Halictus serratus* Bluthgen 1926: 623
60. **shillongense** (Blüthgen, 1926) Meghalaya: Shillong  
*Halictus shillongense* Blüthgen, 1926: 559
61. **schoichi** Ebmer, 2004 Assam  
*Lasioglossum (Evylyaeus) schoichi* Ebmer, 2004: 132
62. **sikkimense** (Blüthgen, 1926) Sikkim  
*Halictus sikkimensis* Blüthgen, 1926: 586
63. **sikkimicum** (Bluthgen 1926) Sikkim  
*Halictus sikkimicus* Bluthgen 1926: 633
64. **simlaense** (Cameron, 1909) Himachal Pradesh, India  
*Halictus simlaensis* Cameron, 1909: 133
65. **splendidulum** (Vachal, 1895) India, Sumatra, Burma

- Halictus splendidulus* Vachal, 1895: 432  
*Halictus proteus* Vachal, 1895: 438  
*Halictus semiaerinus* Vachal, 1895: 443; Blüthgen, 1926: 611, 654  
*Halictus metenus* Cockerell, 1937: 4; Ebmer, 1998: 376  
*Halictus (Evylyaeus) bambusarum* Cockerell, 1937: 10; Ebmer, 1998: 376  
*Halictus (Chloralictus) speculibasis* Cockerell, 1937: 11; Ebmer, 1998: 376
66. **spodiozonium** (Vachal, 1895) Sikkim, India  
*Halictus spodiozonius* Vachal, 1895: 432
67. **subglobosum** (Blüthgen, 1926) Assam  
*Halictus subglobosus* Blüthgen, 1926: 505
68. **sublaterale** (Blüthgen, 1931) India  
*Halictus sublateralis* Blüthgen, 1931: 334
69. **tardum** (Cameron, 1896) Uttarakhand  
*Halictus tardus* Cameron, 1896: 103  
*Halictus refiexoidea* Blüthgen, 1926: 692
70. **tschibuklinum** (Blüthgen, 1931) India  
*Halictus tschibuklinus* Blüthgen, 1931a: 388
71. **tunguense** (Blüthgen, 1926) Sikkim  
*Halictus tunguensis* Blüthgen, 1926: 563
72. **turneri** (Blüthgen, 1926) India  
*Halictus turneri* Blüthgen, 1926: 556
73. **vagans** (Smith, 1857) Karnataka: Bangalore  
 Maharashtra  
 Uttarakhand  
*Halictus vagans* Smith, 1857: 42; Dalla Torre, 1896: 89; Blüthgen, 1931b: 327; Yasumatsu, 1935: 385; Baltazar, 1966: 367-368  
*Halictus cattulus* Vachal, 1895: 437; Dalla Torre, 1896: 57; Blüthgen, 1926: 393; Blüthgen, 1926: 652, 670, 672; Blüthgen, 1930a: 72  
*Halictus cattulus* var *peguanus* Vachal, 1895: 437; Blüthgen, 1926: 654  
*Halictus buddha* Cameron, 1897: 107; Blüthgen, 1930a: 74  
*Halictus vishnu* Cameron, 1897: 106; Blüthgen, 1930a: 74  
*Halictus phillipinensis* Ashmead, 1904b: 128; Blüthgen, 1926: 416  
*Halictus matheranensis* Cameron, 1907a: 1001; Blüthgen, 1930a: 77  
*Halictus emergendus* Cameron, 1908a: 311; Blüthgen, 1926: 654  
*Halictus luteitarsellus* Strand, 1910: 206; Blüthgen, 1926: 654  
*Halictus micado* Strand, 1910: 204; Blüthgen, 1922: 54; Blüthgen, 1926: 386, 397  
*Halictus nasicensis* Cockerell, 1911: 191; Blüthgen, 1926: 654  
*Halictus perhumilis* Cockerell, 1911a: 192; Blüthgen, 1931b: 327  
*Halictus statialis* Cockerell, 1911d: 667; Strand, 1913a: 29; Blüthgen, 1922: 63; Blüthgen, 1926: 386 [Notes]; Sonan,

- 1940: 375  
*Halictus bleharophorus* Strand, 1913: 28; Blüthgen, 1923b: 242  
*Halictus centrophorus* Strand, 1913c: 140; Blüthgen, 1926: 399  
*Halictus nalandicus* Strand, 1913c: 140; Blüthgen, 1926: 399  
*Halictus javanicus* Friese, 1914: 23  
*Halictus schmiedeknechti* Friese, 1914: 24; Blüthgen, 1922: 56  
*Halictus philippinensis* var *nigritarsellus* Cockerell, 1919c: 274; Blüthgen, 1926: 407.  
*Halictus chaldaeorum* Morice, 1921: 826; Blüthgen, 1922: 319; Cockerell, 1924a: 585; Blüthgen, 1926: 386  
*Halictus semivagans* Cockerell, 1937: 5  
*Lasioglossum* (*Ctenonomia*) *vagans* Pesenko, 1986: 121; Sakagami, 1989: 509; Ebmer, 1998: 377; Ebmer, 2004: 140
74. ***villosulum*** (Kirby, 1802) Meghalaya: Shillong  
*Melitta villosula* Kirby, 1802: 62; Ebmer, 1988: 649  
*Melitta punctulata* Kirby, 1802: 66  
*Halictus villosulus* (Kirby, 1802): 90  
*Halictus hirtellus* Schenck, 1868: 31; Blüthgen, 1922: 48  
*Halictus medinai* Vachal, 1895: 148  
*Halictus pauperatulellus* Strand, 1909a: 44  
*Halictus barkensis* Blüthgen, 1930b: 224  
*Halictus villosulus perlautus* Cockerell, 1938a: 95  
*Halictus* (*Evylaeus*) *rufotegularis* Cockerell, 1938b: 7; Ebmer, 1976: 253  
*Halictus villiersi* Benoist, 1941: 80  
*Halictus berbents* Benoist, 1941: 81  
*Halictus trichopsis* Strand, 1914: 156; Ebmer, 1978b: 207  
*Halictus melanomitratatus* Strand, 1914: 156  
*Halictus melanomitratatus* var *mitratolus* Strand, 1914: 156  
*Halictus villosulopsis* Blüthgen, 1926: 540; Ebmer, 1978b: 207  
*Halictus pahanganus* Blüthgen, 1928b: 374; Ebmer, 1978b: 207  
*Lasioglossum villosulum trichopse* (Strand, 1914); Ebmer, 1978b: 207  
*Lasioglossum* (*Evylaeus*) *villosulum arabicum* Ebmer, 2008: 560
75. ***xystonotum*** (Vachal, 1895) India, Burma  
*Halictus xystonotus* Vachal, 1895: 436

#### IV. Genus *Patellapis* Friese, 1909

- Halictus* (*Patellapis*) Friese, 1909a: 148; Michener, 1978: 518  
*Halictus* (*Pachyhalictus*) Cockerell, 1929c: 589; Michener, 2000: 370  
Type species: *Halictus schultzei* Friese, 1909, designated by Cockerell, 1920a: 311

1. ***assamica*** (Blüthgen, 1926) Assam  
*Halictus assamicus* Blüthgen, 1926: 414, 426

- Pachyhalictus (Pachyhalictus) assamicus* (Blüthgen, 1926); Michener, 1978: 517
2. ***interstitialis*** (Cameron, 1903)  
*Halictus interstitialis* Cameron, 1903: 130  
*Pachyhalictus (Pachyhalictus) interstitialis* (Cameron, 1903: 130); Michener, 1978: 517 West Bengal
3. ***intricata*** (Vachal, 1895)  
*Halictus intricatus* Vachal, 1895: 433  
*Halictus validus* Bingham, 1903: 3; Pesenko and Wu, 1997: 288  
*Halictus thoracicus* Friese, 1914: 22  
*Pachyhalictus (Pachyhalictus) intricatus* (Vachal, 1895); Michener, 1978: 518 India  
*Pachyhalictus (Pachyhalictus) validus* (Bingham, 1903); Michener, 1978: 518
4. ***liodoma*** (Vachal, 1895)  
*Halictus liodomus* Vachal, 1895: 435  
*Pachyhalictus (Pachyhalictus) liodomus* (Vachal, 1895); Michener, 1978: 518 India  
*Halictus scopipes* Friese, 1918
5. ***reticulosa*** (Dalla Torre, 1896)  
*Halictus reticulosus* Dalla Torre, 1896: 80 \*Tamil Nadu:  
*Pachyhalictus (Pachyhalictus) reticulosus* (Dalla Torre, 1896); Madurai  
 Michener, 1978: 518; Pesenko & Wu, 1997 : 288; Michener, 2000: 370

#### V. Genus *Sphecodes* Latreille, 1804

*Sphecodes* Latreille, 1804: 182  
*Dichroa* Illiger, 1806: 46  
*Sabulicola* Verhoeff, 1890: 328  
*Drepanium* Robertson, 1903: 103  
*Proteraner* Robertson, 1903: 103  
*Sphecodium* Robertson, 1903: 104  
*Machaeris* Robertson, 1903: 104  
*Dialonia* Robertson, 1903: 104  
*Sphecodes (Callosphecodes)* Friese, 1909b: 182  
 Type species: *Sphex gibba* Linnaeus 1785: 571 (monobasic)

1. ***abuensis*** Nurse, 1903: 549  
*Sphecodes abuensis* Nurse, 1903: 549 Rajasthan: Mount Abu,
2. ***albifrons*** Smith, 1879: 27  
*Sphecodes albifrons* Smith, 1879: 27 Western India
3. ***assamensis*** Blüthgen, 1927  
*Sphecodes assamensis* Blüthgen, 1927: 60 Assam
4. ***chaprensis*** Blüthgen, 1927  
*Sphecodes chaprensis* Blüthgen, 1927: 96 Bihar: Chapra
5. ***crassicornis*** Smith, 1879  
*Sphecodes crassicornis* Smith, 1879: 28 West Bengal: Kolkata  
 \*Tamil Nadu: Coimbatore
6. ***decorus*** (Cameron, 1896)  
*Halictus decorus* Cameron, 1896: 94  
*Halictus cameronii* Bingham, 1897: 432 Uttarakhand: Mussoorie
7. ***dissimilandus*** (Cameron 1896)  
 Uttarakhand

*Halictus dissimilandus* Cameron 1896: 95

8. **fumipennis** Smith, 1853  
*Sphecodes fumipennis* Smith, 1853: 36 Sikkim (Rangit valley), Assam
9. **gibbus** (Linnaeus, 1785: 571)  
*Sphex gibba* Linnaeus, 1785: 571  
*Apis glabra* Fuebly, 1775: 51  
*Andrena ferrugena* Olivier, 1789: 139  
*Apis gibbosa* Christ, 1791: 177  
*Melitta sphecooides* Kirby, 1802: 46  
*Melitta picea* Kirby, 1802: 48  
*Andrena austriaca* Fabricius, 1804: 325  
*Sphecodes apicatus* Smith, 1853: 36; Warncke, 1992: 29  
*Sphecodes nippon* Meyer, 1922: 171  
*Sphecodes castilianus* Blüthgen, 1924: 473; Warncke, 1992: 29 Jammu & Kashmir: Srinagar
10. **indicus** Bingham, 1898  
*Sphecodes indicus* Bingham, 1898: 123 Simla; Mussoorie
11. **invidus** (Cameron 1896)  
*Halictus invidus* Cameron 1896:96 Uttarakhand
12. **iridipennis** Smith, 1879  
*Sphecodes iridipennis* Smith, 1879: 27 \*Bihar: Chapra
13. **lasimensis** Blüthgen, 1927  
*Sphecodes lasimensis* Blüthgen, 1927: 40 Himachal Pradesh: Shimla
14. **monilicornis** (Kirby 1802)  
*Melitta monilicornis* Kirby, 1802:47  
*Sphecodes maculatus* Lepeletier, 1841:545  
*Sphecodes subquadratus* Smith, 1845:1014  
*Sphecodes gibbus* var *ephippium* subvar *rufipes* Sichel, 1865:428  
*Sphecodes gibbus* var *ephippium* subvar *dubious* Sichel, 1865:419  
*Sphecodes gibbus* var *ephippium* subvar *incertus* Sichel, 1865:420  
*Sphecodes gibbus* var *ephippium* subvar *nigrescens* Sichel, 1865: 427  
*Sphecodes gibbus* var *ephippium* subvar *testaceipes* Sichel, 1865:428  
*Sphecodes ruficrus* Dalla Torre, 1896: 10  
*Sphecodes hanuman* Nurse, 1903:538;  
*Sphecodes monilicornis* var *nigerrima* Blüthgen, 1927:41;  
*Sphecodes caucasicus* Meyer, 1920:124  
*Sphecodes monilicornis quadratus* Meyer, 1920: 129  
*Sphecodes monilicornis berberus* Warncke, 1992:22 Jammu & Kashmir
15. **montanus** Smith, 1879  
*Sphecodes montanus* Smith, 1879: 27 Uttarakhand: Mussoorie

16. **olivieri** Lepeletier, 1825  
*Sphecodes collaris* Spinola, 1843: 137  
*Sphecodes hispanicus* var *abyssinicus* Sichel, 1865:447  
*Sphecodes ruficornis* Sichel, 1865:440  
*Sphecodes punctulatus* Sichel, 1865:443  
*Sphecodes subpunctulatus* Sichel, 1865:445  
*Sphecodes rufithorax* Morawitz, 1876: 225  
*Sphecodes verticalis* Hagens, 1882:219  
*Sphecodes desertus* Nurse, 1903:540  
*Sphecodes chionospilus* Cockerell, 1911: 217  
*Sphecodes chionospilus* var *sanguinatus* Cockerell, 1911: 217  
*Sphecodes tenuis* Meyer, 1919: 121  
*Sphecodes olivieri* var *niveatus* Meyer, 1925: 4 Gujarat: Deesa
17. **perplexus** Nurse 1903  
*Sphecodes perplexus* Nurse 1903: 540 Jammu and Kashmir
18. **shillongensis** Blüthgen, 1927 Assam  
*Sphecodes shillongensis* Blüthgen, 1927: 95 Meghalaya: Shillong
19. **sikkimensis** Blüthgen, 1927 Sikkim  
*Sphecodes sikkimensis* Blüthgen, 1927: 54
20. **simlaellus** Blüthgen, 1927 Himachal Pradesh; Shimla  
*Sphecodes simlaellus* Blüthgen, 1927: 46
21. **tantalus** Nurse, 1903 Kashmir  
*Sphecodes tantalus* Nurse, 1903: 539
22. **turneri** Cockerell, 1916 Assam  
*Sphecodes turneri* Cockerell, 1916: 430

## VI. Genus *Thrinchostoma* Saussure, 1890

*Trichostoma* Dalla Torre, 1896: 381; Friese, 1909a: 150  
*Thrinchostoma* Dalla Torre, 1896: 641  
*Thrinchostoma* Ashmead, 1899: 91  
*Rostratilapis* Friese, 1914: 26  
*Nesothrinchostoma* Blüthgen, 1933b: 364  
*Thrinchostoma* Sandhouse, 1943: 548  
Type species: *Thrinchostoma renitantly* Saussure, 1890: 52, monobasic.

1. **assamense** Sladen, 1915: 214 Assam  
*Thrinchostoma assamense* Sladen, 1915: 214
2. **sladeni** Cockerell, 1913: 35 Central Asia  
*Thrinchostoma sladeni* Cockerell, 1913a: 35
3. **wroughtoni** (Cameron, 1897) India  
*Halictus wroughtoni* Cameron, 1897: 93

## Sub Family NOMIINAE Robertson 1904

### I. Genus *Lipotriches* Gerstaecker, 1858

*Lipotriches* Gerstaecker, 1858: 460  
*Rhopalomelissa* Alfken, 1926: 267  
*Nomia* (*Epinomia*) Alfken, 1939: 113

*Alfkenomia* Hirashima, 1956: 33

*Rhopalomelissa (Lepidorhopalomelissa)* Wu, 1985: 58

*Rhopalomelissa (Trichorhopalomelissa)* Wu, 1985: 58

*Rhopalomelissa (Tropirhopalomelissa)* Wu, 1985: 58

Type species: *Lipotriches abdominalis* Gerstaecker 1857; = *Sphecodes cribrosa* Spinola, 1843, by original designation

1. ***albofimbriata*** (Cameron, 1902) West Bengal: Barrackpore  
*Nomia albofimbriata* Cameron, 1902b: 252  
*(Austronomia) albofimbriata* (Cameron, 1902); Pauly, 2009: 195
2. ***anamalaiensis*** Pauly, 2009 Tamil Nadu: Chennai,  
Anamalai hills,  
Kadamparai  
*(Macronomia) anamalaiensis* Pauly, 2009: 185
3. ***antennata*** (Smith, 1875) Maharashtra: Pune  
*Nomia antennata* Smith, 1875a: 46  
*Nomia sykesiana* Westwood, 1875: 211; Pauly, 2009: 184  
*Nomia aureohirta* Cameron, 1898: 59; Pauly, 2009: 184  
*Lipotriches (Lipotriches) aureohirta* (Cameron, 1898);  
Pauly, 2009: 184
4. ***arcuata*** Pauly, 2009 Karnataka: Bengaluru  
Kerala;  
Maharashtra: Mumbai;  
Madhya Pradesh: Satpura  
Hills;  
Pondicherry: Karaikal  
*(Austronomia) arcuata* Pauly, 2009: 197
5. ***aurodigitata*** Pauly, 2009: 179 Goa: Mormugao  
*aurodigitata* Pauly, 2009: 179
6. ***bombayensis*** (Cameron, 1908) Maharashtra: Mumbai  
Deesa  
*Andrena bombayensis* Cameron, 1908a: 308; Pauly, 2009:  
175
7. ***bouceki*** Pauly 2014 Karnataka: Bengaluru
8. ***capitata*** (Smith, 1875) \*Bihar: Pusa, Chapra  
\*Karnataka: Bengaluru  
*Nomia capitata* Smith, 1875b: 54  
*(Austronomia) krombeini* Hirashima, 1978: 97; Pauly,  
2009: 195

9. **ceratina** (Smith, 1857) India  
*Halictus ceratinus* Smith, 1857: 42; Baker, 1993: 192  
*Halictus basalis* Smith, 1857: 43; Pauly, 2009: 175  
*Nomia floralis* Smith, 1875b: 58; Pauly, 2009: 175  
*Nomia exilipes* Vachal, 1897: 81; Pauly, 2009: 175  
*Nomia bicarinata* Cameron 1903: 177; Pauly, 2009: 175  
*Lipotriches bidiensis* Cameron 1905: 166; Pauly, 2009: 175  
*Halictus anterufus* Strand, (1913)1914: 148; Pauly, 2009: 175  
*Nomia palavanica* Cockerell, 1915: 178; Pauly, 2009: 175  
*Nomia mediorufa morata* Cockerell, 1920b: 619; Pauly, 2009: 175  
*Rhopalomelissa esakii* Hirashima, 1961: 257; Pauly, 2009: 175  
*Rhopalomelissa montana* Ebmer, 1978b: 214; Pauly, 2009: 175  
*Rhopalomelissa (Tropirhopalomelissa) nigra* Wu, 1985: 59; Pauly, 2009: 175  
*Lipotrichus ceratina* (Smith, 1857); Pauly, 2009: 175
10. **chalcea** (Cockerell, 1920) Kerala: Wayanad, Manantoddy  
*Nomia chalcea* Cockerell, 1920a: 208  
*Lipotriches (Maynenomia) chalcea* (Cockerell, 1920); Pauly, 2009: 191
11. **chaprensis** (Cockerell, 1920) Bihar: Chapra  
*Nomia chaprensis* Cockerell, 1920: 208  
*(Maynenomia) chaprensis* (Cockerell, 1920); Pauly, 2009: 191
12. **clypeata** (Smith, 1875) India  
*Nomia nasalis* (Westwood) Smith, 1853: 89  
*Nomia clypeata* Smith, 1875b: 54; Michener, 1965; Baker 1993: 265; Pauly, 2009: 196
13. **collina** (Cameron, 1908) Rajasthan: Mount Abu  
*Nomia collina* Cameron, 1908b: 658  
*(Austronomia) collina* (Cameron, 1908); Pauly, 2009: 196
14. **dilatata** (Pauly, 2009) Kerala: Walayar  
*(Macronomia) dilatata* Pauly, 2009: 186
15. **exagens** (Walker, 1860) India  
*Andrena exagens* Walker, 1860: 305  
*Halictus timidus* Smith, 1879: 31; Meade-Waldo, 1916: 459  
*Nomia puttalama* Strand, 1913c: 143; Pauly, 2009: 176
16. **fervida** (Smith, 1875) \*Bihar; Uttar Pradesh: Allahabad Haryana: Ferozepur \*Punjab: Rohtak Rajasthan: Mount Abu Uttar Pradesh Gujarat: Deesa  
*Nomia fervida* Smith, 1875b: 55  
*Nomia chrysopa* Cameron, 1898: 69; Pauly, 2009: 176  
*Nomia carinicollis* Cameron, 1902b: 251; Pauly, 2009: 176  
*Nomia shiva* Nurse, 1902: 148; Pauly, 2009: 176  
*Nomia nursei* Cameron, 1907b: 284; Pauly, 2009: 176  
*Nomia abuensis* Cameron, 1908b: 658; Pauly, 2009: 176

- Nomia virgata* Cockerell, 1911c: 229  
*Nomia nursei semifortis* Cockerell, 1911c: 229  
*Lipotriches (Lipotriches) abuensis* (Cameron, 1908: 658);  
 Pauly, 2009: 176
17. ***fulvinerva*** (Cameron, 1907) Gujarat: Deesa  
 West Bengal: Barrackpore  
*Nomia silhetica* (Westwood) Smith, 1853: 90  
*Lipotriches aurifrons* (Smith, 1853); Baker, 1993: 258  
*Nomia fulvinerva* Cameron, 1907a: 1004; Baker, 1993: 258  
*Nomia andrenina* Cockerell, 1911c: 230; Pauly, 2009: 177  
*Nomia ceylonica* Friese, 1913: 84; Pauly, 2009: 177  
*Lipotriches (Lipotriches) fulvinerva* (Cameron, 1907:1004);  
 Pauly, 2009: 176-177  
*Lipotriches (Lipotriches) andrenina* (Cockerell, 1911: 230);  
 Pauly, 2009: 177  
*Lipotriches (Lipotriches) ceylonica* (Friese, 1913: 84);  
 Pauly, 2009: 177
18. ***ghatensis*** (Pauly, 2009) Maharashtra: Lonavala,  
 Western Ghats  
 L. (*Maynenomia*) *ghatensis* Pauly, 2009: 192
19. ***gracilis*** Pauly 2009:179 Meghalaya  
 (*Rhopalomelissa*) *gracilis*
20. ***himalayana*** (Nurse, 1902) Himachal Pradesh: Shimla  
*Nomia himalayana* Nurse, 1902: 148  
 (*Austronomia*) *himalayana* (Nurse, 1902); Pauly, 2009: 196
21. ***immsi*** (Cockerell, 1920) Uttarakhand: Dehradun  
*Nomia immsi* Cockerell, 1920a: 209  
 (*Maynenomia*) *immsi* (Cockerell, 1920); Pauly, 2009: 191
22. ***kangrae*** (Nurse, 1904) \*Bihar: Pusa, Chapra;  
 \*Jammu & Kashmir:  
 Janjgir, Bilaspur;  
 Himachal Pradesh: Kangra  
 valley  
 \*Tamil Nadu: Coimbatore  
 Karnataka: Bangalore,  
 Doddgubi  
 Kerala: Walayar
23. ***karnatakaensis*** (Pauly, 2009)  
 (*Macronomia*) *karnatakaensis* Pauly, 2009: 186
24. ***keralensis*** (Pauly, 2009) Kerala: Walayar  
 (*Maynenomia*) *keralensis* Pauly, 2009: 192  
 Tamil Nadu: Coimbatore,  
 Marudhamalai  
 Pondicherry: Karaikal
25. ***lonavlaensis*** (Pauly, 2009) Tamil Nadu  
*Maynenomia lonavlaensis* Pauly, 2009: 193  
 Maharashtra: Lonavala
26. ***madrassensis*** (Pauly, 2009) Tamil Nadu: Chennai  
 (*Macronomia*) *madrassensis* Pauly, 2009: 187

27. **minutula** (Friese, 1909) India  
*Nomia minutula* Friese, 1909b: 203  
*Nomia elongatula* Cockerell, 1915: 178; Pauly, 2009: 177  
*Lipotriches (Lipotriches) elongatula* (Cockerell, 1915)
28. **mollis** (Smith, 1879) Assam;  
 Maharashtra: Mumbai  
*Andrena mollis* Smith, 1879: 50; Pauly, 2009: 177  
*Lipotriches mollis* (Smith, 1879); Pauly, 2009: 177
29. **nanensis** (Cockerell, 1929) India  
*Nomia nanensis* Cockerell, 1929b: 133  
*(Maynenomia) nanensis* (Cockerell, 1929); Pauly, 2009: 191
30. **nathani** (Pauly, 2009) Kerala: Walayar  
*L. (Maynenomia) nathani* Pauly, 2009: 193
31. **nilgiriensis** (Pauly, 2009) Tamil Nadu: Nilgiris,  
 Moyar, Singara
32. **notiomorpha** (Hirashima, 1978) India  
*Nomia (Austronomia) notiomorpha* Hirashima, 1978: 100;  
 Pauly, 2009: 196  
*(Austronomia) notiomorpha* (Hirashima, 1978); Pauly, 2009:  
 196
33. **parciformis** (Cockerell, 1913) Maharashtra: Nasik  
*Nomia parciformis* Cockerell, 1913a: 35  
*Lipotriches parciformis* (Cockerell, 1913); Pauly, 2009: 178
34. **phenacopsis** (Cockerell, 1911) Maharashtra: Nasik  
*Nomia phenacopsis* Cockerell, 1911c: 224  
*Lipotriches phenacopsis* (Cockerell, 1911); Pauly, 2009:  
 178
35. **phenacura** (Cockerell, 1911) Maharashtra: Nasik  
*Nomia phenacura* Cockerell, 1911: 224  
*Lipotriches phenacura* (Cockerell, 1911); Pauly, 2009: 178
36. **pilipes** (Smith, 1875) North Western India  
*Nomia pilipes* Smith, 1875b: 56  
*Nomia ardjuna* Cockerell, 1911c: 231; Pauly, 2009: 197  
*(Austronomia) pilipes* (Cockerell, 1911); Pauly, 2009: 197
37. **poonaensis** (Pauly, 2009) Maharashtra: Pune, Katraj  
 Ghat  
*(Maynenomia) poonaensis* Pauly, 2009: 194
38. **pseudoscutellata** (Pauly, 2009) Tamil Nadu: Nilgiris,  
 Devala  
*(Austronomia) pseudoscutellata* Pauly, 2009: 203
39. **pulchriventris** (Cameron, 1897) Kerala: Walayar  
 Uttarakhand: Mussourie  
 Maharashtra: Nasik  
 West Bengal  
*Nomia clavata* Smith, 1862: 59; Pauly, 2009: 178  
*Halictus pulchriventris* Cameron, 1897: 110; Cameron,  
 1902b: 250  
*Nomia dimidiata* Vachal, 1897: 92; Pauly, 2009: 178  
*Nomia pulchriventris* (Cameron, 1897);  
*Nomia aureobalteata* Cameron, 1902: 250; Pauly, 2009: 178  
*Nomia halictella var triangularis* Cockerell, 1905: 307;  
 Pauly, 2009: 178  
*Nomia pseudoceratina* Cockerell, 1910b: 222; Pauly, 2009:

- 178  
*Nomia halictura* Cockerell, 1911c: 228; Pauly, 2009: 178  
*Nomia levicauda* Cockerell, 1919a: 5; Pauly, 2009: 178  
*Rhopalomelissa xanthogaster* Alfken, 1926: 267; Pauly, 2009: 178  
*Nomia wallacei* Cockerell, 1939: 123; Pauly, 2009: 178  
*Rhopalomelissa (Trichorhopalomelissa) hainanensis* Wu, 1985: 58; Pauly, 2009: 178  
*Rhopalomelissa (Trichorhopalomelissa) zae* Wu, 1985: 59; Pauly, 2009: 178  
*Lipotriches (L.) pulchriventris* (Cameron, 1897); Pauly, 2009: 178
40. *savannakheti* (Pauly, 2009) Tamil Nadu: Nilgiris, Gudabu, Singara  
*(Macronomia) savannakheti* Pauly, 2009: 189  
 West Bengal: Kolkata
41. *scutellata* (Smith, 1875)  
*Nomia scutellata* Smith, 1875a: 45  
*(Austronomia) scutellata* (Smith, 1875); Pauly, 2009: 197
42. *taprobanae* (Cameron 1897:111) Pondicherry: Auroville  
*Lipotriches edirisingheri* Pauly, 2005:32; Pauly 2009:178
43. *torrida* (Smith, 1879) Maharashtra: Mumbai, Nasik  
*Andrena torrida* Smith, 1879a: 50  
*Nomia comperta* Cockerell, 1912b: 493; Pauly, 2009: 179  
*Lipotriches (Lipotriches) comperta* (Cockerell, 1912);
44. *tubulisetae* Pauly, 2009 Karnataka: Coorg  
*Lipotriches tubulisetae* Pauly, 2009: 181  
 Tamil Nadu: Nilgiris  
 Devala, Cherangod,  
 Coimbatore, Siruvani  
 India
45. *ustula* (Cockerell, 1911)  
*Nomia ustula* Cockerell, 1911c: 231  
*(Austronomia) ustula* (Cockerell, 1911); Pauly, 2009: 197
46. *walayarensis* (Pauly, 2009) Kerala: Walayar  
*(Macronomia) walayarensis* Pauly, 2009: 189
47. *yasumatsui* Meghalaya: Shillong  
*Rhopalomelissa yasumatsui* Hirashima, 1961: 263  
*Rhopalomelissa yasumatsui koreana* Hirashima, 1961: 269;  
 Pauly, 2009: 179

## II. Genus *Nomia* Latreille, 1804

*Nomia* Latreille, 1804: 182

*Nitocris* Rafinesque, 1815: 123

Type species: *Andrena curvipes* Fabricius, 1781: 473; Blanchard, 1849: 125; Michener, 1997: 41

1. *anthophoroides* (Meade-Waldo, 1916) Sikkim: Lebung  
*Melitta anthophoroides* Meade-Waldo, 1916: 463  
*Nomia (Maculonomia) anthophoroides* (Meade-Waldo, 1916); Pauly, 2009: 161

2. ***apicalis*** (Smith, 1857) Sikkim  
*Nomia apicalis* Smith, 1857: 43; Baker, 1993: 192  
*Nomia fuscipennis* Smith, 1875b: 57; Baker, 1993: 192  
*Nomia robusta* Cameron, 1902a: 114; Pauly, 2009: 161  
*Nomia violaceipennis* Cameron, 1903: 176; Baker, 1993: 192  
*Nomia megasoma nitidata* Strand, 1913b: 105; Pauly, 2009: 161  
*Nomia nitens* Cockerell, 1931b: 351-359; Baker, 1993: 192  
*Nomia (Maculonomia) apicalis* (Smith, 1857); Pauly, 2009: 161
3. ***argenteobalteata*** (Cameron, 1902) West Bengal  
*Nomia (Paranomia) argenteobalteata* Cameron, 1902b: 249  
*Nomia (Gnathonomia) argenteobalteata* (Cameron, 1902); Pauly, 2009: 155
4. ***aurata*** (Bingham, 1897) Uttarakhand: Dehradun  
 Maharashtra: Nasik  
*Nomia aurata* Bingham, 1897: 458  
*Nomia nasicana* Cockerell, 1911c: 221; Pauly, 2009: 155  
*Nomia crassiuscula* Friese, 1913: 87  
*Nomia perconcinna* Cockerell, 1920a: 210; Pauly, 2009: 155  
*(Gnathonomia) nasicana* (Cockerell, 1911)  
*Nomia (Gnathonomia) aurata* (Bingham, 1897); Pauly, 2009: 155
5. ***buddha*** (Westwood, 1875) \*Bihar: Chapra  
*Nomia buddha* Westwood, 1875: 209; Pauly, 1990: 48  
*Nomia bahadur* Nurse, 1904b: 568  
*Nomia (Crocisaspidia) buddha* (Westwood, 1875); Pauly, 2009: 169
6. ***carinata*** (Smith, 1875) Sikkim  
*Nomia carinata* Smith, 1875b: 57  
*Nomia (Hoplonomia) carinata* (Smith, 1875); Pauly, 2009: 167
7. ***chalybeata*** (Smith, 1875) India  
*Nomia chalybeata* Smith, 1875b: 59  
*Nomia pavonura* Cockerell, 1912a: 11; Baker, 1993: 266  
*Nomia (Curvinomia) chalybeata* (Smith, 1875); Pauly, 2009: 159

8. ***crassipes*** (Fabricius, 1798) \*Bihar: Pusa  
*Eucera crassipes* Fabricius, 1798: 278  
*Nomia curvipes* Smith, 1875a: 42  
*Nomia megasomioides* Strand, 1913a: 31; Hirashima, 1956: 32; Pauly, 2008: 214
9. ***curvipes*** (Fabricius, 1793) \*Maharashtra: Mumbai  
 \*Punjab  
 Tamil Nadu: Madurai\*, Trinelveli, Kovilpatty  
 Uttar Pradesh  
*Andrena curvipes* Fabricius, 1793 (1781): 310; Smith, 1875a: 42  
*Megilla curvipes* Fabricius, 1804: 330; Illiger, 1806: 142; Illiger, 1807: 197; Smith, 1875a: 42  
*Nomia curvipes* Latreille, 1804: 182; Latreille, 1805: 369; Klug, 1808: 55; Olivier, 1811: 377; Olivier, 1811: 377; Lepeletier, 1825: 797; Smith, 1875a: 42  
*Nomia indica* Lepeletier De Saint Fargeau, 1841: 292; Pauly, 2008: 213  
*Nomia combusta* Smith, 1875b: 56; Pauly, 2008: 213  
*Nomia calida* Westwood, 1875: 215; Pauly, 2008: 213  
*Nomia varipes* Cameron, 1898: 66; Baker, 1966: 546; Pauly, 2008: 213  
*Nomia eburnigera* Cockerell, 1911c: 220; Pauly, 2008: 213  
*Nomia histrionica* Cockerell, 1919c: 104; Pauly, 2008: 213
10. ***elliottii*** (Smith, 1875) West Bengal: Barrackpore  
 \*Bihar: Chapra  
*Nomia elliotti* (Westwood) Smith, 1853: 89  
*Nomia elliotti* Smith, 1875a: 44; Baker, 1993:  
*Nomia simplicipes* Friese, 1897: 73; Cockerell 1919a: 3; Pauly, 2009: 167  
*Nomia (Hoplonomia) elliottii* (Smith, 1875); Pauly, 2009: 167
11. ***incerta*** (Gribodo, 1894) Meghalaya: Shillong, Khasi hills  
*Nomia punctata* Westwood, 1875: 213; Pauly, 2009: 167  
*Nomia punctulata* Dalla Torre, 1896: 169; Pauly, 2009: 167  
*Nomia pilosella* Cameron, 1904b: 211; Pauly, 2009: 167  
*Nomia maturans* Cockerell 1912a: 10; Pauly, 2009: 167  
*Nomia (Hoplonomia) incerta* (Gribodo, 1894); Pauly, 2009: 167
12. ***interrupta*** (Cameron, 1904) Meghalaya: Shillong, Khasi hills  
*Nomia interrupta* Cameron, 1904b: 215  
*Nomia (Maculonomia) interrupta* (Cameron, 1904);

Pauly, 2009: 162

13. ***interstitialis*** (Cameron, 1898)  
*Nomia interstitialis* Cameron, 1898: 74  
*Nomia rothneyi* Cameron, 1904: 214; Pauly, 2009: 154  
*Nomia (Leuconomia) interstitialis* (Cameron, 1898); Pauly, 2009: 154  
 Uttar Pradesh: Allahabad  
 \*Madhya Pradesh: Indore  
 \*New Delhi  
 \*Rajasthan: Bharatpur  
 Uttarakhand: Musoorie,  
 \*Dehradun, Bodowala  
 \*Odisha: BHubaneshwar.
14. ***iridescens*** (Smith, 1853)  
*Nomia iridescens* Smith, 1853  
*Nomia iridescens* Smith 1857: 43; Baker, 1993: 193  
*Nomia (Paranomia) zebrata* Cameron, 1902b: 248; Pauly, 2009: 159  
*Nomia (Paranomia) frederici* Cameron, 1902b: 248; Pauly, 2009: 159  
*Nomia iridescens* var *rhodochlora* Cockerell, 1919a: 5; Pauly, 2009: 159  
*Nomia subpurpurea* Cockerell, 1920b: 616; Pauly, 2009: 159  
*Nomia (Curvinomia) iridescens* (Smith, 1853); Pauly, 2009: 159  
 West Bengal: Barrackpore
15. ***kulliensis*** Tomar and Tomar, 2005  
*Nomia (Hoplonomia) kulliensis* Tomar and Tomar, 2005: 148-150  
 India.
16. ***maculitarsis*** Cameron, 1898  
*Nomia maculitarsis* Cameron, 1898: 71  
 Maharashtra: Pune
17. ***mahratta*** Cameron, 1898  
*Nomia mahratta* Cameron, 1898: 71  
 Maharashtra: Mumbai
18. ***purpureolineata*** Cameron, 1898: 62  
*Nomia purpureolineata* Cameron, 1898: 62  
 West Bengal: Barrackpore
19. ***radiata*** (Pauly 2009)  
*Gnathonomia radiata* Pauly 2009; Michener 2007  
 Tamil Nadu
20. ***strigata*** (Fabricius, 1793)  
*Andrena strigata* Fabricius, 1793: 311  
*Nomia strigata* Dalla Torre, 1896: 170; Strand, 1913c: 142  
 \*Tamil Nadu: Nagarkoil  
 \*Odisha: Bhubaneshwar.

*Nomia varibalteata* Cameron, 1902: 132; Pauly, 2009: 159  
*Nomia iridescens* var *ridleyi* Cockerell, 1910a: 503; Pauly, 2009: 159  
*Nomia selangorensis* Cockerell, 1920: 617; Pauly, 2009: 159  
*Nomia mimosae* Cockerell & Levecque, 1925: 170; Pauly, 2009: 159  
*Nomia oryzae* Cockerell, 1929b: 135; Pauly, 2009: 159  
*Nomia (Acunomia) strigata* (Fabricius, 1793); Pauly, 2009: 159

21. ***terminata*** (Smith, 1875)

Sikkim

*Nomia terminata* Smith, 1875b: 56  
*Nomia megaera* Gribodo, 1894: 130; Pauly, 2009: 163  
*Nomia tuberculata* Cameron, 1904b: 215; Pauly, 2009: 163  
*Nomia maculipennis* Friese, 1914: 28; Pauly, 2009: 163  
*Nomia anthracoptera* Cockerell, 1918: 103; Pauly, 2009: 163  
*Nomia (Maculonomia) terminata* (Smith, 1875); Pauly, 2009: 163

22. ***thoracica*** Smith, 1875

Sikkim, West Bengal

*Nomia dorsalis* (Westwood) Smith, 1853: 90  
*Nomia thoracica* Smith 1875a: 45; Baker, 1993: 259  
*Nomia albofasciata* Smith, 1875b: 57; Baker, 1993: 259 of *N. thoracica*  
(*Paranomia*) *stantoni* Ashmead, 1904a: 4; Pauly, 2009: 155  
*Nomia thoracica excellens* Cockerell, 1931: 40  
*Nomia excellens* Friese, 1930: 23; Pauly, 2009: 155  
*Nomia melior* Cockerell, 1931b: 281; Pauly, 2009: 155  
*Nomia (Gnathonomia) thoracica* (Smith, 1875); Pauly, 2009: 155

23. ***westwoodi*** Gribodo, 1894

Maharashtra: Mumbai  
\*Karnataka: Mangalore  
Gujarat: Ahmadabad  
Tamil Nadu: Chennai, \*Madurai,  
\*Alanganallur,  
West Bengal: Barrackpore  
\*Madhya Pradesh: Indore  
New Delhi  
\*Odisha: Bhubaneshwar

*Nomia simillima* Smith, 1875a: 44; Pauly, 2009: 168  
*Nomia westwoodi* Gribodo, 1894: 128  
*Nomia erythrogaster* Cameron, 1898: 61; Baker, 1993: 253  
*Nomia (Hoplonomia) westwoodi* (Gribodo, 1894); Pauly, 2009: 168

### III. Genus *Pseudapis* Kirby, 1900

*Pseudapis* Kirby, 1900a: 15

*Nomia* (*Lobonomia*) Warncke, 1976: 99

Type species: *Pseudapis anomala* Kirby, 1900a: 15, by original designation

1. ***aliena*** (Cameron, 1898) Maharashtra: Nasik  
*Nomia aliena* Cameron, 1898: 72; Baker, 2002: 29  
 Uttarakhand: Mussoorie,
2. ***armata*** (Olivier, 1812) India  
*Nomia armata* Olivier, 1812: 376  
*N. latipes* Morawitz, 1880: 368  
*P. armata latipes* (Morawitz, 1880)  
*N. nilotica* Smith, 1875: 63; Warncke, 1976: 105.  
*N. monstrosa* Costa 1861; Baker, 2002: 23
3. ***bispinosa*** (Brullé, 1832) Pakistan: Peshawar  
 India  
*Nomia bispinosa* Brullé, 1832: 348; Warncke, 1976: 109  
*N. rufiventris* Spinola, 1839: 514; Walker, 1871: 44  
*N. ruficornis* Spinola, 1839: 514; Smith, 1875b: 62  
*N. perforata* Lucas, 1849: 185  
*N. albocincta* Lucas, 1849: 187  
*N. aureocincta* Costa, 1861: 8  
*N. albocincta* var *basirubra* Magretti, 1884: 624  
*N. aureocincta* var *turcomanica* Radoszkowski, 1893: 54  
*N. fletcheri* Cockerell, 1920a: 172  
*N. basalocincta* Cockerell, 1922: 663  
*Nomia basalis* (Smith, 1875b: 55); Baker 2002: 35  
*Nomiapis bispinosa* (Brullé, 1832: 35); Baker 2002: 35
4. ***carcharodonta*** (Baker, 2002) Kerala: Walayar  
*Nomiapis carcharodonta* Baker, 2002: 45
5. ***edentata*** (Morawitz, 1876) Gujarat: Deesa  
 \*Tamil Nadu: Madurai  
*Nomia edentata* Morawitz, 1876b: 259; Warncke, 1976 : 104  
*Nomia minor* Radoszkowski, 1893: 54; Warncke, 1976 : 104  
*Nomia albifrons* Vachal, 1897: 74; Warncke, 1976: 104  
*Nomia albolobata* Cockerell, 1911a: 225; Warncke, 1976: 104  
*Nomia inermis* Popov, 1949: 692  
*Pseudapis inermis* sensu Baker, 2002: 28  
*Nomia* (*Lobonomia*) *orientana* Warncke 1976; Baker 2002: 26
6. ***flavolobata*** (Cockerell, 1911) Gujarat: Deesa

- Pseudapis flavolobata* (Cockerell, 1911a: 226);  
Warncke, 1976: 105  
*Nomia iranica* Warncke, 1979b: 169  
*Nomia armata latipes* Morawitz, 1880; Baker,  
2002: 105;
7. **nathani** (Pauly, 2009)  
*Pachynomia nathani* Pauly, 2009: 173
8. **oxybeloides** (Smith, 1875)  
*Nomia oxybeloides* Smith, 1875a: 43  
*Nomia latispina* Cameron, 1898: 64  
*Nomia lepidota* Cockerell, 1905b: 218  
*Nomia biroi* Friese, 1913: 84; Baker 2002: 24
9. **patellata** (Magretti, 1884)  
*Nomia patellata* Magretti, 1884: 621
10. **indorensis** sp. nov
- Kerala: Walayar  
Tamil Nadu: Nilgiris Hills Kallar  
Gujarat: Deesa  
MadhyaPradesh: Jabalpur  
Maharashtra: Western ghats, Nasik  
\*New Delhi  
Rajasthan: Mount Abu, Udaipur;  
Tamil Nadu: Coimbatore, Anamalai  
Hills, Tanjore  
Uttarpradesh; Allahabad  
West Bengal: Kolkata  
India  
\*Madhya Pradesh: Indore

#### IV. Genus *Steganomus* Ritsema, 1873

*Steganomus* Ritsema, 1873: 226

*Cyathocera* Smith, 1875; Ritzema, 1876: xlv

*Nomia* (*Dinomia*) Hirashima, 1956:29; Michener, 2000: 329

Type species: *Steganomus javanus* Ritsema, 1873: 226, by original designation

1. **bipunctatus** (Fabricius, 1804)  
*Nomada bipunctata* Fabricius, 1804: 392  
*Cyathocera nodicornis* Smith, 1875a: 47; Pauly, 2009: 173  
*Nomia matalea* Strand, 1913:144; Baker, 2002: 30  
*Steganomus nodicornis* (Smith, 1875); Baker, 2002: 30
2. **fulvipennis** Cameron, 1898: 56
3. **gracilis** Cameron, 1898: 58  
*Nomada bipunctata* Fabricius, 1804; Baker 2002: 31
4. **lieftincki** Pauly, 2009: 174
- Uttar Pradesh: Lucknow  
West Bengal: Barrackpore  
\*Tamil Nadu: Madurai  
Maharashtra: Poona,  
Bombay  
Uttarakhand: Mussoorie,  
Haldwani  
Bihar: Ranchi (Namkum)  
Delhi: Delhi University  
West Bengal: Barrackpore

#### Subfamily NOMIOIDINAE Börner 1919

##### I. Genus *Ceylalictus* Strand, 1913

*Halictus* subgenus *Ceylalictus* Strand, 1913c: 137

*Nomioides* (*Eunomioides*) Blüthgen, 1937: 3; Michener, 1978: 505

Type species: *Halictus horni* Strand, 1913, by original designation

1. **cereus** (Nurse, 1902)  
*Ceratina cerea* Nurse, 1901: 152  
*Ceratina divisa* Cameron, 1907a: 1003; Blüthgen, 1934: 259  
*Ceratina pilaspis* Cameron, 1908b: 657  
*Nomioides cerea* Blüthgen, 1934: 259  
*Ceylalictus cereus* Pesenko, 1983: 108
- Deesa

2. ***punjabensis*** (Cameron, 1907) Pakistan: Karachi;  
North western India;  
Punjab: Ferrozepore  
*Ceratina punjabensis* Cameron, 1907a: 1003; Pesenko, 1983: 182  
*Nomioides excellens* Saunders, 1908: 223; Pesenko, 1983: 183  
*Nomioides comberi* Cockerell, 1911a: 236; Cockerell, 1919c: 9
3. ***variegatus*** (Olivier, 1789) Northern India  
*Apis variegata* Olivier, 1789a: 139  
*Andrena pulchella* Jurine, 1807: 231; Handlirsch, 1888: 402  
*syrphoides* Walker, 1871: 50 Michener, 1975: 235  
*Andrena flavopicta* Dours, 1873: 284; Handlirsch, 1888: 403  
*Nomioides jucunda* Morawitz, 1874: 161; Handlirsch, 1888: 403  
*Nomioides fasciatus* Friese, 1898: 307, Pesenko, 1983: 180  
*Nomioides fasciatus* var. *intermedius* Alfken, 1924: 250; Blüthgen, 1925: 54;  
*Nomioides variegata* var. *simplex* Blüthgen, 1925: 51; Pesenko 1983: 180  
*Nomioides variegata* var. *unifasciata* Blüthgen, 1925: 53  
*Nomioides labiatarum* Cockerell 1931: 204; Blüthgen, 1934b: 255  
*Nomioides variegata* var. *nigrita* Blüthgen, 1934b: 257; Pesenko, 1983: 181  
*Nomioides variegata* var. *pseudocerea* Blüthgen, 1934b: 257; Pesenko, 1983: 181  
*Nomioides variegata* var. *nigriventris* Blüthgen, 1934b: 258; Pesenko, 1983: 181

## II. Genus *Nomioides* Schenck, 1867

*Nomioides* Schenck, 1867: 333

Type species: *Apis minutissima* Rossi, 1790; Pesenko and Kerzhner, 1981

1. ***curvilineatus*** (Cameron, 1907) India  
*Ceratina curvilineata* Cameron, 1907: 1004
2. ***dubius*** Blüthgen, 1925: 42 India
3. ***fortunatus*** Blüthgen, 1937: 3 \*Tamil Nadu: Adhalai.  
*Nomioides minutissimus* f. *fortunatus* Pesenko, 1983: 137
4. ***minutissimus*** (Rossi, 1790) Northern India  
*Nomioides (Nomioides) minutissimus maurus* Blüthgen, 1925  
*Apis minutissima* Rossi, 1790: 109  
*Halictus pulchellus* Giraud, 1861:  
*Nomioides minutissima* var. *schrencki* Blüthgen, 1925: 10  
*Nomioides minutissima* var. *obscurata* Blüthgen, 1925: 9  
*Nomioides minutissima* var. *versicolor* Blüthgen, 1925: 9  
*Nomioides minutissima* var. *violascens* Blüthgen, 1925: 9  
*Nomioides minutissima* var. *fusca* Blüthgen, 1934b: 241  
*Nomioides minutissima* var. *tristis* Blüthgen, 1934b: 241  
*Nomioides maura* Blüthgen, 1925: 14; Pesenko 1983: 135  
*Nomioides campanulae* Cockerell, 1931b: 206; Blüthgen 1933a: 63; Blüthgen, 1934b: 242

*Nomioides senecionis* Cockerell, 1931b: 208; Pesenko and Pauly, 2005: 174

*Nomioides maura* var. *tingitana* Blüthgen, 1933a: 63; Pesenko and Pauly, 2005: 174

*Nomioides minutissimus* f. *maurus*: Pesenko, 1983: 137

5. *patruelis* Cockerell, 1919: 102 India
6. *pusillus* Blüthgen, 1925: 25 India

## Subfamily ROPHITINAE Schenck 1861

### I. Genus *Dufourea* Lepeletier, 1841:227

*Dufourea* Lepeletier, 1841: 227

*Halictoides* Nylander, 1848: 195

*Halictoides* (*Epihalictoides*) Cockerell and Porter, 1899: 420

*Halictoides* (*Parahalictoides*) Cockerell and Porter, 1899: 420

*Conohalictoides* Viereck, 1904a: 245

*Neohalictoides* Viereck, 1904b: 261

*Cryptohalictoides* Viereck, 1904b: 261

*Mimulapis* Bridwell, 1919: 162

*Betheliella* Cockerell, 1924: 169

*Halictoides* (*Cephalictoides*) Cockerell, 1924a: 244

Type species: *Dufourea minuta* Lepeletier, 1841: 227; Richards, 1935: 172

1. *gkuruensis* (Warncke, 1979) Jammu and Kashmir  
*Rophites gkuruensis* Warncke, 1979a: 69
2. *kashmirensis* (Warncke, 1979) Jammu and Kashmir  
*Rophites kashmirensis* Warncke, 1979a: 67
3. *ladakhensis* (Warncke, 1979) Jammu and Kashmir  
*Rophites ladakhensis* Warncke, 1979a: 69

### II. Genus *Systropha* Illiger, 1806

*Systropha* Illiger, 1806 : 145

*Systropha* (*Systrophidia*) Cockerell, 1936: 477-483

*Eucera* Scopoli, 1770: 9

*Tenthredo* Linnaeus, 1758: 731

*Andrena* Fabricius, 1775; Olivier 1789a: 135; Eversmann, 1852: 10, 22

Type species: *Andrena spiralis* Olivier, 1789: 135 = *Eucera curvicornis* Scopoli, 1770: 9, by original designation

1. *punjabensis* Batra and Michener, 1966: 651 Punjab: Ludhiana, PAU campus  
*Systropha* (*Systropha*) *punjabensis* Batra & Michener, 1966: 651

The checklist compiled during the present study revealed that, family Halictidae currently consists of 215 species under 14 genera including five species new to science from India. All the four subfamilies viz., Halictinae, Nomiinae, Nomioidinae and Rophitinae are present in India except tribe Augochlorini and subtribe Caenohalictina under subfamily Halictinae. Sub family Halictinae is the most abundant includes six genera and 120 species under tribe Halictini. Subfamily Nomiinae is represented by four genera and

Rophitinae & Nomioiinae with two genera each. The genus *Lasioglossum* Curtis of Halictinae is more diverse with 75 species, followed by the genus *Lipotriches* Gerstaecker and *Nomia* Latreille of Nomiinae with 47 and 23 species respectively. The parasitic genus *Sphecodes* Latreille is represented by 22 species while genus *Halictus* Latreille includes only 14 species. The subfamily Rophitinae is poorly represented by 4 species followed by Nomioiinae with 9 species. India being blessed with a wide range of habitat diversity indicates this bee group to be distributed from all parts of India, However the distribution records is somewhat inclined more towards the mid and northern states of India, probably due to presence of wide mountain ranges. More exploration in the northern region can also be another reason for this skewed distribution pattern.

#### 4.1.3. REDESCRIPTION / DESCRIPTION

##### Family Halictidae

**Diagnosis:** branched or plumose body hairs, a collar like pronotum which is not reaching tegulae; basal vein of forewing strongly arched; single subantennal suture; first flagellar segment shorter than scape; lacinia as a small, hairy lobe on anterior surface of labiomaxillary tube above rest of maxilla and stigma well developed; first segment of metatarsus often enlarged and flattened; jugal lobe of hind wing longer than the submedian cell.

##### Key to subfamilies studied (modified after Michener, 2007)

1. Antenna starts below the midlength of eyes or clypeoantennal distance slightly more than the diameter of antennal socket; female labrum without keel; hind basitarsi without penicillus; tibial scopa present; trochanteral and femoral scopa reduced; hairs of femoral scopa shorter than that of tibia.....Rophitinae
- Antenna starts from midlength of eyes or if below then clypeoantennal distance more than the diameter of antennal socket; female labrum with strong keel; hind basitarsi with penicillus; scopa present on trochanter, femur and tibia; hairs of femoral scopa longer than that of tibia.....2

2. Episternal groove beneath scrobal groove weak or heading forward strongly; third submarginal cell longer than first or twice as long as second submarginal cell; prepygidial fimbriae not divided medially; male S7 transverse with short apodemes and mid apical projections absent.....Nomiinae

-Episternal groove distinct, directed strongly downwards underneath the scrobal groove; third submarginal cell shorter than first and lesser than twice as long as second.....3

3. Apex of marginal cell pointed; prepygidial fimbriae divided longitudinally or triangle of very fine hairs and punctations; male S7 small, long basolateral apodemes with mid apical process; male S8 broader, variable in shape.....Halictinae

-Apex of marginal cell rounded or truncate. Prepygidial fimbriae not divided medially; S7 of male broad; S8 of male longer with broad speculum and long apical process.....Nomioidinae

### **Subfamily: Nomiinae**

**Diagnosis:** Submarginal cells of forewings i.e., first and third submarginal cells long, second shorter; third marginal cell at least twice as long as second. Apex of marginal cell rounded; male S7 transverse plate like with short apodeme but lacking apical protrusion at middle. Episternal groove weak and heading forward below the scrobal groove; clypeoantennal distance at least more than the diameter of antennal socket; female labrum with keel; female hind basitarsi with penicillus; hind femoral and tibial scopa well developed in female.

### **VI. Genus *Lipotriches* Gerstaecker, 1858**

*Lipotriches* Gerstaecker, 1858: 460

*Rhopalomelissa* Alfken, 1926: 267

*Nomia (Epinomia)* Alfken, 1939: 113

*Alfkenomia* Hirashima, 1956: 33

*Rhopalomelissa (Lepidorhopalomelissa)* Wu, 1985: 58

*Rhopalomelissa (Trichorhopalomelissa)* Wu, 1985: 58

*Rhopalomelissa (Tropirhopalomelissa)* Wu, 1985: 58

Type species: *Lipotriches abdominalis* Gerstaecker 1857; = *Sphecodes cribrosa* Spinola, 1843, by original designation.

**Diagnosis:** Head broad or longer; mandible bidentate or tridentate; clypeus with a row of long hairs at apex; last two antennal segments simple or curled if enlarged; ocellocular distance more or less than diameter of ocelli; pronotal lamella transverse and notched laterally at middle or absent; tegula simple; hind tibial spur with simple lamella or few teeth; hind basitibial plate carinated partially or completely; one to three strong teeth on

hind femur; basal area of propodeum reduced or horizontal or declivious; T1 minutely tessellate with fine or coarse punctations; vertical tergal bands pale yellow uniform coarse hairs.

**Key to the species of *Lipotriches* Gerstaecker, 1858** (modified after Pauly, 2009)

1. Abdomen orange or yellowish brown.....7  
     Abdomen black or dark brown.....2
2. Smaller species 5 to 6mm in length; male hindleg more slender and not extensively modified; hind basitarsi slightly bulged; hind femur ferruginous.....6  
     --Comparatively larger species up to 9mm in length; male hindlegs largely modified, basitarsi long not bulged; hind femur not ferruginous; T1 longer.....3
3. Legs not bright yellow; hind femur toothless or tooth reduced apical end of hind femur  
     **Strong punctures on all terga; T4 to T5 apical bands expanded at middle** .....4a  
     --Terga with strong, big and deep punctures; T4 to T5 apical band straight at middle.....4b
4. a.White, silky fine hairs on S5, disc not well defined; hind femur with reduced tooth at the apex.....5a  
     b.S5 with characteristic black, silky fine hairs on midapical disc; hind femur with preapical tooth at apex..... 5b
5. a.Male genitalia rectangular, broadened at apex and 1.29x as long as broad; laterally 0.49x as high as long; gonobase 1.45x as broad as long; genital foramen 0.88x as broad as long; ventral retrorse lobe oval, narrowed at apex, concave ventrally; sparse long stout bristles on their dorsolateral surface; outer surface with long sparse fine hairs, 0.5x as long as breadth of ventral retrorse lobe; inner surface with short, stout bristles; base of lobe depressed, laterally curved downward; small parallel lobe with rounded edge at base; gonobase anterolaterally rounded..... *kangrae*  
     b.Genitalia oval, 1.46x as long as broad and 0.53x as high as long; gonobase 1.5x as broad as long; genital foramen 0.41x as broad as long; ventral retrorse lobe 0.42x as broad as long, apical outer margin with denticles; anterior longitudinal half of inner surface of retrorse lobe covered with short uniform soft hairs; inner basal surface with tuft of long thick, dense hairs; upper lobe small, thin, broadened apically; hairs at base of ventral retrorse lobe 0.27x as long as broad of ventral retrorse lobe ..... *fervid*
6. dorsolateral black bands on T2 narrowly intermittent black band on T4; black shiny basal propodeum, fine punctures on scutum.....*jhajhraensis* sp. nov

--dorsolateral black bands not present; no black bands on T4; basal propodeum, not shiny; T1-T3 completely ferruginous, T4 with lateral brown patches; T5 with blackened premarginal area; ridges on basal propodeum narrower, not strong and interspaces not smooth and shiny; small dense uniform punctures on propodeum..... *makaliyammani* sp. nov.

8. hind basitibial plate carinated only posteriorly and apex not closed; hind femur without apical tooth; T2 with sparse uniform slightly strong punctures; pale pubescence sparse on scutum, clypeus and paraocular area; basal propodeum ridges found as a transverse groove at anterior margin with traces of ridges; posterior angle of basal propodeum with tiny transverse striae and not smooth.....*sathiarensis* sp.nov

hind basitibial plate carinated on both sides with closed apex; hind femur with a single tooth at apical base; fine strong dense punctures on scutum, scutellum with sparse tomentum on the surface; metanotum and propodeum with fine shallow dense punctures; basal propodeum declivious; T1 and T2 with dense shallow punctures..... *anaiyurensis* sp. nov

9. T1 not long; T4 to T5 apical border irregular and sparse; punctures small, dense, shallower on terga.; male genitalia rectangular, 1.2x as broad as long, 0.39x as high as long; slightly broader at posterior; genital foramen short or small egg shaped; gonobase rectangular; ventral retrorse lobe broader 0.64x as broad as long with row of long fine hairs at midbase; inner surface of ventral lobe completely covered with short, stout, dense flat hairs bent at apex; ventral arm longer, slender, blunt, gradually broadening towards apex; penis valve stronger; mid lateral tooth curved upwards, apical and inner preapical tooth absent; volsella broader at apex..... *capitata*

### 1. *Lipotriches capitata* Smith

[Fig. 8: ♂ A to N; Plate VI (a): ♂ A to H; Plate VI (b): ♂ A to G]

*Nomia capitata* Smith, 1875b: 54

*Nomia (Austronomia) krombeini* Hirashima, 1978: 97; Pauly, 2009: 195

#### Male

#### Diagnosis

**Color:** Body black; inner surface of flagellum, mouth parts, compound eyes brown; outer surface of flagellum yellowish brown; coxa, trochanter black; femur reddish brown; tergal apex hyaline; marginal zones of T1 and T2 translucent at middle.

**Sculpture:** Fine and densely punctured; dorsal propodeum with very sparse small punctures and lateral side with fine dense irregular punctures; T1 with sparse uniform punctures small, little dense near premarginal area; premarginal line well defined with similar punctures comparatively smaller; T2 with small, sparse, complete punctures on disc; pregradular area of T2 with small sparse (smaller than gradular punctures) punctures except near base; punctures on T3, T4 shallower than on T1 and T2.

**Pilosity:** Pale yellowish sparse thick pubescence appressed on scutum, scutellum; few fine, long, erect, tiny plumose hairs scattered on paraocular area; scape with long fine sparse, pale yellowish hairs, mostly on outer surface; frons, vertex, upper paraocular with tiny fine sparse hairs; long, sparse hairs on occiput and post occiput; white silky pubescence at mid region behind compound eyes; antenna with fine, tiny, shiny hairs except on scape; inner hind femur with fine, very sparse, long pubescence; inner hind tibia with tiny, sparse hairs and their anterior marginal area with longer pubescence; inner hind tibia posterior area glabrous; dorsolateral propodeum with long thick pubescence; abdominal hairs typically fine of medium length pale yellowish pubescence; T1 anterior surface slightly dense, pale yellowish medium pubescence; apex hyaline with slightly dense apical bands; T2 gradulus smooth, well depressed; high plumose hairs arise from premarginal line.

**General Structure: Head:** 1.19x as broad as long; clypeus 1.4x as long as clypeoantennal distance; compound eye 0.72x as long as head; upper interocular 1.5x as long as lower interocular distance; alveolar distance 0.81x as long as antennocellar distance; inter ocellar distance 0.72x as long as ocello ocular distance; F11 longer, narrower than other flagellar segments, clypeus broad; scape 5x as long as pedicel; flagellum 3.07x as long as scape; F1 1.45x as long as pedicel. **Mesosoma:** tegulae 2.12x as long as broad; forewing 2.92x as long as broad; hindwing 3.5x as long as broad; forewing 1.28x as long as and 4.5x as broad as hindwing; scutum 0.43x as long as broad at the anterior and 0.56x as long as broad at the posterior; scutum 2.72x as long as scutellum; scutellum 2.3x as long as metanotum; Metanotum 2.03x as long as propodeum; posterior surface 5.46x as broad as the length of propodeum; hindleg longer but not much enlarged in male; hind tibia 0.75x as long as femur; apical tooth narrowing gradually with a strong tibial spur near apex; tibial spur 0.28x as long as hind tibia; tibial

spur with serration at lower margin, curved at tip; basitarsi enlarged, 3.73x as long as broad and 1.21x as long as hind tibia; scutum 0.43x as long as broad anteriorly and 0.56x as long as broad posteriorly; scutum 2.72x as long as scutellum; scutellum 2.3x as long as metanotum. propodeal triangle well defined; basal propodeum narrower; metanotum 2.03x as long as propodeum; posterior surface 5.46x as broad as length of basal propodeum; abdomen cylindrical. **Metasoma:** T1 pre marginal line not well defined compared to other terga; T2 to T4 equally broad and slightly broader than T1 and other terga; apex narrowed T5 onwards; S4 anterior margin triangular with a small apodeme; marginal zone with tiny hairs mesad; S5 variously curved at apex; small mid apical lobe with rounded head; two bunches of hairs on each side mid lateral apex; outer bunch of hairs longer, curved mesad; S6 anterior margin straight; long apodeme, narrower at base unlike in *L. capitata*; curvature present on mid disc; S7 broader, two bunches of long fine hairs on their lateral apical lobes; S8 lateral curvature semicircular (lateral curvature angulated); midapical lobe rounded not convex.

**Genitalia:** Rectangular, slightly broader posteriorly; gonobase rectangular; genital foramen short egg shaped; ventral retrorse lobe broader with a row of long fine hairs at midbase; ventral lobe inner surface completely covered with short, stout, dense flat hairs bent at apex; ventral arm longer, slender, blunt gradually broadening towards apex; penis valve stronger; mid lateral tooth curved upward, apical and inner preapical tooth absent; volsella broader at apex.

**Female:** Unknown

**Measurement (mm):** ♂ Body length  $5.08 \pm 0.25$ ; fore wing length  $3.36 \pm 0.02$ ; hind wing length  $2.74 \pm 0.02$ ;

**Specimens examined:** 4♂♂, INDIA: 1 ♂, Bihar: Pusa, 10.XII.1915, Boy Coll.; ♂, Bengal: Chapra, Mackenzie Coll., G.R. Dutt det., H-6444. (NPC); 2 ♂♂, Madhya Pradesh: Indore, 05. VI. 2010, M. Punitha Coll on wild grass.

**Floral records:** Wild grass.

**Distribution:** India: \*Bihar: Pusa, Chapra; \*Madhya Pradesh: Indore.

## 2. *Lipotriches fervid* Smith

[Fig. 9: ♂ A to K; Plate VII (a): ♂ A to H; Plate VII (b): ♂ A to H]

*Nomia chrysopa* Cameron, 1898: 69; Pauly, 2009: 176  
*Nomia carinicollis* Cameron, 1902: 251; Pauly, 2009: 176  
*Nomia shiva* Nurse, 1902: 148; Pauly, 2009: 176  
*Nomia nursei* Cameron, 1907: 284; Pauly, 2009: 176  
*Nomia abuensis* Cameron, 1908: 658; Pauly, 2009: 176  
*Nomia virgata* Cockerell, 1911: 229  
*Nomia nursei semifortis* Cockerell, 1911: 229  
*Lipotriches (Lipotriches) abuensis* (Cameron, 1908);

## Male

### Diagnosis

**Colour:** Mandible ferruginous; inner scape, pedicel pale yellow; femur, tibia lemon yellow along with brownish markings; hind leg lemon yellow; outer hind femur distal half dark brown, extending towards apical inner surface and both surface of middle of hind tibia; pronotal lobe amber; coxa, trochanter, sternum, dorsolateral tergum dark brown.

**Pilosity:** Dense yellow pubescence on head, pronotum, mesepisternum except vertex; occiput, gena with sparse pubescence; very fine sparse hairs on anterior surface of pronotum; short dense pubescence on scutum and scutellum; sparse short hairs on all legs; short dense keirotrichia on inner hind tibia; long, little dense, yellow pubescence on dorsolateral propodeum; S1, S2 apical bands silky, with fine sparse pubescence; S3 with dense silky, pubescence extending at both depressed apical ends; hairs sparse, short on coxa, trochanter, femur; tibia with comparatively denser and stouter hairs; comparatively longer hairs at outer margin of fore basitarsi.

**Sculpture:** Fine dense punctures all over head; comparatively wider, larger punctures on ocellocular space, vertex; pronotum with fine, dense punctures all over, pronotum lobe comparatively wider with shallow punctures; fine, dense, uniform punctures on scutum, scutellum, dorsolateral propodeum; dense, coarse punctures on mesepisternum; metanotum with denser and finer punctures than those on scutum and scutellum; irregular, weak rugose pattern on posterior surface of propodeum than on basal area of propodeum, propodeum posterior angle carinate; T1 basal area with fine dense irregular punctures extending to middle; T1, T2 apical half with deep rounded punctures, same

kind of punctures present only on middle in T3 and T4; Other parts of tergum with fine dense deep punctures.

**General structure: Head:** 1.25x as broad as long; clypeus 1.94x as long as clypeoantennal distance; compound eye 0.83x as long as head; upper interocular 1.22x as long as lower interocular distance; alveolar distance 0.67x as long as antennocellar distance; inter ocellar distance 1.04x as long as ocello ocular distance; scape 4.5x as long as pedicel; flagellum 0.47x as long as scape; F1 2.21x as long as pedicel. **Mesosoma:** Pronotum carinate at anterior margin till lobe; scutum 0.75x as long as broad anteriorly and 0.9x as long as broad posteriorly; tegula small, brownish, transparent, 3.2x as long as broad; length of basal propodeum approximately half of metanotum; propodeum 0.43x as long as metanotum; scutum 2.65x as long as scutellum; scutellum 1.56x as long as metanotum;; posterior surface of propodeum 8.4x as broad as length of propodeum. hind leg: Long, femur bulging with subapical tooth; tibia not broader than femur; hind tibia 1.08x as long as femur; basitarsi long, slender and 0.7x as long as hind tibia; forewing 3.36 as long as broad; hindwing 4.11x as long as broad; forewing 1.38x as long as and 1.69x as broad as hindwing; stigma 2.65x as long as broad, 3.27x as long as prestigma; prestigma 2.1x as long as broad; Marginal cell 1.94x as long as free marginal cell and 1.21x as long as marginal cell length beyond stigma; marginal cell 3.52x as long as broad. **Metasoma:** Abdomen slightly broader towards middle and 0.63x as long as broad; T1 smaller, rectangular, 0.85x as broad as T2; few or no hairs on anterior surface; premarginal line from T1 to T5 angular, strong and elevated; apical bands neat and straight. S3, S4 with both apical ends depressed; mid line deeply depressed; surface covered with dense pale pubescence with few long hairs on lateral margin; S5 variously curved at premarginal area; two discs at mid apex with short, laterally elongated lobes; stout hairs present on lobes, bifid at tip; long hairs on margin of middle lobe; two peg like structure at the base of lobes; S6 with long apodeme, slightly broader at the base and 0.6x as long as disc; mid apex deeply cleft with a thin sparse hairs mesad; S7 broader, 7x as wide as long; two bunches of long thin hairs on apical lobes; S8, 1.86x as long as broad with convex mid apical lobe 1.25x longer than broad.

**Genitalia:** Oval; 1.46x as long as broad and 0.53x as high as long; gonabase conical blunt, gonocoxite smooth, not broad, arm simple, small depression with laterally at their

joints; gonobase 1.5x as broad as long; genital foramen 0.41x as broad as long; volsella narrower at apex; ventral retrorse lobe 0.42x as broad as long, apical outer margin with denticles; anterior longitudinal half of retrorse lobe inner surface covered with short, uniform soft hairs; inner basal surface with tuft of long thick dense hairs; upper lobe small, thin, broader apically; ventral arm small, 2.75x as long as broad and 3.14x as broad as ventral retrorse lobe; penis valve 3.5x as long as broad; mid lateral tooth curved upwards, apical and inner preapical tooth angulated mesad; hairs at base of ventral retrorse lobe 0.27x as long as broad of ventral retrorse lobe.

**Female:** Unknown.

**Measurement (mm):** ♂ Body length  $8.89 \pm 0.35$ ; fore wing length  $6.66 \pm 0.02$ ; hind wing length  $4.82 \pm 0.02$ ;

**Specimens examined:** 4♂♂, INDIA: ♂, Bihar: Baghouse, Laheria sarai, Inglis coll, H-6495; ♂, Bihar: Baghouse, Laheria sarai, Inglis coll, H-6498; ♂, Punjab: Rohtak, 29.IX.II, G. R., Dutt, lectotype, G., Meado-Waldo det, H- 6490; ♂, Bihar: Baghouse, Laheria sarai, Inglis Coll, H-6495 (NPC).

**Distribution:** \*Bihar; Gujarat: Allahabad; Punjab: Ferozepur; Rajasthan: Mount Abu; Uttar Pradesh; Gujarat: Deesa; Bihar: Baghouse, Laheria sarai; Haryana: Rohtak.

### 3. *Lipotriches kangrae* (Nurse)

[Fig. 10: ♂ A to K; Plate VIII (a): ♂ A to H; Plate VIII (b): ♂ A to E]

*Nomia kangrae* Nurse, 1904: 569; Pauly, 2009: 17

#### Male

#### Diagnosis

**Color:** Head black, shiny; antenna light brown; pronotum, scape and pedicel dark brown; pronotal lobe glossy brown; legs brown, tarsi pale, claws dark; abdomen amber or black.

**Pilosity:** Head covered with pale golden, dense pubescence; short dense yellow pubescence on pronotum, posterior margins of scutum, posterior and mid line of scutellum and metanotum except anterior pronotum, metepisternum, basal and dorso-lateral propodeum; scutum and scutellum with sparse, fine hairs on disc; long, dense, pale

pubescence on metanotum, postero-lateral propodeum; outer hind tibial surface with short, appressed white pubescence along with sparse yellowish pubescence; abdominal tergum with thick, dense, golden yellow pubescent apical bands on T3 to T6; sparse hairs on T1 basal half, no hairs found near premarginal area; tergal bands from T4 to T5 extending at middle; S1 to S4 with fine, silky, sparse apical bands; S5 plate with dense silky hairs on surface.

**Sculpture:** Dense, fine, uniform punctures on frons; comparatively larger but sparse punctures above compound eye and behind ocelli; punctures absent near ocelli; fine, dense punctures on scutum, scutellum, metanotum; abdomen with fine, dense punctures on all terga; premarginal lines of T2, T3 slightly elevated, edges angular; punctures present on sterna and dense punctures covered by pubescence, few sparse punctures seen above and other parts are shiny.

**General structure:** Head 1.28x as broad as long; upper interocular distance wider, 0.74x as long as lower interocular distance; carina surrounding ocelli; clypeus 1.75x as long as clypeoantennal distance; compound eye 0.79x as long as head; alveolar distance 0.84x as long as antennocellar distance; inter ocellar distance 0.84x as long as ocello ocular distance; scape 4.41x as long as pedicel; flagellum 2.72x as long as scape; F1 0.89x as long as pedicel; **Mesosoma:** pronotum with lamellate extension notched at middle, lamellate lobes small; tegulae 0.53x as long as broad; forewing 3.21x as long as broad; scutum 1.01x as long as broad anteriorly and 1.13x as long as broad posteriorly; scutellum 0.29x as long as scutum; scutellum 3x as long as metanotum; hindwing 3.8x as long as broad; forewing 1.3x as long as hindwing; marginal cell 1.96x as long as free marginal cell and 1.19x as long as marginal cell length beyond stigma; marginal cell 3.48x as long as broad; hind tibia slightly enlarged at apex; hind tibia 1.36x as long as femur; basitarsi 0.58x as long as hind tibia; hind basitarsi gradually narrowed towards apex, generally thin compared to body size; **Metasoma:** as long as propodeum. All terga wider than long; T6 triangular, fine dense yellowish pubescence at margins, mid apical with small pygidium; T7 apical margin inwards at middle, marginal zone hard and ventrally depressed with dense thick yellowish pubescence; S5 dorsolaterally curved, apodeme short; basal margin slightly inwarded at middle; gradular line apparent; two discs elevated with fine dense short hairs on them; apical margin invaginated at middle

with fine hairs; S6 dorsolaterally curved and apical half strongly depressed, curved; apodeme short; gradular line discontinuous; two mid discs slightly depressed at middle with fine sparse hairs at their margin; two discs distinctly separated at middle; S7 laterally extended and wider at middle; base rounded, longer at middle, narrowing down suddenly towards ex; dorsal mid apical with long lobe, concave ventrally; mid apical invaginated slightly; S8 short, wider, simple, basal margin straight, dorsolaterally curved slightly; lateral apodeme short, blunt; dorsolaterally with few long hairs at apex.

**Genitalia:** Rectangular; broadened at apex and 1.29x as long as broad; laterally 0.49 x as high as long; gonobase 1.45x as broad as long; genital foramen 0.88x as broad as long; ventral retrorse lobe oval, 0.46 as broad as long and narrowed at apex; lobes smooth with two layers, folded together and forms ventral concavity; sparse long stout bristles at dorsolateral surface; few long hairs at below inner base; outer surface with long sparse fine hairs, 0.5x as long as breadth of ventral retrorse lobe; inner surface with short, stout bristles; base of lobe depressed laterally curved downward; small parallel lobe with rounded edge at base; gonocoxite smooth and 0.34 x as broad as length of genitalia; volsella 1.5x as broad as long; penis valve with narrow apodeme slightly broadened at base; penis valve 3.38x as long as broad; base of valve blunt, mid tooth angulate anteriorly, apical tooth curved and bent ventrally; preapical tooth found but not well developed; gonobase anterolaterally rounded.

**Female:** Comparatively smaller than male; hind femur dark brown shiny with sparse long hairs; hind tibia with dense shiny light yellowish hairs, longer hairs towards apex; hairs on clypeus longer, fine, shiny; short, shiny, thick, pale yellow pubescence on paraocular area; short, sparse pubescence on supraclypeus, frons and slightly wider at vertex and occiput; gena and post gena with thick, pale yellow, sparse pubescence; long fine shiny yellowish hairs very sparse on femur and sparse on tibia, tarsi; fore tarsi, mid tarsi, hind tibia, hind tarsi light brown; hind coxa preapically short, flat, tooth with rounded edge; T1-T4 with dense apical bands, not on T5; T5 with dense yellow pubescence.

**Measurement (mm):** ♂ Body length  $8.07 \pm 0.5$ ; fore wing length  $7.0 \pm 0.04$ ; hind wing length  $5.35 \pm 0.04$ ;

**Specimens examined:** ♀, INDIA: ♀, Bengal: Chapra, Mackenzie coll, G.R. Dutt det., H-6508; 3 ♂♂, INDIA: ♂, Tamil Nadu: Coimbatore, IV.1915, G.R. Dutt Coll, G., Meadowaldo det, H-6513; ♂, Jammu & Kashmir: Janjgir, Bilaspur, X.1915, C.S.M., H-6509; ♂, Bihar: Pusa, Bengal, 0.VI. 1910, H-6507 (NPC).

**Distribution:** Himachal Pradesh: Kangra valley; \*Tamil Nadu: Coimbatore; \*Bihar: Chapra, Pusa; \*Jammu & Kashmir: Janjgir, Bilaspur.

#### 4. *Lipotriches jhajhraensis* sp. nov.

[Plate. IX (a): ♀ (A-H); IX (b): ♀ (A-F)]

#### Female

#### Diagnosis

**Color:** Body black; metasoma yellowish brown with black markings on apical fascia; head and mesosoma black hairs pale golden yellow; fore and hind wing slightly fuscous; lateral apex of clypeus, base of mandible, antennifer and base of scape yellow; antenna and apex of mandible dark brown; hind tibia black; apex of metasoma black; inner surface of flagellum, tibia, basitarsi, and pretarsi yellow; tegula shiny, yellowish brown; T1 and T2 disc area glossy; T1 with black band marking only on dorsolateral area of disc; Similar of mark but extending towards dorsum of T3; T4 black band narrowly intermittent at middle; T5 completely black including apical fascia;

**Pilosity:** short fine dense subdecumbent hairs on frons, upper paraocular area, vertex, scutum and scutellum; Similar hairs but relatively long, sparse, subdecumbent posteriorly on supraclypeus, and clypeus; tiny pale tomentum covered head, scutum and scutellum; thick dense pubescence completely covering pronotum, pronotal lobe, metanotum; slightly denser at posterior margins of scutum and scutellum; propodeum covered with tiny pale tomentum; fine long hairs on posterior propodeum and relatively denser on anterior surface of T1; very sparse, sparse scattered hairs on T1-T2; sparser on T3 onwards; S2 to S4 with sparse apical hair bands, comparatively denser than on tergal hair bands; hind femoral scopa of long hairs, hind tibia with strong dense hairs;

**Sculpture:** small dense punctures ( $\geq 0.03$  mm) on frons, paraocular area, supraclypeus and clypeus; Similar of punctures scattered on vertex, interspaces smooth, shiny; tiny

shallow dense punctures and interspace tessellate; basal propodeum without punctures, smooth and shiny; scattered small, shallow punctures on disc of T1; shallow dense punctures on disc of T2, interspaces less than the diameter of punctures, smooth and shiny.

**General structure: Head:** mandible bidentate, apical tooth broad, curved with rounded edge; preapical tooth short and blunt; supraclypeus slightly elevated; clypeus slightly elevated transversely at middle; face nearly flat; ocellocular distance 1.7x as long as diameter of ocelli; head 1.04x as broad as long; alveolar distance 0.68x as long as antennocellar distance; upper interocular 1.23x as long as lower interocular distance; interocellar distance 0.78x as long as ocellocular distance; scape 5.6x as long as pedicel; flagellum 2.32x as long as scape. **Mesosoma:** pronotal carina reduced or absent; inner hind tibial spur simple, preapically curved with lower margin minutely serrate; hind basitibial plate posteriorly carinated; tegula short, oval and translucent; metanotum 1.8x as long as mid basal propodeum; basal propodeum shiny black without punctures with no defined posterior margin; hind tibia 1.30x as long as femur; hind tibia 1.41 as long as basitarsi; tegulae 1.83x as long as broad; forewing 2.51x as long as broad; hindwing 3.63x as long as broad; forewing 1.28x as long as and 1.86x as broad as hindwing; stigma 3.22x as long as broad, 3.62x as long as prestigma; prestigma 5.33x as long as broad; marginal cell 1.75x as long as free marginal cell and 1.19x as long as marginal cell length beyond stigma; marginal cell 4.66x as long as broad; scutum 0.70x as long as broad and 2.42 x as long as scutellum; scutellum 1.9x as long as metanotum. **Metasoma:** T1-T2 glossy with shallow punctures; T2-T3 disc with dorsolateral, black band; T4 with intermittent black band on disc; T5 black marking extending up to apical margin.

**Remarks:** *L. jhajhraensis* sp. nov. exhibits all the characters of subgenus *Mayenomia* viz., bidentate mandible, reduced transverse lamina of pronotum, hind tibial spur simple and serrated, ocellocular distance 1.7x as long as diameter of ocelli, scape not reaching midocelli and long slender glossa. It differs from other species by the presence of an additional dorsolateral black band on T2 and a narrowly intermittent black band on T4, which are absent in closely related species *mollis* and *aurodigitata* (specimens not examined but clearly evident from the photographs and descriptions of ); also it differs due to its black shiny basal propodeum, fine punctures on scutum.

**Measurements (mm):** ♀ Body length  $7.75 \pm 0.06$ ; forewing length  $6.18 \pm 0.02$ ; hindwing length  $4.80 \pm 0.03$ ; scutum  $1.38 \pm 0.02$ ; scutellum  $0.57 \pm 0.02$ ; metanotum  $0.3 \pm 0.01$ .

**Specimens examined:** HOLOTYPE: ♀, INDIA: Uttarakhand: Jhajhra, Dehradun, 16.X.2013, Preeti S. Virkar Coll. on *Ageratum* spp, (NPC); PARATYPE: ♀, Uttarakhand: Jhajhra, Dehradun, 9.X.2013, Preeti S. Virkar Coll. on *Jasminum* spp. (NPC)

**Floral records:** *Ageratum* spp, and *Jasminum* spp.

**Etymology:** Named after the place of collection Jhajhra, Dehradun.

### 5. *Lipotriches makaliammani* sp. nov.

[Plate. X: ♀, (A-I)]

#### Female

#### Diagnosis

**Color:** head, scutum and scutellum black; eyes dark brown; anterior base of tibia yellow; basitarsi yellow with dark brown margin; glossa, tegula, abdomen and wing lamina yellowish brown; innersurface of antenna, pronotal lobe, scrobe, lateral mesosoma, metanotum, propodeum, coxa, trochanter, femur and tarsi light or reddish brown; hairs golden yellow and shiny.

**Pilosity:** finely branched thick pubescence (atleast 0.5x as long as scape) sparsely covering head; tiny matt of hairs on surface of antenna; posterior surface and lateral propodeum with long fine sparse pubescence; T1,T2 apical bands feeble with short fine hairs scattered on surface; T3, T4 with sparse pubescence on apical bands; hind femoral scopa with long sparse hairs but weaker than that of tibial hairs; hind tibial hairs strong, finely branched; hind tibial spur simple, curved preapically; short, fine sparse hairs on other parts of hind leg.

**Sculpture:** tiny dense, round punctures on vertex, frons, paraocular area; similar punctures but slightly wider on occiput, supraclypeus and clypeus; small round, dense uniform punctures on scutum and scutellum; punctures on scutum is slightly bigger than

those on head; very small, strong dense punctures on metanotum; basal propodeum narrower, demarcated by tiny transverse groove both anteriorly and posteriorly; short longitudinal ridges on midbasal propodeum narrow, shiny spaces between lateral and posterior propodeum with small dense, uniform punctures; T1-T3 with shallow sparse uniform punctures

**General structure: Head:** broad; apical tooth of mandible short broad and preapical tooth small; head 1.28x as broad as long; clypeoantennal distance 0.71x as long as antennocellar distance; upper interocular 1.29x as long as lower interocular distance; ocelli diameter 0.40x as long as ocellocular distance; alveolar distance equal to antennocellar distance; inter ocellar distance 1.04x as long as ocello ocular distance; scape 5x as long as pedicel; flagellum 1.7x as long as scape **Mesosoma:** pronotal transverse carina much reduced; forewing submarginal venations weak; hind tibia 1.24 as long as femur; basitarsi 0.73x as long as hind tibia; tegulae 1.8x as long as broad; hind tibial spur simple with tiny serrations at lower margin; forewing 2.7x as long as broad; hindwing 3.10x as long as broad; forewing 1.37x as long as and 1.57x as broad as hindwing; stigma 2.8x as long as broad, 3.5x as long as prestigma; prestigma 2x as long as broad; marginal cell 2x as long as free marginal cell and 1.15x as long as marginal cell length beyond stigma; marginal cell 4.28x as long as broad; scutum 0.77x as long as broad anteriorly and 0.87x as long as broad posteriorly; scutum 2.5x as long as scutellum; scutellum 2x as long as metanotum; **Metasoma:** short, oval with pointed apex; mostly glabrous with scattered hairs; T1-T3 smooth and shiny without black patches on disc.

**Remarks:** *L. makaliammani* sp. nov is closer to species *phenacura* (Cockerell 1911) but differs by the following characters viz., T1-T3 completely ferruginous, T4 with lateral brown patches; T5 with blackened premarginal area; ridges on basal propodeum narrower, not as strong as in *phenacura* and interspaces not smooth and shiny; lateral and posterior surface of propodeum with uniform, small dense round punctures.

**Measurements (mm):** ♀ body length 4.88; forewing length 3.24 and width 1.20; hindwing length 2.36 and width 0.76;

**Specimens examined:** ♀, HOLOTYPE, INDIA: Tamil Nadu: T Mettupatti, 12.II.2011, M. Balaji Coll. on *Tribulus* sp. (NPC)

**Floral records:** *Tribulus* sp., (Zygophyllaceae)

**Etymology:** Named after the goddess of the foot hills of Mettupatti where it has been collected.

**6. *Lipotriches sathiarensis* sp. nov.**

[Plate. XI: ♀, (A-H)]

**Female**

**Diagnosis**

**Color:** head and mesosoma black; inner apex of antenna light brown; apex of abdomen black; legs dark brown; T1 to T3 ferruginous; dark brown transverse band on mid disc of T1; T2 with black trasverse bands on disc; T4 onwards black;

**Pilosity:** thick, pale, yellow pubescence sparse on paraocular, alveolar space and scape; clypeus and supraclypeus with scattered pubescence; short, thick pubescence uniformly on surface of scutum and scutellum; few longer and thicker pubescence on metanotum; fine, long scattered hairs on posterior surface of propodeum; basal propodeum glabrous; hind femur with sparse fine scattered pubescence forming a weak scopa; stout long finely branched plumose hairs sparsely covering surface of hind tibia; similar hairs on basitarsi but relatively sparser; T1 to T3 nearly glabrous with scattered fine hairs limited to laterad; weak apical bands on T4 onwards with sparse fine hairs; sternum with very sparse, short fine hairs.

**Sculpture:** small, shallow dense punctures on paraocular region, vertex and frons; shallow punctures, scattered on clypeus; very small, dense, strong punctures on scutum and scutellum; interspaces shiny and smooth; strong, very dense tiny punctures on metanotum; anterior transverse groove on basal propodeum widely placed weak longitudinal striae; tiny, fine transverse striae at posterior angle of basal propodeum; T1 with tiny shallow punctures scattered on disc; anterior surface of T1 shiny glabrous; T2 with small relateively strong, dense uniform punctures; T3 with very shallow scattered punctures; all sternum with tiny very sparse punctures on its premarginal area; surface of sternum not smooth and tessellate;

**General structure: Head:** mandible bidentate with small preapical tooth; glossa slender; head 1.30x as broad as long; clypeus 1.55x as long as clypeoantennal distance; upper interocular 1.28x as long as lower interocular distance; alveolar distance 0.77x as long as antennocellar distance; inter ocellar distance 1.10x as long as ocelloocular distance; ocelloocular distance 1.90x as long as diameter of ocelli; scape not reaching ocelli; compound eye 0.85x as long as length of head; scape 5x as long as pedicel; flagellum 1.8x as long as scape; **Mesosoma:** transverse carina on anterior pronotum reduced to a tiny carina; hind tibia 1.17x as long as femur; lower margin of hind tibial spur with rows of denticles; basitarsi 0.65x as long as hind tibia; tegulae 2.11x as long as broad; forewing 2.9x as long as broad; hindwing 3.1x as long as broad; forewing 1.35x as long as and 1.5x as broad as hindwing; stigma 2.62x as long as broad, 2.7x as long as prestigma; prestigma 2x as long as broad; marginal cell 1.33x as long as free marginal cell and 1.22x as long as marginal cell length beyond stigma; marginal cell 4.71x as long as broad; scutum 0.76 as long as broad at middle; scutum 2.71x as long as scutellum; scutellum 1.75x as long as metanotum; **Metasoma:** abdomen broad at middle; mostly glabrous with scattered hairs; apex of sternum not pointed;

**Diagnosis:** *L. sathiarensis* is closer to *kaeralensis* Pauly (2009) but differs by the following characters *viz.*, T2 with sparse uniform slightly strong punctures; pale sparse pubescence on scutum, clypeus and paraocular area; basal propodeal at anterior margin with only traces of ridges; posterior angle of basal propodeum with tiny transverse striae and not smooth.

**Measurements (mm):** ♀ body length  $6.04 \pm 0.12$ ; forewing length  $4.17 \pm 0.02$  mm and width  $1.44 \pm 0.02$  mm; hindwing length  $1.44 \pm 0.05$  mm and width  $0.96 \pm 0.05$ mm;

**Specimens examined:** ♀, HOLOTYPE, INDIA: Tamil Nadu: T Mettupatti, Sathiar, 12.II.2011, M. Balaji Coll. on *Tribulus* sp. (NPC); Paratype, 2 ♀♀, Tamil Nadu: T Mettupatti, Sathiar, 12.II.2011, M. Balaji Coll. on *Tribulus* sp.(NPC)

**Distribution:** \*Tamil Nadu: Adhalai, Madurai.

**Floral record:** *Tribulus* sp (Zygophyllaceae)

**Etymology:** Named after the place of collection, Sathiar, Mettupatti, Tamil Nadu.

**7. *Lipotriches anaiyurensis* sp. nov.**

[Plate. XII: ♀, (A-K)]

**Female**

**Diagnosis**

**Colour:** body black; dark brown, abdominal sternum, mouth parts, legs; yellowish brown; inner flagellum except first F1 with pale yellowish hairs.

**Pilosity:** Pale yellow, sparse, slightly appressed pubescence on head except frons and vertex; short fine sparse hair on frons; shiny, sparse fine yellowish hairs on vertex; short thick sparse pubescence on scutum and scutellum; comparatively long, thick yellowish pubescence at middle; laterally with short pubescence; coxa, trochanter with shiny sparse hairs; hind femur with long, fine apically branched hairs on posterior and anterior lower margins of hind femur forming scopa; hind femur ventral surface smooth and shiny; hind tibia with finely branched plumose hairs sparsely on both anterior and posterior surface; basitarsi with similar but short hairs; pale, sparse pubescence on metasoma; short fine uniform hairs on tergum; anterior surface of T1 with sparse long hairs similar to as that on propodeum; pubescent apical band of T1 sparse slightly exceeding margin and apical band comparatively thinner than on other terga; T5 with dark brown stiff sparse suberect pubescence; dark brown, apically with very fine long medium erect hairs on S2, S3, S4, S5 and S6;

**Sculpture:** Fine shallow, nearly round punctures on head; scape, pedicel with tiny punctures; small round uniform sparse punctures on scutum, scutellum; comparatively tinier, shallower on metanotum; shiny, basal area merged with posterior surface; anteriorly with weak longitudinal ridges; tiny uniform sparse punctures on dorsolateral and lateral propodeum; propodeal triangle not defined and surface not smooth;

**General structure: Head:** mandible bidentate with curved preapical tooth; head 0.75x as broad as long; clypeus 1.72x as long as clypeoantennal distance; glossa 0.46x as long as head; compound eye 0.79x as long as head; ocellocular distance 1.96x as long as diameter of ocelli; upper interocular 1.42x as long as lower interocular distance; alveolar

distance 0.73x as long as antennocellar distance; inter ocellar distance 0.92x as long as ocello ocular distance; scape 4.45x as long as pedicel; flagellum 1.71x as long as scape; **Mesosoma:** tegula small, oval and translucent; pronotal transverse vertical carina reduced; hind tibia 1.56x as long as femur; hind tibial spur preapically curved with ciliated lower margin; basitarsi 0.70x as long as hind tibia; tegulae 1.90x as long as broad; forewing 2.57x as long as broad; hindwing 4.1x as long as broad; forewing 1.31x as long as and 2.1x as broad as hindwing; stigma 2.5x as long as broad, 3.75x as long as prestigma; prestigma 2x as long as broad; marginal cell 1.68x as long as free marginal cell and 1.23x as long as marginal cell length beyond stigma; marginal cell 4.74x as long as broad; scutum 0.70x as long as broad at the anterior and 0.78x as long as broad at mid; scutum 2.92x as long as scutellum; scutellum 5.12x as long as metanotum; **Metasoma:** subcylindrical; premarginal area of tergum hyaline; midapical margins of sternum translucent; fairly covered with hairs;

**Remarks:** *L. anaiyurensis* sp. nov exhibits the following characters and therefore is being placed under subgenus *Afronomia*, viz., ocellocular distance twice as long as diameter of ocelli; hind basitibial plate carinated on both sides with closed apex; glossa shorter than head; hind femur with a single tooth at apical base; fine strong dense punctures on scutum; scutellum with sparse tomentum on surface; metanotum and propodeum with fine, shallow, dense punctures; basal propodeum declivious; T1 and T2 with shallow, dense sculpture. It is closer to *L. karnatakaensis* but differs in sculptures of mesosoma, basal propodeum and T1-T2.

**Measurements (mm):** ♀ body length  $6.08 \pm 0.16$ ; forewing length  $4.32 \pm 0.08$ ; hindwing length  $1.68 \pm 0.04$

**Specimens examined:** ♀, HOLOTYPE, INDIA: Tamil Nadu: Madurai, Anaiyur, 3.II.2011, M. Balaji Coll., on *Acacia* spp., *Tribulus* sp. (NPC); Paratype, 8♀♀, Tamil Nadu: Madurai, Anaiyur, 3.II.2011, M. Balaji Coll., on *Acacia* spp., *Tribulus* sp. (NPC)

**Distribution:** Tamil Nadu: Madurai, Anaiyur.

**Floral records:** *Acacia* sp., *Tribulus* sp., and grasses.

**Etymology:** Named after the place of collection, Anaiyur, Madurai.

## II. Genus *Nomia* Latereille

*Nomia* Latreille, 1804: 182

*Nitocris* Rafinesque, 1815: 123

Type species: *Andrena curvipes* Fabricius, 1781: 473; Blanchard, 1849: 125; Michener, 1997: 41

**Diagnosis:** Colored tergal or apical bands (white/yellow/blue/green). The apical bands are without punctures and hairs (Michener, 2007). The species could be easily distinguished by males which possess extensively modified hind legs and genitalia features. Both sexes are similar, however varied in size and their hindleg.

**Key to species studied** (modified after Michener 2007 and Pauly, 2009)

1. Metanotum with projections.....2
  - Metanotum without projections.....3
2. Large species >10 mm long; Scutellum and metanotum with two lamellate projection at lateroposterior and dorsoposterior mid apex; Metanotal lamella with broad triangular lamina carinated around the margin vertically upwards; male S5 with a tuft of hairs on both the sides of mid apex; S8 midapical peg slightly narrow at apex; S6 basolateral apodeme at least equal to the length of disc; male genitalia broadened at apex; 1.19x as long as broad; gonobase narrow at base; genital foramen 0.41x as broad as long; ventral gonostylus broad and erected dorsally; inner surface with dense soft hairs and outer surface with few long hairs; upper gonostylus small, oval and inner surface folded at one margin with short uniform sparse hairs; the dorsoapical margin not extended and the apical margin folded outwards slightly ..... *buddha*
  - smaller species <10mm long; scutellum without lamelliform projection; metanotum with dorsoposterior spines not lamelliform; smaller species.....3
3. Mid carina of clypeus reaching anteclypeal margin; T1 with strong and sparse tiny punctures; ; Males: S5 the space between the pair of hair bunches on each side of apex is relatively wider; S8 midapical peg relative longer; apex of the dorsal gonostylus not extended laterally; genital foramen 0.76x as broad as long; penis valve 3.15x as long as broad; gonostylus 0.67x as broad as long; genitalia 0.82x as high as length; genitalia 1.23x as long as and 1.18x as broad as long..... *elliotti*
  - Mid carina of clypeus not reaching anteclypeal margin; T1 with shallow and very sparse tiny punctures; Males: S5 the space between the pair of hair bunches on each side of apex not as wide as *elliotti*. S8 midapical peg relative shorter; apex of the dorsal gonostylus extended laterally and slightly bent inwardly; genital foramen 0.60x as broad as long; genitalia 0.81x as long as and 0.84x as broad as long..... *westwoodi*
4. Outer hind tibial spur of female bent near apex, with projection towards main shaft; mid tibial spur with few coarse preapical teeth; basitibial plate of female completely carinated except base; hind femur of female without tooth.....5

---Outer hind tibial spur tapering or unmodified; mid tibial spur with minute teeth.....6

5. S8 small, with midapical peglike projection; S7 with two apical projections covered with hairs (hirsute); male gonostylus flattened, expanded or curved basad; S6 apical margin emarginated, surface without oblique setae; S5 apex variously sclerotised with hair tufts; Metanotum without spine; female, hind basitibial plate completely carinated; apical margin of forewing fuscous; strong punctures on scutum and scutellum. genitalia oval, broader at middle, 1.29x as long as broad, 0.82x as high as long; gonostylus arched towards middle; gonostylus small, broader at preapex with sparse fine hairs laterally extended like inverted triangular; gonobase 0.74x as broad as long; penis valve longer and 3.15x as long as broad; midapical tooth broad and apex angulated anteriorly; preapical tooth as long brush comb with dense hairs, bent at tip; a row of finger like hairs inwardly bent at base of lateral margin (hind leg slender)... *strigata*

---S8 mid apical peglike projection absent; relatively large, broadened base and preapex; lateral margin concave; S7 basolateral apodeme long, length >0.5x as width; male gonostylus slender, not flattened, much exceeding penis valves, directed posteriorly and arising from distal end of elongated gonocoxite; S6 rounded apex, with oblique rows of flattened setae; S5 unmodified.....*N. (Paulynomia)*

6. T1 without colored band and having lateral hair band Males with basitibial plate and slender legs; hind femur of male with tooth at base; body length <10mm; colored bands white or pale; metanotum without spines and apical bands absent in T1; Males with S2-S5 lateral long hairs; pale apical bands; genitalia broadened apically; 0.67x as broad as long; gradually narrower towards anterior; gonostylus, lobe shovel like, 1.8x as long as broad; genital foramen 3x as long as broad; gonobase longer, 0.3x as long as genitalia and 1.33x as broad as long; gonostylus lobe laterally broad, concave and bent towards mesad; short hairs sparsely on outersurface and long hairs along the distal margin of gonostylus..... *interstitialis*

--T1 with colored band and without hair band; Males without basitibial plate; hind leg enlarged, femur with one or two preapical teeth; body >9mm; colored bands more bright.....7

7. Female: Scutum glabrous at middle, the edges with a short pubescence, Males S5 without clubbed head hairs on the apex; genitalia 1.27x as long as broad and 0.03x as high as long; upper gonostylus 0.52x as broad as long with three thin lobes; dorsal lobe broader apically and inside with few short hairs, outer surface with long typical, plumose at apical half ventral lobe apically rounded, fine small sparse hairs on mid lateral inner surface, apical and lateral margin; lower gonostylus 0.57x as broad as long and 0.80x as broad as upper gonostylus; few long weaker oblique depression across the middle.....*curvipes*

---Female: Scutum completely covered by dense short pubescence; Males S5 with club headed hairs on the apex; apical border of S4 widely concave. Hind tibia widest at middle with a slender apical process; male genitalia oval, 1.45x as long as broad and laterally 0.26x as high as long;

gonostylus dorsal lobe rectangular, curved mesad and inner surface completely covered with long flap like clubbed hairs in uniform rows; dorsal gonostylus 0.41x as broad as long whereas ventral gonostylus 0.12x as broad as long and 0.25x as broad as upper gonostylus; ventral arm long, broad at base, apex slightly broader than the middle; the outer surface with long, sparse hairs..... *crassipes*

### 1. *Nomia buddha* (Westwood)

[Fig. 1: ♂ A to H, Fig. 1(a): ♂ I to S; Plate I (a): ♂ A to J; Plate I(b): ♀ A to I)]

*Nomia buddha* Westwood, 1875: 209; Pauly, 1990: 48

*Nomia bahadur* Nurse, 1904: 568

*N. (Crociaspidia) buddha* (Westwood, 1875); Pauly, 2009: 169

#### Male

#### Diagnosis

**Color:** Body black; antenna, mandible, pronotal lobe, sternum, scutellar and metanotal lamella dark brown; base of scape pale yellow.

**Pilosity:** Long yellowish, thick, dense pubescence on frons, clypeus, supraclypeus, paraocular area, basal scape; pale yellow long, fine sparse pubescence on vertex, gena, post gena, mesepisternum and metepisternum basal half; pale brown long fine sparse hairs on occiput; pale yellow fine dense hairs on pronotum and its lobe; pronotum anterior surface with silky short fine sparse hairs laterally; medium fine dense uniform hairs on scutum and its anterior half with long hairs; same kind of hairs but shorter on scutellum; pale brown short fine dense hairs on tegula anterior surface; few long pubescence on scutellar and metanotal lamella; pale yellow, long, thick dense hairs on dorsolateral propodeum; very fine silky, sparse appressed hairs on lateral propodeum; pale brown short, fine dense hairs at apex of hind femur and their inner surface with sparse hairs; short, pale dense, appressed hairs on anterior surface of hind tibia and basitarsi; short, dense hairs on inner surface of hind tibia; very sparse, fine, uniform hairs on all terga; T1 with sparse long hairs anterior surface with sparse short hairs; T1 to T5 with fine sparse plumose; dark hairs at middle and pale yellow sparse, long hairs at near lateral premarginal line; T6 gradular area with minute dense hairs scattered with short sharp hairs; brown long sparse hairs on premarginal lines of T 6 and T 7; S1, S2 with pale white, very fine sparse hairs with few long hairs interspersed; S3 with long, dense hairs at mid apical margin.

**Sculpture:** Fine, dense punctures on head; few shallow punctures at base of mandible; pronotal upper anterior surface with fine dense punctures; fine uniform dense punctures on scutum and scutellum, comparatively larger at scutellum apex; punctures shallow, irregular on metanotum; shallow, dense punctures on apex of hind femur; dense, fine irregular elongated punctures on lateral and posterior propodeum; shallow large punctures on T1 to T5, interspace with fine dense rounded punctures; few shallow punctures on T1 anterior surface; T2 mid disc with dense punctures; few punctures found near pregradular line.

**General structure: Head:** 1.32x as broad as long; upper interocular 1.35x as long as lower interocular distance; compound eye 0.91x as long as head; ocellular area depressed, ocelli rounded and prominent; inter ocellar distance 1.0x as long as ocellular distance; frontal line reaching supraclypeus splitting into tiny furrows when reaching alveolar space; alveolar distance 1.21x as long as antennocellar distance; clypeus 2.30x as long as clypeoantennal distance; supraclypeus longitudinally finely rugose raised at middle; clypeus with weak longitudinal carina at middle; depressed at midapical with strong smooth carinae along their margin; epistomal suture weakly carinated laterally; antennal suture strong; scape 6.35x as long as pedicel; flagellum 9.49x as long as scape; F1 1.76x as long as pedicel. **Mesosoma:** Pronotum 0.10x as long as scutum; carinated smoothly at both margins; pronotal anterior surface depressed laterally; scutum 2.78x as long as scutellum; scutellum 3.96x as long as metanotum; scutum with hind margin carinated laterally and curved upwards; scutum 0.60x as long as broad at anterior and 0.98x as long as broad at posterior; scutellum 2.59x as broad as long with two small, transparent, lamellate extension laterally scutellum, approximately 1/3<sup>rd</sup> length of metanotal extension; tegula auriform, transparent, outer margin carinated and 2.17x as long as broad; metanotum basally with a pair of lamellate extension which exceeds propodeum; irregular rugose pattern below lamella; metanotum 0.90x as long as propodeum; hindleg largely modified: hind femur broadened at middle; hind tibia 0.74x as long as femur; hind tibia extending apically, with two lean spurs, outer surface depressed apically and carinated strongly at margin; femur 7.06x as long as trochanter; basitarsi 1.05x as long as hind tibia; forewing 3.2x as long as broad; hindwing 3.22x as long as broad; forewing 1.36x as long as and 1.35x as broad as hindwing; stigma 2.8x as

long as broad, 2.2x as long as prestigma; prestigma 1.73x as long as broad; marginal cell 1.88x as long as free marginal cell and 1.12x as long as marginal cell length beyond stigma; marginal cell 4.76x as long as broad; basal propodeum weakly carinated at posterior angle and weakly longitudinally rugose at middle; basal propodeum smooth, not shiny; posterior surface 7.74x as broad as the length of propodeum. **Metasoma:** T1 with defined anterior surface, right angled; bluish green, intermittent apical fascia present on T1 to T5 without hairs; apical fascia intermittent space gradually reduced towards T5 and gives “V” appearance at middle; lateral carina observed on all terga; T5 broader than long and lateral weak carina near gradulus; T6 dorsolaterally bent, pregadular area strong, laterally curved; T7 apically curved, convex at middle; lateral arm of graduli weakly carinated on T1 to T6; S3 and S4 with small, thin, transparent lamina expanded at midapex and fine short hairs on their margin; S4 with two large discs dorsolaterally depressed and deeply inward at midapex; lateral carina with long pale dense hairs; S5 with antecostal suture deeply inwarded and spicule like projection at middle; gradulus depressed posteriorly and curved laterally; three sets of hair bunches on each side of midapex; stout hairs, slightly appressed and bent at tip; hair bunches appressed towards lateral, middle and apex; S6 variously curved and depressed near to middle sublaterally; S7 mid apical lobe narrow towards apex; two lateral apodemes at end of pre apical lobe; S8 bent ventrally towards genitalia; apical margin arched inwardly and their angles with long uniform hairs.

**Genitalia:** Triangular, narrowed anteriorly and broadened at apex; genitalia 1.19x as long as broad; laterally 0.32x as high as long; gonobase narrow at base, broadend apically; gonobase 3.84x as broad as long; genital foramen 0.41x as broad as long; gonocoxite 0.35x as broad as the width of genitalia; gonocoxite smooth, large with convex groove across; penis valve 6.1x as long as broad; volsella 1.77x as broad as long; ventral retrorse lobe broad, erect dorsally; inner surface with dense soft hairs and outer surface with few long hairs; upper lobe small, oval and inner surface folded at one margin with short uniform sparse hairs; arm holding lobes with angular ends; ventroapical margin angular and extended slightly; dorsal gonostylus 0.42x as broad as long; ventral arm of gonostylus 0.14x as broad as long and 4.39x as broad as upper cleft of gonostylus;

dorsoapical margin not extended and apical margin slightly folded outwards; volsella small, curved dorsally.

### Female

Females are similar to males in size and coloration, differing in sculpture and structure and size of hindleg; shallow and sparse punctures on head, scutum and scutellum; sparse pubescence on paraocular area shorter than male. hind femur and tibia not extensively enlarged and covered completely with dense white hairs.

**Measurement (mm):** ♂ Body length  $17.40 \pm 0.45$ ; head length  $3.07 \pm 0.07$ ; head width  $4.08 \pm 0.06$ ; forewing length  $13.11 \pm 0.10$ ; hindwing length  $9.59 \pm 0.08$ ; abdomen length  $8.94 \pm 0.16$ .

♀ Body length 18.01; head length 3.10; head width 4.21; forewing length 13.18; hindwing length 9.63; abdomen length 9.02.

**Specimens examined:** 2 ♂♂, INDIA: ♂, Bihar: Chapra, 00.0.1912, Mckenzie Coll., G., Meado-Waldo det., H- 6436; ♂, Bihar: Chapra, 00.0.1912, Mckenzie Coll., G. Meado-Waldo det., H- 6437; ♀, INDIA: ♀, Bihar: Chapra, 00.0.1912, Mckenzie Coll., G., Meado-Waldo det. (NPC).

**Distribution:** North India; \*Bihar: Chapra.

### 2. *Nomia curvipes* (Fabricius)

[Fig. 2: ♂ A to L; Plate II (a): ♂ A to D; Plate II (b): ♂ I to L; Plate II (c): ♂ Q to T]

*Andrena curvipes* Fabricius, 1793: 310; Smith, 1875: 42

*Megilla curvipes* Fabricius, 1804: 330; Illiger, 1806: 142; Illiger, 1807: 197; Smith, 1875: 42

*Nomia curvipes* Latreille, 1804: 182; Latreille, 1805: 369; Klug, 1808: 55; Olivier, 1811: 377; Olivier, 1811: 377; Lepeletier 1825: 797; Smith, 1875: 42

*Nomia indica* Lepeletier De Saint Fargeau, 1841: 292; Pauly, 2008: 213

*Nomia combusta* Smith, 1875: 56; Pauly, 2008: 213

*Nomia calida* Westwood, 1875: 215; Pauly, 2008: 213

*Nomia varipes* Cameron, 1898: 66; Baker 1966: 546; Pauly, 2008: 213

*Nomia eburnigera* Cockerell, 1911: 220; Pauly, 2008: 213

*Nomia histronica* Cockerell, 1919: 104; Pauly, 2008: 213

### Male

**Description:** ♂ Body length  $11.25 \pm 0.15$ mm.

**Color:** Body black; coxa, trochanter, sternum, edge of pronotal lobe and except base of mandible dark brown; hind tibia and base of hind femur yellowish brown; tegula glossy light brown; pronotal lobe edge ferruginous; anteclypeal margin, base of mandible, apex of hind femur, hind basitarsi, inner forefemur, dorsolateral foretibia and fore tarsi yellow.

**Pilosity:** Short fine sparse hairs on vertex and frons; creamy white, shiny thick plumose hairs on supraclypeus, lateral propodeum, base of mandible and paraocular area; similar hairs present sparsely on scape and mesepisternum, shorter on frons, metepisternum; long, fine, sparse hairs on gena, postgena and short but denser hairs behind compound eye; dense, short, stout creamy white plumose hairs on pronotum, pronotal lobe, margins of scutum, posterior margin of scutellum and metanotum; short sparse, uniform plumose hairs thinner than the marginal hairs completely covering the scutum, scutellum and metanotum; anterior tegula with thick, sparse pubescence; fine, sparse hairs on mid tegula and wing base; axilla with long, fine, shiny, appressed hairs; fore and midlegs with long, fine, sparse hairs on their outer surfaces; anterior surface of hind coxa and trochanter with fine, dense, appressed hairs; hind femur with short, fine, sparse hairs except on inner base; inner hind basitarsi with golden, fine, long, dense hairs and outer surface with very sparse short hairs; posterior surface of propodeum with long, dense, creamy white pubescence; T1 with short, pale plumose hairs denser on dorsoanterior margin but sparse on disc; T2 to T5 with sparse, fine, uniform hairs all over the disc; sparse, thin, long hairs on apical half of T6; T7 with uniform, long, dense hairs, along the marginal area; S1 with short, dense long, sparse hairs; S2 to S4 with long, fine, pale white hairs on the marginal zone slightly extending in to middle and long, sparse hairs on laterad; lateral half of S5 mid apical discs with stout and fine, dense hairs on their margin and corners with fine dense bunch of hairs; S6 with sparse fine short hairs on its apical half.

**Sculpture:** Fine dense punctures on vertex, frons, paraocular and interocellar area; few punctures unite and appear as larger punctures; gena and post gena with shallow sparse irregular punctures; anterior surface of pronotum smooth, shiny with few small punctures; scutum midline and parapsidal lines smooth; small round dense punctures on scutum, scutellum, metanotum, mesepisternum and pronotum; fine, irregular punctures at posterior margins which fade at anterior margins of scutum, basal propodeum with long striae deep at middle gradually reducing towards end; hind margin angle to posterior

surface irregularly carinate; posterior surface with dense round punctures smaller near propodeal pit, and spiracle, pits sparse and fade near lateral lower base; S2 to S4 with shallow dense irregular punctures on all sterna.

**General structure: Head:** 1.07x as broad as long; clypeus 3.3x as long as clypeoantennal distance; compound eye 0.77x as long as head; upper interocular 1.08x as long as lower interocular distance; alveolar distance 0.82x as long as antennocellar distance; inter ocellar distance 1.03x as long as ocello ocular distance; scape 4x as long as pedicel; flagellum 4.3x as long as scape; F1 2.3x as long as pedicel. **Mesosoma:** Scutum and metanotum elevated; tegula oval. hindleg: femoral spine 0.51x as long as femur; mid femur with outer margin angulate and extended slightly at base; hind tibia 1.14x as long as femur; hind trochanter with tooth on inner middle; hind femur broad at apex, narrow at base with sub apical tooth at anterior surface; hind femur 6.3x as long as trochanter; hind tibial apical extension: long, apically narrowed, curved towards inner side, basal inner margin with small curvature, outer apical margin transparent and at rest it is reaching beyond trochanter; inner margin weakly carinated at mid ventral surface; one spur, inner, small, lean, tip short, margin serrated; hind basitarsi narrower; basitarsi 0.69x as long as hind tibia; pronotum 0.08x as long as scutum; scutum length  $2.08 \pm 0.4$ ; scutum 0.70x as long as broad anteriorly and 0.97x as long as broad posteriorly; scutum 3.3x as long as scutellum; scutellum 1.40x as long as metanotum; scutellum 2.67x as broad as long. tegulae 1.70x as long as broad; forewing 3.18x as long as broad; hindwing 3.53x as long as broad; forewing 1.4x as long as and 1.5x as broad as hindwing; stigma 2.3x as long as broad, 1.6x as long as prestigma; prestigma 2.7x as long as broad; marginal cell 1.9x as long as free marginal cell and 1.06x as long as marginal cell length beyond stigma; marginal cell 4.04x as long as broad; metanotum 2.5x as long as propodeum; posterior surface 10.9x as broad as the length of propodeum. **Metasoma:** T1 to T5 with bright yellow apical bands completely covering marginal area; T1 with deep furrow at middle of anterior surface; T6 pygidium broad, with straight end; T7 pregradulus depressed ventrally at middle; apical margin deeply concave and extended laterally; marginal area deflexed ventrally; T8 small, long apodemes wider at apex; disc area small with two small dents at lateral apex; S5 with spicule like projection at midapex; pregradular line curved and makes two distinct, depressed, mid apical and lateral discs; mid disc apically

curved; one finger like curved projection apically between the discs; S6 transverse with deep depression on the middle; apical midline in between the discs, projected anteriorly; mid anterior and mid laterad of S7 angulated; S8 broader narrower towards lateral ends; the hind margin with two bunch of few long hairs.

**Genitalia:** 1.27x as long as broad and 0.03x as high as long; gonocoxite inner margin with dense long, soft plumose just above the upper dorsal lobe; gonobase laterally oval and 2x as broad as long; genital foramen 0.65x as broad as long; upper gonostylus 0.52x as broad as long; with three, thin lobes; dorsal upper lobe small, narrow apically; dorsal gonostylus upper cleft length 0.65mm; lower gonostylus 0.57x as broad as long and 0.80x as broad as upper gonostylus; ventral lobe smaller than dorsal lobe, apically rounded, fine small sparse hairs on mid lateral inner surface, apical and lateral margin; few (four) long weak carina like oblique lines across middle; dorsal lobe broadened apically and its inner surface with few short hairs and apical half of outer surface with long plumose hairs; hairs of gonostylus 0.38x as long as broad of upper gonostylus; penis valve 4.32x as long as broad; apodemes short; broader at middle; short knob or lobe with dentate tip, present away from base of apodemes; long narrow apical tooth curved towards midline; middle angular teeth also towards midline; dorsal midlateral tooth curved up and margin with short tiny hairs.

**Female:** Unknown.

**Measurement (mm):** ♂ Body length  $11.25 \pm 0.15$ ; scutum length  $2.08 \pm 0.4$ ; fore wing length  $8.02 \pm 0.05$ ; hind wing length  $5.72 \pm 0.05$ ;

**Specimens examined:** 3♂♂, INDIA: ♂ Punjab: Lyallpur, 17.VIII.1911, T.B. Fletcher det. 6482; ♂, Punjab: Lyallpur, 00.X.1921, Dutt. Coll, 6483 (NPC); ♂, Tamil Nadu: Madurai, Valasai, 11.I.2011, Balaji Coll., on Zygophyllaceae; ♂, Odisha: Bhubaneshwar, 00.0.2013-14, C.R. Satpathy Coll.

**Distribution:** Maharashtra: Mumbai; Punjab; Tamil Nadu: Trinaveli, Kovilpatty, \*Madurai; Uttar Pradesh.\*Odisha: Bhubaneshwar

**Floral records:** Zygophyllaceae.

### 3. *Nomia crassipes* (Fabricius)

[Fig. 3: A to L; Plate II (a): ♂ E to H; Plate II (b): ♂ M to P; II (c): Q to T]

*Eucera crassipes* Fabricius, 1798: 278

*Nomia curvipes* Smith, 1875: 42

*Nomia megasomioides* Strand, 1913: 31; Hirashima, 1956: 32; Pauly, 2008: 214

#### Male

#### Diagnosis

**Color:** Antenna inner surface dark, outer surface light brown; scape and pedicel completely reddish brown; upper part of hind femur posterior base black; abdominal fascia yellow, glabrous; pubescence pale yellow.

**Pilosity:** Head with golden yellow shiny short sparse pubescence, subdecumbent anteriorly; yellow suberect dense pubescence on mid vertex, frons, pronotum, scutum, scutellum, metanotum and dorsolateral propodeum; hind femur posterior surface brown, shiny, glabrous or scattered with hairs; short hairs on half of midapical part; sparse hairs on inner hind femur; hind tibia with short uniform, appressed sparse hairs; T1 with long, fine hairs on disc and sparse hairs on anterior surface; similar hairs scattered on laterad of all terga; long fine, very sparse hairs on pregradular lines of T2 to T6; S4 midapical disc with fine hairs.

**Sculpture:** Small, round dense punctures on vertex, paraocular area, frons, interocular area; shallower, irregular punctures on gena and post gena; small, round, dense punctures comparatively shallower on scutum, scutellum, epimeral area; interspace not smooth; metanotum punctures slightly obscure; basal propodeum with strong longitudinal striae, carinated posteriorly; shallow, dense round punctures on dorsolateral and posterior surface of propodeum; very shallow, sparse, irregular punctures on disc of all sterna.

**General structure: Head:** Vertex almost horizontal; head 1.11x as broad as long; clypeus 2.03x as long as clypeoantennal distance; compound eye 0.80x as long as head; upper interocular distance 1.18x as long as lower interocular; alveolar distance 0.83x as long as antennocellar distance; inter ocellar distance 1.08x as long as ocello ocular distance; scape 6.42x as long as pedicel; flagellum 3.91x as long as scape; F1 2.57x as long as pedicel. **Mesosoma:** Hind femur posterior base of lower margin dark, angulated slightly extended; hind femur base black anteriorly, apex brownish, shiny; extended

narrow part of hind tibia not longer and directed towards inner lateral apex; almost straight apical margin; stigma 3.15x as long as broad, 1.74x as long as prestigma; prestigma 1.88x as long as broad; marginal cell 2.18x as long as free marginal cell and 1.14x as long as marginal cell length beyond stigma; marginal cell 4.80x as long as broad; hind femur enlarged at middle with spine at apex; hind tibia apical tooth extended broadly with narrow end; femur 4.95x as long as trochanter; hind tibia 0.85x as long as femur; basitarsi 0.66x as long as hind tibia; tegulae 1.93x as long as broad; forewing 2.85x as long as broad; hindwing 3.43x as long as broad; forewing 1.16x as long as and 1.4x as broad as hindwing; pronotum 0.09x as long as scutum; scutum 0.64x as long as broad at anterior and 0.87x as long as broad at posterior; scutum 2.52x as long as scutellum; scutellum 1.66x as long as metanotum; scutellum 2.88x as broad as long. Basal propodeum shorter, carinated posteriorly at middle; posterior surface 2.40x as broad as length of propodeum; metanotum 0.6x as long as propodeum. **Mesosoma:** Abdomen cylindrical, broadened at middle; T6 posterior margin invaginated at mid with dense pubescence. S5 anterior margin triangular, very short apodeme, depressed at middle with pair of extended apical lobes; apical lobes with uniform, short, thick erect hairs; midapex with two small bunches of club headed long hairs; S6 with long lateral apodeme, narrower apex and curved; S7 transverse with two apical lobes wide apart, with long hairs at apex; S8 broader, apical lobe short, convex.

**Genitalia:** Oval, 1.45x as long as broad; laterally 0.26x as high as long; gonobase 0.6x as broad as long; genital foramen, conical, broad at base; gonostylus dorsal lobe rectangular, curved mesad and inner surface completely covered with long flap like bead headed hairs uniformly in rows; 0.81x as broad as long; penis valve 6.1x as long as broad; dorsal gonostylus 0.41x as broad as long; ventral gonostylus 0.12x as broad as long and 0.25x as broad as upper gonostylus; ventral arm long, broad at base, apex slightly broader than the middle; the outer surface with long, sparse hairs; hairs of ventral arm 0.38x as long as breadth of dorsal gonostylus; gonocoxite 0.31x as broad as the length of genitalia; volsella 0.78x as broad as long; gonostylus broad.

**Remarks:** Hind femur base black; yellowish erect pubescence on the thorax; in *curvipes*, pale creamy short thicker pubescence, slightly appressed; S5 with clubbed hairs near mid

apex; posterior base of lower margin extended as in *N. curvipes*; wide variation in genitalia.

**Female:** Unknown

**Measurement (mm):** ♂ Body length 12.05; head length 3.12; head width 3.47; fore wing length 8.90; hind wing length 7.64; scape 0.99;

**Specimens examined:** ♂, INDIA: ♂ Bihar: Pusa, G.R. Dutt Coll. H-6479 (NPC).

**Distribution:** Bihar: Pusa.

#### 4. *Nomia ellioti* (Smith 1875)

[Fig. 4: ♂ A to K; Plate III(a): ♂ E to H; Plate III(b): ♂ M to P; Plate III(c): ♂ V to Y; Plate III (d): ♂ A to D]

*Nomia ellioti* (Westwood) Smith, 1853: 89; Smith, 1875: 44; Baker, 1993

*Nomia simplicipes* Friese, 1897: 73; Cockerell, 1919: 3; Pauly, 2009: 167

*Nomia (Hoplonomia) elliotii* (Smith, 1875); Pauly, 2009: 167

#### Male

#### Diagnosis

**Colour:** Body black; tergum with four bluish green transverse fasciae; wings fuscous; tegulae pale transparent at anterior and posterior ends, fuscous at middle; hind tibia, hind femur and sternum except apex ferruginous; pubescence white to pale creamy.

**Pilosity:** White thick, sparse, long pubescence appressed down on clypeus and lower paraocular area, erect, sparse on upper paraocular, gena and post genal area; similar hairs scattered on vertex, supraclypeus, sparse on anterior surface of pronotum, epimeron, finer and denser on metanotum; fine, short, very sparse hairs on disc of scutum and scutellum; longer, brown, stout, erect hairs along margins of scutum and scutellum; basal propodeum glabrous and long, finely branched pubescence sparsely on lateral area, scattered on posterior surface; long, sparse, hairs on hind femur, comparatively dense medium hairs on hind tibia, tarsi; long dense white hairs on fore and midlegs; terga with sparse black sharp stiff hairs on premarginal lines on dorsum; dorsal fasciae without hairs pale band; lateral tergum long with sparse white hairs; tip of abdomen with black sharp hairs; S1 to S6 with slightly long shiny hairs on surface but sparser at margins.

**Sculpture:** Fine, dense punctures on vertex, paraocular area and frons; supraclypeus fine, longitudinally rugose; clypeus with mid carina and lateral carina reaching anteclypeal margin; lateral carina starts well below posterior margin of clypeus; scutum and scutellum with large, round dense punctures; scutum with short dorso lateral tooth; metanotum with lateroposterior spines; small, rounded, strong punctures on T1.

**General structure: Head:** Head 1.36x as broad as long; clypeus 2.25x as long as clypeoantennal distance; compound eye 0.85x as long as head; upper interocular 1.30x as long as lower interocular distance; vertex without carina and slightly elevated; supraclypeus finely longitudinally rugose at middle, reaching clypeus; alveolar distance 0.88x as long as antennocellar distance; inter ocellar distance 0.85x as long as ocellar distance; scape 6.91x as long as pedicel; flagellum 3.92x as long as scape; F1 1.5x as long as pedicel. **Mesosoma:** Anterior surface of pronotum not smooth; scutum with two parapsidal lines parallel to one another on each side of dorsum; mid line present; metanotal spines covered with white plumose hairs; tegulae 2.10x as long as broad; forewing 2.73x as long as broad; hindwing 2.89x as long as broad; forewing 1.17x as long as and 1.25x as broad as hindwing; stigma 3.13x as long as broad, 2.57x as long as prestigma; prestigma 0.87x as long as broad; marginal cell 2.09x as long as free marginal cell and 1.18x as long as marginal cell length beyond stigma; marginal cell 4.1x as long as broad; scutum 0.83x as long as broad at anterior and 1.20x as long as broad at posterior; scutum 2.64x as long as scutellum; scutellum 1.57x as long as metanotum; hind femur enlarged at middle; hind tibial apical tooth slightly long; femur 5.27x as long as trochanter; hind tibia 0.84x as long as femur; basitarsi 1.03x as long as hind tibia; basal propodeum shorter. metanotum 2.04x as long as propodeum; Posterior surface 6.29x as broad as the length of propodeum; **Metasoma:** abdomen black, shiny, cylindrical; S8, small, midapical lobe slightly longer; S7, small, mid apical lobes with long bunch of hairs; S6 with narrow, long apodeme; S5 broad, hind margin with two bunches of hairs, wider apart arising from apex; hind margin with median projection; T7 with long thin hairs; hind margin concave.

**Genitalia:** Ventral surface of gonostylus broad concave; short flap like dense hairs on inner surface of lobe; distal end of dorsal gonostylus blunt rounded and folded inwardly; genital foramen 0.76x as broad as long; genitalia 0.43x as high as long; volsella 1.42x as

broad as long; genitalia 1.23x as long as and 1.18 as broad as that of *N. westwoodi*; gonostylus on ventral surface broad, concave; short flap like dense hairs covers inner surface of lobe; both ends long rounded and folded inwardly; gonocoxite simple, surface smooth; penis valve tip angular, sharp, heavily sclerotized.

**Remarks:** This species differs from a closely related species *westwoodi* by type of pubescence, sculpture, and slight variation in genitalia; clypeus with mid carina and lateral carina reaching anteclypeal margin; tergum, shiny black with rounded, strong punctures; pubescence long white, sparse not thin and scattered as in *westwoodi*; scutum and scutellum with round, strong dense punctures; hind tibia with slightly longer apical tooth than *westwoodi*; T1 and T2 with large sparse, strong punctures; lateral extension of gonostylus shorter than that of *westwoodi*.

**Female:** Unknown

**Measurement (mm):** ♂ Body length 10.56; fore wing length 7.82; hind wing length 6.26; head width 2.93; head length 2.14; scape 0.83.

**Specimens examined:** ♂, INDIA: Bihar: Chapra, Meckenzie Coll. (NPC)

**Distribution:** Bihar: Chapra

### 5. *Nomia interstitialis* Cameron

[Fig. 5: ♂ A to M; Plate IV (a): ♀ A to G; ♂ H; Plate IV (b): ♂ I to N; Plate IV (c): ♂ O to V]

*Nomia interstitialis* Cameron, 1898: 74

*Nomia rothneyi* Cameron, 1904: 214; Pauly, 2009: 154

*Nomia (Leuconomia) interstitialis* (Cameron, 1898); Pauly, 2009: 154

#### Male

#### Diagnosis

**Color:** Body black, shiny; abdominal fascia pale yellow; antenna, compound eye brown.

**Pilosity:** Slightly dense pale white erect or suberect pubescence on paraocular area, clypeus, similar hairs but sparse on scape; similar slightly longer hairs, subdecumbent on frons and upper paraocular area; long fine few plumose hairs on interocellar region; fine, long, sparse plumose hairs interspersed with pale dense pubescence; hind femur with shiny, scattered hairs on its outer surface and inner surface glabrous; pale white, short

appressed pubescence on outer surface of hind tibia interspersed long sparse hairs; basitarsi with pale, short pubescence appressed than that of tibial hairs; pale yellow, short, dense pubescence around margins of scutum, similar hairs sparse on scutellum as a band; similar hairs, covering pronotum, pronotal lobe and metanotum; metanotum interspersed with long, fine, sparse erect hairs; posterior surface of propodeum with fine scattered hairs; laterally with long fine branched, sparse pubescence; disc of scutum and scutellum with tiny sparse hairs; T1 with incomplete band of pale white pubescence, laterally other terga with pale or creamy white apical fasciae without hairs; very sparse, short hairs pale and shiny on tergal, laterad and anterior surfaces; marginal zone black with scattered delicate hairs; T2 to T4 with delicate fine scattered hairs on terga; premarginal line stronger than T1 with a row of sparse, fine hairs; long, lateroventro abdominal hairs on S2 to S5; S3 to S5 with long, slightly dense fine plumose hairs on apical margin; S6 with sparse fine hairs at middle; lateral apex slightly extended posteriorly with long, fine, sparse hairs, continuously along posterior margin.

**Sculpture:** Fine dense punctures all over head; similar punctures same on clypeus, supraclipeus, paraocular and interocellar area; basal scape and their interspace not smooth; scutum with smaller, dense punctures which are shallower than those on head and interspaces sculptured more prominently than on head; posterior surface of propodeum with small, sparse punctures with tiny sculptured interspaces; basal area of propodeum with weak striae transverse at middle and longitudinal at laterad; propodeal triangle smoothly defined laterally; T2 gradulus with sparse punctures, clear, comparatively stronger than in females;

**General structure: Head:** Head 1.19x as broad as long; clypeus depressed at middle and laterad slightly elevated; clypeus 3.0x as long as clypeoantennal distance; compound eye 0.60x as long as head; upper interocular 1.47x as long as lower interocular distance; alveolar distance 0.93x as long as antennocellar distance; interocellar distance 1.25x as long as ocellocular distance; scape 4.57x as long as pedicel; flagellum 3.84x as long as scape; F1 1.28x as long as pedicel. **Mesosoma:** forewing length  $5.38 \pm 0.03$ mm; hindwing length  $4.02 \pm 0.03$ mm; tegulae 1.90x as long as broad; forewing 2.82x as long as broad; hindwing 3.43x as long as broad; forewing 1.33x as long as and 1.62x as broad as hindwing; stigma 3.33x as long as broad, 2.5x as long as prestigma; prestigma 2.5x as

long as broad; marginal cell 1.79x as long as free marginal cell and 1.18x as long as marginal cell length beyond stigma; marginal cell 4.20x as long as broad; femur 2.92x as long as trochanter; hind tibia 1.30x as long as femur; basitarsi 0.63x as long as hind tibia; scutum 0.64x as long as broad at anterior and 1.05x as long as broad at posterior; scutum 2.46x as long as scutellum; scutellum 1.76x as long as metanotum; scutellum 2.53x as broad as long; Metanotum 1.70x as long as propodeum; posterior surface 8x as broad as the length of propodeum. **Metasoma:** T1, surface shiny, not smooth; black; T1 premarginal line less defined than other tergum; T1 anterior surface depressed well at mid; lateral mid above with spine like slight angular extension latero posteriorly. S3 to S4 disc area slightly depressed, gradulus strong; S6 smaller, undulated, discontinuous graduli; mid laterally slightly depressed; lateral apodeme not long; S5, wider at mid apex with two small rounded flap like extension from gradulus.

**Genitalia:** Broadened apically; 0.67x as broad as long; laterally 0.46x as high as long; gradually narrower towards base; genital foramen long oval, 3x as long as broad; gonobase longer, 0.3x as long as genitalia and 1.33x as broad as long; gonostylus lobe shovel like, 1.8x as long as broad; gonostylus lobe laterally broad, concave and bent towards mesad; short hairs sparsely on outersurface and long hairs along distal margin of gonostylus; penis valve with short apodeme, broadened preapically; apical tooth curved at mesad; preapical tooth angulate; 2.6x as long as broad.

**Female:** Very similar to males except few characters like, antenna, pubescence on head, hind legs, T6 and lateroventral hairs of sternum; hind femur, tibia with long curved, branched hairs, sparse on tibia; sparse and thinner on laterad of femur; Long lateroventral hairs seen in lateral view on S2-S5; abdomen slightly broadened apically or cylindrical; punctuations on posterior propodeum comparatively stronger in male; T6 with typical white hairs typical, curved at mesad; hind leg femur and tibia with short hairs; T2 gradulus punctures sparse, clear, comparatively stronger than those of females.

**Measurement (mm):** ♂ Body length  $11.25 \pm 0.15$ ; fore wing length  $5.38 \pm 0.03$ ; hind wing length  $4.02 \pm 0.03$ ; ♀ Body length  $11.02 \pm 0.05$ ; fore wing length  $5.41 \pm 0.02$ ; hind wing length  $4.11 \pm 0.04$ ;

**Specimens examined:** 6 ♂♂, INDIA: ♂, New Delhi, 16.VIII.2010, M. Balaji Coll.; 5 ♂♂, Madhya Pradesh: Indore, 05.VIII. 2010, M. Punitha Coll.; 27 ♀♀, INDIA: 13♀♀, Madhya Pradesh: Indore, 05.VIII. 2010, M. Punitha Coll.; 11 ♀♀, Uttarakhand: Dehradun, Bodowala, 30.IX.2013, Preeti S. Virkar Coll.; 2♀♀, Odisha: Bhubaneswar, 2013-14, C.R. Satpathy Coll.; ♀, Andhra Pradesh: ARS, Vijayarai, 17.VII. 2014, Mohan Rao Coll. on *Tridox* sp.

**Distribution:** \*New Delhi, \*Rajasthan: Bharatpur; \*Madhya Pradesh: Indore; \*Uttarakhand: Dehradun; \*Odisha: Bhubaneswar; Andhra Pradesh: Vijayarai.

**Floral records:** *Brassica* sp., Cucumber, *Ipomea* sp., *Tridox* sp.

### 6. *Nomia strigata* (Fabricius)

[Fig. 6: ♂ A to M; Plate V (a): ♀ A to G, ♂ H to I; Plate V (b): ♂ A to H; Plate V (c): ♂ A to F, ♀ G to J]

*Andrena strigata* Fabricius, 1793: 311; Dalla Torre, 1896: 170; Strand, 1913: 142; Pauly, 2009: 159

*Nomia varibalteata* Cameron, 1902: 132; Pauly, 2009: 159

*Nomia iridescens* var *ridleyi* Cockerell, 1910: 503; Pauly, 2009: 159

*Nomia selangorensis* Cockerell, 1920: 617; Pauly, 2009: 159

*Nomia mimosae* Cockerell & Levecque, 1925: 170; Pauly, 2009: 159

*Nomia oryzae* Cockerell, 1929: 135; Pauly, 2009: 159

#### Male

#### Diagnosis

**Color:** Body black; apical bands are hyaline; hairs are pale white to shiny golden yellow; dark brown hairs on scutum.

**Pilosity:** Paraocular area with short, thick, finely branched pubescence, extending upto lateral clypeus; sparse long, finely branched hairs on supraclypeus with few long fine hairs on mid area; few long plumose hairs scattered on inter antennal area, scape and interocellar area; few short, fine hairs on pedicel; fine, sparse hairs on frons, vertex and upper paraocular area; dark brown stiff hairs sparsely scattered on scutum; very thick, short pubescence on metanotum longer than the premarginal hairs of scutum; short, fine silky amber colored hairs, slightly appressed at apex on outer surface of hind femur; long fine, sparse plumose hairs present at middle of hind femur; sparse uniform fine hairs on posterior surface of hind tibia, inner surface glabrous; sparse, long, stiff, pale,

subdecumbent hairs along with shorter hairs on outer surface of basitarsi; golden brown, dense hairs subdecumbent transversely on inner surface. Long, thick, finely branched pubescence on the dorsolateral propodeum; short finely branched pubescence, appressed laterally on their posterior surface; short, fine, pale decumbent hairs, sparsely covering all terga; short, pale, thick plumose denser on posterior margin; sparse, dark brown hairs on premarginal line of T1 and anterior surface with fine hairs; finely branched long plumose hairs sparsely present on dorsolateral area of all terga.

**Sculpture:** Hexagonal punctures on frons and vertex; clypeus mid carina not reaching anteclypeal margin; small, rounded, dense punctures on scutum, shallower at middle; five longitudinal sulcus on scutum; interspace of punctures not smooth; punctures dense at marginal area of scutum; same kind of punctures on scutellum, marginal area with irregular and bigger punctures; small, round to oblong, shallow punctures on posterior surface of propodeum. Large, rounded shallow punctures on T1; interspace more than the diameter of punctures with sparse, tiny strong round punctures.

**General structure: Head:** 1.18x as broad as long; supraclypeus elevated at middle; midcarina of clypeus not reaching anteclypeal margin; clypeus 2.30x as long as clypeoantennal distance; compound eye 0.88x as long as head; upper interocular area 1.25x as long as lower interocular distance; alveolar distance 0.81x as long as antennocellar distance; interocellar distance 1.04x as long as ocello ocular distance; Scape 5.1x as long as pedicel; flagellum 4.10x as long as scape; F1 1.6x as long as pedicel. **Mesosoma:** Scutellum depressed at middle and slightly elevated laterally; scutum 0.76x as long as broad anteriorly and 1.30x as long as broad posteriorly; scutum 2.52x as long as scutellum; scutellum 1.91x as long as metanotum; scutellum 2.04x as broad as long; tegulae 2.52x as long as broad; femur 3.58x as long as trochanter; forewing 3.38x as long as broad; hindwing 2.72x as long as broad; forewing 1.46x as long as and 1.18x as broad as hindwing; Stigma 3.33x as long as broad, 3.33x as long as prestigma; prestigma 1.2x as long as broad; marginal cell 2.05x as long as free marginal cell and 1.16x as long as marginal cell length beyond stigma; marginal cell 4.56x as long as broad; hind tibia 1.15x as long as femur; basitarsi 0.70x as long as hind tibia; basal propodeum carinated at both margins with short, longitudinal striations from anterior or posterior margin not reaching other; marginal carina weaker at middle; propodeal triangle

defined with weak striations; metanotum 1.91x as long as propodeum; posterior surface 7.5x as broad as the length of propodeum. **Metasoma:** Marginal zones transparent and length gradually increasing from T1 to T4; S4 with tuft of long erect hairs restricted to midlateral area; prelaterad broadly invaginated; short apodeme; anterior margin triangular; posterior margin lined with short, fine dense hairs; 0.93x as broad as long; S5 with two sets of stout hairs with bifid bend at tip present on each side of premarginal disc; these two sets of hairs separated at middle and slightly appressed in opposite directions; 0.90x as broad as long; S6 variously curved, emarginated at midapex; apodemes short, no oblique row of setae; S7 transverse, 0.2x as broad as long with two hirsute apical processes, the hairs long and apically branched; S8, 0.83x as broad as long, midapical projection broad at middle and 0.52x as long as disc.

**Genitalia:** Oval; broader at middle and 1.29x as long as broad; laterally 0.82x as high as long; gonostylus 0.67x as broad as long and arched towards middle; gonobase 0.74x as broad as long; penis valve 3.15x as long as broad; apical tooth simple and blunt; midapical tooth broad with apex angulated anteriorly; dense, bent hairs at preapex; gonostylus small, broader at preapex; lateral extension of gonostylus triangular shaped with fine sparse hairs; a row of finger like hairs inwardly bent at base of lateral margins; hairs of gonostylus 0.29x as long as broad of those on upper gonostylus; stout curved hairs 1.33x as long as other hairs of gonostylus; volsella broader; genital foramen short egg shaped and 0.60x as broad as long.

### **Female**

Females are very much similar with males similar in size, color and sculpture except pilosity of hind femur and hind tibia; both sexes are similar in following characters: hind basitibial plate completely carinated; apical margin of forewing fuscous; metanotum without spine; strong punctures on scutum and scutellum. Hind femoral posterior surface of female with long curved golden plumose hairs acting as a pollen basket; hind tibia with plumose hairs denser than those in male; abdomen little broader at middle than in male.

**Measurement (mm):** ♂ Body length  $11.25 \pm 0.15$ ; forewing length  $7.86 \pm 0.05$ ; hindwing length  $5.49 \pm 0.05$ ; ♀ Body length  $11.10 \pm 0.05$ ; forewing length  $7.66 \pm 0.10$ ; hindwing length  $5.38 \pm 0.10$ ;

**Specimen examined:** 5♂♂, INDIA: Tamil Nadu: Nagarkoil, 15.V.2010, M. Punitha Coll., on Malvaceae; 11♀♀, INDIA: 10♀♀, Tamil Nadu: Nagarkoil, 15.V.2010, M. Punitha Coll., on Malvaceae; ♀, Odisha: Bhubaneshwar, 2013-14, C.R. Satpathy Coll., Asteraceae.

**Floral records:** Malvaceae and Asteraceae.

**Distribution:** INDIA: \*Tamil Nadu: Nagarkoil; \*Odisha: Bhubaneshwar.

### 7. *Nomia westwoodi* (Gribodo)

[Fig. 7: ♂ A to M; Plate III (a)I: ♂ A to D; ♂ H; Plate III (b): ♂ I to L; Plate III (c): ♂ Q to U; Plate III (d): ♂ E to H]

*Nomia simillima* Smith, 1875: 44; Gribodo, 1894: 128; Pauly, 2009: 168

*Nomia erythrogaster* Cameron, 1898: 61; Baker, 1993: 253

(*Hoplonomia westwoodi* (Gribodo, 1894: 128); Pauly, 2009: 168

#### Male

#### Diagnosis

**Colour:** Body black; abdominal terga with four iridescent transverse fasciae; fore and hind wings fuscous at apex; tegula transparent at both anterior and posterior ends, blackish brown at middle; inner hind femur, hind tibia, apex of mandible, abdominal sternum S1 to S6 and hind femur except dorsal tip rufous; tip of ventral abdomen black with a hollow appearance; hind femur outer surface black.

**Pilosity:** White, dense, plumose hairs on paraocular area, clypeus, supraclipeus area, above antennal area, margins of pronotum, posterior margin of scutum, lateral scutellum, metanotum and its spines; comparatively less dense behind ocular area (occiput), long sparse hairs on pedicel, sparse fine hairs on interocellar area, dorsal surface of scutum and scutellum; sparse, medium length hairs on hind femur, comparatively dense medium shiny hairs on hind tibia, tarsi; fore and middle legs with medium dense white hairs; long white comparatively dense plumose hairs on lateral posterior propodeum; sparse black

sharp stiff hairs on premarginal lines on dorsum; dorsal fasciae without hairs; T1 with sparse soft white hairs; lateral abdomen with short dense white hairs at end; tip of abdomen with black sharp hairs; S1 to S6 with short shiny hairs on surface, denser at margins.

**Sculpture:** Sparse, fine, uniform punctures on head and thorax except an anterior surface of pronotum; space between punctures less than diameter of punctures; scutum with uniform, small, shallow punctures; fine, shallow punctures on T1.

**General structure: Head:** 1.23x as broad as long; vertex with fine shallow punctures without any carina; slightly elevated; frontal carina strong, fades near alveolar region, frons and supraclypeal area: supraclypeus slightly convex, fine longitudinally rugose at middle, reaching clypeus, rest area punctured; clypeus 2.47x as long as clypeoantennal distance; upper interocular 1.45x as long as lower interocular distance; clypeus with middle, lateral and marginal carina; middle carina strong and not reaching anteclypeal margin; lateral carina starting well below lateral margin and reaching apical carina with blunt angle; apical carina slightly elevated, covering middle; apical margin straight; alveolar distance 1.03x as long as antennocellar distance; inter ocellar distance 1.15x as long as ocello ocular distance; scape 5.28x as long as pedicel; flagellum 4.24x as long as scape; F1 1.28x as long as pedicel; mandible without apical tooth. **Mesosoma:** Tegulae 2.39x as long as broad; forewing 3.36x as long as broad; hindwing 3.34x as long as broad; forewing 1.35x as long as and 1.34x as broad as hindwing; Stigma 2.92x as long as broad, 3.45x as long as prestigma; prestigma 1.37x as long as broad; marginal cell 1.86x as long as free marginal cell and 1.14x as long as marginal cell length beyond stigma; marginal cell 3.72x as long as broad; anterior surface of pronotum smooth; dorsal surface finely punctured including pronotal lobe; scutum with two parapsidal lines, mid line present; two lateroposterior short projection present; scutum 0.86x as long as broad at anteriorly and 1.08x as long as broad at posteriorly; scutum 2.70x as long as scutellum; two long spines arising from mid dorsal towards posterior and exceeding basal propodeum; spines covered with white plumose hairs; slightly broadened at middle; hind tibia, rufous with apical tooth short and blunt; femur 7.0x as long as trochanter; hind tibia 0.78x as long as femur; basitarsi 0.97x as long as hind tibia; hind tibial spur, long tip bent downwards with short tooth along lower margins. Longitudinal ridges at base;

scutellum 2.26x as long as metanotum; metanotum 1.50x as long as propodeum; posterior surface 7.2x as broad as length of propodeum; propodeal triangle impunctate; sparse fine punctures on posterior surface and white dense plumose hairs laterally. **Metasoma:** abdomen cylindrical; S8 with midapical lobe ending bluntly; two apodeme like structure on sides of lobes; S7 small, mid apical lobes with very long bunch of hairs on the lobe and nearby area; anterior ends with angular margin; S6 larger, broad, rufous, apodeme long and thin; median area strongly sclerotised; anterior margin with tuft of hairs; S5 larger than S6, broad, hind margin with two bunches of shiny hairs, not much wider apart, arising from small projections on each side; hind margin with a median projection; T7 apodeme long; hind margin with long thin hairs; hind margin concave.

**Genitalia:** Gonostylus ventral surface broad, concave; short, flap like dense hairs covering inner surface of lobe; both ends long, rounded and folded inwardly; gonocoxite, simple, surface smooth; penis valve, apical tooth angular, strong; ventral surface of gonostylus broad, concave; short flap like sparse broad hairs on inner surface of lobe; long lobe at distal end of dorsal gonostylus, folded inwardly; genital foramen 0.60x as broad as long; penis valve 3.15x as long as broad; gonostylus 0.67x as broad as long; genitalia 0.82x as high as long; gonocoxite 0.25x as broad as genitalia length; volsella 0.65x as broad as long; genitalia 0.81x as long as and 0.84 as broad as that of *N. ellioti*.

### **Female**

**Color:** Body black; abdomen matte black; base of hind tibia and apex of hind femur black; pronotum and their lobes shiny black; tegula dark brown at middle, transparent at posterior and anterior ends; coxa, trochanter brown; T1 to T4 with iridescent apical bands comparatively thinner on T1; femur, tibia, dorsolateral T1 to T3, S1, S2 basal half, S5 mid apex and S6 mid base reddish brown.

**Pilosity:** Vertex with very fine, sparse hairs; short sparse plumose hairs on occiput; long, sparse, white, plumose on alveolar and paraocular area; fine, sparse, white hairs on clypeus; pronotum, pronotal lobes and posterior margin of scutum with pale white dense pubescence along posterior margin; anterior margin of scutum with few, dark brown pubescence and surface with very sparse, few short creamy plumose hairs; scutellum with few long brown sharp hairs; few, sparse dull plumose hairs at laterally; sparse fine,

long, creamy white hairs on premarginal area of S2 to S5, mesepisternum, metepisternum, ventral coxa and dorsum of fore femur; tegula with few sparse dark brown and creamy white hairs; metanotum with short pale dense appressed pubescence and few long hairs along edges of metanotal spines and maxilla; posterior surface of propodeum with short, white plumose hairs appressed laterally; dorsolateral surface with long dense white pubescence; inner surface of hind femur smooth, with long erect hairs; long fine dense hairs on hind tibia; dorsolateral margin of T1 to T4 with few, sparse, long fine white hairs; fine, sparse black hairs on premarginal line; fine, sparse black hairs on T5; approximately 1/3<sup>rd</sup> of T5 with stout, dark sharp hairs and apically with longer hairs; hairs on T6 long, dark and few of them curved; S1 with few, sparse fine hairs; S6 with short fine white hairs except lateral surface.

**Sculpture:** Few, fine shallow punctures on ocellocular, interocellar, occipital area; small shallow uniform sparse punctures on frons; interspace between punctures not smooth; frontal carina starts well below midocelli and becoming wider in between alveolar space; tiny longitudinally rugose on upper mid area of supraclypeus; clypeus with sparse small, shallow punctures and fine irregular longitudinal sculpture; clypeus with strong mid carina not reaching apex; two lateral carina from apex not reaching epistomal suture; anteclypeal margin carinated between the lateral carina; Pronotum with shallow irregular punctures with fine weak bumps on their lobes; anterior surface smooth and shiny; small, round shallow punctures on scutum and scutellum; punctures sparse at middle; interspace not smooth; basal propodeum longitudinally weakly rugose pattern and not carinated posteriorly; posterior surface with sparse, round shallow punctures slightly dense at dorsolateral surface; S1 with few, fine sparse punctures; S2-S5 with shallow irregular dense rugose punctures at apical half and extending slightly laterally.

**General structure: Head:** 1.04x as broad as long; clypeus 2.26x as long as clypeoantennal distance; compound eye 0.67x as long as head; upper interocular 1.23x as long as lower interocular distance; alveolar distance 0.84x as long as antennocellar distance; inter ocellar distance 1.15x as long as ocello ocular distance; scape 6.17x as long as pedicel; flagellum 1.65x as long as scape; F1 as long as pedicel; **Mesosoma:** pronotum laterally carinated, with strong carination at posterolateral margin; tegulae 2.23x as long as broad; tegula auriform; scutum 0.62x as long as broad anteriorly and

0.99x as long as broad posteriorly; scutum 3.96x as long as scutellum; scutellum 1.59x as long as metanotum; metanotum with two mid dorsal spines; propodeal triangle apparent; forewing 3.04x as long as broad; stigma 3.08x as long as broad and 2.84x as long as prestigma; hindwing 2.9x as long as broad; forewing 1.33x as long as and 1.27x as broad as hindwing; marginal cell 1.98x as long as free marginal cell and 1.18x as long as marginal cell length beyond stigma; marginal cell 4.02x as long as broad; femur 2.91x as long as trochanter; hind tibia 1.06x as long as femur; basitarsi 0.55x as long as hind tibia; hind femur with small apical spine posterior end; hind tibial spur long, a row of tooth on lower margin; outer spur bent downwards at apex; metanotum 2.90x as long as propodeum; posterior surface 14.7x as broad as the length of propodeum; abdomen glabrous, oval and narrowed apically; **Metasoma:** premarginal line smooth, elevated slightly on laterad of T1 to T3; T5 curved laterally with apical margin straight; T6 apically narrowed; S6 longer, dorsolaterally curved, deeply emarginated at middle of basal margin.

**Remarks:** *N. westwoodi* differs from closely related species *elliotti*, by type of pubescence, sculpture, and slight variation in genitalia; terga, shiny black; pubescence not as long as in *elliotti*; scutum and scutellum with shallow sparse punctures; apical tooth of hind tibia slightly shorter than in *elliotti*; T1 and T2 with small sparse, shallow punctures; the lateral extension of gonostylus longer than in *elliotti*.

**Measurement (mm):** ♀ Body length  $10.59 \pm 0.42$ ; fore wing length  $7.74 \pm 0.03$ ; hind wing length  $5.80 \pm 0.03$ ; ♂ Body length  $9.61 \pm 0.50$ ; fore wing length  $7.12 \pm 0.05$ ; hind wing length  $5.62 \pm 0.04$ ; head length  $2.13 \pm 0.04$ ; head width  $2.63 \pm 0.04$ ; scape  $0.65 \pm 0.03$ .

**Specimens examined:** 9 ♂♂, INDIA: ♂, Mangalore, 18-22.IV.1915, G.R. Dutt Coll., H-6559 (NPC); 5 ♂♂, Tamil Nadu: Madurai, Alanganallur, 23.III.2011, M. Balaji Coll., on *Leucas* sp.; ♂, Madhya Pradesh: Indore, 01. I. 2011, M., Punitha Coll., on *Cleome* sp; 2 ♂♂, Odisha: Bhubaneshwar, 2013-14, C.R. Satpathy Coll.; 25 ♀♀, INDIA: ♀, Ahmedabad, Bombay, 11-15.III.1917, G.R. Dutt Coll., H-6560 (NPC); 10 ♀♀, Tamil Nadu: Madurai, 10.I.2011, M., Balaji Coll. on *Leucas* sp.; 12 ♀♀, Madhya Pradesh: Indore, 01. I. 2011, M., Punitha Coll., *Cleome* sp.; 2 ♀♀, Odisha: Bhubaneshwar, 2013-

14, C.R. Satpathy Coll.; ♀, Uttarakhand: Dehradun, Ramgarh, organic agroecosystem, 2015, Preeti S. Virkar Coll.; Andhra Pradesh: ARS, Vijayarai, 17.VII. 2014, Mohan Rao Coll.

**Floral records:** *Leucas* sp., *Cleome* sp.

**Distribution:** \*Karnataka: Mangalore; Maharashtra: Bombay; Gujarat: Ahmedabad; Tamil Nadu: Chennai, \*Madurai, \*Alanganallur; West Bengal: Barrackpore; \*Madhya Pradesh: Indore; New Delhi; \*Odisha: Bhubaneshwar; \*Uttarakhand: Dehradun

### III. Genus *Pseudapis* Kirby, 1900

*Pseudapis* Kirby, 1900a: 15

*Nomia* (*Lobonomia*) Warncke, 1976: 99

Type species: *Pseudapis anomala* Kirby, 1900a: 15, by original designation

**Diagnosis:** Tegulae greatly enlarged, extending beyond scutoscutellar suture; preoccipital carina present behind gena; body short and robust; anterior scutum with transverse vertical carina; pronotal lobe with large lamella, translucent extendeding mesad; the lamella similar in both sexes; both apical and basal pubescent bands on tergum.

**Key to the species of female *Pseudapis* Kirby 1900 studied** (modified after Astafurova, 2008)

- 1 Basitibial plate of female carinated only at posterior margin; tegula pale brown with black patch at middle or yellowish translucent with short plumose.....5
  - Basitibial plate of female carinated at both anterior and posterior margins; tegula yellowish brown; base with black patch; tegula with shallow punctures.....2
2. Scutum black with sparse uniform punctures slightly wider at apex of para notaulices; interspaces not smooth.....4
  - Scutum shiny black with large punctures scattered on middle area, comparatively smaller and sparse on other parts; interspace smooth.....3
3. Basal of bands T1 complete; premarginal line slightly elevated laterally with sparse strong punctures, middle with scattered small punctures; T1 anterior surface with sparse short hairs; sparse small punctures towards dorsoanterior end.....*oxybeloides*
  - 4(1)Basal band of T1 not complete; T1 premarginal strongly defined laterally with shallow punctures; premarginal line well defined, elevation at middle of T2; T1 anterior surface with short sparse pubescence.....*edentata*
4. Tegula pale brown with black patch at middle; scutum and scutellum matt black, not shiny with small scattered punctures; long and small hairs scattered on scutellum; T1 matt black without punctures, surface not smooth or tessellated; T1 basal band restricted

to dorsolateral surface; short scattered hairs at anterolateral surface and sparse hairs at middle; premarginal line not well defined; scattered hairs on lateral premarginal line .....*indorensis* sp. nov

Tegula yellow translucent; scutum entirely tessellated with few scattered punctures; T1 matt without hair bands and punctures.....*aliena*

### 1. *Pseudapis edentata* (Morawitz)

[Fig. 11: ♀ A to F; Plate XIII: ♀ A to G]

*Nomia edentata* Morawitz, 1876: 259; Warncke, 1976: 104  
*Nomia minor* Radoszkowski, 1893: 54; Warncke, 1976: 104  
*Nomia albifrons* Vachal, 1897: 74; Warncke, 1976: 104  
*Nomia albolobata* Cockerell, 1911: 225; Warncke, 1976: 104  
*Nomia inermis* Popov, 1949: 692  
*Pseudapis inermis* sensu Baker, 2002: 28  
*Nomia edentata* Morawitz, 1876: 259

#### Female

#### Diagnosis

**Color:** Body black; tegulae orange; antennae, sternum brown; scutum, shiny black,

**Pilosity:** Dense, thick, short pale yellow appressed pubescence band along anterior, posterior margins of scutum, pubescence band not well defined on scutellum; same pubescence covers completely pronotum, pronotal lobes and metanotum; outer hind tibia with long dense, plumose short white laterally appressed pubescence on posterior surface of propodeum; white hair bands on anterolateral surface of T1 incomplete at middle; apical white hair bands restricted laterally; T2 with bands on gradular area, anteriorly with discontinuous white bands; sternum shiny; anterior surface with short sparse hairs; fine, pale yellow sparse hairs slightly longer on apex of S1; small, white pubescence at lateral apex and brown short sparse hairs on disc of S2; S3 to S5 with comparatively longer, slightly denser hairs at pre marginal areas.

**Sculpture:** Head with small, round, punctures on frons, vertex and paraocular area; punctures shallow, sparse on clypeus; scutum with round, same size as on vertex, sparsely on the disc; punctures middle slightly larger; interspaces smooth; same kind of punctures on scutellum; tegula lateral apex with dense, shallow, small punctures; basal propodeum with weaker sculpture, posterior margin strong, carinate at middle, laterally weak; propodeal triangle smooth; medium sparse punctures on posterior surface and

lateral propodeum; few small punctures, laterally under hair band above premarginal line on T1; premarginal line strong laterally; dense, minute punctures scattered, slightly bigger punctures above premarginal lines; S2 graduli strong at middle and lateral.

**General Structure:** Body wider, tegula base with black patch, anterior middle shiny slightly convex; abdomen oval; head 0.38x as broad as long. **Head:** Clypeus 1.53x as long as clypeoantennal distance; compound eye 0.65 as long as head; upper interocular 1.61x as long as lower interocular distance; alveolar distance 1.33x as long as antennocellar distance; inter ocellar distance 1.0x as long as ocellar distance; scape 7.5x as long as pedicel; flagellum 1.56x as long as scape; F1 0.68x as long as pedicel; T1 disc almost glabrous, not as shiny as scutum; posterior surface smaller with sparse, short plumose hairs; interspace smooth, premarginal line well defined laterally; well defined elevation on premarginal line at middle on T2. **Mesosoma:** Scutellum, slightly elevated transversely; hind tibia 1.25x as long as femur; basitarsi 0.62x as long as hind tibia; forewing length  $5.11 \pm 0.25$  mm; hindwing length  $3.67 \pm 0.25$  mm; tegulae 2x as long as broad; forewing 2.6x as long as broad; hindwing 2.91x as long as broad; forewing 1.37x as long as and 1.48x as broad as hindwing; stigma 1x as long as broad, 3.22x as long as prestigma; prestigma 2.25x as long as broad; marginal cell 2.12x as long as free marginal cell and 1.17x as long as marginal cell length beyond stigma; marginal cell 3.47x as long as broad; scutum 0.71x as long as broad at anterior and 1.13x as long as broad at posterior; scutum 3.05x as long as scutellum; scutellum 1.5x as long as metanotum; femur 3.5x as long as trochanter; metanotum 2.4x as long as propodeum; posterior surface 9x as broad as length of propodeum.

**Diagnosis:** Tegulae orange, base with black patch; middle shiny slightly convex; lateral apex with small dense punctures; sparse, short plumose hairs present; scutum, shiny black, interspace smooth, large punctures scattered at middle, comparatively smaller and sparser on other parts; dense pubescent bands along the posterior and anterior margin of scutum and slightly on scutellum; short sparse hairs on anterior surface of T1; premarginal line well defined laterally; T2 premarginal line well defined, elevation at middle.

**Male:** Unknown

**Measurement (mm):** ♀ Body length  $7.14 \pm 0.23$ ; fore wing length  $5.11 \pm 0.25$ ; hind wing length  $3.67 \pm 0.25$ ;

**Specimens examined:** 10 ♀♀, INDIA: 10 ♀♀, Tamil Nadu: Madurai, 23.IX.2010, M. Balaji Coll. on wild grass;

**Floral records:** Wild grass.

**Distribution:** India: \*Gujarat: Deesa; \*Tamil Nadu: Madurai.

## 2. *Pseudapis indorensis* sp. nov.

[Fig. 12: ♀ A to F; Plate XIV: ♀ A to G]

### Female

#### Diagnosis

**Color:** Body matt black; basitarsi, apical flagellomeres outer surface, sternum apical margins light brown; hairs pale yellow; trochanter, tibia, tarsi black; hairs pale white on coxa, trochanter, femur, tibia; golden yellow on basitarsi, tarsi.

**Pilosity:** Apex of clypeus with long row of pale yellow hairs; paraocular area with white short, laterally subdecumbent very sparse hairs, very sparse, very thin, short hairs scattered, few long hairs on mid vertex; short, dense, thick pubescence covering pronotal lobe, anterior and posterior margins of scutum and completely on metanotum; bands on scutum are less thicker; anterior margin of scutellum with only traces of bands; mesepimeron with long, sparse fine hairs same as on outer surface of foretibia, gena; sparse long branched curved hairs on coxa, ventral trochanter, both side of femur; dorsal trochanter with unbranched fine hairs, longer in femur to form basket; dorsal apex of femur smooth; pale white, silky plumose subdecumbent hairs on anterior surface of tibia; basitarsi with white silky penicillus at apex; short fine, hairs appressed laterally on posterior surface; few long thick hairs middle near pit; scattered, fine, long hairs at lateral propodeum, dorsolateral propodeum with pale, white sparse pubescence, slightly thicker; short pale yellow fine hairs on anterior surface of T1 and white appressed pubescent patch on dorsolateral surface; T1 glabrous at middle; T2 basal band seen laterally; row of scattered long pale, yellow shiny hairs along premarginal line of T3 to T6; above that, sparse, Similar white short hairs, appressed below premarginal line and anterior region;

T4 with white appressed band at apex; T5 apex with pale brown dense, uniform pubescence exceeding border.

**Sculpture:** Body smooth; paraocular area with small sized punctures, interspaces with tiny punctures; punctures strong at frons; comparatively wider on supraclypeus and clypeus; posterior surface of propodeum not smooth, without punctures, few shallow punctures near pit; basal propodeum posterior margin with no carina at middle; propodeal triangle not defined; basal area almost merged, with no definite demarcation; lateral propodeum with small to medium size, rounded sparse punctures; interspace not smooth; mesepimeron with dense large strong punctures; T1 without punctures; smooth not shiny; premarginal line laterally with few long hairs not beyond apex; T2 same, fades towards middle; T3 premarginal line strong at middle.

**General Structure: Head:** Clypeus not depressed at middle; occipital carina present; supraclypeus flat, slightly elevated at midbase; clypeal tooth present; vertex slightly elevated at middle; light brown flagellomere; carina present behind compound eyes; frontal carina shrunken; head 1.25x as broad as long; clypeus 1.4x as long as clypeoantennal distance; compound eye 0.9x as long as head; upper interocular 1.41x as long as lower interocular distance; alveolar distance 0.81x as long as antennocellar distance; inter ocellar distance 0.7x as long as ocellar distance; scape 6.87x as long as pedicel; flagellum 1.89x as long as scape; F1 1.25x as long as pedicel. **Mesosoma:** Femur 2.5x as long as trochanter; hind tibia 1.11x as long as femur; basitarsi 1.46x as long as hind tibia; forewing length  $5.54 \pm 0.05$  mm; hindwing length  $4.37 \pm 0.05$  mm; tegulae 2.05x as long as broad; forewing 2.66x as long as broad; hindwing 2.81x as long as broad; forewing 1.26x as long as and 1.22x as broad as hindwing; stigma 2.69x as long as broad, 3.5x as long as prestigma; prestigma 1.3x as long as broad; marginal cell 2.02x as long as free marginal cell and 1.31x as long as marginal cell length beyond stigma; scutum 0.77x as long as broad at the anterior and 1.15x as long as broad at the posterior; scutum 3x as long as scutellum; scutellum 1.53x as long as metanotum; propodeum without punctures; surface not smooth; hind tibia with incomplete carina, metanotum 2.6x as long as propodeum; posterior surface 8.4x as broad as length of propodeum. **Metasoma:** T6 with well developed pygidium, pale brown sharp hairs curved laterally towards middle.

**Remarks:** *P. indorensis* is close with *P. (Pachynomia) aliena* but differs from it due to the following: tegula, impunctate, transparent apex and black at middle; pubescence of soft tiny small hairs except middle; scutum and scutellum surface black not shiny, smooth; with small scattered punctures; scattered small hairs long on scutellum; T1 matte black without punctures, surface not smooth; anterior surface with scattered short hairs on lateral and sparse at middle; premarginal line present; dorsolateral surface with white plumose bands; premarginal line with scattered hairs laterally.

**Male:** Unknown

**Measurement (mm):** ♀ Body length  $7.5 \pm 0.3$ ; fore wing length  $5.54 \pm 0.05$ ; hind wing length  $4.37 \pm 0.05$ ;

**Specimens examined:** ♀, HOLOTYPE, INDIA: Madhya Pradesh: Indore 23.IX.2010, M. Punitha Coll., (NPC); Paratype, 2 ♀♀, Madhya Pradesh: Indore 23.IX.2010, M. Punitha Coll., (NPC)

**Distribution:** \*Madhya Pradesh: Indore.

**Etymology:** Named after the place of collection, Indore, Madhya Pradesh.

### 3. *Pseudapis oxybeloides* (Smith)

[Fig. 13: ♀ A to E; Plate XV: ♀ A to G]

*Nomia oxybeloides* Smith, 1875: 43  
*Nomia latispina* Cameron, 1898: 64  
*Nomia lepidota* Cockerell, 1905: 218  
*Nomia biroi* Friese, 1913: 84

#### Female

#### Diagnosis

**Color:** Body black; tegula yellowish brown; body hairs and bands yellow.

**Pilosity:** White, short, thick, dense pubescence on paraocular area, sparse at supraclypeus; long, sparse, fine on scape; sparse fine thin on vertex, similar but short on frons; long golden curved hairs on anteclypeal margin; yellowish, short, dense pubescence on pronotal lobe, anterior margin and posterior margin of scutum and metanotum, forms thick pubescent band along margin; fine, thin sparse, short hairs on scutum, anterior margin of scutellum; metanotum completely covered with dense

pubescence; short fine slightly dense, yellow hairs at apex of tegula; yellow, thick short, pubescence forming metasomal hair bands; posterior surface of propodeum with very fine sparse pubescence appressed laterally; lateral propodeum with tiny hairs and long sparse fine hairs; T1 with typical complete dorsoanterior hair band slightly extended at middle; incompatible apical band restricted laterally; marginal area smooth, impunctate; thick basal and apical bands complete on T2, T3; short, sparse tiny hairs on the disc of T3 and slightly increasing in density on succeeding terga; thicker marginal sternum with fine long hairs, very sparse on premarginal area of S1, S2 and sparse on S3 to S6.

**Sculpture:** Round dense small strong punctures on vertex, frons, paraocular area, supraclipeus and clypeus; same sized punctures, sparse on scutum and scutellum; punctures slightly crowded at laterally than at mid area; punctures interspaces not smooth; basal propodeum smooth, weakly carinated posteriorly; laterally with weak carina not reaching posterior margin; posterior surface with very shallow sparse punctures; shallow punctures on lateral and dorsolateral propodeum; small puncture shallower than on scutum at apex of tegula; scattered shallow punctures on dorsolateral propodeum; posterior surface lateral margin well defined at lower; T1 with large, shallow punctures laterally above the pregradular line; pregradular line well defined laterally on T1 and at middle of T2 onwards; T2 with same punctures completely on disc area.

**General Structure:** Body pubescent, wider; thorax broad, abdomen subconical. **Head:** Carina present behind compound eyes and covered with white pubescence; clypeus slightly depressed at midapex; lateral apex of clypeus slightly elevated, smooth with few shiny punctures; head 1.17x as broad as long; clypeus 0.83x as long as clypeoantennal distance; compound eye 0.71x as long as head; upper interocular 1.35x as long as lower interocular distance; alveolar distance 1.29x as long as antennocellar distance; inter ocellar distance 1.11x as long as ocello ocular distance. **Mesosoma:** anterior marginal area of pronotal lobe transparent; femur 2.41x as long as trochanter; hind tibia 1.27x as long as femur; basitarsi 0.58x as long as hind tibia; tegulae 2.2x as long as broad; forewing 3.19x as long as broad; hindwing 2.26x as long as broad; forewing 1.22x as long as and 1.20x as broad as hindwing; stigma 2.6x as long as broad, 3.25x as long as prestigma; prestigma 2x as long as broad; marginal cell 1.78x as long as free marginal cell and 1.13x as long as marginal cell length beyond stigma; marginal cell 4.25x as long

as broad; scutum 0.71x as long as broad at the anterior and 1.14x as long as broad at the posterior; scutum 3.16x as long as scutellum; scutellum 1.63x as long as metanotum. propodeum smooth, with tiny sculpture; smooth, with weak striations; basal propodeum anterior margin carinated strongly; metanotum 1.42x as long as propodeum; posterior surface 4.2x as broad as length of propodeum; **Metasoma**: all sterna with small shallower punctures.

**Male**: Unknown.

**Measurement (mm)**: ♀ Body length  $7.54 \pm 0.4$ ; fore wing length  $6.0 \pm 0.05$ ; hind wing length  $4.95 \pm 0.05$ ;

**Specimens examined**: 15 ♀♀, INDIA: 15 ♀♀, New Delhi, 20.IX.2010, M. Balaji Coll., on *Ocimum* sp.; ♀, INDIA: Punjab: Lyllapur, 00.X.1921. G.R. Dutt. Coll.

**Floral records**: *Ocimum* sp.

**Distribution**: \*New Delhi; Gujarat: Deesa; MadhyaPradesh: Jabalpur; Maharashtra: Western ghats, Nasik; Rajasthan: Mount Abu, Udaipur; Tamil Nadu: Coimbatore, Anamalais Hills, Tanjore; Uttar Pradesh; Allahabad; West Bengal: Kolkata.

#### IV. Genus *Steganomus* Ritsema, 1873

*Steganomus* Ritsema, 1873: 226

*Cyathocera* Smith, 1875; Ritzema, 1876: xlv

*Nomia* (*Dinomia*) Hirashima, 1956:29; Michener, 2000: 329

Type species: *Steganomus javanus* Ritsema, 1873: 226, by original designation.

**Diagnosis**: Robust body; forewings with only two submarginal cells; large tegulae lamella on pronotum reduced in female; male hind tibia with two spurs; gena without preoccipital carina.

##### 1. *Steganomus bipunctatus* (Fabricius)

[Fig. 14: ♂ A to L; Plate XVI (a): ♀ A to D; ♂ A to D; Plate XVI (b): ♀ A; ♂ B to G]

*Nomada bipunctata* Fabricius, 1804: 392

*Cyathocera nodicornis* Smith, 1875: 47; Pauly 2009: 173

*Nomia matalea* Strand, 1913:144; Baker 2002:30

*Steganomus nodicornis* (Smith, 1875); Baker 2002:30

**Male**

**Colour:** Head, thorax, apical F10, 11 black; antenna, legs, wings, tegulae, T1 and T2 base ferruginous with yellow to golden yellow pubescence; T1 mid premarginal area, disc area of all terga except T1 black with yellow to golden yellow pubescence.

**Pilosity:** Sparse, short, pale pubescence on vertex, long sub erect pubescence on frons; paraocular area with dense, thick yellow pubescence; scape with long, erect sparse hairs; scutum short, very sparse thick pubescence completely on scutum and scutellum; similar pubescence but thicker and denser along anterior and posterior margins of scutum and completely on pronotum; basal and posterior propodeum glabrous; dorsolateral propodeum with long erect, yellow thick pubescence; similar hairs on mesepimeron; T1 with thick, short pubescent apical band restricted to lateral ends; sparse long golden hairs not dense on dorsoanterior lateral surface; T2 pregradular lines with long fine, sparse row of fine hairs, marginal zone glabrous; thick, golden, pubescent apical band T3 onwards; white dense short pubescent basal band on gradular area comparatively short, thick not shiny as apical bands; sternum with long, fine hairs along premarginal line; S4 with fine erect hairs on premarginal line.

**Sculpture:** Small, dense shallow punctures on paraocular, frons and vertex; interspace not smooth as in females; same punctures slightly sparse on clypeus and on elevation of supraclypeus; propodeum posterior surface with small to medium punctures, stronger, wider, deeper at middle and comparatively larger laterally; lateral surface with tiny punctures along with slightly big punctures in between; dorsolateral surface with tiny dense punctures; basal propodeum impunctate; T1 with irregular row of large deep punctures on mid elevated area; fine, sparse, punctures along premarginal line with smooth interspaces; T1 premarginal area elevated and blunt; T2 premarginal line strong with large irregular, deep punctures on disc; tiny sparse punctures near pregradular area; same kind of punctures on disc of T3 and succeeding terga; T3 gradulus prominent; T3 premarginal area with sparse small, shallow punctures, punctures smaller below gradulus and larger towards premarginal line; T4 similar as T3 except for narrower apex; S2 with small shallow punctures on laterad; S3 no apparent punctures.

**General structure:** Head: Apical flagellomere enlarged, flattened; head 1.06x as broad as long; upper interocular 1.6x as long as lower interocular distance; alveolar distance

0.63x as long as antennocellar distance; inter ocellar distance 0.92x as long as ocellar distance; scape 5.7x as long as pedicel; flagellum 2.52x as long as scape; F1 1.4x as long as pedicel. **Mesosoma:** Femur 3.13x as long as trochanter; hind tibia 1.08x as long as femur; basitarsi 0.74x as long as hind tibia; tegulae 1.82x as long as broad; forewing 2.74x as long as broad; hindwing 3.63x as long as broad; forewing 1.33x as long as and 1.76x as broad as hindwing; stigma 2.58x as long as broad, 3.1x as long as prestigma; prestigma 1.66x as long as broad; marginal cell 1.89x as long as free marginal cell and 1.12x as long as marginal cell length beyond stigma; marginal cell 3.48x as long as broad; scutum 0.87x as long as broad at anterior and 1.28x as long as broad at posterior; scutum 2.27x as long as scutellum; scutellum 1.89x as long as metanotum. basal area of propodeum narrower and impunctate; declivious. **Metasoma:** Abdomen gradually narrowed toward apex; T6 narrower at middle with apical bands; T5 longer than T6. S4 midapically narrowed slightly with short fine hairs completely on the disc; S5 curved variously at middle, lateral apex with short, sparse hairs; S6 lateral apodeme broader, variously curved graduli; preapex at mid and posterior margins with short fine hairs.

**Genitalia:** Dorsally convex; gonobase, small, laterally oval, short; not covering the base of gonocoxite; genital foramen small, subconical; gonocoxite broadened at base; gonostylus dorsal lobe wider, thin leaf like, curved or folded laterally, inner surface with sparse uniform short hairs and mid inner base with stout, dense, long hairs; ventral lobe small, broad preapically and blunt; penis valve enlarged dorsally, broader at middle and tapering strongly towards apical tooth; volsella simple plates latero posteriorly extended.

### **Female**

**Color:** Head and thorax black; antenna, legs, wings, tegulae, abdomen brown; flagellum outer surface fuscous; yellow to golden pubescence.

**Pilosity:** Golden yellow, shiny dense hairs on paraocular area, very sparse on supraclypeus and clypeus; apex of scape and pedicel with shallow punctures smaller than those on supraclypeus; fine long hairs sparse on occipital and post occipital area of head; pronotal lobe with dense golden yellow pubescence; surface of scutum not covered with short pubescence matt; scutum with short, yellowish thick pubescence forming a band

along the posterior margin; same kind of pubescence completely covers metanotum; hind femur with long sparse pubescence on outer surface and tibia with long comparatively thicker pubescence on anterior surface; propodeum glabrous, lateral surface with very fine, sparse, hairs; not thicker as in male; presence of golden yellow apical bands on T3 to T5; basal band on T3 present; no blackish pattern on abdomen as in male.

**Sculpture:** Small, strong, punctures, not uniform on paraocular, alveolar space and sparse on supraclypeus, interocellar and vertex; tiny uniform punctures sparse on scutum and scutellum; interspace 10x more than the diameter of punctures; posterior, lateral and dorsolateral surface of propodeum without punctures.

**Remarks:** Smaller species, midtrochanter without tooth at base; distinct apical tooth on hind tibia; dorsally convex; male genital foramen small, subconical; gonocoxite broadened at base; gonostylus dorsal lobe wider, thin leaf like, curved or folded laterally, inner surface with sparse uniform short hairs and mid inner base with stout, dense, long hairs; ventral lobe small, broad preapically and blunt; penis valve: enlarged dorsally, broader at middle and tapering strongly towards apical tooth. Antenna longer in male and their apical segment enlarged and flattened; scape with long sparse hairs around; hind tibia slightly enlarged with narrow apical tooth; females without black coloration on terga; scutum and scutellar disc not covered with pubescent matt in female; posterior propodeum impunctate in female; pubescence on lateral propodeum finer than that of male.

**Measurement (mm):** ♂ Body length  $7.21 \pm 0.04$ ; fore wing length  $6.62 \pm 0.02$ ; hind wing length  $4.96 \pm 0.02$ ; ♀ Body length  $7.34 \pm 0.02$ ; fore wing length  $6.71 \pm 0.01$ ; hind wing length  $5.01 \pm 0.01$ ;

**Specimens examined:** 1♂, INDIA: 1♂, Uttarankhand : Haldwani, 20.VIII.1998, D. Dey Coll.; 34 ♀♀, INDIA: 14 ♂♂, Bihar: Chapra, Mckenzie Coll.,; 16 ♀♀, Bihar: Chapra, Mckenzie Coll. (NPC). ♀, Uttarankhand : Haldwani, 20.VIII.1998, D. Dey Coll.; 3 ♀♀, Tamil Nadu: Madurai, Alanganallur, 12.IX.2010, M. Balaji Coll., on *Abutilon indicum*;

**Floral records:** *Abutilon indicum*.

**Distribution:** \*Tamil Nadu: Madurai, Alanganallur; \*Bihar: Chapra; Uttar Pradesh: Lucknow; Uttarakhand: Haldwani

**Subfamily: Halictinae**

**Diagnosis:** Episternal groove strong and heading downwards below scrobal groove; third submarginal cell shorter than the first; marginal apex pointed; pre pygidial fimbriae present and divided longitudinally in female; male S7 small, possess long basolateral apodeme and a process at mid apex; male S8 variable, broad.

**I. Genus *Halictus* Latreille, 1804**

*Halictus* Latreille, 1804: 182

*Seladonia* Robertson, 1918: 91

*Odontalictus* Robertson, 1918: 91

*Halictus (Monilapis)* Cockerell, 1931: 529

Type species: *Apis quadricincta* Fabricius, 1777: 247; Michener, 1991: 232

**Diagnosis:** Metallic or non metallic forms tergum with dense apical pubescent bands; distal veins of forewings strong; males with ventral base of penis valve slender and rounded at apex; ventral gonostylus absent or directed apically and not retrorse:

**Key to the species of genus *Halictus* Latreille, 1804 (modified after Pesenko, 2004)**

1. Body metallic green, male S4 margin straight, S6 of male without depression .....4  
 --Body black, S4 of male broadly emarginate; clypeus lower margin straight; male S5 with straight margin or broadly weakly emarginated.....2
2. Female scutum sparsely punctuate; male flagellum flattened with long fringe on lower; last segment flat and curved; Apical bands of terga usually not narrowed in the middle; T2 with anterior band or lateral spots; male: flagellum light yellow, fuscous on upper side, except for 1 or 2 black last segments, first 5 segments usually with large fuscous spots; S6 pubescent nearly throughout; genitalia round to oval, 0.97x as long as broad, laterally 0.5x as high as long; genital foramen very wide and 1.67x as broad as long; gonostylus long, concave laterally, base narrowly attached with gonocoxite; dorsal gonostylus 1.13x as broad as long; dorsal lobe, almost trapezoidal, extended prelaterally from the apex of gonostylus with clump of long hairs bent at the middle..... *brunnescens*  
 ---Female scutum densely punctuate; male flagellum not flattened, with short hairs; last flagellomere unmodified; hind basitarsi straight.....3
3. Metasomal tergum T1, T2 black; clypeal apical tooth at laterad of anteclypeal margin; fine dense strong punctures on head; scutum with dense strong small puncture; hind tibial spur small tooth at lower margin; hind basitibial plate with well defined margin, rectangular; genitalia shorter, gonostylus and the lobe lateroventrally convex, broadened at middle, apical margin curved strongly upward; genitalia broader, laterally convex; 1.21x as long as broad

and laterally 0.47x as high as long; gonobase larger, almost square, 0.87x as broad as long; gonocoxite long and broadened at the middle then steeply narrowed towards apex; gonostylus shorter, lobe lateroventrally convex, broadened at middle, apical margin curved strongly upward; fine sparse hairs at the apex of the lobe; dorsal gonostylus 0.57x as broad as long; ventral lobe long, slender, bent mesad..... *fimbriatus*

----Metasomal tergum T1 to T2 is red; Quadrangular head, T1 red, with dense tiny punctures, T1 to T2 with very scattered hairs; characteristic tubercle present on the clypeus..... *latisignatus*

4. basal propodeum with sparse longitudinal rugose; pale white pubescence densely covering gena and paraocular area; tegula widely impunctate..... *lucidipennis*

----the basal propodeum of densely rugose; pale white pubescence sparse on gena and paraocular area; tegula impunctate; hypostoma striated; lateral pronotum with strong striae..... *propinquus*

### 1. *Halictus brunnescens* (Eversmann)

[Fig. 16: ♂ A to G; Plate XVIII (a): ♀ A to H; Plate XVIII (b): ♂ A to H; Plate XVIII (c): ♂ A to H]

*Hylaeus brunnescens* Eversmann, 1852: 34

*Halictus brunnescens* Eversmann, 1852: 23; Pesenko, 1984: 23

*Halictus quadricinctus* var *maximus* Friese, 1916: 23; Pesenko, 1984: 23

*Halictus (Halictus) brunnescens* (Eversmann 1852:34); Pesenko, 1984: 346

*Halictus quadricinctus* var *aegyptiacus* Friese, 1916: 346; Pesenko, 1984: 346

#### Male

#### Diagnosis

**Color:** Body black; legs, outer surface of antenna brownish yellow; dark brown eyes, inner surface of antenna and sternum; anterior half of clypeus, anterior part of tegulae, yellow.

**Pilosity:** White, long, thick pubescence subdecumbent laterally on paraocular area, supraclypeus hairs finer and scattered on clypeus; long sparse hairs on vertex, around occiput, post occiput, pronotum, pronotal lobe and epimerons; dense, short, uniform, thick pubescence appressed variously on scutum, scutellum, mid metanotum slightly denser on dorsoposterior, dorsolateral, posterior surface of propodeum; few, longer hairs scattered at lateral ends of scutellum, metanotum; basal propodeum glabrous; short, fine, sparse hairs on femur, tibia and tarsi of all legs; no scope absent; tiny, very fine uniform, decumbent sparse hairs, on whole of terga; thick apical bands with short, thick, denser

pubescence on T1-T6; comparatively sparse hairs on basal bands; longer white, pubescence scattered on anterior surface of T1; same kind of hairs also at lateral ends of T1-T4; dorsolateral band on T1 discontinuous at middle; light golden yellowish hairs on S6; S4 posterior margin not straight, invaginated; S4 with fine, dense pale yellowish hairs on mid apex; S5 middle surface glabrous, depressed mesad; S5 apex and lateral sides with sparse tiny hairs; S6 surface with yellow, thick, long hairs decumbent at apex; S2 to S4 with uniform slightly dense, tiny hairs appressed posteriorly; hairs short, fine and dense at apex of S4 and S5.

**Sculpture:** Head completely covered with dense, small, rounded, strong punctures uniformly on paraocular areas, frons, vertex, slightly wider in clypeus, denser on supraclypeus; similar punctures slightly dense on scutum and scutellum; punctures comparatively shallower and irregular on metanotum; fine, irregular, dense reticulation entirely on basal and lateral propodeum; ventral surface of abdomen, not smooth, tiny scattered shallow punctures on their laterad; T1 anterior surface with scattered, small, round uniform dense punctures; same kind of punctures evenly in all the tergum and comparatively shallower on sterna.

**General structure: Head:** Body narrow; head longer than wide; clypeus long, dorsolaterally curved and elevated transversely; abdomen cylindrical; head 0.82x as broad as long; clypeus 0.53x as long as clypeoantennal distance; compound eye 0.60x as long as head; upper interocular 1.07x as long as lower interocular distance; alveolar distance 0.57x as long as antennocellar distance; inter ocellar distance 1.11x as long as ocellar distance; flagellum F1 to F5 with large fuscous spots; apical flagellum bent; scape 3.82x as long as pedicel; flagellum 4.58x as long as scape; F1 1.8x as long as pedicel. **Mesosoma:** Hind femur and tibia linear, slender; basitarsi long; forewing length  $8.23 \pm 0.05$ ; hind wing length  $6.15 \pm 0.05$ ; tegulae 2.80x as long as broad; forewing 3.03x as long as broad; hindwing 3.34x as long as broad; forewing 1.33x as long as and 1.47x as broad as hindwing; stigma 6.3x as long as broad, 4.25x as long as prestigma; prestigma 2.5x as long as broad; marginal cell 1.97x as long as free marginal cell and 1.16x as long as marginal cell length beyond stigma; marginal cell 4.03x as long as broad; scutum 0.80x as long as broad at anteriorly and 1.02x as long as broad posteriorly; scutum 2.59x as long as scutellum; scutellum 1.77x as long as metanotum; femur 3.36x as long

as trochanter; hind tibia 1.40x as long as femur; basitarsi 0.66x as long as hind tibia; metanotum 0.83x as long as propodeum; posterior surface 2.91x as broad as the length of propodeum **Metasoma:** S7 longer mid, very narrow toward mid lateral, broadened at apex; S8 longer than S7 with extended midapical lobe; ventral abdomen with light brown edges; S6 with short apodeme, transversely widened at middle.

**Genitalia:** Round to oval; 0.97x as long as broad; laterally 0.5x as high as long; gonobase 1.3x as broad as long; gonostylus long, concave laterally, broader at middle slightly broader and the base narrowly attached with gonocoxite; dorsal gonostylus 1.13x as broad as long; genital foramen very wide and 1.67x as broad as long; gonocoxite 0.29x as broad as width of genitalia; dorsal lobe almost trapezoidal, extending prelaterally from apex of gonostylus, with a bunch of long hairs bent at middle; penis valve 3.7x as long as broad; penis valve broader at middle; preapical and midlateral tooth; a bunch of long compact hairs on upper apex; hairs on dorsal lobe 0.52x as long as gonostylus; volsella 0.53x as broad as long;

### **Female**

**Color:** Body black; dark brown eyes; inner surface of antenna, legs, sterna; clypeus black, tegulae light brown.

**Pilosity:** White, long, fine pubescence subdecumbent laterally on paraocular area, fine hairs scattered on clypeus, supraclypeus, vertex and occipital area; the same kind of hairs, but slightly thick, longer, sparse on vertex pronotum, pronotal lobe, and epimerons, anterior surface of T1, dorsoventral areas of all terga; short, pale, pubescence very sparse on scutum, scutellum, mid metanotum and slightly denser on dorsolateral, posterior surface of propodeum; few longer hairs scattered at lateral ends of scutellum, metanotum; posterior surface and basal propodeum glabrous; long, fine, sparse plumose hairs on whole of all terga mid and hind femur, tibia and basitarsi; scopa present; tiny, very fine, uniform, decumbent hairs, sparse completely on tergum; thick apical bands with short, denser pubescence on T1-T6; comparatively sparse hairs on basal bands; longer white, pubescence scattered on anterior surface of T1; same kind of hairs also at lateral ends of T1-T4; dorsolateral band on T1 discontinuous at middle; S1 to S3 almost glabrous; long, fine, dense hairs at apex of S4 and S5; tiny, fine, pale hairs on marginal

line of all the sterna; S5 middle surface glabrous, depressed mesad; S2 to S4 with widely scattered tiny hairs.

**Sculpture:** Head completely covered with dense, small, round strong, punctures uniformly on paraocular areas, frons, vertex on slightly wider on clypeus, denser on supraclypeus; interspaces smooth; same size punctures slightly dense on scutum and scutellum; punctures comparatively irregular collapse on metanotum; fine, irregular, dense, reticulation completely over basal and lateral propodeum; transverse rugose, well defined; posterior surface margin clearly defined laterally; shallow comparatively larger punctures on disc of all sterna ventral surface of abdomen, not smooth, tiny scattered shallow punctures on their laterad; T1 with tiny, round uniform dense punctures; same kind of punctures uniformly in all terga.

**General structure: Head:** Head 1.08x as broad as long; clypeus depressed at middle, slightly broader than in female; clypeus 0.73x as long as clypeoantennal distance; abdomen subconical, body, head and clypeus wider than male; compound eye 0.70x as long as head; upper interocular 1.04x as long as lower interocular distance; alveolar distance 0.33x as long as antennocellar distance; inter ocellar distance 0.93x as long as ocello ocular distance; scape 8x as long as pedicel; flagellum 1.71x as long as scape; F1 1.3x as long as pedicel. **Mesosoma:** Hind femur with strong scopa; basitarsi long; tibial spur of female long denticles at lower margin; forewing length  $8.9 \pm 0.05$  mm; Hind wing length  $6.80 \pm 0.05$ mm; tegula, short and brown; tegulae 1.70x as long as broad; forewing 3.28x as long as broad; hindwing 2.91x as long as broad; forewing 1.31x as long as and 1.29x as broad as hindwing; stigma 4.7x as long as broad, 6.7x as long as prestigma; prestigma 1.6x as long as broad; marginal cell 2x as long as free marginal cell and 1.17x as long as marginal cell length beyond stigma; marginal cell 4.18x as long as broad; scutum 0.85x as long as broad at anterior and 1.05x as long as broad at posterior; scutum 2.93x as long as scutellum; scutellum 2.38x as long as metanotum; basitarsi 0.65x as long as hind tibia; basal propodeum with transverse rugose, well defined; posterior surface margin clearly defined laterally; metanotum 0.65x as long as propodeum; posterior surface 2.10x as broad as the length of propodeum; **Metasoma:** Light brown edges; S6 with short apodeme, transversely widened at middle.

**Remarks:** Basal propodeum of male densely reticulate, strong complete irregular rugose than female; small punctures on lateral and posterior surface; rugose pattern on propodeal triangle not well defined as in female, slightly truncate than in female; males with dense pale thick pubescence sparsely on posterior surface, lateral and dorsolateral propodeum; propodeum comparatively broader in females; transverse rugose, well defined; posterior surface margin clearly defined laterally; tibial spur of female, long with denticles at lower margin. Male flagellum light yellow, fuscous on upper side except for 1 or 2 apical segments, F1 to F5 segments usually with large fuscous spots; S6 completely pubescent; lower gonostylus slightly widened in distal half.

**Measurement (mm):** ♂ Body length  $11.80 \pm 0.23$ ; forewing length  $8.23 \pm 0.05$ ; hind wing length  $6.15 \pm 0.05$ . ♀ Body length  $12.49 \pm 0.3$ ; forewing length  $8.9 \pm 0.05$ ; hind wing length  $6.80 \pm 0.05$ .

**Specimens examined:** 4 ♂♂ INDIA: Srinagar, Kashmir, VI-VIII-1923, Dutt Coll.; 12 ♀♀ INDIA: Srinagar, Kashmir, VI-VIII-1923, Dutt Coll.

**Distribution:** \*Jammu & Kashmir: Srinagar; North India.

## 2. *Halictus fimbriatus* Smith

(Fig. 17: ♂ A to F; Plate XIX (a): ♂ A to H; Plate XIX (b): ♂ A to H)

*Halictus fimbriatus* Smith, 1853: 63;

*Halictus asperatus* Bingham, 1898: 123; Pesenko, 1984: 19

### Male

### Diagnosis

**Color:** Body black; tibia, tarsi of all legs and tip of clypeus yellow; coxa, trochanter and femur black; abdominal fascia hyaline; eyes, antenna, tegulae and sterna dark brown;; hairs golden yellow.

**Pilosity:** Pale yellow, long, thick pubescence sparsely on paraocular area, alveolar hairs finer, scattered on clypeus; very tiny sparse matt hairs on flagellum; long scattered hairs on vertex, around occiput, post occiput, pronotum, pronotal lobe, epimerons; tiny fine hairs scattered on scutum; thick long sparse pubescence on scutellum, metanotum; basal propodeum glabrous, lateral propodeum with few long scattered hairs; posterior surface

with few scattered hairs; short, fine, sparse hairs on hind tibia and tarsi of all legs; scope absent; fine, shiny sparse, hairs on apical bands; short, tiny uniform sparse hairs appressed laterally on disc of all terga; anterior surface of T1 with comparatively longer scattered hairs; thick apical bands with short, thick, denser pubescence on T1; same kind of hairs slightly denser on disc of T2-T5; pale, long, fine hairs, scattered widely on sterna; S1 to S3 with long, very sparse fine hairs on disc; hairs on posterior margin of S4 slightly denser than previous sterna.

**Sculpture:** Head completely covered with sparse uniform, small, rounded shallow punctures on paraocular areas, frons, vertex, scattered on clypeus, slightly wider on supraclipeus; similar punctures but slightly bigger and sparse on scutum smaller on scutellum; same punctures but small and denser on metanotum; strong longitudinal striae, wider, well defined anteriorly and fading towards posterior area of basal propodeum; posterior margin not defined; dorsolateral propodeum with fine transverse striae; posterior surface smooth, shiny depressed deeply at middle; tiny rounded, dense punctures only on mid disc of T1; base and apex without punctures, smooth; interspace of punctures smooth on all terga; same kind of punctures on complete on disc, except transverse fascia on T2 to T5; very shallow irregular and very sparse punctures on all sterna; interspaces smooth and shiny.

**General structure:** Body small. **Head:** Antenna longer, dorsoventrally flattened, reaching beyond metanotum; flagellum robust; ocelli big; clypeus, square, depressed deeply at midapex; mandible narrower towards apex; head 1.17x as broad as long; clypeus 1.46x as long as clypeoantennal distance; compound eye 0.78x as long as head; upper interocular 1.29x as long as lower interocular distance; alveolar distance 0.55x as long as antennocellar distance; inter ocellar distance 0.71x as long as ocello ocular distance; scape 5x as long as pedicel; flagellum 4.46x as long as scape; F1 1.4x as long as pedicel. **Mesosoma:** Wings long, broad; Hindleg: Long, linear, slender; basitarsi long; tibial spur; tegulae 1.6x as long as broad; forewing 2.9x as long as broad; hindwing 3x as long as broad; forewing 1.22x as long as and 1.26x as broad as hindwing; stigma 4x as long as broad, 6.6x as long as prestigma; prestigma 1.5x as long as broad; marginal cell 1.61x as long as free marginal cell and 1.25x as long as marginal cell length beyond stigma; marginal cell 3.77x as long as broad; scutum 0.81x as long as broad at anteriorly

and 1.10x as long as broad at posteriorly; scutum 2.5x as long as scutellum; scutellum 2.01x as long as metanotum; scutellum 0.46x as broad as long. : Metanotum 0.74x as long as propodeum. **Metasoma:** Lateroventrally flattened; T1 to T3 longer and broader than other tergum; T1 punctures with interspace more than the diameter of punctures. : Abdomen dorsoventrally flattened with transparent abdominal fasciae; oval; S7 long and broad at midapex, transversely very narrow towards mid lateral and broadened at apex; S8 longer with small midapical lobe with few hairs; S6 widened at middle.

**Genitalia:** Broader, laterally convex; 1.21x as long as broad and laterally 0.47x as high as long; gonobase 0.87x as broad as long; gonobase larger, almost square; gonocoxite long and broadened at middle then steeply narrowed towards apex; penis valve simple, broadened at middle, narrower towards apex, apical tooth strongly curved downwards; penis valve 6.42x as long as broad; volsella broadened at base; gonostylus shorter, lobe lateroventrally convex, broadened at middle, apical margin curved strongly upwards; fine sparse hairs at apex of the lobe; dorsal gonostylus 0.57x as broad as long; ventral lobe long, slender, bent at mesad; genital foramen small, round to oval.

**Remarks:** Shorter, gonostylus lobe lateroventrally convex, broadened at middle, apical margin curved strongly upward; very similar to closely related species *H. atripes* (Ebmer 2000), material not examined) and *H. fimbriata* distinguished by sparse punctures on scutum, scutellum; clypeus strongly projecting; F1-F11 shiny glabrous rounded area on lower side; hind basitarsi broadened and curved; T7 roundly emarginated at posterior margin; lower gonostylus without clublike enlargement in distal part.

**Female:** Male and female very similar in size, pilosity and sculpture except shape of size antenna and yellow spot on the clypeus of male.

**Measurement (mm):** ♂ Body length  $8.01 \pm 0.2$ ; forewing length  $6.25 \pm 0.01$ ; hind wing length  $5.10 \pm 0.01$ ; ♀ Body length  $8.22 \pm 0.15$ ; forewing length  $6.29 \pm 0.05$ ; hind wing length  $5.07 \pm 0.05$ .

**Specimens examined:** 15 ♂♂, INDIA: Jammu Kashmir: Srinagar, 15.III.2010, G. Mahindiran Coll., on saffron; 13 ♀♀, INDIA: Jammu Kashmir: Srinagar, 15.III.2010, G. Mahindiran Coll., on saffron.

**Floral records:** Saffron.

**Distribution:** Jammu & Kashmir: \*Srinagar, Shimla.

### 3. *Halictus latisignatus* Cameron

(Plate XX: ♀ A to I)

*Halictus latisignatus* Cameron, 1908: 310

#### Female

#### Diagnosis

**Color:** Head and thorax black; T1 reddish brown; abdomen brown; S1 light brown.

**Pilosity:** White, fine, subdecumbent laterally, comparatively dense, short hairs on lower paraocular area and scattered on clypeus; white, short, fine, very sparse hairs on upper paraocular area, frons, vertex, supraclypeus, scutum and scutellum; white, thick, short pubescence appressed on gena, sparse, erect on postgena, pronotum; T1 with fine, tiny, uniform, sparse; posterior surface of propodeum with small, scattered long hairs, same on lateral propodeum; apical bands narrow with short, pale, pubescence; basal bands slightly wider than apical bands with long hairs T2 onwards; tiny, scattered, fine hairs on T1, anterior surface glabrous and shiny; S1 with few long hairs along the premarginal line; S2 to S4 with same, fine, long sparse hairs on disc.

**Sculpture:** Clypeus with rounded tubercle at midapical margin; fine dense punctures on head, comparatively less dense punctures near mid ocellar and, ocello ocular region, vertex; small punctures, wider, inter space smooth, shiny on clypeus; same as clypeus but scattered and tiny on supraclypeus; same kind of punctures as on head but sparse, uniform on scutum and scattered, comparatively smaller on scutellum; interspace smooth, shiny; metanotum with dense, small punctures as on head and granulated; basal propodeum with dense, transverse fine striae laterad, middle with very fine transverse striae, finely rugose at dorsolateral angles of propodeum; S1 with shallow, uniform, sparse punctures on disc area.

**General structure: Head:** Head oval; wide at middle; clypeus with rounded tubercle at midapical marginscape longer; head 1.02x as broad as long; clypeus 1.38x as long as clypeoantennal distance; compound eye 0.58x as long as head; upper 1.04x as long as lower interocular distance; alveolar distance 0.28x as long as antennocellar distance; inter

ocellar distance 1.33x as long as ocello ocular distance; scape 5.29x as long as pedicel; flagellum 1.59x as long as scape; F1 0.6x as long as pedicel.

**Mesosoma:** Femur 4.5x as long as trochanter; hind tibia 1.1x as long as femur; basitarsi 0.77x as long as hind tibia; forewing length  $5.50 \pm 0.02$  mm; hindwing length  $3.96 \pm 0.02$  mm; tegulae 1.98x as long as broad; forewing 2.98x as long as broad; hindwing 2.82x as long as broad; forewing 1.40x as long as and 1.27x as broad as hindwing; stigma 3.63x as long as broad, 3.7x as long as prestigma; marginal cell 1.77x as long as free marginal cell and 1.28x as long as marginal cell length beyond stigma; marginal cell 3.88x as long as broad; scutum 0.77x as long as broad anteriorly and 1.01x as long as broad at posteriorly; scutum 2.68x as long as scutellum; scutellum 1.47x as long as metanotum; scutellum 2.2x as broad as long. : Basal propodeum depressed at middle, slightly elevated posteriorly; posterior surface depressed around pit; very fine transverse striae on surface; metanotum 1.23x as long as propodeum; posterior surface 1.75x as broad as the length of propodeum; **Metasoma:** Dorsoventrally flattened; T1 completely red; T3, T4 broader than other terga.

**Remarks:** *H. latisignatus* is the only species belonging to subgenus *Ramalictus* from India and could be identified by its characteristic rounded tubercle at midapical margin on clypeus which differentiates it from other species of genus *Halictus*;

**Male:** Unknown

**Measurement (mm):** ♀ Body length  $8.1 \pm 0.5$ ; forewing length  $5.50 \pm 0.02$ ; hind wing length  $3.96 \pm 0.02$ .

**Specimens examined:** 1♀, INDIA: Karnataka: Coorg, Fraserpet, 29.I.1924, T.B., Fletcher Coll., L. Packer det. 1940 (NPC).

**Distribution:**\* Maharashtra: Mumbai; Karnataka: Coorg, Fraserpet.

#### 4. *Halictus lucidipennis* Smith

[Plate. XXI (a): ♀ (A-H); Plate. XXI (b): ♂ (A-K)]

*Halictus (Seladonia) lucidipennis* Smith, 1853: 362; Ebmer, 1980: 483

*H. varipes* Morawitz, 1876: 223-224; Sakagami and Ebmer, 1987: 326; Pauly, 1999: 146

*H. vernalis* Smith, 1879: 30; Ebmer, 1980: 483

*H. niloticus* Smith, 1879: 32  
*H. magrettii* Vachal, 1892: 137  
*H. dives* Pérez, 1895: 52  
*H. (S) sudanicus* Cockerell, 1945: 352  
*H. (S) tokarensis* Cockerell, 1945: 352-353  
*H. (S) dissensis* Cockerell, 1945: 353  
*H. omanicus* Pérez, 1907: 489  
*H. variipes* var *koptica* Blüthgen, 1933a: 16-17  
*H. (S) medanicus* Cockerell, 1945: 354  
*H. (S) mogrensis* Cockerell, 1945: 355  
*H. (S) tokariellus* Cockerell, 1945: 355  
*H. (S) medaniellus* Cockerell, 1945: 356  
*H. (S) morinellus hyemalus* Warncke, 1982: 134; Ebmer, 1988: 356  
*H. (S) lucidipennis* (Smith, 1853: 62); Sakagami and Ebmer, 1987: 321; Pesenko, 2004: 101

**Remarks:** Sakagami and Ebmer, (1987), Pesenko, (2004) have studied in details of *H. lucidipennis*. In the present study the missing links of the earlier study i.e., colour images on diagnostic features of both sexes has been included; synonyms, distribution of the species has been compiled from different sources of literatures; several specimens collected from the different locations viz., Madhya Pradesh and Tamil Nadu, were identified as *lucidipennis*. *Halictus lucidipennis* can be differentiated from other species by following set of characters viz., body metallic green, male S4 margin straight, deep cleft on dorsal gonostylus of male; well developed scopa; mandible of female with subapical tooth; female T5 with tiny hairs at median zone; basal propodeum as long as metanotum; hind basitibial plate anteriorly carinated with pointed apex; S6 of male without depression; male antenna not reaching metanotum; The present study augmented the existing species description with photographs of different key features for quick and authentic identification. The species can be differentiated by the basal propodeum of with sparse longitudinal rugose; pale white pubescence densely covering gena and paraocular area; tegula widely impunctate.

**Specimens examined:** 38 ♀♀, INDIA: 34 ♀♀, Madhya Pradesh: Indore, 11. I. 2010, M. Punitha Coll. on *Brassica* sp.; ♂, INDIA: ♂, Madhya Pradesh: Indore, 1.XII. 2010, M. Punitha Coll. on grass; 2♀♀, Odisha: Bhubaneswar, 2013-14, C. R. Satpathy Coll. on *Brassica* sp.; 2♀♀, Tamil Nadu: Madurai, 00.I.2010, Balaji Coll. on *Parthenium* sp.;

**Floral records:** *Brassica* sp., *Parthenium* sp.

**Distribution:** Haryana: Hissar; Karnataka: Bangalore; Maharashtra; Rajasthan: Bharatpur.

### 5. *Halictus propinquus* Smith

[Plate. XXII: ♀ (A-K) ]

*Halictus grandiceps* Friese, 1925: 161; Blüthgen, 1931b: 325

*Halictus alexis* Cameron, 1896: 99; Bingham, 1897: 430

*Halictus pinguis* Vachal, 1902: 230; Blüthgen, 1931b: 325

*Halictus (Seladonia) propinquus* Smith, 1853: 61; Michener, 1978: 528

**Remarks:** Sakagami and Ebmer, (1987) have studied species *propinquus* in detail. In the present study colour images on diagnostic features of the species has been included; synonyms, distribution of the species has been compiled from different sources of literatures; species *propinquus* has been identified from the collections of Uttarakhand. *Halictus propinquus* can be differentiated with other members of *Halictus* by following set of characters *viz.*, body metallic green, male S4 margin straight, deep cleft on dorsal gonostylus of male; well developed scopa; mandible of female with subapical tooth; female T5 with tiny hairs at median zone; basal propodeum as long as metanotum; hind basitibial plate anteriorly carinated with pointed apex; S6 of male without depression; male antenna not reaching metanotum; The present study augmented the existing species description with photographs of different key features for quick and authentic identification. However, the two species *lucidipennis* and *propinquus* can be differentiated from each other by the following: basal propodeum of *H. lucidipennis* with sparse longitudinal rugose; pale white pubescence densely covering gena and paraocular area; tegula widely impunctate while the basal propodeum of *H. propinquus* densely rugose; pale white pubescence sparse on gena and paraocular area; tegula impunctate; hypostoma striated; lateral pronotum with strong striae;

**Specimens examined:** 2 ♂♂, INDIA: ♂, Bihar: Chapra, Mackenzie Coll., G. R. Dutt det., H-6388; ♂, Uttarakhand : Pant Nagar, 4.II.2013, C P. Singh Coll. on mustard.

**Floral records:** *Brassica* sp.,

**Distribution:** Andhra Pradesh: Vijayarai; Karnataka: Bengaluru; Orissa: Jeypore; Uttaranchal: Dehradun; Uttarakhand: Mussoorie,\*Pant nagar; West Bengal: Barrackpore;

## II. Genus *Lasioglossum* Curtis, 1833

*Hemihalictus* Cockerell, 1897: 288

*Halictus* (*Lucasius*) Dours, 1872: 350; Sandhouse, 1943: 566

*Halictus* (*Lucasiellus*) Cockerell, 1905: 272

*Halictus* (*Lucasellus*) Schulz, 1911: 202

*Halictus* (*Pallhalictus*) Warncke, 1975: 92

*Halictus* (*Fahrhalictus*) Warncke, 1975: 95

*Halictus* (*Leuchalictus*) Warncke, 1975: 98

*Sphecodogastra* Ashmead, 1899: 92

*Paralictus* Robertson, 1901: 229

*Dialictus* Robertson, 1902: 48

*Evyllaeus* Robertson, 1902: 247

*Chloralictus* Robertson, 1902: 248

*Curtisapis* Robertson, 1918: 91

Type species: *Lasioglossum triangulum* Curtis, 1833: 448; = *Melitta xanthopus* Kirby, 1802, by original designation.

**Diagnosis:** Second submarginal crossvein (SMC) is as strong as the third vein or the second submarginal cross vein is weaker than the first SMC, yet not as weak as the third; This genus is distinguished from *Halictus*, by its weaker distal veins, basal & apical bands, presence of ventral gonostylus and truncated ventral base of penis valve.

### 1. *Lasioglossum albescens* (Smith)

(Fig.18. ♂ A to K; Plate XXIII (a): ♂ A to H; Plate XXIII (b): ♀ A to G; ♂ H; Plate XXIII (c): ♂ A to C)

*Halictus albescens* Smith, 1853: 61; Blüthgen, 1926: 491

*Halictus albozonatus* Smith, 1879: 32; Bingham 1897: 423

*Halictus senescens* (Smith) var Vachal 1895: 430

*Halictus albicinctus* Dalla Torre, 1896: 52

*Halictus picipes* Cameron, 1896: 102

*Halictus minikoiensis* Cameron, 1902: 58

*Halictus bengalensis* Cameron, 1903: 131

*Halictus manilae* Ashmead, 1904: 281

*Halictus luzonicus* Strand, 1910: 208

*Halictus javanensis* Strand, 1910: 198

*Halictus amblypygus* Strand, 1913: 141; Blüthgen, 1926: 492

*Halictus javanicus* Friese, 1914: 23; Blüthgen, 1926: 492

*Lasioglossum* (*L.*) *albescens* (Smith); Michener, 1965: 173

### Male

### Diagnosis

**Color:** Body black, shiny; antenna F1 reddish, F2 to F3 yellow, F4 onwards fuscous apex; S1 to S3 mid apex light brown, translucent.

**Pilosity:** Long fine, scattered hairs on posterior surface basal bands of T2 with white, appressed pubescence comparatively less dense at middle; T3 without hairs on disc and marginal area; bands on T3 not well present; T4, T5 with preapical bands; T1 of male slightly broader anteriorly than in female; T4 to T6 with few long hairs suberect at lateral extreme on terga; S5 with short, fine hairs, sparse at disc area; short, fine dense, golden hairs, appressed mesad on disc of S6; anterior surface of T1 with scattered pale white hairs on laterad; apical hairs on sternum long, pale fine, shiny, sparse, comparatively denser than in female.

**Sculpture:** Head with small, rounded, shallow punctures, denser on paraocular, vertex and, frons; slightly denser on supraclypeus, scattered on clypeus; scutum with shallow, small, scattered tiny punctures; basal propodeum with small, longitudinal striations, well defined anteriorly, and weaker posteriorly; propodeal triangle striations weaker with no punctures on dorsolateral surface; T1, T2 with smooth premarginal line weaker at middle and near dorsolateral convexity; T2 with slightly stronger elevation; anterior surface of T1 with very minute, shallow, sparse punctures and their interspace with slightly dense, tiny punctures.

**General structure: Head:** Frontal carina strong in mid antennocellar region; antenna robust and longer than in female; head 1.08x as broad as long; clypeus 1.28x as long as clypeoantennal distance; supraclypeus and clypeus elevated; compound eye 0.72x as long as head; upper interocular 1.21x as long as lower interocular distance; alveolar distance 0.38x as long as antennocellar distance; inter ocellar distance 1.43x as long as ocello ocular distance; scape 4.03x as long as pedicel; flagellum 2.66x as long as scape; F1 0.25x as long as pedicel. **Mesosoma:** Hind tibia 1.46x as long as femur; basitarsi 0.72x as long as hind tibia; tegulae 1.78x as long as broad; forewing 3.40x as long as broad; hindwing 3.1x as long as broad; forewing 1.42x as long as and 1.29x as broad as hindwing; stigma 3.4x as long as broad, 5.16x as long as prestigma; marginal cell 1.76x as long as free marginal cell and 1.22x as long as marginal cell length beyond stigma; marginal cell 4.40x as long as broad; scutum 0.82x as long as broad at anteriorly and 2.07x as long as broad at posteriorly; scutum 2.98x as long as scutellum; scutellum 1.57x as long as metanotum; metanotum 0.70x as long as propodeum. posterior surface of propodeum, depressed at middle and lower lateral surface shiny, not smooth; posterior

surface margin well defined and irregular, strong carina, extending laterally; basal propodeum of male longer than in female; **Metasoma**: prepigidium absent; S5 to S6 with pale brown shiny hairs on both sexes.

**Genitalia**: Laterally oval, broader than long; 0.83x as long as broad; laterally 0.81x as high as long; gonobase 2.3x as broad as long; gonocoxite broadened, 3.47x as broad as the width of genitalia; a row of short, stiff, curved hairs, longitudinally at midbase of ventral side gonostylus; genital foramen 1.06x as broad as long; penis valve 3.7x as long as broad; dorsal gonostylus 5.36x as broad as long; gonobase broader than long; ventral lobe short broad, laterally extending near apex of gonocoxite with short flap and sparse hairs inside; volsella long, strong, narrowed apex mesad and volsella 0.42x as broad as long; penis valve broad preapically, strong apical tooth curved; gonostylus short, laterally broad, bent mesad at prebase, concave; fine sparse hairs on surface of gonostylus, slight denser at base of arm and apex of gonocoxite.

### **Female**

**Colour**: Body black, shiny; three apical flagellomere light brown; S1 to S3 mid apex light brown, translucent.

**Pilosity**: White, fine, subdecumbent; very sparse hairs on clypeus, supraclypeus, paraocular (except upper); scattered tiny hairs on vertex, frons; tiny white, slightly dense appressed hairs behind compound eyes; very fine hairs scattered on gena and post gena;

**Female**: White pubescence appressed, basal band comparatively thicker on T2; T3 with tiny subdecumbent, sparse, uniform hairs on disc and marginal area; prepigidium on T5 onwards; T3 with both basal and preapical bands; T4 with preapical bands; anterior surface of T1 with scattered pale white, hairs on lateral tergum; S1, S2 with few long fine plumose hairs; hairs present on S1 to S3 very fine and soft at tip, bent when compared to long hairs of S4 and S5; apical hairs on sternum long, pale fine, shiny sparse.

**Sculpture**: Very sparse, irregular shallow punctures on paraocular area; fine dense punctures on vertex, frons, upper paraocular areas; medium size scattered punctures on supraclypeus, clypeus and lower paraocular area; scutum with fine, shallow, scattered punctures on both sides; other areas with same punctures along with very fine punctures in their interspaces; scutellum anteriorly with tiny scattered punctures comparatively

bigger punctures at posterior; basal propodeum smooth; dorsolateral surface with tiny transverse striae; comparatively weaker striae on propodeal triangle that of male; T1, T2 with smooth premarginal line weaker at middle and near dorsolateral convexity; T2 with slightly stronger elevation and very minute, shallow, sparse punctures; their interspaces with slightly dense and tiny punctures.

**General structure:** Lower part of head slightly elevated; T1 slightly narrower anteriorly compared to its male; basal propodeum with small, longitudinal striations, well defined in anterior area and weaker towards posterior; propodeal triangle striations weaker with no punctures on dorsolateral surface; S5 to S6 with pale brown shiny hairs in both sexes; dorsolateral convexity and their lower part with same hairs as in apex; sterna dark brown; female hairs comparatively sparse; both sexes very similar in size.

**Remarks:** Basal propodeum of male slightly longer than in female; abdomen equally long in both sexes; T2 basal bands with white appressed pubescence comparatively thicker in females; T3 of female with tiny subdecumbent, sparse, uniform hairs on the disc and marginal area; hairs of this type absent in males; females with prepigidium on T5 onwards; T3 with both basal and preapical bands not clear in male; T4, T5 of male and T4 of female with preapical bands; T1 of male slightly broader anteriorly than female.

**Measurement (mm):** ♂ Body length  $8.37 \pm 0.20$ mm. forewing length  $5.83 \pm 0.03$  mm; hindwing length  $4.10 \pm 0.03$  mm; ♀ Body length  $8.28 \pm 0.02$ ; forewing length  $5.84 \pm 0.05$ ; hindwing length  $4.31 \pm 0.05$ ;

**Specimens examined:** 26 ♂♂, INDIA: 20 ♂♂, New Delhi, 11.II.2010, M. Balaji Coll., *Aster* sp. ; 5 ♂♂, Madhya Pradesh: Indore, 03. III. 2010, M., Punitha Coll. on *Ipomea* sp.; ♂, Uttarakhand : Pant Nagar, 4.II.2013, C. P. Singh, Coll. ; 33 ♀♀, INDIA: 24 ♀♀, New Delhi, 11.II.2010, M. Balaji Coll., on *Gerbera* sp.; 9 ♀♀, Madhya Pradesh: Indore, 05. II. 2010, M. Punitha Coll., on *Gerbera* sp.; 9 ♀♀, Rajasthan: kota, 14.IV.2012, L. Meena, Coll. soil nest.; ♀, Uttar Pradesh: Varanasi, 28.III. 2015, Jaydeep, Haldar, Coll. on Sponge gourd.

**Floral records:** *Aster* sp., *Gerbera* sp., *Ipomea* sp., Sponge gourd

**Distribution:** India: \*New Delhi; \*Madhya Pradesh: Indore; Maharashtra; Punjab; Uttar Pradesh; West Bengal.

#### **IV. Genus *Patellapis* Friese, 1909**

*Halictus (Patellapis)* Friese, 1909a: 148; Michener, 1978: 518

*Halictus (Pachyhalictus)* Cockerell, 1929c: 589; Michener, 2000: 370

Type species: *Halictus schultzei* Friese, 1909, designated by Cockerell, 1920a: 311

**Diagnosis:** Metasoma black with white or colored tergal apical bands with or without pubescence; paraocular lobe in to the clypeus is obtuse; the epistomal suture not bent robustly near tentorial pit; the dorsal gonostylus of male bifid; posterior margins of tergum without strong apical hair band; scutum and scutellum with strong sculpture and T2 to T3 with basal tomentum;

##### **1. *Patellapis reticulata* (Dalla Torre)**

(Plate XXIV: ♀ A to F)

*Halictus reticulosus* Dalla Torre, 1896

*Pachyhalictus (P.) reticulosus* (Dalla Torre, 1896); Michener 1978: 518; 2000: 370

#### **Female**

#### **Diagnosis**

**Color:** Body black; vertex, T1 shiny; brownish pink eyes; pubescence pale yellow.

**Pilosity:** Short, thick, sparse pubescence, appressed laterally on paraocular and alveolar area of head; fine, tiny, brownish hairs, sparsely matt over frons, supraclypeus, upper paraocular area and vertex; long fine, anteriorly decumbent hairs, sparsely over clypeus; fine long, scattered hairs ocellar stage, sparse on occiput, gena, slightly dense behind compound eye; scutum with short, fine scattered hairs on surface; pale, short, thicker pubescence on postmarginal line and dense at lateral extremes; same kind of pubescence, densely covers middle area of metanotum; long, finely branched, dull plumose on axillae, dorsolateral and posterior surface of propodeum; basal area glabrous; inner surface of hind femur with pale, sparse, long, branched plumose hairs curved ventrally to form pollen basket; stout, yellowish, thick, sub decumbent, typically branched hairs on outer surface of hind tibia and basitarsi; scattered fine hairs on dorsoanterior, lateral surface of

T1; short thicker, pubescence of basal bands of T2 to T4 slightly extended laterally at base; short fine, sparse sub decumbent hairs on surface of all terga.

**Sculpture:** Head with tiny, dense, reticulate granulations on vertex, paraocular, alveolar, supraclypeus and clypeus; scutum with fine strong, reticulate marks, forming irregular cells, completely on surface of scutum, scutellum and irregularly granulated on metanotum; T1 glabrous at middle, anterior surface smooth and shiny; basal propodeum smooth, shiny with thicker reticulation, reaching both margins; reticulations larger and wider compared to scutellar marking; interspaces matt not shiny; same kind of markings continue to posterior surface; terga minutely granulated.

**General structure: Head:** Supraclypeus elevated at base; strong frontal carina reaching posterior margin of supraclypeus; ocellocular space depressed; ocelli well developed with elevated carina; tegula small, transparent except at base; head 1.21x as broad as long; clypeus 1.26x as long as clypeoantennal distance; compound eye 0.78x as long as head; upper interocular 1.12x as long as lower interocular distance; alveolar distance 0.30x as long as antennocellar distance; inter ocellar distance 1.23x as long as ocellular distance; scape 4.57x as long as pedicel; flagellum 1.92x as long as scape; F1 0.63x as long as pedicel. **Mesosoma:** Hind tibia 1.32x as long as femur; basitarsi 0.53x as long as hind tibia; forewing length  $4.61 \pm 0.02$  mm; hindwing length  $3.22 \pm 0.03$  mm; tegulae 1.4x as long as broad; forewing 3.36x as long as broad; hindwing 3.54x as long as broad; forewing 1.44x as long as and 1.51x as broad as hindwing; stigma 4x as long as broad, 3.93x as long as prestigma; marginal cells 1.65x as long as free marginal cell and 1.26x as long as marginal cell length beyond stigma; marginal cell 3.85x as long as broad; scutum 0.52x as long as broad anteriorly and 0.80x as long as broad at posteriorly; scutum 2.51x as long as scutellum; scutellum 1.3x as long as metanotum. : Basal propodeum well defined carina on posterior margin; posterior surface margin with strong carina; metanotum 0.77x as long as propodeum; propodeum 1.2x as long as metanotum; posterior surface 1.7x as broad as the length of propodeum; **Metasoma:** Abdomen short cylindrical; posterior margin with a very lean hyaline area; characteristic pubescence present on all legs and sterna.

**Measurement (mm):** ♀ Body length  $5.81 \pm 0.3$ ; forewing length  $4.61 \pm 0.02$ ; hindwing length  $3.22 \pm 0.03$ ;

**Male:** Unknown

**Specimens examined:** 2 ♀♀, INDIA: Tamil Nadu: Madurai, 03.II.2011, M. Balaji Coll. on Zygothylaceae; ♀ Uttarakhand : Dehradun, Ramgarh, organic agroecosystem, 2015, Preeti S. Virkar Coll. on *Lantana* sp and *Adhatoda* sp.

**Floral records:** Zygothylaceae; *Lantana* sp., *Adhatoda* sp.,

**Distribution:** India: \*Tamil Nadu: Madurai; \*Uttarakhand: Dehradun

### III. Genus *Sphecodes* Latreille, 1804

*Sphecodes* Latreille, 1804: 182

*Dichroa* Illiger, 1806: 46

*Sabulicola* Verhoeff, 1890: 328

*Drepanium* Robertson, 1903: 103

*Proteraner* Robertson, 1903: 103

*Sphecodium* Robertson, 1903: 104

*Machaeris* Robertson, 1903: 104

*Dialonia* Robertson, 1903: 104

*Sphecodes* (*Callosphecodes*) Friese, 1909b: 182

Type species: *Sphex gibba* Linnaeus 1785: 571.

**Diagnosis:** Cleptoparasitic bees; recognised by their broad head; short eyes not converging downwards; metasoma red or with black tinges; propodeum with strong punctations and coarse areola; female hindleg without scopa; T5 without longitudinal fimbriae; males with long antenna and robust flagellomere.

#### Key to the species of genus *Sphecodes* Latreille 1804 (modified after Blüthgen 1927)

1. Legs completely black and apex of the forewing hyaline, length 5-6 mm.....2
  - Legs not completely black and apex of the forewing fuscous, T1 constricted at base.....3
2. Uniform, strong punctures on head and thorax; Small irregular, dense punctures on head; small, rounded uniform dense punctures on scutum which are wider in scutellum; interspaces smooth; metanotum with fine irregular dense punctures; basal area of propodeum longer than metanotum; strong irregular reticulated sculpture on propodeum strong basolaterally; margin well defined; tiny shallow sparse punctures on T1 ..... *crassicornis*
  - Fine, shallow or strong scattered punctures on head and thorax .....3

3. Shallow, fine dense punctures on head; frontal carina strong; shallow, irregular to round punctures on scutum and scutellum; basal propodeum strongly reticulated and carinated strongly at posterior margin; interspaces smooth and shiny; sculptures on posterior propodeum transverse and towards the pit; shallow, scattered small punctures on T1..... *irridipennis*

---Strong, small, dense punctures on head; large rounded punctures sparsely on scutum, scutellum smooth interspaces, clypeus with median vertical depression; large scattered punctures along with tiny punctures on T1 except anterior surface; male genitalia oval, greatly convex and broad at middle, gonobase 1.9x as broad as long; gonostylus laterally broader and concave; dorsal lobe 1.45x as long as broad and the apex 0.5x as broad as long; the dorsal lobe with deep semicircular preapical cleft; apex narrow towards down with long bent hairs; ventral lobe 2.6x as long as broad and 3.6x as broad as dorsal lobe; the ventral lobe smaller than dorsal lobe, broader at apex with short, fine hairs and few strong hairs at base; penis valve small with apical as well as mid lateral tooth; hairs of dorsal lobe 0.93x as long as their apex..... *gibbus*

### 1. *Sphecodes crassicornis* Smith

(Fig.19(a). ♂ A to I; Fig. 19 (b). ♀ A to H; Plate XXV (a). ♀ A to D; ♂ A to D;  
Plate XXV (b): ♀ A & C; ♂ B, D, E)

#### Male

**Description:** ♂ Body length 6.25 mm

**Color:** Head and thorax black; abdomen ferruginous; pale white pubescence; apical fascia of tergum hyaline;

**Pilosity:** White silky pubescence on paraocular, pronotum, around pronotal lobe, post occiput, metanotum, frons, alveolar space and supraclypeus; fine silky pale white pubescence appressed on anterior surface of lower pronotum, forecoxa, and posterior surface of propodeum; short fine silky sparse plumose ubescence on mesepimeron; long sparse hairs on metanotum; dorsolateral propodeum with long, slightly dense silky pubescence; scattered hairs on anterior surface of T1; T3 to T6 with same type of scattered hairs except apex; short fine sparse hairs on S1 to S6 comparatively sparser than on tergum.

**Sculpture:** Small irregular, dense punctures on head; punctures on vertex denser than in scutum with slightly elevated interspaces; supraclypeus elevated mid dorsally; frontal carina present; punctures on clypeus slightly wider than on supraclypeus and rest of head; small rounded uniformly dense punctures sparsely on scutum; same kind of punctures but

slightly wider on scutellum; small wide punctures with smooth interspaces on scutellum; metanotum with fine irregular dense punctures; dorsolateral and basal propodeum with strong sculpturing of irregular reticulations; posterior margin irregularly defined; small wider punctures on posterior surface which is strongly carinated at basolaterad; tiny shallow punctures sparsely present on T1; T2 with same punctures except marginal zone; shallow dense punctures on S2 to S5;

**General structure:** male much smaller in size,  $6.25 \pm 0.5$  mm; body long, slender, cylindrical; **Head** small, 1.16x as broad as long; antenna long, dorsolaterally flattened reaching scutellum; antennal flagellum stout; first flagellomere next to ring segment small and slightly extending outwards; surface not smooth; clypeus 2.03x as long as clypeoantennal distance; compound eye 0.62x as long as head; upper interocular distance 0.78x as long as lower interocular; Alveolar distance 0.42x as long as antennocellar distance; Inter ocellar distance 0.78x as long as ocello-ocular distance; scape 3.36x as long as pedicel; flagellum 7x as long as scape; F1 0.66x as long as pedicel and F2 2.4x as long as pedicel; **Mesosoma:** longer, almost rectangular; femur 5.2x as long as trochanter; hind tibia 0.79x as long as femur; basitarsi 0.66x as long as hind tibia; forewing length  $4.75x \pm 0.05$ mm; Hindwing length  $3.65 \pm 0.05$  mm; Tegulae 2x as long as broad; forewing 2.96x as long as broad; Hindwing 2.88x as long as broad; forewing 1.31x as long as and 1.28x as broad as hindwing; stigma 3.13x as long as broad, 4.54x as long as prestigma; prestigma 1.35x as long as broad; marginal cell 2.06x as long as free marginal cell and 1.42x as long as marginal cell length beyond stigma; marginal cell 5.21x as long as broad; scutum 0.85x as long as broad at anterior and 1.02x as long as broad at posterior; scutum 2.93x as long as scutellum; scutellum 1.6x as long as metanotum; scutellum 1.92x as broad as long; metanotum 0.62x as long as propodeum; posterior surface 0.53x as broad as the length of propodeum; basal propodeum reticulated strongly and longer than metanotum; posterior surface slightly depressed inwards; posterior surface with sparse short plumose; punctures irregularly, slightly deep and scattered; Basal area of propodeum longer than metanotum; **Metasoma:** simple, seem to be glabrous; T2 with transverse apparent depression near graduli.

**Genitalia:** Oval, broad at middle, 1.12x as long as broad; laterally 0.56x as high as long; Gonobase 1.47x as broad as long; genital foramen as broad as long; Gonocoxite long,

broad at base and 2.26x as long as broad; gonocoxite 0.32x as broad as width of genitalia; penis valve slightly broader at apex and 10x as long as broad; gonostylus shorter; dorsal lobe of gonostylus 0.78x as broad as long whereas ventral lobe 0.56x as broad as long; dorsal lobe parallel and elongated at apex with long hairs; hairs 0.56x as long as dorsal lobe; ventral lobe broad, oval; volsella longer, 0.37x as broad as long.

## **Female**

### **Diagnosis**

**Color:** Body black; antenna, eyes and legs dark brown; abdomen ferruginous; apical fascia of tergum hyaline;

**Pilosity:** Pale white, dense plumose hairs on frons, supraclypeus, paraocular alveolar area, pronotum, pronotal lobe and metanotum; fine plumose hairs scattered on clypeus, hypostoma, occiput and vertex; fine silky appressed pubescence on anterior surface of lower pronotum, forecoxa, mesepimeron, lateral and posterior surface of propodeum; pale white, silky pubescence along the lateral and posterior margin of propodeum; short fine silky plumose sparse hairs on mesepimeron and post occiput; long sparse hairs on lateral metanotum; long silky dense pubescence on dorsolateral propodeum; short white plumose scattered hairs on anterior surface of T1 and T2; short, tiny sparse fine hairs on T2-T4; hairs comparatively longer on T5; fine, slightly dense hairs on S1; short, fine sparse hairs (sparser than on tergum) on S2 to S4; long dense hairs at apex of S5;

**Sculpture:** small irregular dense punctures on head; small and larger punctures sparsely present on scutum, punctures wider on posterior scutum; small punctures scattered on scutellum with smooth interspaces (Fig.); punctures on vertex denser and stronger than on scutum; supraclypeus strongly elevated; frontal line irregular; punctures on clypeus slightly wider than on supraclypeus and rest of head; scrobe of mesepimeron with areolated sculpture; small rounded dense punctures on scutum; punctures slightly dense near parapsidal lines, fine irregular dense punctures on metanotum; strong irregular areolate on basal propodeum; posterior margin irregularly defined; small wider punctures on posterior surface; basolateral margin strongly carinated; tiny shallow sparse punctures on T1-T2; no punctures on marginal zone of T2; shallow sparse punctures on S2 to S5 (punctures larger than on tergum);

**General: Head** 1.37x as broad as long; short alveolar distance; long scape; pedicel and F1 small; supraclypeus strongly convex; clypeus 1.5x as long as clypeoantennal distance; compound eye 0.66x as long as head; upper interocular 1.15x as long as lower interocular distance; frontal carina strong near alveolar space; clypeus elevated transversely at middle and lateral apex bent down; mandible long; alveolar distance 0.28x as long as antennocellar distance; inter ocellar distance 0.61x as long as ocello ocular distance; scape 7.85x as long as pedicel; flagellum 2.14x as long as scape; F1 2.1x as long as pedicel; **Mesosoma:** basitarsi 0.65x as long as hind tibia; tegulae 1.91x as long as broad; forewing 2.91x as long as broad; hindwing 3.50x as long as broad; forewing 1.29x as long as and 1.55x as broad as hindwing; stigma 3.46x as long as broad, 4.5x as long as prestigma; prestigma 1.66x as long as broad; marginal cell 1.70x as long as free marginal cell and 1.15x as long as marginal cell length beyond stigma; marginal cell 3.71x as long as broad; scutum 0.84x as long as broad at anterior and 1.09x as long as broad at posterior end scutum 3.08x as long as scutellum; scutellum 1.53x as long as metanotum; basal propodeum longer than metanotum; metanotum 0.75x as long as propodeum; posterior surface slightly depressed; **Metasoma:** seems to be glabrous but with sparse tiny pale brown hairs; transverse depression near graduli on T2;

**Measurement (mm):** ♂ Body length 6.2; forewing length 4.7; hindwing length 3.65; ♀ Body length 9.15; forewing length 7.0; hindwing length 5.4.

**Specimens examined:** 1 ♂, INDIA: Tamil Nadu: Coimbatore, IV.1915. C.R., Dutt coll, P., Blüthgen det, H-6341; 1 ♀, INDIA: 1♀, Bihar, 16.V.1919, H., Inglis Coll, H-6339.

**Distribution:** \*Tamil Nadu: Coimbatore; West Bengal: Kolkata

## 2. *Sphecodes gibbus* (Linnaeus, 1785: 571)

(Fig. 20 (a). ♀ A to G; Fig.20 (b). ♂ A to L; Plate XXVI (a): ♀ A to E; ♂ F to J; Plate XXVI (b): ♂ A to G)

*Sphex gibba* Linnaeus 1785:571

*Apis glabra* Fuebly 1775:51

*Andrena ferrugena* Olivier 1789:139

*Apis gibbosa* Christ 1791:177

*Melitta sphecoides* Kirby 1802:46

*Melitta picea* Kirby 1802:48

*Andrena austriaca* Fabricius 1804:325

*Sphecodes apicatus* Smith 1853:36; Warncke 1992:29

*Sphecodes nippon* Meyer 1922:171

*Sphecodes castilianus* Blüthgen 1924:473; Warncke 1992:29

## Male

### Diagnosis

**Color:** Body ferruginous; head, scape and thorax black; legs, mandible, flagellum and compound eye dark brown; wings fuscous with hyaline apex; S1 brownish red; S2 ferruginous;

**Pilosity:** Generally fine hairs scattered all over body; tiny hairs sparse on flagellum and dense at base of each flagellomere; thick pubescence on paraocular area; sparse, short hairs on clypeus, scape, frons and vertex; tiny dense white hairs on pronotum and pronotal lobe; fine long amber hairs scattered on mesepisternum, sparse on femur, tibia and fore basi tarsi; fine long hairs scattered on posterior hind coxa, trochanter, femur, mesepisternum, anteclypeal margin and mandible; long sparse hairs on outer hind tibia; anterior hind coxa, trochanter and femur glabrous; short plumose hairs scattered on anterior surface of T1; short tiny hairs scattered at laterad and premarginal area of T1 to T3;

**Sculpture:** small dense strong punctures on head; small punctures on supraclypeus and ocular margins; punctures scattered on clypeus and vertex near mid ocelli; punctures denser on paraocular area; scattered shallow punctures on occiput; transverse discontinuous carina on post occipital region; large rounded punctures sparsely on scutum and scutellum; interspaces smooth; tiny punctures scattered on scape; irregular strong dense punctures on metanotum; basal propodeum strongly reticulated; posterior surface of propodeum with defined marginal carina; large strong punctures scattered on T1 along with tiny and small punctures (Fig.); marginal zone glossy; punctures on T1 comparatively stronger in male than in female; marginal disc broad at middle; premarginal line strong at laterad on T3 than T2, T1; tiny dot like punctures on T1 to T3.

**General structure: Head:** 1.15x as broad as long; clypeus 1.13x as long as clypeoantennal distance; compound eye 0.62x as long as head; antenna dorsoventrally flattened reaching beyond scutum; scape 3.3x as long as pedicel; pedicel 0.27x as long as F11; scape 0.03x as long as flagellum; F1 as long as pedicel; upper interocular 1.2x as

long as lower interocular distance; alveolar distance 0.74x as long as antennocellar distance; inter ocellar distance 1.41x as long as ocello ocular distance; hind legs are slender; **Mesosoma:** scutum 0.88x as long as broad at anteriorly and 1.05x as long as broad at posteriorly; scutum 2.46x as long as scutellum; metanotum oblong; scutellum 1.6x as long as metanotum; hindcoxa longer than other coxae; femur 4.6x as long as trochanter; hind tibia 1.29x as long as femur; basitarsi 0.50x as long as hind tibia; wings fuscous with hyaline apex; legs slender compared to body; tegula small, oval and 1.5x as long as broad; forewing 2.71x as long as broad; hindwing 1.25x as long as and 1.9x as broad as hindwing; stigma 2.43x as long as broad, 4.18x as long as prestigma; marginal cell 1.91x as long as free marginal cell and 2.87x as long as marginal cell length beyond stigma; marginal cell 4.1x as long as broad; posterior surface of propodeum depressed at middle; metanotum 1.51x as long as propodeum. **Metasoma:** abdomen long cylindrical; S2 transparent, amber glossy; graduli strong and not straight depression below; S3 blackish, transparent with short scattered fine hairs; S4, S5 with sparse, short; S5 1.89x as long as broad; S6, 1.68x as broad as long and mid disc broad, with short, sparse hairs on both sides of middle laterally; S7 transverse, wider and broad at middle; 3.5x as long as broad; mid apical lobes with sparse fine erect hairs; S8 0.88x as broad as long with short lateral apodeme; mid apical lobe simple; lateral apex with a small bunch of long fine hairs; disc broad;

**Genitalia:** Oval; greatly convex and broader at middle; 0.98x as long as broad; laterally 0.61x as high as long; gonocoxite long, oval and 0.20x as broad as length of genitalia; gonobase 1.9x as broad as long; gonostylus laterally broader and concave; dorsal lobe 1.45x as long as broad and apex 0.5x as broad as long; dorsal lobe with deep semicircular cleft at preapex; apex narrow towards down with long bent hairs; ventral lobe 2.6x as long as broad and 3.6x as broad as dorsal lobe; the ventral lobe smaller than dorsal lobe, broader at apex with short, fine hairs and few strong hairs at base; penis valve smaller, simple with apical and midlateral tooth; penis valve 7.4x as long as broad; hairs of dorsal lobe 0.93x as long as their apex.

## **Female**

## **Diagnosis**

**Head:** Females differ from males in size of mandible antenna, abdomen, hind tibia, size of the punctures and; punctures same as present on male except slightly dense small punctures on mid clypeus; antenna small, without tiny hair bands at base of each flagellomere; punctures on scutum and scutellum smaller than in male and widely scattered; few smaller punctures scattered on scutellum; mandible longer than in male; posterior margin of outer hind tibia with a row of teeth along margin, angulated and directed downwards; hind tibia slightly broadened at apex; abdomen broader at middle; T1 and T2 completely ferruginous; tiny small punctures scattered on T1-T2, not as strong as in males; marginal zone transparent glossy, through this antecostal suture visible and row of fine tiny hairs visible; metanotum almost rectangular with slightly angled posterior margin.

**General structure: Head:** 1.31x as broad as long; clypeus 1.31x as long as clypeoantennal distance; compound eye 0.61x as long as head; upper interocular 0.97x as long as lower interocular distance; alveolar distance 0.55x as long as antennocellar distance; inter ocellar distance 0.53x as long as ocello ocular distance; scape 2.61x as long as pedicel; flagellum 2.27x as long as scape; F1 0.44x as long as pedicel; **Mesosoma:** femur 1.23x as long as trochanter; hind tibia 1.06x as long as femur; basitarsi 1.58x as long as hind tibia; tegulae 2x as long as broad; forewing 2.85x as long as broad; hindwing 2.84x as long as broad; forewing 1.28x as long as and 1.31x as broad as hindwing; stigma 0.31x as long as broad, 3.41x as long as prestigma; prestigma 2.4x as long as broad; marginal cell 1.84x as long as free marginal cell and 1.27x as long as marginal cell length beyond stigma; marginal cell 0.24x as long as broad; scutum 0.75x as long as broad at anteriorly and 0.95x as long as broad at posteriorly; scutum 2.42x as long as scutellum; scutellum 1.61x as long as metanotum; : scutellum 1.6x as broad as long; propodeum 1.6x as long as metanotum; posterior surface 2.52x as broad as the length of propodeum; scutellum 0.64x as long as broad;

**Measurement (mm):** ♂ Body length  $8.0 \pm 0.05$ ; forewing length  $6.56 \pm 0.05$ ; hindwing length  $2.60 \pm 0.03$ ; ♀ Body length 12.2; Forewing length 9.9; hindwing length 3.47;

**Specimens examined:** 3 ♂♂, INDIA: 1 ♂, Kashmir: Srinagar, I-XIII.1923, C.R., Dutt coll, P., Blüthgen det, H-6337; 1 ♂, Kashmir: Srinagar, I-XIII.1923, C.R., Dutt coll, P.,

Blüthgen det, H-6336; 1 ♂, Kashmir: Srinagar, I-XIII.1923. C.R., Dutt coll, P., Blüthgen det, H-6334; 1 ♀, INDIA: 1 ♀, Kashmir: Srinagar, I-XIII.1923, T.B., Fletcher coll, P., Blüthgen det, H-6333.

**Distribution:** India: Kashmir: Srinagar.

### 3. *Sphecodes iridipennis* Smith, 1879: 27

(Fig.21. ♀ A to E; Plate XXVII: ♀ A to H)

*Sphecodes iridipennis* Smith, 1879: 27

#### Female

#### Diagnosis

**Color:** Body black; metasoma ferruginous; antenna and sterna dark brown; **Pilosity:** sparse fine, white pubescence on paraocular, supraclypeus, pronotum, pronotal lobe and frons and very sparse on clypeus; fine, scattered plumose hairs on vertex and occiput; pale white hairs, sparsely on anterior surface of pronotum; tiny scattered hairs on scutum; fine, pale, short hairs on anterior margin of metanotum; dorsal and lateral propodeum glabrous; long, white, silky, sparse subdecumbent hairs on femur, tibia and basitarsi of all legs; short tiny, fine hairs on mid premarginal line; T1 glossy, smooth, and tiny hairs scattered on anterior surface; long scattered hairs on marginal zones of all the tegum; slightly long very fine scattered hairs on lateral apex of S1 to S3; same kind of hairs sparsely present on S4 to S6;

**Sculpture:** fine, dense, shallow punctures on paraocular, vertex, clypeus, supraclypeus and occiput; frontal carina irregular but strong reaching upto interantennal area; shallow round punctures on scutum and scutellum, sparser than on head (Fig.); supraclypeus slightly elevated; irregular sculpture on metanotum; mid and fore femur glabrous; basal propodeum strongly reticulated and carinated strongly posterior margin; interspaces smooth and shiny; transverse carina towards the pit on posterior propodeum; small shallow punctures scattered on T1; small shallow sparse punctures on T2 to T5; few shallow sparse punctures on midlateral S1; the same kind of punctures laterally on S2 to S5; mesepimeron scrobe areolated.

**General structure: Head:** scape long; pedicel and F1 smaller; supraclypeus slightly elevated; frontal carina well defined; clypeus short and transversely elevated at middle; mandible long and strong with a preapical tooth; scape longer; head 1.30x as broad as long; clypeus 1.2x as long as clypeoantennal distance; compound eye 0.73x as long as head; upper interocular 0.91x as long as lower interocular distance; alveolar distance 0.5x as long as antennocellar distance; inter ocellar distance 0.93x as long as ocello ocular distance; scape 5x as long as pedicel; flagellum 2.13x as long as scape; F1 0.75x as long as pedicel; **Mesosoma:** metanotum smaller than scutellum; hind femur slightly broader at base; hind tibia broader at apex; tibial spur long narrow towards apex and lower margin finely serrated near base; femur 2x as long as trochanter; hind tibia 1.02x as long as femur; basitarsi 0.65x as long as hind tibia; tegulae 1.4x as long as broad; forewing 3.26x as long as broad; hindwing 3.37x as long as broad; forewing 1.30x as long as and 1.35x as broad as hindwing; stigma 3x as long as broad marginal cell, 1.50x as long as free marginal cell and 1.22x as long as marginal cell length beyond stigma; marginal cell 3.5x as long as broad; scutum 0.82x as long as broad anterior by and 1.20x as long as broad posterior by scutum 2.61x as long as scutellum; scutellum 1.63x as long as metanotum; scutellum 1.66x as broad as long; basal propodeum depressed at middle; posterior surface slightly depressed; metanotum 0.68x as long as propodeum; posterior surface 3.18x as broad as length of propodeum; **Metasoma:** T1 anterior surface slightly flattened; T3 marginal zone slightly longer at middle than T1.

**Male:** Unknown

**Measurement (mm):** ♀ Body length 5.10; forewing length 4.41; hindwing length 3.37;

**Specimens examined:** ♀, INDIA: Bihar: Chapra, G. R. Dutt Coll., Mackenzie det., H-6346 (NPC).

**Distribution:** \*Bihar: Chapra.

### **Subfamily Nomioidinae**

**Diagnosis:** Episternal groove strong and directed downwards below scrobal groove; third submarginal cell shorter than the first; marginal cell with truncated or rounded apex; male S7 broad, unmodified; male S8 long with broad spiculum; S8 apical process present

### **I. Genus *Nomioides* Schenk, 1867**

*Nomioides* Schenck, 1867: 333

Type species: *Apis minutissima* Rossi, 1790; Pesenko and Kerzhner, 1981

**Diagnosis:** Small sized, metallic blue body; second submedian cell trapezoidal or triangular; r-m vein of hind wing 0.3-0.5x as long as Rs; metathorax yellow almost or pale integumental bands on pregradular areas of terga appearing through hyaline posterior areas of succeeding terga; female metasoma heart shaped with longer or short propodeum; inner orbits slightly emarginated;

### 1. *Nomioides fortunatus* Blüthgen

[Fig. 15: ♀ A to J; Plate XVII: A to F]

*Nomioides (Nomioides) fortunata* Blüthgen, 1937: 3,

*Nomioides minutissimus* f. *fortunatus* Pesenko, 1983: 137

#### Female

#### Diagnosis

**Color:** Body metallic blue; clypeus, outer surface of antenna, triangular spot on supraclypeus, tibia, tarsi, fore and midfemur upto preapex, hind femur apex; yellow, pronotum, patches on scutellum, metanotum, tegula anterior patch pale yellow; sternum, hind femur, tibia and tarsus light brown; abdominal fascia hyaline; T1 apex hyaline; hyaline area larger towards succeeding tergum; generally marking pattern of basal half pale white, creamy, apical half blackish; hairs extending to both side of mid black area; black pattern at middle of T3 to T4; S1 and S2 pale yellowish; brownish black with yellowish pattern on marginal zones of S4 to S6.

**Pilosity:** Pronotum with a row of long, very sparse, pale yellow hairs; dense, short pale pubescence around pronotal lobe; pale white fine hairs scattered on surface of scutum; sparse long erect pubescence on metanotum; hind tibia pale yellow; with long, sparse, typical branched, dark hairs; basitarsi with long (shorter than tibial hairs), pale yellow subdecumbent hairs; sparse yellow hairs on others; golden penicillus at apex; hind femur with fine, long, sparse hairs on anterior surface, form weak basket ventrad; few long hairs scattered on base of propodeum; fine pale, sparse hairs, subdecumbent laterally, comparatively longer, fine, scattered hairs at lateral propodeum; dorsolateral propodeum with few long pubescence; T1, T2 almost glabrous, except the anterior surface of T1 with scattered short pubescence; T3 to T4 with tiny hairs, shiny sparse on middle area; premarginal line with pale yellow shiny, long scattered hairs; S1 to S2 with few sharp,

short erect, dark hairs near marginal area; other area of sternum with very sparse long hairs.

**Sculpture:** Pronotal lobe with two transparent spot at middle; anterior surface black, shiny; lateral surface with transverse fine rugose pattern; scutum, metallic green; sculpture of minute dense punctures, interspace granulate, shiny; notaulices strong at mid and lateral; transverse weak striation on surface of metanotum; lateral propodeum with fine, transversely granulated laterad; sculpture tiny on posterior surface of propodeum.

**General structure:** Head oval; tegulae, pale, small, hyaline anteriorly with pale yellowish patch at base of wing; head 0.88x as broad as long; clypeus 0.56x as long as clypeoantennal distance; compound eye 0.74x as long as head; upper interocular 1.26x as long as lower interocular distance; alveolar distance 0.23x as long as antennocellar distance; inter ocellar distance 0.98x as long as ocello ocular distance; scape 6.90x as long as pedicel; flagellum 1.63x as long as scape. **Mesosoma:** Basitarsi 0.78x as long as hind tibia; tegulae 1.78x as long as broad; scutum 0.72x as long as broad at the anterior and 1.15x as long as broad at the posterior; scutellum black shiny, granulate; two pale, rectangular, creamy yellow patches, slightly wider apart; pale yellowish patch laterally on auxilla; scutum 3.58x as long as scutellum; Metanotum shiny black, mid surface completely pale yellow and laterad black; scutellum 2.23x as long as metanotum. propodeum as long as metanotum; basal propodeum with fine network of sculpture at middle; posterior propodeum smaller; posterior margin of propodeum well defined; posterior surface steep. propodeum 1.32x as long as metanotum; posterior surface 1.71x as broad as length of propodeum. **Metasoma:** Blackish pattern of terga clearly seen on lateral base through its transparent fascia;

**Male:** Unknown

**Measurement (mm):** Body length  $4.1 \pm 0.3$ ; forewing length  $2.55 \pm 0.03$ ; hindwing length  $1.95 \pm 0.05$ ; scutum length  $0.69 \pm 0.02$ ; scutellum length  $0.24 \pm 0.01$ ; metanotum  $0.12 \pm 0.04$ ;

**Specimens examined:** 4 ♀♀ INDIA: 4 ♀♀, Tamil Nadu: Madurai, Adhalai, 10.VII.2009, M. Balaji Coll., on Zygothlyaceae.

**Floral records:** Zygophyllaceae.

**Distribution:** \*INDIA: Tamil Nadu, Madurai, Adhalai;

**Remarks:** Different colour patterns have been reported on clypeus, scutellum and pale bands on abdomen of *Nomioides fortunatus* Blüthgen (1937) by Pesenko and Pauly (2009), and we have described female specimen with poor fuscous marking on clypeus. ♀ Head and mesosoma dull, dark olive-green; uniform, dense and coarse granulations on mesoscutum and scutellum; head and mesosoma dull dark olive green; scutellum dark entirely; dorsal surface of propodeum 1.32x as long as scutellum; body without tomentose pubescence; both sexes with wider and shorter head; mesoscutum and scutellum uniformly densely and coarsely granulate; propodeum longer.

## CHAPTER - 5

### DISCUSSION

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The results of the present study on Indian Halictidae are discussed under the following subheadings.

#### 5.1 Taxonomic placement of family Halictidae

The composition and classification of the bee families have been constantly changing over the past centuries. The present day halictids were initially classified under *Andrena*, *Apis* by Linnaeus (1758) and *Sphex* & *Tenthredo* by Fabricius (1775). Kirby (1802) & Latreille (1802) classified bees on the basis of their mouth parts which gave an impetus to the bee workers and led to the development of several bee genera in quick succession. Lepeletier (1841) added another dimension to bee classification wherein he segregated them based on their social and nesting behavior. He grouped members of genera *Halictus*, *Nomia* and *Dufourea* as solitary nesting bees and genus *Sphecodes* as parasitic bees.

Thereafter, Schenk (1861, 1869) coined the names of several subfamilies based on their generic roots and included genera *Halictus* and *Nomia* under subfamily Andrenidae while he placed *Dufourea*, *Rophites*, and *Systropha* under different subfamilies. No tribes were reported until Thomson (1872) separated *Halictus* from *Andrena* and raised the tribe Halictina based on genus *Halictus*. He also included *Dufourea*, *Rophites*, *Sphecodes* under the tribe Halictina and treated them as closely related genera. However, the behavioral classification of Lepeletier (1841) was still not ruled out as it was adopted with a few modification by Schmiedeknecht's (1882) and Ashmead (1899). The later author separated halictines from Andrenidae and raised the status of tribe Halictina to a subfamily Halictinae for the first time.

Robertson (1904) was the first to propose family names viz., Halictidae, Nomiidae and Dufouridae in his classification under two large groups viz., Pygidialia and Apygidialia. He kept Halictidae under Pygidialia, Andrenoidea and included genera like *Augochlora*, *Halictus*, *Sphecodes* under Halictidae, *Nomia* under Nomiidae and

*Dufourea*, *Rhophites* under Dufouridae. Thereafter Börner (1919) reorganized bees into appropriate family groups and raised two subfamilies under Halictidae *viz.*, Halictinae and Halictoidinae, with Halictinae consisting of three tribes Nominii, Halictini and Nomioidini.

Bischoff (1934) emphasized the importance of characters like subantennal sutures, episternal groove and jugal lobe of hindwing in his classification. Based on the same principle Michener (1944, 1965) added three subfamilies Dufoureae, Nomiinae and Halictinae under Halictidae in his classification of bees of the world. Warncke (1977) divided bees into two broad families and placed subfamily Halictinae under Andrenidae, however no tribe names were used. The subfamily Halictinae was again divided by Michener (1979) into three tribes Augochlorini, Halictini and Nomioidini.

The current classification followed widely is that of Michener (2007) who classified bees into seven family groups *viz.*, Stenotritidae, Colletidae, Andrenidae, Halictidae, Melittidae, Megachilidae and Apidae comprising of 1,234 genera and subgenera. Further family Halictidae was divided into four subfamilies, *viz.*, Rhophitinae, Nomiinae, Nomioidinae and Halictinae and subfamily Halictinae was subdivided into two tribes Halictini and Augochlorini consists of 24 and 25 generic groups while the subfamilies Nomiinae, Rophitinae, Nomioidinae included 11, 13 and 3 generic groups, respectively.

Family Halictidae commonly known as ‘sweat bees’ is one of the largest among the bee groups consisting of 4146 described species under 75 genera worldwide. Subfamily Halictinae is the most diverse under Halictidae with 2,711 valid species recorded worldwide (Alexander and Michener 1995, Ascher and Pickering 2014). They are quasisocial or solitary bees with pretty and colorful hair patterns adapted for pollen collection. They are significant pollinators of wide range of agricultural and medicinal crops. They live in nest made in underground or wood. The genera such as *Nomia*, *Pseudapis*, *Halictus*, *Sphecodes* and *Lasioglossum* are known to be pollinators of agriculturally important crops fruits and flowers *viz.*, *Halictus* on Okra, *Brassica rapa*, Strawberry, Apple, Allspice and *Lasioglossum* on Guava. (McGregor 1976)

The members of family Halictidae can be distinguished from other bee group by following set of characters *viz.*, forewing basal vein strongly arched; stigma well developed; F1 shorter than scape; subantennal suture single; lacinia modified as small, hairy lobe on the anterior surface of labiomaxillary tube; pronotum collarlike and not reaching tegulae; hind wing jugal lobe as long as submedian cell.

## 5.2 On Indian Halictidae

Bees in the family Halictidae have been described as difficult to characterize taxonomically and little is known about many species outside of their original descriptions. However, only few genera and few species of these bees have been studied from India. The earliest record of halictid fauna from India can be seen on “*Species insectorum*” by J. C. Fabricius (1781) who described *Andrena curvipes* from Southern India, However the species was later transferred to genus *Nomia* Latreille by Blanchard (1849) and Michener (1997) also accepted its placement. Smith (1879) reviewed collections of British Museum and described many species from India but most of them have been synonymised by subsequent workers. The only comprehensive work on Indian bees was that of Bingham (1897, 1898, 1908-09) in the series entitled “*Fauna of British India*” which listed 24 species under genus *Halictus* and 13 species under genus *Nomia* belonging to the present day Halictidae from India but most of them have either been synonymized or transferred to other genera.

Subsequently, the nest and social behavior, pollination and flower relationships and their behaviour management have been studied in a few Indian halictines (Batra 1966;#1967;#1977; Solomon and Puranachandra, 2004). Apart from these work on this family has been restricted to publication of a first record of Genus *Conanthalictus* bee from Amritsar, India (Tomar and Suniti 2002) or genitalic studies of a few Halictid genera (Tomar and Tomar, 2005). Systematic work by specialists located outside India on oriental (Sakagami, 1968 & 1989) and African bee fauna (Pauly, 1984b, 1990 & 2001) included a few Indian species.

Pertinent literature reveals that this group of non *Apis* bees had been deserted sporadically with no comprehensive work undertaken on them. The taxonomy of these species is inadequately worked out as the descriptions of most of the known species were

based on color and pattern of pubescence and hence outdated, lack illustrations and inadequate for quick and authentic identification of Indian species. Thus serious gap exists in the present knowledge of taxonomy of Indian Halictidae. Establishing accurate taxonomic identities of species belonging to these genera will aid studies involving pollination biology. Keeping this in view, the present study aimed to address this gap by improving the descriptions of the species based on stable taxonomic characters in a comprehensive manner by including, morphometrics ratios, sculpture, pilosity, male genitalia and illustrations of key features and colored photographs to place the identity of the species on a firm footing.

The checklist compiled during the present study revealed that, family Halictidae currently consists of 215 species under 14 genera including five species new to science from India. All the four subfamilies viz., Halictinae, Nomiinae, Nomioidinae and Rophitinae are present in India except tribe Augochlorini and subtribe Caenohalictina under subfamily Halictinae. Sub family Halictinae is the most abundant includes six genera and 120 species under tribe Halictini. Subfamily Nomiinae is represented by four genera and Rophitinae & Nomioidinae with two genera each. The genus *Lasioglossum* Curtis of Halictinae is more diverse with 75 species, followed by the genus *Lipotriches* Gerstaecker and *Nomia* Latreille of Nomiinae with 47 and 23 species respectively. The parasitic genus *Sphecodes* Latreille is represented by 22 species while genus *Halictus* Latreille includes only 14 species. The subfamily Rophitinae is poorly represented by 4 species followed by Nomioidinae with 9 species. India being blessed with a wide range of habitat diversity indicates this bee group to be distributed from all parts of India, However the distribution records is somewhat inclined more towards the mid and northern states of India, probably due to presence of wide mountain ranges. More exploration in the northern region can also be another reason for this skewed distribution pattern.

During present study 29 species under nine genera has been redescribed including the five species described as new to science from India viz., *Pseudapis indorensis*, *Lipotriches makaliyammani*, *L. anaiyurensis*, *L. sathiarensis* from Tamil Nadu and *Lipotriches jhajhraensis* from Uttarakhand under subfamily Nomiinae. Two species

*Nomia strigata* (Fabricius, 1793) and *Nomioides fortunatus* Bluthgen (1937) are being recorded for the first time from India.

In addition to the above several new distribution within India have been established for 21 species viz., *H. fimbriata* from Srinagar; *H. latisignatus* from Maharashtra and Karnataka; *H. lucidipennis* from New Delhi; *H. propinquus* from Pant Nagar (Uttarakhand); *Lasioglossum albescens* from New Delhi, Madhya Pradesh; *Patellapis reticulosa*, *Sphecodes crassicornis* from Tamil Nadu; *S. irridipennis* from Bihar; *Lipotriches fervida* from Bihar, Punjab; *L. kangrae* from Jammu&Kashmir, Bihar, Tamil Nadu; *N. buddha*, *crassipes* from Bihar; *N. curvipes* from Maharashtra, Punjab, Madurai (Tamil Nadu); *N. ellioti* from Bihar; *N. interstitialis* from Madhya Pradesh, New Delhi, Rajasthan, Uttarakhand, Odisha; *N. strigata* from Tamil Nadu, Odisha; *N. westwoodi* from Karnataka, Madurai (Tamil Nadu), Madhya Pradesh, Odisha; *P. edentata* from Tamil Nadu; It can be inferred from the collection habitats that these bees prefer, refuge area nearby agricultural land and bunds of canal or river bed for their nests.

Several floral or plant records have also been established for these bees, belonging to families Asteraceae, Cleomaceae, Convolvulaceae, Cucurbitaceae, Poaceae, Lamiaceae, Leguminaceae, Malvaceae, Zygophyllaceae viz., *Aster*, *Ageratum*, *Abutilon*, *Gerbera*, *Ipomea*, *Jasminum*, *Leucas aspera*, *Ocimum*, *Psidium*, *Parthenium*, *Tridox*, *Tribulus*, *Sachharum* spp, Cucumber, Grasses, Saffron and other unidentified ornamentals seems to be preferred by these bees for nectar and pollens. The significant floral records which need mention are those of are *Steganomus bipunctatus* on *Abutilon indicum*, *H. fimbriata* on saffron; *Pseudapis oxybeloides* on *Ocimum* spp., etc.

### 5.2.1 On the subfamily Halictinae

Ashmead (1899) was the first erect subfamily Halictinae and separated halictines from Andrenidae. The composition of this subfamily kept on changing by either inclusion or removal of members belonging to Nomiini, Nomioidini under Halictinae (Robertson, 1904; Börner, 1919; Michener 1944, 1965, 1979). Finally Michener (2007) divided the subfamily into two tribes viz., Halictini and Augochlorini. The tribe Halictini commonly found in oriental region with four subtribes viz., Thrinchostomina, Caenohalictina, Sphecodina and Halictina divided based on morphology and DNA phylogeny (Danforth

et al., 2004; Pesenko 2004) includes 2161 species worldwide. Members of Augochlorini and Caenohalictina have not been reported from India yet. Only six genera viz., *Eupetersia*, *Halictus*, *Lasioglossum*, *Patellapis*, *Sphecodes*, *Thrinchostoma* with a total of 120 species have been reported from India. The subfamily Halictinae can be diagnosed by its strong episternal groove extending downwards below scrobal groove; third submarginal cell shorter than the first with pointed marginal apex; prepygidial fimbriae divided longitudinally in female; S7 of male small, possess long basolateral apodeme and a process at mid apex; male S8 variable, broad. There was no comprehensive work done on Indian Halictinae except that of Bingham (1897). A few scattered descriptions of new species (Cameron, 1902b; Bluthgen 1926a; Batra, 1966; Sakagami, 1968; Ebmer 1980; Sakagami & Ebmer 1987) from the oriental region include a few species from India.

In the present study ten species have been redescribed under four genera viz., *Halictus brunnescens*, *H. fimbriatus*, *H. lucidipennis*, *H. propinquus*, *H. latisignatus*, *Lasioglossum albescens*, *Sphecodes crassicornis*, *S. gibbus*, *S. irridipennis* and *Patellapis reticulata*. The existing information on species was supplemented by additional characters used in standard bee taxonomy, morphometric ratios and illustrations of important taxonomic features including male genitalia and colored photographs.

#### **5.2.1.1 GENUS *Halictus* Latreille 1804**

The genus *Halictus* was established by Latreille (1804) with the type species *Apis quadricincta* designated by Michener (1991). A total of 185 species are recorded on worldwide out of which only 14 species are from India. The genus *Halictus* can be easily recognized by its dense apical hair bands on terga; metallic or non metallic; strong distal veins on forewings differentiates it from a closely related genus *Lasioglossum*; ventral base of penis valve slender with rounded apex; ventral gonostylus of male absent or if present directed apically.

Out of five species redescribed, *H. brunnescens* is a relatively large species, 11.8 mm long; it belongs to subgenus H. (*Halictus*) with a black body; male S5 margin straight; last flagellum of antenna flat and curved in male; Additional key features include viz., posterior bands of terga not narrowed at middle; T2 with anterior or lateral bands; lower gonostylus of male slightly widened at its distal half; a bunch of long

compact hairs on the upper apex of gonostylus; penis valve with a midlateral tooth; The two sexes differed morphologically. Male could be differentiated by its antennal segments which are F1 to F5 with large fuscous spots on outer surface, except on one or two last segments; S6 disc completely with pubescence; males with dense pale thick pubescence sparsely on lateral, dorsolateral and posterior propodeum; propodeum slightly truncate in male. Female can be characterized from the following features viz., basal propodeum with a strongly rugose with small punctures on lateral and posterior surface; propodeal triangle well defined; posterior surface clearly defined at laterad; propodeum comparatively broader; female hind tibial spur long with denticles at their lower margin.

Another species *H. fimbriata*, collected from Srinagar during the course of study, is being recorded for the first time on saffron. The earlier description on male of *fimbriata* mainly based on a mutilated specimen was from Dunga Gali (Pakistan) by Pesenko (2005). Both the sexes of *fimbriata* has been studied well during the present study. Species *fimbriata* belongs to subgenus *H. (Protohalictus)* can be differentiated by following characters viz., male flagellum without tiny hairs and last segment unmodified; lateral and posterior surface of propodeum granulated; basal propodeum rugulose; hind tibia black; head as broad as long; antennae reaching propodeum; male with shorter gonostylus, with the lobe lateroventrally convex, broadened at middle, apical margin curved strongly upwards; male and female very similar in size, pilosity and sculpture except for antenna and clypeus. This species also similar to *H. atripes* (material not examined but based on the description by Ebmer 2000) but distinguished by sparse punctures on scutum and scutellum; clypeus strongly projecting; F1-F11 with shiny glabrous area on inner surface; hind basitarsi broadened; T7 broadly emarginated at posterior margin; lower gonostylus without clublike enlargement in distal part.

*H. latisignatus* is the only species belonging to subgenus *Ramalictus* from India and could be identified by its characteristic rounded tubercle at midapical margin on clypeus which differentiates it from other species of genus *Halictus*; female *latisignatus* with fine dense punctures on head; same as on clypeus but scattered, tiny on supraclypeus; same kind of punctures but sparse uniformly on scutum and scattered, comparatively smaller on scutellum; interspaces smooth, shiny; metanotum with dense, small punctures and granulated interspace; basal propodeum dense, transverse fine striae

laterad, middle with very fine transverse striae, same fine rugose at dorsolateral angles of propodeum; S1 with shallow, uniform sparse puncture on disc.

Two *Halictus* species *lucidipennis* and *propinquus* belong to subgenus *Seladonia*, but can be differentiated from others by the following set of characters *viz.*, body metallic green, male S4 margin straight, deep cleft on dorsal gonostylus of male; well developed scopa; mandible of female with subapical tooth; female T5 with tiny hairs at median zone; basal propodeum as long as metanotum; hind basitibial plate anteriorly carinated with pointed apex; S6 of male without depression; male antenna not reaching metanotum; The present study augmented the existing species description with photographs of different key features for quick and authentic identification. However, these two species can be differentiated from each other by the following: basal propodeum of *H. lucidipennis* with sparse longitudinal rugose; pale white pubescence densely covering gena and paraocular area; tegula widely impunctate while the basal propodeum of *H. propinquus* densely rugose; pale white pubescence sparse on gena and paraocular area; tegula impunctate; hypostoma striated; lateral pronotum with strong striae.

#### **5.2.1.2 GENUS *Lasioglossum* Curtis, 1833**

Genus *Lasioglossum* was established by Curtis (1833) with the type species *Melitta xanthopus* Kirby, (1802). Currently 1228 species are reported under this genus worldwide out of which 75 species are from India. Species of *Lasioglossum* are so similar that they are often difficult to recognize at species level. They are characterized by a much weakened distal wing venation, second submarginal crossvein as strong as first as or weaker than the first. However this genus can be distinguished from *Halictus*, by its weaker distal veins, basal bands on terga, presence of ventral gonostylus and truncated ventral process of penis valve.

Males of *L. albescens* can be identified by their cylindrical or slender abdomen and relatively longer antenna; basal propodeum of male slightly longer than that of female; abdomen equally long in both sexes; T2 basal bands with appressed white pubescence and are comparatively thicker in female; T3 of female with tiny subdecumbent, sparse, uniform hairs on disc and marginal areas; but it is absent in male; generally females with prepygidium on T5; T3 with both basal and preapical bands,

which is not prominent in male; T4, T5 of male and T4 of female with preapical bands; T1 of male slightly broader anteriorly compared to female; male genitalia laterally oval, broader than long; a row of short, stiff, curved hairs, longitudinally on mid base of ventral gonostylus; volsella long, strong, narrowed at apex; gonostylus short, laterally broad, bent mesad near base, concave; fine sparse hairs on surface of gonostylus.

### 5.2.1.3 GENUS *Patellapis* Friese, 1909

Genus *Patellapis* was erected by Cockerell, (1920a) with the type species *Halictus schultzei* Friese, 1909. Approximately 170 species are recorded worldwide out of which only 5 species are from India. The genus can be characterized by the following set of characters viz., body black or non metallic; terga with or without coloured tergal bands and pubescence weaker near posterior margin; paraocular lobe absent; epistomal suture without bend near tentorial pit; male dorsal gonostylus bifid; males rarely known; scutum and scutellum strongly sculptured; T2 to T3 with basal area of pale tomentum. Female of *P. reticulata* has been characterised as follows: head with tiny, dense, reticulate granulations on vertex, paraocular, alveolar, supraclypeus and clypeus; fine strong, reticulate mark, completely on surface of scutum, scutellum and irregularly granulated on metanotum; T1 glabrous at middle, anterior surface smooth and shiny; basal propodeum with, smooth, shiny thicker reticulation, reaching both margins; reticulations larger and wider with strong ridges; interspace matt, not shiny; same kind of markings continue on its posterior surface; tergum minutely granulated.

### 5.2.1.4 GENUS *Sphecodes* Latreille 1804

The species of genus *Sphecodes* are commonly cleptoparasitic. This genus can be recognised by its broad head, short eyes; sparsely covered with hairs; body 4.5 to 15 mm long; red metasoma or with black **tinch**; strong punctations on mesosoma; propodeum with coarse areola; hindlegs of female without scopa; T5 without prepygidial fimbriae; males with long antenna and big flagellomere; F4 twice as long as the F3 in males; sculptures on scutum, propodeum and tergum with unique features amongst all the species. Male possess more significant features than female in differentiating species. 285 species reported worldwide out of which only 22 species are from India.

The present study included three species *viz.*, both males and females of *crassicornis*, *gibbus* and female of *irridipennis*; It is extremely difficult to recognize species of genus *Sphécodes* as they are cleptoparasitic and do not possess much specialized features. The male genitalia and sculpture of mesosoma are the only stable features for identification at species level. Generally females are much bigger and males are slender with a longer antenna.

*S. crassicornis* can be characterized by the following characters *viz.*, uniform, strong punctures on head and thorax; small irregular, dense punctures on head; small, round uniform dense punctures on scutum which are wider on scutellum; interspaces smooth; metanotum with fine irregular dense punctures; basal area of propodeum longer than metanotum; strong irregular reticulated sculptures on propodeum stronger at basolaterally; margin well defined; tiny shallow sparse punctures on T1; males usually small and slender with long antenna; gonocoxite long, broad at base and 2.26x as long as broad; genital foramen broad, as broad as long; dorsal lobe parallel and elongated at apex with long hairs; ventral lobe broad oval;

Females of *S. gibbus* differ from males by their size, antenna, color of abdomen, hind tibia, size of the punctures and mandible; punctures on scutum and scutellum are smaller than in male and scattered widely; few smaller punctures scattered on scutellum; posterior margin of outer hind tibia with a row of spine like tubercles along margin directed downwards; T1 and T1 completely reddish brown; metasoma black T5 on wards; T1, T2 with scattered tiny small punctures not as strong as in males; metanotum almost rectangular with slightly angled posterior margin; male genitalia oval, greatly convex and broad at middle; gonostylus laterally broader and concave; dorsal lobe with deep semicircular cleft at preapex; apex narrowing down with long bent hairs;

Presence of shallow, fine, dense punctures on head; frontal carina strong; shallow, irregular to round punctures on scutum and scutellum; basal propodeum strongly reticulated and carinated strongly at posterior margin; interspaces smooth and shiny; sculpture on the posterior propodeum, transverse also towards the pit; shallow, scattered small punctures on T1 characterise *S. irridipennis* very well.

All the three species generally vary in size and also in the strength of punctures on mesosoma. Small, dense punctures are seen in *S. crassicornis* while large sparse punctures are on *S. gibbus* and shallow punctures on *S. irridipennis*; the density of punctures varies slightly between the sexes, for example, the punctures on scutum of male *S. gibbus* is denser than those of female. Similar was the case in *S. crassicornis*. As far as the male genitalia is concern, wide variation was observed in gonostylus viz., dorsal lobe of gonostylus showed a deep semicircular cleft *S. gibbus* while it was parallel in case of *S. crassicornis*.

### 5.2.2 On the subfamily Nomiinae

Robertson (1904) was the first who proposed a family status for Nomiidae and included genus *Nomia*, under it, however it was later downgraded to subfamily level by Michener (2007). Subfamily Nomiinae can be diagnosed by submarginal cells of forewings: first and third submarginal cells long and the second is shorter *i.e.*, third marginal cell twice as long as second; marginal cell apex rounded; male S7 transverse with short apodeme but lacking projection at mid apex; female labrum with keel; female hind basitarsi with penicillus; hind femoral and tibial scopa well developed in female. A few papers on fauna of Old world and Russian species were found useful for identification of species (Westwood, 1875; Smith 1875; Pauly, 1990; Baker, 2002; Astafuravo, 2008)

In total 421 species under 10 genera (Michener 2000) were reported worldwide out of which 235 species were recognized from the oriental region (Ascher *et al.*, 2014). However the Indian fauna comprises of only 83 species including four genera viz., *Lipotriches*, *Nomia*, *Pseudapis*, *Steganomus* with 47, 23, 9, and 4 species respectively. In the present study additionally five species were described as new to science under subfamily Nomiinae. A total 18 species have been studied as follows: seven species each under *Nomia* and *Lipotriches*, three species under *Pseudapis* and a single species under *Steganomus*. Four new species have been described under genus *Lipotriches* viz., *jhajhraensis*, *makaliammani*, *sathiarensis* *anaiyurensis* spp. nov. and one under genus *Pseudapis* viz., *indorensis* sp. nov.

Six species has been redescribed and their sex association was completed *viz.*, *N. buddha*, *interstitialis*, *strigata*, *westwoodi*, *L. kangrae*, and *S. bipunctatus*. The difference in the male genitalia between closely related species *N. ellioti* and *westwoodi* has been described for the first time. Likewise the male genitalic characters of *N. curvipes* and *crassipes* have been compared for the first time in the present study. In addition to the above several floral records have also been established during the course of study.

#### **5.2.2.1 GENUS *Lipotriches* Gerstaecker 1858**

Genus *Lipotriches* was established by Gerstaecker (1858) with designated type species *Lipotriches abdominalis* but was later synonymised with *Sphecodes cribrosa* Spinola, 1843. A total of 178 species reported worldwide out of which 47 species are from India. The species have been reorganised by Michener (2007) into eleven subgeneric groups out of which *Austronomia*, *Macronomia* and *Mayenomia* are commonly found in India.

Genus *Lipotriches* can be distinguished from other members of Nomiinae by the pronotal carina at ocelli, lamellate extension on pronotum; marginal area of tergum with typical apical bands. However, the following set of characters can be used to narrow down at the subgeneric level *viz.*, head broad or longer; mandible simple or tridentate; clypeus with row of large hairs at apex; last two antennal segments simple or curled if enlarged; ocellocular distance more or less than the diameter of ocelli; pronotal lamella transverse and notched laterally or at middle or absent; hind tibial spur with simple lamella or few teeth; hind basitibial plate carinated partially or completely; one to three strong teeth on hind femur; basal area of propodeum reduced or horizontal or declivious; T1 minutely tessellate with fine or coarse punctuations; vertical tergal bands are pale yellow, consisting of uniform coarse hairs.

Males differ from female by its slender abdomen, pubescent pattern and their extensively modified hind legs. Seven species including four species new to the science have been described under this genus. *L. capitata* belonging to subgenus *Lipotriches* show the following characters: possess pronotal vertical carina, hind tibial spur extended at the middle. Further species *capitata* could be differentiated form other species by the following characters *viz.*, smaller species, 5 to 6mm long, male hindleg more slender and

not extensively modified; hind basitarsi slightly bulged; hind femur ferruginous; T1 not long; T4 and T5 apical border irregular and sparse pubescence; punctures small, dense, shallower on tergum; male genitalia nearly rectangular, slightly broader posteriorly; genital foramen short-egg shaped; gonobase rectangular; ventral retrorse lobe broader with row of long fine hairs at midbase; inner surface of ventral lobe completely covered with short, stout, dense flat hairs bent at apex; ventral arm longer, slender, blunt and gradually broadening towards apex; penis valve stronger; mid lateral tooth curved upwards, apical and inner preapical tooth absent.

*L. fervida* is a comparatively larger species up to 9mm in length, male hindlegs largely modified, basitarsi long not bulged; hind femur not ferruginous; T1 longer; legs bright yellow; hind femur with a preapical tooth; tergum with strong, big and deep punctures; T4 to T5 apical band straight at middle; S5 with characteristic black, silky fine hairs on midapical disc; hind femur with preapical tooth at apex; male genitalia oval, ventral retrorse lobe at apical outer margin with denticles; anterior longitudinal half of inner surface of retrorse lobe covered with short uniform soft hairs; inner basal surface with tuft of long thicker, dense hairs; upper lobe small, thin, broadened apically;

*L. kangrae* also is a larger species but male hindlegs largely modified, basitarsi not much enlarged; hind femur not ferruginous; T1 longer; hind femur dark brown shiny with sparse long hairs; hind tibia with dense shiny light yellowish hairs, longer hairs towards apex; hind femur toothless or reduced at the apical end of hind femur; strong punctures on tergum; T4 to T5 apical bands expanded at middle; white, silky fine hairs on S5 and disc not well defined; hind femur with reduced tooth at apex; male genitalia nearly rectangular, broadened at apex and 1.29x as long as broad; ventral retrorse lobe oval, narrowed at apex, concave ventrally; sparse long stout bristles on their dorsolateral surface; outer surface with long sparse fine hairs, 0.5x as long as breadth of ventral retrorse lobe; inner surface with short, stout bristles; base of lobe depressed laterally curved downward; small parallel lobe with rounded edge at base; gonobase anterolaterally rounded.

*L. jhajhraensis*, *makaliamani* and *sathiarensis* spp. nov. exhibit the characters of subgenus *Mayenomia* viz., bidentate mandible; reduced transverse lamina of pronotum;

hind tibial spur simple and serrated; ocellocular distance less than twice as long as the diameter of ocelli, scape not reaching midocelli and long slender glossa.

*L. jhajhraensis* having additionally dorsolateral black bands on T2 narrowly intermittent black band on T4, which are not present on a closely related species *mollis* Smith 1879 (material not examined but based on old description); also it differs due to its black shiny basal propodeum, fine punctures on scutum. *L. makaliammani* is closer to species *phenacura* (Cockerell 1911) but differs by following characters viz., T1-T3 completely ferruginous, T4 with lateral brown patches; T5 with blackened premarginal area; ridges on basal propodeum narrower, not as strong as in *phenacura* and interspace not smooth and shiny; posterior surface and lateral propodeum with small dense uniform punctures; *L. sathiarensis* is closer to *kaeralensis* Pauly 2009 but differs due to the following characters viz., T2 with sparse uniform slightly strong punctures; pale pubescence sparse on scutum, clypeus and paraocular area; basal propodeum ridges found as a transverse groove at anterior margin with traces of ridges; posterior angle of basal propodeum with tiny transverse striae and not smooth.

*L. anaiyurensis* sp. nov exhibits the following characters and therefore is being placed under subgenus *Afronomia*, viz., ocellocular distance twice as long as the diameter of ocelli; hind basitibial plate carinated on both sides with closed apex; glossa shorter than head; hind femur with a single tooth at apical base; fine strong dense punctures on scutum, scutellum with sparse tomentum on the surface; metanotum and propodeum with fine shallow dense punctures; basal propodeum declivious; T1 and T2 with shallow dense sculpture. It is closer to *L. karnatakaensis* but differs in sculptures of mesosoma, basal propodeum and T1-T2.

#### **5.2.2.2 GENUS *Nomia* Latreille 1804**

Genus *Nomia* was established by Latreille (1804) with the type species *Andrena curvipes* (Fabricius, 1781). Currently this genus includes 126 species worldwide out of which only 23 species from India. It is distinguished from other members of Nomiinae by its colored tergal apical bands (white, yellow, blue, green) and marginal area of terga completely impunctate and hairless (Michener, 2010).

The subgeneric groups made by Michener (also modified from Pauly 1980) includes variations in the following set of characters *viz.*, modification of male hind leg; presence or absence of metanotal spines; shape and dentation of outer hind tibial spur; carina of hind basitibial plates of female; presence or absence of mid apical projection on male S8; presence of hairs and margin of S6; S5 thickening and type of hair tufts; basolateral apodemes of S7; male gonostylus and their orientation; presence or absence of colored fascia on T1; In total, seven species belonging to genus *Nomia* (and 3 subgenera) has been studied *viz.*, *strigata*, *interstitialis*, *westwoodi*, *elliotti*, *buddha*, *curvipes* and *crassipes* with the aim to supplement existing knowledge for authentic placement of the species.

The males could be diagnosed conclusively as they have extensively modified hind legs and very stable genitalia features. *N. buddha* one of the largest species under subfamily Nomiinae, typically possesses intermittent colored apical bands. females similar in size, coloration but differs in the sculpture and structure of hind legs; punctures are comparatively shallower and sparser in female; the hind femur and tibia not extensively enlarged as in male and covered completely with dense whitish pubescence; pubescence on head of male is denser and longer than in female; male genitalia nearly triangular, narrowed anteriorly and broadened at apex; ventral retrorse lobe broad, dorsally erect; inner surface with dense soft hairs and outer surface with few long hairs; upper lobe small, oval and inner surface folded at one margin with short uniform sparse hairs.

*N. curvipes* and *crassipes* could be differentiated by the following characters *viz.*, hind femur of *N. crassipes* with black base; pubescence on mesosoma yellow, erect or sub erect of longer hairs; whereas in *curvipes*, pale, creamy, short, thick pubescence, slightly appressed on mesosoma; S5 with clubbed hairs near mid apex in *crassipes* while *curvipes* is without clubbed hairs; genitalia widely varying, gonostylus broad and parallel in *crassipes*; gonostylus narrow with broad apex in *curvipes*.

Males of *interstitialis* similar to females but differ due to the presence of long lateroventral hairs on S2-S5, slightly broadened abdomen apically or cylindrical; sparse and thinner pubescence on femur; punctuations on posterior propodeum comparatively

stronger in male; T6 with white specialised hairs, curved mesad; T2 gradulus punctures sparse, clear, comparatively stronger than in females.

*N. ellioti* morphologically close with *westwoodi*, but can be distinguished with the following set of characters *viz.*, mid and lateral carina of clypeus reaching anteclypeal margin in *ellioti*; tergum, shiny black with rounded, strong punctures; pubescence of long white, sparse not thin, scattered hairs than those in *westwoodi*; scutum and scutellum with round, strong dense punctures; hind tibia with slightly longer apical tooth than *westwoodi*; T1 and T2 with large sparse, strong punctures; lateral extension of male gonostylus shorter than *westwoodi*;

### 5.2.2.3 GENUS *Pseudapis* Kirby 1900

The genus *Pseudapis* was erected by Kirby (1900a) with the type species *Pseudapis anomala* by original designation. 73 species have been recorded worldwide out of which only 9 species are from India. The genus could be recognized by the following set of characters *viz.*, greatly enlarged tegulae extending beyond scutoscutellar suture; preoccipital carina behind gena; carina across anterior scutum; lamella on the pronotal lobe extending mesad; metasoma with both apical and basal pubescent bands; During the present study females of three species including one species new to science has been described *viz.*, *edentata*, *oxybeloides* and *indorensis* sp. nov.

Female of *P. edentata* possess an orange tegulae with a black patch; middle shiny slightly convex; lateral apex with small dense punctures; sparse, short plumose hairs present; scutum, shiny black, interspaces smooth, large punctures scattered at middle, comparatively smaller and sparser on other parts; dense pubescent bands along the posterior and anterior margin of scutum and slightly dense on scutellum; T1 anterior surface with short sparse hairs; premarginal line well defined laterally; T2 premarginal line well defined with elevation at middle.

Hind basitibial plate of female *P. indorensis* sp. nov is posteriorly carinated and therefore it being placed under subgenus *Pachynomia*. It is closer with *P. (Pachynomia) aliena*, but differs due to the following characters *viz.*, tegula of the new species is impunctate, apex transparent and black at the middle; soft tiny pubescence except at middle; scutum and scutellum surface black not shiny, smooth; scattered small punctures;

scattered long hairs on scutellum; T1 matte black without punctures, surface not smooth; anterior surface with scattered short hairs laterally and sparse at middle; premarginal line present; dorsolateral surface with white plumose bands; premarginal line with laterally scattered hairs.

*P. oxybeloides* different from other two species due to its larger, pale brown and transparent tegula, base of tegula black patch and punctures; scutum with black; sparse uniform punctures slightly wider at apex of para notaulices; interspace of punctures not smooth; anterior and posterior margins of scutum and scutellum with dense yellow pubescence; surface of both with sparse tiny scattered hairs; T1 anterior surface with sparse short hairs; sparse small punctures becoming smaller and shallower towards dorso anterior end; near dorsoanterior end the dorsal bands at base complete; premarginal well defined and slightly elevated laterally; premarginal area laterally with sparse punctures bigger than scutal punctures at middle with scattered small punctures;

#### **5.2.2.4 GENUS *Steganomus* Ritsema 1873**

Smith (1875) established a new genus *Cyathocera* based on a type new species *C. nodicornis* collected from Lucknow and Barrackpore which was later transferred to the genus *Steganomus*. It consisted of seven species limited to old world and oriental region out of which four species have been recorded from India. The genus characterized by its robust body and large tegulae similar to that of genus *Pseudapis* but it differs due to the two submarginal cells on wings, two hind tibial spurs in male, a reduced prothoracic lamella in female and gena without preoccipital carina. The carina across the pronotum resembles another genus *Lipotriches* but is distinguished from it due to the characteristics of lamella.

Both male and female of *S. bipunctatus* have been studied. They possess a distinct apical tooth on hind tibia; mid trochanter without tooth at base; dorsally convex; male genital foramen small, subconical; gonocoxite broadened at base; gonostylus dorsal lobe wider, thin leaf like, curved or folded laterally, the inner surface with sparse uniform short hairs and mid inner base with stout, dense, long hairs; ventral lobe: small, broad preapically and blunt; Penis valve dorsally enlarged, broader at middle and tapering strongly towards apical end;

### 5.2.3 On the subfamily Nomioidinae

The subfamily Nomioidinae includes about 90 species under three genera (Pesenko 1993, 2000 a, 2000 b; Michener 2007) and has worldwide distribution. It includes two genera viz., *Ceylalicthus* Strand, 1913 and *Nomioides* Schenck, 1867 which are common in southern Asia. Subfamily Nomioidinae includes three species under *Ceylalicthus* and six species under *Nomioides* including one new record viz., *N. fortunatus* from India.

#### 5.2.3.1 GENUS *Nomioides* Schenk 1867

This genus was established by Schenk (1867) with type species *Apis minutissima* Rossi, 1790, including 60 species worldwide out of which 6 species including a new record are from India. The genus could be recognized by its size and metallic blue body; second submedian cell nearly triangular; r-m vein of hind wing 0.3-0.5x as long as Rs; metathorax yellow; pale bands on pregradular areas of terga; inner orbits slightly emarginated in female; metasoma heart shaped and subgenus *Nomioides* with a longer propodeum.

*N. fortunatus* being recorded for the first from India (Tamil Nadu), female specimens were collected on *Tribulus* sp., (Zygophyllaceae). Different colour patterns were reported on clypeus, scutellum and pale bands on abdomen of this species by Pesenko and Pauly (2009) our female specimen of this species showed poor fuscous markings on clypeus; head and mesosoma dull dark olive-green; uniform dense and coarse granulations present on mesoscutum and scutellum; head and mesosoma dull dark olive green; scutellum dark entirely; dorsal surface of propodeum 1.32x as long as scutellum. body without tomentose pubescence; both sexes with wider and shorter head; mesoscutum and scutellum uniformly densely and coarsely granulate; propodeum longer.

**CHAPTER- 6****SUMMARY AND CONCLUSION**

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Family Halictidae, commonly known as sweat bees, is also one of the largest groups under superfamily Apoidea. Although they are not as abundant as Apidae in terms of number of individuals yet they contribute significantly in pollination of several tropical crop species. The halictids are generally small but morphologically diverse bees, often bright metallic coloured, feed on pollen and nest underground or in wood. This family currently includes four sub families *viz.*, Rhophitinae, Nominae, Nomioidinae, Halictinae and 75 genera and 4146 species worldwide (Alexander and Michener 1995).

The taxonomy of most Indian species is inadequately worked out as the descriptions of most of the known species are obsolete, lack illustrations and inadequate for quick and authentic identification. Pertinent literature reveals that this group of bees had been deserted sporadically with no comprehensive work undertaken on them. Thus serious gap exists in the present taxonomic knowledge of Indian Halictidae. Therefore the present study was formulated with the following objectives: to survey and collect members of family Halictidae; to evaluate various taxonomic characters with a view to establishing accurate identities of various genera and species; preparation of an annotated checklist of species belonging to this family from India; description of new /redescription of known genera and species belonging to family Halictidae by augmenting with new stable characters and finally preparation of diagnostic keys for identification of species.

The topic and the reason for undertaking the present study have been highlighted in the first chapter. All pertinent literature has been reviewed in the second chapter. Standard procedures adopted for processing of the specimens for taxonomic studies *viz.*, collection, killing, mounting, relaxing, preservation, dissection, photography etc have been enumerated in chapter three on material and methods. The source of the material used along with details of the morphological terms used has been given.

The fourth chapter on results includes all the significant findings of this study: The general morphology of halictid bees wherein the terminology used for bee taxonomy has been explained with illustrations. An up to date annotated checklist of the Indian species has

been compiled from all the published literature available on family Halictidae for the last three and a half centuries. An in depth analysis of the checklist revealed that Family Halictidae is represented in India by all its four sub families viz., Rhophitinae, Nominae, Nomioidinae, Halictinae which includes 14 genera with 215 species including the five new species described during the present studies. All the available synonyms have been included. Distribution of genera and species has been included along with several new records which have all been indicated by \*.

Two species *Nomia strigata* Fabricius (1793) and *Nomioides fortunatus* Bluthgen (1937) are being recorded for the first time from India. In addition to the above several new distribution records within India have been established for 21 species viz., *H. fimbriata* from Srinagar; *H. latisignatus* from Maharashtra and Karnataka; *H. lucidipennis* from New Delhi; *H. propinquus* from Pant Nagar (Uttarakhand); *Lasioglossum albescens* from New Delhi, Madhya Pradesh; *Patellapis reticulosa*, *Sphcodes crassicornis* from Tamil Nadu; *S. irridipennis* from Bihar; *Lipotriches fervida* from Bihar, Punjab; *L. kangrae* from Jammu&Kashmir, Bihar, Tamil Nadu; *N. buddha*, *crassipes* from Bihar; *N. curvipes* from Maharashtra, Punjab, Madurai (Tamil Nadu); *N. ellioti* from Bihar; *N. interstitialis* from Madhya Pradesh, New Delhi, Rajasthan, Uttarakhand, Odisha; *N. strigata* from Tamil Nadu, Odisha; *N. westwoodi* from Karnataka, Madurai (Tamil Nadu), Madhya Pradesh, Odisha; *P. edentata* from Tamil Nadu;

Since complex relationships exist between nectar and pollen collecting bees and their food sources therefore floral records are of utmost importance. During our surveys several floral/plant records could be established for these bees. Plants belonging to families Asteraceae, Cleomaceae, Convolvulaceae, Cucurbitaceae, Poaceae, Lamiaceae, Leguminaceae, Malvaceae, Zygophyllaceae viz., *Aster*, *Ageratum*, *Abutilon*, *Gerbera*, *Ipomea*, *Jasminum*, *Leucas aspera*, *Ocimum*, *Psidium*, *Parthenium*, *Tridox*, *Tribulus*, *Sachharum* spp, Cucumber, Grasses, Saffron and other unidentified ornamentals seem to be preferred by these bees for nectar and pollens. The significant floral records which need mention are those of *Steganomus bipunctatus* on *Abutilon indicum*, *Halictus fimbriata* on saffron; *Pseudapis oxybeloides* on *Ocimum* spp., etc.

Studies were conducted on 29 species under 9 genera. Five species new to science viz., *Pseudapis indorensis* from Madhya Pradesh, *Lipotriches makaliammani*, *L. anaiyurensis*, *L.*

*sathiarensis* from Tamil Nadu and *Lipotriches jhajhraensis* from Uttarakhand all under subfamily Nomiinae were described.

The old descriptions of known species were further strengthened by inclusion of new characters *viz.*, type of pubescence and its distribution pattern, sculpture of head, mesosoma and metasoma, morphometric ratios of important taxonomic features, illustrations of all diagnostic characters including male genitalia and coloured photographs. A total of 213 line diagrams and more than 250 photographs have been included in the description/redescription of the species. 245 specimens were augmented to the National Pusa Collection belonging to eight genera and 19 species.

In fifth chapter, the present findings were discussed with relevant literature to analyse and evaluate the gaps being addressed by the present study. Further all the findings were summarized along with conclusions in chapter six, which was followed by bibliography in chronological order.

It can be concluded from the present investigations that family Halictidae is a difficult group for taxonomic studies due to its wide diversity and variations even between males and females of the same species. The males of this genus are very difficult to collect as they emerge only during a specific period of the year. Although this group has attracted the attention of taxonomists abroad but studies on the species from India remains inadequate, scattered, very old, merely based on body colouration, therefore incomplete and useless for authentic identification. In view of the above, the present investigation was significant as it provides valuable information about this family whose members are very efficient pollinators of a wide range of crops. These studies will pave the way for further phylogenetic and evolutionary studies. However, future studies would require a thorough survey for collection of members of family Halictidae for a complete picture of the faunistics of the group and analysis of relationship with other members of the family as well as other closely related bee genera.

## SYSTEMATIC STUDIES ON INDIAN HALICTIDAE (HYMENOPTERA: APOIDEA)

### Abstract

Family Halictidae, commonly known as sweat bees, is also one of the largest groups under superfamily Apoidea. Although they are not as abundant as Apidae in terms of number of individuals yet they contribute significantly in pollination of several tropical crop species. The halictids are generally small but morphologically diverse bees, often bright metallic coloured, feed on pollen and nest underground or in wood. This family currently includes four sub families *viz.*, Rhophitinae, Nominae, Nomioidinae, Halictinae and 75 genera and 4146 species worldwide (Alexander and Michener 1995). Bees of *Halictus*, *Lipotriches*, *Nomia*, and *Pseudapis* belonging to family Halictidae are economically very important pollinators of cultivated crops as well as wild plant species.

The present study provides an updated knowledge on the taxonomy along with illustrations and coloured photographs to facilitate quick and authentic identification of species. during the present study, the members of family Halictidae have been surveyed and collected from different parts of India and their taxonomic characters evaluated to establish accurate identities of various genera and species; An annotated checklist of species belonging to this family from the Indian region has been compiled based on the available literatures and web resources; Studies were conducted on 29 species under 9 genera including five species new to science *viz.*, *Pseudapis indorensis*, *Lipotriches makaliammani*, *L. anaiyurensis*, *L. sathiarensis* from Tamil Nadu and *Lipotriches jhajhraensis* from Uttarakhand under subfamily Nomiinae. Two species *Nomia strigata* Fabricius (1793) and *Nomioides fortunatus* Bluthgen (1937) are being recorded for the first time from India. The descriptions have further been strengthened by inclusion of new characters being used for bee taxonomy *viz.*, type of pubescence and its distribution pattern, sculpture of head, mesosoma and metasoma, morphometric ratios of important taxonomic features , illustrations of all diagnostic characters including male genitalia and coloured photographs.

An up to date annotated checklist of the Indian species has been compiled from all the published literature available on family Halictidae for the last three and a half centuries. Family Halictidae is represented in India by all its four sub families *viz.*, Rhophitinae, Nominae, Nomioidinae, Halictinae which includes 14 genera with 215 species including the

five new species described during the present studies. All the available synonyms have been included. Distribution of genera and species has been included along with several new records which have all been indicated by \*. Sub family Halictinae is the most abundant includes six genera and 120 species under tribe Halictini. Subfamily Nomiinae is represented by four genera and Rophitinae & Nomioidinae with two genera each. The genus *Lasioglossum* Curtis of Halictinae is more diverse with 75 species, followed by the genus *Lipotriches* Gerstaecker and *Nomia* Latreille of Nomiinae with 47 and 23 species respectively. The parasitic genus *Sphcodes* Latreille is represented by 22 species while genus *Halictus* Latreille includes only 14 species. The subfamily Rophitinae is poorly represented by 4 species followed by Nomioidinae with 9 species. A perusal of the checklist indicates that members of this family are distributed in almost all the states of India, However the distribution records is somewhat inclined more towards the mid and northern states of India, probably due to presence of wide mountain ranges. More exploration in the northern region can also be another reason for this skewed distribution pattern.

In addition to the above several new distribution within India have been established for 21 species from various parts of India viz., from New Delhi (4), Uttarakhand (3), Madhya Pradesh (3), Tamil Nadu (5), Bihar (5) Punjab (2), Jammu&Kashmir (1), Maharashtra (1) Rajasthan (1), Odisha (3) and Karnataka (1). Several floral or plant records have also been established for these bees, belonging to nine plant families including 17 plant species. The significant floral records which need mention are those of are *Steganomus bipunctatus* on *Abutilon indicum*, *H. fimbriata* on saffron; *Pseudapis oxybeloides* on *Ocimum* spp., etc.

A total of 213 line diagrams and more than 250 photographs have been included in the description/redescription of the species. More than 350 specimens were examined during the course of the study and 245 specimens were augmented to the National Pusa Collection belonging to eight genera and 19 species. The present investigation was significant as it provides valuable information about this family whose members are very efficient pollinators of a wide range of crops. These studies will pave the way for further phylogenetic and evolutionary studies. However, future studies would require a thorough survey for collection of members of family Halictidae for a complete picture of the faunistics of the group and analysis of relationship with other members of the family as well as other closely related bee genera.

# भारतीय हैलिकिटडी (हायमेनोप्टेरा : एपॉयडिया) का वर्गीकरण संबंधी

## अध्ययन

### सार

बृहदकुल एपॉयडिया के अंतर्गत कुल हैलिकिटडी जिसे सामान्यता स्वीट बीज के नाम से जाना जाता है, सबसे बड़े समूहों में से एक है। यद्यपि संख्या की दृष्टि से वे एपाइडी जितने अधिक नहीं हैं किन्तु वे अनेक उष्णकटिबंधीय फसल प्रजातियों के परागण में महत्वपूर्ण योगदान करती हैं। हैलिकिटड्स प्रायः छोटी किन्तु आकारिकीय रूप से विविधतायुक्त मक्षिकाएं हैं जिनका रंग प्रायः चमकदार धातु के रंग का होता है और वे पराग कणों पर आहार करती हैं तथा जमीन के नीचे अथवा लकड़ी के भीतर निवास करती हैं। वर्तमान में इस कुल में चार उपकुलों नामतः रोफीटाइनी, नोमिनी, नोमियोआइडिनी एवं हैलिकटाइनी का समावेश है और विश्वभर में इसमें 75 जेनेरा एवं 4146 प्रजातियाँ (अलेक्जेंडर एवं माइकेनर 1995) हैं।

हैलिकिटडी कुल की मक्षिकाओं का अभिलक्षणन कठिन है और उनके मूल विवरणों के बाहर अधिकांश प्रजातियों के विषय में बहुत कम ज्ञात है। इस समूह से संबंधित साहित्य को देखने से पता चलता है कि विश्व के कई भागों में इस कुल के विषय में गहन अध्ययन किया जा चुका है किन्तु भारत के संदर्भ में यह जहाँ-तहाँ बिखरा हुआ है और मात्र बाह्य समानता पर आधारित है तथा अपर्याप्त है, इसीलिए आर्थिक रूप से इस महत्वपूर्ण समूह की विश्वसनीय पहचान हेतु प्रस्तुत अध्ययन आवश्यक था।

प्रस्तुत अध्ययन, भा. कृ. अ. परिषद् – भारतीय कृषि अनुसंधान संस्थान, नई दिल्ली के कीटविज्ञान संभाग में राष्ट्रीय पूसा संग्रह में उपलब्ध पहचान किए गए नमूनों तथा दिल्ली, हिमाचल प्रदेश, मध्य प्रदेश, राजस्थान, तमिलनाडु एवं उत्तराखण्ड से एकत्रित नमूनों पर आधारित था। प्रस्तुत अध्ययन के दौरान इस कुल के 500 से अधिक नमूनों का परीक्षण किया गया। विगत साढ़े तीन शताब्दियों के सभी उपलब्ध साहित्य एवं वेब संसाधनों के आधार पर, भारतीय क्षेत्र की इस कुल के अंतर्गत आने वाली प्रजातियों की एक सटिप्पण जाँच – सूची तैयार की गई। इस जाँच – सूची से ज्ञात हुआ कि भारत में हैलिकटाइडी कुल में इसके सभी चार उप-कुल अर्थात् रोफीटाइनी, नोमिनी, नोमियोआइडिनी एवं हैलिकटाइनी का प्रतिनिधित्व है और इसमें 14 जेनेरा एवं 215 प्रजातियों का समावेश है। सभी प्रजातियों के सभी उपलब्ध एवं वितरण रेकार्ड्स का समावेश किया गया है।

दो प्रजातियाँ *नोमिया स्ट्राइगेटा* फेब्रीसियस (1793) एवं *नोमियोइडेज फोर्च्यूनेटस* ब्लूथजेन (1937) को भारत से पहली बार रेकार्ड किया गया है। इसके अतिरिक्त, भारत के कई भागों में 21 प्रजातियों हेतु नए वितरण रेकार्ड्स यथा, नई दिल्ली (4), उत्तराखण्ड (3),

मध्य प्रदेश (3), तमिलनाडु (5), बिहार (5), पंजाब (2), जम्मू एवं कश्मीर (1), महाराष्ट्र (1), राजस्थान (1), ओडिशा (3) एवं कर्नाटक (1), स्थापित किए गए। इसके साथ-साथ नौ पादप कुलों पुष्प एवं पादप रेकार्ड्स भी इन मक्षिकाओं हेतु स्थापित किए गए। कुछ महत्वपूर्ण एवं उल्लेखनीय पुष्प रेकार्ड्स इस प्रकार से हैं, *एब्यूटीलॉन इंडिकम* पर *स्टेगेनोमस बाइपॉन्टेस*, पर *हैलिवटस फिम्रिएटा*, *ओसीमम* प्रजातियों पर *स्यूडेप्सिस ऑक्सीबेलॉयड्स* आदि।

9 जेनेरा के अंतर्गत 29 प्रजातियों का वर्गीकरण संबंधी अध्ययन किया गया। विज्ञान में पाँच नवीन प्रजातियाँ नामतः मध्य प्रदेश से *स्यूडेप्सिस इंदोरेनिस*, तमिलनाडु से *लायपोट्राइकेज माकालियमनी*, *ला. आनइयूरेनसिस*, *ला. साथियारेनसिस* तथा उत्तराखण्ड से *ला. झाझरीनसिस* वर्णित की गईं। नवीन गुणों यथा, प्यूबेसेंस का प्रकार एवं इसके वितरण का ढंग, सिर की संरचना, मीजोसोमा एवं मेटासोमा, नर जननांगों की बनावट, वर्गीकरण संबंधी महत्वपूर्ण गुणों के आकारमितीय अनुपात, नर जननांगों सहित सभी निदानसूचक गुणों के आरेख एवं रंगीन फोटोग्राफ का समावेश कर सभी वर्णनों को पुष्ट किया गया। इन प्रजातियों के वर्णन / पुनर्वर्णन में कुल 213 लाइन रेखाचित्रों एवं 250 से अधिक रंगीन फोटोग्राफ का समावेश किया गया। राष्ट्रीय पूसा संग्रह में आठ जेनेरा एवं 19 प्रजातियों के अंतर्गत आने वाले 245 नमूने जमा किए गए।

प्रस्तुत अध्ययन इस दृष्टि से महत्वपूर्ण है कि वह इस कुल के सदस्यों की विश्वसनीय पहचान हेतु मूल्यवान सूचना उपलब्ध कराता है जो फसलों की एक विस्तृत सीमा के सक्षम परागणकर्ता हैं। यह अध्ययन, जातिवृत्तीय एवं विकास संबंधी अध्ययनों का मार्ग प्रशस्त करेगा। वैसे भविष्य में होने वाले अध्ययनों में हैलिवटाइडी कुल के सदस्यों के विस्तृत सर्वेक्षण की आवश्यकता है ताकि इस समूह के सदस्यों की एक सम्पूर्ण पिक्चर प्राप्त हो सके तथा इस कुल के अन्य सदस्यों के पारस्परिक संबंधों तथा साथ ही निकट संबंधी मक्षिकाओं के जेनेरा के संबंधों का विश्लेषण करने की आवश्यकता है।

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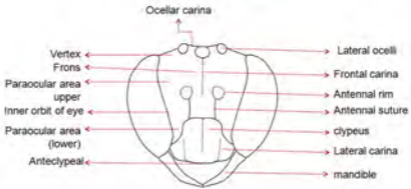
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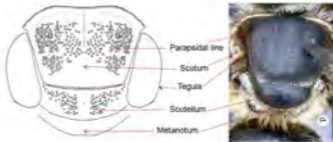
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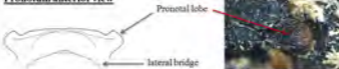
### HEAD FRONT VIEW



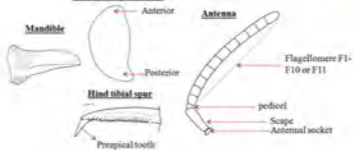
### THORAX DORSAL VIEW



### Pronotum anterior view

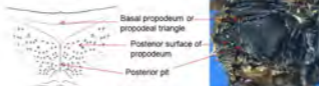


### Left tegula (auriform)



**Figure 22a.** General morphology of Halictidae.

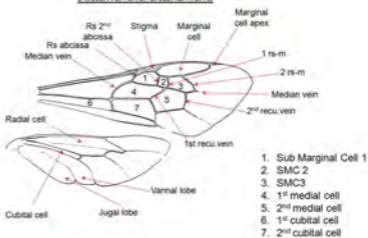
**PROPODEUM POSTERIOR**



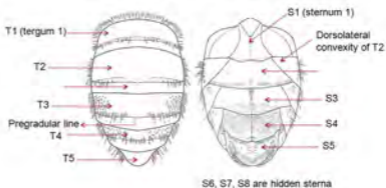
**HINDLEG**



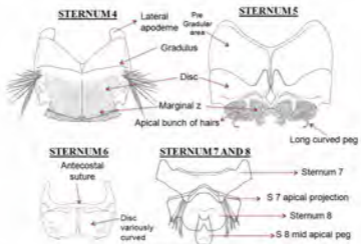
**FOREWING AND HINDWING**



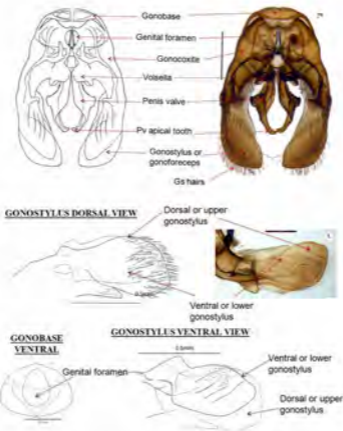
**ABDOMEN DORSAL AND VENTRAL VIEW**



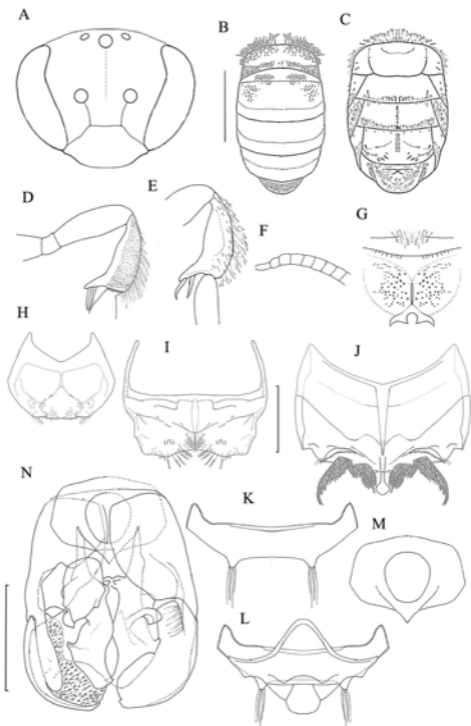
**Figure 22c.** General morphology of Halictidae.



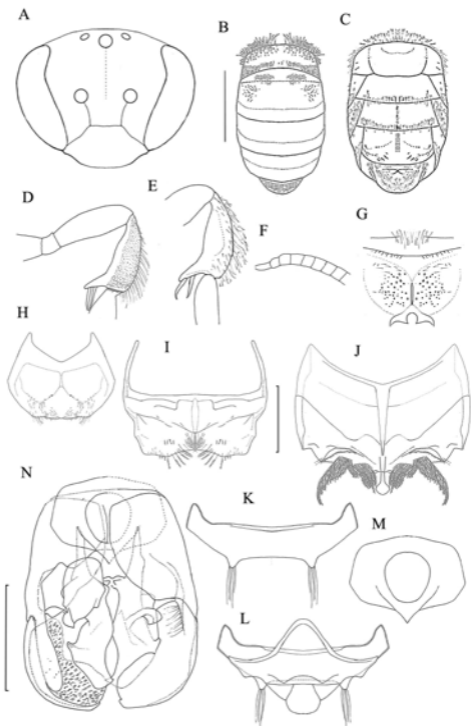
### MALE GENITALIA



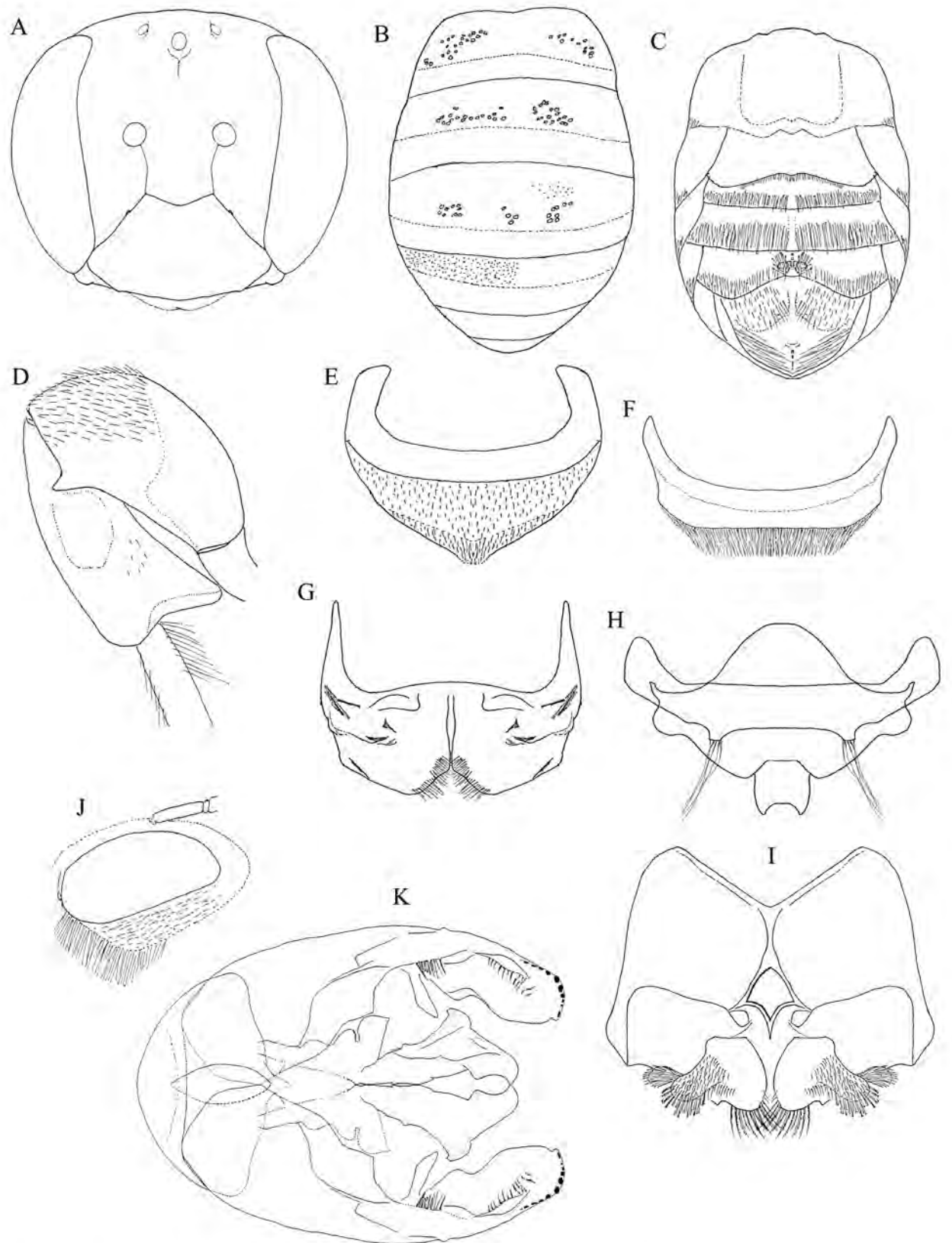
**Figure 22b.** General morphology of Halictidae.



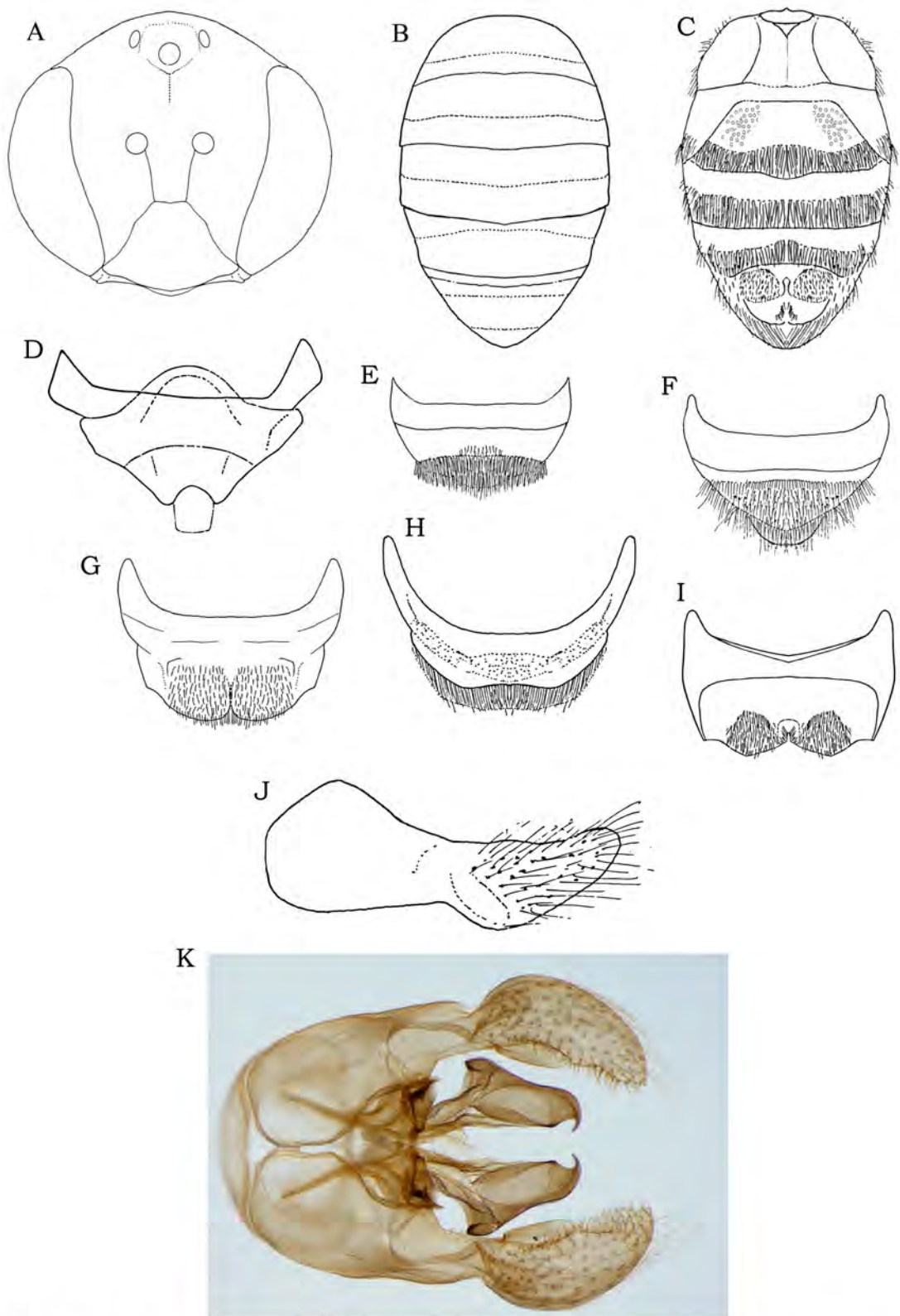
**Figure 8.** *Lipotriches capitata* ♂: (A,B,C) habitus; A, head; B & C, abdomen dorsal & ventral view; D & E, inner & outer hind leg; F, antennal apex; G, propodeum posterior view; H, S4; I, S6; J, S5; K, S7; L, S7 & S8; M, gonobase; N, genitalia dorsal & ventral view.



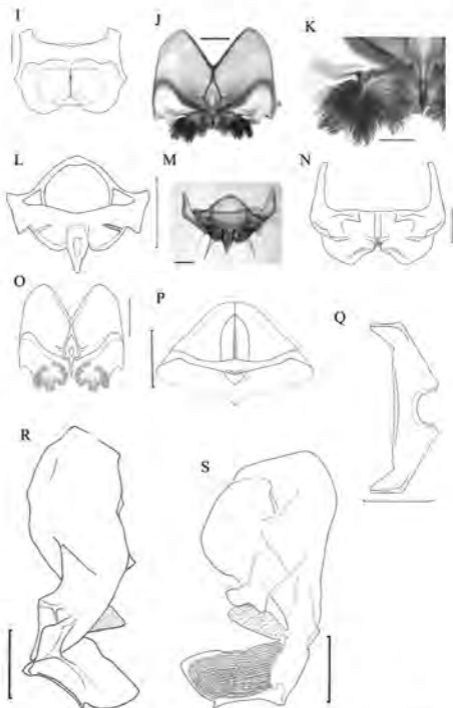
**Figure 8.** *Lipotriches capitata* ♂: (A,B,C) habitus; A, head; B & C, abdomen dorsal & ventral view; D & E, inner & outer hind leg; F, antennal apex; G, propodeum posterior view; H, S4; I, S6; J, S5; K, S7; L, S7 & S8; M, gonobase; N, genitalia dorsal & ventral view.



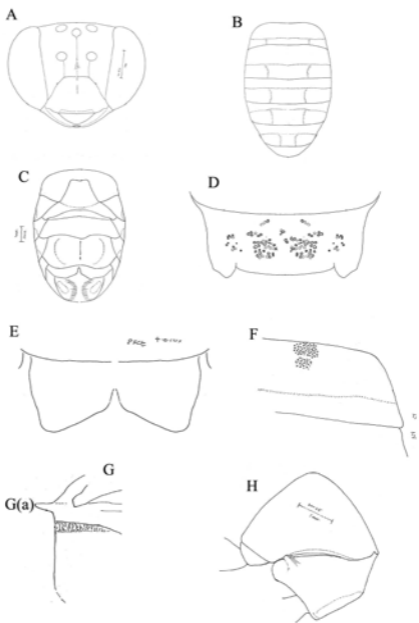
**Figure 9.** *Lipotriches fervida* ♂: (A,B,C) habitus; A, head; B & C, abdomen dorsal & ventral view; D, hind femora & tibia; E, T5; F, T6; G, S6; H, S7 & S8; I, S5; J, lateral head view; K, genitalia dorsal & ventral view.



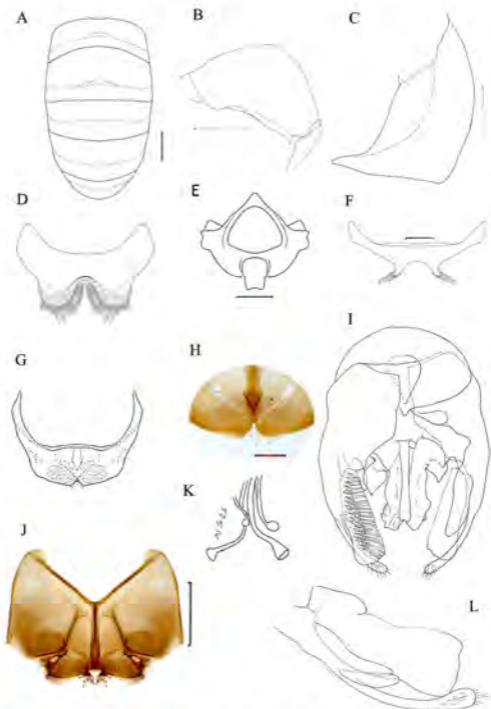
**Figure 10.** *Lipotriches kangrae* ♂: (A,B,C) habitus; A, head; B & C, abdomen dorsal & ventral view; D, S7 & S8; E, T4; F, T5; H, T6; I, S5; J, gonostylus lateral view; K, genitalia.



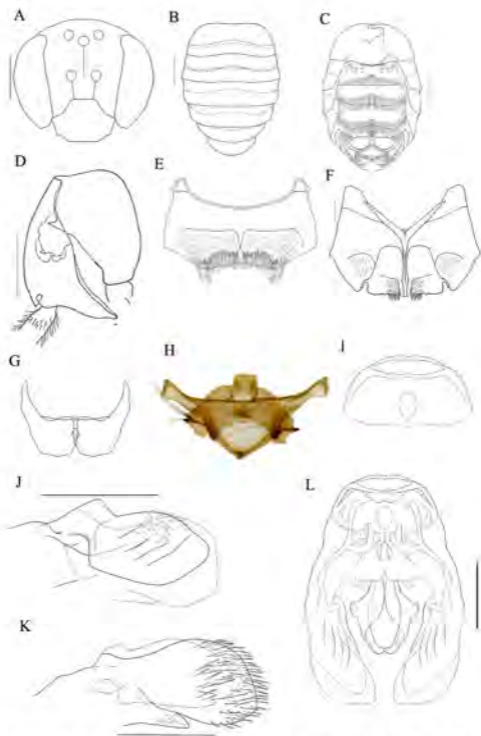
**Figure 1a.** *Nomia buddha* ♂: I, S4; J, S5; K, apical hair bundles of S5; L, S8; M, S7 & S8; N, S6; O, S5; P, gonobase; Q, S7; R, gonostylus lateral view; S, gonostylus ventral view.



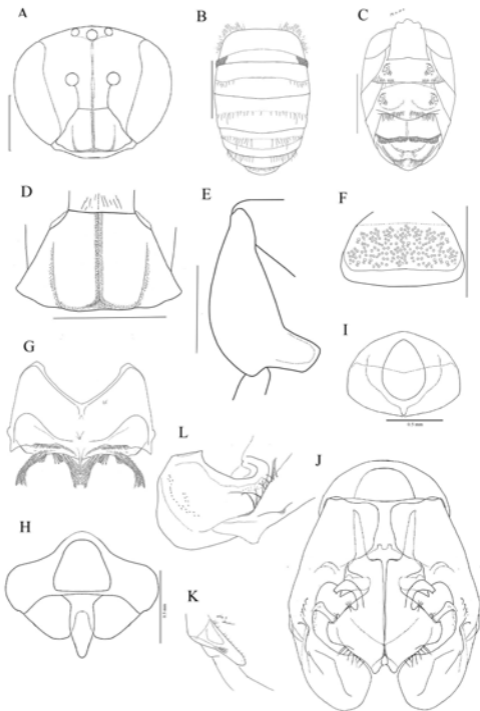
**Figure 1b.** *Nomia buddha* ♂: (A,B,C) Habitus; A, head, anterior view; B & C, abdomen, dorsal & ventral view; D, scutellum; E, metanotum; F, TI punctures; G, propodeum lateral view; G(a), metanotal extension side view; H, hind femur & tibia.



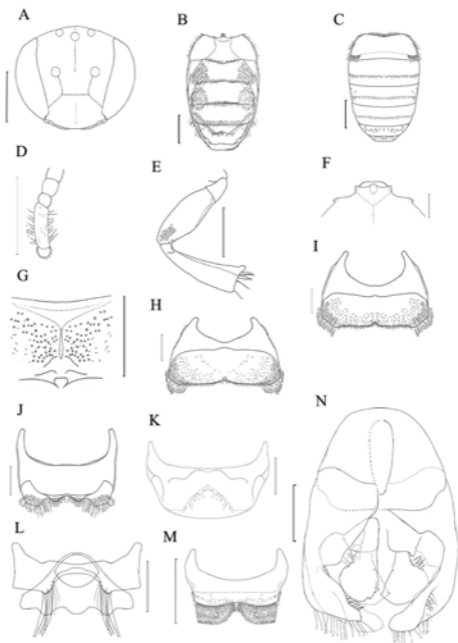
**Figure 3.** *Nomia crassipes* ♂: A, abdomen dorsal view; B, hind femur; C, hind tibia; D, T6; E, S8; F, S7; G, S6; H, S6 mid apex; I, genitalia dorsal & ventral view; J, S5; K, hairs of S5; L, gonostylus lateral view.



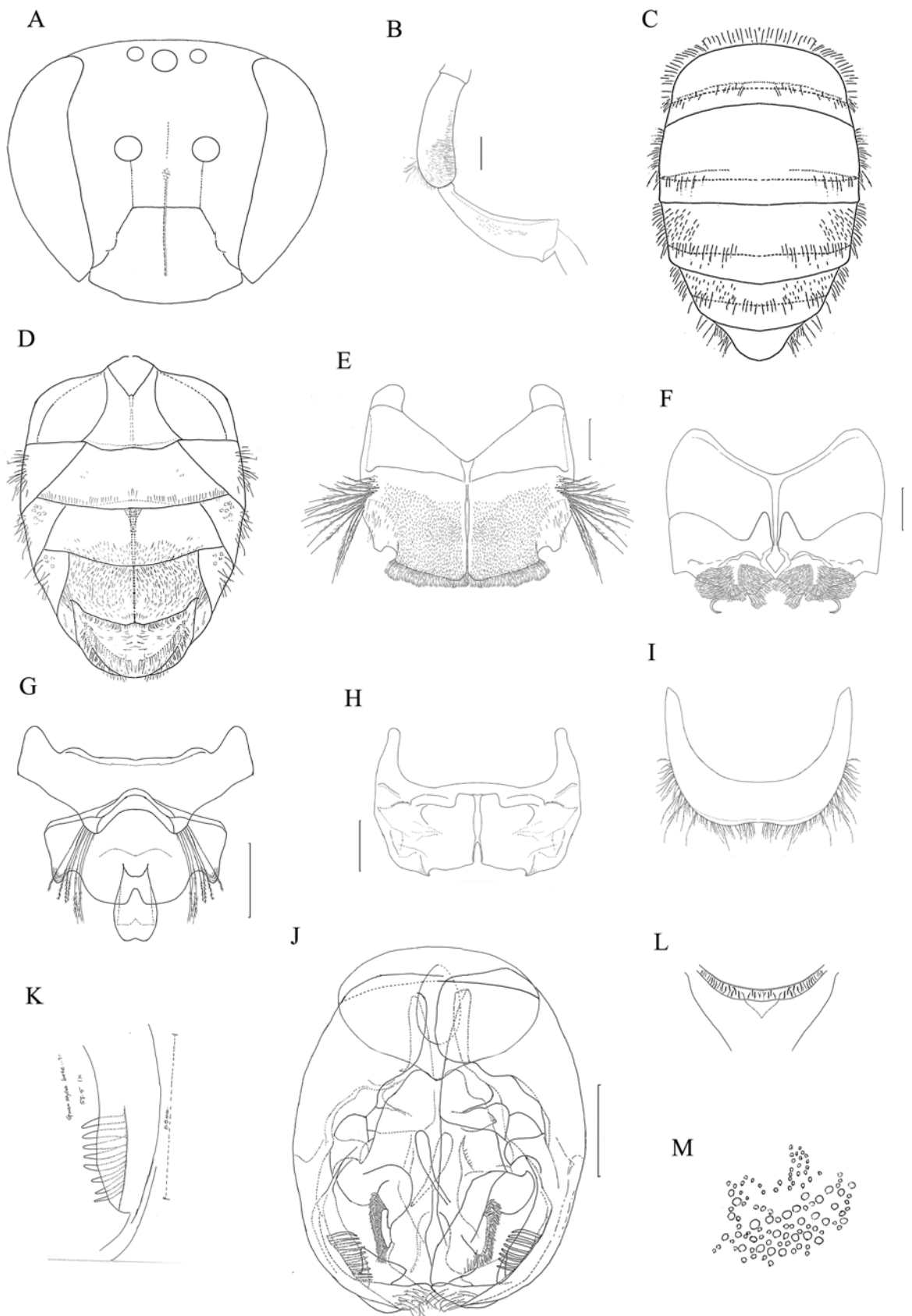
**Figure 2.** *Nomia curvipes* ♂: (A,B,C), habitus; A, head, anterior view, B & C, abdomen dorsal and ventral view; D, hind tibia; E, S4; F, S5; G, S6; H, S7 & S8; I, gonobase; J, gonostylus dorsal view; K, gonostylus ventral view; L, genitalia dorsal & ventral view



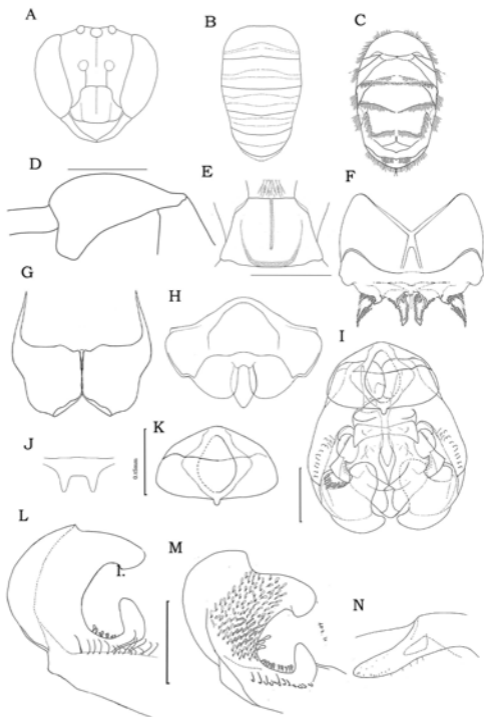
**Figure 4.** *Nomia ellioti* ♂: (A,B,C), habitus; A, head; B & C, abdomen dorsal & ventral view; D, clypeus; E, inner hind tibia; F, T1; G, S5; H, S7 & S8; I, gonobase; J, genitalia dorsal view; K, ventral arm of gonostylus; L, lateral view of gonostylus.



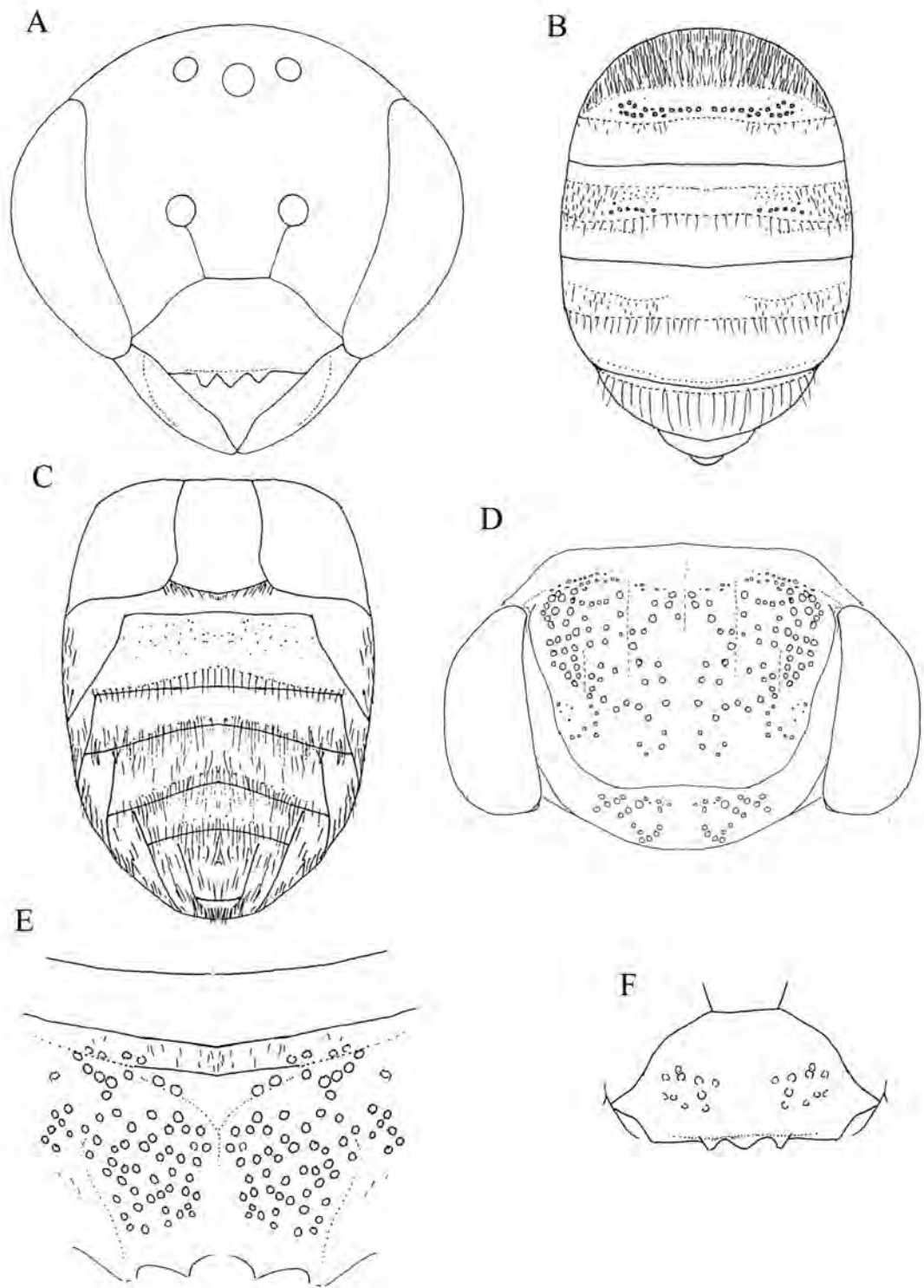
**Figure 5.** *Nomia interstitialis* ♂: (A,B,C), habitus; A, head; B & C, abdomen dorsal & ventral view; D, antennal base; E, hind tibia; F, T1 anterior; G, propodeum posterior view; H, S3; I, S4; J, S5; K, S6; L, S7 & S8; M, T6; N, genitalia dorsal & ventral view.



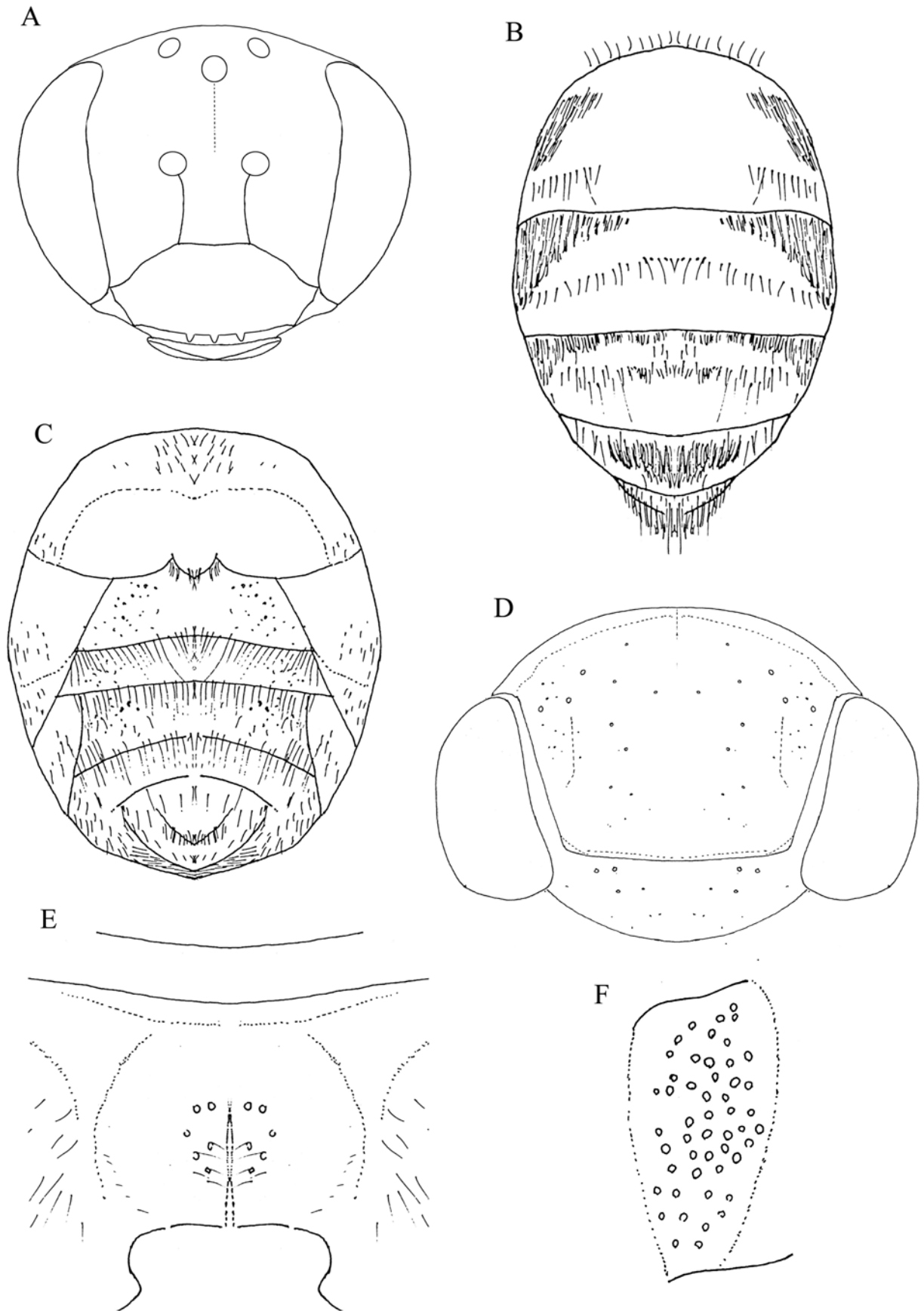
**Figure 6.** *Nomia strigata* ♂: (A,C,D), habitus; A, head; B, hind leg; C & D, abdomen dorsal and ventral view; E, S4; F, S5; G, S7; H, S6; I, T7; J, genitalia dorsal & ventral view; K, gonostylus; L, basal propodeum; M, punctures of scutum.



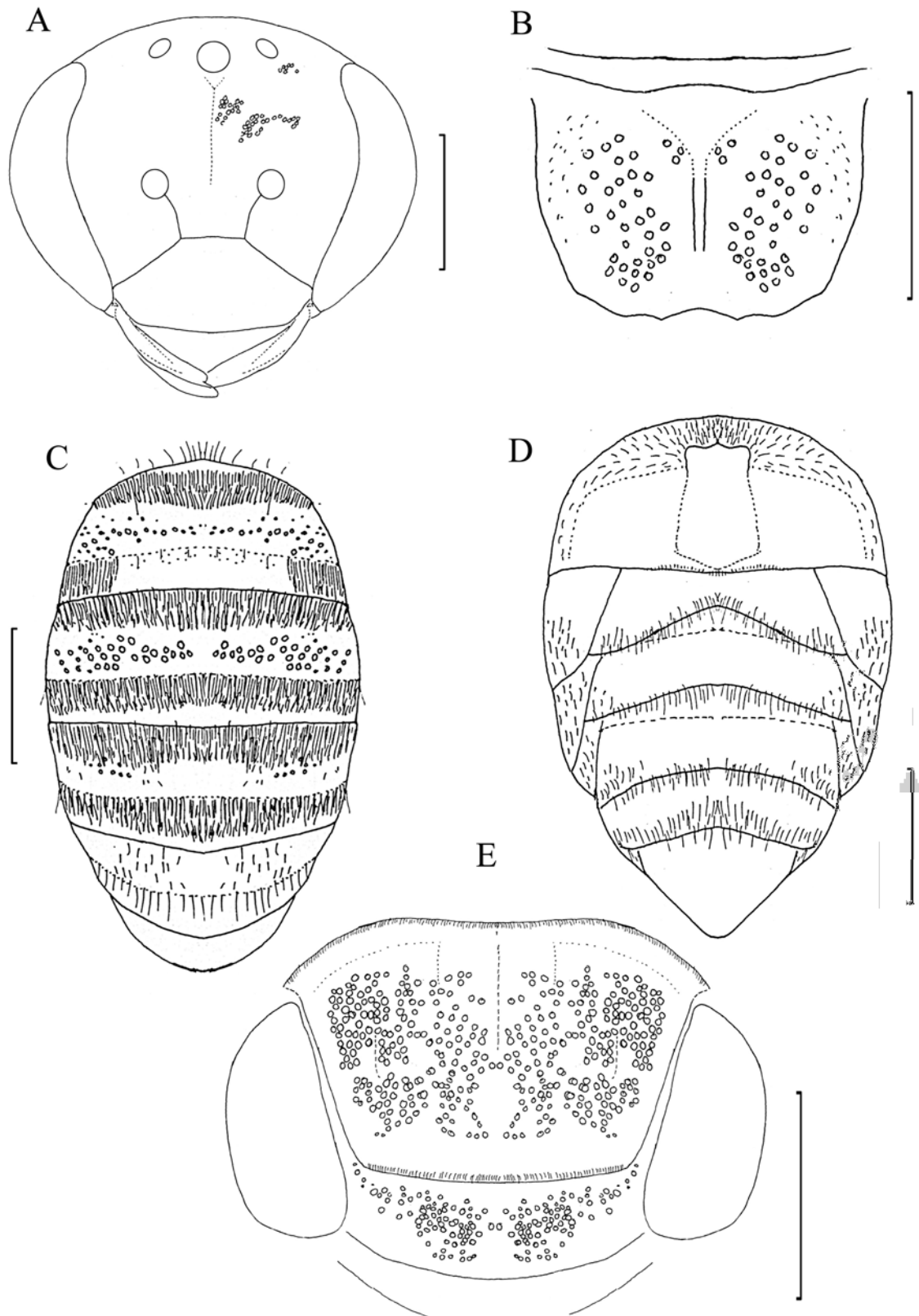
**Figure 7.** *Nomia westwoodi* ♂: (A,B,C), habitus; A, head; B & C, abdomen dorsal & ventral view; D, inner hind tibia; E, clypeus; F, S5; G, S6; H, S7 & S8; I, genitalia dorsal & ventral view; J, metanotal spine; K, gonobase; L & M, gonostylus dorsal & ventral view; N, ventral arm of gonostylus.



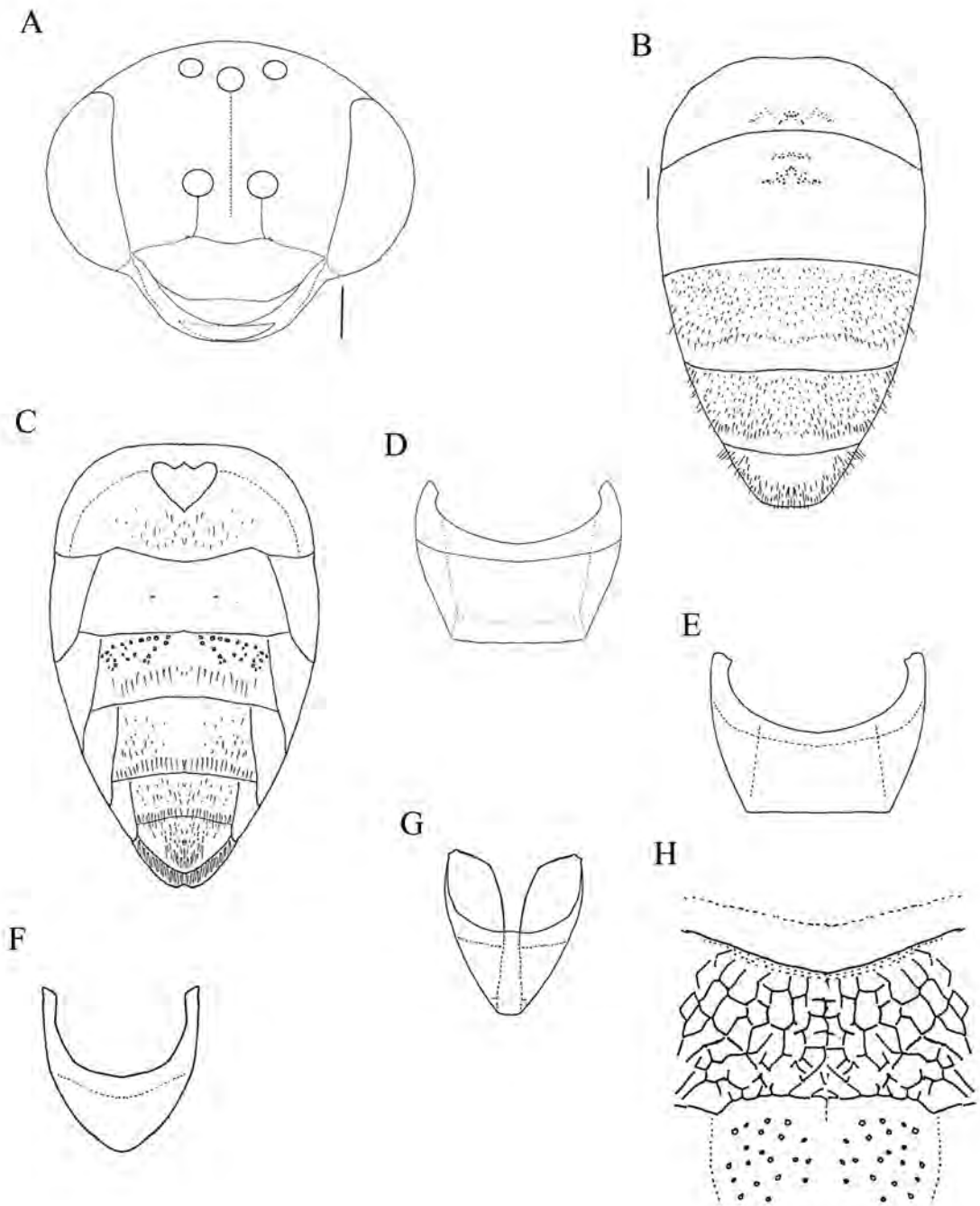
**Figure 11.** *Pseudapis edentata* ♀: (A,B,C), habitus; A, head; B & C, abdomen dorsal & ventral vie; D, scutum & scutellum; E, propodeum posterior view; F, clypeus.



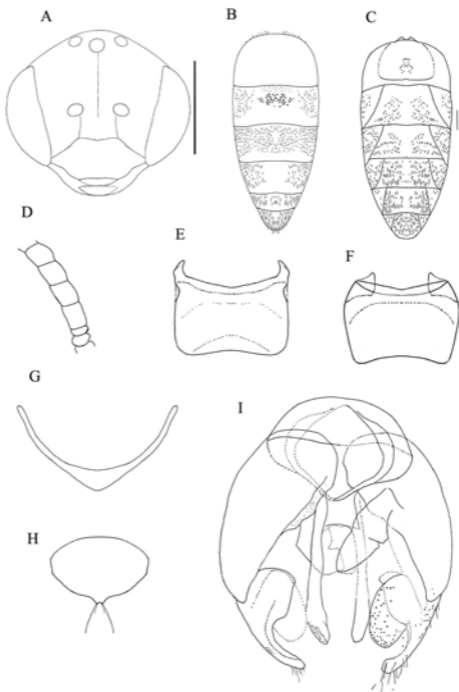
**Figure 12.** *Pseudapis indorensis* sp.nov. ♀: (A,B,C), habitus; A, head; B & C, abdomen dorsal & ventral view; D, scutum and scutellum; E, propodeum posterior view; F, propodeum lateral view.



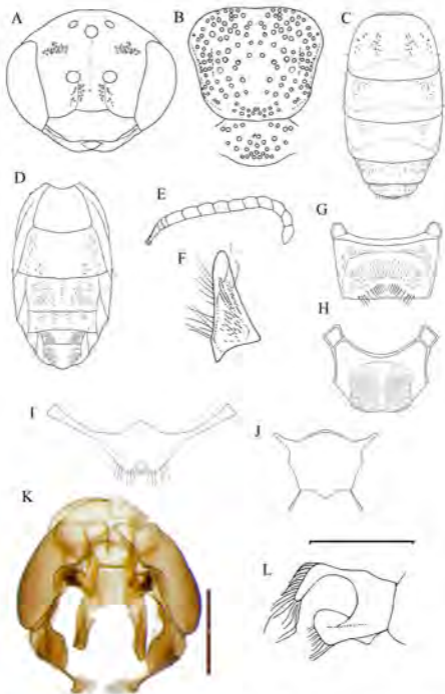
**Figure 13.** *Pseudapis oxybeloides* ♀: (A,C,D), habitus; A, head; B, propodeum posterior view; C & D, abdomen dorsal & ventral view; E, scutum & scutellum. scale bar = 1mm.



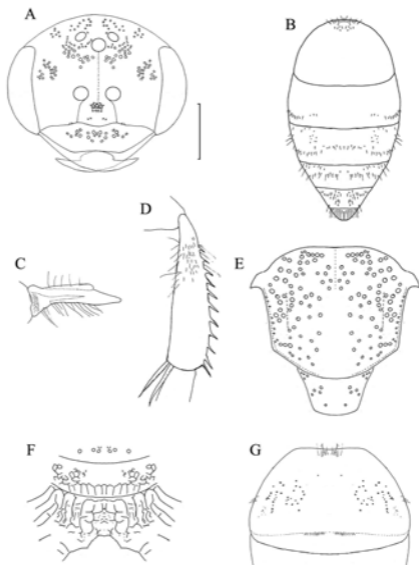
**Figure 19a.** *Sphecodes crassicornis* ♀: (A,B,C), habitus; A, head; B & C, abdomen dorsal & ventral view; D, T4; E, T5; F, T6; G, T7; H, propodeum dorsal & posterior view.



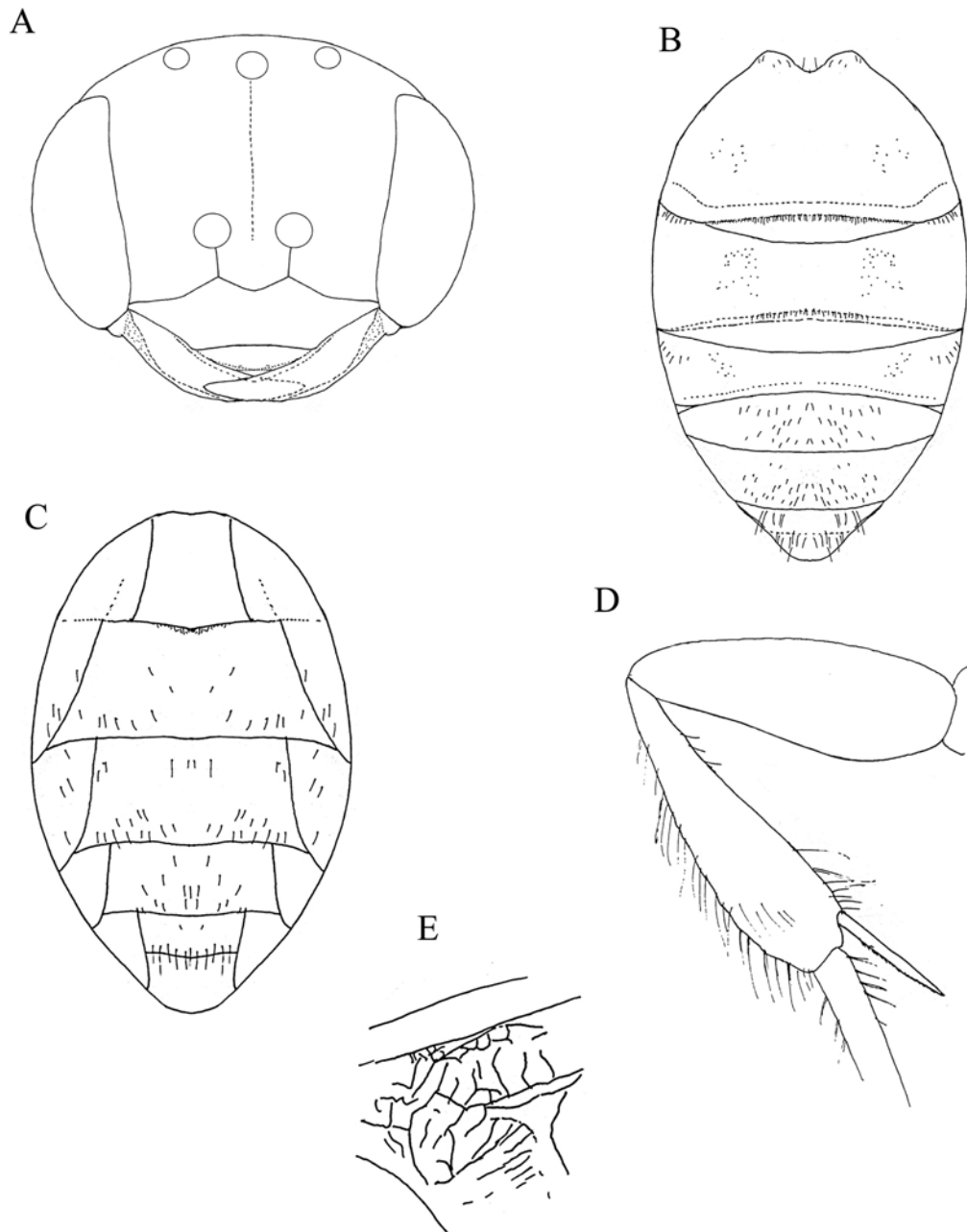
**Figure 19b.** *Sphecodes crassicornis* ♂: (A,B,C), habitus; A, head; B & C, abdomen dorsal & ventral view; D, pedicel flagellomere (F1-F5); E, S5; F, S6; G, S7; H, S8; I, genitalia dorsal & ventral view.



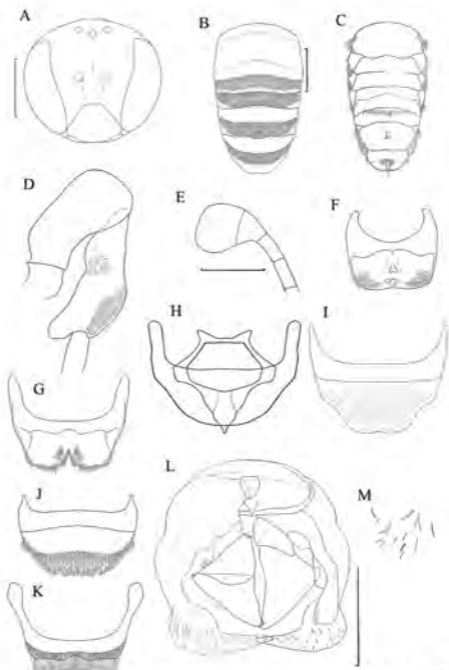
**Figure 20b.** *Sphecodes gibbus* ♂: (A,B,C) habitus; A, head; B, scutum; C & D, abdomen dorsal & ventral; E, antenna; F, mandible; G, S5; H, S6; I, S7; J, S8; K, genitalia; L, lateral view of gonostylus.



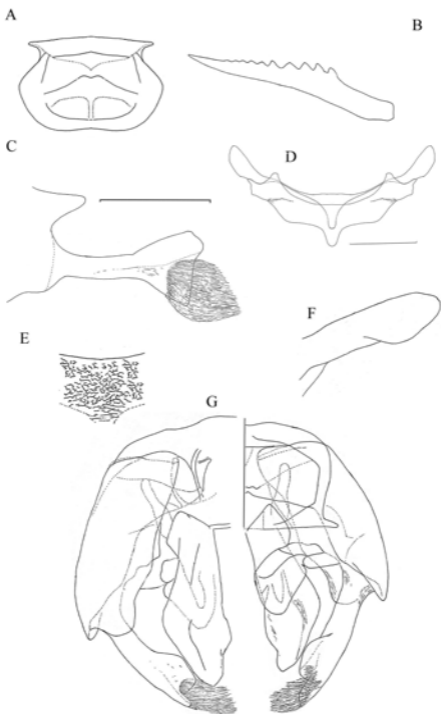
**Figure 20a.** *Sphecodes gibbus* ♀: A, head, anterior view; B, abdomen dorsal view; C, mandible; D, hind tibia; E, scutum & scutellum; F, propodeum posterior view; G, T1.



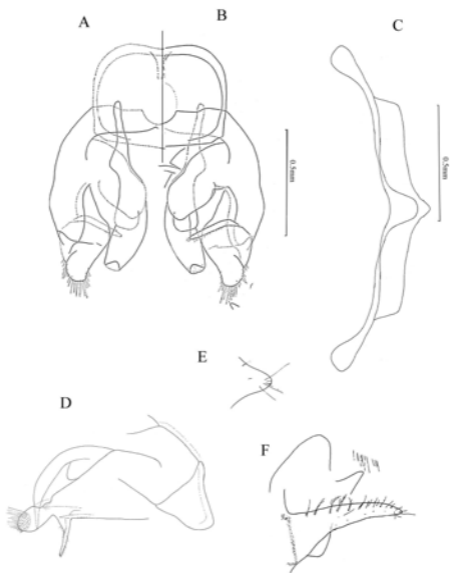
**Figure 21.** *Sphecodes irridipennis* ♀: (A,B,C), habitus; A, head; B & C, abdomen dorsal and ventral view; D, hind femur & tibia; E, latero posterior view of propodeum.



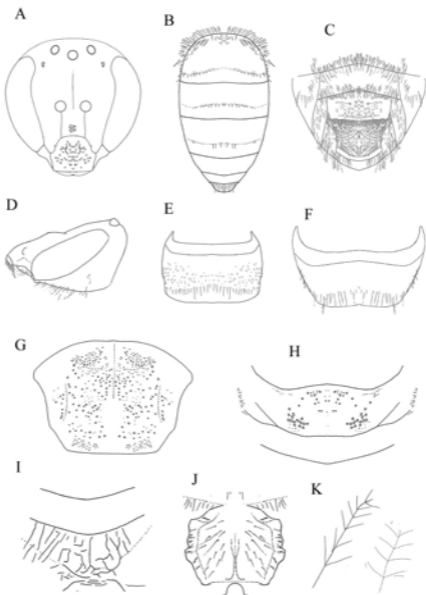
**Figure 14.** *Steganomus bipunctatus* ♂ : (A,B,C), habitus; A, head, B & C, abdomen dorsal & ventral view; D, hind femur and tibia; E, antennal apex; F, S5; G, S6; H, S7&S8; I, T4; J, T5; K, T6; L, genitalia dorsal & ventral view; M, hairs of gonostylus.



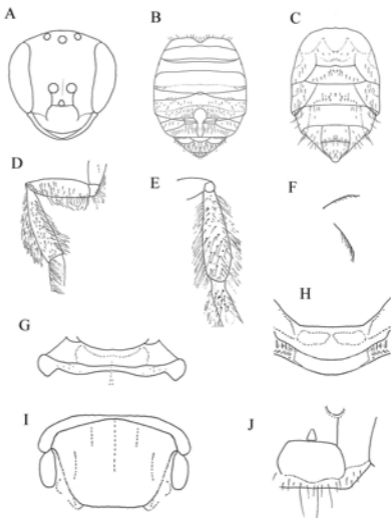
**Figure 16.** *Halictus brunnescens* ♂: A, S6; B, hind tibial spur; C, gonostylus lateral view; D, basal propodeum; E, S7 & S8; F, lateral apex of S7; G, genitalia dorsal and ventral view.



**Figure 17.** *Halictus fimbriatus* ♂: A & B, genitalia dorsal & ventral view; C, S7 & S8; D, gonostylus lateral view; E, S8 mid apex; F, gonostylus ventral arm.



**Figure 18.** *Lasioglossum albescens* ♂ : (A, B, C, D), habitus; A, head; B, abdomen dorsal view; C, abdomen ventral apex; D, head lateral view; E, T4; F, T5; G, scutum; H, scutellum; I, basal propodeum; J, propodeum posterior view; K, hairs of propodeum.



**Figure 15.** *Nomioides fortunatus* ♀: (A,B,C), habitus; A, head; B & C, abdomen dorsal & ventral view; D, inner hind leg; E, outer hind tibia; F, tibial hairs; G, pronotum; H, scutellum & metanotum; I, scutum; J, clypeus.



Figure 1. Micrographs of the larval stages of the insect species under study, showing morphological details.



Figure 1. The growth and development of the plant from a seedling to a mature plant with flowers.



Figure 1. Examples of jewelry designs created by the students. The jewelry was made using recycled materials and was displayed at the school's annual art and craft fair.



Figure 1. The golden, ornate object, likely a ceremonial vessel or a piece of jewelry, set against a dark blue background.

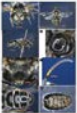


Figure 1: A sequence of images showing the launch of a rocket. The images are arranged in a grid, showing the rocket ascending from the launch pad, the launch pad itself, and the rocket in flight.



Figure 1. Micrographs showing the cross-section of a biological specimen under different conditions.



Figure 1. Eight different species of tangs (Acanthuridae) from the Pacific Ocean. The fish are shown in a dark, possibly underwater, environment.



Figure 1. Various types of insects, including bees, ants, and beetles.



Figure 1. Radiographic and clinical images of a tooth with a root canal filling.



Figure 1. Developmental stages of the specimen. (a) Stage 1, circular view; (b) Stage 2, side view; (c) Stage 3, side view; (d) Stage 4, side view; (e) Stage 5, side view; (f) Stage 6, side view; (g) Stage 7, circular view; (h) Stage 8, circular view.



Figure 1. Life cycle of a tick. The tick is a blood-sucking arthropod that can transmit various pathogens to its hosts. The life cycle of a tick is divided into several stages: egg, larva, nymph, and adult. The tick is most active during the summer and autumn months.



Figure 1. A series of eight images showing a person's face and hands in various stages of a forensic or medical examination. The images are arranged in a 4x2 grid. The top row shows a close-up of a person's face with a white mask or bandage covering the eyes and nose, and a close-up of a person's face with a white mask or bandage covering the eyes and nose. The second row shows a close-up of a person's face with a white mask or bandage covering the eyes and nose, and a close-up of a person's face with a white mask or bandage covering the eyes and nose. The third row shows a close-up of a person's face with a white mask or bandage covering the eyes and nose, and a close-up of a person's face with a white mask or bandage covering the eyes and nose. The bottom row shows a close-up of a person's face with a white mask or bandage covering the eyes and nose, and a close-up of a person's face with a white mask or bandage covering the eyes and nose.



Figure 1. Various stages and types of bird eggs.



Figure 1. Dorsal and ventral views of the shell of *Hydrobia ulvae* (L.) (Gastropoda: Littorinidae) showing the characteristic shape and coloration. The images illustrate the external morphology of the shell, including the aperture and the overall form.



Figure 1. The life cycle of a fly. The fly starts as a cluster of eggs, which hatch into larvae. The larvae grow and develop into pupae, which then emerge as adult flies.

Figure 1 illustrates the life cycle of a fly, showing the progression from a cluster of eggs to a larva, then a pupa, and finally an adult fly. The fly starts as a cluster of eggs, which hatch into larvae. The larvae grow and develop into pupae, which then emerge as adult flies.



Figure 1. The life cycle of a butterfly. The stages are: 1. Egg, 2. Caterpillar, 3. Pupa, 4. Adult butterfly.



Figure 1. The growth of mold on a slice of bread over time. The mold starts in the center and spreads outwards, eventually covering the entire slice. The color of the mold changes from dark brown/black to yellow and orange.



Figure 1. Internal structure of the shell of *Hydrobia ulvae* (L.) (Gastropoda, Littorinidae) showing the siphon (a), the body of the animal (b), the siphon (c), the body of the animal (d), the siphon (e), the body of the animal (f), the siphon (g), and the body of the animal (h).



Figure 1. The bird's head and neck. The left column shows the bird's head and neck in profile, and the right column shows the bird's head and neck in a different view. The top row shows the bird's head and neck in a close-up view, and the bottom three rows show the bird's head and neck in a more distant view.



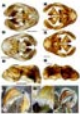


Figure 1. Histological sections showing various stages of cellular morphology and staining, likely related to a pathology or microbiology study.

Figure 1. Histological sections showing various stages of cellular morphology and staining, likely related to a pathology or microbiology study.



Figure 1. The progression of mold growth on a piece of fabric over time. The mold starts as a small, faint mark and gradually expands and darkens, illustrating the process of mold growth.



Figure 1. The following are the most common fish species found in the Chesapeake Bay.

Source: <https://www.fishbase.org/species/summary?region=US&order=popularity>



Figure 1: A grid of ten small images showing various objects, including a globe, a striped sphere, and a globe with a grid.



Figure 1. The process of cell division and tissue development. The images show the progression from a single cell to a cluster of cells, and finally to a more organized structure. The labels 'a' through 'h' indicate the different stages of the process.



Figure 1. Kidney anatomy. a) Coronal section showing the renal cortex, medulla, and pelvis. b) Coronal section showing the renal cortex, medulla, and pelvis. c) Coronal section showing the renal cortex, medulla, and pelvis. d) Coronal section showing the renal cortex, medulla, and pelvis. e) Coronal section showing the renal cortex, medulla, and pelvis. f) Coronal section showing the renal cortex, medulla, and pelvis.



1. *Ascaris suum* (pig roundworm)  
 2. *Trichostrongylus axei* (stomach worm)  
 3. *Ostertagia circumcincta* (brown stomach worm)  
 4. *Haemonchus contortus* (giant esophageal worm)  
 5. *Trichostrongylus colubriformis* (intestinal worm)  
 6. *Trichostrongylus colubriformis* (intestinal worm)  
 7. *Trichostrongylus axei* (stomach worm)  
 8. *Trichostrongylus axei* (stomach worm)  
 9. *Trichostrongylus axei* (stomach worm)  
 10. *Trichostrongylus axei* (stomach worm)



Figure 1. Fossilized skulls and skeletons of early hominids.



Figure 1. The life cycle of the honey bee (*Apis mellifera*) showing the stages of development from egg to adult.



Figure 1: A 2x2 grid of images showing a person's face in different poses, with a larger image below showing a close-up of a mouth.



Figure 1. The figure shows eight different exercises that can be performed with a medicine ball. The exercises are: 1. Squat, 2. Lunge, 3. Squat, 4. Lunge, 5. Squat, 6. Lunge, 7. Squat, 8. Lunge.

Source: Adapted from [1].



Figure 1. The figure shows the external and internal views of the shell of the mollusk, including the hinge area and the siphon.



Figure 1. The figure shows the process of creating a small, dark, textured object. The images are arranged in a 2x4 grid, showing the hands of the person working on the object. The top-left image shows a close-up of the hands holding the object. The top-right image shows the hands holding the object with a white vertical line in the background. The second row shows the hands working on the object with various tools and materials. The third row shows the hands working on the object with a blue background. The bottom row shows the hands working on the object with a blue background.



Figure 1. A series of 12 images showing a person's hands holding a glowing yellow object, likely a piece of evidence or a specimen, in various orientations and lighting conditions.



Figure 1. Life cycle of the housefly (Musca domestica) showing the stages of larval development and pupation.



Figure 1. (a) Axial CT scan of the head showing a large, dark, irregular mass in the posterior region. (b) Axial CT scan of the head showing a large, dark, irregular mass in the posterior region. (c) Coronal MRI scan of the head showing a large, dark, irregular mass in the posterior region. (d) Axial MRI scan of the head showing a large, dark, irregular mass in the posterior region. (e) Axial MRI scan of the head showing a large, dark, irregular mass in the posterior region. (f) Axial MRI scan of the head showing a large, dark, irregular mass in the posterior region. (g) Axial MRI scan of the head showing a large, dark, irregular mass in the posterior region.

Figure 1. (a) Axial CT scan of the head showing a large, dark, irregular mass in the posterior region. (b) Axial CT scan of the head showing a large, dark, irregular mass in the posterior region. (c) Coronal MRI scan of the head showing a large, dark, irregular mass in the posterior region. (d) Axial MRI scan of the head showing a large, dark, irregular mass in the posterior region. (e) Axial MRI scan of the head showing a large, dark, irregular mass in the posterior region. (f) Axial MRI scan of the head showing a large, dark, irregular mass in the posterior region. (g) Axial MRI scan of the head showing a large, dark, irregular mass in the posterior region.



Figure 1: A collage of seven small images showing various pieces of jewelry, including necklaces, earrings, and bracelets, arranged in a grid pattern.



Figure 1. Comparison of the experimental results with the numerical simulation results for the turbine component.

Figure 1. Comparison of the experimental results with the numerical simulation results for the turbine component.



Figure 1. The process of making a traditional woven basket.



The honey bee's mouthparts are used to collect nectar from flowers and to produce honey. The honey bee's mouthparts are used to collect nectar from flowers and to produce honey. The honey bee's mouthparts are used to collect nectar from flowers and to produce honey.

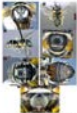


Figure 1. A sequence of images showing a person's face in various expressions and poses, likely for a facial recognition or animation study.



Figure 1. The figure shows eight small images arranged in a 2x4 grid, illustrating various stages or poses of a biological specimen, likely a larva or insect, in different environments.



Figure 1. Life cycle of an insect. The stages shown are: (1) Egg, (2) Larva, (3) Pupa, and (4) Adult. The adult stage is shown in four different views: (4a) Dorsal view, (4b) Ventral view, (4c) Lateral view, and (4d) Frontal view.

Source: Adapted from [1].



Figure 1. Coat color inheritance in dogs. The color of a dog's coat is determined by the presence of the dominant allele (B) and the recessive allele (b). The dominant allele (B) produces black pigment, while the recessive allele (b) produces brown pigment. The color of a dog's coat is determined by the combination of alleles it inherits from its parents. A dog with two dominant alleles (BB) will have a black coat, a dog with one dominant and one recessive allele (Bb) will have a black coat, and a dog with two recessive alleles (bb) will have a brown coat.



Figure 1. Insects in various poses and colors.



1. The dog's face is shown in a close-up view.

2. The dog's face is shown in a close-up view.

3. The dog's face is shown in a close-up view.

4. The dog's face is shown in a close-up view.



The image shows a golden eagle with its wings spread, set against a blue background. The eagle is shown from various angles, including front, back, and side views, and is surrounded by a circular frame.



Fig. 1. (a) Dorsal view of the head capsule of the larva of *Stenobothrus* sp. n. (b) Ventral view of the head capsule of the larva of *Stenobothrus* sp. n. (c) Lateral view of the head capsule of the larva of *Stenobothrus* sp. n. (d) Dorsal view of the head capsule of the larva of *Stenobothrus* sp. n. (e) Lateral view of the head capsule of the larva of *Stenobothrus* sp. n. (f) Ventral view of the head capsule of the larva of *Stenobothrus* sp. n. Scale bars: (a) 0.1 mm, (b) 0.1 mm, (c) 0.1 mm, (d) 0.1 mm, (e) 0.1 mm, (f) 0.1 mm.



Figure 1. Microscopic images of cells in various stages of mitosis. The images show the progression from prophase to telophase and cytokinesis.

Source: Adapted from a public domain image.



Figure 1. A sequence of images showing a person's face from different angles and distances, used for facial recognition.

