

**TAXONOMIC STUDIES ON THE
SPHECIFORMES (HYMENOPTERA: APOIDEA)
OF KERALA**

Thesis Submitted

To

**The University of Calicut
For the award of the degree of
DOCTOR OF PHILOSOPHY
in ZOOLOGY**

By

Baaby Job



Under guidance of

Dr. Joseph Louis Olakkengil

**P. G. AND RESEARCH DEPARTMENT OF ZOOLOGY
ST. THOMAS COLLEGE, THRISSUR
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DECLARATION

I do hereby declare that the thesis entitled “*TAXONOMIC STUDIES ON THE SPHECIFORMES (HYMENOPTERA: APOIDEA) OF KERALA*” submitted to University of Calicut for the award of **DOCTOR OF PHILOSOPHY IN ZOOLOGY** included the data generated by the original research by me under the supervision and the guidance of Dr. Joseph Louis Olakkengil, Rtd. Reader and Former HOD, Department of Zoology, St. Thomas College, Thrissur. The work has not been submitted to any University or Institution for the award of any degree, diploma or title. I further declare that the findings of this research contribute in general to the advancement of Knowledge in Science and in particular to the Spheciformes of Kerala.

Baaby Job

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Dedicated
To the fond memories
my Pappa, &
To my Sir
(Late) Dr. T.C. Narendran

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Chapter 1

INTRODUCTION

'Biodiversity' is currently emerging as a new aspect of human life. This biodiversity is now depleting as natural habitats are being destroyed at an alarming rate. Our precious natural resources are vanishing, yet resource required to make a systematic survey and studies are insufficient for current needs. It has become imperative to study the insect fauna of our country as early as possible before they vanish (extinct) due to large scale destruction and fragmentation. However it is not possible or practicable to study the taxonomy of all the insect fauna all on a sudden basis. Hence it is necessary to choose groups of greatest importance for priority study. Hymenoptera is one such group. It not only forms a major component of diversity in itself, but is also a vital group in sustaining diversity in other groups. To have a deep knowledge on biological diversity of Hymenoptera, it is necessary as a first step to undertake a taxonomic study of the various families belonging to Hymenoptera, since all other studies concerning Biology, Ecology, Conservation, Genetics etc. rely upon a foundation of good taxonomy (Narendran, 2001)

1.1. HYMENOPTERA: CURRENT STATUS

Hymenoptera is one among the four largest insect orders, with about 1, 30, 000 described species in the world. They are the major pollinators, seed dispersers, predators and parasitoids. They account for 44% of prey links and 57% of all insect predation on other insects (Hawkins and Lawton, 1987). In India about 11, 000 species have been described from almost all ecosystems, thereby contributing to nearly 8.5% of the total hymenoptera population (Alfred *et. al.*, 1998; Narendran, 2001).

The order Hymenoptera is divided into two suborders- the Symphyta and the Apocrita. The Apocrita are commonly divided into two groups, Aculeata and Parasitica. The Aculeata have their ovipositor modified into a retractable sting and is not used for egg-laying, where as in Parasitica the ovipositor is non- retractile and

used only for egg-laying. The Aculeata includes the familiar ants, wasps and bees grouped into three Superfamilies: Vespoidea, Apoidea and Chrysidoidea (Mason and Huber, 1993). The superfamily Apoidea has been divided into two informal series- the Apiformes which includes the bees and the Spheciformes including the solitary sphecid wasps.

1.2. THE WORLD OF SPHECIFORMES: AN OVERVIEW

The Spheciformes or Sphecoid or sphecid or apoid wasps, as they have been called by several authors, fails to be generalized under a single common name, but include groups such as digger wasps, sand wasps, thread waisted wasps and mud-dauber wasps. Many are brightly coloured, conspicuous and fast moving, showing great variation in size, appearance, prey choice and nesting behaviour. Majority of these solitary wasps are predators, but some are cleptoparasites (*Stizoides* Guérin-Méneville) and parasitoids (*Larra* Fabricius and *Chlorion* Latreille). Their interesting behaviour patterns, prey capture techniques, nest construction etc. have made them favourite and familiar subjects of taxonomists, ethologists as well as lay men.

The sphechids form a monophyletic assemblage of wasps with 9716 described species coming under 318 genera. In the current system of classification being followed, they come under the Order Hymenoptera, Suborder Apocrita, Super family Apoidea with five included families- Heterogynaidae, Ampulicidae, Sphecidae and Crabronidae, together with Apoidea, the bees (Pulawski,2013).

1.2.1. Diagnostic Features

Sphecid wasps, although similar to bees, wasps and pompilids, can be readily distinguished from them by the following features.

a) Sphechids and bees: Sphecid wasps can be easily distinguished from their closest relatives' bees by the presence of golden and silvery hairs on the lower face, causing the face to glitter in the sunlight. Bees do not show this feature, as their facial hairs are dull. The sphecid wasps possess a cleaning pectan or brush on the inner side of hind

basitarsus, opposed to a pectinate inner hind tibial spur. This feature is absent in bees. In sphecids the hind basitarsus is the same width as succeeding tarsomeres, while in bees the hind basitarsus is much broader and flattened than succeeding tarsomeres. The other major distinctive character is the presence of branched or plumose hairs in bees, while the hairs of sphecids are always simple, unbranched. Biologically, the sphecid wasps feed their larva with paralyzed arthropods, while bees feed their larva with honey.

b) Sphecids and vespids: Sphecids can be distinguished from the true wasps of Vespoidea, in having a well developed, rounded pronotal lobe, where as in vespids pronotal lobe is weak or absent. Sphecid wasps lack the wing folding mechanism of vespids. The inner orbits are characteristically deeply notched in vespids, but inner orbits are usually entire in sphecids, except in Trypoxylonini and Philanthini.

c) Sphecids and pompilids: Pompilids and some sphecids (Sceliphirini) utilize spiders as their prey and show similar behavior patterns. But they can be distinguished by the feature that, in pompilids pronotum is not firmly joined to mesothorax and is capable of considerable movement, while in sphecids, the pronotum is immovably joined to mesothorax. Also the hind wing venation pattern of sphecid and pompilids is quite distinct.

1.2.2. Sphecids in fossil records

Sphecid wasps are supposed to have evolved from a scoliid ancestor and expected to be originally associated with soil. The oldest known fossil record is that of *Archisphex crowsoni*, excavated from the lower Cretaceous amber of Canada and Siberia, resembling Pemphredine wasps (Evans, 1969). According to paleontological evidence the diversification of these wasps has taken place earlier in the Cretaceous (Bennett and Engel, 2006) and the highest number of fossils have been recovered from the Miocene of Coenozoic era (Bohart and Menke. 1976).

1.2.3. Zoogeography

Most of the genera of sphecid wasps are cosmopolitan, with representations in all the continents, except the poles. Certain genera have uneven distribution range, for eg: *Chalybion* Dahlbom is an Old world genus, but represented by two species in the New world; genus *Bembix* Fabricius of the tribe Bembicini is cosmopolitan, but all the other eighteen genera of this tribe is restricted to South America (Bohart and Menke, 1976). The genus *Nesomimesa* Malloch and *Deinomimesa* Perkins are endemic to Hawaii, so is genus *Hovanysson* Arnold to Madagascar. Some species occupy broad ranges, for eg; *Sphex argentatus* Fabricius is distributed from India to Japan and Australia. The distribution patterns of some sphecid wasps (Trypoxylonini) is mainly attributed to human influence, as many species nests in man- made structures and have moved along with them.

1.2.4. Nesting behavior

The general life style of solitary wasps consists of a lone female mating and then provisioning one or more nests, containing one or more cells with food for her young. Depending upon location, nests are of two types - underground nests and above ground nests, usually associated with human dwellings. Nests excavated in soil are the most common type of nests. They can either be simple, unbranched shallow tunnels terminating in single brood cell (*Ammophila* Kirby) or branched tunnels with side tunnels leading to as many as one- two brood cells (*Tahcysphex* Panzer). Above ground nests can be free standing nests constructed of mud (*Sceliphron* Klug, *Chalybion* Dahlbom, *Trypoxylon* Latreille) or of plant materials or silk produced from the body (Pemphredoninae), attached to trees, cliffs or walls of buildings. Some species construct nests in empty shells, crevices, rolled leaves or excavate nest tunnels in plant materials.

Depending on how they acquire their nests, these wasps can be generalized into three categories namely,

a) Squatters: They use holes that are already in existence, often those left behind by wood boring beetles. eg: *Passaloecus* Shuckard.

b) Builders: They create nests from materials collected by themselves. eg: *Sceliphron* Klug, *Chalybion* Dahlbom.

c) Diggers: These wasps dig holes in the grounds as nests. They can again be conveniently grouped into four, depending on how they dig their holes.

I Pushers: These wasps push the soil out of their burrows backwards during digging using flattened pygidium eg: *Cerceris arenaria* (Linnaeus).

II Pullers: These wasps back out of the developing burrow carrying the excavated soil between the underside of their head and forelegs and leave that soil near the entrance. eg: *Mellinus arvensis* (Linnaeus).

III Carriers: These wasps carry the excavated soil beneath their head and forelegs, but they fly off with the soil and deposit it at some distance from the entrance of the nest. eg: *Ammophila pubescens* Curtis.

IV Scrappers: These dig nests by scraping the soil away between their hindlegs using their forelegs or vice-versa. eg. *Oxybelus* Latreille.

1.2.5. Prey provisioning mechanisms

Adult wasps feed on nectar and honey dew, but they provision their nests with arthropods (both larvae and adults) as prey for their larvae. Prey records for sphecids include spiders and insects belonging to the orders Collembola, Ephemeroptera, Odonata, Orthoptera, Psocoptera, Hemiptera, Homoptera, Thysanoptera, Neuroptera, Trichoptera, Lepidoptera, Mecoptera, Coleoptera and Hymenoptera.

Prey is temporarily or weakly paralyzed and carried to nests using any one of the following mechanisms (Evans, 1962). 1 Prey clasped with mandibles is dragged backwards (Ampulicini); 2 Prey held with the mandibles and dragged forwards (*Miscophus* Jurine); 3 Prey held by mandibles and legs, flown to nests (Sphecinae); 4 Prey carried in flight, held only by the midlegs (Nyssonini); 5 Prey carried in flight to nests, but assisted by hindlegs (*Oxybelus* Latreille); 6 Prey carried in flight, but held on the sting (*Oxybelus* Latreille) and 7 Prey grasped by thorax using structures on terminal abdominal segments, called as the ant clasps (*Clypeadon* Patton).

Two types of prey provisioning mechanisms are employed by sphecids- Mass provisioning and Progressive provisioning. Majority of the species are mass provisioners that store cells with one or more prey before the egg hatches. Progressive provisioners continue to bring in prey even after the egg hatches, sometimes until the larva is ready or near to spinning of cocoon. Progressive provisioning is rare and is exhibited by members of the genus *Ammophila* Kirby. Some ground nesting wasps, before departing to hunt, often plug the entrance of the nest temporarily as a means of protection from intruders. The egg is laid either on the first or the last provision, depending on the species, and the nest then permanently closed.

1.2.6. Reproductive and mating strategies

Mating is preceded by a pre-nuptial flight as in *Stictia* Illiger or by a ‘Sand dance’ as in Bembiciniinae, in which hundreds of males swarm over the surface of nesting area, seeking newly emerging females. An alternative strategy is territorial defense which may be defending of nesting or emergence grounds (*Sphecius* Dahlbom, *Philanthus* Fabricius) or hunting areas frequented by females or individual nests that are in the process of being provisioned by the females (*Trypoxylon* Latreille). Territorial defense tactics vary according to species. They may be wrestling, biting, head butting, abdomen slapping or mutual flights in which contestants swirl about one another in dizzying speeds. The reproductive strategies of nest provisioning wasps are different from the parasitoids and brood parasites in the same family. They invest highly in individual offspring and have relatively low life time fecundities. Copulation occurs in air, on plants, grounds or in nests and usually takes place only once (Capinera, 2008).

1.2.7. Sexual dimorphism and Xanthochroism

The sphecid wasps vary widely in body size, form and colour. They are sexually dimorphic, females being usually larger with stout mandibles. Females are usually with six visible metasomal segments and twelve antennal segments, whereas males have seven visible metasomal and thirteen antennal segments. A great variety of swellings, projections and deformities are found in the male flagellum. Females of

ground nesting wasps have conspicuous rows of 'rake spines' on the foretibia, used for digging and a terminal, flattened pygidial plate, for tamping soil during nest construction. This feature is absent in males. Also the males of some species have peculiar structures and modifications used for mate competitions like the clypeal and abdominal hair bristles, spines, serrations or excavations on midtibiae or femora as well as fore coxal excavations for holding females during copulation. In male *Crabro* translucent fore tarsal plates with species specific colour patterns is placed over female's eye during courtship and these leg modifications serve as recognition feature for females. Sternum II in males is usually modified and may bear specialized basal areas or protuberances or transverse ridge or keel or teeth.

A phenomenon called Xanthochroism is exhibited by members of the genus *Bembicinus* Costa. Here larger males of a species have much more yellow than smaller individuals. This increase in yellow is due to the replacement of normally black areas with rich, darker shade of yellow. Xanthochroism is also exhibited in females but to a much lesser extent than in males. This unique phenomenon may be an adaptation for food acquisition, to humidity or seasonal influence (Krombein and Wilink, 1950).

1.2.8. Use of Intelligence

Whether these wasps are intelligent or not has been a source of research for various ethologists. Tinbergen (1932) demonstrated that these wasps do have some sort of image learning mechanism that helps them to find their way back to the nest, even when its nest is one among many and constructed in an apparently featureless soil surface of a nesting area. Another interesting behavior of these wasps is 'tool- use' for nest closure. Many ground nesting species pick up stones, press and vibrate them down into substrate during nest closure. Some species of *Ammophila* hold a stone in the mandible while pounding, thereby giving the appearance of using a hammer (Brockmann, 1984).

1.2.9. Natural Enemies of sphecids

Predators and parasitic insects maintain a constant check on the population of sphecids. The flesh flies (Sarcophagidae), bee flies (Bomylidae), ruby wasps (Chrysididae), velvet ants (Mutillidae), beetles (Rhipiphoridae) are some of the important natural enemies which attack at varying times during the life cycle of these wasps. Members of the Sphecinae are the most commonly attacked. The wasps counter this attack by a strategy of delayed progressive provisioning of nest. This strategy has a selective advantage of protection from natural enemies, which prevent predators and brood parasites from attacking the nest as well as immature stages.

1.2.10. Economic Importance

The sphecid wasps are harmless and should be ignored and tolerated as much as possible. They pose little threat to people and are very beneficial because of the insects they eat. Although sphecid wasps may potentially sting to protect themselves, they are usually quite docile and nonaggressive towards people and will mind their own business when left undisturbed.

As pest management and biocontrol agents: Many species of sphecids have been reported to act as natural control of pests such as *Passaloecus* Shuckard for aphids, *Podalonia* Spinola for cutworms, *Bembix* Fabricius, *Stictia* Illiger for biting flies, *Prionyx* Vander Linden, *Tachysphex* Kohl for grasshoppers and *Palmodes* Kohl for mormon crickets. *Larra analis* Fabricius has been a successful biocontrol agent against mole cricket *Scapteriscus vicinus* Scudder and *Larra bicolor* Fabricius against *Scapteriscus didactylus* (Latreille) (Capinera, 2008; Frank and Sourakov, 2002).

As bioindicators: The diversity of prey records points out to use of sphecids as an excellent bio indicator tool. They are valuable in predicting the diversity of other groups of animals and for all the species of a given area. They form a part of several functional niches (predators, cleptoparasites and pollinators), have economic

importance (pollinators and pest management) and reflect the patterns of other taxa in a given habitat.

As food and medicine: The larvae of many sphecid species are used as food throughout the world, especially Ammophilinae and Ampulicinae (Conconi *et.al.*, 1982). Though food records of sphecid wasps are not available from India, many tribal people of Kerala (Kasargode) has admitted the use Ampulicid larvae as food. Local people use the mud nests of wasps in treating headache. The mud from the nest moistened and applied to the head is said to give relief from head ache.

As pests: Though these wasps are mostly beneficial, two species *Palarus latifrons* Kohl and *Philanthus triangulum* (Fabricius) have been reported to invade apiaries and decimate worker honeybee populations (Capinera, 2008).

These wasps are closely associated to human habitats and evoke great deal of anxiety and fear. These wasps have been subjects of many peculiar and curious stories with regard to their nest construction and provisioning behavior. They are unlikely to sting and not severe if stung. Control of these insects is not warranted since they normally pose little threat. Rather, they should be regarded as beneficial, since they remove and use as prey many species of spiders which most people find disagreeable. They are regarded as nuisance by the people who cannot abide their presence and nest mounds considered unsightly. Prompt and frequent removal of nests is posing a threat to these relatively harmless insects.

1.3. RELEVANCE OF TAXONOMY

Sound taxonomy is the basis of all meaningful research in biology and relevant in various fields such as biodiversity and conservation, agriculture and pest management, medicine, biological control programmes, quarantine measures, fisheries, ecology, parasitology and veterinary sciences (Narendran, 2001). Correct taxonomic information is essential for the agencies and authorities in formulating and implementing effective management strategies for biodiversity conservation, biological control programmes, pest management and quarantine methods against

invasive species and disease outbreaks. Misidentification leads to unaffordable wastage of time, money, energy and effort. Since taxonomy and species conservation are interdependent, correct identification of species is necessary for effective decision making about conservation and sustainable use. Hence to have a deep knowledge on biological diversity, it is necessary as a first step to undertake a taxonomic study of the various families, since all other studies concerning biology, ecology, conservation, genetics etc. rely upon a foundation of good taxonomy.

1.4. SIGNIFICANCE OF THE PRESENT INVESTIGATION

India has a rich fauna of sphecid wasps, but only very few attempts have been made to collect and describe members of this group. All though I.U.C.N. has listed sphecids as threatened taxa from many parts of the world, no such data is available for the country. Due to the difficulties in the collection and documentation, the study of these wasps has been a challenge to taxonomists. Kerala has so far remained, inadequately explored as far as sphecid fauna is considered and the recorded species have been poorly described. The geographic and climatic conditions of the state gives a basis to assume that high species diversity may be present here and still waiting to be discovered. The scanty record of sphecid fauna from Kerala is not because of absence of these wasps, but due to lack of adequate survey and studies. Hence the present studies will contribute to the knowledge of these interesting but difficult group of aculeate wasps of Kerala, which includes several hot spot areas of biodiversity.

1.5. OBJECTIVES OF THE PROPOSED WORK

- a) To make a survey of species of sphecid wasps found in Kerala.
- b) Work out morphological details of species in order to prepare an identification key.
- c) To give detailed illustrations as well as descriptions of new species.
- d) To give a checklist of sphecid fauna found in Kerala.
- e) To assess the diversity of sphecid fauna found in Kerala.

Chapter 2 REVIEW OF LITERATURE

The family name Sphecidae is derived from the Greek word Sphêkos means wasp, from which comes the stem Sphek-. Latinized this forms *Sphec-*.

From examining the literature records, the earliest classification of sphecid wasps can be traced back to Latreille (1802) when he erected two super families, Apoidea and Sphecoidea based on the descriptions of *Apis* and *Spheg* provided by Linnaeus in '*Systemae Naturae*'. He used '*Spheg-*', as the stem for the family group name, latinized to Sphegineae by Fallén (1812). Leach (1815) used the correct stem *Sphec-* and latinized it to Sphecides. Earlier taxonomists like Shuckard (1837), Jurine (1840) placed the sphecids among a large group of fossorial wasps and bees, called as the Fossores. The first attempt to organize the group was done in 1845 by Dahlbom and Lepeletier. Wesmael (1852) recognized seven families. Muller (1872) emphasized on the close relationship between bees and sphecid wasps. Fox (1894) treated all the ground nesting wasps in a single family Sphecidae.

But the initial attempt for modern classification of Sphecidae was made by Kohl in 1897. In his paper 'Die Gattungen der Sphegiden' eighty six genera were recognized. He re-described all the existing genera and arranged them into 'Gattungs-gruppen' equivalent to subfamilies and 'Untergruppen' equivalent to tribes. Kohl's treatment of the group was conservative.

In the same year Acloque (1897) recognized two apparent families- Crabronidi and Sphegidi which also included the pompilids. Kohl's 'Gattungs-gruppen' was given subfamily names by Dalla Torre (1897). Ashmead (1899) made heterogenous grouping of Sphecidae into twelve sub families and recognized one hundred and seventy seven genera.

In 1908, Handlirsch proposed a novel classification, when he placed Apidae and Sphecoidea in the superfamily Sphecoformes. Kohl's classification was further modified by Börner (1919) and Handlirsch (1925). Brues and Melander (1932)

recognized seventeen families and Essig (1942) constructed twenty one families. Michener (1944) based on the studies among bees, supported Handlirsch's classification. Evans (1959) based on larval morphology classified Sphecidae into nine subfamilies- Pemphredoninae, Sphecinae, Astatinae, Nyssoninae, Philanthinae, Mellinae, Larrinae, Trypoxylinae and Crabroninae.

Brother's (1975) studied on the phylogenetic relationships within the Aculeata. He gave evidence for the close relationship between bees and sphecid wasps and placed them in the Superfamily Sphecoidea. He also proposed an informal division of Apoidea into two groups, the Sphecoformes and the Apiformes (bees).

The classification system of sphecid wasps underwent a major change in 1976 when Bohart and Menke published their monumental work '*Sphecid wasps of the world- A Generic revision*'. They revised all the genera of sphecid wasps then known and classified them into eleven subfamilies, thirty three tribes and two hundred and twenty six genera. The following subfamilies were recognized - Ampulicinae, Sphecinae, Pemphredoninae, Astatinae, Laphyragoginae, Larrinae, Crabroninae, Entomosericinae, Xenosphecinae, Nyssoninae and Philanthinae. Their study helped in providing a detailed, descriptive overview and reclassification of all categories down to generic level. They included diagnoses, keys upto subgenus, detailed illustrations, distributional data, biology and establishment of standardized morphological nomenclature for the family. They also listed species under each genus, compiled synonyms and all together reported seven thousand six hundred and thirty four species.

Krombein (1979) elevated the subfamilies of Bohart and Menke into families and placed them in the Superfamily Sphecoidea. Lomholdt (1982) divided sphechids into two families- Sphecidae and Larridae with Larridae representing all sphechids except Ampulicinae and Sphecinae. Michener (1986) showed that the name Apoidea is valid over Sphecoidea. Alexander (1992) gave evidence for the paraphyletic nature of sphecid wasps. Finnamore (1993) elevated subfamilies of Bohart and Menke into

families and regrouped some taxa to include Laphyragoginae in Astatidae, Xenosphecinae in Mellinidae and Entomosericinae in Nyssonidae.

Menke (1997) classified the sphecids as belonging to superfamily Apoidea and divided the group into two families- Heterogynaidae and Sphecidae. Sphecidae was further divided into eight subfamilies- Ampulicinae, Sphecinae, Pemphredoninae, Astatinae, Laphyragoginae, Crabroninae, Bembicinae and Philanthinae. Melo (1999) based on phylogenetic analyses, proposed classification of superfamily Apoidea into five families- Heterogynaidae, Ampulicidae, Sphecidae, Crabronidae and Apidae (bees). Brothers (1999) supported Melo's classification and subdivided the extant Apoidea into five monophyletic families- Heterogynaidae, Ampulicidae, Sphecidae, Crabronidae and Apidae. This classification was supported by Pualwski (2013).

Since a review on the taxonomic studies on the sphecid wasps of the world is not feasible, this review has been restricted to the taxonomic studies carried out in India, with special emphasis to studies conducted in Kerala.

2.1. Taxonomic studies on sphecid wasps of India

Though many species of sphecid wasps have been reported and described from Northern and Central parts of India, the sphecid fauna from many parts of the country, especially the South, is still imperfectly known and remains unexplored. In the following paragraphs an attempt has been made to group together all the scattered literature available on the taxonomic studies of sphecid wasps of India.

The taxonomic studies of sphecid wasps of India was pioneered by Linnaeus (1758), when he described in his book '*Systemae Naturae*' five new species viz., *Sphex asiatica*, *S. fervens*, *S. inda*, *S. indica* and *S. tropica*. In 1775 Fabricius described *Stizus vespiformis* under the name *Sphex vespiformis*. In 1781 Fabricius recorded three new species of *Sphex* Linnaeus from Malabar viz., *Sphex erythrocephala*, *S. madraspatanum* and *S. compressa* in the first volume of '*Species Insectorum*'. Fabricius (1787) reported six new species of sphecid wasps namely *Sphex argentata*, *S. aurata*, *Crabro cornutus*, *C. repandus*, *C. interruptus* and *Bembex interrupta*. In the

second volume of 'Entomologia Systematica', Fabricius (1793) further described four new species viz., *Crabro nitidula*, *Larra cingulata*, *Philanthus interstinctus* and *P. dissectus*.

Fabricius (1804) transferred *Sphex aurata* Fabricius to *Liris* Fabricius, *Sphex erythrocephala* and *S. madraspatana* to *Pelopoeus* Latreille and *S. compressa* to *Chlorion* Latreille. Jurine (1807) erected genus *Ampulex* with *Sphex compressa* Fabricius as the type species. Guerin-Meneville in 1829 described three new species *Cerceris bifasciata*, *Lyrops auriventris* and *Stizus delesserti*.

In 1839 Spinola reported new species *Lyrops savignyi* from India. Westwood (1841a) erected the genus *Trirhogma* with *Trirhogma caerulea* as the type species. Saunders (1841) described new species *Pronaeus campbellii* from North India. Spinola (1842) described a new species *Ampulex aenea* from Malabar Coast. Dahlbom (1845) described nine new species viz., *Bembex sulphurescens*, *B. trepanda*, *Sphex fabricii*, *S. sorrow*, *Cerceris pistiventris*, *Liris orichalcea*, *Palarus interruptus*, *Palepoeus (Chalybion) bengalensis* and *Enodia canescens*. He also transferred *Crabro nitidulus* Fabricius to genus *Tachytes* Panzer and *Sphex vespiformes* Fabricius to genus *Stizus* Latreille. Lepeletier (1845) published descriptions of twelve new species viz., *Pelopoeus coromandelicus*, *P. javanus*, *P. fuscus*, *P. solieri*, *P. spinolae*, *Sphex aegyrticus*, *S. vicinus*, *S. pulchra*, *S. argentifrons*, *S. ferruginae*, *S. lineola*, *Tachytes opulenta* and transferred *Sphex erythrocephala* Fabricius to the genus *Ammophila* Kirby.

The rich and diverse nature of Indian fauna came into light when Smith (1856) described sixty four new species of sphecid wasps collected from different parts of India (Punjab, Madras, Gujarat and Bengal), housed in the British museum viz., *Astata orientalis*, *Larrada conspicus*, *L. argyrea*, *L. simillima*, *L. jaculatrix*, *L. aurulenta*, *L. laboriosa*, *L. exillipes*, *L. subtessellata*, *L. tristis*, *Tachytes fervida*, *T. modesta*, *T. monitaria*, *T. sinensis*, *T. tarsata*, *T. velox*, *Pison rugosum*, *Trypoxylon bicolor*, *T. pileatum*, *Ammophila basalis*, *A. dimidata*, *A. elegans*, *A. smithii*, *A. laevigata*, *A. nigripes*, *A. punctata*, *A. vagabunda*, *A. pulchella*, *A. similima*, *Sphex*

nigripes, *S. crabronaria*, *S. opulenta*, *S. ephipium*, *Harpactus crudelis*, *H. nivosus*, *H. ornatus*, *Nysson basalis*, *Gorytes pictus*, *Larra blandina*, *L. mallea*, *L. malanoxantha*, *L. reversa*, *L. rufescens*, *L. pubilipennis*, *Bembex melancholica*, *Philanthus basalis*, *P. depredator*, *P. pulcherrimus*, *P. sulphurius*, *Cerceris ferox*, *C. flavopicta*, *C. hilarius*, *C. instabilis*, *C. mastogaster*, *C. orientalis*, *C. unifasciata*, *C. vicilans*, *Oxybelus agilis*, *O. ruficornis*, *O. sabulosus*, *O. tridentatus*, *Crabro flavopictus*, *C. insignis* and *Chlorion melanosoma*. He also transferred *Sphex maura* Fabricius and *Pompilus haemorrhoidalis* Fabricius to the genus *Larrada* Smith; *Pissonotus argentatus* Shuckard to *Pison* Jurine; *Philanthus interstinctus* Fabricius to *Cerceris* Latreille and *Lindenius argentatus* Lepletier to the genus *Crabro* Fabricius.

Smith (1858) in further contributions to the sphecid fauna of India described eight new species viz., *Larrada crabronaria*, *L. tisiphone*, *Pisonoides obliterates*, *P. suspiciosum*, *Trypoxylon coloratum*, *Trirhogma prismatica*, *Larra prismatica* and *Sphex diabolica*. He further added (1860b) new species *Larrada rufipes*, *Morphota formosa*, *Pelopoeus intrudens* and *Sphex aurifrons* to the species list. Walker (1860) described a new species *Stigmus congruous*.

Smith (1861) described three new species *Larrada ducalis*, *Trypoxylon gracilescens* and *Sphex morosus*. In the next year (1862) he described a new species *Sphex ferox*. In 1869 he described two new species *Parapison agilis* and *Dolichurus taprobane* and transferred *Pisonoides obliterates* F. Smith and *Pison suspiciosum* Smith to the genus *Parapison* Smith.

Smith continued to dominate in the studies on Indian fauna and in 1873 described eight new species namely *Chlorion regalis*, *Larra cornuta*, *Philanthus elegans*, *Cercedris albopincta*, *C. fervens*, *Larrada vestita*, *Ammophila spinosa* and *Sphex tuberculata*. A new species, *Waagenia sikkimensis* was reported from Sikkim by Kriechbaumer (1874). Smith continued his work and in 1875 added eight new species viz., *Astata agilis*, *Gorytes amatorus*, *G. tricolor*, *Oxybelus sauamosus*, *Trypoxylon accumulator*, *Cerceris viscosus*, *C. rufinodus* and *C. velox*.

Mocsâry in 1883 described a new species *Sphex luteipennis*. Kohl (1884) described two new species *Palarus orientalis* and *Pison erythropus*. He reassigned *Larrada conspicua* Smith, *L. carbonaria* Smith, *L. rufipes* Smith, *L. simillima* Smith, *L. tisiphone* Smith, *L. tristis* Smith, *L. ducalis* Smith and *Sphex maura* Fabricius to the genus *Larra* Fabricius; *Pompilus haemorrhoidalis* Fabricius to genus *Liris* Fabricius; *Morphota Formosa* Smith to genus *Lyroda* Say and *Pisonoides obliterates* Smith to the genus *Pison* Jurine. Kohl (1885) recorded *Sphex luteipennis* Moscardi as *S. rufipennis* Fabricius. Schletter (1887) recorded eleven new species of *Cerceris* Latreille namely *C. albipicta* Smith, *C. bifasciata* Guerin-Menoville, *C. ferox* Smith, *C. flavopicta* Smith, *C. hilarious* Smith, *C. humbertiana* Smith, *C. unifasciata* Smith and *C. vigilens* Smith. In 1888 Handlirsch recorded *Harpactus ornatus* Smith, *Gorytes amatorus* Smith and *G. pictus* Smith.

From the end of nineteenth century, Cameron and Bingham dominated in the work on sphecid wasps of India. In 1889, Cameron in the first part of 'Hymenoptera orientalis' recorded the following; twenty species of *Ammophila* W.Kirby with descriptions of four new species namely *A. buddha*, *A. orientalis*, *A. vischu* and *A. violaceipennis*; fourteen species of the genus *Pelopoeus* Latreille including the biology of *P. bengalensis* Dahlbom, *P. bilineatus* F. Smith and *P. javanus* (Lepelletier); nineteen species of the genus *Sphex* Linnaeus including descriptions of new species *S. erythropoda*, *S. rothneyi*, *S. xanthoptera*, redescriptions of *S. splendida*, *S. aurulenta*, *S. rufipennis* and distribution of *S. argentata*; records of *Trirogma caerulea* Westwood, *Waagenia sikkimensis* Kriechbaumer and five species of the genus *Ampulex* Jurine; five species of the genus *Pison* Jurine namely *P. (Parapison) agile* Smith, *P. (Parapison) erythropus* Kohl, *P. (Parapison) obliteratum* Smith, *P. punctifrons* Shuckard, *P. (Pisonotus) rugosum* Smith and *P. suspiciosum* Smith; seven species of genus *Trypoxylon* Latreille with redescription of *T. geniculatum* Cameron and *T. intrudens* F. Smith; thirteen species of the genus *Larra* Fabricius with two new species *L. fuscipennis* and *L. nigriventris*; four species of the genus *Notogonia* Costa with new species *N. pulcheripennis* and *N. jaculator*; three species of the genus *Liris* Fabricius namely *L. haemorrhoidalis* Fabricius, *L. auratus* Fabricius and new species

L. nigripennis; three species of *Piagetia* with description of new species *P. ruficornis*; thirteen species of the genus *Tachytes* Panzer; four species of the genus *Tachysphex* Kohl with new species *T. erythrogaster*, *T. auriceps* and *T. bengalensis*; two new species of the genus *Gastrosericus* Spinola namely *G. wroughtoni* and *G. rothneyi*; two species of *Palarus* namely *P. orientalis* Kohl and *P. interruptus* Dahlbom; four species of *Astata* namely *A. orientalis* Smith with three new species *A. argentofacialis*, *A. nigricans* and *A. maculifrons*.

In the part II of '*Hymenoptera orientalis*', Cameron (1890) recorded one hundred and eighteen species with descriptions of twenty seven new species viz., *Psen clavatus*, *P. orientalis*, *P. rufiventris*, *Nysson erythropoda*, *N. rugosus*, *Cerceris dentate*, *C. nebulosa*, *C. pentadonta*, *C. pulchra*, *C. rothneyi*, *Cerceris sulphures*, *C. terradonta*, *C. tristis*, *C. vischu*, *C. wroughtoni*, *Oxybelus canescens*, *O. flavipes*, *O. flavipilosus*, *O. lewisi*, *O. robustus*, *O. bellus*, *Crabro ardens*, *C. nanus*, *C. nitidus*, *C. odontophorus*, *C. orientalis* and *Stizus orientalis*. Bingham in the same year (1890) described *Sphex fulvo-hirtus* and listed *Sphex tyrannica* Smith and *Bembex fossoria* Smith from India. Kohl (1890) in his studies on the genus *Sphex* Linnaeus dealt with eighteen species and transferred *Chlorion regalis* Smith and *C. splendidus* Fabricius to the genus *Sphex*.

Handlirsch (1892) worked on the Indian *Stizus* Latreille and described five new species *S. calypterix*, *S. magretti*, *S. proximus*, *S. pusillus* and *S. semperi* and also gave records of nine species already known from the country. He also reassigned *Vespa bichlypeata* Christ and *Larra cornuata* Smith to *Stizus*. Bingham (1894) described three new species of *Bembex* Fabricius namely *B. hesione*, *B. ovans* and *B. westoni* from the Indian sub-continent. Kohl (1893) in his studies on *Ampulex* Jurine prepared keys to all the known species and recorded a new species *A. latifrons* from Sikkim and reassigned *Waagenia sikkimensis* Kriechbaumer to *Ampulex*. Handlirsch in the same year (1893) described seven new species of the genus *Bembix* Fabricius namely, *B. borrei*, *B. buddha*, *B. indica*, *B. latitarsus*, *B. orientalis*, *B. pinguis* and *B. taschenbergi*. Bingham (1896b) described two new species of sphecid wasps from

India namely *Philanthus nigriceps* and *Crabro (Rhopalum) brookii*. He transferred *Larrada tisiphone* Smith to genus *Notogonia* Costa.

The most commendable and basic reference work for Indian sphecid fauna till date was provided by Bingham in his series of the 'Fauna of British India', Hymenoptera Volume I published in 1897. In this noteworthy work he not only recorded all the species known from Indian sub-continent till then but also gave descriptions, genus and species keys and elucidated synonymies. He described thirty two new species including *Ammatomus alipes* from Malabar Coast under the name *Gorytes alipes*, *Tachytes saundersi*, *T. yerburyi*, *Tachysphex rufoniger*, *T. testaceipes*, *Larra elegans*, *L. erratica*, *L. nana*, *Lyroda venusta*, *Lianthrena kohlii*, *Ammophila apicata*, *A. brevipennis*, *A. laeta*, *Paraliris faceta*, *Sphex edax*, *Ampulex crudelis*, *Passaloecus laevipes*, *Helioryctes assimilis*, *Gorytes impiger*, *G. politus*, *Stizus lateralis*, *Cerceris elizabethae*, *Cerceris* Kirby, *Oxybelus aestuosus*, *Oxybelus nanus*, *Crabro auricornus*, *C. opifex*, *C. quadriceps*, *C. sordalis*, *C. spinifrons*, *Miscophus rothneyi* and *Pison kohli*. He also synonymized *Tachytes rothneyi* Cameron and *Tachytes sinensis* Smith to *Larrada vestituta* Smith; *Tachytes basalis* Cameron to *Lyroda formosa* Smith; *Palarus interruptus* Dahlbom to *P. orientalis* Kohl; *Chalybion bengalensis* Dahlbom and *Pelopoeus flabilis* Lepeletier to *Sphex violaceum* Fabricius; *Sphex fabricii* Dahlbom, *Sphex ferruginea* Lepeletier, *S. lineola* Lepeletier, *Pepsis sericea* Fabricius, *Sphex ferox* Smith, *S. lepeletieri* Saussure, *S. godeffroyi* Saussure and *S. aurifex* Smith to *S. aurulentus* Fabricius; *Sphex chrysis* Christ, *Chlorion aeurium* Lepeletier and Serville and *Sphex amaragdinus* Drury to *S. lobatus* Fabricius; *S. albifrons* Fabricius, *S. argentatus* fabricius, *S. argentifrons* Lepeletier, *S. carbonaria* Smith, *S. diabolica* Smith, *S. leutifrons* Gribodo, *S. metallica* Taschenberg, *S. nigerrima* Costa, *S. opulenta* Smith, *S. rufipennis* Fabricius and *S. taschenbergi* Magretti to *Sphex umbrosus* Christ. He also reassigned *Larrada conspicus* Smith to genus *Tachytes* Panzer; *Sphex madraspatanus* Fabricius, *S. violacea* Fabricius, *Pelopeus bilineatus* Smith, *P. coromandelicus* Lepeletier, *P. formosa* Smith, *P. intrudens* Smith and *P. javanus* Lepeletier to the genus *Sceliphron* Klug.

In Part V (1897a) of 'Hymenoptera orientalis' Cameron added five new species viz., *Oxybelus ceylonicus*, *Astata tarda*, *Pison rothneyi*, *P. striolatum* and *Cemnionus suscipennis*. Cameron (1897b) in Part VI of 'Hymenoptera orientalis' described new species viz., *Diodentus striolatus*, *Didineis orientalis*, *Alysson annulipes*, *Gastrosericus binghami*, *Pison orientale*, *P. appendiculatum*, *P. (Parapison) crassicorne*, *Trypoxylon cognatum*. Bingham (1898) described five new species *Cerceris himalayensis*, *Philanthus yerburyi*, *Tachysphex hospes*, *Diodentus geniculatus* and *Passaloecus reticulata*. Cameron (1899) described the following new species *Sceliphron tibiale*, *Caenopsen fuscinervus*, *Dolichurus reticulatus* and *Ampulex nigricans* from Khasia Hills, Assam.

Cameron (1900a) described new species *Trypoxylon pygmaeum*. In the same year, Cameron (1900b) described five new genera- *Caenolarra*, *Cratolarra*, *Leptolarra*, *Odontolarra* and *Spanolarra* with records of twenty one new species namely *Tachytes interstitialis*, *T. ceylonica*, *T. brevipennis*, *T. aurifrons*, *T. tabrobance*, *T. maculitarsis*, *Notogonia chapmani*, *Larra fuscinerva*, *Larra irdipennis*, *L. longicornis*, *Caenolarra appendiculata*, *Leptolarra flavinerva*, *L. longitarsis*, *L. reticulata*, *Spanolarra rufitarsis*, *Cratolarra femorata*, *Odontolarra rufiventris*, *Sceliphron lineatipes*, *Ampulex pilosa*, *A. pulchericeps* and *Oxybelus ceylonicus* from different parts of Indian sub-continent.

Cameron (1901a, 1901b) described three new species from Khasia Hills, Assam including *Chrysolarra appendiculata*, *C. aureoserica* and *Bembex lactea*. Cameron (1902a) described seven new species *Notogonia pulcherrima*, *Gastrosericus rufitarsis*, *Oxybelus aurifrons*, *Psen carinifrons*, *P. reticulatus*, *Alysson testaceitarsis* and *A. erythrothorax* collected from Deesa, Simla and Ferozepore. Cameron in another paper published in the same year (1902b) described twelve new species belonging to genus *Ampulex* Jurine, *Cerceris* Latreille, *Crabro* Fabricius, *Psen* Latreille and *Tachytes* Panzer from Assam. Cameron in another contribution (1902c) described new species *Ampulex brevicornis*, *Trypoxylon geniculatum* and *T. trochanteratum*.

Cameron (1903) added three new species of Ampulex namely *A. himalayensis*, *A. montana* and *A. interstitialis*. Rothney (1903) described fifteen new species of subfamily Larrinae viz., *Notogonia piliventris*, *N. parva*, *N. anthracina*, *N. indica*, *N. striaticollis*, *N. varipilosa*, *N. fuscostigma*, *N. bengalensis*, *N. picipes*, *N. pilosa*, *Tachysphex striolata*, *T. puncticeps*, *T. varihirta* and *Odynerus sibilans* from Barrackpore, West Bengal. Nurse in the same year (1903a) described nineteen new species including *Tachytes flagellata*, *T. proxima*, *Tachysphex nudus*, *T. pollux*, *T. inventus*, *T. projectus*, *T. conclusus*, *Astata lubricate*, *Trypoxylon responsum*, *Ammophila philomela*, *A. durga*, *Psen kashmirensis*, *Gorytes lenis*, *Stizus conscriptus*, *S. coloratus*, *S. imperator*, *Bembex irritata*, *Cereris kashmirensis*, *C. dolosa* and *Crabro gulmargensis*. Nurse in another publication in the same year (1903b) further described *Ammophila bolanica*, *A. funera*, *Astata quettae*, *Crabro balucha*, *C. prosopiformis*, *C. elongates*, *Diodontus tenius*, *D. selectus*, *Gorytes intrudens*, *G. impudens*, *Homogambrus creon*, *Larra neara*, *Miscophus quettaensis*, *M. difficilis*, *Palarus indicus*, *P. quiescens*, *P. fabius*, *Passaloecus dudgeon*, *Psen refractus*, *Sphex fragilis*, *Stigmus cuculex*, *Tachytes dilware*, *T. shiva* and *Trypoxylon mediator*.

Cameron further contributed to discovery of new species from India. In 1904a, he recorded four species from genus *Trypoxylon* Latreille namely *T. placidum*, *T. fulvocollare*, *T. khasiae*, *T. orientale* and *Psen rufobalteata* from Khasia Hills. In the same year (1904b) he described *Crabro trichiosomus*, *C. agycus*, *Bembex megadonta* from Himalayas and Darjeeling. Cameron (1904c) further described *Cereris violaceipennis*, *C. latibalteata*, *larra bicolorata*, *L. pygidialis*, *L. apicipennis*, *Liris violaceipennis*, *Tachysphex tinctipennis*, *Tachytes assamensis* and *Trypoxylon orientale*. Cameron (1904d) described a new species *Bembex khasiana*. Cameron (1904e) recorded three new species from Sikkim namely *Odontolarra nigra*, *Piagetia varicornis* and *Nysson violaceipennis*.

Cameron (1905a) described fourteen new species *Crabro himalayensis*, *C. monozonus*, *Cerceris bimaculata*, *C. canaliculata*, *C. himalayensis*, *C. intimella*, *Cerceris rufoplagiata*, *C. aureobarba*, *C. lepcha*, *Tachysphex bituberculata*, *Notogonia fuscinerva*, *N. aciculate*, *N. khasiana* and *N. sulcifrons* from Khasia Hills.

In 1906, he further added *Trypoxylon testaceicorne*, *Cereris lanata*, *Miscophus nigricans*, *Astatus interstitiallis* from North India. Cameron (1907a) recorded *Cereris baluchistanicus*, *C. quattaensis*, *C. basimacula*, *C. violaceipennis*, *Palarus fortistriolatus*, *Crabro ctenopus*, *C. violaceipennis*, *Psen montanus*, *P. rufoannulatus* and *P. puncticeps*. Paiva (1907) recorded *Larra maura* (Fabricius), *Notogonia subtessellatus* (Smith), *N. tristis* (Smith), *Liris aurata* (Fabricius), *Trypoxylon intrudens* Smith, *Ammophila atripes* Smith, *A. punctata* (Smith), *Sceliphron violaceum* (Fabricius), *S. madraspatanum* (Fabricius), *Psen orientalis* Cameron, *Pemphredon fuscipennis* Cameron, *Stizus vespiformis* Fabricius, *S. prismaticus* (Smith), *Oxybelus canescens* Cameron and *Crabro Buddha* Cameron from the Himalayas. Cameron (1908) further described *Oxybelus latilineatus*, *O. pictisensis*, *O. fulvicaudis*, *O. forticarinatus*, *Dasyproctus testaceipalpis* and *Tachysphex striolatus* from Bombay presidency.

Turner (1912) in his monograph on the genus *Cerceris* Latreille described eighteen new species *C. abuensis*, *C. belli*, *C. binghami*, *C. bolanica*, *C. compta*, *C. downesivors*, *C. epihipium*, *C. fastidiosa*, *C. fletcheri*, *C. inexorabilis*, *C. miliana*, *C. malicula*, *C. nursei*, *C. opulenta*, *C. pretea*, *C. aridea*, *C. lama*, and *C. saussurei* var *chrysasthamia*. Nurse (1914) reported new species *Ampulex aborensis*. Kohl (1915) in his account on Palearctic Crabronidae described two new species *Crabro funestus* and *C. arreptus* from Sikkim and *C. nursei* from Kashmir along with six new records of species found in Europe. Aiyar (1915-1918) listed all the species recorded after Bingham's (1897) work. Strand (1915) reported *Sceliphron curvatum* and redescribed *Sceliphron javanum* Strand. Turner (1916) described *Pison differens* from Assam.

Turner (1917) reported fifty six species from India in which he reported eighteen new species, *Stigmaeus atterimus*, *Diodontus fletcheri*, *Cerceris rejecta*, *Philanthus sumptuosus*, *Bembex persimilis*, *B. relegatus*, *Stizus erythrogaster*, *Arpactus remotes*, *Nysson dutti*, *Entomognathus chapprensis*, *E. isolates*, *Rhopalum iridiscens*, *Dasyproctus funestus*, *Oxybelus nigrutilus*, *O. furcifer*, *O. transience*, *O. linguifera*, *Dimorpha fletcheri*, *Tachysphex substriatulus*, *T. lilliputianus*, *T. latissimus*,

T.comberi, *T. celsissimus* and *T. nodosicornia*. Dutt (1917) in the appendix to Turner's paper described a new species *Solierella turneri* and redescribed *Gorytes ornatipes* Smith. Turner (1918a, b) described five new species *Sphex* (*Parapsammophila*) *mahatma*, *Spilomena indostana*, *Tachysphex fulvicornis*, *Philanthus ramakrishnae* and *Trypoxylon fletcheri*. Kohl (1918) in his worldwide revision of the genus *Sceliphron* Klug prepared keys and described all known species of *Sceliphron*. In this work he described *Sceliphron* (*Chalybion*) *bengalense* Dahlbom, *Sceliphron* (*Pelopoeus*) *madraspatanum* Fabricius var. *andamanica*, *Sceliphron* (*Pelopoeus*) *rectum* Kohl, *S. (P) coromandelicum* Lepeletier, *S. (P) deforme* Smith, *S. (P) javanum* Smith var. *nalandicum* Strand and *S. (P) madraspatanum* Fabricius from India.

Dutt (1921) described two new species *Gorytes confuscus* and *Crabro fulvonigra* from Bihar. Turner and Waterson (1926) described *Crabro duplicata* from Sikkim. Lal (1939) described *Psenulus sinclairi* from Delhi. Giner Mari (1945a) described *Cerceris salai* and *Passaloecus bandraensis* from Bombay. Usman and Puttarudraiah (1955) listed twenty five species of sphecid wasps from Mysore state. Leclercq (1956) added *Crossocerus* (*Apocrabro*) *byrrhus*, *C. (A) ursidus*, *Crossocerus* (*Coelocrabro*) *distortus*, *C. (Crossocerus) taxus*, *C. (C) aerardi*, *C. (C) pusanus* and *C. (C) brahmanus* to the new species' list.

Van Der vecht (1961) studied Fabrician types, revised generic assignments and also proposed nomenclatural changes. Van Lith (1965) described five new species of *Psen* Latreille namely *P. assamensis*, *P. eurypygus*, *P. nepalensis*, *P. nitidus*, *P. simiensis* and subspecies *P. extractus indicus*. Van der Vecht and Van Brugel (1968) revised the genus *Sceliphron* Klug and divided into two subgenera: *Sceliphron* Latreille and *Prosceliphron* Vander Vecht. In this study he prepared keys, described the species and gave distribution patterns of all the known species of *Sceliphron*. Van Lith (1972) described two new species *Psenulus bengalensis* and *P. pulcherrimus eburneus* from India.

Tsuneki (1979) in his work on Oriental and Australian *Trypoxylon* Latreille described nineteen new species from India namely *T. annamalaiense*, *T. breviclypeatum*, *T. himachalense*, *T. indianum*, *T. lamellatum*, *T. longipilosum*, *T. matheranicum*, *T. nathani*, *T. nilgiriense*, *T. operculum*, *T. pendleburyi*, *T. prominense*, *T. punjabense*, *T. membranaceum*, *T. nigripes*, *T. vardyi*, *T. yogator*, *T. attenuatum kashmirensis* and *T. orientale keralae*. Pulawski (1979) in his work on the revision of world *Prosopiagastra* described a new species *P. durga* from Madras.

Another major contributor to the study of wasps was Krombein. In 1984, he recorded the following new species *Stizus rufescens*, *Bembicinus krameri*, *B. broomfieldi* and redescribed *S. vespiformis* Fabricius, *Bembicinus pusillus* (Handlirsch) and *B. proximus* (Handlirsch). Krombein and Van der Vecht (1987) revised the South Indian *Bembix* Fabricius and redescribed *B. orientalis* Handlirsch, *B. tranquebarica* (Gmelin), *B. glauca* Fabricius, *B. lunata* Fabricius, *B. budha* Handlirsch, *B. borrei* Handlirsch and described a new species *B. antoni*.

Hensen (1988) in his revision on the nominate subgenus *Chalybion* Dahlbom redescribed *C. bengalense* (Dahlbom) and *C. malignum* (Kohl). Hensen (1991) in his review on Malesian Sphecinae listed *Sphex praedator* Smith, *S. subtruncatus* Dahlbom, *S. sericeus* Fabricius, *S. argentatus* Fabricius, *S. fumiscatus* Christ, *S. diabolicus* Smith, *Isodontia nigelloides* (Strand) from India. Antropov (1994) reviewed the *Agile* species group of the genus *Pison* Jurine. In this work he recorded *P. agile* (Smith), *P. erythropus* Kohl, *P. rothneyi* Cameron and a new species *P. pulawski* from India.

Krombein and Pulawski (1994) in his revision on the genus *Tachysphex* Kohl of Sri Lanka recorded twenty nine species from India including new species viz., *T. sri pulawski*, *T. indicus* Pulawski, *T. sympleuron* Pulawski, *T. chiastotrichus* Pulawski, *T. noar* Pulawski, *T. rugicauda* Pulawski and *T. xanthoptesimus* Pulawski. He also gave descriptions of *T. gujaraticus* Nurse, *T. morosus* (F. Smith), *T. consocius* Kohl, *T. mediterraneus* Kohl, *T. plicosus* (Costa), *T. changi* Tsuneki, *T. bengalensis* Cameron, *T. panzer* (Vander Linden), *T. selectus* Nurse, *T. erythrophorus* Dalla Torre,

T. puncticeps Cameron, *T. bituberculatus* Cameron, *T. instructus* Nurse, *T. auriceps* Cameron, *T. conclusus* Nurse, *T. minutus* Nurse, *T. fulvicornis* Turner, *T. vulneratus* Turner, *T. testaceipes* Bingham, *T. erythropus* (Spinola), *T. grandissimus* Gussakovskij and *T. albocinctus* (Lucas).

Taxonomic research on the rich sphecid fauna of India was left obscured after the days of Imperial entomologists of the early 20th century and taxonomic works exclusively from India fell scarce. This changed when Gupta (1995) listed sixty two species under seven subfamilies namely Dolichurinae, Ampulicinae, Sphecinae, Ammophilinae, Sceliphrinae, Larrinae, Nyssoninae, Philanthinae and Crabroninae from Western Himalayas (Uttar Pradesh). Manikandan *et.al* (1998, 1999) recorded six new species of *Oxybelus* Latreille from India namely *O. furculatus*, *O. menoni*, *O. paraagilis*, *O. paramenoni*, *O. paratrasiensis* and *O. paratridentatus*.

From the twenty first century, taxonomic works on Sphecidae by Indian workers showed a slow increase. Jonathan *et.al* (2000) recorded seventy five species of sphecid fauna from Meghalaya. In 2001 Manikandan and Dey reviewed the systematic position of the genus *Oxybelus* Latreille and described and prepared keys to all the oriental species. In a continuation of his work Jonathan and Kundu (2003) listed sixty species from Sikkim with thirteen new records of species namely *Sphex argentatus* Fabricius, *Sphex sericeus fabricii* Dahlbom, *Prionyx viduatus* (Christ), *Ammophila basalis* Smith, *A. laevigata* Smith, *L. subtessellata* (Smith), *L. jaculator* (Smith), *L. aurulenta* (Smith), *Lyroda venusuta* Bingham, Philanthinae *instabilis* Smith, *P. tristis* Cameron, *P. vigilans* Smith and *Larra polita rufipes* (Smith), with the last species a new record for India. Tiwari *et.al.* (2004) recorded *Chlorion regale* F. Smith from Rajasthan. Kundu *et.al* (2006) recorded thirty three species from Arunachal Pradesh with new records of twenty three species and *Carinostigmus congruous* (Walker) as a new record for India. Coumer and Dey (2007) recorded a new species *Cerceris delhiensis* and gave a new record for *C. lunata* Costa.

Dollfuss (2008) reported *Isodontia aurifrons* (F. Smith), *Isodontia diodon* Kohl, *I. formosicola* Strand, *I. ochroptera* (Kohl), *I. splendidula* (Costa), *Sphex deplanatus*

Kohl, *S. diabolicus* F. Smith, *S. praedator* F. Smith, *S. sericeus* (Fabricius) and *S. subtruncatus* Dahlbom in a study on Sphecini wasps in the Linz museum Australia.

Kannagi *et.al.*(2013) listed *Ammophila humbertiana* de Saussure, *Sceliphron curvatum* F. Smith, *S. caementarius* (Drury), *Tachytes monetarius* Smith and *Sphex lobatus* Fabricius from the deciduous forests of Toothukudi district of Tamilnadu. Recently, Dollfuss (2013) in his revision work on the wasp genus *Ammophila* Kirby of India and Palearctic region synonymized *A. atripes* Smith to *A. clavus* (Fabricius).

2.2. Taxonomic studies in Kerala

Though many species of sphecid wasps were reported and described from Kerala by many earlier workers. The initial reports of sphecids in Kerala were by Fabricius (1781), Spinola (1841) and Bingham (1897). Tsuneki (1979), Krombein and Van der Vecht (1987) and Krombein and Pulawski (1994) recorded several species from the state. But a complete and authoritative listing of sphecid wasps of the state was done by Sudheendrakumar and Narendran. In 1985, they described three new species *Gastrosericus menoni*, *Larra vechti* and *Polemistus raoi* from the Malabar region. In 1989 they listed forty six species of sphecid wasps from Kerala including twenty four new records for the state namely *Trirogma caerulea* Westwood, *Ammophila atripes* Smith, *A. laevigata* Smith, *Chalybion bengalense* (Dahlbom), *Sceliphron coromandelicum* (Lepletier), *Sphex argentatus* Fabricius, *S. praedator luteipennis* Moscary, *Astata boops* (Schrank), *Dasyproctus budha* (Cameron), *Oxybelus* sp. nr. *agilis*, *Liris aurulentus* (Fabricius), *Liris subtessellatus* (Smith), *Lyroda Formosa* (Smith), *Pison punctifrons* Schuckard, *Solierella turneri* Dutt, *Tachysphex bengalensis* Cameron, *Tachytes modestus* Smith, *T. nitidulus* (Fabricius), *Trypoxylon errans* Saussure, *Ammoplanellus* sp., *Carinostigmus congruous* (Walker), *Bembicinus pusillus* (Handlirsch), *Bembix borrei* Handlirsch, *Bembix glauca* Fabricius and *Stizus rufescens* (Smith).

After a gap of ten years, Sudheendrakumar and Mathew listed fourteen species of sphecid wasps from Parambikulam Wildlife Sanctuary namely, *Ammophila atripes*

Smith, *Ammophila laevigata* Smith, *Chalybion bengalense* Dahlbom, *Sceliphron coromandelicum* (Lepeletier), *Sceliphron javanum* Lepeletier, *Sceliphron madraspatanum* Fabricius, *Chlorion lobatum* Fabricius, *Cerceris* sp., *Sphex argentatus* Fabricius, *Sphex praedator luteipennis* Moscardi, *Sphex* sp.nr. *nigripes*, *S. sericeus* Fabricius, *Trirogma caerulea* Westwood and *Trypoxylon errans* Saussure.

Madhavikutty (2004) published records of a new species of *Trirogma* Westwood from Wayanad, Kerala namely *T. narendrani*. Mathew *et. al.* (2004, 2005) in two different surveys conducted on the fauna of protected areas of Peechi and Peppara wild life sanctuary listed *Ammophila laevigata* Smith, *Chalybion bengalense* Dahlbom and *Sceliphron javanum* Lepeletier. In a similar study Mathew *et.al.* (2007) listed again *Ammophila laevigata* Smith, *Sceliphron javanum* Lepeletier and *Chalybion bengalense* Dahlbom from Neyyar Sanctuary, Kerala. More recently Baaby and Joseph (2014) listed ten species of sphecids belonging to two families Ampulicidae and Sphecidae from Thrissur district of Kerala.

Although lists of commonly collected species within known ranges has been published on the fauna of Kerala a detailed comprehensive study on the sphecid wasps is yet to be done.

Chapter 3

RESEARCH METHODOLOGY

The study has been carried out in the Kerala state (Map 1).

3.1 STUDY AREA

Kerala lies along the Southwest coast of India between 8°18'- 12°48'N latitudes and 74°52'-77°22'E longitudes. The state has an area of 38,863 km², forming about 1.18% of total area of country. It is bounded by Karnataka in the North, Tamil Nadu in the South and the East and Arabian Sea in the West. Kerala has a coastline of 500 km², varying in width from 35-120 kms. On the Eastern boundary of the state, the Western Ghats forms a continuous wall of mountains except near Palakkad, where it breaks through to provide 'Palakkad Gap' giving access to Tamil Nadu. Administratively, the state is divided into fourteen districts.

3.1.1. Physiography

Due to the presence of the Western Ghats along the eastern side and the Arabian Sea along the west, the physiography of the state is highly diversified. The altitude varies from sea level to 2695m above mean sea level. Based on altitude the state is divided into three regions:

- A) Mountainous region: The eastern edge of state, close to Ghats comprises of steep mountains and deep valleys, covered with dense forest.
- B) Midland Plains: In the central region, the hills are not very steep and have wide valleys which have been converted to paddy fields and Plantation estates.
- C). Lowlands or Coastal region: The coastal strip is relatively plain, characterized by extensive paddy fields, thick coconut groves and interconnected riverine- backwater systems.

Out of forty four rivers in the state, forty one originate from the Western Ghats and flow westwards into the Arabian Sea; only three tributaries of the river Cauvery originate in Kerala and flow eastwards into neighbouring states. The lakes and backwaters are linked by canals thereby facilitating an uninterrupted inland water

navigation system. Kerala has also two wetland systems- Lake Sasthamkotta and Vembanad –Kol.

3.1.2. Climate

Although Kerala lies close to the equator, its proximity to sea and presence of Western Ghats provides the state with an equable warm humid tropical climate throughout the year. The state has an average rainfall of 3,020mm/year and a relative humidity ranging between 75-92%. The state is blessed with two seasons of heavy rains- the Southwest monsoon from May- August and the Northeast monsoon from October-November. The southern parts of Kerala experiences comparatively higher rates of both monsoons, while the northern tips of the state receive poor rains from Northeast monsoon. Average daily temperature varies from 23.9°-31°C in midlands and plains to 4.2°-30°C in the hilly areas. March-May are the hottest months and temperature rises above 40°C in plains.

3.1.3. Geology and Soil

The state being in the centre of the Indian tectonic plate is subjected to relatively little seismic and volcanic activity. Precambrian and Pleistocene geological formations compose the bulk of Kerala's terrain. The soil type is highly heterogeneous like alluvial, sandy loam, laterite, clay soil and sandy soil.

3.1.4. Forests

The state has a forest stretch of 9400km², contributing to 24% of the total forest area of the country. This includes tropical wet evergreen and semi evergreen forests (low and middle elevations, 3470 km²), tropical and dry deciduous forests (mid elevations, 4100 km² and 100 km²), and montane subtropical and temperate (shoal) forests (high elevations, 100 km²).

Kerala's fauna and flora are noted for their diversity and high degree of endemism. The Western Ghats represent one of world's hotspots of biodiversity and is considered to be a repository of endemic, rare and endangered flora and fauna

3.2. SAMPLING SITES

A random sampling procedure was carried out for specimen collection. For this purpose the state was grouped into three zones (Map 1)

- a). North Kerala- Kasargode, Kannur, Wayanad, Kozhikode and Malappuram.
- b). Central Kerala- Palakkad, Thrissur, Ernakulam and Idukki.
- c). South Kerala- Thiruvananthapuram, Kollam, Alappuzha, Pathanamthitta and Kottayam.

From each zone, species were collected randomly, but care was taken to represent a minimum of five collection sites from each district (Plates 3, 4 & 5). During collection process the following criteria was also taken into consideration: human habitats, open areas, forest, nurseries and vegetable gardens, paddy fields, rubber plantations and hilly areas. A total of 92 places were used as collection sites (Table 4).

3.3 Collection Methods (Plate: 1)

Sampling was carried out from the period 2009-2012. The specimens were collected during day time from 8A.M. to 5P.M. These wasps are fast flyers and a combination of collection methods namely Sweep net, Malaise trap, Yellow-pan trap, Food bait and Rearing with different success rates were used to collect these wasps.

1) Sweep Net: Hand netting using aerial nets is one of the best methods for collecting several groups of insects (Narendran, 2001). The frame of the net consists of light weight material like Aluminium or Iron, for easy handling. The net bag is composed of entirely meshed material. The net bag is usually white in colour, to easily visualize the insect once inside the net.

2) Rearing: This is a useful method for collecting wasps constructing aerial mud nests. The nests recovered from their sites of construction by means of knife or sharp object was carefully placed in a plastic jar. The mouth of the jar was closed with a fine net to allow air circulation. The wasps were mounted after hatching.

3) Malaise trap: This trap makes use of the negatively geotactic and positively phototactic behavior of insects. This is a tent like trap made up of fine mesh tereylene gauze with a specially adapted 550ml capacity collection bottle at the top and usually placed in the direction of sunlight. The trap is 6 feet wide, 3 feet 6 inches high at one end and 6 feet 6 inches height at the other end. The insects flying into sides of the trap by chance, crawl up to the roof (negatively geotactic behavior), where they enter the collecting bottle containing 70-80% alcohol (Narendran, 2001).

4). Yellow-pan trap or Moericke trap: This method is based on the fact that many insects are attracted to yellow colour. This is a simple square or round tray measuring 60-70mm deep and about 30 cm wide. It is painted bright yellow on inside and black on outside, placed on the ground in a suitable habitat such as grassland. The tray is filled with water to which a few drops of detergent are added to break the surface tension. The pan is emptied once in a day using fine mesh net in order to filter the specimens

5) Food Bait: This method was experimented, taking into consideration the fact that adults of these wasps are nectar feeders. Pure honey was applied to tree trunks to see if these wasps are attracted to honey.

3.4. Killing

The collected insects were immediately transferred to a killing jar. A killing jar consists of tight lid plastic jar with one- two inch thick cotton wool placed at bottom. To this added periodically a few drops of Ethyl acetate (or nail polish remover, as it is easier to obtain and more easy to handle than chloroform). The killed insect is then prepared for mounting.

3.5. Mounting, Labeling and Registering

The method followed in the present work is that adopted by Bouček and Noyes (Noyes, 1982).

3.5.1. Mounting of specimens

For studying various parts it is necessary to spread out the specimens properly before they are mounted and preserved. In the case of dried specimens, they were subjected to a relaxing agent prior to mounting. As far as possible spreading of wings, mandibles and other body parts were done when the specimen was fresh. For mounting Asta No.3 (0.38 x 0.5mm) entomological pins were employed. Two methods were adopted for mounting.

1. Pinning: As these are large specimens pinning method was adopted for mounting. The insect was placed on a pinning block and entomological pin was inserted in the centre of scutum, to the right side, with a quarter of the pin visible above the specimen. The wings, mandibles and body parts were then spread on a spreading board using paper strips and pins.

2. Card mounting: Very small specimens were mounted using this technique. With the help of a microscope the appendages, wings and mandibles were carefully maneuvered into correct position using fine pins. A drop of glue was applied to a rectangular or triangular paper (about two-third the volume of the mesosoma of the specimen to be mounted). The tip of a moistened brush was used to pick up the specimen and gently pressed to the adhesive with brush. After carefully positioning the antennae, appendages and body parts, the base of the card was pinned.

The specimens were then kept for labeling.

3.5.2. Labeling

Temporary labels were written in the field at the time of collection. The mounted specimens held on entomological pins were given permanent labels containing the following information: name of country in capital letters, state, district, exact collection locality, latitude and longitude, collector's name and date of collection with month in Roman numerals. The latitudes and longitudes of the collection locations for each specimen were determined using Google Earth.

Registering of specimens was done after the specimens have been identified at least to the generic level. The registering of entries is as follows: 1) Serial number, 2) Collection number, 3) Scientific name, 4) Name of person who determined the specimen, 5) Name of locality, 6) Date of collection & Name of host, 8) Name of collector and 9) Remark. The labels were written using Rotring 0.2 microtip pen. The mounted, labeled specimens were preserved in insect boxes for further studies.

3.6. Storing and Preservation

The mounted specimens were stored and preserved in wooden insect boxes. Naphthalene balls were placed on the inside corners of the box in order to protect the specimens from other infectious insects and cotton balls dipped in Phenol- Camphor solution (3:1) were placed to prevent fungal growth. The insect boxes were periodically subjected to warming by using table lamps to avoid fungal growth.

3.7. Relaxing of Specimens

Relaxing dry specimens prior to mounting helps prevent breakage of dried insects. For relaxing specimens were kept in an atmosphere of glacial acetic acid for 6-8 hours. A plastic jar with tight fitting lid was taken and inside covered with thick layer of cotton wool. To this added a few drops of glacial acetic acid and placed a second layer of cotton wool. Specimens to be relaxed were placed on a piece of tissue paper in a glass dish and the dish together with the specimen was placed in the jar and tightly closed (Narendran, 2001).

3.8. Identification

a) Literature: Identification up to genus level was carried out using Bohart and Menke (1976). A detailed taxonomic study was carried out on the basis of keys of Bingham (1857), Tsuneki (1979), Krombein and Pulawski (1994), Jonathan and Kundu (2003), Kundu *et.al* (2006) and other relevant literature. Taxonomic classification followed is that suggested by Pulawski (2013).

b) Microscopy and Photography: Species identification as well as drawing of figures was carried out using Leica MZ6 stereozoom microscope (German made) with attached camera lucida.

Field photography was taken using Sony digital camera DSC W570 model The back grounds, colour balance and contrast were adjusted using Adobe Photoshop CS 3.

3.9. Depository

All the specimens collected are stored in the research lab, Department of Zoology, St.Thomas College, Thrissur, which will be eventually transferred to Zoological Survey of India Western Ghat Regional Centre, Calicut (ZSIWGRC).

3.10. Terminology used in the study

The morphological terminology used is based primarily of Bohart and Menke (1976) and for sculpture based on Eady (1968)

In this work the term Plesiotype has been used as defined by Mayr *et.al.* in 1953. Accordingly Plesiotype is a specimen upon which subsequent redescription and figures are made.

- Admedian lines** (Fig 2a) : A median pair of lines originating anteriorly on scutum.
- Antennae** (Fig 1a) : Composed of a basal scape, pedicel and terminal flagellum which is composed of flagellomeres.
- Appressed hairs** : The hair that is parallel to or nearly parallel to the body surface.
- Areolate** (Fig 6a) : Divided into small, irregular spaces.
- Arolium** (Fig 2c) : A sac like organ between claws (Pulvillus).

- Basitarsus** (Fig 2c) : The basal most tarsomere.
- Bevel** : The median portion of the clypeus, in front view.
- Bituberculate** : Covered with two rounded lobes separated by median impression.
- Carina** (Fig 1b) : Elevated ridge on the body surface.
- Clypeal free margin** : Anterior margin of clypeus.
- Clypeus** (Fig 1a) : A broad plate situated in the front of the head, between the bases of the antennae and the mandibles.
- Coxa** (Fig 2c) : The basal segment of a leg, that articulates with the thorax.
- Cu-a** (Fig 3b) : Cubito-anal cross vein of each wing, forming outer end of Submedial cell.
- Cubitus** (Fig 2b) : The fifth longitudinal vein.
- Cuspis** : Stationary outer apical extensions of volsella in male genitalia.
- Dentate** : Teeth like projection.
- Episternal sulcus** (Fig 2b) : Originating in subalar fossa and extending ventrally on mesopleuron, when complete, reaching antero-ventral margin of mesothorax, often joined by scrobal sulcus.
- Erect hair** (Fig 10b) : A hair projecting essentially at right angle to the

surface of integument.

- Frons** (Fig 1a) : The area on the front of the head lying below the vertex, but not including the interantennal area.
- Frontal line** (Fig 1a) : Median line leading from mid ocellus to interantennal area.
- Frontoclypeal suture** (Fig 1a) : Upper margin of clypeus.
- Gena** (Fig 1b) : Posterolateral part of head between outer orbit and occipital carina.
- Glabrous** : Smooth, without pubescence or hairs or sculpture.
- Hamuli** : Hooks on margin of hind wing beyond origin of radial sector.
- Hind face** (Fig 22d) : The posterior sloping face of propodeum.
- Impunctate** : Without any punctae.
- Inner orbits** (Fig 1b) : Inner margin of compound eyes.
- Jugal lobe** (Fig 3b) : Posterior basal lobe of anal area on hind wing, marked by jugal excision.
- Labrum** (Fig 1a) : Mouthpart sclerite that hinges on the free margin of the clypeus, usually folding back and down over the apices of maxillae and labium, when mouth parts are not in use.
- Lateral carina** : A carina or line usually found only on the first tergum and positioned lateral to spiracle.

- M+Cu** (Fig 3b) : Media + Cubitus.
- Malar space** (Fig 1a) : Area between compound eye and mandible socket.
- Mandibular notch** (Fig 20a) : Externo-ventral emargination or stepped angulation on the mandible.
- Maxillary palpus** (Fig 1a) : The segmented sensory palps of the maxillae. Each palp has atmost six segments, but these are variously reduced in different genus.
- Media** (Fig 3b) : The fourth longitudinal vein.
- Mesopleuron** (Fig 2b) : Sides of mesothorax.
- Metasternum** : The underside of metathorax.
- Midtibial spur** (Fig 2c) : One or two movable spine like process, usually much larger than nearby setae arising from rings set in membraneous area at inner apex of midtibia, spur pectinate along its shaft.
- Notaulus** (Fig 2a) : Paired lines or grooves on scutum, originating anteriorly and outside.
- Omaulus** : Ridge or carina originating at lower base of pronotal lobe and extending postero-ventrally.
- Ocellar scars** (Fig 20a) : Flattened opaque remnants of ocelli.
- Palpal formula** : Number of segments in maxillary palpus compared to those in labial palpus.
- Petiole socket** (Fig 14c) : Orifice on posterior end of propodeum in which

gaster is inserted.

- Petiole** (Fig 10e) : Slender, parallel sided or cylindrical stalk of gaster.
- Plantulae** (Fig 12b) : Small oval pad which maybe found apicomediaally on underside of tarsomere.
- Prepectus** : Area of mesopleuron in front of episternal sulcus.
- Pronotal collar** : Raised posterolateral part of pronotum.
- Pronotal lobe** (Fig 2b) : Posterolateral part of pronotum covering mesothoracic spiracles.
- Pronotum** (Fig 2a) : The upper or dorsal surface of the prothorax.
- Propleuron** : Paired ventral plates of prothorax in front of fore coxae.
- Propodeal enclosure** (Fig 2a) : Area of propodeal dorsum usually delimited by grooves or carina, sometimes extending into posterior face of propodeum.
- Propodeum** (Fig 2a) : True first abdominal segment that forms an integral part of thorax, delimited anteriorly by posterior margin of metanotum and by metapleural sulcus.
- Pubescence** : Short, fine hairs typically forming a second layer beneath longer hairs.
- Punctate** (Fig 9c) : Fine, impressed points or punctures.
- Rake** (Fig 18c) : Linear series of setae on outer margins of fore tarsus, which function as a rake, in most females

and some males.

Recurrent veins (Fig 2b)	:	m-cu cross veins between media and cubitus of forewing, used with reference to their termination at submarginal cells.
Reticulate	:	Net like or made of network of lines.
Rugose (Fig 29b)	:	Wrinkled.
Rugo-reticulate	:	Rugae forming a coarse network.
Rugose- punctuate (Fig 19a)	:	Rugae with punctures.
Scape (Fig 1a)	:	First segment of the antennae, articulating with head.
Scutellum (Fig 2a)	:	Small posterior mesonotal plate behind scutum.
Scutum (Fig 2a)	:	Large anterior mesonotal plate in front of scutellum.
Sessile	:	To indicate a metasoma without petiole, directly attached to propodeum.
Sinuuous hairs	:	Hairs curved in and out.
Stigma	:	Sclerotized area on leading edge of base of marginal cell and in front of submarginal cell.
Striate (Fig 9c)	:	Parallel, longitudinal impressed lines or furrows.
Suberect hair	:	A small hair that projects from the integument at an angle less than 90° but more than 45°.
Tegula (Fig 2a)	:	Ovoid plate over base of forewing.

Tibia (Fig 2c) : The fourth segment of the leg (between the femur and tarsus).

Tuberculate : Covered with rounded, projecting lobe.

Vertex (Fig 1a) : The top of the head, beneath the ocellar triangle.

Volsella : Paired structure associated with inner base of gonostyles.

3.11. Measurements and Abbreviations used in description

ASD : Antennal Socket Diameter.

AV (Fig 15e) : Anterior Vein of Submarginal cell.

AS (Fig 1a) : Antennal sockets, the region of articulation of scape with the head.

AS-FC : The distance between the Antennal Sockets to Frontoclypeal suture.

BV (Fig 15e) : Basal Vein of Submarginal cell.

CL (Fig 4a) : Clypeal Length measured as the maximum distance from the midpoint of clypeal free margin to the midpoint of frontoclypeal suture.

CW (Fig 4a) : Clypeal Width, measured at the widest point of the clypeus.

FWL (Fig 4b) : Fore Wing Length, measured as the maximum distance from the tip of tegulae to the anterior

most margin of the wing.

- F1: F2: F3: F10** : Length of flagellomeres, as measured in dorsal view.
- HBT** (Fig 4b) : Hindbasitarsus, the basal most tarsomere of the hind leg.
- HL** (Fig 4a) : Head Length, measured as the maximum distance from the midpoint of the anterior clypeal margin to the midpoint of posterior margin of the head, in full face view.
- HTS** (Fig 4b) : Hindtibial Spur.
- HW** (Fig 4a) : Head Width, measured at widest point of head, in full face view.
- LID** : Lower Interocular Distance, measured as the distance between the inner orbits near the clypeus.
- MID** : Mid Interocular Distance, measured as the distance between the midpoints of the length of the inner orbits.
- MOD** : Mid Ocellar Diameter.
- OOL** (Fig 4a) : Ocello-Ocular Length, measured as the distance between the posterior ocellus and inner orbit margin.
- PBV** (Fig 15e) : Posterobasal Vein of Submarginal cell.

- PL** : Propodeal length, measured as the distance from the anterior margin (posterior margin of metanotum) to the posterior margin of propodeum, in dorsal view.
- POL (Fig 4a)** : Posterior Ocellar Length, measured as the distance between hind ocelli.
- PPS (Fig 7a)** : Post Petiolar Segments, metasomal segments preceding petiole.
- SMC I, II, III (Fig 3a)** : Sub Marginal Cell, usually one- three cells behind the marginal cells.
- SW** : Scutum Width, measured as the distance between the midpoints of tegulae.
- Scutum length** : Measured as the distance from the anterior margin (posterior margin of pronotum) to the posterior margin of scutum, in dorsal view.
- T (Fig 2c)** : Tarsomere, numbered as I, II, III, IV and V
- TBL (Fig 4b)** : Total Body Length, measured as the distance from the base of the antennae to the tip of the metasoma, in lateral view.
- UID** : Upper Interocular Distance, measured as the distance between the inner orbits at vertex.

3.12 General Abbreviations

e.g.	:	example
I. C. Z. N.	:	International Commission on Zoological Nomenclature
I. U. C. N.	:	International Union for Conservation of Nature.
K. A. U.	:	Kerala Agricultural University.
viz.	:	namely
Fig.	:	Figure

3.13. Symbols used

♀: Female

♂: Male.

3.14 Acronyms of Museums and Depositories

BMNH	:	The Natural History Museum, formerly British Museum (Natural History), London, Great Britain
CAS	:	California Academy of Sciences, San Francisco, California, USA.
DEI	:	Deutsches Entomologisches Institut, Eberswalde, Germany.
MHNG	:	Musée d'Histoire Naturelle, Genève, Switzerland.
MNCN	:	Museo Nacional de Ciencias Naturales, Madrid, Spain.
MNHN	:	Muséum National d'Histoire Naturelle, Paris, France.

- NHMW** : Naturhistorisches Museum, Wien, Austria.
- OXUM** : Hope Department of Entomology, Oxford, Great Britain
- RMNH** : Nationaal Natuurhistorisch Museum (formerly Rijksmuseum van Natuurlijke Historie), Leiden.
- TMB** : Természettudományi Múzeum, Budapest, Hungary.
- TORINO** : Museo Regionale di Scienze Naturali di Torino
- USNM** : United States National Museum (= National Museum of Natural History, Smithsonian Institution), Washington, USA.
- ZIN** : Zoological Institute, Russian Academy of Sciences, St. Petersburg, Russia.
- ZMAN** : Instituut voor Taxonomische Zoölogie (Zoölogisch Museum), Universiteit van Amsterdam, Amsterdam, the Netherlands.
- ZMUC** : Zoological Museum, University of Copenhagen, Copenhagen, Denmark.
- ZSIWGRC** : Zoological Survey of India Western Ghat Regional Centre, Calicut.

Chapter 4

RESULTS AND OBSERVATIONS

In the present investigation sphecid wasps belonging to three families- Ampulicidae, Sphecidae and Crabronidae were identified and studied. 35 species under 14 genera were collected from different parts of the state. Out of these 12 species were new to science and 3 species new record for the state. The diagnoses of 14 species under 5 genera were included from literature citations. Consequently 49 species of sphecid fauna coming under 19 genera has been dealt with in this study.

Detailed descriptions were given for new species and known species redescribed, since the available data were inadequate for the identification of the species. Dichotomous keys to subfamilies, genera and species as well as character data matrix for the genera *Liris* Fabricius, *Tachysphex* Panzer and *Sphex* Linnaeus were prepared, since these genera recorded the highest number of species. In addition to this, distribution maps, graphical representation of species diversity and check list of sphecid fauna dealt with in the present work also provided.

4.1 SYSTEMATIC POSITION OF SPHECID FAUNA DEALT WITHIN THIS WORK (Classification follows Pulawski, 2013).

Superfamily Apoidea

I Family Ampulicidae

Subfamily Ampulicinae

1. Genus *Ampulex* Jurine, 1807
2. Genus *Trirogma* Westwood, 1841

II Family Sphecidae

Subfamily Ammophilinae

3. Genus *Ammophila* W.Kirby, 1798
4. Genus *Parapsammophila* Taschenberg, 1869

Subfamily Chloriontinae.

5. Genus *Chlorion* Latreille, 1802

Subfamily Sceliphrinae

6. Genus *Sceliphron* Klug, 1801
7. Genus *Chalybion* Dahlbom, 1843

Subfamily Sphecinae.

8. Genus *Sphex* Linnaeus, 1758
9. Genus *Isodontia* Patton, 1880

III Family Crabronidae

Subfamily Crabroninae

10. Genus *Gastrosericus* Spinola, 1839
11. Genus *Tachysphex* Kohl, 1883
12. Genus *Tachytes* Panzer, 1806
13. Genus *Larra* Fabricius, 1793
14. Genus *Liris* Fabricius, 1804
15. Genus *Lyroda* Say, 1837
16. Genus *Miscophus* Jurine, 1807
17. Genus *Solierella* Spinola, 1851
18. Genus *Pison* Jurine, 1808
19. Genus *Trypoxylon* Latreille, 1796

4.2 DIAGNOSTIC CHARACTERS OF SUPERFAMILY APOIDEA

Antennae with ten flagellomeres in females and eleven in males; setae plumose; pronotum with postero-dorsal margin U-shaped; tegula separated from pronotum; postnotum fused with propodeum; forewing with nine-ten closed cells, hindwing with two closed cells; hindwing with jugal lobe; metasomal sterna 1 and 2 not separated by constriction; ovipositor concealed, modified as sting.

4.2.1 KEY TO FAMILIES OF APOIDEA IN KERALA

1. Body hairs simple, unbranched (Fig 2e); inner side of hind basitarsus pectinate; hind basitarsus as wide as rest of tarsomeres (Fig 2c).....2

- Body hairs branched or plumose (Fig 2d); inner side of hind basitarsus not pectinate; hind basitarsus wider than succeeding tarsomeres.....**Family APIDAE**

2. Tarsal claws with teeth along inner margin; mid tibia with two apical spurs; hind wing jugal lobe absent or small (Fig 5c).....**Family AMPULICIDAE**

- Tarsal claws simple or toothed; mid tibia with two, one or apical spurs absent; hind wing with jugal lobe when present covering as much as half of anal area.....**3**

3. Metasoma with petiole composed of sternum (Fig 9g) only (except in *Ammophila* Kirby, petiole two segmented); jugal lobe of hind wing more than half length of anal area.....**Family SPHECIDAE**

- Metasoma sessile or with petiole compose of both tergum I and sternum I; hind wing jugal lobe less than half length of anal area.....**Family CRABRONIDAE**

4.3 FAMILY AMPULICIDAE

Ampulicidae Shuckard, 1840:178, 180. Based on *Ampulex* Jurine (stem: *Ampulic*-).

Diagnosis: Body elongate; inner orbits entire; antennae low on face, narrowly separated or contiguous with frontoclypeal suture; male with thirteen and female with twelve antennal segments; mandibles without notch exteroventrally; tarsal claws toothed or bifid on inner margin; mid tibia with two apical spurs; hind wing jugal lobe small or absent; Metasoma sessile or with petiole composed of tergum and sternum; propodeum posteriorly with projections.

Distribution: Mainly Tropical family.

Biology: These wasps prey on cockroaches and nests in hollow branches. Eggs are laid after dragging prey to the nest (Krombein, 1979a).

4.3.1 Key to the Subfamilies and Genera of Ampulicidae in India

1. Fore wing with SMC III ending after midway of marginal cell or towards wing margin (Fig 5c; 6c); fore wing media diverging before or at cu-a; lower metapleural area well defined; plantulae present.....**Subfamily AMPULICINAE**.....2
- Fore wing with SMC III ending before midway of marginal cell, much away from outer wing margin; fore wing media diverging after cu-a; lower metapleural area not defined; plantulae absent.....**Subfamily DOLICHURINAE**
(Not represented in this study)

2. Antennal sockets separated from frontoclypeal suture by socket diameter; each socket covered by frontal lobe (Fig 5b); fore wing with SMC's three or two; recurrent vein II received by SMC III (in two celled forms in SMC II); hind wing jugal lobe absent.....Genus *Ampulex* Jurine
- Antennal sockets contiguous with frontoclypeal suture, covered by longitudinally grooved 'U' shaped frontal platform (Fig 6a); fore wing with three SMC's; recurrent vein I received by SMC I and recurrent vein II received by SMC II; hind wing with jugal lobe small.....Genus *Trirogma* Westwood

4.3.2 SUBFAMILY AMPULICINAE

Ampulicinae Shuckard, 1840:178, 180. Based on *Ampulex* Jurine (stem: *Ampulic*-).

The Ampulicinae is regarded as the most primitive subfamily among Spheciformes. They are readily distinguishable by their metallic blue or black and red colour and the habit of rapidly running up and down tree trunks hunting for their prey (Krombein, 1979).

Diagnosis:

Head: Inner orbits entire; ocelli normal; male with thirteen and female with twelve antennal segments; mandibles without notch externo-ventrally; palpal formula 6-4, maxillary palp long.

Mesosoma: Pronotum with collar high and tuberculate, not closely appressed to scutum; pronotal lobe touching or close to tegula; notauli extending length of scutum; episternal sulcus absent, except for a ventral remnant; omaulus present; metapleuron composed of upper metapleural area; scutellum with pitted basal transverse sulcus; mid tibia with two spurs; claws unidentate or bifid; propodeum with U-shaped or triangular enclosure; fore wing with three or two submarginal cells, recurrent vein I received by submarginal cell I or II and recurrent vein II received by submarginal cell II or III; marginal cell apically acuminate; jugal lobe small or absent, anal vein absent. Metasoma: Gaster sessile or with petiole composed of tergum and sternum; first three metasomal segments enlarged; male gaster with only three visible segments, segments IV-VIII withdrawn or narrowly exposed; sternum VI of female modified as tapering tube for the exertion of sting apparatus; volsella with movable digitus and cuspis, aedeagus ventrally with teeth; cerci present or absent.

Distribution: World wide

Biology: Members of this subfamily are commonly called as ‘Cockroach wasps’, as they capture cockroaches to serve as food for their larvae. The egg is laid on the mid coxa and only one roach is provisioned per cell. The cockroach is weakly paralyzed and the wasp uses her mandibles to drag the prey by its antennae. While dragging the prey, the wasp walks backwards, this being a unique and primitive character (Bohart and Menke, 1976; Krombein, 1979a).

Genus *Ampulex* Jurine

Ampulex Jurine, 1807:132. Type species: *Chlorion compressum* of Latreille and of Fabricius [= *Chlorion compressum* (Fabricius, 1804) = *Sphex compressus* Fabricius, 1781], designated by Audouin, 1822:301.

Pronaeus Latreille, 1809:56. Type species: *Dryinus aeneus* Fabricius, 1804, designated by Latreille, 1810:438. [Synonymized by Pate, 1935:247].

Lorrhoeum Shuckard, 1837:18. Type species: *Chlorion compressum* (Fabricius, 1804) [= *Sphex compressus* Fabricius, 1781], by original designation and monotypy.

Rhinopsis Westwood, 1844:68. Type species: *Rhinopsis abbotti* Westwood, 1844 [= *Ampulex canaliculata* Say, 1823], by monotypy.

Waagenia Kriechbaumer, 1874:55. Type species: *Waagenia sikkimensis* Kriechbaumer, 1874, by monotypy.

Chlorampulex de Saussure, 1892:441. Type species: *Sphex compressus* Fabricius, 1781, designated by Pate, 1937:18.

Diagnosis:

Head: Inner eye margins usually converging above, but parallel or converging below in some species; female mandible bent upward forming an angle of 40⁰ or less, inner margin simple; male mandible not bent and with single teeth; malar space usually absent; clypeus with polished carina, free margin usually tridentate; labrum thick, exposed beneath the clypeal margin; each antennal socket covered by frontal lobe; vertex raised above eyes, post ocellar area twice or longer than ocellar triangle; U-shaped occipital carina, evanescent or absent in females; mandibular sockets closed.

Mesosoma: Pronotal lobe angulate; pronotal collar tuberculate; scutum in lateral view convex, with notauli distinctly impressed; scutum depressed posterolaterally; inner margin of tegulae slightly overhanged by scutal margin; scutellum and metanotum flat; propodeum dorsally with median longitudinal carina and two or more sub median carina, converging posteriorly; propodeum with interspaces transversely carinate, sides areolate, its posterolateral margin produced into tooth; sternaulus and remnants of episternal sulcus sometimes present; hypoepimeral area bulging near scrobe; lower metapleural area smooth; fore wing media diverging at or slightly before cu-a; submarginal cells two or three, recurrent vein I received by SMC I and recurrent vein II received by SMC III (SMC II in two-celled wings), SMC I twice as long as SMC II; hindwing without jugal lobe.

Metasoma: Petiole composed of both tergum and sternum; tarsomere V inserted dorsally at base of IV; transverse basal groove on sternum II; cerci absent.

Distribution: Worldwide; mainly a tropical genus.

Biology: Preys on cockroaches, they are seen exploring for prey in the holes of tree barks and even in the households. *Ampulex ruficornis* (Cameron) and *A. formicoides*

Turner exhibit mimicry (Turner, 1926). They have the habit of licking the fluid oozing out from the amputated part of their prey. The prey is stored in crevices or holes, and may construct multicellular nests in hollow plant stems (Williams, 1929; Krombein, 1967b).

Remarks: Genus *Ampulex* Jurine is similar to *Trirogma* Westwood in having 1. SMC I elongate; 2. SMC III placed closer to outer margin of wing; 3. Forewing media diverging basally and 4. Pronotal lobe posteriorly angled. However *Ampulex* differs from *Trirogma* in having 1. Cerci absent (in *Trirogma* cerci present); 2. Mandibular sockets closed (mandibular sockets open in *Trirogma*) and 3. Absence of jugal lobe (in *Trirogma* jugal lobe present).

Key to Species of the Genus *Ampulex* Jurine in Kerala.

1. Scutum oblong, exceeding beyond tegulae; propodeum with six oblique carina converging posteriorly; arms of metasternum subtriangular, attached at an acute angle.....*Ampulex aenea* Spinola
- Scutum broad, depressed not extending beyond tegulae (Fig 5a); propodeum with seven longitudinal carina; arms of metasternum tapering.....*Ampulex compressa* (Fabricius)

1. *Ampulex aenea* Spinola

Ampulex aenea Spinola, 1842:110, ♀, junior secondary homonym of *Ampulex aenea* (Fabricius, 1804). India (TORINO).

Diagnosis

Carina on face arcuate; scutum punctate, oblong, exceeding beyond tegulae; propodeum with six oblique longitudinal carina, outer four converging posteriorly; mesopleuron with scrobal sulcus pitted; metasternum 'Y' shaped, with diverging arms subtriangular and attached at acute angle.

Material examined: No material examined. The above description of the species is based on that by Spinola, 1842.

Distribution: India, Kerala: Malabar.

Biology: Unknown.

Remarks. This species was first reported from Malabar, Kerala by Spinola in 1842

2. *Ampulex compressa* (Fabricius)

(Fig 5a-c; Plate 16a)

Sphex compressus Fabricius, 1781: 445, sex not indicated (misspelled as *compressa* by Fabricius). India (BMNH).

Chlorium compressum (Fabricius): Billberg, 1820: 105, new combination for *Sphex compressus* Fabricius.

Chlorampulex compressa (Fabricius): Saussure, 1892: 443, new combination for *Sphex compressus* Fabricius.

Ampulex compressa (Fabricius): Jurine, 1807: 134, new combination for *Sphex compressus* Fabricius.

Chlorampulex striolata Saussure, 1892: 446, ♀. Tanzania (MHNG). [Synonymized by Schulz, 1911b: 152].

Redescription

Female.

Measurements in mm

TBL=18.8; FWL=10.7; SW= 3.5

Colour: Body metallic green blue; mid and hind coxa orange red; mandibles except apically, tarsomeres II-V, antennae except scape black; hind and mid coxa brassy; fore coxa ventrally red; hairs white.

Vestiture: Clypeus and lower frons with appressed hairs; vertex, gena, pronotum, scutum, mesopleuron and propodeum posteriorly with erect, sparse hairs.

Sculpture: Frons, vertex, scutum antero-laterally, scutellum posteriorly and mesopleura coarsely punctate, the punctae closer near margins; pronotum anterior one third transversely ridged; propodeum dorsally transversely striate, sides areolate rugose to smooth; metapleura smooth; prosternum, mesosternum and coxa ventrally punctate.

Head: 0.8x as long as wide (HL = 3.2mm, HW = 4mm); vertex convex, with longitudinal line arising from midocelli; inner orbits converging above, UID:MID:LID = 1.4:2.1:2.2; POL:OOL = 0.25:0.5; frontal line finely impressed; carina above each antennal tubercle, evanescent beyond midocelli; antennae twelve segmented, filiform; scape 2x and F1 5.8x as long as its apical width; F1 0.8x as long as F2 and F3 combined (F2+F3 = 2.8mm); F1:F2:F3: F10 = 2.3:1.5:1.3:0.5; clypeus 0.8x as long as wide, with median keel not touching apex; clypeal free margin sinuate with acute corners, apicolaterally notched (CL = 1.1mm, CW = 1.4mm); mandibles simple.

Mesosoma: Pronotum with median longitudinal line, anterolaterally bituberculate and with acute median tubercle on posterior margin; sternaulus absent; omaulus present; admedian lines, notauli and paradiscal lines finely impressed; propodeum with seven longitudinal carina, the submedian carina ending on sharp posterolateral tubercles; wings hyaline; veins of fore wing much darker; fore wing marginal cell apically appendiculate and acuminate; three SMC's present, SMC II almost square; AV of SMC III 2.4x as long as AV of SMC II (SMC II AV = 0.5mm, AV of SMC III = 1.2mm); first recurrent vein received by SMC I and second recurrent received by SMC III; hind wing media diverging at cu-a; legs stout; tarsal claws with single tooth; T IV ventrally with hair mat; hind tibial spur 0.2x as long as hind basitarsus (HTS = 0.5mm, HBT = 3.2mm).

Metasoma: 0.8x as long as mesosoma (Metasoma = 7mm, Mesosoma = 9.2mm); petiole short, 0.5x as long as hindcoxa (petiole = 0.8mm, hind coxa = 1.7mm); relative

length of metasomal segments I: II = 2.2:2.8; second metasomal segment 1.38x as long as wide (2.8/3.3mm); sternum II with basal transverse sulcus.

Male

Diagnosis: Length 15-16mm. Body metallic blue, hairs white; frons, vertex coarsely punctate than in females; gena punctate; pronotum rugulose; vertex narrow with median groove; tergum II with punctae closer and coarse than in females; UID 0.7x as long as F2; F1 three-fourth length of F2+F3; carina above frontal lobe much distinct than in females; pronotum with anterolateral tubercle weaker than in females; strenualus absent; petiole 0.2x as long as hindcoxa (Krombein 1979a).

Material examined, Plesiotype: 1♀, India: Kerala, Thrissur, Ayyanthole 10⁰32'12"N 76⁰11'8"E. 11.ii.2011. Baaby Job.

Other material examined: 1♀, India: Kerala, Malappuram: Calicut University Campus 11°8'N 75°53'E. 04.xi.1996. Leena P.T.; 1♀, India: Kerala, Thrissur, Ayyanthole 10⁰32'12"N 76⁰11'8"E. 2.vi.2010. Baaby Job; 1♀ India: Kerala, Thrissur, Ayyanthole 10⁰32'12"N 76⁰11'8"E. 11.ii.2011. Baaby Job; 1♀, India: Kerala, Ernakulam: Koothattukulam 9° 49' N 76° 36' E, 6.vi.2011. Baaby Job; 1♀, India: Kerala, Kasargode: Karim's forest, Parappa 12⁰20'N 75⁰14'E. 1.i.2012, Baaby Job.

Distribution: Africa, Bangladesh, China, Hawaii, Indonesia, Mauritius, Philippines, Singapore, Sri Lanka, India [Sikkim, Meghalaya, Assam, Arunachal Pradesh, Orissa, Bihar, Maharashtra, West Bengal, Andaman & Nicobar Islands, Kerala: Thrissur, Palakkad, Kasargode, Malappuram].

Biology: Preys on the roach *Periplaneta americana* Linnaeus; Williams (1929) reported that after paralyzing the cockroach, the wasp dragged it to a crack in wall and when the cockroach was too big, the wasp bit off the prey's tegmina or its legs. The wasp stings the roach twice, first on thorax ventrally causing a temporary and reversible paralysis, second on suboesophageal ganglion resulting in irreversible and permanent paralysis and behavioural changes. After dragging the prey to a suitable place, egg is laid on the surface and the nest closed. The wasp larva feed on the

immobilized prey as an internal parasite and finally kills it (Piek et.al, 1984; Libersat, 2003). The wasp larva secretes antibacterial secretions against virulent bacteria in the roach tissue, which may kill it Yong (2013).

Remarks: Usually called as ‘Emerald wasps’, due to their brilliant metallic blue colour.

Ampulex compressa Fabricius closely resembles *Ampulex crudelis* Bingham in having (i) brilliant metallic blue body colour; (ii) propodeum with seven longitudinal carina and (iii) hind femora red.

However *A.compressa* differs from *A. crudelis* in having 1. Forewing with three submarginal cells (in *A. crudelis* forewing with two sub marginal cells); 2. Both mid and hind femora red (in *A. crudelis* mid femora metallic blue); 3. Pronotum tuberculate (in *A. crudelis* pronotum not tuberculate).

Genus *Trirogma* Westwood

Trirogma Westwood, 1841a:152 (April). Type species: *Trirogma caerulea* Westwood, by monotypy.

Trirogma Westwood, 1841b:16 (June). Objective synonym of *Trirogma* Westwood, 1841a.

Trirogma Westwood, 1842:223. Objective synonym of *Trirogma* Westwood, 1841a.

Trirhogma Agassiz, 1847:378. Emendation of *Trirogma* Westwood, 1841.

Diagnosis:

Head: Inner margin of female mandibles with one weak subapical and three median teeth, males with single median tooth; male clypeus concave, slightly emarginate, female clypeal margin with reflexed lip and eight macrochaetae behind lip in a curved row; labrum not exposed, pointed in males; antennal sockets covered by U shaped frontal lobe; vertex raised above eyes, post ocellar area twice or longer than ocellar triangle; U shaped occipital carina or absent.

Mesosoma: Pronotal collar as long as scutum with two rounded or acute lobes posteriorly; notauli complete or defined anteriorly; paradiscal lines indistinct; scutum posterolaterally reflexed; propodeal enclosure U shaped, posterolaterally with dentiform angles, posterior face declining abruptly, dorsally areolate; omaulus, anteroventral remnant of episternal sulcus and anterior impression of sternaulus present; scrobal sulcus joining omaulus; lower metapleural area distinct; fore wing media diverging before or at cu-a; three SMC's, SMC I twice as long as II, III trapezoidal; first recurrent received by SMC I or interstitial, second recurrent by SMC II; hind wing jugal lobe small, media diverging after cu-a.

Metasoma: Petiolate; sternum II swollen with curving sulcus.

Distribution: Asia, Arabian Peninsula.

Biology: Preys on *Periplaneta* sp. and *Neostylopyga* sp. (Bohart and Menke, 1976)

Remarks: Genus *Trirogma* Westwood closely resembles genus *Dolichurus* Latreille in having 1. Frontal platform; 2. Hind wing jugal lobe and 3. General body, clypeal and mandibular structure. However *Trirogma* differs from *Dolichurus* in having 1. Forewing media diverging at or before cu-a (in *Dolichurus* forewing media diverging before cu-a); 2. Well defined lower metapleural area (lower metapleural area not defined in *Dolichurus*); 3. Plantulae absent (plantulae present in *Dolichurus*).

Key to Species of the Genus *Trirogma* Westwood in Kerala

1. Metasoma smooth; antennae twelve segmented; body metallic blue; scutum with scattered punctae.....*Trirogma caerulea* Westwood
- Metasoma, scutum coarsely punctate; antennae fourteen segmented; body metallic bluish green.....*Trirogma narendrani* Madhavikutty

3. *Trirogma caerulea* Westwood

(Fig 6a-c; Plate 16b)

Trirogma caerulea Westwood, 1841a: 152, ♂. India (OXUM).

Trirogma caerulea Westwood, 1841b: 16, ♂. Objective synonym of *Trirogma caerulea* Westwood, 1841a.

Trirhogma[!]caerulea Westwood, 1842: 225, ♂. Objective synonym of *Trirogma caerulea* Westwood, 1841a.

Redescription.

Female.

Measurements in mm

TBL = 23.2; FWL = 12; SW = 3.7

Colour: Metallic blue; antennae black; apical segments of metasoma with brown reflections; hairs white.

Vestiture: Appressed hairs on clypeus, lower frons and tergites II- V; vertex, scutum, scutellum, metanotum with erect hairs; gena, propodeum and base of terga I with semierect hairs.

Sculpture: Body shining; frons coarsely punctate; propleura medially ridged; pronotum, scutum, scutellum punctate; notuali and upper mesopleural groove crenulate; propodeum medially longitudinally striate to areolate rugose, sub medially transversly ridged, sides areolate rugose; tergites IV-V micropunctate and VI-VII apicolaterally punctate.

Head: Nearly as long as wide (2.8mm); vertex convex; inner orbits converging towards vertex, UID: MID: LID = 1.9: 2.09: 2.27; POL: OOL = 0.45: 0.81; hind ocelli margined by groove; frontal platform with median and lateral furrows; frontal line finely impressed; antennae filiform, twelve segmented; scape 2.5x and F1 4x as long as apical width, F1 nearly as long as F2+F3 (1.8mm); F1: F2: F3: F10 = 1.7: 1.3: 1.5:

0.7; clypeus 0.12x as long as wide, freemargin arched (CL = 03mm, CW = 2.5mm); mandibles weakly dentate, pointed.

Mesosoma: Pronotum posterior margin with lateral tubercles; omaulus present; sternaulus, admedian lines absent; paradiscal lines faintly impressed; scutellum with anterior and lateral sulcus; propodeum with four carina; wings hyaline, fore wing marginal cell apically acuminate, not appendiculate; AV of SMC II as long as AV of SMC III (AV of SMC = 0.3mm, AV of SMC III = 1.2mm); jugal lobe small, one-third length of anal area; hind wing media diverging after cu-a, at a distance 0.3x length of cu-a (M+Cu = 0.3, cu-a = 1.2mm); legs stout, slender; hind coxa with baso-dorsal carina; tarsal claws with single teeth; hind tibial spur 0.4x of hindbasitarsus (HTS = 1mm, HBT = 2.7mm).

Metasoma: 1.4x as long as mesosoma, tapering posteriorly (Metasoma = 10.8mm, Mesosoma = 9.5mm); TgI: TgII = 3.5: 3; sternum II with anterolateral transverse, bisinuate groove and median bulge.

Male.

Diagnosis:

Length 12-13mm. Body metallic blue; hairs white; pronotum coarsely punctate; notuali, upper mesopleural groove and sternaulus crenulate; inner orbits not converging towards vertex, least interocular distance 1.2x as long as F1; frontal platform with lateral grooves; frons above frontal platform pitted with median groove; posterolateral tubercles of pronotum angulate; sternum II with bisinuate groove medially interrupted by tubercle (Krombein, 1979a).

Material examined, Plesiotype: 1♀ India: Kerala, Thrissur, Ayyanthole 10⁰32'N 76⁰11'E. 05.ii.2010. Baaby Job

Other material examined: 1♀, India: Kerala, Malappuram: Calicut University Campus 11°8'N 75°53'E. 01.iii.1977. V.V.S.Kumar; 1♀, India: Kerala, Malappuram: Mampad. 27.ix.2001. Madhavikutty; 2♀, India: Kerala, Thrissur, Ayyanthole 10⁰32'N

76⁰11'E. 03.iv.2009. Baaby Job; 1♀, India: Kerala, Thrissur, Ayyanthole 10⁰32'N
76⁰11'E. 05.ii.2013. Baaby Job.

Distribution: Singapore, Indonesia, China, Taiwan, Iraq, Sri Lanka, Iran and India [Uttar Pradesh, West Bengal and Kerala: Thrissur, Palakkad, Malappuram].

Biology: Tsuneki (1972) recorded female *T. caerulea*, 25 mm long, transporting 18mm long *Periplaneta australasiae* (Fabricius) in Taiwan.

Remarks: Mainly found indoors.

Trirogma caerulea Westwood is similar to *Trirogma prismatica* Smith in having 1. Metasoma broad with three visible segments; 2. Filiform antennae and 3. Shape of clypeus. However *T. caerulea* differs from *T. prismatica* in having 1. Mandibles black (mandibles white at base in *T. prismatica*); 2. Metasoma smooth (in *T. prismatica* metasoma punctate) and 3. Anterior elevated tubercle on scutellum (tubercle absent in *T. prismatica*).

4. *Trirogma narendrani* Madhavikutty

Trirogma narendrani Madhavikutty, 2004: 594, ♀, India: (ZSIWGRC).

Female.

Diagnosis: Length 15mm; colour blue green; coxae , mandibles black; hairs white; vertex, pronotum, scutum, scutellum coarsely punctate; propodeum dorsally and laterally longitudinally carinate; eyes oval, extending to antennal base; ocelli in triangle; antennal sockets with U shaped, longitudinally grooved frontal lobe; antennae filiform, fourteen segmented; pronotum laterally tuberculate; cone like projections on scutum and scutellum; U shaped propodeal enclosure margins irregular; forewing with three SMC's, media diverging before cu-a; SMC III trapezoidal; legs long, slender; mid coxae nearly contiguous; femora flat; claws with single teeth; metasoma with three visible segments, apical segment rounded.

Male: Unknown.

Material Examined: No material examined. The above description of the species is based on that by Madhavikutty, 2004.

Distribution: India [Kerala: Wayanad].

Biology: Unknown.

Remarks: *Trirogma narendrani* Madhavikutty was collected from Chembra Hills, Wayanad.

Trirogma narendrani Madhavikutty closely resembles *Trirogma caerulea* Westwood in having 1. Mandibles black; 2. Body covered with white hairs; 3. Longitudinally grooved frontal platform.

However *T. narendrani* differs from *T. caerulea* in having 1. Antennae fourteen segmented (in *T. caerulea* antennae thirteen segmented; 2. Metasoma punctate (in *T. caerulea* metasoma smooth); 3. Scutum, scutellum with cone like projections (absent in *T. caerulea*).

4.4. FAMILY SPHECIDAE

Sphecidae Latreille, 1802b: 331 (November). Based on *Sphex* Linnaeus, 1758 (stem: *Sphec*-).

Diagnosis

Male with twelve and female with thirteen antennal segments; mandible simple exteroventrally; palpal formula normally 6-4; pronotal lobe well separated from tegula; fore wing with three SMC's; mid tibia with two or one apical spurs; pronotum short with posteriorly directed rounded lobe; propodeal enclosure present or absent; mid tibia usually with two apical spurs; tarsal claws simple or toothed along inner margin; hind wing with jugal lobe covering more than half length of anal area; metasoma with petiole composed of sternum I.

Distribution: Worldwide.

Biology: Solitary wasps, constructs aerial or ground nests. They are found in diverse habitats including forests, fields, vacant lots, houses and even seen peeping in and out of electric plug hole. These wasps are predatory; their prey ranges from spiders to a variety of Dictyopterans or Orthopteroids to caterpillars of Lepidoptera or other Hymenoptera. Most of them practice mass provisioning (Bohart and Menke, 1976; Krombein, 1967b).

4.4.1 Key to Subfamilies and Genera of Sphecidae in Kerala

1. Third maxillary palp expanded laterally (Fig 12a); tarsal claws with one median tooth; tarsi with plantulae (Fig 12b).....2
 - Third maxillary palp not expanded; tarsal claw with basal teeth; plantulae absent.....3
2. Recurrent vein II received by SMC III (Fig 9e); spiracular groove present; midcoxae separated by distance equal to petiole width.....**Subfamily Chloriontinae**
.....Genus *Chlorion* Latreille.....*Chlorion lobatum* (Fabricius)
 - Recurrent vein II received by SMC II (Fig 10c); spiracular groove absent; midcoxae nearly contiguous.....**Subfamily Sceliphrinae**.....5
3. Body robust; tarsal claws of fore and midlegs with two or more basal teeth (Fig 17d); recurrent vein II received by SMC III, recurrent vein III received by SMC II (Fig 15e).....**Subfamily Sphecinae**.....6
 - Body much slender; tarsal claws simple or with teeth; both recurrent veins received by SMC II (Fig 7e).....**Subfamily Ammophilinae**.....4
4. Petiole composed of sternum I followed by tergum I (Fig 8a); apex of sternum I not reaching base of sternum II (Fig 8e), intervening space composed of membranous ligaments; tarsal claws simple (Fig 7c).....Genus *Ammophila* Kirby
 - Petiole composed of sternum I only; apex of sternum I reaching base of sternum II; tarsal claws with two basal teeth.....Genus *Parapsammophila* Taschenberg
.....*Parapsammophila erythrocephala* (Fabricius)

5. Propodeum with 'U' shaped dorsal enclosure (Fig 10b); tarsomeres with plantulae (Fig 12b); petiole 2.5-3.6x as long as hind coxa.....Genus *Sceliphron* Klug
- Propodeum with median longitudinal sulcus or posteromedian pit; plantulae absent; petiole 1.9-2.1x as long as hindcoxa.....Genus *Chalybion* Dahlbom
6. Propodeum with complete spiracular groove (Fig 15c); AV of SMC III 0.2-0.8x as long as its PBV; outer margin of female forelegs with tarsal rake (Fig 18c).....
.....Genus *Sphex* Linnaeus
- Propodeum without complete spiracular groove; AV of SMC III 2.7x as long as PBV; outermargin of female foretarsus without rake; propodeum (Fig 19a) rugose-punctate.....Genus *Isodontia* Patton.....*Isodontia diodon* (Kohl)

4.4.2 SUBFAMILY AMMOPHILINAE

Ammophilinae André, 1886: 50. Based on *Ammophila* Kirby, 1798 (stem: *Ammophil*).

The members are distinguished by their long and slender metasoma. *Ammophila* Kirby forms the largest and much known genus of this subfamily. Their interesting behaviour patterns, like 'tool use' for nest closure have made them popular subjects for ethologists.

Diagnosis

Head: Antennal sockets separated from frontoclypeal suture; male flagellomeres without placoids; inner mandibular margin with teeth; mandibular socket usually closed; maxillary palp III not expanded; occipital carina incomplete or meeting hypostomal carina at apex.

Mesosoma: Propodeal enclosure present; episternal sulcus complete; lower metapleural area defined by sulcus or ridge; fore wing with three SMC's; tarsal claws simple or with two basal teeth; plantulae present (except in *Parapsammophila*).

Metasoma: Petiole composed of sternum I only (except in *Ammophila*); cerci absent; volsella with digitus joined.

Distribution: Worldwide.

Biology: Prey consists of mainly Lepidopterous and Hymenopterous caterpillars (except *Eremochares* provisioning with grasshoppers). These are fossorial wasps. Mass provisioning is the rule, but sometimes *Ammophila* exhibits progressive provisioning (Bohart and Menke, 1976).

Genus *Ammophila* Kirby

Ammophila Kirby, 1798: 199. Type species: *Sphex sabulosus* Linnaeus, 1758, designated by I.C.Z.N., 1946:571 (Opinion 180).

Ammophylus Latreille, 1802b:332. Lapsus or emendation of *Ammophila* W. Kirby, 1798.

Miscus Jurine, 1807:130, no included species. Type species: *Miscus campestris* (Latreille, 1809) [= *Ammophila campestris* Latreille, 1809], designated by Shuckard, 1837:79

Ammophilus Latreille, 1829: 322. Lapsus or emendation of *Ammophila* W. Kirby, 1798.

Coloptera Lepeletier, 1845: 387. Type species: *Coloptera barbara* Lepeletier de Saint Fargeau, 1845, by monotypy.

Argyrammophila Gussakovskij, 1928a: 7. Type species: *Ammophila induta* Kohl, 1901b, by original designation.

Apynemia Leclercq, 1961: 211. Type species: *Ammophila fallax* Kohl, 1884 [= *Ammophila hungarica* Mocsáry, 1883], by original designation.

Diagnosis

Head: Inner orbits converging below; frontal line present or absent; male terminal flagellomeres with tyli; antennal sockets in females contiguous or separated by socket diameter from frontoclypeal suture and in males by two socket diameters; clypeal free margin of female usually arcuate or sinuate with median lobe, delimited by lateral tooth, male clypeus variable; labrum sometimes with apicomedian process; inner mandibular margin with one – three mesal teeth in females and one – two subapical

teeth in males; when folded, galea reaching or exceeding the base of stipes; mandibular socket closed .

Mesosoma: Propodeal enclosure defined; propodeal socket bounded ventrally by propodeal sternite; mesopleuron in some species concave for receiving fore coxae, sometimes margined with carina or by mesal process projecting towards fore coxae; lower metapleural area well defined; marginal cell apex acuminate or rounded; SMC III sometimes petiolate or absent; both recurrent veins received by SMC II or in some species interstitial or rarely first recurrent vein received by SMC I; fore tarsal rake well developed in females; outer apex of fore tarsomere I prolonged, asymmetrical; mid tibia usually with two spurs; hind tibial spur closely, finely pectinate; tarsal claws usually simple, but dentate in some species.

Metasoma: Petiole two segmented composed of sternum I and weakly dilated tergum I, sternum I bent downward at base of tergum I; sternum I not reaching apex of sternum II intervening space connected by membrane and ligament; tergum I spiracle located beyond middle; male sternum VIII usually emarginated; penis valve with teeth on ventral margin and basal spine like process.

Distribution: Worldwide; cosmopolitan wasps.

Biology: Solitary nesters; nests are provisioned with usually hairless Lepidopterous and Hymenopterous (sawfly) caterpillars. The caterpillar with head first and face down is held by the mandibles and either flown or dragged, depending on the size of the prey. Egg is laid near cephalic end. Burrows are closed with stones and debris found around the nesting site and packed by pounding with stones or pebbles held by mandibles, reveals “tool-use” behaviour among these wasps (Brockmann, 1984). They usually form loose sleeping aggregations (Evans and Linsley, 1960; Vardy, 1995). Nests are parasitized by Sarcophid flies. *Ammophila* may maintain multiple nests simultaneously.

Remarks: Genus *Ammophila* Kirby closely resembles genus *Podalonia* Fernald in having 1. Tarsal claws simple; 2. Elongated mouthparts, galea reaching base of stipes

when folded; 3. Episternal sulcus passing straight down and 4. Petiole socket bound by propodeal sternite.

However Genus *Ammophila* differs from *Podalonia* in having 1. Sternum I ending before the base of sternum II, the intervening space membranous (in *Podalonia* sternum I reaching base of sternum II); 2. Spiracle of tergum I located at the level of apex of sternum I or beyond it (in *Podalonia* spiracle of tergum I located at or before middle); 3. Sternum I bend downward at base of tergum I (in *Podalonia* sternum I bend upward) and 4. Tergum I slender in females (in *Podalonia* dilated posteriorly).

Key to Species of *Ammophila* Kirby in Kerala

1. Scutum transversly striate; scutellum, metanotum longitudinally striate (Fig 7a); metasoma metallicblue-black; forebasitarsus in females with six rake spines.....*Ammophila clavus* (Fabricius)
- Scutum, scutellum, metanotum coarsely punctuate (Fig 8a); Metasoma black; forebasitarsus with seven rake spines.....*Ammophila laevigata* F. Smith

5. *Ammophila clavus* (Fabricius)

(Fig 7a-e; Plate 8a)

Sphex clavus Fabricius, 1775: 348, sex not indicated (misspelled as *clauus*). Australia: (BMNH).

Ammophila clavus (Fabricius): F. Smith, 1856: 214, new combination for *Sphex clavus* Fabricius.

Ammophila atripes F. Smith, 1852a: 46, ♀. India (BMNH). [Synonymized with *Ammophila clavus* by Dollfuss, 2013: 419].

Ammophila clavus atripes Tsuneki, 1967: 15, new status for *Ammophila atripes* F. Smith.

Ammophila basalis F. Smith, 1856: 214, ♀. India (BMNH). [Synonymized with *Ammophila clavus* by Dollfuss, 2013: 419].

Ammophila nigripes F. Smith, 1856: 215, ♂. India: (BMNH). [Synonymized with *Ammophila basalis* by R. Turner, 1919: 396].

Ammophila dimidiata F. Smith, 1856: 216, ♀, junior primary homonym of *Ammophila dimidiata* (Christ, 1791). India (BMNH). [Tentatively synonymized with *Ammophila atripes* by R. Bohart and Menke, 1976: 151, Synonymy confirmed by Dollfuss, 2013: 418].

Ammophila simillima F. Smith, 1856: 217, ♀. China: (BMNH). [Synonymized with *Ammophila atripes* by Bingham, 1897: 229].

Ammophila pulchella F. Smith, 1856: 218, ♂. China: (BMNH). [Synonymized with *Ammophila atripes* by Bingham, 1897: 229].

Ammophila longiventris Saussure, 1867: 24, ♂. Sri Lanka (MHNG), designated by Menke in R. Bohart and Menke, 1976:151. [Synonymized with *Ammophila atripes* by Bingham, 1897:229, Synonymy confirmed by W. Schulz, 1911:162].

Ammophila humbertiana de Saussure, 1867: 25, ♀. Sri Lanka: (MHNG), designated by Menke in Bohart and Menke, 1976:151. [Synonymized with *Ammophila atripes* by W. Schulz, 1911: 161].

Ammophila spinosa F. Smith, 1873a: 259, ♀. China (BMNH). [Synonymized with *Ammophila atripes* by Bingham, 1897: 229].

Ammophila orientalis Cameron, 1889: 93, ♀. India (OXUM). [Synonymized with *Ammophila basalis* by Bingham, 1897: 231].

Ammophila buddha Cameron, 1889: 94, sex not indicated. India (OXUM). [Synonymized with *Ammophila atripes* by Bingham, 1897: 229].

Redescription.

Female

Measurements in mm

TBL=25; FWL=14; SW= 2.7.

Colour: Black; scape, femur, tibiae, fore tarsomeres I-IV, mid and hind tarsomeres I-II and petiole red; metasoma metallic blue black; wings yellow; hairs with golden tinge; clypeus, gena, pronotum, scutum, propodeum with brown hairs.

Vestiture: Clypeus, frons, pronotal; lobe, propodeum posterolaterally with dense, appressed hairs; clypeus, gena, pronotum, scutum, propodeum and coxa with dark, semierect hairs; metasoma with fine velvety pubescence.

Sculpture: Clypeus with sparse punctae, interspaces micropunctate; pronotum, scutum transversely striate; scutellum, metanotum longitudinally striate; mesopleuron, metapleuron, propodeal sides striato-rugose; propodeal enclosure medially areolate rugose, striato-rugose near margin; metasomal segments IV-V sparsely punctate; pygidium micropunctate.

Head: 0.8x as long as wide (HL = 3.6mm, HW = 4.5mm); vertex convex; inner orbits parallel, UID: MID: LID = 2.5: 2.6: 2.3; POL: OOL = 0.4: 0.8; frons depressed; frontal line finely impressed; antennae twelve segmented, scape 1.2x and F1 5.2x as long as its apical width; F1 as long as F2+F3(1.4mm); F1: F2: F3: F10= 1.4: 0.7: 0.6: 0.3; clypeus 0.7x as long as wide (CL = 1.4mm, CW = 1.9mm), free margin sharp edged, sinuate; mandibles medially with two teeth.

Mesosoma: Pronotum separated; admedian lines present; notauli and paradiscal lines absent; episternal sulcus ending near the level of scrobe; propodeum as long as scutum (2.6mm); wings hyaline, infusate at apex; SMC III almost rounded; AV of SMC II 0.6x as long as its BV, 0.8x as long as AV of SMC III (AV of SMC II = 0.5mm, BV of SMC II = 0.7mm; AV of SMC III = 0.6mm); hind wing media diverging beyond cu-a at distance equal to length of cu-a (0.36mm); legs slender; fore basitarsus with seven rake spines; fore tarsomeres I-II asymmetrical. Tarsal claws simple; hind tibial spur 0.4x as long as hind basitarsus (HTS = 0.8mm, HBT = 1.2mm).

Metasoma: 1.9x as long as mesosoma (Metasoma = 16.3mm, Mesosoma = 7.8mm); petiole 1.9x as long as post petiolar segments I and II, 2.7x as long as hind tarsomeres II-IV (petiole = 9.1mm, PPS = 4.7mm, hind tarsomeres II-IV = 3.2mm); relative length of metasomal segments I: II = 2.8:4.2.

Male

TBL=20; FWL=11.5; SW= 1.5.

Colour: Black; metasoma metallic blue black, sternum I apicodorsally and ventrally with red mark; wings brown, median cell with yellow tinges; hairs silver.

Vestiture: Clypeus, frons, gena, pronotal lobe and propodeum posterolaterally with dense, appressed hairs; semi erect hairs on clypeus, frons, gena, pronotum, mesopleuron, scutum and propodeum; petiole and metasoma with fine velvety pubescence.

Sculpture: Clypeus micropunctate; frons coarsely punctate; pronotum, scutum transversely striate; scutellum, scutum longitudinally striate; propodeal enclosure medially areolate, striato rugose near margins; propodeum laterally rugose; mesopleuron coarsely striate.

Head: 0.7x as long as wide (HL = 2.8mm, HW = 3.8mm); vertex convex; inner orbits parallel, converging towards clypeus; UID: MID: LID = 1.8: 1.2: 1.1; POL: OOL = 0.4:0.8; frons depressed; frontal line finely impressed; antennae thirteen segmented, scape 2.4x and F1 4x as long as its apical width; F1 0.8x as long as F2+F3 (F2+F3 = 1.2mm); F1: F2: F3: F11 = 0.9 : 0.6: 0.6: 0.3; clypeus 1.4x as long as wide (CL = 1.4mm, CW = 1mm); free margin arcuate, medially emarginate; mandibles with single sub apical teeth.

Mesosoma: Pronotum separated from scutum; admedian lines present; scutellum convex in lateral view; omalae present; propodeum 0.7x as long as scutum(propodeum = 1.2mm, scutum = 1.7mm); wings hyaline, apically infusate; SMC II rounded, AV 0.5x as BV; AV of SMC III = BV of SMC II = 0.6mm, AV of SMC II = 0.3mm; hind wing media diverging beyond cu-a at a distance equal to length of cu-a(0.3mm); legs slender, fore tarsal rake absent; hind tibial spur 0.75x as long as hind basitarsus (HTS = 1mm, HBT = 1.3mm).

Metasoma: 2.8x as long as mesosoma, apicoventrally flat (Metasoma = 13.3mm, Mesosoma = 4.8mm); petiole 2.4x as long as post petiolar segments I+II and 4.5x as long as hind tarsomeres II-IV combined (petiole = 8.3mm, PPS = 3.5mm, hind tarsomeres II-IV = 1.8mm); sternum VIII truncate; gonostyle with hairs.

Material examined: Plesiotype: 1♀, India: Kerala, Thrissur, Kanimangalam 12.iv.2009. Baaby Job

Other materials examined: 1♀, India: Kerala, Malappuram: Calicut University Campus 11°8'N 75°53'E. 3.iii.1997. Narendran and party; 1♂ India: Kerala, Palakkad: Parambikulam, 30.iii.1996, Radhakrishnan; 2♀, India: Kerala, Malappuram: Calicut University Campus 11°8'N 75°53'E. 5.v.2001. Madhavikutty; 1♂, India: Kerala, Thiruvananthapuram, KAUUV 8°26'N 76°59'E. 04.iv.2012. Simon George.

Distribution: Australia, China, Japan, South East Asia, SriLanka, India [Sikkim, Assam, Madhya Pradesh, Meghalaya, Tripura, Himachal Pradesh, Karnataka, Uttar Pradesh, Orissa, West Bengal, Kerala: Palakkad, Thrissur, Thiruvananthapuram, Malappuram].

Biology: Krombein (1984) reported *Ammophila clavus* (Fabricius) carrying noctuid caterpillar.

Remarks: Since the available description of this species is inadequate for easy identification, a redescription is provided here.

The males and females of this species are differently coloured with females having legs and petiole red, while the males have black coloured petiole and legs.

Ammophila clavus (Fabricius) closely resembles *Ammophila laevigata* F.Smith in having 1. Sculpture of propodeal enclosure medially aroelate; 2. Legs of female red and 3. Wings with yellow tinge. However *A. clavus* differs from *A. laevigata* in having 1. Pronotm, scutum and scutellum striate (in *A. laevigata* pronotum, scutum punctate); 2. Wings brown (in *A. laevigata* wings yellow) and 3. Clypeal free margin arcuate (in *A. laevigata* clypeal free margin sinuate).

6. *Ammophila laevigata* F. Smith

(Fig 8a-e; Plate 8b)

Ammophila laevigata F. Smith, 1856: 215, ♀. India (BMNH).

Ammophila laevigata ab. *bicellularis* Strand, 1915: 97, ♂. Sri Lanka (DEI).

[Synonymized with *Ammophila laevigata* by R. Bohart and Menke, 1976:152].

Redescription.

Female

Measurements in mm

TBL=19.3; FWL=14.6; SW= 2.5.

Colour: Black; femora, tibiae of fore and mid legs, fore tarsomere I-IV, hind femur ventrally, petiole, sternum II ventrally and base of sternum III red; mid and fore femora baso-dorsally and post petiolar segments I-II with black markings; tegulae semi-transparent brown; wings yellow; hairs silver.

Vestiture: Clypeus, lower frons, gena, pronotal lobe, mesopleura, propodeum apically and laterally and coxa with dense, appressed hairs; frons, vertex, gena, pronotum, scutum, propodeum, mesopleura, coxa and basal one-third of forefemur with semi erect hairs; pygidium laterally with semi erect stiff hairs; metasoma with fine appressed pubescence.

Sculpture: Clypeus micropunctate; scutum, scutellum and metanotum coarsely punctate; propodeal enclosure medially areolate-rugose and striate along margins; propodeum laterally punctate; tergites IV-V micropunctate; pygidium apically punctate.

Head: 0.7x as long as wide (HL = 2.4, HW = 3.3mm); ocellar area raised; POL: OOL = 0.4: 1.0; inner orbits parallel converging slightly towards clypeus; UID: MID: LID = 1.8: 1.6: 1.4; antennal sockets separated from frontoclypeal suture by socket diameter (0.3mm); frontal line present, antennae twelve segmented, scape 1.9x and F1 5.4x as long as its apical width; F1 0.8x as long as F2+F3(F2+F3 = 1.2mm); F1: F2: F3: F10 = 0.9: 0.6: 0.55: 0.4; clypeus 0.4x as long as wide (CL =0.6mm, CW = 1.6mm); free

margin with sinuate median lobe, delimited by teeth on either side; mandibles medially with three teeth.

Mesosoma: Scutum with admedian and paradiscal lines; scutellum medially impressed; propodeum 1.6x as long as scutum (propodeum = 2.2mm, scutum = 1.5mm); wings hyaline; AV of SMC II 2x as long as AV of SMCIII (AV of SMC II = 0.52, AV of SMC II = 0.26mm); hind wing media diverging beyond cu-a at distance 1.2x as length of cu-a (M+Cu = 0.26, cu-a = 0.21); legs spinous, slender; outer apex of fore tarsomeres I-II prolonged; fore basitarsus with 6 rake spines; tarsal claws simple; hind basitarsus 2.6x as long as hind tibial spur (HTS = 0.8mm, HBT = 2.2mm).

Metasoma: dorsoventrally flattened, 2.4x as long as mesosoma (Metasoma = 12.4mm, Mesosoma = 5.2mm); petiole 1.7x as long as post petiolar segments I+II (petiole = 6.7mm, PPS = 4mm); relative length of metasomal segments I: II = 3.3:2.2.

Male

TBL=18; FWL=8.52; SW= 1.7.

Colour: Black; femora, tibiae of fore and mid legs, fore tarsomere I-IV, hind femur ventrally, sternum II ventrally red; mid and fore femora basodorsally and post petiolar segments I-II with black markings; tegulae semitransparent brown; wings yellow; petiole and sternum III black; hairs silver.

Vestiture: Clypeus, lower frons, gena, pronotal lobe, mesopleura, propodeum apically and laterally and coxa with dense, appressed hairs; frons, vertex, gena, pronotum, scutum, propodeum, mesopleura, coxa and basal one-third of forefemur with semi erect hairs; pygidium laterally with semi erect stiff hairs; metasoma with fine appressed pubescence.

Sculpture: Clypeus micropunctate; scutum, scutellum and metanotum coarsely punctate; propodeal enclosure medially areolate rugose and striate along margins; propodeum laterally punctate; tergites IV-V micropunctate; pygidium apically punctate; apical sternites micropunctate.

Head: 0.8x as long as wide (HL = 2.5mm, HW = 3.1mm); UID: MID: LID = 1.9: 1.2: 0.84; POL: OOL= 0.7: 1.0; antennal sockets separated from frontoclypeal suture by 2.5x as ASD (ASD = 0.2mm, AS-FC = 0.5mm); antennae thirteen segmented; scape slender, 2.8x and F1 3.5x as long as its apical width, F1 0.6x as long as F2+F3 (F2+F3 = 1.1mm); F1: F2: F3: F11 = 0.7: 0.5: 0.5: 0.3; clypeus as wide as long (1.05mm), free margin arcuate with median emargination; mandibles medially with single teeth.

Mesosoma: Propodeum 1.1x as long as scutum (propodeum = 1.7mm, scutum = 1.5mm); wings hyaline, apically infusate; AV of SMC II 1.6x as long as AV of SMC III (AV of SMC II = 0.26mm, AV of SMC III = 0.42mm); fore tarsal rake absent; hind tibial spur 0.4x as long as hind basitarsus (HTS = 0.7mm, HBT = 1.9mm)

Metasoma: 2.6 x as long as mesosoma (Metasoma = 1.9mm, Mesosoma = 4.5mm); petiole 1.96x as long as post petiole segments I+II (petiole = 6.7mm, PPS = 3.4mm); relative length of metasomal segments I: II = 3.1:2.2.

Material examined: Plesiotype: 1♀, India, Kerala, Thrissur: Ayyanthole 10°32'12"N 76°11'8"E. 07.vii.2009. Baaby Job.

Other material examined: 1♀, India, Kerala, Malappuram: Calicut University 11°8'N 75°53'E. 1985. Narendran and Party; 1♀, India, Kerala, Malappuram: Calicut University 11°8'N 75°53'E. 24.viii.1992. Sheeba; 1♀, India, Kerala, Malappuram: Calicut University 11°8'N 75°53'E. 15.viii.1999, Madhavikutty; 1♀, India: Kerala, Palakkad: Koottupatha 10°72'N 76°68'E. 3.iii.2011. Baaby Job; 1♀, India: Kerala, Thrissur: Eravu 10°47'N 76°15'E. 11.iii.2011. Baaby Job; 1♀, India: Kerala, Malappuram: Valanchery 10°89'N 76°07'E. 12.iii.2011. Baaby Job; 1♀ India: Kerala, Ernakulam: Koothattukulam 9° 49' N 76° 36' E. 5.v.2011. Simon George; 1♀, India, Kerala, Kottayam: Kozha 9°46'N 76°34'E. 25.i.2012. Simon George; 1♀, India, Kerala, Kottayam: RubberBoard 9°36' N 70°31'E. 30.1.2012. Baaby Job; 1♀, India, Kerala, Wayanad: Ambalavayal 11°61' N 76°21' E. 21.iv.2012. Baaby Job; 1♂, India: Kerala, Ernakulam: Koothattukulam 9° 49' N 76° 36' E. 28.v.2012, Baaby Job. 1♀, India: Kerala, Palakkad: Tippu's Fort 10°76'N 76°65'E. 27.vi.2012. Simon George; 1♂ India:

Kerala, Malappuram: Nilambur Teak Museum 11°18' N 76°15' E. 11.ii.2012. Baaby Job; 1♀ India: Kerala, Malappuram: Chamramattom 10°81'N 75°95'E. 21.iii.2012. Baaby Job; 1♀, India: Kerala, Ernakulam: Koothattukulam 9° 49' N 76° 36' E. 28.v.2012, Baaby Job; 1♂, India: Kerala, Kottayam: Bharanamganam 9° 42' N 76°43'E 18.vi.2012. Baaby Job; 1♀, India, Kerala, Alappuzha: Thiruvambady 9°48'N 76°37'E. 10.vii.2012. Simon Goerge.

Distribution: China, Madagascar, Nepal, SriLanka, Thailand, Vietnam, India [Sikkim, Arunachal Pradesh, Bihar, Gujarat, Himachal Pradesh, Karnataka, Tamil Nadu, West Bengal, Kerala: Alappuzha, Palakkad, Thrissur, Ernakulam, Kottayam, Malappuram, Wayanad].

Biology: Preys on species belonging to Noctuidae and Satyridae (Krombein, 1984).

Remarks: Since the available description of this species is inadequate for easy identification, a redescription is provided here.

Ammophila laevigata F. Smith closely resembles *Ammophila smithii* F. Smith in having 1. Pronotum and scutum punctate; 2. Propodeum sculpture and 3. Forefemora and tibia red. But *A. laevigata* differs from *A. smithii* in having 1. Hind tibia and tarsomeres black (hind tibia and tarsomeres red in *A. smithii*); 2. Metasomal segments I and II red with black markings (in *A. smithii* segments I and II red, black markings above fourth segment) and 3. Clypeus black (in *A. smithii* clypeus brown red).

Genus *Parapsammophila* Taschenberg

Parapsammophila Taschenberg, 1869:469. Type species: *Parapsammophila miles* Taschenberg, 1869 [= *Ammophila cyanipennis* Lepelletier de Saint Fargeau, 1845], designated by Pate, 1937: 48.

Ceratosphex Rohwer, 1922: 671. Type species: *Sphex bakeri* Rohwer, 1922, by original designation and monotypy.

Diagnosis

Head: Inner orbits converging towards clypeus in male and parallel in female; frontal line weak or absent; male flagellomeres with tyli; clypeal free margin of female with truncate median lobe and in male rounded or truncate; inner mandibular margin of female with one to two median teeth and in males with variably placed one to four teeth; mouthparts short; mandibular socket closed in female, open in males.

Mesosoma: Petiole socket bounded by propodeal sternite; mesopleura concave to receive fore coxa; episternal sulcus running straight down, not reaching scrobe; lower metapleural area defined; marginal cell apically rounded; females with foretarsal rake, composed of long, blade like spines; outer apex of tarsomere I prolonged, asymmetrical; forecoxa posteriorly with spur or angulation; mid coxa contiguous; mid tibia with two apical spurs; tarsi with plantulae; claws with two basal teeth, proximal tooth blunt or rounded, distal pointed.

Metasoma: Petiole composed of sternum I only, apex reaching base of sternum II; spiracle of tergum I located medially or slightly beyond; sternum VIII apically truncate or sinuate; gonostyle not biramous.

Distribution: Africa, India, Philippines, Australia, United Arab Emirates, Kazakhstan, South Africa, Iran.

Biology: Fossorial (Misra, 1984).

Remarks: Genus *Parapsammophila* Taschenberg closely resembles genus *Hoplammophila* Beaumont in having 1. Petiole socket bounded ventrally by T shaped propodeal sternite; 2. Tarsal claws with basal teeth; 3. Episternal sulcus running down straight, not passing through scrobe. However, *Parapsammophila* differs from genus *Hoplammophila* in 1. Outer apex of female fore basitarsus strongly asymmetrical (in *Hoplammophila* outer apex not asymmetrical); 2. Fore tarsal rake consisting of stiff long setae (in *Hoplammophila* fore tarsal rake composed of short stiff spines); 3. Male clypeus rounded or arcuate (in *Hoplammophila* male clypeus triangular with reflexed lip) and 4. Gonostyle simple (in *Hoplammophila* gonostyle apically biramous).

7. *Parapsammophila erythrocephala* Fabricius

Sphex erythrocephalus Fabricius, 1781: 204, sex not indicated (as *erythrocephala*, incorrect original termination). India (BMNH).

Pelopoeus erithrocephalus (Fabricius): Fabricius, 1804: 203, new combination for *Sphex erythrocephalus* Fabricius.

Ammophila erythrocephala (Fabricius): Lepeletier 1845: 385, new combination for *Sphex erythrocephalus* Fabricius.

Podalonia erythrocephala (Fabricius): Ebrahimi, 1993: 93, new combination for *Sphex erythrocephalus* Fabricius.

Parapsammophila erythrocephala (Fabricius): Menke, 1966: 150, new combination for *Sphex erythrocephalus* Fabricius.

Ammophila fuscipennis F. Smith, 1870: 187, ♂. India (BMNH). [Synonymized with *Sphex erythrocephala* by R. Turner, 1918a: 90].

Ammophila violaceipennis Cameron, 1889: 100, ♂. junior primary homonym of *Ammophila violaceipennis* Lepeletier 1845. (questionable synonym of *Parapsammophila erythrocephala* by Bohart and Menke, 1976: 139)

Ammophila indica Dalla Torre, 1897: 403. Replacement name for *Ammophila violaceipennis* Cameron.

Diagnosis

Colour black; scape, F1, F2 and F3, pronotum, petiole red; coxa, trochanters and apical tarsomeres red brown; metasoma blue black; wings brown with purple effulgence; body smooth and shining; head punctate; scutum reticulate; scutellum, metanotum longitudinally striate; propodeum medially reticulate, transversely striate on sides; clypeus convex, free margin truncate; inner orbits parallel, vertex convex; F1 2x as long as F2.

Material examined: No material examined. The above description of this species is based on Bingham's (1897), Cameron's (1889) and Van der Vecht (1961) papers.

Distribution: Iran, India [Uttar Pradesh, West Bengal, Kerala: Malabar].

Biology: Fossorial wasp; egg is white, semitransparent; the adult emerges from nest after nearly twenty seven days (Misra, 1984).

Remarks: This species was collected and reported from Malabar, Kerala as *Sphex erythrocephala* by Fabricius in 1781.

4.4.3 SUBFAMILY CHLORIONTINAE

Chloriontinae Fernald, 1905: 16. Based on *Chlorion* (stem: *Chloriont-*)

They are regarded as most handsome among sphecids and exhibit parasitoid like behaviour. They are usually metallic green or blue, but some species may be black or red with metallic tinge, ranging in length from 16-37mm.

Diagnosis

Head: Inner orbits usually parallel on lower half; frons glabrous; male flagellomeres with placoids; mandibular socket closed; mouthparts short; third maxillary palp expanded; occipital carina complete

Mesosoma: pronotal collar high; notauli short; claws with basal or median tooth; plantulae present; wings yellow or black; recurrent vein I received by SMC II, recurrent vein II received by SMC III or interstitial between II and III; midcoxae separated by distance equal to petiole width; spiracular groove present.

Metasoma: Petiole composed of sternum I; petiole as long as or 2x as long as hind coxa.

Distribution: Worldwide.

Biology: Fossorial wasps, prey consists of Gryllidae (Bohart and Menke, 1976).

Genus *Chlorion* Latreille

Chlorion Latreille, 1802b: 333. Type species: *Sphex lobatus* Fabricius, 1775, by monotypy.

Chlorium Billberg, 1820: 105. Emendation of *Chlorion* Latreille, 1802b.

Chlorium W. Schulz, 1906: 193. Emendation of *Chlorion* Latreille, 1802b.

Diagnosis

Head: Inner orbits straight on lower half; vertex in females convex, head wider than long; frons glabrous or setose; frons above antennal sockets in males with median, elevated, plate-like area; male flagellomeres usually with placoids; antennal sockets contiguous or separated by socket diameter from frontoclypeal suture; female clypeus 2-7x as wide as long, convex, free margin with five teeth; male clypeal margin with median lobe having three teeth; labrum straight or concave; female mandible long, slender with two teeth on inner margin; male inner mandibular margin with single tooth; mouthparts short; third maxillary palpal segment expanded laterally; hypostomal carina ending near mandibular socket or evanescent.

Mesosoma: Pronotal collar with median longitudinal line; propodeal enclosure U shaped, transversely striate; spiracular groove present; episternal sulcus complete, scrobal sulcus weakly impressed; lower metapleural area not well defined; SMC II narrowed anteriorly, BV longer than AV; mid coxa separated by petiole length; female with fore tarsal rake composed of blade like spines; claws with teeth.

Metasoma: Sterna VII-VIII in males apically with tufts of hairs; sterna VIII triangular; digitus head rounded, penis valve ventrally with row of teeth.

Distribution: Africa, Asia.

Biology: Prey consist mainly Gryllidae (Lefroy, 1904; Krombein 1953); nests in partially shaded sandy areas; paralysis is temporary and prey resumes activity; eggs are laid near legs. Prey is dragged to the burrow by mandibles (Hook, 2004).

Remarks: Genus *Chlorion* Latreille resembles genus *Stangeella* Menke in having 1. First recurrent vein received by SMC II; 2. Presence of foretarsal rake in female and 3. Presence of spiracular groove. However *Chlorion* differs from *Stangeella* in 1. Petiole as long as hind coxa (in *Stangeella* petiole longer than hind coxa); 2. Closed mandibular socket (open mandible socket in *Stangeella*); 3. Antennal sockets

continuous with frontoclypeal suture in female (*antennal* sockets separated from frontoclypeal suture in *Stangeella*) and 4. Sterna IV-VI without pubescence (in *Stangeella* sterna IV-VI with pubescence).

8. *Chlorion lobatum* (Fabricius)

Sphex lobatus Fabricius, 1775: 348, sex not indicated (misspelled as *lobata* by Fabricius). Africa (BMNH), designated by van der Vecht, 1961: 37

Chlorion lobatum (Fabricius): Fabricius, 1804: 217, new combination for *Sphex lobatus* Fabricius (Musuem Dom).

Sphex semiauratus viridis Barbut, 1781: 255, sex not indicated (misspelled as *semiaurata viridis* by Barbut). [Synonymized with *Sphex lobatus* by Kohl, 1890:177].

? *Sphex ferus* Drury, 1782: 57, China. (Senior synonym of *Chalybion bengalense* (Dahlbom, 1845)).

Sphex chrysis Christ, 1791: 308, ♀. West Indies [Synonymized with *Sphex lobatus* by Kohl, 1885: 164].

? *Sphex smaragdinus* Christ, 1791: 310, sex not indicated. China.

Chlorion azureum Lepeletier de Saint Fargeau and Audinet-Serville, 1828: 451, ♀. "Patrie inconnue " (M. Spinola collection, TORINO), designated by Menke *in* R. Bohart and Menke, 1976: 90.

Redescription

Female

Measurements in mm

TBL=22.2; FWL=12.5; SW= 3.0.

Colour: Metallic green; mandibles brown; metasoma purple under certain lights; wings yellow; hairs black.

Vestiture: Semierect hairs on gena, propleuron, mesosternum, coxa and sides of pygidium.

Sculpture: Body shining; clypeus, frons, vertex, pronotum, scutum, scutellum, mesopleuron with scattered punctae; frons obliquely striate above antennal sockets; propodeal enclosure transversely striate; metasomal segments I-V apicomediaally impunctate; pygidium coarsely punctate.

Head: 0.6x as long as wide (HL = 3.1mm, HW = 5.2mm); vertex convex; frons sunken near antennal sockets; frontal line present; evanescent line from midocelli to vertex; inner orbits parallel on lower two-thirds, converging towards clypeus; UID: MID: LID = 4.5: 2.9: 3.0; POL: OOL = 0.5: 0.8; antennal sockets continuous with frontoclypeal suture; scape 1.8x and 4x as long as its apical width; F1 0.8x as long as F2+F3 (F2+F3 = 1.9mm); F1: F2: F3: F10 = 1.6: 0.9: 0.9: 0.6; clypeus medially convex, 0.4x as long as wide (CL = 0.9mm, CW = 2.3mm); free margin arcuate with five teeth; mandibles pointed, medially toothed.

Mesosoma: Pronotum posteromedially notched; scutum with admedian lines and paradiscal lines, notauli absent; propodeum 1.2x as long as scutum; wings hyaline, apically infusate; AV of SMC II and SMC III equal (0.4mm); hind wing media diverging beyond cu-a at 0.13x as length of cu-a; legs spinous, fore basitarsus with five rake spines; claws with single median tooth; hind tibial spur 1.8x as long as hind basitarsus.

Metasoma: 0.9x as long as mesosoma; petiole as long as hind coxa (7.2mm); segment I as long as segment II (2.6mm); sternum II with transverse carina; pygidium apically U shaped.

Male: Unknown.

Material examined, Plesiotype: 1♀, India: Kerala, Wayanad, Kuruva 11°49'N 76°5'E. 18.iv.2012. Baaby Job.

Other material examined: 1♀, India: Kerala, Wayanad 28.iv.1982, V.V.S. Kumar; 1♀ India: Kerala, Wayanad: Thiruvambady 27.iv.1982. V.V.S. Kumar; 1♀, India: Kerala, Kozhikode. 05.x.2000. Madhavikutty.

Distribution: Bangladesh, China, Egypt, Indonesia, Malaysia, Philippines, Sri Lanka, Vietnam, West Indies, India [Sikkim, Arunachal Pradesh, Karnataka, Madhya Pradesh, West Bengal, Kerala: Palakkad, Thrissur, Kozhikode, Wayanad].

Biology: Hingston (1925) reported *Brachytrypes achatinus* as prey species.

Remarks: Since the available description of this species is inadequate for easy identification, a redescription is provided here.

Chlorion lobatum Fabricius closely resembles *Chlorion splendidum* Fabricius in having 1. Tarsal claws with single teeth; 2. Metasoma purple blue; 3. Propodeum transversely striate. However, *C. lobatum* differs from *C. splendidum* in 1. Head and mesosoma metallic blue (in *C. splendidum* head and mesosoma red); 2. Propodeum without hairs (in *C. splendidum* propodeum with golden coppery hairs) and 3. Wings yellow, hyaline (in *C. splendidum* wings reddish yellow).

4.4.4 SUBFAMILY SCELIPHRIINAE

Sceliphriinae Ashmead, 1899: 349 (1815). Based on *Sceliphron* (stem: *Sceliphri-*).

They are commonly called as ‘mud-dauber wasps’. The well known black and yellow muddaubers and metallic blue *Chalybion* are well known members of this subfamily. Their black and yellow colour makes them easily recognizable in fields.

Diagnosis

Head: Antennae placed submedially; male flagellomeres with placoids; labrum freemargin straight; mandibles simple or with one or two teeth; mandibular sockets closed; third maxillary palp expanded.

Mesosoma: Propodeal enclosure, spiracular groove present or absent; episternal sulcus present; forewing with three SMC's; both recurrent veins received by SMC II; claws with one median teeth; plantulae usually present.

Metasoma: Petiole composed of sternum I; cerci usually present; digitus articulated.

Distribution: Cosmopolitan.

Biology: Nests are provisioned with spiders or Orthoptera (Bohart and Menke, 1976). Some members are fossorial (*Penepodium* Menke) but most are aerial mud nesters (*Sceliphron* Klug, *Chalybion* Dahlbom, *Trigonopsis* Perty). Some form sleeping aggregations at night (*Chalybion* Dahlbom).

Genus *Sceliphron* Klug

Sceliphron Klug, 1801: 561. Type species: *Sphex spirifex* Linnaeus, 1758, designated by Bingham, 1897: 235.

Pelopoëus Latreille, 1802b: 334. Type species: *Pelopoëus spirifex*, Fab. [= *Pelopoëus spirifex* of Fabricius, 1804 = *Sphex spirifex* Linnaeus, 1758], designated by Latreille, 1810: 438.

Pelopaëus Latreille, 1804: 180. Lapsus or emendation of *Pelopoëus*.

Sceliphrum Schulz, 1906: 192. Emendation of *Sceliphron* Klug, 1801.

Prosceliphron van der Vecht in van der Vecht and van Breugel, 1968: 192. Type species: *Sceliphron coromandelicum* (Lepelletier de Saint Fargeau, 1845) [= *Pelopoëus coromandelicus* Lepelletier de Saint Fargeau, 1845], by original designation. Junior homonym of *Prosceliphron* Frenguelli, 1946.

Hensenia Pagliano and Scaramozzino, 1990:5. Substitute name for *Prosceliphron* van der Vecht, 1968.

Diagnosis

Head: Inner orbits parallel or converging towards vertex in female, in males variable; vertex depressed in some species; head with hairs erect; antennal sockets separated from frontoclypeal suture by 0.5x socket diameter; F1 longer than F2; placoids absent

on male flagellomeres; clypeus free margin in female sharp edged with a pair of median lobes separated by median and lateral incisions; mandibles usually simple; third maxillary palp expanded.

Mesosoma: Pronotal collar with median marking; propodeum with U shaped enclosure, spiracular groove absent; episternal sulcus complete; scrobal sulcus present or absent; marginal cell apically rounded or acuminate; both recurrent veins received by SMC II; midcoxae contiguous; foretarsal rake absent; claws with tooth.

Metasoma: Petiole 2.5-3.6x as long as hindcoxa; sterna hair mats absent in female; sternum VIII triangular in males; penis head valve ventrally with teeth.

Distribution: Cosmopolitan.

Biology: Constructs aerial multicellular mud nests. Nests are mass provisioned with spiders. They are mainly parasitized by *Chrysis* sp., *Trichrysis* sp., *Ceratochrysis* sp. (Chrysididae); *Acroricnus* sp (Ichneumonidae); *Dolichomutilla* sp. (Mutillidae), bombylid flies and Sarcophagidae (Bohart and Menke, 1976).

Remarks: Genus *Sceliphron* Klug was divided into two subgenera- *Prosceliphron* van der Vecht and *Sceliphron s.s.* and *Sceliphron s.s.* divided into two species group: *madraspatanum* group and *spirifex* group (van der Vecht, 1968). Subgenus *Prosceliphron* differs from *Sceliphron s.s.* in having 1. Lower half of inner eye margin parallel (in *Sceliphron s.s.* lower half of inner eye margins converging towards clypeus); 2. Mandibles simple (in *Sceliphron s.s.* mandibles with inner teeth); 3. Apical sternite sharply keeled (in *Sceliphron s.s.* sternum weakly keeled).

In India this genus is represented by twentyfour species and subspecies. In this study *Prosceliphron* is represented by single species - *Sceliphron coromandelicum* (Lepeletier) and *Sceliphron s.s.* by two species - *Sceliphron javanum nalandicum* Strand and *Sceliphron madraspatanum* Fabricius.

Key to species of the Genus *Sceliphron* Klug in Kerala

1. Hypostomal carina not joining mandibular socket, vanishing about halfway to socket (Fig 10a); episternal sulcus complete without any interruptions; petiole curved

(Fig 10e); clypeus medially with yellow-brown spots; wings hyaline, basally with shades of yellow.....*Sceliphron coromandelicum* (Lepeletier)

- Hypostomal carina joining mandibular socket; episternal sulcus interrupted by pleural bulge at level of pronotal lobe; petiole straight (Fig 12d); clypeus black; wings yellow, hyaline.....**2**

2. Inner mandibular margin simple in females (Fig 11a); pronotum black without any yellow markings; body with black hairs; fore and mid tibiae black; apical one-third of fore and mid femur orange yellow; hind coxae swollen, angular on outer side (Fig 11d).....*Sceliphron javanum nalandicum* Strand

- Inner mandibular margin in females apically with single teeth; pronotum posterior margin with medially interrupted yellow transverse band; hairs golden; apical one-third of fore and mid femur, fore and midtibiae yellow; hindcoxae slightly swollen, rounded in outer side (Fig 12c)*Sceliphron madraspatanum* (Fabricius)

9. *Sceliphron coromandelicum* (Lepeletier de Saint Fargeau)

(Fig 10a-e; Plate 8d)

Pelopaesus coromandelicus Lepeletier de Saint Fargeau, 1845: 306, ♀. (misspelled as *Coromandelicus* by Lepeletier). India (TORINO).

Ammophila coromandelica (Lepeletier): Casolari and Casolari Moreno, 1980: 100, new combination for *Pelopaesus coromandelicus* Lepeletier de Saint Fargeau.

Sceliphron coromandelicum (Lepeletier): Bingham, 1897: 238, new combination for *Pelopaesus coromandelicus* Lepeletier de Saint Fargeau.

Redescription

Female

Measurements in mm

TBL = 21.2; FWL = 11.4; SW = 2.3.

Colour: Black; median spot on clypeus, scape ventrally, F1 apico-ventrally, F2 ventrally, F3 basally, transverse band on pronotum posteriorly, spot on tegulae and beneath it and petiole yellow; fore and mid femora, hind femora apical two-third,

tibiae and tarsomeres I-III of all legs yellow-brown; tarsomere IV black-brown; wings basally with yellow shades; hairs black, clypeus with silvery pubescence.

Vestiture: Clypeus, frons with appressed pubescence; vertex, metanotum, propodeal enclosure, propodeum posteriorly, petiole basal half with erect hairs; frons, gena, scutum, mesopleuron, coxa, tergum VI laterally with semierect hairs; metasoma with glistening velvety pubescence.

Sculpture: Scutum, metanotum, propodeal enclosure transversely striate; mesopleuron striato-punctate, metapleuron finely striate; scutellum longitudinally striate; propodeum laterally striato-rugose; pygidium except apically coarsely punctate.

Head: 0.9x as long as wide (HL = 3.8mm, HW = 4.3mm); inner orbits converging towards vertex, basal two-thirds parallel, UID: MID: LID = 1.5: 2.5: 2.5; POL: OOL = 0.4: 0.5; antennae twelve segmented, scape 2.5x and F1 5.7x as long as its apical width; F1 as long as UID (1.5mm), 0.7x as long as F2+F3 (F2+F3 = 2.2mm); F1: F2: F3: F10 = 1.5: 1.5: 0.7: 0.4; clypeus 0.7x as long as wide (CL = 1.5mm, CW = 2.3mm), with median carina; freemargin with paired median lobes medially and laterally incised.

Mesosoma: Posterior margin of pronotum medially notched; admedian lines, paradiscal lines finely impressed; episternal sulcus complete; propodeum 2.1x as long as scutum (propodeum = 4.4mm, scutum = 2.1mm); propodeal enclosure with apical median depression; propodeum apically with median longitudinal and postero-lateral sulcus; wings hyaline, apically infuscent; fore wing marginal cell apically rounded; AV of SMC II 0.7x as long as AV of SMC III (AV of SMC II = 0.5mm, AV of SMC III = 0.7mm); hind wing media diverging beyond cu-a at 0.4x length of cu-a (M+Cu = 0.2mm, cu-a = 0.5mm); legs slender, tarsomeres with plantulae; tarsal claws with median teeth; hind tibial spur pectinate, 0.6x as long as hind basitarsus (HTS = 1.7mm, HBT = 2.8mm).

Metasoma: 1.13x as long as Mesosoma (Metasoma = 11.3mm, Mesosoma = 11mm); petiole curved, 1.2x as long as hindtarsomeres II-IV (petiole = 4.2mm, tarsomeres II-IV = 3.5mm); relative length of segments I: II = 1.5:2.9; pygidium with lateral carina.

Male

TBL = 16.1; FWL = 10.5; SW = 2.2.

Colour: Black; transverse band on pronotum posteriorly, spot on tegulae and beneath it and petiole yellow; fore and mid femur apical one-third, hind femur except basal black mark, fore and mid tibiae, fore and hindbasitarsus, tarsomere II basal half brown yellow; wings basally with yellow shades; hairs black, clypeus with silvery pubescence.

Vestiture: Clypeus, frons with appressed pubescence; frons, gena, scutum, mesopleuron, coxa, tergum VI laterally with semierect hairs; vertex, metanotum, propodeal enclosure, propodeum posteriorly, petiole basal half with erect hairs; metasoma with velvety pubescence.

Sculpture: Scutum, metanotum, propodeal enclosure transversly striate; mesopleuron striato-punctate, metapleuron finely striate; scutellum longitudinally striate; propodeum laterally striato-rugose.

Head: POL: OOL = 0.3: 0.4; antennae thirteen segmented, scape 1.5x as long as its apical width; clypeal freemargin arcuate with median incision; mandibles simple.

Mesosoma: Posterior margin of pronotum medially notched; propodeum 1.9x as long as scutum (propodeum = 2.9mm, scutum = 1.5mm); wings hyaline, apically infusate; AV of SMC II 0.7x as long as AV of SMC III (AV of SMC II = 0.5mm, AV of SMC III = 0.7mm); hindwing media diverging beyond cu-a at 0.7x length of cu-a (M+Cu = 0.2mm, cu-a = 0.3mm); hindtibial spur pectinate, 0.5x as long as hindbasi tarsus (HTS = 1.0mm, HBT = 2.1mm).

Metasoma: 1.6x as long as mesosoma (Metasoma = 9.1mm, Mesosoma = 5.8mm); petiole curved, 1.3x as long as hindtarsomeres II-IV (petiole = 3.9mm, tarsomeres II-IV = 2.9mm); relative length of segments I: II = 1.6mm; sternum VIII with cerci.

Material examined: Plesiotype: 1♂, India: Kerala, Ernakulam: Koothattukulam 9° 49' N 76° 36' E. 28.v.2012. Baaby Job.

Other material examined: 1♀, India: Kerala, Malappuram: Nilambur, 4.iii.1987, V.V.S.Kumar; 1♀, India: Kerala, Malappuram: Nilambur, 3.vi.1981. V.V.S.Kumar; 1♀, India: Kerala, Malappuram: Calicut University campus 11°8'N 75°53'E .10.iv.1993. Neena; 1♀, India: Kerala, Palakkad: Tippu's Fort 10°76'N 76°65'E. 27.vi.2011. Baaby Job; 1♂, India: Kerala, Palakkad: Paalana 10°73'N 76°65'E. 15.iii.2012. Baaby Job; 1♀, India: Kerala, Kottayam: Kozha 9°16'N 76°54'E. 25.1.2012. Baaby Job; 1♀, India: Kerala, Malappuram: Nilambur teak museum 11°18'N 76°15'E. 11.ii.2012. Baaby Job; 2♀, India: Kerala, Thiruvananthapuram: T.B.G.R.I. 8°34'N 76°50'E. 9.iii.2012. Simon George; 1♂, India: Kerala, Thiruvananthapuram: T.B.G.R.I. 8°34'N 76°50'E. 9.iii.2012. Baaby Job; 1♀, India: Kerala, Ernakulam: Aluva 10°6'N 76°55'E. 16.iii.2012. Baaby Job; 1♀, India: Kerala, Malappuram: KAU Thavanoor 10°51'N 75°58'E. 26.iii.2012. Simon George; 1♀, India: Kerala, Palakkad: KAU Pattambi 10°48'N 76°11'E. 28.iii.2012, Simon George; 1♀, India: Kerala, Wayanad: Kambamala 11° 26' N 75° 46' E. 17.iv.2012. Baaby Job; 1♀, India: Kerala, Wayanad: Kuruva 11°49'N 76°5'E .17.iv.2012. Baaby Job; 2♀, India: Kerala, Ernakulam: Koothattukulam 9° 51' N 76° 36' E. 28.v.2012. Baaby Job; 1♀, India: Kerala, Kottayam: Munakkal 9°7'N 76°70'E. 18.vi.2012. Baaby Job; 1♀, India: Kerala, Alappuzha: Chungam 9°49'N 76°34'E.10.vii.2012. Simon George.

Distribution: Bangladesh, Malaysia, Sri Lanka, Thailand, India [Assam, Bihar, Karnataka, Maharashtra, Orissa, Tamil Nadu, West Bengal, Kerala: Alappuzha, Ernakulam, Kottayam, Malappuram, Palakkad, Thrissur, Thiruvananthapuram, Wayanad].

Biology: Nests are observed to be constructed of mud in walls, crevices etc; each nest consisting of four-six cells, provisioned with spiders.

Remarks: *Sceliphron coromandelicum* (Lepelletier) closely resembles *Sceliphron rectum pulchellum* Gussakovskij in having 1. Body black, with yellow spot on clypeus; 2. Petiole yellow; 3. Wings yellow, hyaline, apically infusate.

However, *S. coromandelicum* differs from *S. rectum pulchellum* in 1. Petiole curved in lateral view (in *S. rectum pulchellum* petiole in lateral view straight); 2. Metasoma black (in *S. rectum pulchellum* terga I yellow); 3. Propodeum black (in *S. rectum pulchellum* propodeum with yellow markings).

10. *Sceliphron javanum nalandicum* Strand.

Pelopoeus spinolae: F. Smith, 1856:231, India: (Torino), corrected to *Sceliphron javanum* var. *nalandicum* by van der Vecht and van Breugel, 1968:244.

Sceliphron javanum var. *nalandicum* correction by Kohl, 1918:92

Sceliphron javanum var. *nalandicum* Strand, 1915:93, ♀. Sri Lanka: (DEI)

Sceliphron javanum nalandicum van der Vecht and van Breugel, 1968:244. New status for *Sceliphron javanum* var. *nalandicum* Strand.

Redescription

Female

Measurements in mm.

TBL=24.7; FWL=16.7; SW=3.8.

Colour: Black; scape ventrally trochanter, femur, tibiae and basitarsus of hind legs and petiole yellow; hind femur and basitarsus apically with brown marking; apical one-third of fore and mid femur, fore and mid basitarsus orange yellow; hind tarsomere apically black; wings yellow; hairs silvery on clypeus, rest of body with black hairs.

Vestiture: clypeus and frons laterally with appressed hairs intermixed with semi erect hairs; vertex, gena, scutellum and metanotum apically with semierect hairs; propodeum, mesopleuron, scutum and propodeal enclosure with erect hairs; metanotum with appressed hairs, pygidium laterally with stiff semi-erect hairs.

Sculpture: Frons, vertex coarsely punctate; scutum striate with punctate interspaces; scutellum, metanotum longitudinally striate; propodeal enclosure with oblique striae, sides of propodeum and apex transversly striate; metapleuron smooth and shiny.

Head: 0.9x as long as wide; frons around antennal sockets depressed; POL: OOL = 0.4: 0.6; inner orbits converging towards vertex, slightly emarginated above antennal sockets, UID: MID: LID = 2.1: 2.8: 2.6; antennal sockets continuous with frontoclypeal suture; ASD 3x as MOD; antennae twelve segmented; scape 2x and F1 5.5x as long as its apical width; F1 0.8x as long as F2 and F3 combined, F1: F2: F3 = 1.8: 1.3: 1.0; clypeus 0.8x as long as wide (CL = 2.1mm, CW = 2.7mm), basally convex; freemargin arcuate, medially with paired lobes separated by median and lateral incisions; inner mandibular margin simple.

Mesosoma: Pronotum posterior margin with median impression, bituberculate; scutum with admedian lines, paradiscal lines, notuali faintly impressed; metanotum distinctly separated; propodeum 1.2x as long as scutum, enclosure with median longitudinal sulcus; spiracular groove visible above hindcoxa; wings hyaline, AV of SMC II as long as PV (0.83mm); AV of SMC III 0.8x as long as its PV (AV = 1.3mm, PV = 1.7mm); hindwing media diverging beyond cu-a at distance 0.25x length of cu-a (cu-a = 0.7mm, M+Cu beyond cu-a = 0.2mm); legs stout; tarsomeres with plantulae; single claw teeth; hindtibial spur 0.5x as long as hind basitarsus (hindtibial spur = 1.2mm, basitarsus = 2.3mm); hind coxa with dorsal carina.

Metasoma: 1.3x as long as mesosoma (Metasoma = 13.3mm, Mesosoma = 10mm); petiole straight, 1.6x as long as hind tarsomeres II-IV combined (petiole = 5mm, TII-IV = 3.2mm); relative length of metasomal segments I:II = 2.5mm.

Male: Unknown.

Material examined: Plesiotype: 1♀, India: Kerala, Thrissur: Thumburmuzhi 10⁰29' N, 76⁰46'E. 05.V.2012. Baaby Job

Other material examined: 1♀, India: Kerala, Malappuram: Calicut University Campus 11°8'N, 75°53'E. 10.viii.1997. Anoopkumar; 1♀, India: Kerala, Malappuram: Calicut University Campus 11°8'N, 75°53'E. 05.05. 2000. Jobiraj; 1♀, India: Kerala, Wayanad: Thamarassery 11°24'N 75°55'E. 18.v.2009. Baaby Job; 1♀, India: Kerala, Thrissur: Eravu, 10⁰47'N, 76⁰15'E. 11.iii.2011. Baaby Job.

Distribution: SriLanka, India [Maharashtra, Tamilnadu, West Bengal, Kerala: Thrissur, Malappuram, Kozhikode, Palakkad, Wayanad].

Biology: Unknown

Remarks: Since the available description of this species is inadequate for easy identification, a redescription is provided here.

Sceliphron javanum nalandicum Strand closely resembles *Sceliphron javanum chinense* Van Breugel in having 1. hind tibia and tarsomeres black; 2. Apical one third of hind femur black; 3. Tegulae and metanotum black.

However *S. javanum nalandicum* differs from *S. javanum chinense* in having 1. Apical one third of fore and mid femur orange yellow (in *S. javanum chinense* orange yellow covering three- fifth of fore and mid femur); 2. Hind femur with apical brown markings (in *S. javanum chinense* brown markings covers apical one- third of hind femur and much darker); 3. Brown markings on inner side of femur regular in outline, medially not projecting (in *S. javanum chinense* brown markings on inner side of femur irregular in outline, medially projecting).

11. *Sceliphron madraspatanum* Fabricius

Sphex madraspatanus Fabricius, 1781: 445, sex not indicated (misspelled as *madraspatana* by Fabricius), India: (BMNH).

Pelopaeus madraspatanus (Fabricius): Fabricius, 1804: 203, new combination for *Sphex madraspatanus* Fabricius.

Sceliphron madraspatanum (Fabricius): Moscáry, 1892: 127, new combination for *Sphex madraspatanus* Fabricius.

? *Sphex lugubris* Christ, 1791: 306, St. Domingo junior primary homonym of *Sphex lugubris* Villers, 1789.

Sceliphron lugubre new combination for *Sphex lugubris* by DallaTorre, 1897: 387.

Pelopoeus interruptus Palisot de Beauvois, 1806: 51, sex not indicated, locality unknown. [Synonymized with *Sceliphron maderospatanum* by Schulz, 1906: 192].

Sceliphron interruptum (Palisot de Beauvois): Dalla Torre, 1897: 386, new combination for *Pelopoeus interruptus* Palisot de Beauvois.

Pelopaeus bilineatus F. Smith, 1852a: 47, ♀. India (BMNH). [Synonymized with *Sceliphron madraspatanum* by R. Turner, 1917e: 176].

Sceliphron blineatum (F.Smith): Bingham, 1897: 238, new combination for *Pelopaeus bilineatus* F. Smith.

Pelopoeus separatus F. Smith, 1852: 47, ♀. India (BMNH). [Synonymized with *Sceliphron madraspatanum* by Bingham, 1897: 237].

Sceliphron separatum (F.Smith): Dalla Torre, 1897: 389, new combination for *Pelopoeus separatus* F. Smith.

Redescription.

Female.

Measurements in mm

TBL = 18.4; FWL = 11.8; SW = 2.4.

Colour: Black; scape ventrally, medially interrupted transverse band on pronotum posterior margin, tegulae, transverse band on metanotum, petiole, apical one-third of fore and mid femora, fore and mid tibiae, mid and hind basitarsus medially, hind trochanter, femur basally yellow; apical half of mandible brown; wings yellow; hairs golden.

Vestiture: Clypeus, frons, vertex and metanotum with appressed hairs; clypeus, vertex, gena, prothorax, scutum, mesopleuron, coxa and propodeum with semi erect hairs; pygidium laterally with stiff, semierect dark hairs.

Sculpture: Clypeus except apically and mesopleuron punctate; upper frons rugose; ocellar area and pygidium ventrally coarsely punctate; pronotum, scutum and propodeal enclosure with transverse striae, interspaces punctate; scutellum longitudinally striate; sides and apical half of propodeum striato-punctate; mesopleuron shiny.

Head: 0.9x as long as wide (HL = 3mm, HW = 3.3mm); frons above antennal sockets tuberculate; ocellar area convex; frontal line finely impressed; inner orbits curved inside above antennal sockets, UID: MID: LID = 2.7: 3.7: 3.1; POL: OOL = 0.3: 0.4; antennal sockets separated from frontoclypeal suture by 0.8x ASD; scape 2.3x and F16x as long as its apical width; F1 0.6x as long as F2+F3; F1: F2: F3: F10 = 1.0: 0.9: 0.7: 0.6; clypeus 0.6x as long as wide (CL = 1mm, CW = 1.6mm), basally convex, free margin arcuate with paired median lobe separated by median and lateral incisions; mandibles apically with single teeth.

Mesosoma: Pronotum posterior margin rounded, bituberculate; scutum with admedian lines and paradiscal lines, notauli absent; propodeum 1.3x as long as scutum (propodeum = 2.2mm, scutum = 1.7mm), with median longitudinal sulcus; wings hyaline, apically infusate, AV of SMC II as long as AV of SMC III and 1.3x as long as its BV (AV of SMC II = AV of SMC III = 0.8mm, BV = 0.6mm); hind wing media diverging beyond cu-a at distance 0.4x length of cu-a (cu-a = 0.5mm, M+Cu = 0.2mm); legs slender, tarsomeres with plantulae, claws with single median teeth; foretibia without outer spines, hind tibialspur 0.6x as long as hind basitarsus (hindtibial spur = 1.3mm, basitarsus = 2.1mm).

Metasoma: 1.4x as long as Mesosoma (Metasoma = 8.6mm, Mesosoma = 5.9mm); petiole 2.1x as long as hind tarsomeres II-IV combined (petiole = 3.3mm, hind tarsomeres II-IV = 1.6mm); relative length of segments I:II = 0.8:1.7.

Male

TBL = 18.4; FWL = 10.2; SW = 1.8.

Colour: Black; scape ventrally, pronotum posterior margin with medially interrupted transverse band, tegulae, transverse band on metanotum, petiole, apical one-third of fore and mid femora, fore and mid tibiae, hind basitarsus medially, hind trochanter, femur basally yellow; apical half of mandible brown; wings yellow; hairs golden.

Vestiture: Clypeus, frons, vertex and metanotum with appressed hairs; clypeus, vertex, gena, prothorax, scutum, mesopleuron, coxa and propodeum with semi erect hairs.

Sculpture: clypeus except apically and mesopleuron punctate; upper frons rugose; ocellar area coarsely punctate; pronotum, scutum and propodeal enclosure with transverse striae, interspaces punctate; scutellum longitudinally striate; sides and apical half of propodeum striato-punctate; mesopleuron shiny.

Head: 0.8x as long as wide (HL = 2.8mm, HW = 3.3mm); UID: MID: LID = 1.3: 1.7: 1.4; POL: OOL = 0.3: 0.4; antennal sockets separated from frontoclypeal suture by 0.8x ASD; scape 2.3x and F1 5x as long as its apical width; F1 0.8x as long as F2+F3, F1: F2: F3: F11 = 1.1: 0.8: 0.7: 0.3; clypeus as long as wide(1mm), free margin with paired pointed lobe; mandibles simple.

Mesosoma: propodeal enclosure with median longitudinal sulcus and carina; wings hyaline, apically infusate; AV of SMC II as long as its BV and AV of SMC III (0.7mm); hind tibial spur 0.5x as long as hind tarsomeres II-IV combined (HTS = 2.2mm, HBT = 1.0mm).

Metasoma: 0.9x as long as mesosoma (metasoma = 9.5mm, mesosoma = 8.8mm); petiole 2.1x as long as hind tarsomeres II-IV combined (petiole = 5.4mm, hind tarsomeres II-IV = 2.5mm); relative length of metasomal segments I:II = 1.5:1.7.

Material examined: Plesiotype: 1♀, India: Kerala, Ernakulam: Koothattukulam 9° 49' N 76° 36' E. 04.IV.2011. Baaby Job.

Other material examined: 1♀, India: Kerala, Malappuram: Calicut University Campus 11°8'N 75°53'E. 20. x.1997. V.V.S. Kumar; 1♀, India: Kerala, Malappuram: Calicut University Campus 11°8'N 75°53'E. 16. iii.1998. Suneetha; 1♀, India: Kerala, Malappuram: Calicut University Campus 11°8'N 75°53'E. 7. vi.2001. Madhavikutty; 1♀, India: Kerala, Thrissur, Ayyanthole 10°32'N 76°11'E. 02.vi.2009. Baaby Job; 1♀, India: Kerala, Thrissur, Ayyanthole 10°32'N 76°11'E. 10.vi.2010. Baaby Job; 1♂, India: Kerala, Kannur: Sree Narayana park 11°87' N 75°36' E, 21.vii.2009. Chitra Fenil; 1♀, India: Kerala, Thrissur, Ayyanthole 10°32'N 76°11'E. 13.vii.2010. Baaby Job; 1♀, India: Kerala, Ernakulam: Karimugal 9°59'N 76°23'E 21.iii.2010. Chithra; 1♀, India: Kerala, Ernakulam: Kizhakombu 9°86'N 76°57'E .23.viii.2011. Baaby Job; 2♀ India: Kerala, Malappuram: Vazhikadavu 11°38'N 76°34'E. 10. ii.2012. Baaby Job; 1♀, India: Kerala, Thiruvananthapuram: KAU Vellayani 8°26'N 76°59'E. 04. iv.2012. Simon George; 1♂, India: Kerala, Kottayam: Layikad 9°42'N 76°54'E .22.V.2012. Baaby Job; 1♀, India: Kerala, Pathanamthitta: Perumthuruthy 9°41'N 76°55'E. 23. v.2012. Simon George; 1♂ India: Kerala, Ernakulam: Koothattukulam 9° 49' N 76° 36' E. 28.V.2012. Simon George.

Distribution: Afghanistan, China, Egypt, France, Japan, Kazakhstan, Maldives, Saudi Arabia, South East Asia, SriLanka, Syria, Tajikistan, Tibet, Turkey, Ukraine, India [Assam, Jammu and Kashmir, Karnataka, Madhya Pradesh, Maharastra, Sikkim, Tamilnadu, Uttar Pradesh, West Bengal, Kerala: Ernakulam, Kannur, Kottayam, Kozhikode, Malappuram, Palakkad, Pathanamthitta, Thiruvananthapuram, Thrissur].

Biology: Constructs aerial multicellular mud nests; Chatenoud et.al (2012) has detailed mud balling activity of *S.madraspatanum* Fabricius in four phases. In the first phase the wasp searches suitable humid soil for mudball construction followed by the second phase of cleaning the selected area from leaves, stones etc. In third phase the wasp constructs spherical balls of mud with the help of mandibles and first pair of legs and in the final and fourth phase the wasps' flies to the nesting site with the mud ball.

The nests are sealed with white cementing substance and mass provisioned with spiders. Maxwell-Leffroy (1909) has described the developmental stages of *S. madraspatanum*. These wasps are parasitised by *Hedychridium rugosum* Smith. The egg is white, soft. The larva first feeds on the abdomen of the spider. Larval life is completed in thirteen days. Cocoon is constructed with fine yellow silk, which changes to dark brown. The whole development is completed in twenty four to thirty days.

Remarks: This species was first recorded by Fabricius in 1781 from Malabar as *Sphex madraspatanus*.

Since the available description of this species is inadequate for easy identification, a redescription is provided here.

Sceliphron madraspatanum Fabricius closely resembles *Sceliphron andamanicum* Kohl in having 1. Mesopleuron with yellow mark below tegulae; 2. Pale golden hair colour; 3. Body black variegated with yellow.

However *S. madraspatanum* differs from *S. andamanicum* in having 1. Pronotum posterior margin with narrowly interrupted transverse yellow band (in *S. andamanicum* pronotum is black without yellow band); 2. metanotum with transverse yellow band (metanotum black, yellow band absent in *S. andamanicum*); 3. Basal one third of hind femur with yellow colour (in *S. andamanicum* basal half of hind femur yellow).

Genus *Chalybion* Dahlbom

Chalybion Dahlbom, 1843: 21. Type species: "*Chalybion caeruleum*" [= *Sphex caeruleus* of Linnaeus, 1767: 941 = *Sphex caeruleus* Linnaeus, 1763 (nec *Sphex caeruleus* Linnaeus, 1758) = *Sphex cyaneus* Fabricius, 1775 (nec *Sphex cyaneus* Linnaeus, 1758) = *Pelopeus* (sic) *californicus* de Saussure, 1867], designated by Patton, 1880: 378.

Chalybium Agassiz, 1846: 77. Emendation of *Chalybion* Dahlbom, 1843.

Chalybium Schulz, 1906: 192. Emendation of *Chalybion* Dahlbom, 1843, junior homonym of *Chalybium* Agassiz, 1846.

Hemichalybion Kohl, 1918: 79. Type species: *Pelopoeus eckloni* Dahlbom, 1845, designated by Pate, 1937: 30

Diagnosis

Head: Inner orbits curving inwards medially; hairs erect on head; frons above antennal sockets tuberculate; F1 nearly as long as F2; male flagellomeres with placoids; clypeus 1.3x as wide as long, convex, clypeal free margin toothed or medially lobed; mandibles simple, except subapical tooth in females; mouth parts short, third maxillary palp expanded laterally; hypostomal carina ending near mandibular sockets, occipital carina contiguous with or narrowly separated from hypostomal carina.

Mesosoma: Pronotal collar with median depression; propodeal enclosure absent, spiracular groove absent; episternal sulcus complete, scrobal sulcus present; fore wing marginal cell apically acuminate; both recurrent veins received by SMC II; hindwing third anal vein separated from wing margin; mid coxae nearly contiguous; tibiae aspinose; foretarsal rake, plantulae absent; hind leg claw simple.

Metasoma: Petiole longer than hind coxa; tergum VIII in males with cerci; sternum IV in females with hairmat; sternum IV-VI in males with velvety pubescence, sternum VIII triangular or with finger like apical process; penis valve head ventrally with teeth.

Distribution: Worldwide

Biology: Nests in pre-existing cavities; nests are mass provisioned with spiders. Rau (1928) reported *Chalybion californicum* Saussure female entering and provisioning sealed nest of *Sceliphron caementarium* Drury. Nests are partitioned using mud, and water to moisten soil is carried by wasps herself (Rau 1928, Ward, 1971). Nests are sealed with white cementing material, either uric acid from animal feces or lime (Jayakar and Spurway, 1963; Ward, 1970). They usually form sleeping aggregations (Bohart and Menke, 1963, Ward, 1972).

Remarks: Bohart and Menke (1976) divided the genus *Chalybion* into subgenus *Chalybion* Dahlbom and subgenus *Hemichalybion* Kohl. Subgenus *Chalybion* Dahlbom differs from subgenus *Hemichalybion* in having 1. Clypeal free margin with three or five lobes or teeth or with median notch (in *Hemichalybion* Clypeal free

margin with projecting median lobe, weakly emarginated in females or bi/trilobite in males); 2. Inner mandibular margin with subapical teeth in females (in *Hemichalybion* inner mandibular margin simple in females); 3. Body without yellow markings (in *Hemichalybion* legs and petiole yellow).

In India this genus is represented by five species.

Key to species of the genus *Chalybion* Dahlbom in Kerala

1. Clypeal free margin in females with five median lobes; inner mandibular margin with subapical teeth in females; body without yellow markings; petiole 1.2 x as long as hindtarsomeres II-IV combined.....*Chalybion bengalense* (Dahlbom)

- Clypeal freemargin in females medially with three lobes (Fig 14a); inner mandibular margin simple; legs and petiole yellow; petiole as long as combined lengths of hindtarsomeres II-IV.....*Chalybion keralensis* sp. nov.

12. *Chalybion bengalense* (Dahlbom)

(Fig 13a; Plate 9c)

Sphex violaceus Fabricius, 1775: 346, ♀ (misspelled as *violacea* by Fabricius), junior primary homonym of *Sphex violaceus* Scopoli, 1763, South Africa (ZMUC), designated by van der Vecht, 1961: 41.

Pepsis violacea (Fabricius): Fabricius, 1804: 211, new combination for *Sphex violaceus* Fabricius.

Pelopaeus violaceus (Fabricius): Billberg, 1820: 105, new combination for *Sphex violaceus* Fabricius (collection Billberg).

Sceliphron violaceum (Fabricius): de Saussure, 1892: 440, new combination for *Sphex violaceus* Fabricius.

Sceliphron violaceum(Fabricius): de Saussure, 1892: 433, ♀ India (Lund). [Synonymized with *Pelopaeus violaceus* by Bingham, 1896a: 438].

Sceliphron bengalensis (Dahlbom): Kohl, 1894: 342, new combination for *Pelopoeus bengalensis* Dahlbom.

Chalybion bengalense (Dahlbom): F. Smith, 1871: 360, new combination for *Pelopoeus bengalensis* Dahlbom.

Pelopoeus convexus F. Smith, 1876: 449, ♂. Mascarenes (BMNH). [Synonymized with *Chalybion bengalense* by Hensen, 1988: 51].

Sceliphron convexum (F. Smith): Dalla Torre, 1897: 382, new combination for *Pelopoeus convexus* F. Smith.

Chalybion convexum ((F. Smith) Bohart and Menke, 1976: 102, new combination for *Pelopoeus convexus* F. Smith.

Redescription.

Female

Measurements in mm.

TBL = 15.3mm; FWL = 10.5mm; SW = 2.3mm.

Colour: Metallic blue; flagellomeres, mandibles black; hairs silver.

Vestiture: Dense, appressed pubescence on clypeus, lower frons, gena, pronotum posterior margin, pronotal lobe, scutellum and propodeum postero-lateral margin; frons, vertex, scutum, pronotum, propodeum, mesopleuron, coxa and petiole with erect hairs; metasoma and petiole apical half with fine velvety pubescence.

Sculpture: Clypeus, frons, mesopleura, hind coxa and propodeum coarsely punctate; pronotum, scutum, scutellum, metanotum punctate; propodeal enclosure striate, interspaces punctate; propodeum laterally with smooth area; sternum VI medially glabrous, sides punctate; sternites II-V apically glabrous.

Head: as long as wide (3.1mm); frons elevated above antennal sockets; frontal line thick; ocelli deep-set, POL: OOL = 0.2: 0.4; inner orbits medially curved inwards, converging towards clypeus, UID: MID: LID = 1.3: 3.3: 1.1; antennal sockets separated from frontoclypeal suture by 0.3x as ASD (ASD = 0.3mm, AS-FC = 0.1mm); antennae twelve segmented, scape 1.7x and F1 2.3x as long as its apical width; F1 0.3x as long as F2+F3 (1.3mm), F1: F2: F3: F10 = 0.5: 0.6: 0.7: 0.4;

clypeus as long as wide (1.0mm), convex with median carina; free margin medially with five lobes; inner mandibular margin with subapical teeth.

Mesosoma: Pronotum flat with median longitudinal depression; scutum with admedian lines and paradiscal lines finely impressed; episternal sulcus present; propodeum 1.9x as long as scutum (propodeum = 3.1mm, scutum = 1.6mm), propodeal enclosure defined by median longitudinal sulcus; wings hyaline, apically infusate, forewing darker than hind wing; AV of SMC II 0.7x as long as AV of SMCIII (AV of SMC II = 0.4mm, AV of SMC = 0.6mm); hind wing media diverging at cu-a; legs slender; tarsal claws of fore and mid legs medially with single teeth, hind leg claws simple; hind tibial spur 0.5x as long as hind basitarsus (HTS = 1.3mm, HBT = 2.6mm).

Metasoma: 1.9x as long as mesosoma (Metasoma = 7.7mm, Mesosoma = 6.2mm); petiole 1.9x as long as hindcoxa, 1.2x as long as hind tarsomeres II-IV combined (petiole = 2.9mm, hind coxa = 1.5mm, TII-IV = 2.4mm; relative length of segments I:II = 2.4mm).

Male

TBL = 15.5mm; FWL = 11.5mm; SW = 2.1mm.

Colour: Metallic green; hairs silver; wings with brown tint.

Vestiture: Dense, appressed pubescence on clypeus, lower frons, gena, pronotum posterior margin, pronotal lobe, scutellum and propodeum postero-lateral margin; frons, vertex, scutum, pronotum, propodeum, mesopleuron, coxa and petiole with erect hairs; sternites IV-VI and petiole apical half with fine velvety pubescence.

Sculpture: Clypeus, frons, mesopleura, hind coxa and propodeum coarsely punctate; pronotum, scutum, scutellum, metanotum punctate; propodeal enclosure striate, interspaces punctate; propodeum laterally with smooth area; sternum VI medially glabrous, sides punctate; sternites II-V apically glabrous.

Head: POL: OOL = 0.2:0.4; inner orbits emarginated medially, UID:MID:LID = 1.4:1.9:1.5; antennae thirteen segmented, F6-F9 with placoids, scape 2x and F1 3.5x as long as apical width, F1 0.4x as long as F2+F3 (F2+F3 = 1.6mm), F1: F2: F3: F11 = 0.7: 0.8: 0.8: 0.3; clypeus convex, with median longitudinal carina, free margin with three median lobes; mandibles simple.

Mesosoma: Pronotum with median depression; wings hyaline, apically infusate, AV of SMC II 0.7x as long as SMC III AV; hind claws simple; hind tibial spur 0.7x as long as hind basitarsus (HTS = 1.4mm, HBT = 2mm).

Metasoma: 1.5x as long as mesosoma (Metasoma = 6.7mm, Mesosoma = 4.5mm); petiole 2x as long as hindcoxa, 1.4x as long as hind tarsomeres II-IV combined (petiole = 2.9mm, hind coxa = 1.5mm, TII-IV = 2.1mm; relative length of segments I:II = 0.7:1.3).

Materials examined: 1♂, India: Kerala, Ernakulam: Koothattukulam 9° 49' N 76° 36' E. 19.v.2012. Baaby Job.

Other material examined: 1♀, India, Kerala, Malappuram, Calicut University 11°8'N 75°53'E. 4.ix.1996, Sudha; 1♂, India: Kerala, Kozhikode, 2.v.2001, Madhavikutty; 1♀, India, Kerala, Thrissur: Ayyanthole 10°32'N, 76°11'E. 16.vi.2009. Baaby Job; 3♀, India, Kerala, Kannur: St. Angelo's Fort 11°85'N 75°37'E. 21.vii.2009. Chitra Fenil; 1♂, India, Kerala, Kannur: Sree Narayana Park 11°87'N 75°36'E. 30.viii.2009. Chitra Fenil; 1♀, India, Kerala, Ernakulam: Karimugal 9°59'N 76°23'E. 21.iii.2010. Chitra Fenil; 1♂, India, Kerala, Thrissur: Ayyanthole 10°32'N 76°11'E. 13.iv.2010. Baaby Job; 1♀, India, Kerala, Thrissur: Ayyanthole 10°32'N 76°11'E. 2.vi.2010, Baaby Job; 1♂, India: Kerala, Palakkad: Paalana 10°73'N 76°65'E. 15.iii.2011, Baaby Job; 1♂, India: Kerala, Kasargode: C.P.C.R.I 12°52'N 74°96'E. 02.i.2012. Baaby Job; 1♂, India: Kerala, Ernakulam: Aluva 10°11'N 76°35'E. 08.ii.2012. Baaby Job; 1♀, India: Kerala, Malappuram: KAU Thavanoor 10°51'N 75°58'E. 26.iii.2012. Baaby Job; 1♀, India: Kerala, Palakkad: KAU Pattambi 10°48'N 76°11'E. 28.iii.2012. Baaby Job; 1♀, India: Kerala, Ernakulam: Koothattukulam 9°

49' N 76° 36' E. 04.iv.2012. Baaby Job; 1♀, India: Kerala, Wayanad: Kuruva 11°49'N 76°5'E. 17.iv.2012. Baaby Job; 1♀, India: Kerala, Wayanad: Mananthavady Park 11°48'N 76°1'E. 19.iv.2012. Baaby Job; 2♂, India: Kerala, Kollam: Punalur 9°03'N 76°9'E. 02.v.2012. Baaby Job; 1♂, India: Kerala, Kollam: Urukunnu 8°98'N 77°2'E. 02.v.2012, Baaby Job; 1♂, India: Kerala, Kollam: Thenmala 8°57'N 77°4'E. 02.v.2012. Simon George; 1♀, India: Kerala, Kollam: Munroethuruth 8°59'N 76°36'E. 04.v.2012. Baaby Job; 1♀, India: Kerala, Thrissur: Thumburmuzhi 10°29' N, 76°46'E. 05.v.2012. Baaby Job; 1♀, India: Kerala, Kottayam: Layikad 9°42'N 76°54'E. 22.v.2012. Simon George; 1♂, India: Kerala, Pathanamthitta: Perumthuruthy 9°41'N 76°55'E. 23.v.2012. Baaby Job; 1♂, India: Kerala, Pathanamthitta: Thiruvalla 9°38'N 76°57'E. 24.v.2012, Baaby Job; 1♂, India: Kerala, Idukki: Kunijimala 9°84'N 76°47'E. 16.vi.2012. Baaby Job; 1♀, India: Kerala, Kottayam: Munakkal 9°7'N 76°70'E. 18.vi.2012. Baaby Job; 2♂, India: Kerala, Alappuzha: Chungam 9°49'N 76°34'E. 10.vii.2012. Simon George.

Distribution: Bangladesh, China, Eritria, Ethiopia, Japan, Madagascar, Malay, Maldives, Mozambique, Seychelles, Singapore, South Africa, South East Asia, SriLanka, Tanzania, Timor, Yemen, India [West Bengal, Uttar Pradesh, Tamil nadu, Meghalaya, Andaman Islands, Bihar, Goa, Himachal Pradesh, Kashmir, Sikkim, Tripura, Kerala: Alappuzha, Ernakulam, Idukki, Malappuram, Kannur, Kasargode, Kollam, Kottayam, Kozhikode, Palakkad, Pathanamthitta, Thrissur, Thiruvananthapuram, Wayanad].

Biology: Nests in pre-existing cavities, including plug holes, animal feaces are used to plug nest holes, forms sleeping aggregations (Jayakar and Spurway, 1963; Jayakar and Mangipudi, 1965).

Remarks: Since the available description of this species is inadequate for easy identification, a redescription is provided here.

Chalybion bengalense (Dahlbom) closely resembles *Chalybion petroleum* Hensen in having 1). Head and mesosoma with erect white hairs; 2). Petiole nearly as long as

hind basitarsus; 3). Metapleuron without striae. However *C. bengalense* differs from *C. petroleum* in having 1). Pronotal collar anteriorly less differentiated, punctate and not concave (in *C. petroleum* pronotal collar anteriorly strongly differentiated, concave and impunctate; 2). Frons densely coarsely punctate (in *C. petroleum* frons sparsely punctate; 3). F6-F9 with placoids ((in *C. petroleum* F2 –F9 with placoids).

13. *Chalybion keralensis* sp. nov.

(Fig 14a-d; Plate 9d)

Description.

Female

Measurements in mm

TBL = 31.5; FWL = 22.3; SW = 4.7.

Colour: Black; mesosoma and metasoma with purple reflections; scape, pedicel, F1-F6, pronotum posterior margin, spot on tegulae, trochanter, femur and tibiae of fore and hind legs, midtibiae except basodorsally, tarsomeres I-IV of mid and hind legs, sternum I basally brown yellow; foreleg tarsomeres, mid tarsomere V, mandibles except apically, clypeus, antennal tubercles, spot beneath tegulae, pronotal lobe margin brown; trochanters with dorsoapical yellow mark; wings yellow, apically infusate; hairs black, clypeus, frons with golden pubescence and hairs on head golden brown.

Vestiture: Clypeus, frons with appressed pubescence; semierect hairs on clypeus, frons, vertex, gena, scutum, metapleuron, coxa, propodeum sides; scutum apical half with erect hairs; metasoma with appressed pubescence.

Sculpture: Propodeum medially rugose to transversly striate submedially, sides and apical half transversly striate with punctate interspaces; upper frons, pronotum, scutum, scutellum, metanotum, mesopleuron, coxa punctate; clypeus, antennal tubercles, sternites IV-V, terga VI coarsely punctate; metapleuron smooth to sparsely punctate; sternites IV-V medially smooth; propleura glabrous.

Head: 0.8x as long as wide (HL = 5mm, HW = 6.2mm); vertex raised; frons with tubercles above antennal sockets; frontal line carinate; inner orbits converging towards vertex, parallel on lower two-thirds, UID: MID: LID = 2.7: 3.4: 3.1; ocelli deep set, POL: OOL = 0.5: 0.8; antennal sockets contiguous with frontoclypeal suture; clypeus 0.7x as long as wide (CL = 2mm, CW = 2.8mm), convex with median longitudinal carina; free margin medially trilobed; mandibles simple, apically blunt.

Mesosoma: Pronotum posterior margin medially notched; admedian lines separated, paradiscal lines present; scutellum with median sulcus; propodeum with median longitudinal carina, absent on apical one third; wings hyaline; AV of SMC II 0.3x as long as AV of SMC III (AV of SMC II = 0.5mm, AV of SMC III = 1.7mm); marginal cell apically acuminate; hindwing media diverging at cu-a; legs spinous; hind tibial spur 0.4x as long as hind basitarsus (HTS = 1.7mm, HBT = 4.7mm); tarsal claws with median teeth.

Metasoma: 1.2x as long as mesosoma (Metasoma = 15.3mm, Mesosoma = 12.8mm); petiole as long as hind tarsomeres II-IV combined (5.1mm); relative length of segments I: II = 2.1:3.5; sternum IV with median flat depressed region.

Male: Unknown

Etymology: The species derives its name from its place of occurrence, Kerala.

Material examined: Holotype: 1♀, India: Kerala, Wayanad: Tholpetty 11°54'N 76°3' E. 18.iv.2012, Simon George.

Paratype: 2♀, India: Kerala, Wayanad: Tholpetty 11°54'N 76°3' E. 18.iv.2012, Simon George.

Depository: The specimen deposited at the Research Lab, Department of Zoology, St. Thomas College, which will be transferred to ZSIWGRC.

Distribution: India (Kerala: Wayanad).

Biology: Observed to be constructing mud nests.

Remarks: *Chalybion keralensis* closely resembles *Chalybion spinolae* (Lepeletier) in having 1. Body black and yellow; 2. Hairs black; 3. Clypeus with median longitudinal carina. However, *C. keralensis* sps A. differs from *C. spinolae* (Lepeletier) in having 1. Scutum punctate (in *C. spinolae* (Lepeletier) scutum striate); 2. hairs on head golden brown (in *C. spinolae* (Lepeletier) hairs on head black); 3. Metasoma smooth, not striate (in *C. spinolae* (Lepeletier) Metasoma longitudinally striate).

4.4.5 SUBFAMILY SPHECINAE

Sphecinae Latreille, 1802b:331. Based on *Sphex* Linnaeus, 1758

These are robust wasps, black, black and red or sometimes golden colour. Many are famous members, known by common names as ‘Golden digger wasps’, ‘Yellow winged Sphex’ etc. The use of tools for nest closure, prey capture techniques etc. have made them favourite subjects of taxonomists as well as ethologists.

Diagnosis

Head: Antenal sockets in middle of face; sockets separated from frontoclypeal suture by socket diameter; F1 longer than F2; inner mandibular margin with teeth; mandibular socket closed; third maxillary palp normal; hypostomal carina complete.

Mesosoma: Propodeal enclosure not defined; spiracular groove absent (except in *Sphex* Linnaeus); episternal sulcus complete; forewing with three SMC's; recurrent vein I received by SMC II and recurrent vein received by SMC III; midcoxa contiguous; inner margin of claws with basal teeth; plantulae absent.

Metasoma: Petiole composed of sternum I; cerci present or absent; volsella with or without digitus.

Distribution: Worldwide.

Biology: Fossorial or nests in pre-existing cavities. Prey consists of Tettigoniidae (Grylloptera) and Acrididae (Orthoptera). They are mainly parasitized by Sacrophagidae and Stylopidae (Bohart and Menke, 1963).

Genus *Sphex* Linnaeus

Sphex Linnaeus, 1758: 569. Type species: *Sphex flavipennis* Fabricius, 1793, designated by I.C.Z.N., 1946: 571.

Sphaex Scopoli, 1772: 122. Lapsus or emendation of *Sphex* Linnaeus, 1758.

Ammobia Billberg, 1820: 105. Type species *Pepsis argentata* (Fabricius, 1804) [= *Sphex argentatus* Fabricius, 1787], designated by Rohwer, 1911: 153.

Proterosphex Fernald, 1905: 163. Type species: *Sphex maxillosus* Fabricius, 1793, junior primary homonym of *Sphex maxillosus* Poiret, 1787 [= *Sphex funerarius* Gussakovskij, 1934].

Fernaldina R. Bohart and Menke, 1963: 130. Type species: *Sphex lucae* de Saussure, 1867, original designation.

Diagnosis:

Head: Male antennae with placoids on flagellomeres IV-VI; clypeal free margin of female arcuate with median notch, truncate with shallow emargination in male; labrum in female with median longitudinal carina; female mandible broad in middle, when folded apex surpassing base of opposite mandible, inner mandibular margin with large median tooth, subtended by a small tooth; male mandible slender, inner margin with single subapical tooth; malar space absent.

Mesosoma: Pronotal collar separated from scutum; complete spiracular groove present; propodeal enclosure present or absent; basal vein of SMC II equal to or shorter than anterior vein; posterobasal vein of SMC III longer than anterior vein; female fore tarsal rake well developed with long, blade like setae, asymmetrical tarsomere I bearing rake setae on both margins; claw tooth present, obliquely oriented or perpendicular; petiole straight, less than two-thirds length of hind tarsomeres II-IV combined.

Metasoma: Male tergum VIII with cerci, setae on terminal sternum in tufts or patches; sternum VIII triangular or rounded with apicomedian projection; penis valve ventrally toothed, inflated or with apicodorsal or lateral wings; volsella digitus usually simple.

Distribution: Worldwide; Cosmopolitan.

Biology: Gregarious, ground nesting wasps, colonies maintained for many years; nests are constructed in open areas with sparse vegetation; prey includes Tettigoniidae, Gryllacrididae and Gryllidae; eggs laid on thorax, ventrally; Cleptoparasites include Sarcophagid and Tachnid flies (Bohart and Menke, 1976).

Remarks: The genus *Sphex* Linnaeus is divided into two subgenera: *Sphex* sub genus *Sphex* Linnaeus and subgenus *Fernaldina* Bohart and Menke. All species reported from India belong to subgenus *Sphex*, while *Fernaldina*, represented by two species, is Holarctic. The subgenus *Sphex* is similar to subgenus *Fernaldina* in having 1. Male flagellomeres IV-VI with non spiculate placoids; 2. Female fore leg with tarsal rake well developed; 3. Petiole shorter than length of hindtarsomeres II-IV combined. This genus can be readily separated from subgenus *Fernaldina* by the 1. Presence of complete spiracular groove (groove absent in *Fernaldina*); 2. Variable petiole length (in *Fernaldina* two-third length of hind tarsomeres II-IV) and 3. Cerci present (cerci absent in *Fernaldina*).

Key to species of the genus *Sphex* Linnaeus in Kerala

1. Propodeal enclosure with transverse ridges (Fig 18f); scape orange red in females; clypeal freemargin with median notch (Fig 18a); forebasitarsus with nine rake spines (Fig 18c).....2
- Propodeal enclosure with fine transverse striae (Fig 15d); scape black; clypeal freemargin medially lobed (Fig 15a); foretarsus with ten rake spines.....3

2. Clypeus with baso-longitudinal carina and subapical median depression; clypeal freemargin medially emarginated bounded on each side with lateral lobe (Fig 16a); petiole black.....*Sphex neosericeus* sp. nov.
- Clypeus without carina and subapical median depression; clypeal freemargin without lateral lobes (Fig 18a); petiole orange red.....*Sphex sericeus* (Fabricius)
3. Clypeal freemargin medially bilobed (Fig 15a); body with white hairs; legs black; petiole as long as hindcoxa.....*Sphex argentatus* Fabricius
- Clypeal freemargin with single median lobe (Fig 17a); hairs black; foretibia dorsally, mid and hindtibia red-black; petiole 1.2x as long as hindcoxa.....*Sphex praedator* F. Smith

14. *Sphex argentatus* Fabricius

(Fig 15a-f; Plate 10a)

Sphex argentatus Fabricius, 1787: 274, sex not indicated (misspelled as *argentata* Fabricius). India (ZMUC), designated by van der Vecht, 1961: 28.

Sphex unicolor Fabricius, 1787: 275, Spain: (depository uncertain). [Synonymized with *Sphex argentatus* by Fabricius, 1804: 209].

Sphex umbrosus Christ, 1791: 293, (origin destroyed). Synonymized by van der Vecht, 1961: 28, and 1973: 345.

Sphex argenteus Turton, 1801: 485 (misspelled as *argentea* by Turton). Lapsus or emendation of *Sphex argentatus* Fabricius. [Synonymized by van der Vecht, 1960: 6].

Sphex argentifrons Lepeletier de Saint Fargeau, 1845: 337, ♀. Indonesia (TORINO), designated by Menke in R. Bohart and Menke, 1976: 114. [Synonymized by F. Smith, 1856: 252].

Sphex plumifer Costa, 1864: 112, sex not indicated (as *plumifera*, incorrect original termination). Philippines: (NAPOLI).

Sphex umbrosus var. *nanulus* Strand, 1913: 83. Holotype: ♀ Taiwan (DEI).

Redescription

Female

Measurements in mm

TBL=31.7; FWL=21.5; SW=4.7.

Colour: Black; clypeus, frons and pronotal lobe with silver hairs, frons near ocelli with dark hairs; rest of body covered with white hairs.

Vestiture: Clypeus, frons, pronotal lobe, anterior and posterior pronotal margin with dense, appressed hairs; white, semi erect hairs on clypeus, frons, vertex, gena, pronotum, petiole and coxa; frons near ocelli, sternites apically and pygidium with semierect hairs; mesopleuron, scutum and propodeum with erect, hairs.

Sculpture: Vertex, scutum and mesopleuron punctate; metapleuron and propodeum shiny; propodeal enclosure transversely striate, propodeum posteriorly rugose; metasomal segments II-V medially smooth, impunctae, laterally coarsely punctate; pygidium smooth ventro-medially, dorsally coarsely punctate.

Head: 0.8x as long as wide (HL = 5.6mm, HW = 6.9mm); inner orbis parallel on lower two-thirds, converging towards vertex; UID: MID: LID= 2.8:3.4:3.1; ocellar area triangular, POL: OOL= 0.8:0.6; frontal line distinctly impressed; antennal sockets separated from fronto clypeal suture by ASD (0.5mm); antennae twelve segmented; scape 1.4x and F1 6.5 x as long as its apical width, 0.9x as long as F2+F3 (1.6mm), F1: F2: F3: F10= 1.4: 0.8: 0.7: 0.5; clypeus as long as wide (2.9 mm), free margin medially bilobed, arcuate; mandibles medially with two teeth.

Mesosoma: Pronotum posteriorly rounded; scutum with admedian lines, notuali and paradiscal lines; scutellum, metanotum bituberculate; wings hyaline, basally and apically infusate; AV of SMC II as long as BV(1.5mm), 2.6x as long as AV of SMC III(0.6mm); hind wing media diverging beyond cu-a at 0.3x length of cu-a (cu-a = 1mm, M+Cu = 0.25mm); legs spinous; fore tarsal rakes with ten outer rake spines; hind tibial spur 0.6x as long as hind basitarsus (HTS = 4.3mm, HBT = 2.7mm); claws medially with two teeth.

Metasoma: 1.2x as long as mesosoma (Metasoma = 14.7, Mesosoma = 11.7mm); petiole as long as hind coxa (2 mm), 0.4 x as long as hind tarsomeres II-IV combined(4.7mm); relative length of segments I:II = 2.0:4.0; pygidium with U shaped carina.

Male

TBL=22.7mm; FWL=18.2 mm; SW=3.8mm.

Colour: Black; hairs white, clypeus, frons, and pronotal lobe with silver hairs; frons near ocelli and pygidium laterally with black hairs.

Vestiture: Clypeus, frons, pronotal lobe, anterior and posterior pronotal margin with dense, appressed hairs; semi erect hairs on clypeus, frons, vertex, gena, pronotum, petiole and coxa; frons near ocelli, sternites apically and pygidium with dark semi erect hairs; mesopleuron, scutum and propodeum with erect, hairs.

Sculpture: Clypeus micropunctate; vertex, scutum and mesopleuron punctate; metapleuron and propodeum shiny; propodeal enclosure transversely striate, propodeum posteriorly rugose; metasomal segments II-V medially smooth, impunctae, laterally coarsely punctate; pygidium smooth ventro-medially, dorsally coarsely punctate.

Head: 0.8x as long as wide (HL = 4.7mm, HW = 5.7mm); POL:OOL= 0.6:0.5; UID:MID:LID= 2.1:2.5:2.1; antennal sockets separated from frontoclypeal suture ASD(0.4mm); antennae thirteen segmented; scape 1.3x and F1 5x as long as its apical width, F1 0.8x as long as F2+F3(2.1mm); F1:F2:F3:F11 = 1.7:1.2:0.6:0.5; F2–F9 with flat placoids; clypeus as wide as long (2.6mm), free margin with median emargination; mandibles medially with single teeth.

Mesosoma: Scutellum, metanotum longitudinally notched; propodeum 0.9x as long as scutum, basal one- third with median carina (propodeum = 3.2mm, scutum = 3.5mm); wings hyaline, infuscent apically and basally; hind wing media diverging beyond cu-a at 0.2x as long as cu-a (M+Cu = 0.2mm, cu+a = 7mm); fore tarsal rake not well

developed, 0.7x as long as in female; fore basitarsus with seven stiff, rake spines; hind tibial spur 0.7x as long as hind basitarsus (HTS = 2.2mm, HBT = 3.2mm).

Metasoma: 1.1x as long as mesosoma (Metasoma = 11mm, Mesosoma = 9.7mm); petiole as long as hind coxa (2mm); Tg1:Tg2= 2.2:3.3; sternum VII emarginate; Sternum VIII apically rounded, with apico-median projection.

Material examined: Plesiotype: 1♀, India, Kerala, Thrissur, Peechi 10°31'N 76°22'E, 12.ii.2012. Baaby Job.

Other material examined: 1♀, India, Kerala, Malappuram: Calicut University Campus 11°8'N 75°53'E. 04.x.1992. Manju M.K.; 1♂, India, Kerala, Kozhikode: Balussery 16.iii.2000, GirishKumar; 1♀, India: Kerala, Malappuram: Calicut University Campus 11°8'N 75°53'E. 13. v.2000. Madhavikutty; 3♀, India, Kerala, Thrissur: Peechi 10°31'N 76°22'E. 12.ii.2012. Baaby Job; 1♂, India: Kerala, Thiruvananthapuram: KAU Vellayani 8°26'N 76°59'E. 04. IV.2012.Simon George.

Distribution: Africa, Australia, China, Dubai, Israel, Japan, Kazakhstan, Korea, Kuwait, Seychelles Islands, South East Asia, Spain, SriLanka, Taiwan, India [Assam, Sikkim, Bihar, Orissa, UttarPradesh, Meghalaya, Kerala: Kozhikode, Malappuram, Palakkad, Thrissur, Thiruvananthapuram].

Remarks: *Sphex argentatus* Fabricius closely resembles *Sphex diabolicus* Smith in having 1.Black colour 2.Scutellum and metanotum bituberculate 3. Propodeum with fine transverse striae and 4. Vertex and scutum punctate.

However *S. argentatus* differs from *S.diabolicus* in having 1. White pubescence (hairs black in *S.diabolicus*)(ii) Propodeum with erect hairs (in *S.diabolicus* semi erect black hairs) and (iii) Wings clear, infuscate at base and apex(in *S.diabolicus* wings dark).

15. *Sphex neosericeus* sp. nov.

(Fig 16a-e; Plate 10b)

Description

Female .

Measurements in mm

TBL=27; FWL=18.3; SW=4.7.

Colour: Black; mandibles basal half, scape, pedicel, F1 dorsally, spot apico-dorsally on F2 and F3, clypeus, pronotum anterior and posterior margin, pronotal lobe, tegulae, scutellum, metanotum, legs, metasomal segment I and basal two-third of segment II orange red; coxa, trochanter dorsally and apical tarsomeres black; wings brown, infusate at apex, with purple effulgence; hairs golden.

Vestiture: Clypeus (except medially), frons, vertex, gena, pronotum and scutum with dense, appressed hairs; clypeus, mesopleura, propodeum, coxa and petiole with semierect hairs; hairs erect on frons, vertex, pronotum, scutum and metanotum; metasomal segments I-III with fine velvety pubescence; pygidium laterally with stiff, semierect hairs.

Sculpture: Clypeus micropunctate; mesopleura shiny, punctate; metapleura upper half punctate, lower half smooth, shiny; propodeal enclosure with four transverse ridges, the interspaces striate; propodeum posteriorly rugose; tergites II-IV medially and apically smooth, laterally with scattered punctae; tergum V coarsely punctate, apico-medially smooth; sternites II-V laterally with coarse punctae; pygidium coarsely punctate.

Head: 0.8x as wide as long (HL = 5.2mm, HW = 6.5mm); inner orbits converging towards vertex, parallel on lower two-thirds, UID: MID: LID = 2.7: 2.9: 3.2; POL: OOL = 0.6: 0.7; antennal sockets separated from frontoclypeal suture by 0.6x ASD (AS-FC = 0.3mm, ASD = 0.5mm); antennae twelve segmented, scape 1.3x and F1

5.7x as long as its apical width, F10.7x as long as F2+F3 (F2+F3 = 2.6mm); F1: F2: F3: F10 = 1.8: 1.3: 1.3: 0.9; clypeus 0.9x as long as wide, convex; clypeus with baso-median longitudinal carina, subapical crest like carina and median depression; free margin arcuate, with sharply toothed median notch, lobed on each side; mandibles with two median teeth.

Mesosoma: Pronotum separated from scutum, not closely appressed; scutum with admedian lines, notuali and paradiscal lines finely impressed; episternal sulcus complete, scrobal sulci present; scutellum, metanotum bituberculate; wings hyaline; AV of SMC II as long as its BV (1.3mm), 5.2x as long as AV of SMC III (0.25mm); hind wing media diverging beyond cu-a at 0.15x as long as cu-a (M+Cu = 0.2mm, cu+a = 1.2mm); legs spinous, stout; fore basitarsus with nine rake spines, apical spines of tarsomeres I-III longer than succeeding tarsomeres; hind tibial spur 0.6x as long as hind basitarsus (HTS = 2.1mm, HBT = 3.5mm); tarsal claws with two teeth.

Metasoma: 0.9x as long as mesosoma (Metasoma = 11.3mm, Mesosoma = 12.2mm); petiole 0.4x as long as hind tarsomeres II-IV combined (petiole = 1.9mm, hind tarsomeres II-IV = 4.3mm); relative length of segments I:II = 2.8:3.3; pygidium with median U-shaped carina.

Etymology: The term 'neo' means new. The name indicates, this is a new species resembling *S. sericeus* (Fabricius).

Material examined: Holotype: 1♀, INDIA: Kerala, Thrissur, Ayyanthole 10⁰32'12"N, 76⁰11'8"E.10.iii.2013, Baaby Job.

Depository: The specimen deposited at the Research Lab, Department of Zoology, St. Thomas College, which will be transferred to ZSIWGRC.

Remarks: This species is similar to *Sphex sericeus* in having 1. Body orange red 2. Propodeum with transverse ridges and 3. Fore basitarsus with nine rake spines. However *Sphex neosericeus* sp. nov. differs from *Sphex sericeus* in having 1. Free clypeal margin with sharply toothed median notch, bounded by lateral lobes (in *S. sericeus* lateral lobes on clypeal free margin absent); 2. Basal longitudinal carina on

clypeus (absent in *S. sericeus*) 3. Subapical crest like carina on clypeus with median depression (absent in *S. sericeus*); 4. Petiole black (In *S. sericeus* petiole orange red).

16. *Sphex praedator* F. Smith

(Fig 17a-d; Plate 10c)

Sphex praedator F. Smith, 1858b:14, ♂. Indonesia (OXUM).

Sphex tyrannicus F. Smith, 1860ab:122, ♀ (misspelled as *Tyrannica* by F. Smith). Moluccas. [Synonymized with *Sphex praedator* by Hensen, 1991:26].

Sphex luteipennis Moscáry, 1883:33, ♀. Indonesia (TMB), designated by Van der Vecht, 1973:348. [Synonymized with *Sphex praedator* by Hensen, 1991a:26].

Sphex nigripes var. *calopterus* Kohl, 1890:168 and 422, ♂. Indonesia: (NHMW). [Synonymized with *Sphex praedator* by Van der Vecht, 1973:347].

Sphex melanopodus Strand, 1915:89, ♀ (misspelled as *melanopoda* by Strand). Sri Lanka: (NHMW), designated by van der Vecht, 1973:347.

Redescription.

Female.

Measurements in mm

TBL=31.2; FWL=23.3; SW=4.6.

Colour: Black; fore tibia dorsally, mid and hind tibia, mid and hind femur, spot on tegulae brown red; wings yellow, infuscate at apex; tergum III apically with yellow marking; hairs black.

Vestiture: Clypeus, gena and lower frons with semi erect stiff hairs; hairs sparse on vertex; mandibles ventrally with erect hairs; propleura, prosternum, mesopleuron and propodeum with fine, semi erect hairs; metasoma almost bare.

Sculpture: Clypeus micropunctate; frons, vertex and gena punctate; scutum, scutellum punctate, the interspaces micropunctate; propodeal enclosure striate,

propodeum posteriorly rugose; metasomal segments II-III punctate, medially impunctate; segments IV-V and pygidium coarsely punctate.

Head: 0.8x as long as wide (HL = 5.4mm, HW = 6.4mm); ocellar area triangular, well defined; POL: OOL = 0.6: 0.8; inner orbits converging towards vertex, parallel on lower two-thirds, UID: MID: LID = 2.7: 3.4: 3.3; antennal sockets separated from frontoclypeal suture by 0.8x as ASD (ASD = 0.5mm, AS-FC = 0.4mm); antennae twelve segmented, scape 1.8x and F1 3.4x as long as its apical width; F1 0.6x as long as F2+F3 (2.3mm); F1: F2: F3: F10 = 1.4: 1.2: 1.1: 0.7; clypeus nearly as wide as long (3.3mm), convex, free margin arcuate with median lobe; mandibles medially with two teeth.

Mesosoma: Pronotum, scutellum and metanotum bituberculate; scutum with admedian lines, notuali and paradiscal lines finely impressed; episternal sulcus complete; propodeum 1.5 xs as long as scutum (propodeum = 5.8mm, scutum = 4mm); wings hyaline; AV of SMC II 1.3x as long as its BV (AV = 1.8mm, BV = 1.4mm), 4x as long as AV of SMCIII (AV = 0.8mm); hind wing media diverging at cu-a; legs spinous, fore basitarsus with ten rake spines; apical spines of mid tarsomere I and II longer than succeeding aricles; hind tibial spur 0.5x as long as hind basitarsus (HTS = 2.2mm, HBT = 4.1mm); tarsal claws with two teeth.

Metasoma: 1x as long as mesosoma (Metasoma = 14.3mm, Mesosoma = 13.9mm); petiole 1.2x as long as hind coxa, 0.6x as long as hind tarsomeres II-IV combined (petiole = 2.2mm, hind coxa = 1.9mm, hind tarsomeres II-IV = 3.5mm); relative length of segments I:II = 2.4:3.6.

Male: Unknown

Material examined: Plesiotype: 1♀, INDIA: Kerala, Malappuram: Nilambur, V.V.S.Kumar.

Distribution: China, Egypt, India, Indonesia, Malaysia, Philippines, South Africa, Srilanka, Taiwan, Tanzania, Zambia, Zimbabwe, India [Assam, Sikkim, West Bengal, Kerala]

Biology: Prey on *Anacridium maestum* Audinet-Serville (Bristowe, 1925).

Remarks: Since the available description of this species is inadequate for easy identification, a redescription is provided here.

Sphex preadator F. Smith closely resembles *Sphex subtruncatus* Dahlbom in having 1. Mandibles bidentate; 2. Scutellum convex, medially impressed; 3. Propodeum with sparse hairs.

However, *S. preadator* differs from *S. subtruncatus* in 1. Midtibia outer margin with straight spines (in *S. subtruncatus* outer margin of midtibia with with curved spine); 2. Pygidium present (in *S. subtruncatus* pygidium present); 3. Wings yellow to brown (in *S. subtruncatus* wings brown to clear).

17. *Sphex sericeus* (Fabricius)

(Fig18a-f; Plate 10d)

Sphex aurulentus Fabricius, 1793: 201, sex not indicated, junior primary homonym of *Sphex aurulentus* Fabricius, 1787, India: (depository unknown: van der Vecht, 1961: 30).

Pepsis sericeus Fabricius, 1804: 211, ♀. (misspelled as *sericea* by Fabricius), (ZMUC), designated by van der Vecht, 1961:30. [Synonymized by Kohl, 1890: 392].

Sphex fabricii Dahlbom, 1843: 27, ♀. (misspelled as *Fabricii* by Dahlbom). India (depository unknown: Hensen, 1991: 22). [Synonymized by Kohl, 1885b:194 and 1885c:164].

Sphex lineolus Lepeletier de Saint Fargeau, 1845: 353, ♂, Indonesia: (TORINO). [Synonymized by Kohl, 1885b: 195 and 1885c: 165]

Sphex ferrugineus Lepeletier de Saint Fargeau, 1845: 345, ♀ (misspelled as *ferruginea*, by Lepeletier), (MNHN) [Synonymized by Kohl, 1885b: 194, and 1885c: 165].

Sphex ferox F. Smith, 1862: 55, ♂, junior primary homonym of *Sphex ferox* Westwood, 1837. Indonesia (BMNH and OXUM). [Synonymized by Kohl, 1885b: 195]

Sphex lepeletierii Saussure, 1867: 40, ♀. Indonesia (NHMW) [Synonymized with *Sphex sericeus* by Kohl, 1885b: 195 and 1885c:165].

Sphex godeffroyi Saussure, 1869: 57, ♀, Australia (Mus. Hamburg, destroyed in World War II). [Synonymized by Kohl, 1885b: 195, and 1885c: 165].

Sphex aurifex F. Smith, 1873c: 460, ♀. Australia (BMNH). [Synonymized by Kohl, 1890: 392].

Sphex aurulentus var. *pallidehirtus* Kohl, 1890: 393, ♂. Papua New Guinea (NHMW). [Synonymized by Hensen, 1991: 22].

Sphex rugosus Matsumura, 1912: 176, 177. Junior primary homonym of *Sphex rugosus* De Geer, 1773 (ichneumonid). Taiwan (Hokkaido University). [Synonymized with *Isodontia auripygata* by Sonan, 1931: 7, and with *Sphex sericeus* by Hensen, 1991: 22].

Sphex lineolus wegneri van der Vecht and Krombein, 1955: 39, ♂. Indonesia (RMNH). Synonymized with *Sphex sericeus* by Hensen, 1991:22.

Sphex sericeus nigrescens van der Vecht and Krombein, 1955: 39, ♀ Philippines (USNM). [Synonymized by Hensen, 1991: 22].

Sphex sericeus ferocior van der Vecht and Krombein, 1955: 40. Substitute name for *Sphex ferox* F. Smith. [Synonymized by Hensen, 1991: 22].

Sphex stueberii van der Vecht and Krombein, 1955: 42, ♀, Indonesia: (RMNH). [Synonymized by Hensen, 1991: 22].

Redescription

Female.

Measurements in mm

TBL=23.7; FWL=14.9; SW=3.7.

Colour: Black; mandible basal half, scape, pedicel, basal half of F1, clypeus except sides, median spot beneath antennal socket, pronotal lobe, pronotum except medially,

tegulae, subalar area, scutellum, metanotum, trochanter ventrally, femora, tibiae, foreleg tarsomere I-IV, mid and hindleg tarsomeres I-III and metasomal segments I-II orange red; wings brown; hairs golden.

Vestiture: Appressed hairs on clypeus, frons, pronotum posterior margin, scutum and scutellum laterally: clypeus, gena, pronotum, prosternum, mesopleura, propodeum, coxa and petiole with semi erect hairs; erect hairs on frons, vertex and scutum.

Sculpture: Clypeus punctate; frons, vertex coarsely punctate; scutum, scutellum punctate, interspaces micropunctate; propodeum enclosure transversely ridged, propodeum posteriorly rugose; tergites III-IV medially impunctate; Sternites II-V with scattered punctae; pygidium coarsely punctate; mesopleura and metapleura shiny.

Head: Head nearly as long as wide (5.3mm); ocellar area triangular, well defined; frontal line faintly impressed; POL: OOL = 0.6: 0.7; inner orbits converging towards clypeus, lower two-thirds parallel, UID :MID: LID = 2.3:2.8 :2.6; antennal sockets separated from fronto clypeal suture by the length of socket diameter; scape globose, 1.6x as long as wide; F1 0.8x as long as F2+F3(F2+F3 = 1.9mm); F1: F2:F3: F10 = 1.7: 1.1: 0.8: 0.5; clypeus convex, 0.7x as long as wide, with sub apical, transverse median carina; free margin arcuate, with median sharp defined notch (CL = 1.9mm, CW = 2.6mm); mandibles medially with two teeth.

Mesosoma: Pronotal margin postero-medially impressed; scutum with notauli, admedian lines and paradiscal lines; metanotum bi-tuberculate; propodeum 1.5x as long as scutum (propodeum = 4.2mm, scutum = 2.9mm); wings hyaline, forewing darker than hindwing; AV of SMC II as long as its BV(1.1mm) 4x as long as AV of SMC III(0.3mm); hind wing media diverging beyond cu-a at 0.14x as long as length of cu-a(cu-a = 0.8mm, M+Cu = 0.11mm); legs spinous; fore basitarsus with 9 rake spines, fore basitarsus 5x as long as wide; hind tibial spur 0.5x as long as hind basitarsus(HTS = 1.7mm, HBT = 3.2mm); claws basally with two teeth.

Metasoma: Metasoma 1.2x as long as Mesosoma (Metasoma = 10.6mm, Mesosoma = 8.9mm); petiole as long as hind coxa (1.5mm), 0.5x as long as hind tarsomeres II-IV combined (3.3mm); segment I as long as segment II (2.5mm).

Male

TBL=17.5; FWL=8.6; SW=4.

Colour: Black; metasomal segment I red brown, segment II black brown, rest of segments apically shining golden brown; hairs white; clypeus, frons with silver hairs; Metasoma with golden hairs.

Vestiture: Clypeus, frons with appressed hairs; upper frons, vertex with erect, hairs; clypeus, lower frons, propodeum, gena, pronotum, mesopleuron, coxa, trochanter, tibia ventrally and petiole with semi erect hairs; metasoma covered with fine, appressed hairs.

Sculpture: Clypeus micropunctate; frons, vertex, gena punctate; terga VII basally punctate; sterna VII shiny.

Head: 0.8x as long as wide (CL = 2.1mm, CW = 2.6mm); inner orbits converging above, UID:MID:LID = 1.0:1.1:0.9; POL:OOL = 0.2:0.3; antennae thirteen segmented; scape 1.7x and F1 4.7x as long as its apical width, F1 0.7x as long as F2+F3 (1.7mm), F1: F2: F3: F11 = 1.5: 1.2: 1.1: 0.6, F2-F11 with placoids; clypeus convex, as long as wide (1.54mm), free margin arcuate, medially emarginate; mandibles with single median tooth.

Mesosoma: Scutellum, metanotum bituberculate; propodeum 1.6x as long as scutum (propodeum = 1.9mm, scutum = 1.2mm); wings hyaline, infuscent at apex; AV of SMC II 1.5x as long as BV, 6x as long as AV of SMC III (AV of SMC II = 1.2mm, BV = 0.8, AV of SMC III = 0.2mm); hind wing media diverging beyond cu-a at 0.13x length of cu-a (M+Cu = 0.1mm, cu+a = 0.4mm); foretarsal rake absent; hind tibial spur 0.47x as long as hind basitarsus (HTS = 0.8mm, HBT = 1.7mm); tarsal claws with two teeth.

Metasoma: 1.1x as long as mesosoma (Metasoma = 8.1mm, Mesosoma = 7.7mm); petiole 0.5 x as long as hind tarsomeres II-IV combined (petiole = 1.4mm, hind tarsomeres II-IV = 2.7mm); relative length of segments I:II = 2.0:2.5; sternum VII apically emarginate.

Material examined: Plesiotype: 1♀, India: Kerala, Wayanad, Tholpetty 11°54'N 76°3'E. 19.iv.2012. Baaby Job..

Other material examined: 3♀, India: Kerala, Malappuram: Calicut University Campus 11°8'N 75°53'E. 05.viii.1980, V.V.S.Kumar; 1♀, India: Kerala, Kozhikode: Balussery 07.x.1998, Girish Kumar; 3♂, INDIA: Kerala, Thrissur, Chelakkottukara 10°39'N 76°21'E. 18.vii.2011. Baaby Job; 1♀, India: Kerala, Thiruvananthapuram: T.B.G.R.I. 8°34'N 76°50'E. 09.iii.2012. Simon George; 1♀, India: Kerala, Thrissur: Thumburmuzhi 10°29'N 76°46'E. 13.iv.2012. Baaby Job; 1♂, India: Kerala, Kollam: Thenmala 8°57'N 77°4'E. 02.v.2012. Simon George; 1♀, India: Kerala, Ernakulam: Koothattukulam 9° 51' N 76° 36' E. 28.v.2012. Simon George; 1♂, India: Kerala, Thrissur, Chelakkottukara 10°39'N, 76°21'E. 30.VI.2011. Baaby Job 1♀, India: Kerala, Kottayam: Bharanamganam 9° 42' N 76°43'E. 18.x.2012. Baaby Job

Distribution: Australia, China, Japan, Madagascar, Papua New Guinea, Philippines, SriLanka, South East Asia, Yemen, India [Sikkim, West Bengal, Meghalaya, Orissa, Karnataka, Kerala: Ernakulam, Kottayam, Kollam, Kozhikode, Malappuram, Palakkad, Thrissur, Thiruvananthapuram, Wayanad].

Biology: Nests are constructed in open areas, mass provisioned with slightly paralysed Orthoptera, mainly Gryllacrididae, Tettigoniidae and Gryllidae (Krombein, 1984). Eggs are laid close to cephalothoracic region. Cocoon consists of single layer of whitish silk; insect emerges from nest 30-35 days after hatching. These insects are subjected to high degree of parasitism mainly by phorid flies (cleptoparasites) and *Melittobia* sp. (Eulophidae) (Barthelemy, 2012).

Remarks: Since the available description of this species is inadequate for easy identification, a redescription is provided here.

This species occur in many colour forms and even the males and females are differently coloured; Males of this species have white hairs, black legs and gaster red and black, while females have golden hairs, orange red legs and gaster orange red and black (Bohart and Menke, 1976).

Sphex sericeus Dahlbom closely resembles *Sphex argentatus* Fabricius in having 1. Metanotum bituberculate; 2. Wings clear, hyaline and 3. Punctate sculpture of scutum and scutellum.

However *S.sericeus* differs from *S. argentatus* in having 1. Propodeal sculpture consisting of transverse ridges (propodeum with fine transverse striae in *S. argentatus*); 2. Medially notched clypeal free margin (clypeal free margin bilobed in *S. argentatus*) and 3. Colouration of body (body black in *S. argentatus*).

Genus *Isodontia* Patton

Isodontia Patton, 1880:380. Type species: *Isodontia philadelphica* (Lepeletier, 1845) [= *Sphex philadelphicus* Lepeletier, 1845], by original designation.

Leontosphex Arnold, 1945:90. Type species: *Sphex leoninus* de Saussure, 1890, by original designation.

Murrayella R. Bohart and Menke, 1963:137. Type species: *Sphex elegans* F. Smith, 1856, by original designation.

Diagnosis

Head: Male flagellomeres with flat or curved placoids, sometimes spiculate; clypeal free margin medially thickened or double edged, in females with median lobe or notch, bounded by two small lobes; surface of labrum plain in males, in females with median or lateral carina or apically with paired ridges extending backwards as short, narrow channel along midline; mandibles short, apically bi or tridentate or with subapical teeth; malar space absent or narrow.

Mesosoma: Pronotal collar thickened, separated from scutum or sharp edged, appressed

to scutum; propodeum with spiracular groove absent or visible only near hind coxa; basal vein of submarginal cell II equal to or shorter than anterior vein; anterior vein of submarginal cell III longer than or equal to posterobasal vein; outer surface of hindtibia nearly spineless; female foreleg usually without tarsal rake or represented by a single, slender seta on outer margin of tarsomere II; tarsomere I weakly asymmetrical; apico-ventral blade like setae of last tarsomere of mid and hind leg separated by setal width or less; claws arcuate, prehensile and teeth obliquely oriented.

Metasoma: Petiole length usually longer than combined length of tarsomeres II-IV; male tergum VIII with cerci; sterna of male with erect setae or transverse bands of appressed or suberect fimbriae; sternum VIII notched; penis valve ventrally with teeth, and basal process; volsella simple.

Distribution: Worldwide.

Biology: Non fossorial wasps; tubular nests are constructed in pre-existing cavities such as crevices, hollow plant stems, abandoned burrows etc., nests are partitioned using grass stems or blades, fibres, moss, wood bits etc. nests are provisioned with Gryllidae and Tettigoniidae; some species usually lay single larva per cell or construct single large brood cell with two- twelve larvae; eggs are laid ventrally on thorax of prey; these wasps are Cleptoparasitized by flies of the families Tachinidae, Sarcophagidae, Phoridae, Anthomyidae and Bombylidae and chalcid wasps, Pteromalidae and Eulophidae.

Remarks: Genus *Isodontia* Patton is similar to *Sphex* Linnaeus in having 1. Inner orbits curving towards vertex; 2. Inner hindtibial spur closely finely pectinate and 3. Length of basal vein of SMC II equal or shorter to anterior vein. However genus *Isodontia* differs from *Sphex* Linnaeus in 1. Complete spiracular groove being absent (in *Sphex* complete spiracular groove present); 2. Foretarsal rake absent or poorly developed in females (in *Sphex* fore tarsal rake well developed) and 3. Long and arcuate petiole (in *Sphex* petiole straight).

18. *Isodontia diodon* Kohl

(Fig 19a-b)

Sphex diodon Kohl, 1890:377, ♂, Indonesia: (NHMW) designated by Hensen, 1991:17.

Sphex maia Bingham, 1894:379, ♂, Burma (BMNH). [Synonymized by Bingham, 1897:249]

Redescription.

Female.

Measurements in mm

TBL=13.7; FWL=10.9; SW=2.2

Colour: Black; tergum I with basal red marking; tergites I-III with lateral and apical red brown reflections; wings brown; hairs silver, clypeus, lower frons, vertex, tibiae and coxa with brown hairs.

Vestiture: Clypeus, frons, mesopleuron and sides of propodeum with appressed silver hairs; pronotum, scutum, propodeum and petiole with erect hairs; clypeus, lower frons, vertex, coxa, tibia with erect, hairs; metanotum with fine appressed pubescence, segments IV-VI with semierect to erect hairs.

Sculpture: Frons, propodeum rugose punctate; scutum, scutellum, metanotum punctate; mesopleuron and metapleuron coarsely punctate.

Head: nearly as long as wide (3mm); inner orbits converging towards clypeus, emarginated above antennal sockets; UID: MID: LID = 1.5:1.8:1.2; POL: OOL = 0.37: 0.4; antennal sockets separated from frontoclypeal suture by 2x ASD (ASD = 1.5mm, AS-FC = 3mm); scape 1.7x and F1 5x as long as wide; F1 1.2x as long as F2; F1: F2 = 1.1:0.9; clypeus as wide as long (1.2mm), with basomedian carina; free margin sinuate, medially emarginate, with tooth like projections under orbits; mandibles slender, arcuate, apically bidentate and with sub apical teeth.

Mesosoma: Pronotum depressed below scutum; scutum with admedian lines, paradiscal lines and notuali faintly impressed; propodeum with posteromedian sulcus; wings hyaline; forewing with apical dark spot; AV of SMC II 1.4x as long as its BV (AV of SMC II = 0.7mm, BV of SMC II = AV of SMC III = 0.5mm); hind wing media diverging at cu-a; legs slender, claws with two teeth obliquely oriented; hind tibia with one outer spine; hind tarsomere IV 0.85x as wide as long; hind tibial spur 0.6x as long as hind basitarsus (HTS = 0.8mm, HBT = 1.3mm).

Metasoma: Oblong, tapering, 1.3x as long as Mesosoma (Metasoma = 5.7mm, mesosoma = 4.8mm); segment I as long as segment II (1.7 mm); petiole curved, 1.4x as long as hind tarsomere II-IV combined (petiole = 2.6mm, hind tarsomere II-IV = 1.4mm).

Material examined: Plesiotype: 1♀, INDIA: Kerala, Ernakulam, Koothattukulam, 9° 53' N, 76° 36' E. 04.v.2011. Baaby Job.

Distribution: China, Indonesia, Malaysia, Nepal, Thailand, India [Tamil Nadu, Kerala: Ernakulam, Kollam].

Biology: constructs multi cellular nests which are partitioned using plant pubescence; prey includes lightly paralyzed Blatellidae; eggs are laid lateroventrally, close to fore and mid coxae; each cell consists of four to nine prey per single larva per cell; egg hatches in two-three days; pupa consists of double layered cocoon, outer layering containing prey remnants and cell partitioning material (Barthelemy, 2010). *Amobia quatei* Kurahashi (Diptera: Sarcophagidae) is a known cleptoparasite of *I. diodon* (Krombein, 1991; O'Neill et al, 2007; Barthelemy, 2010).

Remarks: Since the available description of this species is inadequate for easy identification, a redescription is provided here.

Isodontia diodon Kohl closely resembles *Isodontia nigelloides* Strand in having 1. Similar body shape; 2. Dark spot on the apical margin of forewing and 3. Structure of clypeal freemargin; However *I. diodon* Kohl differs from *I. nigelloides* in having 1.

Metasomal tergite I with red coloration (in *I. nigelloides* metasoma black); 2. Petiole longer than hind tibiae (in *I. nigelloides* petiole shorter than hind tibia) and 3. Scutum punctuate (in *I. nigelloides* scutum coriaceous-punctate).

4.5. FAMILY CRABRONIDAE

This is the largest family of sphecoid wasps. They are dark coloured wasps, with metasoma sessile or petiolate. Their size ranges from 2mm-30mm. Most of them are fossorial; some are twig nesters (*Trypoxylon* Latreille). Prey upon spiders, Orthoptera, Hemiptera, Coleoptera, Diptera and even Hymenopteran adults.

Diagnosis

Inner orbits converging towards vertex; hindocelli normal (scar-like in Larrini); antennae situated low on face; AS contiguous with frontoclypeal suture; clypeus transverse; mandibles externally simple or notched, inner margin with subbasal teeth; mouth parts usually short; pronotal lobe separated from tegula; oblique scutal carina absent; episternal sulcus usually present; metapleuron represented by upper metapleural area only; midtibia with one apical spur; precoxal lobe present; propodeal enclosure present or absent; SMC varying from three to none, second recurrent vein received by SMC II; hind wing media usually diverging after cu-a; metasoma usually sessile, when petiolate, composed of tergum and sternum; terga I with lateral carina; pygidial plate present or absent; volsella simple, cerci absent.

Disribution: Worldwide.

Biology: Nesting habits are variable from ground nesting to nesting in pre-existing cavities to constructing tubular mud nests> Prey consists of wide range of insects from Orthoptera, Hemiptera, Thysanoptera, Lepidoptera; Diptera, Coleoptera, Hymenoptera, Collembola to Spiders.

4.5.1 Key to Subfamilies and Genera of Crabronidae in India

1. Forewing with three, two or one SMC's; SMC II sometimes petiolate; labrum hidden inside clypeus; forewing with pre-stigmal length less than half length of SMC I; midtibia with one apical spur.....**Subfamily Crabroninae**.....**2**
 - Forewing with three SMC's; SMC II not petiolate; labrum protruding outside; forewing with pre-stigmal length more than half length of SMC I midtibia with two apical spurs.....**Subfamily Bembicinae**
(Not dealt with this study)

2. Hind ocelli reduced to flat opaque scars (Fig 20a); jugal lobe of hindwing nearly as long as anal area.....**7**
 - Hind ocelli with convex, transparent lens; jugal lobe absent or never more than half length of anal area.....**3**

3. Inner orbits parallel or converging towards clypeus; hind femur thick at middle, gradually tapering towards apex.....**4**
 - Inner orbits emarginated (Fig 37a); hind femur not as above, broadened apically.....**6**

4. Fore wing with two SMC's (Fig 35e); SMC II petiolate; clypeal free margin laterally excised (Fig 35a); forewing marginal cell apically acuminate.....
.....Genus *Miscophus* jurine.....*Miscophus apoorvus* sp. nov.
 - Fore wing with three SMC's (Fig 32c); clypeal free margin laterally toothed or with median lobe; forewing marginal cell appendiculate.....**5**

5. Pronotal collar with three dorsal projections; SMC II trapezoidal; frons simple; metasomal segments I and II red.....
.....Genus *Solierella* Spinola.....*Solierella turneri* Dutt
 - Pronotal collar flat; SMC II triangular, petiolate; frons with V shaped carina; Metasoma black.....Genus *Lyroda* Say.....*Lyroda formosa* (F. Smith)

6. Fore wing with one SMC (Fig 37e); metasoma clavate, petiolate; antennal sockets separated from frontoclypeal suture.....Genus *Trypoxylon* Latreille
- Fore wing with three SMC's; metasoma sessile (Fig 39a); antennal sockets contiguous with frontoclypeal suture.....Genus *Pison* Jurine
.....*Pison punctifrons* Shuckard
7. Mid ocelli in deep transverse depression; hindocellar scars elliptic, long axes straight (Fig 30a); frons with M shaped swelling along inner orbits.....**10**
- Mid ocelli not in broad transverse depression; scars oblong, oval not elliptic, long axes forming angle of less than 145° (Fig 22a); frons without M shaped swelling.....**8**
8. Fore wing with two SMC's; occipital carina disappearing just before reaching hypostomal carina.....
.....Genus *Gastrosericus* Spinola.....*Gastrosericus siamensis* Tsuneki
- Fore wing with three SMC's; occipital carina joining hypostomal carina.....**9**
9. Ocellar scars long golf club, comma shaped, distance between midocellai and tail of scar less than the length of scar (Fig 21a); dense setae of pygidial plate silver or golden.....Genus *Tachytes* Panzer
- Ocellar scars oval, oblong, distance between midocellai and tail of scar equal to or greater than the length of scar, pygidial plate bare.....Genus *Tachysphex* Kohl
10. Propodeal side punctate, shiny, pronotal collar flat/arcuate in front view (Fig 34c).....Genus *Larra* Fabricius
- Propodeal side dull impunctate, pronotal collar wedge like (Fig 27c)
.....Genus *Liris* Fabricius

4.5.2 SUBFAMILY CRABRONINAE

Crabroninae Latreille, 1802a. Based on *Crabro* Fabricius, 1775 (stem: *Crabron-*)

The members of this subfamily show considerable diversity in colour, size and shape.

Adults may be robust and large to some representing the smallest forms among sphecids. They are known as ‘Silver mouth wasps’ or ‘digger wasps’.

Diagnosis

Head: Inner orbits entire or emarginated; hind ocelli normal except in Larrini and Palarini; antennal sockets low on face; scape never reaching above half length of flagellum; male with eleven- thirteen and female with twelve antennal segments; clypeus transverse; mandible externoventrally notched or simple, inner margin simple or with teeth; mandibular sockets closed or open.

Mesosoma: pronotal lobe separated from tegula; oblique scutal carina absent; episternal sulcus present; upper metapleural area defined; midtibia with one apical spur; claws usually simple; forewing with number of SMC’s variable; hindwing media usually diverging after cu-a.

Metasoma: Metasoma sessile to pedunculate; tergum I with lateral carina; pygidial plate present or absent; volsella simple; cerci absent.

Distribution: Worldwide.

Biology: Fossorial wasps, but some may nest in pre-existing cavities or construct nests. Prey includes mostly Diptera, Orthoptera, Coleoptera, Hymenoptera and even spiders (Bohart and Menke, 1976).

Genus *Gastrosericus* Spinola

Gastrosericus Spinola, 1839: 480. Type species: *Gastrosericus waltlii* Spinola, 1839, by monotypy. – As *Gasterosericus* (unjustified emendation or misspelling): Dahlbom, 1845: 467; Brauns, 1906:49, 51, 52.

Eparmatostethus Kohl, 1907: 167. Type species: *Eparmatostethus madecassus* Kohl, 1907, by monotypy. [Synonymized with *Gastrosericus* by Arnold, 1927: 116]. – As *Eparmostethus* (misspelling): Pate, 1937: 26, Bohart and Menke, 1976: 43.

Parallemopsis Maidl, 1914: 147. Type species: *Parallemopsis africana* Maidl, 1914 [= *Gastrosericus neavei* Turner, 1913], by original designation and monotypy. [Synonymized with *Gastrosericus* by Arnold, 1922: 114]. – As *Parallelopsis* (misspelling): Turner, 1916:258; Pate, 1937:47.

Dinetomorpha Gussakovskij, 1931: 451. Not available: type species not designated (Article 13.3 of the Code).

Gastrargyron Gussakovskij, 1931: 451. Not available: type species not designated (Article 13.3 of the Code).

Dinetomorpha Pate, 1937: 22, validation of *Dinetomorpha* Gussakovskij, 1931: 451, a subgenus of *Gastrosericus* (Article 13.1.2). Type species: *Gastrosericus flavicornis* Gussakovskij, 1931 [= *Gastrosericus electus* Nurse, 1903], designated by Pate, 1937:22. Validation of Gussakovskij's (1931: 451) name. [Synonymized with *Gastrosericus* by Bohart and Menke, 1976: 43].

Gastrargyron Pate, 1937: 28, validation of *Gastrargyron* Gussakovskij, 1931: 451, a subgenus of *Gastrosericus* (Article 13.1.2). Type species: *Gastrosericus marginalis* Gussakovskij, 1931, designated by Pate, 1937: 22. [Synonymized with *Gastrosericus* by Bohart and Menke, 1976: 43].

Diagnosis

Head: Inner orbits converging towards vertex or parallel; hindocellar scars narrow, forming angle of 130°-140°; frons with flattened elevation, separated from inner orbits by linear impression; frontal lines strongly impressed; clypeus flat, occasionally tuberculate or lamellate with freemargin arcuate, sinuate or with variably shaped median lobe and bearing lateral teeth; inner margin simple or dentate; gena in females with ventral tubercles.

Mesosoma: Pronotum depressed below scutum, propleuron with postero-lateral process; anterior end of subalar fossa with episternal sulcus, scrobal sulcus absent; forecoxae ventrally with tubercle or angulate process; male trochanter excavate postero-basally, fore femur simple; mid and hind tibia spinous, hind tibiae without carina; female fore tarsal rake present; inner claw of mid and hind tarsomeres shorter than outer claws; wings with two SMC's, both recurrent veins received by SMC II, jugal lobe present.

Metasoma: Tergum impunctate; tergum I with lateral carina; pygidial plate with lateral carina, surface in females either setose or glabrous and punctate; male sternum sometimes with fimbriae; volsella flat, apically triangular or with slender, spinose, hook like process; aedeagus head without teeth.

Distribution: Found in hot, dry regions of old world including Africa, Arabian Peninsula, India, Sri Lanka, Vietnam, Kazakhstan, Mongolia.

Biology: Nests are dug in sandy soil, prey consists of acrid nymphs, tridactylid crickets, adult cicadellids and asilids (Iwata and Yoshikawa, 1964; Arold, 1922; Pulawski, 1995).

Remarks: Genus *Gartosericus* Spinola appears to be an isolated genus among tribe Larrini (Bohart and Menke, 1976). Pulawski (1995) reported *Gastrosericus* to be the sister group of genus *Holotachysphex*, *Kohliella*, *Parapiagetia* and *Tachysphex*.

19. *Gastrosericus siamensis* Tsuneki.

Gastrosericus siamensis Tsuneki, 1974: 626, ♂. Thailand (Tadashi Tano coll., Fukui).

Gastrosericus binghami: Tsuneki, 1963:3. [Synonymized with *Gastrosericus siamensis* by Tsuneki, 1974: 626].

Gastrosericus menoni Sudheendrakumar and Narendran, 1985: 50, ♀. India. (ZSIWGRC). [Synonymized with *Gastrosericus siamensis* by Pulawski, 1995: 127].

Diagnosis

Female

Length 9-11mm. Black; basal half of mandibles, pronotal lobe apically, tegulae, dorsal band on tibiae pale yellow; tibiae and tarsomeres of all legs with brown shades; hairs silvery; clypeus, frons, pronotum, mesonotum, metanotum, propodeum, mesopleura, metapleura, legs with appressed hairs; vertex, pygidium sparsely pubescent; sternites III-IV with fimbriae; clypeus, frons, vertex, propodeal enclosure, metapleura microsculptured; pronotum, scutum, scutellum, metanotum, mesopleuron, sides and hindface of propodeum punctate; pygidium smooth, shiny with scattered punctae; F1 longer than F2; clypeal freemargin with median lobe and lateral teeth; inner mandibular margin with one subbasal tooth; wings clear, hyaline; both recurrent veins received by SMC II at common point.

Male: Unknown.

Material examined: No material examined. The above description of species is based on that given by Sudheendrakumar and Narendran, 1985.

Distribution: Thailand, SriLanka, India [Kerala: Kozhikode].

Biology: Unknown.

Remarks: *Gastrosericus siamensis* Tsuneki closely resembles *Gastrosericus rothneyi* Cameron in having 1. Metasoma black; 2. Head and mesosoma punctate; 3. Frons, clypeus with dense appressed hairs.

However, *G. siamensis* differs from *G. rothneyi* in 1. Propodeum microsculptured (in *G. rothneyi* propodeum transversly striate); 2. Pygidium smooth, shiny with scattered punctae (in *G. rothneyi* pygidium with dense pubescence); 3. hairs silver (in *G. rothneyi* hairs silvery with golden tinge).

Genus *Tachysphex* Kohl

Type species: *Tachysphex filicornis* Kohl, 1883 [= *Tachytes fugax* Radoszkowski, 1877], designated by Bingham, 1897: 192.

Schistosphex Arnold, 1922: 137. Type species: *Schistosphex breiferi* Arnold, 1922, [= *Tachysphex marshalli* R. Turner, 1917], by original designation and monotypy.

Atelosphex Arnold, 1923: 177. Type species: *Atelosphex miscophoides* Arnold, 1923, [= *Tachysphex brevipennis* Mercet, 1909], by original designation and monotypy

Diagnosis

Head: Hindocelli modified to oval or oblong scar, long axes forming an angle of 80° - 130°, each scar partly bordered by narrow translucent lens, scar length shorter than or equal to the distance between midocellus and lower end of scar; an oblong, glabrous swelling above each antennal socket; occipital carina joining hypostomal carina; frontal line present or absent; flagellomeres longer than broad; clypeus usually

convex, sometimes partially divided by paired vertical suture like lines into three sections, free margin with prominent median lobe, which may be arcuate, truncate or angular and variably toothed; inner mandible usually dentate, externoventral margin with deep notch.

Mesosoma: Episternal sulcus separated from postspiracular carina; scrobal sulcus usually absent; propodeum not elongate, spiracle separated from metanotum by less than its own length; male fore femur with shallow depression; fore tarsal rake well developed in females, male with or without fore tarsal rake; claws not dentate; hind tibia not ridged; fore wing with three nonpetiolate submarginal cells, forewing marginal cell apex narrowly truncate, jugal lobe of hind wing larger than anal cell.

Metasoma: Short, length of tergum I equal to apical width and laterally carinate; female tergum VI with flat, triangular, laterally carinate pygidial plate; male tergum VII usually flattened and sternum VIII apically bidentate or tridentate.

Distribution: Worldwide

Biology: Nests in sandy or sandy loam soil are constructed prior to prey provisioning. After choosing the nesting site, soil is scraped with mandibles and burrow dug with foretarsal rake. Prey includes nymphs as well as adults of Acrididae, Tettigoniidae, Gryllidae, Blattidea, Mantidae and Eumastacidae (Pulawski, 1971, 1988, 1994). Eggs are deposited ventrally, around fore coxae.

Remarks: In India this genus is represented by twenty two species.

Genus *Tachysphex* Kohl closely resembles genus *Tachytes* Panzer in having 1. hindocelli scar-like; 2. Occipital carina joining hypostomal carina; 3. Frons with swellings.

However, *Tachysphex* differs from *Tachytes* in 1. Hind ocellar scars oval, oblong (in *Tachytes* hindocellar scars golf-club shaped); 2. Length of scar greater than or equal to distance between midocellus and scar end (in *Tachytes* length of scar less than distance between midocellus and scar end); 3. Frons with paired glabrous tubercles above antennal sockets (absent in *Tachytes*).

Key to species of the genus *Tachysphex* Kohl in Kerala

1. Metasoma partly red; femora ventrally red; clypeal free margin sinuate, medially emarginated (Fig 23a, b); mouth parts elongated.....
.....*Tachysphex panzeri* (Vander Linden)
- Metasoma black; femora black; clypeal free margin variable; mouth parts not elongate.....2
2. Fore basitarsus apicolaterally expanded (Fig 21c); hind wing cu-a curved inwards; male sterna IV-VI shining.....*Tachysphex indicus* Pulawski
-Fore basitarsus apicolaterally not expanded; hind wing cu-a curving outwards; male sterna setose.....3
3. Clypeal free margin without median emargination; apical tarsomeres ventrally without spines.....4
- Clypeal free margin medially emarginated; apical tarsomeres ventrally with cluster of minute spines.....5
4. Clypeal free margin sinuate in females, in males with arcuate median lobe (Fig 22a, b); tergites I-III with silver fasciae; fore basitarsus with five rake spines; in males with four preapical spines.....*Tachysphex morosus* (F. Smith)
- Clypeal free margin in females arcuate with two lateral incisions on each side, in males free margin arcuate with prominent corners; tergites I-IV with silver fasciae; fore basitarsus with eight to ten rake spines; in male fore basitarsus without preapical spines.....*Tachysphex gryllivorus* Pulawski
5. Tarsomere V swollen with minute spines ventrally and on lateral margins; vertex 0.9-1.0x as wide as long; F1 in males 1.6x as long as its apical width; tergites I-IV with silver fasciae.....*Tachysphex changi* Tsuneki
- Tarsomere V not swollen, ventrally with median cluster of spines; vertex 1.2x as wide as long; F1 in males 1.7x as long as its apical width; tergites I-III with silver fasciae.....*Tachysphex bengalensis* Cameron

20. *Tachysphex bengalensis* Cameron

(Fig 20a-f; Plate 11a)

Tachysphex bengalensis Cameron, 1889: 144, India (OXUM), designated by Pulawski, 1975:311.

Tachysphex brevitarsis Kohl, 1901a: 783, ♀. Sri Lanka (NHMW). [Synonymized with *Tachysphex bengalensis* by Pulawski, 1975: 311].

Redescription.

Female.

Measurements in mm

TBL=7.7; FWL= 5.6; SW=1.9.

Colour: Black; tegula yellow brown; hairs silver; tergites I-III with apical silver fasciae.

Vestiture: Clypeus, frons and propodeum dorsally with semierect hairs; hairs erect on vertex; hairs sinuous on scutum, mesopleuron, propodeum hind face and femora ventrally; tergites I-IV sparsely pubescent.

Sculpture: Punctae on the clypeus bevel larger than on the basomedian area; frons, vertex, scutum and scutellum punctate; propodeum dorsally rugose, sides and hind face striate; pygidium coarsely punctate.

Head: Head 0.8x as long as wide (HL = 2.3mm, HW = 2.8mm); vertex with 'Y' shaped depression, 1.2x as wide as long; ocellar area bituberculate, traversed with median longitudinal line originating from mid ocelli; frontal line finely impressed; inner orbits converging towards the vertex, UID: MID: LID= 0.6: 1.4: 1.4; antennal sockets contiguous with fronto-clypeal suture; ASD 3x midocelli diameter (ASD = 0.2mm, MOD = 0.06mm); scape and F1 2.5x as long as its width, F1: F2: F3: F10 = 0.34: 0.34: 0.27: 0.27; clypeus 0.2x as long as wide (CL = 0.3mm, CW = 1.4mm),

free margin medially emarginate, with two lateral incisions on each side; mandibles medially bidentate.

Mesosoma: Admedian lines, notuali and paradiscal lines finely impressed on the scutum; posterior margin of scutum separated from scutellum; metanotum medially notched; propodeum 0.5x as long as scutum (propodeum = 0.7mm, scutum = 1.5mm); hindface with median depression, traversed by longitudinal line; wings hyaline, AV of SMC II 1.4x as AV of SMC III (AV of SMC II = 0.27mm, AV of SMC III = 0.2mm), marginal cell apex narrowly truncate, hind wing media diverging beyond cu-a at a distance equal to the length of cu-a (0.13mm); legs with fore tarsal rake well developed, fore basitarsus with ten rake spines, T IV small compared with the rest of the tarsomeres, tarsal claws unequal, hind tibial spur 0.6x hind basitarsus (HTS = 0.5mm, HBT = 0.8mm).

Metasoma: as long as mesosoma (3.4mm); relative length of segments I:II = 1.5:0.89; pygidium 1.25x as long as its basal width, laterally carinate.

Male

TBL = 8.3; FWL = 6.2; SW = 1.9

Colour: Black; mandibles medially and scape ventro-apically red; tegulae semitransparent brown; sternites II-VIII and tergites IV-VII with coppery lusture; wings pale brown; hairs pale golden; tergites I-IV with silvery fasciae.

Vestiture: Clypeus with appressed hairs; frons, scutum, scutellum, metanotum, propodeum with semierect hairs; fore and midfemora with sinuous hairs; metasoma with fine appressed hairs.

Sculpture: Clypeus coarsely punctate; frons rugose-punctate; ocellar area, vertex punctate, scutum, scutellum, tergum VII, sternites III-IV and metapleuron punctae, much closer near margins; propodeum dorsally rugose; propodeum sides and hindface striate with rugose interspaces.

Head: 0.7x as long as wide (HL = 2.3mm, HW = 3.1mm); vertex with Y shaped depression, 1.27x as long as wide; ocellar bituberculate; frontal carina visible above antennal sockets; inner orbits converging towards vertex, UID: MID: LID = 0.6:1.5:1.6; antennal sockets contiguous with fronto-clypeal suture; antennae thirteen segmented, scape 2.8x and F1 1.8x as long as its apical width; F1 0.4x as long as F2+F3 (F2+F3 = 0.74mm); F1: F2: F3: F11 = 0.3: 0.36: 0.38: 0.16; clypeus 0.3x as long as wide (CL = 0.5mm, CW = 1.6mm), free margin arcuate, distance between corner of median lobe 0.8x distance between corner and orbit; mandibles apically pointed, with two teeth.

Mesosoma: Scutum with admedian lines and paradiscal finely impressed; notauli absent; scutellum elevated; propodeum 0.5x as long as scutum (propodeum = 0.8mm, scutum = 1.5mm), hindface with median longitudinal furrow; wings hyaline, forewing marginal cell apically rounded; AV of SMC II 1.6x as long as AV of SMC III (AV of SMC II = 0.4mm, AV of SMC III = 0.25mm); forefemoral notch glabrous, foretarsal rake absent; hind tibial spur as long as hind basitarsus (HBT = HTS = 0.8mm)

Metasoma: 1.3x as long as mesosoma (Metasoma = 4.4mm, Mesosoma = 3.4mm); relative length of segments I:II = 1.4:1.0; tergum I with lateral carina; sternum I apically with longitudinal carina; sterna VIII emarginate.

Material examined: Plesiotype: 1♀, India: Kerala, Ernakulam, Aluva 10°6'N, 70°21'E. 16. iii. 2012. Preisty John.

Other material examined: 1 ♀, India: Kerala, Ernakulam, Aluva 10°6'N, 70°21'E. 16. iii.2012. Baaby Job; 2♂ India: Kerala, Kollam: Kolathupuzha 8°9'N 77° 05'E. 03.v.2012. Baaby Job; 1♂, India: Kerala, Kollam: Kolathupuzha 8°9'N 77° 05'E. 03.v. 2012. Simon George.

Distribution: China, SriLanka, India [Bihar, Maharashtra, TamilNadu, UttarPradesh, Kerala: Ernakulam , Kollam].

Biology: Nests in soil; collected from sandy soil.

Remarks: Since the available description of this species is inadequate for easy identification, a redescription is provided here.

Tachysphex bengalensis Cameron closely resembles *Tachysphex macakayensis* R. Turner in having 1. Hairs sinuous on head and mesothorax; 2. Labrum flat, apically emarginated; 3. Forebasitarsus with eight rake spines.

However, *T. bengalensis* differs from *T. mackayensis* in 1. Mesopleural punctae large, distinct (in *T. mackayensis* mesopleuron punctae indistinct, small); 2. Tarsomere V in male apico-ventrally with cluster of spines (in *T. mackayensis* tarsomere V apico-ventrally with one –two spines; 3. Propodeum irregularly rugose (in *T. mackayensis* propodeum rugose-punctate).

21. *Tachysphex changi* Tsuneki

Tachysphex changi Tsuneki, 1967b:53, ♂. Taiwan (USNM).

Tachysphex nambui Tsuneki, 1973:5, ♀. Ryukyu Islands (T. Nambu coll.).
[Synonymized with *Tachysphex changi* by Tsuneki, 1983a:60].

Tachysphex changi luzonicus Tsuneki, 1983a:60, ♂. Philippines (K. Tsuneki coll.).

Diagnosis:

Female

Length 7.0-9.5mm. Black; frons with silver pubescence; vertex, scutum with semierect hairs; mid femora ventrally with erect hairs; propodeum with erect to semierect hairs; tergites I-IV apically with silver fasciae; scutum, mesopleuron, fore femur ventrally punctate; propodeum longitudinally rugose; vertex 1x as wide as long; clypeal free margin medially emarginate with two lateral incisions; F1 2.0-2.7x as long as its apical width; wings infumate; fore basitarsus with nine –twelve rake spines; tarsomere ventro-medially with cluster of spines.

Male

Length 6.0-7.5mm. Black; frons with silver pubescence having golden tinge; vertex, scutum with semierect hairs; mid femora ventrally with erect hairs; propodeum with

erect to semierect hairs; tergites I-IV apically with silver fasciae; sternites III-V with sparse semierect hairs; scutum, mesopleuron, fore femur ventrally, sternites III-V punctate; propodeum longitudinally rugose; pygidium sparsely punctate; vertex 0.8-1.0x as wide as long; F1 1.6x as long as its apical width, 0.7x as long as F2; clypeal free margin arcuate; tarsomere V ventrally swollen with spines; volsella with hairs, penis valve head with teeth.

Material examined: No material examined. The above description of species is based on that by Krombein and Pulawski, 1994.

Distribution: Japan, South East Asia, SriLanka, India [Kerala: Palakkad].

Biology: Unknown.

Remarks: *Tachysphex changi* Pulawski closely resembles *Tachysphex drymobius* Pulawski in having 1. Mesopleuron punctate; 2. Vertex, Mesosoma and gena along hypostomal carina with erect hairs; 3. Apico-ventral margin of tarsomere IV with lobe.

However, *T. changi* differs from *T. drymobius* in 1. Tergum IV with silvery fasciae (in *T. drymobius* silver fasciae on tergum IV absent); 2. T5 swollen in males, ventrally with minute spines (in *T. drymobius* T 5 not swollen); 3. Mesopleural punctures at centre have scattered distribution (in *T. drymobius* mesopleural punctures are much closer).

This species has been recorded from Walayar forests, Kerala.

22. *Tachysphex gryllivorus* Pulawski

Tachysphex gryllivorus Pulawski in Krombein and Pulawski, 1994:34, ♀. Sri Lanka (USNM).

Diagnosis

Female

Length: 9.0-10mm. Black; mandibles medially red; tegula brown; tergites I-IV apically with silver fasciae; vertex, hypostomal carina with erect setae; scutum, propodeum with semierect hairs; mesopleuron shiny, punctate; propodeum rugose or ridged, sides punctate, with anterior and posterior ridges; forefemur ventrally shiny, punctate; pygidium punctate; vertex 1.1x as wide as long; labrum with indistinct notch; clypeal free margin arcuate, with two lateral incisions on each side; F1 1.4x as long as its apical width, 0.7x as long as F2; foretibia outer surface without spines, mid tarsomere II 1.6x as long as apical width, TIV as long as wide, TV stout, ventrally with single pre apical seta; sternum I apically with median longitudinal carina; pygidium apically emarginate.

Male

Length: 7.0-9.5mm. Black; mandibles medially, scape except baso-dorsally yellow-red, femora, tibiae and tarsomeres apically ferruginous; hairs on frons, clypeus golden; tergites I-IV apically with silver fasciae; scutum, propodeum, sternites II-IV with semierect setae; propodeum rugose or ridged, sides punctate; scutum, fore femoral notch, sternites II-VII punctate; clypeal margin arcuate with corners prominent than in females; F1 1.2x as long as its apical width, 0.6x as long as F2; fore femoral notch with longitudinal swelling; preapical spines absent on outer margin of forebasitarsus; penis valve head ventrally with teeth.

Material examined: No material examined. The above description of species is based on that by Krombein and Pulawski, 1994.

Distribution: SriLanka, Nepal, India [Kerala: Palakkad]

Biology: Nests in sandy loam soil; during digging, the wasp spreads removed soil grains, in heaps around the entrance of burrow ; nests are vertical, 25-60 mm deep and contains one-three cells; preys consists of small nymphs of *Teleogryllus* sp. and

Gymnogryllus sp. (Gryllidae), paralysis is temporary, eggs are loosely attached between fore and mid coxae (Krombein and Pulawski, 1994).

Remarks: *Tachysphex gryllivorus* Pulawski closely resembles *Tachysphex haematopus* Pulawski in having 1. Metasoma black; 2. Pygidial plate shiny, punctate; 3. Fore tarsal rake absent in males; 4. Sternites III-V with hairs in males.

However, *T. gryllivorus* differs from *T. haematopus* in 1. Femora black (in *T. haematopus* femora red); 2. Male clypeal freemargin arcuate with corners not prominent (in *T. haematopus* male clypeal free margin sinuate with prominent corners); 3. Mandible externo-ventrally with notch not so deep (in *T. haematopus* externo-ventral mandibular notch deeply set).

This species was recorded from Walayar forests, Kerala.

23. *Tachysphex indicus* Pulawski
(Fig 21a-e; Plate 11b)

Tachysphex indicus Pulawski in Krombein and Pulawski, 1994: 74, ♀ India (CAS)

Redescription.

Male

Measurements in mm

TBL=11.6; FWL= 9; SW= 2.7.

Colour: Dull black; mandibles mesally red; tarsomeres apically brownish, eyes yellowish brown; wings basally yellow; tegula light brown; hairs pale golden, frons with black hairs; tergites I-IV apically with silvery fasciae.

Vestiture: Clypeus posteriorly with dense, appressed hairs; vertex, scape ventrally, gena, scutum anterolaterally, scutellum laterally, propodeum and forecoxa ventrally with sinuous hairs; tergum I with appressed hairs.

Sculpture: Frons, vertex and scutellum punctate with interspaces micropunctate; clypeus basomedially, terga VII apically punctate; scutum with punctate compressed

against each other on posterior margin; mesopleuron and metanotum finely rugose; propodeum dorsally rugose, hind face anteriorly rugose to transversly striate; sternites II-V with scattered punctae, sternum IV-VI glabrous.

Head: 0.5x as long as wide (HL = 2.8mm, Hw = 5.6mm); vertex with glabrous broad 'V' shaped depression and weak longitudinal line; vertex 0.83x as wide as long; ocellar area bituberculate; frontal line absent; inner orbits converging towards the vertex, UID: MID: LID = 0.72: 1.72: 1.6; ASD 3x as MOD (ASD = 0.3mm, MOD = 0.1mm); AS contiguous with frontoclypeal suture; antennae thirteen segmented, scape 2.2x and FI 2x as long as its apical width; F1: F2: F3: F11 = 0.42: 0.36: 0.36: 0.26; clypeus 0.5x as long as wide (CL = 0.8mm, CW = 1.7mm), bevel convex, free margin arcuate; labrum convex protruding beyond the clypeal margin, galea 0.77x as long as its basal width.

Mesosoma: Pronotum depressed; scutum with admedian lines, paradiscal lines finely impressed, notauli absent; scutellum elevated; episternal sulcus, scrobe present; propodeum 0.7x as long as scutum (propodeum = 1.4mm, scutum = 2.1mm), hind face basomedially with a 'V' shaped depression; wings hyaline, fore wing marginal cell apically rounded, AV of SMC II and III equal (0.34mm), hind wing media diverging beyond cu-a at a distance 0.2x the length of cu-a (cu+a = 0.34mm, M=Cu = 0.07mm); jugal lobe covering half the length of hind wing; foretarsal rake well developed, fore tarsomeres I-II apicolaterally expanded, with 7 and 3 rake spines, T III-T IV with two rake spines, fore femoral notch shallow; hind coxa not carinate dorsally, hind tibial spur 0.6x as long as hind basitarsus (HBT = 0.7mm, HTS = 1.2mm).

Metasoma: Metasoma as long as mesosoma (4.3mm); relative length of segments I:II = 2.9:1.9; apex of S I without longitudinal carina, S VIII apically emarginate.

Female

Length 9.5-10.5mm; labrum not emarginated; vertex 0.8-1x as wide as long; clypeal free margin arcuate with two lateral incisions; fore tibia with outer spines; T IV as

long as wide; pygidial plate with punctae; tergites I-IV with silvery fasciae (Krombein and Pulawski, 1994).

Material examined: Plesiotype: 1♂, India, Kerala, Wayanad: Kuzhinilam. 11°49'N 75°58'E. 20. iv.2012. Baaby Job.

Other material examined: 1♂, India, Kerala, Palakkad: Malampuzha 10°49'N 76°41' E. 17.iii.2011, Baaby Job.

Distributon: Africa, Israel, Jordan, Syria, Yemen, Tajikistan, Turkmenistan, Uzbekistan, Pakistan and India [Gujarat, Kerala: Palakkad, Wayanad].

Biology: Nests in sandy areas, contain three to five cells; the entrance is temporarily closed during provisioning with mantids, when provisioning is completed the burrow is filled with soil, thus giving burrow a characteristic mound; The female malaxates the mantid after stinging and drinks the fluid pouring from prey's mouth and then flown to nest with head first; one to seven prey deposited per cell and egg deposite on prey's throat, next to its legs (Ferton 1912, Bristowe 1925, Gess 1981, Asis et.al 1989)

Remarks: Since the available description of this species is inadequate for easy identification, a redescription is provided here.

Tachysphex indicus is similar to *Tachysphex albocinctus* Pulawski in 1. Clypeal free margin arcuate; 2. Forebasitarsus apicolaterally expanded; 3. Male sterna IV-VI glabrous and 4. Presence of foretarsal rake.

But *T. indicus* differs from *T. albocinctus* in having 1.tergal setae appressed (the tergal setae long and suberect in *T. albocinctus*); 2. Subcoastal vein brown (in *T. albocinctus* black subcostal vein) and 3. Tarsal apex black (tarsal apex reddish in *T. albocinctus*). This species was first reported by Krombein and Pulawski, 1994 from Walayar forests, Kerala.

24. *Tachysphex morosus* (F. Smith)
(Fig 22a-g; Plate 11c)

Tachytes morosus F. Smith, 1858b: 18, ♀. Indonesia: Sulawesi (BMNH).

Tachysphex morosus (F. Smith): R. Bohart and Menke, 1976: 275, new combination for *Tachytes morosus* F. Smith.

Tachysphex tinctipennis Cameron, 1904f: 301, ♀. India: Assam (OXUM). [Synonymized with *Tachysphex morosus* by Pulawski in Krombein and Pulawski, 1994: 24]

Tachysphex lihyuetanus Tsuneki, 1971: 15, ♂. Taiwan (USNM). [Synonymized with *Tachysphex tinctipennis* by Tsuneki, 1983a: 64]

Redescription.

Male .

Measurements in mm.

TBL= 8.1; FWL=6.1; SW=1.3.

Colour: Black; mandibles medially dark brown; sternites apically with brown reflections; hairs silver; tergites I-III with apical silvery fasciae.

Vestiture: Dense, appressed hairs on clypeus laterally and frons; erect hairs on upper frons and vertex; hairs inclined posterad on scutum, mesopleuron and propodeum hind face; hairs inclined anterad on propodeum dorsum; sinuous hairs on fore and mid femora ventrally.

Sculpture: Body shining; clypeus, frons coarsely punctate; vertex; punctae on scutum and scutellum more close near the margins; propodeum dorsally rugose, sides striate and hind face irregularly striate; tergites VII-VIII minutely punctate.

Head: 0.8x as long as wide (HL = 1.8mm, HW = 2.4mm); vertex 1.3 x as wide as long, with 'Y' shaped depression; ocellar area bituberculate; frontal line finely impressed; inner orbits converging towards the vertex, UID: MID: LID = 0.75: 1.3: 1.93; antennal sockets contiguous with fronto-clypeal suture; ASD 1.7 x as MOD (ASD = 0.15mm, MOD = 0.09mm); antennae thirteen segmented, scape as long as its apical width (0.27mm), length of F1 1.5x as its apical width; F1 0.4x as long as F2+F3 (F2+F3 = 0.47mm); F1: F2: F3: F11 = 0.2: 0.2: 0.27: 0.24; clypeus 0.13x as

long as wide (CL = 0.2mm, CW = 1.5mm), free margin lobe with the corners prominent, sinuate, distance between lobe corner and orbit 0.7x distance between the lobe corners; inner mandibular margin with single teeth.

Mesosoma: Admedian and paradiscal lines on scutum finely impressed, notuali absent; episternal sulcus complete, crenulate; scutellum elevated slightly; propodeum 0.8x as long as scutum (propodeum = 1mm, scutum = 1.2mm), dorsally rounded, furrow on the basal half of the hind face; wings hyaline, slightly infumate; marginal cell apex truncate, AV of SMC II 1.5 x as AV of SMC III (AV of SMC II = 0.3mm, AV of SMC III = 0.2mm); hind wing media diverging beyond cu-a at a distance equal to the length of cu-a (0.14mm); legs with foretarsal rake, fore basi tarsus with five rake spines, apical rake spine of T II as long as T III, forefemoral notch shiny, edges well defined; T IV shallowly emarginate; hind tibial spur 0.85 x as hind basitarsus (HTS = 0.6mm, HBT = 0.7mm), hind coxa dorsally carinate, hind leg arolium 0.33x as long as hind tarsomere V; tarsal claws equal.

Metasoma: Nearly as long as mesosoma (3.5mm); relative length of segments I:II = 0.9: 0.8; apex of terga VII broadly rounded, sternum VIII trispinose.

Female

TBL = 9.4; FWL = 7.0; SW = 1.7

Colour: Black; wings with brown shades; tegulae semitransparent brown; hairs silver with golden tinge; tergites I-III with apical silvery fasciae.

Vestiture: Sides of frons and clypeus with appressed hairs; erect setae on vertex, scutum sides, mesopleuron, propodeum dorsally, fore and midfemur ventrally; propodeum hindface with semierect hairs.

Sculpture: Clypeus coarsely punctate; upper frons rugose punctate; vertex, scutum, scutellum, metanotum punctate; mesopleuron shiny, punctate; propodeum longitudinally rugose, sides and hindface striate; sternites II-V with scattered punctae,

medially glabrous; pygidium dorsally with scattered punctae, ventrally punctate on apical half.

Head: 0.8x as long as wide (HL = 2.2mm, HW = 2.8mm); vertex 1.5x as wide as long, with triangular glabrous depression; frontal line weak; clypeal freemargin arcuate; antennae twelve segmented, F1 0.4x as long as F2+F3 (F2+F3 = 1.1mm); F1: F2: F3: F10 = 0.4: 0.5: 0.6: 0.3; clypeal freemargin arcuate.

Mesosoma: Propodeum rugose, sides striate; forewing marginal cell apically obliquely truncate; forebasitarsus with seven rake spines; apical spines of tarsomeres II and III longer than succeeding tarsomeres; hind tibial spur 0.7 x as hind basitarsus (HTS = 0.5mm, HBT = 0.7mm).

Metasoma: nearly as long as mesosoma (4.2mm); relative length of segments I:II = 1.4: 0.8; pygidium laterally carinate.

Material examined: Plesiotype: 1♂, India: Kerala, Wayanad: Kuzhinilam 11°49'N 75°58'E. 21.iv.2012. Baaby Job

Other material examined: . 1♀, India: Kerala,Wayanad: Kuzhinilam 11°49'N 75°58'E. 21.iv.2012. Baaby Job; 1♀ India: Kerala, Pathanamthitta: Perumthuruthy 9°41'N, 76°55'E. 23.v.2012, Baaby Job.

Distribution: SriLanka, Nepal, China, Fiji, Hawaii, Papua New Guinea, Pacific ocean Islands, South East Asia, India [Assam, Bihar, Karnataka, TamilNadu, Kerala: Palakkad, Wayanad, Pathanamthitta].

Biology: Collected from shady area; nests in sandy soil; prey include Acrididae nymphs; prey paralysed temporarily (Krombein and Pulawski, 1994); prey's antennae is clasped using mandibles and carried with ventral side up; eggs are placed between the mid and hind coxae. (Iwata, 1964).

Remarks: Krombein and Pulawski,1994 reported this species from Walayar forests, Kerala.

Since the available description of this species is inadequate for easy identification, a redescription is provided here.

Tachysphex morosus (F. Smith) closely resembles *Tachysphex nigricolor* Dalla Torre in having 1. Mesopleuron shiny, punctate; 2. Hairs erect on scutum, vertex and midfemora ventrally; 3. Legs and metasoma black.

However, *T. morosus* differs from *T. nigricolor* in 1. Male fore basitarsus with rake spines (in *T. nigricolor* foretarsal rake absent in males); 2. Apical spine on tarsomere II longer than tarsomere III (in *T. nigricolor* apical spine on tarsomere II shorter than tarsomere III); 3. Freemargin of clypeal lobe in same plane as rest of clypeus (in *T. nigricolor* free margin bent toward back of head and separated from rest of clypeus).

25. *Tachysphex panzeri* (Vander Linden)
(Fig 23a-e; Plate 11d)

Tachytes panzeri Vander Linden, 1829: 22, ♂, Spain (RMNH) designated by Pulawski, 1971: 262.

Lyrops rufiventris Spinola, 1839: 479, ♀. France (RMNH) [Synonymized with *Tachytes panzeri* by A. Costa, 1884: 246].

Larrada rufiventris (Spinola): F. Smith, 1856: 280, new combination for *Lyrops rufiventris*.

Tachytes rufiventris (Spinola): A. Costa, 1867: 87, new combination for *Lyrops rufiventris* Spinola.

Lyrops haemorrhoea Spinola, 1843: XXXVI, sex not indicated, origin unknown (Berlin Museum)

Tachytes oraniensis Lepeletier de Saint Fargeau, 1845: 253, ♀, (misspelled as *Oraniensis* by Lepeletier). Algeria (MNHN). [Synonymized with *Tachysphex panzeri* by Kohl, 1884: 368]

Tachytes aurifrons Lucas, 1849: 246, ♀. Algeria (MNHN). [Synonymized with *Tachysphex panzeri* by Kohl, 1884:368 (tentatively) and by de Beaumont, 1947: 662 (definitely)].

Tachytes discolor Frivaldszky, 1877: 351, ♂. Hungary (TMB), designated by Pulawski in Krombein and Pulawski, 1994:63. [Synonymized with *Tachysphex panzeri* by Kohl, 1883: 226.]

Tachytes pulverosus Radoszkowski, 1886: 32, ♀, Uzbekistan (Kraków), designated by de Beaumont, 1936: 610 [Synonymized with *Tachysphex panzeri* by Pulawski in Krombein and Pulawski, 1994: 63]

Tachytes ceylonicus Cameron, 1900b: 21, ♂ (misspelled as *ceylonica* by Cameron). Sri Lanka (OXUM). [Synonymized with *Tachysphex panzeri* by Pulawski, 1975: 312].

Tachytes aurifrons Cameron, 1900b: 23, ♂, junior primary homonym of *Tachytes aurifrons* Lucas, 1849. Sri Lanka (BMNH), designated by Pulawski, 1975: 312. [Synonymized with *Tachysphex panzeri* by Pulawski, 1975: 312].

Tachysphex ablatius Nurse, 1909: 516, ♀. India (BMNH), designated by Pulawski, 1975: 312. [Synonymized with *Tachysphex panzeri pulverosus* by Pulawski, 1975: 312].

Tachysphex auriceps: Giner Mari, 1945b: 856 India (MNCN), corrected to *Tachysphex panzeri* by Krombein and Pulawski, 1994: 63.

Tachysphex panzeri fortunatus de Beaumont, 1968: 261, ♀. Canary Islands: (BMNH). [Synonymized with *Tachysphex panzeri* by Pulawski in Krombein and Pulawski, 1994: 63].

Tachysphex panzeri cyprius Pulawski, 1971: 272, ♀, Cyprus (W.J. Pulawski coll.). [Synonymized with *Tachysphex panzeri* by Pulawski in Krombein and Pulawski, 1994: 63].

Tachysphex panzeri sareptanus Pulawski, 1971: 272, ♀, Russia (ZIN). [Synonymized with *Tachysphex panzeri* by Pulawski in Krombein and Pulawski, 1994: 63].

Redescription

Female

Measurements in mm

TBL=12.2; FWL=7.47; SW=2.7.

Colour: Black; mandibles except apically, scape ventrally, femora ventrally, tibiae, tarsi, basal and apical gastral segments (I-III & VI) red; clypeal bevel yellow, labrum and tegula yellowish brown; wings light brown; gastral segment IV black, V

brownish-black; hairs silver, pygidium laterally with brown setae; tergites I-IV apically with silvery fasciae.

Vestiture: Clypeus basally, lower frons, gena, antennae, propleura, scutum lateral margin, mesopleuron and propodeum laterally with appressed hairs; sternites shiny; pygidium laterally with erect brown setae.

Sculpture: Basal half of the clypeus and gena minutely punctate; frons and vertex coarsely and contiguously punctate; scutum and scutellum punctate; propodeum dorsally and laterally uniformly micro sculptured, hind face with broad transverse striae; sternites II-V and terga V laterally micropunctate; pygidium coarsely punctate.

Head: 0.9x as long as wide (HL = 4mm, HW = 4.4mm); vertex with broad 'U' shaped depression 0.7x as wide as long; ocellar area bituberculate, mid ocelli with posterior line towards vertex; frontal line finely impressed; inner orbits converging towards the vertex, UID: MID: LID = 0.7: 2: 2.1; antennae twelve segmented, scape as long as F1(0.5mm); scape 2x and F1 2.4x as long as its apical width; F1: F2: F3: F10 = 0.5: 0.54: 0.54 :0.3, clypeus 0.4x as long as wide (CL = 0.8mm, CW = 2mm), free margin sinuate, medially emarginate; mandible apically blunt, with two teeth; labrum convex, protruding beyond the clypeus; mouth parts elongate; galea 0.8x as long as scape.

Mesosoma: Pronotum depressed beneath the level of scutum; admedian lines, notuali and paradiscal lines on the scutum finely impressed; scutellum raised above the rest of the thorax; propodeum 0.4x as long as scutum (propodeum = 0.8mm, scutum = 1.9mm), hind face basally with a depression; wings hyaline, fore wing marginal cell narrowly truncate obliquely; AV of SMCII 0.7x as long as AV of SMC III (AV of SMC II = 0.2mm, AV of SMC III = 0.3mm); hind wing media diverging beyond cu-a at distance 0.28x the length of cu-a (cu-a = 0.7mm, M+Cu = 0.2mm); fore tarsal rake well developed, outer margin of forebasitarsus with seven, tarsomere II with four and tarsomere III with two rake spines, apical spines being longer than the following article; T IV emarginate; hind tibial spur 0.7x as long as hind basitarsus (HTS = 0.8mm, HBT = 1.1mm).

Metasoma: Metasoma as long as mesosoma (5.2mm); relative length of segments I:II = 1.4: 1.2; sternum I without apical longitudinal carina; pygidium 0.7x as long as its basal width, laterally carinate.

Male

Length 6.5-10.0mm; Black; mandibles except apically, scape ventrally, femora ventrally, tibiae, tarsi, basal and apical gastral segments (I-III & VI) red; clypeal bevel yellow, labrum and tegula yellowish brown; wings light brown; frons with golden hairs; clypeal freemargin arcuate, medially emarginate; F1 1.5-2.3x as long as its apical width; forefemoral notch shallow, covered with fine setae; forebasitarsus with three to five spines; apical spine of tarsomeres II longer than tarsomere III; sternites punctuate (Krombein and Pulawski, 1994).

Material examined: Plesiotype: 1♀ India: Kerala, Wayanad: Ambalavayal, 11°61' N 76°21' E. 22.iv.2012. Baaby Job.

Other material examined: 2 ♀, India: Kerala, Ernakulam, Aluva 10°6'N, 70°21'E. 16. iii.2012. Baaby Job;

Distribution: Pakistan, SriLanka, Thailand, North Europe, North Africa, Russia, Kazakhstan, Iran, Turkey, Ukraine, India [Andhra Pradesh, Karnataka, Madhya Pradesh, Maharashtra, Punjab, Rajastan, Tamilnadu, Kerala: Ernakulam, Wayanad] **(New record to Kerala).**

Biology: Unknown.

Remarks:

Since the available description of this species is inadequate for easy identification, a redescription is provided here.

Tachysphex panzeri (Vander Linden) closely resembles *Tachysphex tessellates* (Dahlbom), in having 1. Clypeal free margin medially emarginated; 2., Propodeal not ridged on sides, microsculptured; 3. Tergum V punctate; 4. Metasoma red.

However, *T. panzeri* differs from *T. tessellatus* in having 1. Longitudinal line on vertex absent (in *T. tessellatus* vertex with longitudinal line finely impressed); 2. Pygidial plate dull (in *T. tessellatus* pygidial plate shiny); 3. Hind margin of postocellar impression obtusely angulate (in *T. tessellatus* post ocellar impression rectangular).

Genus *Tachytes* Panzer

Tachytes Panzer, 1806:129. Type species: *Pompilus tricolor* of Fabricius, 1798 [= *Sphex tricolor* Fabricius, 1793 (junior primary homonym of *Sphex tricolor* Schrank, 1781) = *Sphex tricoloratus* Turton, 1801 = *Tachytes obsoletus tricoloratus* (Turton, 1801)], by monotypy.

Lyrops Illiger, 1807a:162. Type species: *Andrena etrusca* Rossi, 1790, by monotypy. Illiger, 1807b:195 (*Lyrops* Illiger = *Larra* of Jurine).

Tachyptera Dahlbom, 1843:133. Type species: *Apis obsoleta* Rossi, 1792, designated by Patton, 1880: 391. Junior homonym of *Tachyptera* Berge, 1842.

Holotachytes Turner, 1917: 10. Type species: *Tachytes dichrous* F. Smith, 1856, by original designation.

Calotachytes Turner, 1917: 10. Type species: *Tachytes marshalli* Turner, 1912, by original designation.

Tachyoides Banks, 1942: 397. Type species: *Tachytes mergus* Fox, 1892, by original designation.

Tachyplena Banks, 1942: 397. Substitute name for *Tachyptera* Dahlbom, 1843. *Tachyplena* regarded as a new genus name because Banks designated *Tachytes mandibularis* Patton, 1880, as type species (R. Bohart and Menke, 1976:44).

Tachynana Banks, 1942: 398. Type species: *Tachytes obscurus* Cresson, 1872 [= *Tachytes chrysopyga obscurus* Cresson, 1872], by original designation.

Diagnosis

Head: Inner orbits converging towards vertex; hind ocellar scars golf club shaped, long axes forming an angle of 70°, scar length less than distance between midocellus and scar end; frons above antennal sockets with median swelling; frontal line present or absent; antennal sockets contiguous with frontoclypeal suture or separated; clypeus

convex or tripartite, divided by longitudinal lines, free margin with median lobe, bounded by lateral teeth; inner mandible margin usually dentate, externoventrally notched or absent.

Mesosoma: Pronotum depressed and closely applied to scutum; episternal sulcus complete, scrobal sulcus weak or absent; male fore legs modified, fore coxa posteriorly with triangular or finger-like process; female hind femur with dorsal oblique truncation covered with appressed setae and ventral plate like area; tibia with outer rows of spines, females with fore tarsal rake well developed.

Metasoma: Tergum I with lateral carina; pygidial plate in both sexes covered with appressed metallic setae, usually laterally carinate; male sternum VIII emarginate or triangular; volsella slender, gonostyle ventrally with setae.

Distribution: Cosmopolitan.

Biology: Nests are dug in pre-existing holes. Nests are multicellular; cells are placed on ends of branches originating from main tunnel. Preys are Orthopterous insects, usually flown to nest. Egg is laid after completion of provisioning and paralysis is complete. Nests are parasitized by Sarcophagid flies (Pulawski, 1962; Evans and Kurczewski, 1966).

Remarks: Genus *Tachytes* Panzer is considered to be most advanced among tribe Larrini. In India this genus is represented by twenty eight species.

Genus *Tachytes* closely resembles genus *Larropsis* Patton in having 1. Ocellar scars similar; 2. Male fore coxa with posterior process; 3. Pygidial plate covered with appressed setae.

However, *Tachytes* differs from *Larropsis* in 1. Forewing marginal cell apically rounded or truncate (in *Larropsis* marginal cell apically obliquely truncate); 2. Pygidial plate covered with appressed setae (in *Larropsis* pygidial plate with apical setae); 3. Clypeal free margin with median lobe bounded by lateral teeth (in *Larropsis* clypeal free margin without lateral teeth).

Key to species of the genus *Tachytes* Panzer in Kerala.

1. Hairs pale golden; tibiae red; clypeus with freemargin medially emarginate; pygidial plate covered with silvery setae.....*Tachytes modestus* F. Smith
- Hairs silvery; tibiae black; clypeal freemargin arcuate; pygidial plate with black setae.....*Tachytes nitidulus* (Fabricius)

26. *Tachytes modestus* F. Smith

Tachytes modestus F. Smith, 1856: 299, ♀. India (BMNH), designated by Pulawski, 1975: 316.

Tachytes maculipennis Cameron, 1904c: 299, ♂. India (OXUM). [Synonymized with *Tachytes modestus* by Pulawski, 1975: p [316].

Diagnosis:

Female

Length 11-15mm. Black; femora apically and tibiae red; hairs pale golden; tergites I-IV apically with silvery fasciae; wings hyaline with yellow tinge; clypeus, frons, gena, pronotum, scutum sides and apex, metanotum, propodeum with dense hairs; sternum II in females densely punctate; pygidial plate in females with dense, stiff silvery hairs, in males with sparse pubescence; galea as long as scape; clypeal freemargin medially emarginate.

Male: Unknown

Material examined: No material examined. The above description of species is based on that given by Bingham, 1897 and Pulawski, 1975.

Distribution: China, Japan, Korea, South East Asia and India [Assam, Maharashtra, Uttar Pradesh, Sikkim, West Bengal and Kerala: Malabar].

Biology: Parasitized by *Paraxenos indicus* (Pierce) (Kifune, 1997).

Remarks: This species was first reported from Malabar, Kerala by Sudheendrakumar and Narendran, 1985.

Tachytes modestus F.Smith closely resembles *Tachytes ornatipes* Cameron in having 1. Metasoma black and 2. Length of body less than 15mm

However, *T.modestus* differs from *T.ornatipes* in 1. Wings with yellow tinge (in *T.ornatipes* wings much more pale yellow); 2. Femora apically and tibiae red (in *T.ornatipes* mid and hind tibiae brown red); 3. Metasoma slightly longer than mesosoma (in *T.ornatipes* metasoma more slender and longer).

27. *Tachytes nitidulus* (Fabricius).

Crabro nitidulus Fabricius, 1793: 294, ♂, India (ZMUC).

Tachytes nitidulus (Fabricius): Dahlbom, 1845: XXIV, new combination for *Crabro nitidulus* Fabricius.

Diagnosis:

Female

Length 12-14mm. Black; hairs silvery, pygidium with stiff, black setae; tergites I-IV apically with silver fasciae; wings subhyaline with yellow tinge; clypeus, frons, propodeum sides and apically with dense, appressed hairs; vertex with sparse punctae; scutum, scutellum punctate; propodeum coarsely punctate; vertex with V shaped groove behind hindocelli, clypeal freemargin arcuate; UID less than half the length of LID, longer than F1.

Male: Unknown

Materials examined: No material examined. The above description of species is based on that given by Bingham, 1896 and Vander Vecht, 1961.

Distribution: Borneo, India [Delhi, Maharashtra, Punjab, Tamil Nadu and Kerala: Malabar].

Biology: Unknown.

Remarks: *Tachytes nitidulus* (Fabricius) closely resembles *Tachytes vicinus* Cameron in having 1. Legs black; 2. Body length less than 15mm; 3. Hairs silvery.

However, *T. nitidulus* differs from *T. vicinus* in 1. Pygidial plate with black setae (in *T. vicinus* pygidial plate with silvery hairs; 2. Propodeum coarsely punctate (in *T. vicinus* propodeum with punctae running into transverse striae); 3. Propodeum without median groove (in *T. vicinus* propodeum with median groove).

This species was reported from Malabar, Kerala by Sudheendrakumar and Narendran, 1989.

Genus *Larra* Fabricius

Larra Fabricius, 1793: 220. Type species: *Larra ichneumoniformis* Fabricius, 1793 [= *Sphex anathema* Rossi, 1790], designated by Latreille, 1810: 438.

Larrana Rafinesque, 1815: 124. Emendation or new name for *Larra* Fabricius, 1793.
Lara Drapiez, 1819: 54. Lapsus or emendation of *Larra* Fabricius, 1793. [*Lara* LeConte, 1852, is a junior homonym].

Monomatium Shuckard, 1840: 181, no included species. Type species: *Larraxena princeps* F. Smith, 1851, designated by Pate, 1935: 246, by subsequent designation (first included species).

Lyrops Dahlbom, 1843: 132, junior homonym of *Lyrops* Illiger, 1807a. Type species: *Tachytes paganus* Dahlbom, 1843, by monotypy.

Larraxena F. Smith, 1851: 30. Type species: *Larraxena princeps* F. Smith, 1851, by monotypy. Synonymized with *Monomatium* Shuckard by Pate, 1935: 246.

Larrada F. Smith, 1856: 273. Type species: *Larrada anathema* (Rossi, 1790) [= *Sphex anathema* Rossi, 1790], by original designation.

Cratolarra Cameron, 1900b: 34. Type species: *Cratolarra femorata* Cameron, 1900, junior secondary homonym of *Larra femorata* (de Saussure, 1854), by monotypy. Treated as subgenus of *Larra* by Menke in R. Bohart and Menke, 1976: 42.

Diagnosis

Head: Inner orbits near vertex with deep sulcus; hindocellar scars indistinct; frontal line interrupted by transverse swelling; frons impunctate, vertex coarsely punctate, both shining; flagellomeres with placoids in males; clypeus flat, free margin arcuate, sharp-edged; labrum projecting beyond clypeus; inner mandibular margin simple, exteroventrally with subbasal notch.

Mesosoma: Pronotal collar same level as scutum, posterior margin flat or arcuate (in anterior view), in males collar depressed beneath level of scutum, margin sharp, wedge shaped, closely appressed to scutum; notauli absent; propodeum flat, sides parallel or constricted at level of spiracles, punctate; female tibiae with outer rows of stout spines, male tibiae with sparse spines; hind tibia without longitudinal carina; females with fore tarsal rake; tarsomere V arcuate (in lateral view), widened from base to apex in dorsal view, claws simple; SMC II petiolate or triangular.

Metasoma: Tergites polished, smooth in females, apical fasciae absent, in males fasciae present; tergum I with lateral carina, II basally with weak carina; pygidial plate in females glabrous, impunctate to punctate, in males pygidial plate weak, punctate and covered with setae; volsella slender, gonostyle basally with paired lobes forming circular enclosure.

Distribution: Mainly a tropical genus, but has been introduced to other areas as bio-control agents.

Biology: They are parasitoids attacking mole crickets (Gryllotalpidae). They can be seen running along the ground in search of prey, prey paralysis is temporary. The egg is deposited ventrally, between the legs (Nambu, 1970; Frank and Sourakov, 2002).

Remarks: *Larra* Fabricius is divided into two subgenus- subgenus *Larra* Fabricius and subgenus *Cratolarra* Cameron.

In India this genus is represented by ten species,

Members of *Larra* have been successfully introduced to other areas as biocontrol agents against mole crickets. *Larra analis* Fabricius, parasite of the Puerto Rican

mole-cricket *Scapteriscus vicinus* Scudder has been introduced from Brazil to Puerto Rico (Martorell, 1939); *Larra bicolor* fabricius against *Scapteriscus didactylus* (Latreille) was introduced successfully into Puerto Rico and Florida from Brazil (Frank and Sourakov, 2002); *Larra polita luzonensis* Rohwer and *Larra amplipennis*(F.Smith) introduced to Hawaii from Philippines (Williams, 1928).

Genus *Larra* Fabricius share structural resemblences to genus *Liris* Fabricius in having 1. Pygidial plate apically without transverse row of setae; 2. Propodeum constricted at spiracles; 3, inner mandibular margin simple.

However, *Larra* differs from *Liris* in having 1. Propodeum side smooth, punctate and shiny (in *Liris* sides of propodeum dull, smooth); 2. Tarsomere V in females widening from base to apex and arcuate in lateral view (in *Liris* tarsomere V medially parallel sided; 3. Ventral hairmat absent on tarsomere V (in *Liris* tarsomere V with ventral hair mat.

Key to species of the genus *Larra* Fabricius in Kerala.

1. Hindfemora orange red; metasoma black; propodeum punctate; clypeal freemargin arcuate.....***Larra vechti*** Sudheendrakumar and Narendran
- Hind femora black; metasomal segments I apically, segment II and segment III basal two-third red; propodeum with puctae running to transverse striae; clypeal free margin sinuate (Plate 14c).....***Larra stom* sp. nov.**

28. ***Larra stom* sp. nov.**
(Fig 34a-e; Plate 14c)

Description.

Female

Measurements in mm

TBL =13.8; FWL = 8.3; SW = 1.9

Colour: Black; metasomal segment I apically, segment II and segment III basal two-third red; hairs silvery, with coppery tinge on scutum, tergites I-IV with silvery fasciae.

Vestiture: Clypeus, gena, base of mandibles, legs with appressed hairs; pronotum, scutum, tegulae, scutellum, metanotum, with semierect hairs; erect hairs on upper frons, scape ventrally, vertex, mesopleuron, propodeum dorsally with erect hairs; metasoma laterally and ventrally with fine velvety pubescence.

Sculpture: Frons above antennal sockets glabrous; clypeus, frons, vertex, gena, pronotum, scutum, mesopleuron, scutellum, metanotum, coxa, propodeum laterally and hindface punctate; propodeum dorsally with punctae running into transverse striae, submedially with sparsely punctate, smooth area; tergites I, sternites II-V with fine punctae; scape, tergites II-IV smooth, shiny; sternum VI coarsely punctate; pygidial plate shiny, sparsely punctate.

Head: 0.8x as long as wide (HL = 2.4mm, HW = 2.9mm); vertex above hindocelli with transverse line; inner orbits converging towards vertex, UID: MID: LID = 1.1: 1.3: 1.9; frons depressed above antennal sockets; frontal line finely impressed; antennal sockets contiguous with frontoclypeal suture; antennae twelve segmented; scape 3.1x and F1 2.8x as long as its apical width; F1 0.8x as long as F2+F3(F2+F3) = 0.8mm); F1: F2: F3: F10 = 0.6: 0.4: 0.4: 0.3; clypeus 0.2x as long as wide (CL = 0.3mm, CW = 2mm), transverse, freemargin medially pointed, sinuate; mandibles simple.

Mesosoma: Admedian lines, paradiscal lines present; propodeum with baso-median carina, hindface with median longitudinal furrow not reaching apex; wings clear, hyaline, forewing darker than hindwing; forewing with three SMC's, both recurrent veins received by SMC II; AV of SMC II 0.5x as long as AV of SMC III (AV of SMC II = 0.2mm, AV of SMC III = 0.4mm); hindwing media diverging beyond cu-a at length of cu-a (0.2mm); legs spinous; hindtibial spur 0.7x as long as hindbasitarsus (HTS = 1.0mm, HBT = 1.6mm).

Metasoma: 1.6x as long as mesosoma (Metasoma = 7.2mm, Mesosoma = 4.6mm); relative length of segments I:II = 1.8:1.7; pygidium laterally carinate.

Male: Unknown.

Etymology: The species name '*stom*' is an arbitrary combination of characters.

Material examined: Holotype: 1 ♀, India: Kerala, Ernakulam: Koothattukulam 9° 49' N 76° 36' E, 6.vi.2011. Baaby Job.

Depository: The specimen deposited at Department of Zoology, St. Thomas College, which will be transferred to ZSIWGRC.

Distribution: India (Kerala: Ernakulam).

Biology: Unknown.

Remarks: *Larra stom* sp. nov. closely resembles *Larra simillima* (F. Smith) in having 1. Head, mesosoma punctate; 2. Metasoma black and red, legs black; 3. Pygidial plate sparsely punctate.

However, *L. stom* sp. nov. differs from *L. simillima* in 1. Wings clear, hyaline, with shades of brown colour (in *L. simillima* wings dark fuscous with purple effulgence); 2. pygidial area without lateral grooves, smooth, shiny (in *L. simillima* pygidial plate with lateral grooves); 3. Metasomal segment I apically, segment II and segment III basal two-third red, rest black (in *L. simillima* metasomal segments I-IV red, rest black).

29. *Larra vechti* Sudheendrakumar and Narendran

Larra vechti Sudheendrakumar and Narendran, 1985:50, ♀ India (ZSIWGRC).

Diagnosis

Female

Length 9-13mm. Black; hind femora orange red; hairs silvery, pygidium laterally with red-brown hairs; wings with brown tinge; clypeus, lower frons with appressed hairs; pronotum, scutum, metanotum, propodeal enclosure, propodeum postero-laterally, mesopleura, legs with sparse semierect hairs ; pygidium bare, laterally with stiff hairs; clypeus punctate, interspaces rugose; frons polished, shiny; vertex with scattered punctae; propodeum, scutum punctate; propodeal enclosure reticulate; propodeum posteriorly striato-punctate; tergites I-III with dense, micropunctae; tergum V and pygidium with scattered punctae; sternites smooth, shiny.

Male: Unknown.

Distribution: India [Kerala: Malappuram].

Biology: Unknown.

Remarks: *Larra vechti* Sudheendrakumar and Narendran closely resembles *Larra maura* (Fabricius) in having 1. Body black with hind femora red; 2; Propodeal enclosure reticulate; 3. Pygidial plate bare with punctae.

However *L. vechti* differs from *L.maura* in 1.Clypeal free margin arcuate , medially pointed (in *L. maura* clypeal freemargin arcuate); 2. Scape black (in *L. maura* scape reddish-brown); 3. Propodeum punctate, posteriorly striato-punctate (in *L. maura* propodeum coarsely punctate).

Genus *Liris* Fabricius

Liris Fabricius, 1804: 227. Type species: *Sphex auratus* Fabricius, 1787, junior primary homonym of *Sphex auratus* Linnaeus, 1758 [= *Sphex aurulentus* Fabricius, 1787], designated by Patton, 1880: 386.

Lirisis Rafinesque, 1815: 124. Emendation or substitute name for *Liris* Fabricius, 1804.

Notogonia Costa, 1867: 82, junior homonym of *Notogonia* Perty, 1850 (Crustacea).
Type species: *Tachytes niger* of Vander Linden, 1829 [= *Larra nigra* of Latreille, 1805 = *Pompilus niger* of Panzer, 1799 = *Sphex niger* Fabricius, 1775], by monotypy.

Motes Kohl, 1897: 351. Type species: "*Notogonia odontophora* Kohl, 1892" [= *Larra odontophora* Kohl, 1894], designated by Pate, 1937: 41.

Caenolarra Cameron, 1900b: 28. Type species: *Caenolarra appendiculata* Cameron, 1900 [= *Spanolarra rufitarsis* Cameron, 1900b], junior secondary homonym of *Liris appendiculatus* (Taschenberg, 1870), by monotypy.

Leptolarra Cameron, 1900b: 29. Type species: *Leptolarra reticulata* Cameron, 1900, junior secondary homonym of *Liris reticulatus* (de Saussure, 1892) [= *Leptolara nigricans reticuloides* Richards, 1935 = *Liris nigricans reticuloides* (Richards)], designated by Richards, 1935: 164.

Spanolarra Cameron, 1900b: 32. Type species: *Spanolarra rufitarsis* Cameron, 1900b, by monotypy.

Notogonius Howard, 1901: pl. 6, fig. 1 (June). Lapsus for *Notogonia* Costa. Bohart and Menke (1976: 43)

Chrysolarra Cameron, 1901b: 118 (Aug.). Type species: *Chrysolarra appendiculata* Cameron, 1901b, junior secondary homonym of *Liris appendiculatus* (Taschenberg, 1870), designated by Pate, 1937: 18.

Notogonidea Rohwer, 1911: 234. Substitute name for *Notogonia* Costa, 1867.

Dociliris Tsuneki, 1967b: 26, as subgenus of *Liris*. Type species: *Larrada subtessellata* F. Smith, 1856, by original designation. Synonymized with *Leptolarra* Cameron, 1900b, by Menke in R. Bohart and Menke, 1976: 43.

Nigliris Tsuneki, 1967a: 27, as subgenus of *Liris*. Type species: *Notogonia japonica* Kohl, 1885a [= *Liris festinans japonicus* (Kohl), by original designation. Synonymized with *Leptolarra* by Menke in R. Bohart and Menke, 1976: 43.

Colloliris Tsuneki, 1974: 612, as subgenus of *Liris*. Type species: *Notogonidea negrosensis* F. Williams, 1928, by original designation and monotypy. Synonymized with *Leptolarra* by Menke in R. Bohart and Menke, 1976: 629.

Pitaliris Tsuneki, 1982: 26, as subgenus of *Liris*. Type species: *Cratolarra pitamawa* Rohwer, 1916, original designation.

Diagnosis

Head: Inner angle of eyes without deep sulcus; midocelli normal, hind ocelli reduced to scar-like; scape long, slender, flagellomeres longer than wide, male flagellomeres with placoids; clypeus with median longitudinal ridge, free margin with medially notched lobe; inner mandibular margin toothed.

Mesosoma: Pronotal collar below the level of scutum, closely appressed; notauli present; propodeum variously sculptured; male hind femur flattened; fore tibia without spines on outer margin, midtibia with two-three, hind tibia with two outer row of spines; hind tibia with polished longitudinal carina; fore tarsal rake usually present; mid and hind leg tarsomere V in female angled in lateral view, parallel sided in dorsal view, ventrally with dense hair mat; tarsal claws in female prehensile, usually simple.

Metasoma: Terga I with lateral carina; female sternum II basally with paired, flattened, oval area separated by median longitudinal ridge; male sterna apically with erect hairs; pygidial plate with carina, glabrous or fully or partially covered with stiff, setae; sternum VIII apically rounded or truncate.

Distribution: Cosmopolitan.

Biology: Nests in soil; prey is weakly paralysed; prey includes crickets of the family Gryllidae; each cell contains two-seven immature and adult insects; no temporary closure of nests during provisioning (Bohart and Menke, 1976).

Remarks. Genus *Liris* Fabricius is divided into three subgenera- subgenus *Liris* Fabricius, subgenus *Leptolarra* Cameron and subgenus *Motes* Kohl. In India this genus is represented by forty six species falling under the subgenus *Liris* Fabricius and *Leptolarra* Cameron (Bohart and Menke, 1976).

Key to species of the genus *Liris* fabricius in Kerala

1. Mandible with externo-ventral notch absent (Fig 26a) or atmost with V shaped notch.....2
- Mandible with externo-ventral notch deep (Fig 31a), emarginated.....3

2. Scutum with dense golden pubescence, concealing sculpture (Plate 12c); inner mandibular margin with two subbasal teeth; tergites I-IV with silver fasciae; pygidial plate dorsally with stiff, appressed setae.....*Liris aurulentus* Fabricius
- Scutum with sparse golden pubescence, sculpture visible (Plate 14b); mandibles simple; tergites I-III with silver fasciae; pygidium coarsely punctate without setae (Fig 33a).....*Liris wayanadensis* sp. nov.
3. Pygidium covered with appressed, stiff setae (Fig 27e).....4
- Pygidium bare, glabrous with punctae (Fig 25b).....8
4. Pygidium basally with 'U' shaped glabrous area (Fig 31d); propodeum dorsally transversely striate, interspaces rugose (Fig 24c).....5
- Pygidium completely or apical half covered with setae, basal glabrous area absent; propodeum striato-rugose.....6
5. Hind femora red; admedian lines finely impressed; wings yellow (Plate 13c).....*Liris subtessellatus* (F. Smith)
- Hind femora black; admedian lines weakly impressed; wings with yellow colour more distinct (Plate 12a).....*Liris anupamus* sp. nov.
6. Legs black; pygidium covered with stiff setae appearing brassy under certain lights, apically with five or six spatulate spines.....7
- Legs red; pygidium apical half covered with appressed setae, apically with six spines (Plate 14a).....*Liris thenmalaensis* sp. nov.
7. Length 20-25mm; propodeum dorsally with fine oblique striae, interspaces rugose; pygidium apically with six spatulate spines (Fig 27)..... *Liris narendrani* sp. nov.
- Length 9.5-11mm; propodeum medially rugose, submedially striato-rugose; pygidium apically with five setae (Fig 29).....*Liris simoni* sp. nov.

8. Clypeal freemargin sinuate (Fig 30a); second recurrent vein medially strongly angulate (Fig 30e); pronotum depressed beneath level of scutum; pygidium punctate near margins (Fig 30).....*Liris sinuatus* sp. nov.
- Clypeal freemargin arcuate (Fig 25a); second recurrent vein not angulate; pronotum same level as scutum; pygidium dorsally with scattered punctae.....9
9. Hairs silver; pygidium apically truncate with two spines (Fig 25b); mandibles submedially with two teeth.....*Liris arcuatus* sp. nov.
- Hairs silver with golden tinge; pygidium apically with five spies (Fig 28b); mandibles inner margin simple, apically blunt.....*Liris pentaspinosus* sp. nov.

30. *Liris anupamus* sp.nov.

(Fig 24a-d; Plate 12a)

Description

Female

Measurements in mm.

TBL= 11.3; FWL= 6.6; SW= 1.7

Colour: Black; mandibles medially and scape ventromedially red; wings yellow; hairs silver; tergites I-III apically with silvery fasciae.

Vestiture: Dense appressed hairs on clypeus except apically, lower frons, gena and base of the mandibles; appressed hairs moderately dense on scutum, scutellum, metanotum, mesopleuron and legs; hairs semi erect on propodeum dorsally; tergites I-V and sternites II-V laterally with fine appressed hairs; pygidium except basally covered with stiff hairs appearing brassy under certain lights.

Sculpture: Basomedian area of clypeus, frons, vertex, scutum, scutellum and metanotum micropunctate; clypeal bevel smooth and shiny; fine transverse striae on propodeum, the interspaces rugose, the sides delicately striate, the hind face transversly striate; tergites IV-V, sterna III micropunctate; scattered punctae on

sternites IV-V; pygidium apico-ventrally punctate, basally with 'U' shaped glabrous area; sternites IV-VI shiny.

Head: Head 0.7x as long as wide (HL = 3.3mm, HW = 4.6mm); vertex with sub triangular shallow depression, 0.6x as long as wide; inner orbits converging towards the vertex, UID: MID: LID= 1.3: 1.7: 2.7; ASD 1.5 x as MOD; antennae twelve segmented, scape 2.3x and F1 3x as long as its apical width, F1: F2: F3: F10 = 0.5: 0.6: 0.5: 0.3; antennal sockets contiguous with fronto-clypeal suture; clypeus 0.3 x as long as wide (CL = 0.8mm, CW = 2.5mm, free margin arcuate, medially emarginate, the distance between corner and orbit 2x the distance between the corners.

Mesosoma: Pronotum depressed beneath the level of scutum; admedian lines, notuali and paradiscal lines on the scutum finely impressed; episternal sulcus complete, scrobe present; propodeum with dorsally median longitudinal carina ending after midway, hind face gradually sloping with median longitudinal line; wings hyaline, infumate apically, AV of SMC II as long as AV of SMC III (0.16mm), marginal cell apex truncate; hind wing media diverging beyond cu-a at 1.3 x length of cu-a (M+Cu = 0.25mm, cu-a = 0.2mm); legs spinous, fore basitarsus with four rake spines; forefemur excavated beneath on the apical half; hind tibial spur 0.75x as long as hind basitarsus (HTS = 0.75mm, HBT = 1.0mm); claws simple, prehensile.

Metasoma: Metasoma as long as mesosoma (Metasoma = Mesosoma = 4.5mm); relative length of segments I: II = 1.58:1.1; pygidium 0.85x as its basal width (length = 0.6mm, width = 0.7mm), carinate laterally, apically with six spatulate setae.

Male: Unknown.

Etymology: The species derives its name from the Sanskrit word '*anupamus*' meaning unique.

Material examined: Holotype: 1♀, India: Kerala, Ernakulam: Koothattukulam 9°49' N 76° 36' E. 28.V.2012. Simon George.

Paratype: 1♀, India: Kerala, Thiruvananthapuram, KAU Vellayani 8°26'N 76°59'E. 10.iii.2012. Baaby Job; 1♀, India: Kerala, Malappuram: Chamramattom 10°81'N 75°95'E. 21.03.2012, Baaby Job.

Depository: The specimen deposited at Department of Zoology, St. Thomas College, which will eventually be transferred to ZSIWGRC.

Distribution: India [Kerala: Ernakulam, Malappuram, Thiruvananthapuram].

Biology: Unknown.

Remarks: *Liris anupamus* closely resembles *Liris subtessellatus* (F. Smith) in 1. Propodeal sculpture; 2. Body length; 3. Propodeum sides transversely striate.

However *L. anupamus* differs from *L. subtessellatus* in having 1. Legs black (in *L. subtessellatus* hind femora red); 2. Fore basitarsus with four rake spines (in *L. subtessellatus* fore basitarsus with five rake spines); 3. Tergites I-III with apical fasciae (in *L. subtessellatus* tergites I-IV with apical fasciae).

31. *Liris arcuatus* sp. nov.
(Fig 25a-d; Plate 12b)

Description

Female

Measurements in mm.

TBL = 9.4; FWL = 7.1; SW = 1.6.

Colour: Black; tegula semi transparent brown; mandibles medially and scape ventro-medially brown; hairs silvery; tergites I-III apically with silver fasciae.

Vestiture: Clypeus except apically, lower frons, scape, mandibular base, scutum, mesopleuron, propodeum, mesoscutum, femur, metasomal segment I, tergites II-V, sternites II-IV laterally with appressed hairs.

Sculpture: Clypeus, frons, vertex, scutum, scutellum punctate; propodeum dorsally rugose with transverse striae on edges, sides and hind face; sternites V-VI with scattered punctae; pygidium dorsally shining with sparse, scattered punctae, ventrally coarsely punctate; metasomal segments apically shiny.

Head: Head 0.8x as long as wide (HL = 2.3mm, HW = 2.9mm); vertex with broad V shaped depression; ocellar area slightly bituberculate ; inner orbits converging towards the vertex, UID: MID: LID = 0.6: 1.2: 1.3; frontal line finely impressed; antennal sockets contiguous with fronto-clypeal suture; antennae twelve segmented, scape ventro-medially with longitudinal carina; scape 3.5x and F1 2.8 x as long as its apical width, F1 = F2 = 0.47mm, 0.5x as long as F2+F3 (F2+F3 = 0.97mm), F3 = F4 = 0.5mm, F10 = 0.3mm; clypeus 0.3x as long as wide (CL = 0.4mm, CW = 0.9mm), free margin arcuate, mandibles inner margin with two sub-media teeth.

Mesosoma: Pronotum same level as scutum, but separated; admedian lines, notauli and paradiscal lines on scutum finely impressed; episternal sulcus complete, scrobal sulcus thinly visible; propodeum 1.5x as long as scutum (propodeum = 1.9mm, scutum = 1.2mm), with median longitudinal carina not reaching base of hind face, hind face with median longitudinal sulcus; wings hyaline, apically infuscate; AV of SMC II 0.8x as long as AV of SMC III (AV of SMC = 0.16mm, AV of SMC III = 0.26mm); hind wing media diverging beyond cu-a at 3x length of cu-a (cu-a = 0.1mm, M+Cu = 0.3mm); fore basitarsus with three preapical spines; hind tibial spur 0.6x as hind basitarsus (HTS = 0.9mm, HBT = 1.5mm)

Metasoma: as long as Mesosoma (4.2mm); sterna I with baso-median carina; relative length of segments I:II = 0.9:1.1; pygidium laterally carinate, apically truncate with two spines.

Male: Unknown.

Etymology: The species derives its name from the shape of its arcuate clypeal free margin.

Material examined: Holotype: 1♀, India: Kerala, Wayanad: Kottiyoor 11°52'N 5°51'E, 19.iv.2012. Baaby Job

Paratype: 1♀, India: Kerala, Kollam: Thenmala Butterfly Park 8°57'N 76°41'E. 02.v. 2012. Baaby Job.

Depository: The specimen deposited at Department of Zoology, St. Thomas College, which will eventually be transferred to ZSIWGRC.

Distribution: India [Kerala: Wayanad, Kollam].

Biology: Unknown.

Remarks: *Liris arcuatus* sp. nov. closely resembles *Liris sinuatus* sp. nov. in having 1. Body black; 2. Propodeum dorsally rugose with sides transversely striate; 3. Pygidium shining with scattered punctae; 4. F1 = F2 = 0.5mm.

However *Liris arcuatus* differs from *Liris sinuatus* in 1. Clypeal free margin arcuate (in *Liris sinuatus* clypeal margin sinuate); 2. Fore basitarsus with three pre apical spines (in *Liris sinuatus* fore basitarsus with four preapical spines); 3. Pronotum same level as scutum, but separated (in *Liris sinuatus* pronotum separated, but beneath level of scutum); 4. Second recurrent vein medially not strongly angulate (in *Liris sinuatus* second recurrent vein strongly angulate) 5. Sternum I with baso-median carina (in *Liris sinuatus* basomedian carina on sternum I absent).

32. *Liris aurulentus* (Fabricius)

(Fig 26a-c; Plate 12c)

Sphex aurulentus Fabricius, 1787: 274, sex not indicated (misspelled as *aurulenta* by Fabricius). China (ZMUC).

Larrada aurulenta (Fabricius): F. Smith, 1856: 276, new combination for *Sphex aurulentus* Fabricius (BMNH).

Tachytes aurulenta (Fabricius): Lepeletier de Saint Fargeau, 1845: 247, new combination for *Sphex aurulentus* Fabricius.

Larra aurulenta (Fabricius): Cresson, 1862: 237, new combination for *Sphex aurulentus* Fabricius.

Liris aurulenta (Fabricius): Van der Vecht, 1961: 19, new combination for *Sphex aurulentus* Fabricius by.

Liris aurulentus (Fabricius): Yamane, Ikudome, and Terayama, 1999: 513, new combination for *Sphex aurulentus* Fabricius (Japan).

Sphex auratus Fabricius, 1787: 276, ♀, India (ZMUC). [Synonymized with *Sphex aurulentus* by Fabricius, 1793:213].

Pompilus auratus (Fabricius): Fabricius, 1798: 250, new combination for *Sphex auratus* Fabricius .

Lyrops auratus (Fabricius): Guérin-Ménéville, 1844: 440, new combination for *Sphex auratus* Fabricius.

Larra aurata (Fabricius): Jurine, 1807: 145, new combination for *Sphex auratus* Fabricius.

Notogonia aurata (Fabricius): Rothney, 1903: 104, new combination for *Sphex auratus* Fabricius.

Tachytes opulentus Lepeletier de Saint Fargeau, 1845: 246, ♀ (misspelled as *opulenta* by Lepeletier). Indonesia (depository?). [Synonymized with *Larrada aurulenta* by F. Smith, 1856: 276].

Liris opulenta (Lepeletier): Weber, 1947: 22, new combination for *Tachytes opulentus* Lepeletier.

Tachytes auropilosus Rohwer, 1911: 484, ♀. Taiwan (USNM). [Synonymized with *Liris aurulentus* by Tsuneki, 1967b: 27 and 42].

Tachytes sinensis var. *purpureipennis* Matsumura and Uchida, 1926: 42, ♀ Japan (Hokkaido Univ., Sapporo). [Synonymized with *Liris aurulentus* by Tsuneki, 1967b: 27 and 42].

Tachytes sinensis purpureipennis (Matsumura and Uchida): Tsuneki, 1967b: 42, new combination and New status for *Tachytes sinensis* var. *purpureipennis*

Redescription

Female

Measurements in mm

TBL = 17.5; FWL = 11.4; SW = 3.

Colour: Black; mandible basal half, scape, pedicel, tegula, forefemur, apical half of mid and hind femur, tibiae and tarsomeres of all legs orange red; hairs golden, on propodeum yellow, tergites I-IV with silver fasciae; wings brown, basally with brown shades .

Vestiture: Clypeus except apically, frons, vertex, gena, pronotum posterior margin, scutum, mesopleuron, scutellum, legs with appressed hairs; propodeum with erect hairs; metasoma except sternites medially with fine pubescence; pygidial plate dorsally with stiff, appressed setae, sides with semi erect hairs.

Sculpture: Pygidium ventrally coarsely punctate; clypeus, sternites II-V, terga V punctate; propodeum transversly striate, interspaces rugose.

Head: 0.6x as long as wide (HL = 2.3mm, HW = 4mm); vertex with median depression and longitudinal line; frontal line finely impressed; inner orbits converging above, UID: MID: LID = 1.4: 1.7: 2.1; antennae twelve segmented, scape 2.8x and F10.6x as long as apical width; F1 0.5x as long as F2+F3 (F2+F3 = 1.6mm), F1: F2: F3: F10 = 0.8: 0.8: 0.8: 0.5; clypeus with median bulge, 0.3x as long as wide (CL = 0.7mm, CW = 2.3mm), free margin biarcuate; mandibles apically pointed with two subbasal teeth, externoventral notch absent.

Mesosoma: Pronotum closely appressed, beneath level of scutum; propodeum 0.9x as long as scutum (propodeum = 2.3mm, scutum = 2.1mm), with dorso-median carina, hind face with median longitudinal sulcus; wings hyaline, forewing darker than hind wing; AV of SMC II 0.3x as long as AV of SMC III (AV of SMC II = 0.18mm, AV of SMC III = 0.54mm); hind wing media diverging beyond cu-a at length of cu-a (0.3mm); legs stout, spinous; fore basitarsus with three pre-apical spines, fore tibiae with three outer spines; hind tibia with median longitudinal carina bearing spines, hindtibial spur 0.7x as long as hind basi tarsus (HTS = 1.5mm, HBT = 2.2).

Metasoma: 1.3x as long as Mesosoma (Metasoma = 8.6mm, Mesosoma = 6.8mm); relative length of segments I:II = 2mm; sterna I apically emarginated; pygidial plate laterally carinate, apically with six spatulate spines.

Male

Length 10-20mm; Body orange red except scape, coxa, trochanter black; wings brown, with purple effulgence; head and mesosoma covered with dense golden hairs; UID as long as F2+F3; pygidial area covered with golden bristles having coppery tinge in certain lights; sternum VIII apically rounded, emarginated (Tsuneki, 1967b).

Material examined: Plesiotype: 1♀, India: Kerala, Ernakulam: Koothattukulam 9°49' N 76° 36' E. 05.iii.2011. Baaby Job.

Other material examined: 1♀, India: Kerala, Thrissur: Mannuthy 10°49'N 76°25'E. 20.ii.2012. Baaby Job; 1♀, India: Kerala, Malappuram: Chamramattom 10°81'N 75°95'E. 21.iii.2012. Baaby Job; 1♀, India: Kerala, Wayanad: Mannanthavady Park 11°48'N 76°1'E. 19.iv.2012. Simon George.

Distribution: China, Eritrea, Indonesia, Japan, Korea, Malaya, Papua New Guinea, Phillipines, SriLanka, Sulawesi, Taiwan, India [Assam, Bihar, Karnataka, Rajasthan, TamilNadu, Kerala: Ernakulam, Malappuram, Thrissur, Wayanad].

Biology: Nests are dug in soil; prey consists of crickets (Gryllidae), carried face down. *Solenopsis gemminata* (Formicidae) are recorded from around the nest entrance (Williams, 1919).

Remarks: Since the available description of this species is inadequate for easy identification, a redescription is provided here.

Liris aurulentus (Fabricius) closely resembles *Liris haemorrhoidalis* (Fabricius) in having 1. Body covered with golden hairs; 2. Scape, mandible basal half and F1 red; 3. Propodeum transversly striate. However *L. aurulentus* differs from *L.*

haemorrhoidalis in having 1. Wings brown, hyaline with purple tint (in *L. haemorrhoidalis* wings yellow); 2. Metasoma black (in *L. haemorrhoidalis* metasomal segments 4-5 red); 3. Propodeum with median carina (in *L. haemorrhoidalis* median carina absent on propodeum).

33. *Liris narendrani* sp. nov.

(Fig 27a-e; Plate 12d)

Description

Female

Measurements in mm

TBL= 21.8; FWL= 15.2; SW= 4.0.

Colour: Black; scape ventro-medially black-red; wings dark brown with purple effulgence; hairs pale gold; pronotum posterior margin with pale silvery hairs; tergites I-III apically with silvery fasciae; pygidium with setae appearing brassy under certain lights.

Vestiture: Dense appressed hairs on the sides of the clypeus, lower frons, outer orbits, occiput, pronotal lobe, postero-lateral margin of scutum and scutellum; appressed hairs on pronotum posterior margin; propodeum dorsally with appressed hairs; pygidium covered with stiff hairs .

Sculpture: Clypeus except its apex and scutum micropunctate, intermixed with larger punctae; rest of the head and scutellum micropunctate; propodeum obliquely striato-rugose, the sides transversely striate to smooth; tergites IV-V punctate, scattered punctae on sternites III-V, the interspaces submedially micropunctate, scattered punctae on sternites IV-V, pygidium ventrally coarsely punctate.

Head: 0.8x as long as wide (HL = 4.2mm, HW = 5.1); vertex with triangular shallow depression, 0.7x as long as wide; inner orbits converging towards the vertex, UID:

MID: LID= 1.2: 2.1: 3.2; frontal line finely impressed; antennal sockets continuous with frontoclypeal suture, 3.5 x as MOD (MOD = 0.13mm, ASD = 0.46mm); antennae twelve segmented, length of scape 3.8x and F1 3.7x as long as its apical width, F1:F2:F3:F10= 1.2: 1.1:1.1: 0.6; clypeus 0.3x as long as wide (CL = 1.1mm, CW = 3.7mm), free margin biarcuate, medially emarginate; mouth parts elongate, length of galea 0.7x its basal width.

Mesosoma: Pronotum appressed to scutum; scutum with admedian lines, notauli and paradiscal lines finely impressed; episternal sulcus complete, scrobe present; mesopleuron slightly ridged beneath mid coxae; propodeum with median longitudinal carina not reaching the base of hind face, hind face gradually sloping with median longitudinal shallow furrow not reaching the apex; wings darker basally than at apex; AV of SMC II 0.6x as long as AV of SMC III (AV of SMC = 0.3mm, AV of SMC III = 0.5mm), marginal cell apically truncate; hind wing media diverging beyond cu-a at a distance equal to cu-a (0.4mm); legs spinous, fore basitarsus with four stiff rake spines; claws simple; hind tibial spur 0.7x as long as hind basitarsus, pectinate (HTS = 1.1mm, HBT = 1.5mm).

Metasoma: Metasoma 1.1x as long as mesosoma (Metasoma = 8.8mm, Mesosoma = 8.3mm); relative length of segments I:II= 2:2.4; pygidium 0.7x as its basal width, carinate laterally, apically with six spatulate setae.

Male: Unknown

Etymology: This species is named after Dr. T.C. Narendran for his contributions to the world of Taxonomy.

Material examined: Holotype: 1♀, India: Kerala, Ernakulam: Kanjiramala 9°86'N 76°57'E . 23.viii.2011. Baaby Job.

Paratype: 1♀, India: Kerala, Ernakulam: Koothattukulam 9° 49' N 76° 36' E. 27.x.2011. Baaby Job; 1♀, India: Kerala, Kottayam: Ramapuram 9°79'N 76°6'E.

29.v.2012. Simon George; 1♀, India: Kerala, Idukki: Kunijimala 9°84'N 76°63'E.
16.vi.2012, Simon George; 1♀, India: Kerala, Ernakulam: Koothattukulam, 9° 49' N
76° 36' E. 26.xii.2013.

Depository: The specimen deposited at Department of Zoology, St. Thomas College, which will eventually be transferred to ZSIWGRC.

Distribution: India [Kerala: Ernakulam, Idukki, Kottayam].

Biology: observed to be preying on Gryllidae.

Remarks: All specimens were caught during daytime, but one specimen was caught during night at 20.15.

Liris narendrani closely resembles *Liris ducalis* (F.Smith) in having 1. Body black; 2. Pygidial plate covered with stiff, appressed setae; 3. Clypeus, lower frons, outer orbits, occiput with dense appressed hairs.

However *Liris narendrani* differs from *L. ducalis* in having 1. Pubescence pale golden (in *L. ducalis* hairs brilliant golden); 2. Propodeum striate interspaces rugose (in *L. ducalis* propodeum obliquely striate); 3. Median carina on propodeum not reaching apex (in *L. ducalis* median carina reaching apex).

34. *Liris pentaspinosus* sp. nov.

(Fig 28a-c; Plate 13d)

Description

Female

Measurements in mm.

TBL = 13.1; FWL = 8.7; SW = 2.1.

Colour: Black; mandibles medially and scape ventrally red brown; eyes green; wings brown with shades of yellow; hairs silver with golden tinge; tergites I-IV with silver fasciae.

Vestiture: Clypeus except apically, lower frons, antennae, gena, mandibular base, pronotum posterior margin, scutum, mesopleuron, propodeum, tergites I-V, sternites I with appressed hairs.

Sculpture: Clypeus apical one-third with scattered punctae; basal two-third frons, vertex, scutum, scutellum, metanotum, sterna III punctate; propodeum dorso-medially rugose, edges, sides and hind face with transverse striae; mesopleura basally with irregular striae; terga V micropunctate, intermixed with larger punctae; metasomal segments II-V apically shiny, sternites IV-V with coarse punctae; pygidium coarsely punctate, dorsal margin with coarse punctae.

Head: Head 0.8x as long as wide (HL = 2.7mm, HW = 3.6mm); vertex with broad V shaped depression; ocellar area slightly bituberculate; inner orbits converging towards the vertex, UID: MID: LID = 1.0: 1.4: 1.7; frontal line finely impressed; antennal sockets contiguous with fronto-clypeal suture; antennae twelve segmented, scape 2.5x and F1 3.1 x as long as its apical width, F1 0.7x as long as F2+F3; F1: F2: F3: F10 = 0.8: 0.6: 0.4: 0.3; clypeus 0.3x as long as wide (CL = 0.6mm, CW = 1.8mm), with indistinct median carina, free margin arcuate; mandibles apically blunt with inner margin simple, externoventral notch more pronounced.

Mesosoma: Pronotum same level as scutum; propodeum 1.3x as long as scutum, with incomplete median carina, hind face with median longitudinal furrow (propodeum = 2.4mm, scutum = 1.8mm); wings hyaline; AV of SMC II 0.7x as long as AV of SMC III (AV of SMC = 0.2mm, AV of SMC III = 0.3mm), marginal cell apically truncate; hind wing media diverging beyond cu-a at 2x length of cu-a (cu-a = 0.15mm, M+Cu = 0.3mm); legs spinous, fore basitarsus with four pre apical spines, fore coxae flattened ventro-apically; hind tibial spur 0.6x as hind basitarsus (HTS = 0.9mm, HBT = 1.6mm)

Metasoma: 1.1x as long as mesosoma (Metasoma = 6.3mm, Mesosoma = 5.5mm); segments I = II = 1.6mm; pygidium laterally carinate, apically with five spines.

Male: Unknown.

Etymology: The word 'Penta' means five. The species derives its name from the five spines present at the apex of pygidium.

Material examined: Holotype: 1♀, India: Kerala, Malappuram: Tiroor 10⁰45' N, 75⁰54' E. 21.iii.2012, Baaby Job.

Depository: The specimen deposited at Department of Zoology, St. Thomas College, which will eventually be transferred to ZSIWGRC.

Distribution: India [Kerala: Malappuram].

Biology: Unknown.

Remarks: *Liris pentaspinosus* sp. nov. closely resembles *Liris sinuatus* sp. nov. in having 1. Black body; mandibles brown 2. Hairs silver with golden tinge; 3. Propodeal sculpture; 4. Fore tibia with four preapical spines; 5. Clypeal free margin arcuate.

However *L. pentaspinosus* differs from *L. sinuatus* in 1. Mandibles apically blunt (*in Liris sinuatus* mandibles apically pointed); 2. Inner mandibular margin simple, externoventral notch deep (*in Liris sinuatus* mandible inner margin with two submedian teeth, externoventral notch distinct); 3. Clypeus with indistinct median carina (absent *in Liris sinuatus*); 4. Pygidium apically with five spines (*in Liris sinuatus* pygidium apically with two spines); 5. Pronotum same level as scutum (*in Liris sinuatus* pronotum depressed below level of scutum).

35. *Liris simoni* sp. nov.

(Fig 29a-; Plate 13a)

Description

Female

Measurements in mm

TBL= 10.6; FWL= 7.4; SW= 1.6.

Colour: Black; tegula semi transparent brown; mandibles medially and scape ventromedially black-red; apex of tarsomeres medially red; wings yellow; hairs silvery; tergites I-III apically with silvery fasciae; tergites III-V and pygidium dorsally with black setae; pygidial setae appearing brassy under certain lights.

Vestiture: Moderately dense appressed hairs on clypeus except apically and lower frons; appressed hairs fine on scutum, scutellum, metanotum, mesopleuron, legs, mesosternum and propodeum; propodeum dorsally with semi erect hairs; tergites I-II and sternites I-III covered with fine appressed hairs, giving velvety appearance; tergites III-V with appressed hairs; pygidium with stiff, appressed setae.

Sculpture: Clypeus except its apex, frons, vertex micropunctate; punctae on scutum much closer than on scutellum; propodeum rugose medially, striato-rugose submedially, the sides rugose to striate and hind face transversly striate; tegum V and sternum III micropunctate, scattered punctae on sternites IV-V, pygidium ventrally coarsely punctate.

Head: Head 0.8x as long as wide (HL = 2.6mm, HW = 3.2mm); vertex 1.1x as long as wide, with triangular shallow depression; inner orbits converging towards the vertex, UID: MID: LID= 0.72: 2: 2.4; ocellar area slightly bituberculate; frontal line finely impressed; ASD 2.5x as MOD (ASD = 0.2mm, MOD = 0.08mm); antennae twelve segmented, scape 4.8x and F1 2.7x as long as its apical width, F1: F2: F3: F10 = 0.7: 0.6:0.5:0.3; antennal sockets contiguous with fronto-clypeal suture; clypeus 0.2x as long as wide (CL = 0.4mm, CW = 1.9mm), free margin arcuate, with ill defined lateral incision on each corner, apex smooth, shiny; mandibles pointed apically, inner margin medially with two teeth; length of galea 0.56x its basal width.

Mesosoma: Pronotum depressed beneath level of scutum; admedian lines, notuali and paradispal lines on the scutum finely impressed; episternal sulcus complete, scrobe present; metanotum medially notched, transverse furrow on each side; median

longitudinal carina on propodeum not reaching base of hind face, hind face with median longitudinal furrow not reaching the apex; legs spinous; tarsomere III and tarsomere IV emarginate; hind tibial spur 0.9x as long as hind basitarsus (HTS = 1.2mm, HBT = 1.3mm); forefemur excavated ventrally; wings hyaline, apex infumate; AV of SMC II equal to its PV(0.08), AV of SMC II 0.3x AV of SMC III (AV of SMC = 0.08mm, AV of SMC III = 0.25mm); marginal cell apically truncate; hind wing media diverging beyond cu-a at a distance 1.7x as long as cu-a (cu-a = 0.25mm, M+Cu = 0.42mm); hind wing jugal lobe 0.57 x as long as hind wing.

Metasoma: Metasoma 0.9x as long as Mesosoma (Metasoma = 4.3mm, Mesosoma = 4.8mm); relative length of segments I:II = Tg1: Tg2= 1.3:1.2; pygidium as long as its basal width, carinate laterally, apically with five spatulate setae.

Male: Unknown.

Etymology: The species is named after my husband Mr. Simon George, who assisted me in specimen collection.

Material examined: Holotype: 1♀, India: Kerala, Kottayam: Ramapuram 9°79'N 76°6'E. 29.v.2012. Simon George.

Paratype: 1♀, India: Kerala, Kottayam: Ramapuram 9°79'N 76°6'E. 29.v.2012, Simon George; 1♀ India: Kerala, Thrissur: Ayyanthole 10°32'N, 76°11'E. 08.viii.2012, Baaby Job; 1♀ India: Kerala, Ernakulam: Koothattukulam 9° 49' N, 76° 36' E. 20.x.2012, Baaby Job.

Depository: The specimen deposited at Department of Zoology, St. Thomas College, which will eventually be transferred to ZSIWGRC.

Distribution: India [Kerala: Ernakulam, Kottayam, Thrissur].

Biology: Unknown.

Remarks: *Liris simoni* sp. nov. resembles *Liris anupamus* sp. nov. in having 1. Body black; 2; propodeum sculpture and 3. Pronotum below the level of scutum.

However *Liris simoni* differs from *Liris anupamus* in 1) Clypeal free margin arcuate, with ill defined lateral incision on each corner(in *anupamus* clypeal margin arcuate, with median emargination); 2). Pygidium dorsally with stiff, black setae (in *anupamus* apical half with stiff setae) 3). Pygidium apically with six spatulate spines (in *Liris anupamus* pygidium with five spines).

36. *Liris sinuatus* sp. nov.

(Fig 30a-e; Plate 13b)

Description

Female

Measurements in mm.

TBL = 10.8mm; FWL = 6.8mm; SW = 1.6.

Colour: Black; tegula semitransparent brown; mandibles medially brown red; wings brown, apically infusate; hairs silvery with golden tinge, tergites I-IV apically with silvery fasciae.

Vestiture: Appressed hairs on clypeus except apically, frons, gena, scape, mandibular base, femur, scutum, mesopleuron, propodeum, tergites I-III and sternites I-IV laterally.

Sculpture: Clypeus apical one-third smooth, shining, basal two-third punctate; frons, vertex, scutum, scutellum, metanotum, sterna III, terga V punctate; propodeum dorso-medially rugose, edges, sides and hind face with transverse striae; sternites IV-V smooth, shining with scattered punctae, except medially; pygidium dorsally shining with sparse punctae near margins, ventrally coarsely punctate.

Head: Head 0.8x as long as wide (HL = 2.3mm, HW = 2.9mm); vertex with broad V shaped depression, 1.1x as long as wide; ocellar area slightly bituberculate, mid ocelli

set in slight depression; eyes rounded, inner orbits converging towards the vertex, parallel above, UID: MID: LID = 0.7:1.3:1.4; frontal line thinly impressed; antennal sockets contiguous with fronto-clypeal suture; antennae twelve segmented, scape ventro-medially with longitudinal carina; scape 3.8x and F1 3.3 x as long as its apical width, F1 = F2 = F3 = 0.5mm, 0.5x as long as F2+F3, F10 = 0.3mm; clypeus 0.2x as long as wide (CL = 0.3mm, CW = 1.3mm), free margin sinuate, mandibles inner margin sub-medially with two teeth.

Mesosoma: Pronotal collar separated from scutum, below level of scutum; admedian lines, notauli and paradiscal lines on scutum finely impressed; episternal sulcus complete, scrobe visible; propodeum 1.6x as long as scutum (propodeum = 1.9mm, scutum = 1.2mm), median longitudinal carina on propodeum ending short before sloping of hind face, hind face with median longitudinal furrow reaching the apex; wings hyaline, AV of SMC II 0.8x as long as AV of SMC III (AV of SMC = 0.2mm, AV of SMC III = 0.25mm), second recurrent vein angulate; fore wing marginal cell apically truncate; hind wing media diverging beyond cu-a at 3.1x as long as cu-a (cu-a = 0.16mm, M+Cu = 0.5mm); legs with spines stout, fore basitarsus with four pre apical spines, forefemur ventro-apically flattened, claws as long as T5 (0.4mm); hind tibial spur 0.46x as long as hind basitarsus (HTS = 0.7mm, HBT = 1.5mm).

Metasoma: 1.1x as long as Mesosoma (Metasoma = 4.9mm, Mesosoma = 4.3mm); sterna II with basal triangular elevation; relative length of segments I:II = 1.2:1.5; pygidium laterally carinate, apically with two spatulate setae.

Male: Unknown.

Etymology: The species derives its name from its sinuate clypeal free margin.

Material examined: Holotype: 1♀, India: Kerala, Ernakulam: Koothattukulam 9° 49' N, 76° 36' E. 27.x.2011, Baaby Job.

Paratypes: 1♀, India: Kerala, Ernakulam: Koothattukulam 9° 49' N, 76° 36' E. 19.v.2012, Baaby Job.

Depository: The specimen deposited at Department of Zoology, St. Thomas College, which will eventually be transferred to ZSIWGRC.

Distribution: India [Kerala: Ernakulam].

Biology: Unknown.

Remarks: *Liris sinuatus* closely resembles *Liris pitamava* Rohwer in having 1. Body black, mandibles basally red; 2. Middle of pronotum produced roundly into scutum; 3. Innermandibular margin with two teeth.

However *Liris sinuatus* differs from *L. pitamava* in having 1. Pygidium shiny with sparse punctae (in *L. pitamava* pygidium polished, bare) 2. UID slightly shorter than F1 (in *L. pitamava* UID slightly longer than F1) 3. Clypeus free margin sinuate (in *L. pitamava* clypeal free margin arcuate).

37. *Liris subtessellatus* (F. Smith)

(Fig 31a-d; Plate 13c)

Larrada subtessellata F. Smith, 1856: 277, ♀. India (BMNH)

Larrada exilipes F. Smith, 1856: 278, ♂ India (BMNH). [Synonymized with *Liris subtessellata* by Tsuneki, 1983b: 2].

Larrada docilis F. Smith, 1873a: 192, ♀ Japan (BMNH), designated by Pulawski, 1975a:319. [Synonymized with *Liris subtessellatus* by Tsuneki, 1983b: 2].

Larrada tisiphone F. Smith, 1873a: 192, ♀ (misspelled as *Tisiphone* by F. Smith original capitalization), junior primary homonym of *Larrada tisiphone* F. Smith, 1857. Japan (BMNH), designated by Pulawski, 1975: 319. [Synonymized with *Liris docilis* by Tsuneki, 1964b: 221, synonymy confirmed by Pulawski, 1975a:319].

Larra tisiphonoides Dalla Torre, 1897: 675 (misspelled as *Tisiphonoides* by Dalla Torre). Substitute name for *Larrada tisiphone* F. Smith, 1873a.

Notogonidea manilensis Rohwer, 1910: 659, ♂ Philippines (USNM). [Synonymized with *Liris docilis* by R. Bohart and Menke, 1976: 245].

Notogonia insularis Cameron, 1913: 81, ♂ junior secondary homonym of *Liris insularis* (de Saussure, 1867). Indonesia (ZMA). [Synonymized with *Liris subtessellata* by van der Vecht in R. Bohart and Menke, 1976: 248].

Notogonidea luzonensis Rohwer, 1919: 9, ♀. Philippines (USNM). [Synonymized with *Notogonidea subtessellat* by F. Williams, 1927: 438].

Liris vortex Tsuneki, 1966: 7, ♂. Taiwan (Kyushu Univ.). [Synonymized with *Liris docilis* by Tsuneki, 1967b: 34].

Redescription

Female

Measurements in mm

TBL= 14.7; FWL= 8; SW= 2.5.

Colour: Black except the hind femora red; wings with yellow tinge; tegula brown; mandibles medially black-red; hairs silvery; pygidium setae appearing brassy under certain lights; tergites I-IV apically fasciate.

Vestiture: Dense appressed hairs on clypeus and frons; appressed hairs on the thorax moderately dense; fine hairs on sternites II-IV laterally; pygidium covered with stiff hairs.

Sculpture: clypeus except apically, frons and vertex minutely punctate; scutum uniformly punctate, scutellum micropunctate; propodeum transversly striate dorsally, the striae broader near the margins, the interspaces rugose, the sides and the hind face finely striate; clypeal apex smooth and shiny; pygidium ventrally coarsely punctate except its base, with baso-dorsal 'U' shaped glabrous area.

Head: Head 0.8x as long as wide (HL = 2.8mm, HW = 3.6mm); vertex with sub triangular shallow depression, 0.7x as long as wide; inner orbits converging towards the vertex, UID: MID: LID= 0.7: 1.6: 1.8; frontal line finely impressed; ASD 3x as MOD; antennae twelve segmented, scape 2x and F1 3x as long as its apical width, F1 = F2 = F3 = 0.6mm, F10 = 0.4mm; antennal sockets contiguous with fronto-clypeal

suture; clypeus 0.3x as long as wide (CL = 0.5mm, CW = 1.9mm), free margin arcuate, medially emarginate; mandibles pointed apically, inner margin with two submedian teeth.

Mesosoma: Pronotum depressed beneath the level of scutum; admedian lines, notauli and paradiscal lines on the scutum finely impressed; episternal sulcus complete, scrobe present; propodeum nearly as long as wide, dorsally with median longitudinal carina ending halfway, the hind face gradually sloping with median longitudinal line not reaching the apex; wings hyaline, infumate apically, fore wings slightly darker than hind wings; AV of SMC II 0.3x as long as AV of SMC III (AV of SMC II = 0.3mm, AV of SMC III = 0.1mm), marginal cell apex truncate; hind wing media diverging beyond cu-a at 2.6x as long as cu-a (M+Cu = 0.8mm, cu-a = 0.3mm); legs spinous, fore basitarsus with five rake spines; hind tibial spur 0.7x as long as hind basitarsus (HTS = 1.3mm, HBT = 1.0mm); claws simple, prehensile.

Metasoma: Metasoma 1.2x as long as mesosoma (Metasoma = 7mm, Mesosoma = 6mm); relative length of segments I:II = 1.3:1.5; pygidium 1.3x as long as its basal width (1.1mm/0.8mm), carinate laterally, with five spatulate setae.

Male

TBL= 9.5; FWL= 8.3; SW= 1.6.

Colour: Black except the hind femora red; wings with a yellow tint; tegula brownish; mandibles medially dark red; apex of sternites II-VII coppery sheen; hairs with golden tinge; tergites I-IV apically with silvery fasciae.

Vestiture: Clypeus, frons with appressed hairs, thoracic hairs more dense than in females; tergites VI-VII and sternites finely pubescent.

Sculpture: Clypeus except apically, frons and vertex minutely punctate; scutum uniformly punctate, scutellum micropunctate; propodeum transversely striate dorsally, the striae broader near the margins, the interspaces rugose, the sides and the hind face

finely striate; pygidium coarsely punctuate except its base; tegites VI-VII and sternum VIII punctuate.

Head: Head 0.8x as long as wide (HL = 2.6mm, HW = 3.1mm); vertex 0.4x as wide as long, with broad 'Y' shaped depression; ocellar area bituberculate; frontal line finely impressed; inner orbits converging towards the vertex, UID: MID: LID= 0.7: 1.3: 1.3; ASD 3x as MOD; antennae thirteen segmented, scape 2.7x and F1 3x as long as its apical width, F1 = F2 = F3 = 0.4mm F11= 0.3mm; antennal sockets contiguous with fronto-clypeal suture; clypeus free margin arcuate, median emargination less distinct.

Mesosoma: Legs with forefemur excavated ventrally, fore tarsal rake absent, hind femur basoventrally angulate, with tubercle or projection, hind tibial spur nearly as long as hind basitarsus(1.1/1.2).

Metasoma: Metasoma 0.9x as long as mesosoma (Metasoma = 4mm, Mesosoma = 4.4mm); relative length of segments I: II = 0.9:1.2; sterna VIII emarginate; triangular glabrous area on the apex of sternites III-V; sterna VIII emarginate.

Material examined: Plesiotype: 1♀ India: Kerala, Thrissur: Ayyanthole 10°32'N, 76°11'E. 2.vi.2011. Baaby Job.

Other materials examined: 2♀, India: Kerala, Palakkad: Pattambi 10°48'N 76°11'E. 28.iii.2012. Baaby Job; 1♀, India: Kerala, Alappuzha: Pathiramanal 9°1'N 76°23' E. 02. iv.2012. Presty John; 1♀, India: Kerala, Wayanad: Thirunelli 11°54'N 75°59'E. 19.iv.2012. Baaby Job; 2♂, India: Kerala, Kottayam: Layikad 9°42'N, 76°54'E. 22.v.2012, Baaby Job; 1♂, India: Kerala, Ernakulam: Koothattukulam 9° 49' N 76° 36' E. 28.v.2012. Simon George; 1♂ India: Kerala, Thrissur: Ayyanthole 10°32'12"N, 76°11'8"E. 08.vi.2012. Baaby Job ; 1♂, India: Kerala, Ernakulam: Koothattukulam 9° 49' N 76° 36' E. 16.vi.2012, Simon George; 2♂, India: Kerala, Kottayam: Munnakal 9°7'N 76°70'E. 18.vi.2012. Simon George.

Distribution: Afghanistan, Bangladesh, Burma, China, Fiji, Iran, Iraq, Japan, Papua New Guinea, Philippines, Sri Lanka, Thailand, India [Assam, Orissa, Karnataka, Sikkim, Tamil Nadu, West Bengal, Kerala: Alappuzha, Ernakulam, Kottayam, Wayanad].

Biology: Unknown.

Remarks: Since the available description of this species is inadequate for easy identification, a redescription is provided here.

Liris subtessellatus Smith closely resembles *Liris sps H* in having 1. Pygidium basally with U shaped glabrous area; 2. Silver Vestiture; 3. Sculpture of propodeum. However *L. subtessellatus* differs from *L. sps H* in having 1. hind femora orange red (in *L. sps H* hind femora black) 2. Wing pale yellow (in *L. sps H* wings much darker yellow) 3. Hindwing media diverging at 2.6x length of cu-a (hindwing media diverging at 1.3x length of cu-a).

38. *Liris thenmalaensis* sp. nov.

(Fig 32a-e; Plate 14a)

Description

Female

Measurements in mm

TBL= 13.3; FWL= 7.6; SW= 2.

Colour: Black; tegula semitransparent brown; mandibles red except apically; tibiae and

T1-T4 red except T5 blackish red, hind femora red; wings yellow; hairs silver; tergites I-III apically with silvery fasciate; pygidium with setae appearing golden under certain lights.

Vestiture: Dense appressed hairs on clypeus except apically, lower frons and propodeum anterior and postero-lateral margin; appressed hairs moderately dense on

mesopleuron, coxa and mesosternum; hairs sparse on propodeum dorsally and scutum; sternites II-V laterally with fine appressed hairs; apical half of pygidium with stiff appressed setae.

Sculpture: Clypeus, frons, vertex, tergum IV, V and sternum III micropunctate; scutum, scutellum and metanotum punctate; propodeum striato-rugose dorsally, sides transversely striate and the hind face smooth, shiny; scattered punctae on sternites III-V, pygidium coarsely punctate, baso-dorsally basal half shiny, punctate.

Head: Head 0.8x as long as wide (HL = 2.7mm, HW = 3.3mm); vertex 0.7x as long as wide, with triangular shallow depression; inner orbits converging towards the vertex, UID: MID: LID= 0.72: 1.39: 1.67; ocellar area slightly bituberculate; frontal line finely impressed; ASD 1.5x as MOD MOD = 0.14mm, ASD = 0.22); antennae twelve segmented, scape 1.8x and F1 2.2x as long as its apical width, F1: F2: F3: F10 = 0.6: 0.5: 0.4: 0.3; antennal sockets contiguous with fronto-clypeal suture; clypeus 0.4x as long as wide (CL = 0.6mm, CW = 1.8mm), apex shiny; clypeal freemargin arcuate, with ill defined median emargination; mandibles pointed apically, inner margin with two median teeth.

Mesosoma: Pronotum depressed beneath the level of scutum; admedian lines, notuali on the scutum finely impressed, paradiscal lines faintly impressed; episternal sulcus complete, scrobe present; propodeum dorsally with median longitudinal carina, hind face gradually sloping with median longitudinal furrow; wings hyaline, AV of SMC II 0.85x as long as AV of SMC III (AV of SMC = 0.17mm, AV of SMC III = 0.2mm), marginal cell apex truncate; hind wing media diverging beyond cu-a at a distance 1.3x as long as cu-a (cu-a = 0.26mm, M+Cu = 0.33mm), hind wing jugal lobe 1.87x as long as hind wing; legs spinous, fore basitarsus with four rakespines; hind tibial spur 0.75x as long as hind basitarsus (HTS = 0.9mm, HBT = 1.2mm); forefemur excavated ventrally, fore basitarsus 3.3x as long as its apical width.

Metasoma: Metasoma 1.5x as long as mesosoma (Metasoma = 6.6mm, Mesosoma = 4.5mm); relative length of segments I:II = 1.9:1.1; pygidium 1.4x as its basal width, laterally carinate, apically with six spatulate setae.

Male: Unknown.

Etymology: The species is named after 'Thenmala', the place from where the Holotype was collected.

Material examined: Holotype: 1♀, India: Kerala, Kollam: Thenmala Butterfly Park 8°57'N 76°41'E. 02. v. 2012. Baaby Job.

Paratype: 1♀, India: Kerala, Thrissur: Ayyanthole 10°32'N 76°11'E. 2.vi.2010, Baaby Job; 1♀, India: Kerala, Ernakulam: Kanjiramala 9°86'N 76°57' E . 23.viii.2011. Baaby Job.

Depository: The specimen deposited at Department of Zoology, St. Thomas College, which will eventually be transferred to ZSIWGRC

Distribution: India [Kerala: Ernakulam, Kollam, Thrissur].

Biology: Unknown.

Remarks: *Liris thenmalaensis* closely resembles *Liris subtessellatus* (F. Smith) in having 1. Hind femora red; 2. hairs silver; 3. Pygidium with setae having golden tinge.

However, *Liris thenmalaensis* differs from *L. subtessellatus* in 1. legs red (in *L. subtessellatus* legs black except hindfemora); 2. Tergites I-III with apical fasciae (in *L. subtessellatus* tergites I-IV with apical fasciae); 3. Propodeum dorsally striato-rugose (in *L. subtessellatus* propodeum dorsally transversly striate).

39. *Liris wayanadensis* sp. nov.

(Fig 33a-b; Plate 14b)

Description

Female

Measurements in mm.

TBL = 20.7; FWL = 15.2; SW = 3.3.

Colour: Black; mandible except apically, labrum, scape, pedicel, tegula, forefemur, apical half of mid and hind femur, tibiae and tarsomeres of all legs orange red; pygidium basal half with brown tinge; hairs golden, tergites I-III with silver fasciae; wings brown, medially darkened.

Vestiture: Base of mandibles, clypeus basal half, lower frons, depression on vertex, gena, pronotum posterior margin, scutum and scutellum laterally, propodeum laterally, mesopleuron, legs and pygidium medially with appressed hairs; propodeum with erect hairs; tergites I-II with fine velvety pubescence.

Sculpture: Clypeus, frons, vertex, scutum, scutellum, metanotum punctate; propodeum dorso-medially rugose, edges, sides and hind face with transverse striae; sternites II-V punctate; pygidium dorsally coarsely punctate.

Head: 0.8x as long as wide (HL = 4.2mm, HW = 5.5mm); vertex with triangular depression and thinly impressed longitudinal line; ocellar area bituberculate; frontal line finely impressed; inner orbits converging above, UID: MID: LID = 1.4: 2.3: 3.1; antennae twelve segmented, scape, F1 3x as long as apical width; F1 0.5x as long as F2+F3 (F2+F3 = 2mm), F1: F2: F3: F10 = 1:1: 0.9: 0.5; clypeus 0.3x as long as wide (CL = 1.0mm, CW = 3.3mm), free margin arcuate; mandibles apically blunt, simple, externoventral notch absent.

Mesosoma: Pronotum depressed beneath level of scutum; admedian lines, paradiscal lines, notauli thinly impressed; scutum with postero-median line; propodeum 0.7x as long as scutum (propodeum = 2.2mm, scutum = 3.2mm), with dorso-median carina, hind face with median longitudinal sulcus; wings hyaline, forewing darker than hind wing; AV of SMC II 0.4x as long as AV of SMC III (AV of SMC II = 0.3mm, AV of SMC III = 0.7mm) hind wing media diverging beyond cu-a at length of cu-a (0.4mm); legs stout, spinous; hind tibia with median longitudinal carina bearing spines, hind tibial spur 0.7x as long as hind basi tarsus (HTS =1.2mm, HBT = 1.6mm).

Metasoma: 1.3x as long as mesosoma (Metasoma = 9.8mm, Mesosoma = 7.8mm); relative length of segment I: II = 1.7:1.8; tergites apically truncate; sterna I apically emarginate, sternum II with basal ridge; pygidial plate laterally carinate, apically rounded.

Male: Unknown

Etymology: The species derives its name from its place of collection Wayanad.

Material examined: Holotype: 1♀, India: Kerala, Wayanad: Kuruva 11°49'N 76°5'E 17.iv.2012 .Baaby Job.

Paratype: 1♀, India: Kerala, Wayanad: Ambalavayal 11°61' N 76°21' E. 21.iv.2012, Baaby Job.

Depository: The specimen deposited at Department of Zoology, St. Thomas College, which will eventually be transferred to ZSIWGRC.

Distribution: India [Kerala: Wayanad].

Biology: Unknown.

Remarks: *Liris wayanadensis* sp.nov. closely resembles *Liris aurulentus* Fabricius in having 1. Body black with legs orange red; 2. Hairs golden; 3. Propodeum with dorso-median carina.

However *L. wayanadensis* differs from *L. aurulentus* in 1. Hairs sparse, sculpture on head and mesosoma visible (in *L. aurulentus* sculpture on head and mesosoma is concealed by dense vestiture); 2. Pygidium coarsely punctate without apical spines (in *L. aurulentus* pygidium covered with stiff, appressed setae, apically with six spatulate spines); 3. Tergites I-III with silver fasciae (in *L. aurulentus* tergites I-IV with silver fasciae).

Genus *Lyroda* Say

Lyroda Say, 1837: 372. Type species: *Lyroda subita* Say: 1837, designated by Patton, 1880:386.

Morphota F. Smith, 1856: 293. Type species: *Morphota fasciata* F. Smith, 1856, designated by Pate, 1937: 41.

Odontolarra Cameron, 1900b: 35. Type species: *Odontolarra rufiventris* Cameron, 1900b [= *Morphota formosa* F. Smith, 1859], by monotypy.

Lyrodon Howard, 1901: pl. 6, fig. 5. Lapsus for *Lyroda* Say, 1837. Junior homonym of *Lyrodon* Goldfuss, 1837.

Diagnosis

Head: Inner orbits parallel or converging towards vertex; flagellomeres longer than broad; clypeal freemargin with lateral teeth in females, in males with medially truncate or weakly toothed lobe; inner mandibular margin simple in male, in females with two subbasal teeth, mandibles externo-ventrally notched; occipital carina incomplete.

Mesosoma: Pronotal collar dorsally with three tubercles; propodeal enclosure not defined; propodeum dorsally with median longitudinal carina; scrobal sulcus present; fore tarsal rake weakly developed; mid coxae separated, hind coxae contiguous; hind tibiae with two rows of spines, first row of spines situated on carina; forewing with three SMC's; jugal lobe equal to or less than half of anal area.

Metasoma: Sessile; pygidial plate carinate, covered with setae; male sternum VIII trispinose, volsella differentiated.

Distribution: Cosmopolitan.

Biology: Nests in ground, prey includes Orthoptera (Gryllidae and Tetrigidae). The prey is grasped by antennae, either flown directly or in short, gliding flights to nest (Iwata, 1963); Evans (1964) reported nests being parasitized by miltogrammine flies.

Remarks: Genus *Lyroda* Say closely resembles genus *Sericophorus* F. Smith in having 1. Inner orbits converging towards vertex or parallel; 2. mandible externo-ventrally notched; 3. Pygidial plate carinate, covered with setae.

However, genus *Lyroda* differs from *Sericophorus* in 1. SMC II four to six sided (in *Sericophorus* SMC III three sided); 2. Both recurrent veins received by SMC II or recurrent vein I interstitial (in *Sericophorus* recurrent vein I received by SMC I and recurrent vein II received by SMC II); 3. Occipital carina incomplete, not joining hypostomal carina ((in *Sericophorus* occipital carina joining hypostomal carina).

In India this genus is represented by five species.

40. *Lyroda formosa* (F. Smith).

Morphota formosa F. Smith, 1858b:17, ♀. Indonesia, (BMNH).

Lyroda Formosa (F. Smith): Kohl, 1885a: 267, new combination for *Morphota formosa* F. Smith.

Odontolarra rufiventris Cameron, 1900b: 36, ♀. India: Assam (OUM). [Synonymized with *Lyroda formosa* by Pulawski, 1975a:319].

Lyroda rufiventris (Cameron): Turner, 1914:256, new combination for *Odontolarra rufiventris* Cameron, confirmed by Richards, 1935a:165.

Diagnosis

Female

Length 7-8mm. Body with velvety appearance. Black; metasomal segments I-II red; hairs silvery with golden tint; tergites I-IV apically with silver fasciae; clypeus, frons, gena, pronotum, scutum and propodeum apically and on sides with appressed hairs; propodeum rugose; frontal line deeply impressed; scutum anteriorly with median

depression; propodeum basally with median longitudinal carina not reaching apex; metasoma curved.

Male: Unknown.

Material examined: No material examined. The above description of species is based on that given by Bingham, 1897.

Distribution: China, Indonesia, New Guinea, Oman, Philippines, Thailand, India [Assam, Uttar Pradesh, West Bengal, Sikkim and Kerala: Malabar].

Biology: Nests are constructed in ground by renovating crevices and other holes; Iwata (1938, 1964) reported *Lyroda formosa* (F. Smith) utilizing deep burrows of sand wasps as nests.

Remarks: This species was first reported in Kerala by Sudheendrakumar and Narendran, 1989.

Genus *Miscophus* Jurine

Miscophus Jurine, 1807:206. Type species: *Miscophus bicolor* Jurine, 1807, by monotypy.

Niteloapterus Ashmead, 1897: 22. Type species: *Niteloapterus slossonae* Ashmead, 1897, by monotypy.

Hypomiscophus Cockerell, 1898: 321. Type species: *Miscophus arenarum* Cockerell, 1898, by original designation.

Miscophinus Ashmead, 1898:187. Type species: *Miscophus laticeps* Ashmead, 1898, by original designation.

Diagnosis

Head: Inner orbits bowed outwards, sinuate below, converging towards vertex; flagellomeres longer than wide; frons usually simple; frontal line present; clypeal freemargin laterally incised, with truncate median lobe or freemargin sinuate;

mandible simple, teeth absent, externo-ventrally notched; occipital carina ending before hypostomal carina or before it.

Mesosoma: Pronotal collar with median projection, as long as scutum; admedian lines present; scrobal sulcus present or absent; propodeal enclosure absent, with median longitudinal carina; precoxal lobes distinct; female legs with foretarsal rake, absent in males; midcoxa with baso-dorsal tubercle; hindcoxa contiguous, hindtibia with outer row of spines present or absent; forewing with two SMC's and discoidals, SMC II petiolate, marginal cell of apically truncate or acuminate;

Metasoma: sessile; tergum VI in females conical, pygidial plate absent; volsella with freemargin setose.

Distribution: Cosmopolitan

Biology: Nests are dug in loose sandy soil, mass provisioned with immature spiders. They mimic ants and prefer walking to flying (Bohart and Menke, 1976).

Remarks: In India this genus is represented by four species.

Genus *Miscophus* Jurine closely resembles genus *Solierella* Spinola in having 1. Clypeal freemargin in females with truncate median lobe; 2. Inner mandibular margin simple, without teeth; 3. tergum VI conical in females; 4. tarsomere V not swollen.

However, *Miscophus* differs from *Solierella* in having 1. SMC II petiolate (in *Solierella* three SMC's present, if two SMC's then SMC II not petiolate); 2. Frons simple (in *Solierella* frons with V shaped carina); 3. Mandibles notched externo-ventrally (in *Solierella* externo-ventral notch on mandible absent). **New record to Kerala.**

41. *Miscophus apoorvus* sp. nov.

(Fig 35a-h; Plate 15c, d)

Description.

Female.

Measurements in mm.

TBL = 9.2; FWL = 5.2; SW = 1.4.

Colour: Black; metasomal segments I, II and basal half of III red; mandibles brown; tegulae and scape ventrally semi-transparent brown; wings brown, hindwing with purple effulgence, forewing apically with black band; hairs silver.

Vestiture: Clypeus, lower frons, gena, pronotum, scutum lateral margin, mesopleuron, propodeum, legs with appressed hairs; tergites I-IV apically with fasciae.

Sculpture: Clypeus except apically, frons, vertex, gena, scutum, scutellum, mesopleuron, sternites II-IV, pygidium dorsally micropunctate; basal half of pronotum with transverse ridges; propodeum microsculptured, sides and hindface transversly striate; sternum V apical half and pygidium ventrally with coarse punctae.

Head: 0.7x as long as wide (HL = 1.4mm, HW = 1.9mm), depressed below, vertex with fovea between hindocelli and inner orbit; inner orbits converging towards clypeus, UID: MID: LID = 0.8: 0.9: 1.1; POL: OOL = 0.15: 0.21; antennae twelve segmented, scape 2x and F1 2.4x as long as its apical width; F1 0.5x as long as F2+F3 (F2+F3 = 0.58mm); F1: F2: F3: F10 = 0.3: 0.3: 0.28: 0.18; clypeus arcuate with lateral incisions; mandibles notched externo-ventrally.

Mesosoma: Scutum with admedian and paradiscal lines; propodeum dorsally with median longitudinal carina, hind face with median furrow; wings hyaline, SMC II petiolate, four sided; SMC I 0.8x as long as first discoidal (SMC I = 1mm, Discoidal I = 1.3mm); hind wing media diverging beyond cu-a at 1.7x length of cu-a; apical spines of tarsomeres I-III longer than succeeding articles; fore tarsal rake present; hind tibial spur 0.3x as long as hind basitarsus (HTS = 0.7mm, HBT = 1.7mm).

Metasoma: as long as mesosoma (Metasoma = 4.0mm, Mesosoma = 3.9mm); sessile; relative length of segments I: II = 0.9:0.95.

Male: Unknown.

Etymology: The species derives its name from the Sanskrit word ‘*apoorva*’ meaning rare.

Material examined: Plesiotype: 1♀, India: Kerala, Ernakulam: Aluva 10°6’N 76°21’E 16.iii.2012. Baaby Job.

Paratype: 1♀, India: Kerala, Ernakulam: Aluva 10°6’N, 76°21’E 16.iii.2012. Baaby Job.

Depository: The specimen deposited at Department of Zoology, St. Thomas College, which will eventually be transferred to ZSIWGRC.

Distribution: India [Kerala: Ernakulam]

Biology: observed in sandy soil, nests are circular holes of about 3-5cm in diameter.

Remarks: *Miscophus apoorvus* sp. nov. closely resembles *Miscophus quettaensis* Nurse in having 1. Metasomal red and black; 2. Body closely and minutely punctate; 3. Metasoma nearly as long as mesosoma.

However, *Miscophus apoorvus* differs from *M. quettaensis* in having 1. Propodeum microsculptured (in *M. quettaensis* propodeum obliquely striate); 2. Forewing apical margin with black colour (in *M. quettaensis* forewing slightly infuscate); 3. Metasomal segments I, II and basal half of III red (in *M. quettaensis* only basal two segments red).

Genus *Solierella* Spinola

Solierella Spinola, 1851: 349. Type species: *Solierella miscophoides* Spinola, 1851, by monotypy.

Sylaon Piccioli, 1869a: pl. 1. Type species: *Silaon compeditus* Piccioli, 1869, by monotypy.

Silaon Piccioli, 1869b: 283. Lapsus or emendation of *Sylaon* Piccioli, 1869.

Niteliopsis Saunders, 1873: 410. Type species: *Niteliopsis pisonoides* S. Saunders, 1873, by monotypy. Gender: feminine (Article 30.1.2 of the Code).

Ammosphacidium Kohl, 1878: 701. Type species: *Ammosphacidium helleri* Kohl, 1878 [= *Silaon compeditus* Piccioli, 1869a], by monotypy.

Lautara Herbst, 1920: 217. Type species: *Lautara jaffueli* Herbst, 1920, by monotypy.

Diagnosis

Head: Inner orbits converging towards vertex; antennae thirteen segmented in males, F11 short, conical or longer than preceding flagellomeres; frons with V shaped swelling bearing similar carina; clypeal freemargin with rounded or truncate median lobe in female, male with median lobe bearing three teeth; mandibles simple, without teeth; externo-ventral notch absent.

Mesosoma: Pronotal collar short; admedian lines present; propodeal enclosure delimited by carina, without hairs, granulate or foveolate; fore tarsal rake present or absent; male forecoxa with baso-ventral process, fore trochanter posterobasally excavated; hindcoxae contiguous; hind tibiae with or without outer row of spines; fore wing with three SMC's, SMC II petiolate, marginal cell truncate, appendiculate.

Metasoma: Tergum VI in females conical or rounded, tergum VII in males flat; pygidial plate absent; volsella reduced or absent, aedeagus head with teeth.

Distribution: Cosmopolitan, but mainly represented in Nearctic and Palearctic region.

Biology: Nests in pre-existing cavities of plant stems, twigs or abandoned burrows. Prey includes Hemiptera, Orthoptera (grass hoppers) and Psocoptera. Parasitised by chrysidids, *Hedychridium* sp. and *Pseudolopyga* sp. (Carrillo and Caltagirone, 1970; Krombein, 1967b).

Remarks: In India this genus is represented by only one species, *Solierella turneri* Dutt.

Genus *Solierella* Spinola closely resembles genus *Plenoculus* W.Fox in having 1. Forewing with three SMC's, SMC II petiolate; 2. Fore wing marginal cell apically

truncate, appendiculate; 3. Inner orbits converging towards vertex; 4. Mid coxae separated, hindcoxae contiguous.

However, *Solierella* differs from *Plenoculus* in having 1. Pygidial plate absent (in *Plenoculus* females triangular, apically blunt pygidial plate, delimited by carina); 2. Frons with V shaped carina or swelling (absent in *Plenoculus*); 3. Male fore trochanter posterobasally excavated or concave (absent in *Plenoculus*).

42. *Solierella turneri* Dutt

Solierella turneri Dutt in Turner, 1917: 205, sex not indicated. India (BMNH).

Diagnosis

Length 3.5mm; Forewing length 3.5mm. Black; pronotum posterior margin with medially interrupted transverse band, tegulae, pronotal lobe, transverse line on metanotum, marks on fore femorae and tibiae, midtibiae, hindtibiae and tarsomeres except black markings yellow; tegulae with median brown spot; fore tarsomeres slightly brown; clypeus, frons, gena with silver hairs; head, mesosoma, metasoma with fine punctae; propodeum coarsely reticulate, hind face transversely striate; inner orbits converging towards vertex; pronotum transverse, scutellum convex; propodeum above hind face with median pit, hind face with median longitudinal furrow; metasomal segment I concave, metasomal segments II-III basally constricted.

Materials examined: No material examined. The above description of species is based on that given by Dutt, 1917.

Distribution: India [Bihar, Kerala: Malabar].

Biology: Unknown.

Remarks: *Solierella turneri* Dutt has been reported from Kerala by Sudheendrakumar and Narendran, 1989.

Genus *Pison* Jurine

Pison Jurine in Spinola, 1808: 255. Type species: *Pison jurini* Spinola, 1808 [correctly *jurinei* = *Alyson ater* Spinola, 1808], by monotypy.

Tachybulus Latreille, 1809: 75. Type species: *Tachybulus niger* Latreille, 1809 [= *Alysson ater* Spinola, 1808], by monotypy.

Nephridia Brullé, 1833: 408. Type species: *Nephridia xanthopus* Brullé, 1833, by monotypy.

Pisonitus Shuckard, 1838: 79. Type species: *Pison argentatum* Shuckard, 1838, designated by Pate, 1937: 51.

Pisum Agassiz, 1846: 293, junior homonym of *Pisum* Megerle, 1811. Unjustified emendation of *Pison* Jurine, 1808.

Pisonoides F. Smith, 1858a: 104 (authorship attributed to Shuckard, as subgenus of *Pison*). Type species: *Pison obliteratum* F. Smith, 1858a, by monotypy.

Parapison F. Smith, 1869: 298. Type species: *Pisonoides obliteratus* F. Smith, 1858a, designated by Pate, 1937: 47.

Pseudonysson Radoszkowski, 1876: 104 (as *Pseudo-Nysson*, incorrect original hyphenation). Type species: *Pseudonysson fasciatus* Radoszkowski, 1876, by monotypy.

Taranga Kirby, 1883: 201. Type species: *Taranga dubia* W.F. Kirby, 1883 [= *Pison spinolae* Shuckard, 1838], by monotypy.

Paraceramius Radoszkowski, 1887: 432, junior homonym of *Paraceramius* de Saussure, 1854. Type species: *Paraceramius koreensis* Radoszkowski, 1887, by monotypy.

Pisum Schulz, 1906: 212, junior homonym of *Pisum* Megerle, 1811 and *Pisum* Agassiz, 1846. Unjustified emendation of *Pison* Jurine, 1808.

Krombeiniellum Richards, 1962: 118. Substitute name for *Paraceramius* Radoszkowski, 1887.

Entomopison Menke, 1968a: 5. Type species: *Pison pilosum* F. Smith, by original designation.

Diagnosis

Head: Inner orbits converging towards vertex; frons simple or frontal carina present; basal flagellomeres modified in males; clypeal free margin truncate or with V shaped median lobe; mandible usually simple; occipital carina disappearing before hypostomal carina.

Mesosoma: Scutum with notauli present or absent; propodeal enclosure absent, but with median longitudinal sulcus or carina; lateral carina or sulcus between propodeal spiracle and petiole socket; mid coxae separated, hind coxae contiguous; fore wing with three SMC's, SMC II petiolate; marginal cell acuminate, ending well beyond outer veinlet of last SMC; hamuli of hind wing divided into two groups.

Metasoma: Sessile; lateral carina on tergites I-II; sternites in males with median tubercles or welts; tergum VI in females conical; pygidial plate absent; gonostyle simple or biramous, volsella enlarged, partially fused with gonostyle.

Distribution: Cosmopolitan; due to their nesting habits in woods and items transported by ships they have been introduced to many parts of world.

Biology: Nests in pre-existing cavities of plant stems, woods, beetle burrows, nests of other wasps like *Eumenes* sps or *Sceliphron* sps. ; nests are partitioned with mud and provisioned with spiders. The main parasites include eulophid, *Melittobia chalybzi* [on *Pison koreense* (Radoszkowski)], *Chrysis* sp. [on *P. argentaturn*], Dipteran flies [on *Pison atrum* (Spinola)] and *Neoleucospis masculina* Bouček (Sheldon, 1968; Rasplus, 1987).

Remarks: Genus *Pison* Jurine is divided into four subgenus: subgenus *Pison* Jurine, subgenus *Entomopison* Menke, subgenus *Krombeiniellum* Richards and subgenus *Pisonoides* F.Smith (Bohart and Menke, 1976).

In India this genus is represented by eleven species in two subgenera - *Pison* Jurine and *Pisonoides* F.Smith

Genus *Pison* Jurine closely resembles genus *Pisonopsis* Fox in having 1. Propodeum dorsally with median longitudinal sulcus; 2. Metasoma sessile; 3. Fore wing with three SMC's. However, genus *Pison* differs from genus *Pisonopsis* in 1. Sternites without transverse oblique groove (in *Pisonopsis* sternites III-IV laterally with transverse oblique grooves); 2. Mandibular externo-ventral notch absent (in *Pisonopsis* mandibular externo-ventral notch present); 3. Marginal cell acuminate, ending distally well beyond outer veinlet of last SMC (in *Pisonopsis* marginal cell rounded or truncate distally).

43. *Pison punctifrons* Shuckard

(Fig 39a; Plate 16c)

Pison punctifrons Shuckard, 1838: 77, ♀. Holotype or syntypes: India or St. Helena (OXUM).

Pison suspiciosum F. Smith, 1858b: 104, ♀ (misspelled as *suspiciosus* by F. Smith). Singapore (OXUM). [Synonymized with *Pison punctifrons* by Turner, 1916: 625].

Pison fabricator F. Smith, 1869: 297, ♀ China (BMNH). [Synonymized with *Pison punctifrons* by Turner, 1916: 625].

Pison striolatum Cameron, 1897a: 82, ♀. India (OXUM). [Synonymized with *Pison punctifrons* by Turner, 1916: 625].

Pison lagunae Ashmead, 1904b: 131, ♂, Philippines (USNM). [Synonymized with *Pison punctifrons* by Krombein, 1949: 400].

Pison javanus Cameron, 1905b: 63, ♂, (misspelled as *javanum* by Cameron), Indonesia (Amsterdam). [Synonymized with *Pison punctifrons* by Turner, 1916: 625].

Pison japonicum Gussakovskij, 1937: 627, ♂. Japan (ZIL). [Synonymized with *Pison punctifrons* by Tsuneki, 1964a: 49].

Redescription

Female

Measurements in mm

TBL = 8.1; FWL = 6.4; SW = 1.7.

Colour: Black; mandibles medially red; hairs silver.

Vestiture: Clypeus, lower frons along inner orbits with appressed hairs; gena, upper frons, vertex, pronotum, scutum, mesopleuron, propodeum, legs, metasoma with erect hairs.

Sculpture: Body shining; clypeus, mesopleuron coarsely punctate; frons rugose-punctate; vertex, scutum, scutellum, metanotum punctate; propodeum baso-dorsally with oblique ridges, hindface transversely striate, sides shining, sparsely punctate; pronotal punctae running into transverse striae; metanotum finely punctate.

Head: 0.9x as long as wide (HL = 1.9mm, HW = 2.2mm); inner orbits medially emarginate, UID: MID: LID = 0.8: 1.7: 1.0; POL: OOL = 0.1: 0.2, hind ocelli margined above by transverse curved line; antennae twelve segmented, scape 1.5x and F1 2.6x as long as its apical width; F1 0.55x as long as F2+F3 (F2+F3 = 0.4mm); F1: F2: F3: F10 = 0.2:0.2:0.2:0.14; frontal line absent; antennal sockets contiguous with frontoclypeal suture; clypeus 0.4x as long as wide (CL = 0.4mm, CW = 1.0mm), basomedially convex, freemargin obtusely angulate with triangularly pointed median lobe.

Mesosoma: Pronotal collar posteriorly truncate; admedian lines, notualus faintly impressed, paradiscal lines faintly impressed; propodeum dorsally with baso-medain carina, hind face with median longitudinal furrow; wings clear hyaline, apically infusate, with purple effulgence; forewing with three SMC's, SMC II petiolate; recurrent vein I received by SMC I, II ending on posterior margin of SMC II; hindwing media diverging beyond cu-a at 2x length of cu-a (cu-a = 0.2mm, M+Cu = 0.4mm); legs stout, arolium as long as claws; hindtibial spur 0.9x as long as hindbasitarsus (HTS = 0.48mm, HBT = 0.55mm).

Metasoma: Sessile, 1.1x as long as mesosoma (Metasoma = 3.7mm, Mesosoma = 3.4mm); relative lengths of segments I: II = 1.5:0.9; pygidium apically pointed with apico-media longitudinal carina.

Male

Length 10-12mm; body shining; black; hairs silver; propodeum baso-dorsally with oblique ridges, hindface transversely striate; wings hyaline; clypeal freemargin obtusely angulate with triangularly pointed median lobe; vertex with transverse furrow; SMC II petiolate; recurrent vein I received by SMC I (Bingham, 1897).

Material examined: Plesiotype: 1♀ India: Kerala, Thiruvananthapuram: vellayani 8°26'N 76°59'E.10.iii.2012, Baaby Job.

Other material examined: 1♀ India: Kerala, Kollam: Urukunnu 8°98'N 77°2'E 02.v.2012, Baaby Job; 1♀ India: Kerala, Thrissur: Chelakkottukara Chelakkottukara 10°39'57" N, 76°21'4"E. 07.vii.2012, Baaby Job.

Distribution: China, Japan, Korea, SouthEast Asia and India [Maharashtra, Uttar Pradesh, West Bengal, Kerala: Thrissur, Kollam, Thiruvananthapuram].

Biology: Krombein and Norden (2001) detailed nesting habits of *Pison punctifrons* Shuckard; nests are sealed and partitioned with mud, provisioned with spiders.

Remarks: *Pison punctifrons* Shuckard closely resembles *Pison rugosum* F. Smith in having 1. Body black with silvery hairs; 2. Propodeum with oblique striae; 3. Vertex behind hind ocelli with transverse marking.

However *P. punctifrons* differs from *P.rugosum* in 1. Metasoma smooth, shining (in *P.rugosum* metasomal segment I punctate, with rest of segments sparsely punctate; 2. wings apically infusate (in *P.rugosum* wings clear, hyaline); 3. Recurrent vein II ending on posterior margin of SMC II (in *P.rugosum* recurrent vein II received in middle of SMC II).

Genus *Trypoxylon* Jurine

Trypoxylon Latreille, 1796: 121, no included species. Type species: *Sphex figulus* Linnaeus, 1758, designated by Latreille, 1802b: 339 (first included species).

Tripoxilon Spinola, 1806: 65. Lapsus or emendation of *Trypoxylon* Latreille, 1796.
Apius Panzer, 1806:106. Type species: *Sphex figulus* of Panzer, 1801 [= *Sphex figulus* Linnaeus, 1758], by monotypy.

Apius Jurine, 1807: 140, junior homonym of *Apius* Panzer, 1806. Type species: *Sphex figulus* of Fabricius, 1775 [= *Sphex figulus* Linnaeus, 1758], designated by Morice and Durrant, 1915:394.

Trypoxilon Jurine, 1807: 141 and tableau comparatif, p. 2. Lapsus or emendation of *Trypoxylon* Latreille, 1796.

Trypoxylum Agassiz, 1846: 380. Unjustified emendation of *Trypoxylon* Latreille, 1796

Trypoxylum Schulz, 1906: 212, junior homonym of *Trypoxylum* Agassiz, 1846. Unjustified emendation of *Trypoxylon* Latreille, 1796.

Trypargilum Richards, 1934: 191. Type species: *Trypoxylon nitidum* F. Smith, 1856, by original designation.

Asaconoton Arnold, 1959: 322. Type species: *Trypoxylon egregium* Arnold, 1959, by original designation.

Diagnosis

Head: Inner orbits converging towards vertex or clypeus or parallel; frons with carina; frontal line carinate, often bifurcating above; antennal sockets separated from frontoclypeal suture; clypeal free margin entire, notched or with two two finger like process; mandibles simple in male, apically bidentate in females; occipital carina incomplete or meeting hypostomal carina.

Mesosoma: Notauli present or absent; propodeum with dorsal longitudinal sulcus, sides with carina; petiole socket dorsally with concave band or convex band with lamella or sharply edged or lamellate; propodeal sternite may be present; mid coxae separated, female hind coxa with projection resembling perforated tubercle; forewing with one SMC and recurrent vein; marginal cell apically acuminate.

Metasoma: Elongate, clavate, tergum I forming petiole; tergum VI in females conical, pygidial plate absent; male sternum VIII apically with two processes or absent; volsella simple; gonostyle simple or biramous.

Distribution: Cosmopolitan.

Biology: Commonly called as ‘Key-hole wasps’ due to nesting habits; nests in pre-existing cavities like plant stems or burrows in wood, ground or abandoned nests of other wasps, or nail holes, keyholes, folded papers etc. They exhibit unique character in that males often assist female in nest construction, cell closure and nest guarding. Nests are provisioned with spiders (Rau, 1933; Paetzel, 1973).

Remarks: Genus *Trypoxylon* has been divided into two subgenus: subgenus *Trypargilum* Richards and subgenus *Trypoxylon* Latreille (Richards, 1934; Krombein, 1967 a, b). In India only subgenus *Trypoxylon* Latreille is represented by forty eight species and subspecies.

Genus *Trypoxylon* Latreille closely resembles Genus *Pisoxylon* Menke in having 1. Propodeum with median longitudinal sulcus; 2. Hind coxae contiguous; 3. Forewing with one SMC and recurrent vein. However genus *Trypoxylon* differs from genus *Pisoxylon* in 1. Metasoma slender, clavate (in *Pisoxylon* Metasoma compact, sessile; 2. frontal carina bifurcating above (in *Pisoxylon* frontal carina Y shaped); 3. propodeum with lateral carina (in *Pisoxylon* lateral carina absent).

Key to species of the genus *Trypoxylon* Latreille in Kerala

1. Frons with shield-shaped enclosure, with lateral carina extending into emargination of inner orbits (Fig 38a).....*Trypoxylon pileatum* Smith
- Frons without shield- shaped enclosure.....2

2. Propodeum laterally with carina.....3
- Propodeum without lateral carina (Fig 36c)..... *Trypoxylon bicolor* Smith

3. Metasoma black; legs black.....*Trypoxylon nishidai* Tsuneki

- Metasoma black with shades of red; legs whitish yellow or brown.....4
4. Metasomal segments II-III red with black markings above (Plate 14); foretarsomeres whitish yellow; pronotum posterior margin black.....
.....*Trypoxylon errans* Saussure
_ Metasoma black with rust brown or yellow red; foretarsomeres brown; pronotum posterior margin brown.....5
5. Length 10-12mm; metasomal segments II-III rust brown; pronotal collar with median tubercle.....*Trypoxylon vardy* Tsuneki.
- Length 14mm; metasomal segments II-IV red yellow; pronotal collar weakly bituberculate.....*Trypoxylon lamellatum* Tsuneki

44. *Trypoxylon bicolor* F. Smith
(Fig 36a-d; Plate 15a)

Trypoxylon bicolor F. Smith, 1856: 377, ♀, Singapore (BMNH). designated by Tsuneki, 1978: 3.

Trypoxylon bicolor marginatum Tsuneki, 1976: 76, ♀ (junior primary homonym of *Trypoxylon marginatum* Cameron, 1912). Philippines (ZMUC). [Synonymized with *Trypoxylon bicolor* by Tsuneki, 1980: 2].

Trypoxylon bicolor dorsale Tsuneki, 1977b: 4 (junior primary homonym of *Trypoxylon dorsale* Tsuneki, 1977a: 5 (= *Trypoxylon eximium*). Substitute name for *Trypoxylon bicolor marginatum* Tsuneki, 1976). [Synonymized with *Trypoxylon bicolor* by Tsuneki, 1980: 2].

Redescription

Female.

Measurements in mm.

TBL = 14.5; FWL = 7.8; SW = 1.4.

Colour: Black; basal half of mandibles, tegulae semitransparent brown; mandibles apical half, clypeus apical one third red brown; metasomal segments II-III red; fore tarsomeres, mid tarsomere I-II and II-IV ventrally, tibiae of all legs basally white yellow; wings brown; hairs silver.

Vestiture: Clypeus, lower frons, gena with appressed hairs; pronotum, scutum, mesopleuron, fore and mid femur, propodeum with erect hairs; metasoma sparsely pubescent.

Sculpture: Frons rugose-punctate; propodeum smooth, shiny.

Head: 0.9x as long as wide (HL = 1.9mm, HW = 2.3mm); frons above antennal sockets with rounded elevation, frontal line finely impressed, carinate above frontal lobe; inner orbits emarginate, UID: MID: LID = 0.8: 2.1: 0.8, POL: OOL = 0.2: 0.2; antennae twelve segmented, apically wide, scape 2.3x and F1 10.5x as long as its apical width; F10 as long as wide (0.2mm), F1 0.8x as long as F2+ F3 (F2+ F3 = 0.7mm); F1: F2: F3: F10 = 0.6: 0.4: 0.3: 0.3; antennal sockets separated from frontoclypeal suture by ASD (ASD = 0.14mm); clypeus as long as wide (0.6mm), free margin arcuate; mandibles simple.

Mesosoma: Pronotum anterolaterally with pointed triangular teeth, posterior margin rounded, laterally with blunt tubercles; admedian lines, paradiscal lines, notuali finely impressed; propodeum 2.1x as long as scutum (propodeum = 0.7mm, scutum = 1.4mm); propodeal enclosure absent, apical half with median longitudinal sulcus; wings clear, hyaline, apically infusate; SMC I 0.7x as long as first discoidal (SMC I = 1.4mm, Discoidal I = 2.1mm); legs slender; hind tibial spur 0.5x as long as hind basitarsus (HTS = 0.6mm, HBT = 1.1mm).

Metasoma: 2.2x as long as mesosoma (Metasoma = 9.3mm, Mesosoma = 4.3mm); petiole flask shaped; relative length of segment I: II = 4.3:1.1; pygidium apically pointed.

Male: Unknown

Material examined: Plesiotype: 1♀, India: Kerala, Malappuram: Kondotty 11°14'N 75°96' E. 23.iv.2011. Baaby Job.

Other material examined: 1♀, India: Kerala, Malappuram: Chamramattom 10° 81'N 75°95'E. 21.iii.2012, Baaby Job; 1♀ India: Kerala, Kollam: Thenmala Butterfly Park 8°57'N 77°4'E. 02.v.2013, Nithin Saji.

Distribution: China, Hawaii, Malaya, Maldives, South East Asia, SriLanka and India [Sikkim, West Bengal, Tamil Nadu, Kerala: Kollam, Malappuram (**New record to Kerala**)].

Biology: Bridwell (1917) reported cells of *Trypoxylon bicolor* Smith from rotten wood of *Pisonia* sps. Williams (1927) reported *T. bicolor* to be nesting in hollow twigs and old beetle holes. Yoshimoto (1964) made detailed study on the nesting activity of *T. bicolor* in Hawaii. The wasps stocks nests with spiders of family Salticidae, spiders were permanently paralyzed and carried using forelegs. The nest was constructed using pebbles, insect integument pieces, mud pebbles etc. The nests parasitized by *Trogoderma anthrenoides* (Shp.) (Coleoptera: Dermestidae) and *Liposcelis divinatoris* (Muller) (Psocoptera: Liposcelidae).

Remarks: Since the available description of this species is inadequate for easy identification, a redescription is provided here.

Trypoxylon bicolor F. Smith closely resembles *Trypoxylon gracilescens* F. Smith in having 1. Hairs silver; 2. Legs coloured with black and white yellow; 3. Propodeum with median longitudinal sulcus.

However, *T. bicolor* differs from *T. gracilescens* in having 1. Metasomal segments II-III red (in *T. gracilescens* metasomal segment II- VI red); 2. Clypeus and scape black (in *T. gracilescens* clypeus and scape dull yellow brown); 3. median longitudinal sulcus broadening near middle of propodeum (in *T. gracilescens* median longitudinal sulcus broadening near apex).

45. *Trypoxylon errans* Saussure

(Fig 37a-e; Plate 14d)

Trypoxylon errans de Saussure, 1867:84, ♀. Mauritius (MHNG).

Trypoxylon intrudens F. Smith, 1870: 188, ♀. India (BMNH), designated by Tsuneki, 1978:28. [Synonymized with *Trypoxylon errans* by Tsuneki, 1978b: 28].

Trypoxylon canaliculatum Cameron, 1889:122, ♀. India (OXUM), designated by Tsuneki, 1978b:38. [Synonymized with *Trypoxylon errans* by Tsuneki, 1978: 38].

Trypoxylon geniculatum Cameron, 1902c: 313, ♀. India (BMNH), designated by Tsuneki and synonymized with *Trypoxylon errans* by Tsuneki, 1978: 46.

Trypoxylon philippinense Ashmead, 1904a: 283, ♂ (misspelled as *Philippinense*, by Ashmead) Philippines (USNM). [Synonymized with *Trypoxylon errans* by Tsuneki, 1978: 72].

Trypoxylon gardineri Cameron, 1907b: 76, ♀. Seychelles Islands (BMNH). [Synonymized with *Trypoxylon errans* by R. Turner, 1911: 372].

Trypoxylon ornatipes Cameron, 1913: 24, ♀. (junior primary homonym of *Trypoxylon ornatipes* Cameron, 1889, and of *Trypoxylon ornatipes* W. Fox, 1891). India (BMNH). [Synonymized with *Trypoxylon errans* by Tsuneki, 1978: 60].

Trypoxylon pulawskii Tsuneki, 1956: 22, ♀, Japan (Hyogo Mus.). [Synonymized with *Trypoxylon errans* by Tsuneki, 1981b: 59].

Trypoxylon tanoi Tsuneki, 1967c: 13, ♂, Taiwan (USNM). [Synonymized with *Trypoxylon errans* by Tsuneki, 1978b:72].

Trypoxylon saitamaense Tsuneki, 1973: 13, ♂. Japan (Hyogo Mus.). [Synonymized with *Trypoxylon errans* by Tsuneki, 1981b: 59].

Redescription

Female.

Measurements in mm.

TBL = 9.4; FWL = 5.6; SW = 1.4.

Colour: Black; mandibles, clypeus apically, tegulae semitransparent brown; petiole apex, metasomal segments II-III red brown with black markings above; fore and mid trochanter, forefemur except ventrally, fore tarsomeres, midfemur apically and basally, mid tarsomeres I-II and II-IV ventrally, hind tibia basally white yellow; hairs silver.

Vestiture: Clypeus except apically, frons upto middle of orbits, gena, pronotum basal half, propodeum postero-laterally with dense, appressed hairs; fore and mid coxae ventrally, scutum, scutellum, mesopleuron with erect hairs; metasoma with fine appressed hairs; sternites II-V apically with sparse erect setae.

Sculpture: Frons, vertex coarsely punctate; scutum punctate; propodeum transversly striate medially and submedially, intervening space smooth, shiny and with transversly ridged dorsolateral longitudinal rows of carina.

Head: 0.9x as long as wide (CL = 2.1mm, CW = 2.4mm); frontal line thinly impressed, carinate near antennal sockets; inner orbits medially emarginate, UID: MID: LID = 0.7:2.4:0.4; POL: OOL = 0.16: 0.11; antennae twelve segmented; scape 1.8x and F1 5.3x as long as its apical width, F1 0.9x as long as F2+F3 (F2+F3 = 0.5mm), F1: F2: F3: F10 = 0.4: 0.3: 0.2: 0.3; antennal sockets separated from frontoclypeal suture by 2x ASD (ASD = 0.1mm, AS-FC = 0.2mm); clypeus as long as wide (0.6mm), free margin arcuate with medially incised lobe.

Mesosoma: Pronotum antero-laterally with pointed teeth, posterior margin laterally tuberculate; admedian lines, paradiscal lines on scutum; propodeal enclosure present, apical half with median sulcus; wings hyaline, apically infusate; SMC I 0.7x as long as first discoidal; hindwing media diverging beyond cu-a 1.5x as length of cu-a (SMC I = 1.8mm, Discoidal cell = 2.5mm; M+Cu = 0.36, cu-a = 0.2mm); legs slender, basal joints of tarsomeres not constricted; hindtibial spur 0.6x as long as hindbasitarsus (HTS = 0.5mm, HBT = 0.8mm).

Metasoma: 2.6x as long as mesosoma (Metasoma = 3.25mm, Mesosoma = 1.25); petiole flask shaped; relative length of segment I:II = 3.2:1.6.

Male

Length 6.5-9.5mm. scutum punctate; fore and midbasitarsus yellow white; OOL:POL = 2:5; propodeum with lateral carina, with furrows dorsally; F11 as long as F7-F10 combined; paramere apically simple, volsella spatula like, penis valve subapically with paired sickle shaped appendages (Tsuneki, 1979).

Material examined: Plesiotype: 1♀ India: Kerala, Malappuram: Kondotty 11°14'N 75°96'E. 23.iv.2011, Baaby Job.

Other material examined: 1♀, India: Kerala, Kasargode: Karim's Forest, Parappa 12°20'N, 75°14'E. 1.i.2012. Baaby Job; 1♀, India: Kerala, Malappuram: Thavanoor 10°51'N 75°58' E. 26.iii.2012, Baaby Job.

Distribution: Bangladesh, China, Japan, Madagascar, Malaya, Mauritius, Myanmar, Nepal, South East Asia, SriLanka, Seychelles, Tanzania, India [Assam, Uttar Pradesh, West Bengal, Kerala: Palakkad, Kasargode, Malappuram].

Biology: Unknown.

Remarks: Since the available description of this species is inadequate for easy identification, a redescription is provided here.

Trypoxylon errans Saussure closely resembles *Trypoxylon striolatum* Tsuneki in having 1. Propodeum laterally carinate; 2. Fore and mid tarsomere I white yellow; 3. Vertex not depressed.

However, *T. errans* differs from *T. striolatum* in having clypeal free margin arcuate with median incision (in *T. striolatum* clypeus medially raised, freemargin sinuate); 2. Pygidium dorsally with lateral rows of carina (in *T. striolatum* lateral row of carina indistinct); 3. Pronotum posterior margin laterally tuberculate (in *T. striolatum* collar medially tuberculate).

46. *Trypoxylon lamellatum* Tsuneki

Trypoxylon lamellatum Tsuneki, 1979: 136, ♀. India (USNM).

Diagnosis:

Female

Length 14mm. Black; mandibles basally black, apically rusty brown; tegula semitransparent brown; petiole apically, metasomal segments II-IV red yellow, segment II dorsally with black markings; fore and mid tibiae, fore tarsomeres brown, fore tibial spur pale brown; clypeus apically red brown with median yellow spots; pronotum posterior margin brown; frons shiny, sparsely punctate; scutum shining, smooth with fine punctae; lateral carinae on propodeum transversely striate, rest smooth, shining; head in dorsal view converging below, vertex slightly depressed; frons with rounded elevations; clypeus basally convex, free margin sinuate; occipital carina complete without incision; pronotal collar medially raised, weakly bituberculate; propodeum with lateral carina, dorsally with median furrow, posteriorly with carina.

Male: Unknown.

Material examined: No material examined. The above description of species is based on that given by Tsuneki, 1979.

Distribution: India [Kerala: Palakkad].

Remarks: Tsuneki described this species from Walayar forests, Kerala in 1979.

Trypoxylon lamellatum Tsuneki closely resembles *Trypoxylon nigricorne* Tsuneki in having 1. Median transverse carina above antennal tubercles incomplete; 2. Free margin of clypeus medially emarginate; 3. Fore tarsomeres brown.

However *T. lamellatum* differs from *T. nigricorne* in 1. Carina above antennal tubercles medially incomplete (in *T. nigricorne* carina weak, not interrupted); 2. clypeal freemargin sinuate with median emargination (in *T. nigricorne* freemargin of clypeus arcuate); 3. Frons microsculptured with distinct punctae (in *T. nigricorne* frons without microsculpture, shining, punctate).

47. *Trypoxylon nishidai* Tsuneki

Trypoxylon nishidai Tsuneki, 1979: 134, ♂. Laos (Bishop Mus.).

Diagnosis:

Male

Length 7.0-7.5mm; Black; mandibles apically red brown, tegulae semitransparent brown, tibial spurs white; frons punctate, scutum punctate; POL:OOL = 5:1; clypeal freemargin arcuate with median lobe incised; paramere apically not bifid, enlarged forming lobe, volsella robust; sternum VIII medially angulated and apically emarginated.

Female

Length 10.0-11mm; Black; mandibles apically red brown, tegulae semitransparent brown, tibial spurs white; frons punctate interspaces microreticulate; scutum punctate; OOD narrower than in males, POL:OOL = 4:6; clypeal freemargin with medially incised lobe; antennae twelve segmented.

Material examined: No material examined. The above description of species is based on that given by Tsuneki, 1979.

Distribution: Laos, India [Kerala].

Biology: Unknown.

Remarks: Tsuneki (1981a) reported this species from Kerala.

Trypoxylon nishidai Tsuneki closely resembles *Trypoxylon nigripes* Tsuneki in having 1. Clypeal free margin with incised median lobe; 2. Fore tarsomeres brown; 3. propodeum with lateral carina.

However, *T. nishidai* differs from *T. nigripes* in 1. frons with punctae distinct and close (in *T. nigripes* frontal punctae sparse, indistinct); 2. tibial spurs white (in *T. nigripes* tibial spurs brown); 3. Pronotum laterally with pointed triangular projection, angulated (in *T. nigripes* lateral triangular projection on pronotum rounded, blunt).

48. *Trypoxylon pileatum* Smith

(Fig 38a-f; Plate 15b)

Trypoxylon pileatum F. Smith, 1856: 377, ♀, India (BMNH).

Redescription

Female.

Measurements in mm.

TBL = 10.1; FWL = 4.7; SW = 1.5.

Colour: Black; mandibles brown; tegulae semitransparent brown; hairs silver.

Vestiture: Clypeus except apically, lower frons with appressed hairs; clypeus, mandibles ventrally, gena, pronotum with semierect hairs; scutum, mesopleuron, pronotum with erect hairs; apex of frontal carina with curved hairs; metasoma with fine pubescence; sternites II-V apically with erect hairs.

Sculpture: Body shining; frons, vertex micropunctate; scutum with scattered punctae; propodeum with furrows transversely ridged, sides striate to smooth.

Head: 0.9x as long as wide (HL = 1.6mm, HW = 1.8mm); inner orbits medially emarginate, UID: MID: LID = 0.5: 1.5: 0.5; POL: OOL = 0.16: 0.08; frons with shield

shaped enclosure around midocelli, apically produced into sharp carina between antennal bases and lateral carina running into emargination of orbits; frontal line finely impressed; antennal sockets above with median lobe; antennal sockets contiguous with frontoclypeal suture; antennae twelve segmented, scape 1.7x and F1 3.5x as long as its apical width; F1 0.75x as long as F2+F3 (F2+F3 = 0.4mm); F1: F2: F3: F10 = 0.3: 0.2: 0.2: 0.25; clypeus 0.6x as long as wide (CL = 0.4mm, CW = 0.7mm); freemargin arcuate, lip flattened, beneath the level of rest of clypeus; mandibles simple.

Mesosoma: Pronotal collar apically truncate, laterally bituberculate; notuali absent, paradiscal lines finely impressed; propodeum with median and lateral furrows, lateral furrows converging posteriorly enclosing semicircular area; wings hyaline, SMC I as long as discoidal (1.2mm); hind wing media diverging at 3.5x length of cu-a (cu-a = 0.2mm, M+Cu = 0.7mm); legs slender, hind tibial spur 0.5x as long as hind basitarsus (HTS = 0.3mm, HBT = 0.6mm).

Metasoma: 1.7x as long as mesosoma, apically tapering and pointed (Metasoma = 5.6mm, Mesosoma = 3.3mm); tergum I forming parallel sided petiole, apically flask shaped; relative length of segments I: II = 1.6:1.1.

Male.

TBL = 12.9; FWL = 6.7; SW = 2.7.

Colour: Black; mandibles brown; tegulae semitransparent brown; hairs silver, tergites III-VII with black hairs.

Vestiture: Clypeus except apically, lower frons with appressed hairs; clypeus, mandibles ventrally, gena, pronotum, tergites III-VII with semierect hairs; scutum, mesopleuron, pronotum, petiole basally with erect hairs; apex of frontal carina with curved hairs; metasoma with fine pubescence; sternites II-V apically with erect, stiff hairs.

Sculpture: Frons, vertex coarsely punctate, hind ocellar area smooth; propodeum with furrows transversely ridged, sides striate to smooth.

Head: 0.8x as long as wide (HL = 1.9mm, HW = 2.4mm); inner orbits medially emarginate, converging towards clypeus, UID: MID: LID = 0.8: 1.7: 0.8; POL: OOL = 0.2: 0.16; frons with shield shaped enclosure, indistinct above midocelli, lateral carina towards inner orbits less extended than in females; antennae thirteen segmented, scape 3x and F1 2.6x as long as its apical width, F1 0.7x as long as F2+F3 (F2+F3 = 0.6mm); F1: F2: F3: F11 = 0.4: 0.3: 0.3: 0.3, F4 basally emarginate; clypeus 0.7x as long as wide (CL = 0.5mm, CW = 0.7mm), freemargin arcuate.

Mesosoma: Pronotum with pointed medio-lateral tubercle; propodeum dorsally with median and lateral furrows basally enclosing semicircular area; wings hyaline, SMC I as long as discoidal (1.6mm); hindwing media diverging 0.7x length of cu-a (cu-a = 0.3mm, M+Cu = 0.2mm); legs slender, mid femur with basal excavation; hind tibial spur 0.4x as long as hind basitarsus (HTS = 0.4mm, HBT = 0.9mm).

Metasoma: 2.2x as long as mesosoma (Metasoma = 8.3mm, Mesosoma = 3.7mm); relative length of segments I:II = 2.8:1.2; tergum VII apically truncate.

Material examined: Plesiotype: 1♂, India, Kerala, Malappuram: Thavanoor 10°51'N, 75°58'E. 26.iii.2012.

Other material examined: Simon George; 1♀, India: Kerala, Kollam: Pazhayaroor 8°9'N 76°86'E. 03.v.2012. Baaby Job.

Distribution: Bangladesh, China, SriLanka, India [TamilNadu, West Bengal, UttarPradesh, Karnataka, Kerala: Malappuram, Kollam (**New record to Kerala**)].

Biology: Nests in bamboo stems. Maxwell-Lefroy (1909) reported *Trypoxylon pileatum* Smith building nest in cane furniture, nests were partitioned into cells and provisioned with spiders.

Remarks: Since the available description of this species is inadequate for easy identification, a redescription is provided here.

Trypoxylon pileatum Smith resembles *Trypoxylon errans* de Saussure in having 1. Clypeus with silver hairs; 2. Scutum, scutellum smooth, shiny; 3. Frons with carina near antennal sockets.

However, *T.pileatum* differs from *T.errans* in having 1. Frons with shield shaped enclosure (absent in *T.errans*). 2. Metasoma black (in *T.errans* metasomal segments II-III red); 3. Legs black (in *T.errans* legs pale yellow).

49. *Trypoxylon vardy* Tsuneki.

Trypoxylon vardy Tsuneki, 1979: 145, ♂. India (BMNH).

Diagnosis

Male:

Length 10.0mm. Black; mandibles red brown, basally black; palpi, tibial spurs yellow brown; tegulae semitransparent brown; metasomal segments II-III basally rust brown; rest of metasoma, legs and pronotum posteriorly brown; hairs silver; frons micro-reticulate intermixed with punctae; scutum smooth, shiny with sparse punctae; propodeum with striae in furrows; propodeum posteriorly rugose-striate; vertex not depressed; frons with rounded tubercles, frontal line thickly impressed; antennae twelve segmented, F4-F10 ventrally rounded; clypeus slightly raised medially, freemargin glabrous, arcuate with median lobe; complete occipital carina; pronotum with median tubercle, antero-laterally with blunt triangular projection; propodeum with lateral carina, dorsally with lateral furrows, propodeum above petiole socket depressed, smooth, shiny; petiole flask shaped; sternum VIII apically emarginated; paramere bifurcate apically, ventrally with hairs, inner margin with four tubercles having bristles; volsella broad, apically spinous, outer margin with bristles; penis valve with paired sickle shaped appendages.

Female.

Length 11-12mm. Black; mandibles apically red brown, basally black; mouth parts yellow brown; tegulae semitransparent brown; tibial spurs, foretarsus pale brown; petiole apically, metasomal segments II-III red, segments II-III with dorsal black markings; hairs silver; frons with sparse punctae, scutum smooth with sparse punctae; propodeum striate along lateral carina, furrows transversely striate; frons with rounded tubercles; clypeus basally convex, freemargin arcuate with incised median lobe; pronotal collar with weak median tubercle, laterally with blunt projection; propodeum dorsally with furrows, median sulcus deep, carinate laterally; petiole flask shaped.

Material examined: No material examined. The above description of species is based on that by Tsuneki, 1979.

Distribution: Malaya, Indonesia, India [Himachal Pradesh, Kerala: Palakkad].

Biology: Unknown.

Remarks: This species has been recorded from Walayar forests, Palakkad (Tsuneki, 1979).

Trypoxylon vardyi Tsuneki closely resembles *Trypoxylon membranaceum* Tsuneki in having 1. Propodeum laterally carinate; 2. Petiole apically and metasomal segments II-III red; 3. Hairs silver.

However *T. vardyi* differs from *T. membranaceum* in 1. Head wider than long, sides converging below (in *T. membranaceum* head with sides rounded, not converging below); 2. F11 as long as F7-F10 combined (in *T. membranaceum* F11 as long as F8-F10 combined); 3. Body longer and robust, 10mm (body less robust and small in *T. membranaceum*, 6.5mm).

4.6. CHARACTER STATE MATRIX

The character state matrix was prepared for three genera: *Sphex* Linnaeus, *Tachysphex* Kohl and *Liris* Fabricius, as these three genera recorded the highest number of species. The character state matrix was intended only to compare different species and not for any cladistic or phylogenetic analyses.

4.6.1. Character state matrix for the species of the genus *Sphex* Linnaeus

The following diagnostic characters were selected for preparing character state matrix of four species of *Sphex* Linnaeus.

A. Clypeal carina

state 1. Absent

state 2. Subapical.

state 3. Basomedian

B. POL: OOL

state 1. POL 1.3x as long as OOL.

state 2. POL 0.9x as long as OOL.

C. Wings

state 1. Brown.

state 2. Clear, basally and apically infusate.

state 3. Yellow, apically infusate.

D. Metasoma.

state 1. 1.2x as long as mesosoma.

state 2. Less than 1.2x as mesosoma.

E. Foretarsal rake spines

state 1. Nine.

state 2. Ten.

F. Propodeal sculpture.

state 1. Transversely ridged

state 2. Fine transverse striae

G. Length of petiole.

state 1. as long as hindcoxa.

state 2. 1.2x as long as hindcoxa.

H. Hairs.

state 1. Golden

state 2. White.

state 3. Black

**TABLE 1 CHARACTER STATE MATRIX OF FOUR SPECIES OF GENUS
SPHEX LINNAEUS**

SI. No.	Name of Species	A	B	C	D	E	F	G	H
1.	<i>Sphex argentatus</i> Fabricius	1	1	2	1	2	2	1	2
2.	<i>Sphex sericeus</i> (Fabricius)	2	2	1	1	1	1	1	1
3.	<i>Sphex</i> A	3	2	1	2	1	1	1	1
4.	<i>Sphex praedator</i> F.Smith	1	1	3	2	2	2	2	3

4.6.2. Character state matrix for species of the genus *Tachysphex* Kohl

The character state matrix were constructed for four species of *Tachysphex* Kohl namely *Tachysphex bengalensis* Cameron, *Tachysphex indicus* Pulawski, *Tachysphex morosus* (F. Smith) and *Tachysphex panzeri* (Vander Linden). Two species viz., *Tachysphex changi* Tsuneki and *Tachysphex gryllivorus* Pulawski were not included as the data was inadequate for character state matrix preparation. The following diagnostic characters were selected for preparing character state matrix.

A. Clypeal freemargin

state 1. Arcuate.

state 2. medially emarginated

state 3. Sinate.

B. Frontal line.

state 1. Absent.

state 3. Present.

C. Vertex hairs.

state 1. Siuous

state 2. Erect.

state 3. Appressed.

D. Flagellomere

state 1. F1 as long as F2.

state 2. 1.2x as long as F2.

E. Forewing Marginal cell.

state 1. Rounded.

state 2. Truncate.

state 3. Obliquelt truncate.

F. Sternum I.

state 1. Apically carinate.

state 2. absent

G. Hindwing Media.

state 1. Diverging at length of cu-a.

state 2. Diverging at 0.2x length of cu-a.

H. Forebasitarsus.

state 1. Expanded.

state 2. Not expanded.

I. Tergites.

state 1. I-IV with fasciae.

state 2. I-III with fasciae.

TABLE 2 CHARACTER STATE MATRIX OF FOUR SPECIES OF GENUS <i>TACHYSPHEX</i> KOHL										
Sl. No.	Name of Species	A	B	C	D	E	F	G	H	I
1.	<i>Tachysphex bengalensis</i> Cameron	2	2	2	1	2	1	1	2	1
2.	<i>Tachysphex indicus</i> Pulawski	1	1	1	2	1	2	2	1	1
3.	<i>Tachysphex morosus</i> (F. Smith)	3	2	2	1	2	2	1	2	2
4.	<i>Tachysphex panzer</i> (Vander Linden)	3	2	3	1	3	2	2	2	1

4.6.3. Character state matrix for species of the genus *Liris* Fabricius

The following diagnostic characters were selected for preparing character state matrix of ten species of genus *Liris* Fabricius.

A. Clypeal freemargin.

- state 1. Arcuate
- state 2. Arcuate with median emargination.
- state 3. Biarculate.
- state 4. Arcuate with lateral incision.
- state 5. Sinuate.

B. Mandibular teeth.

- state 1. Absent.
- state 2. Submedially bidentate.
- state 3. Medially bidentate.
- state 4. Basally bidentate.

C. Impression on Vertex.

- state 1. Subtriangular
- state 2. Triangular.
- state 3. V- shaped.

D. Carina on propodeum.

- state 1. Ending after midway.
- state 2. ending short of hindface.
- state 3. Reaching apex of hindface.

E. Hindwing Media.

- state 1. Diverging at length of cu-a.
- state 2. Diverging between 1.3-1.7x length of cu-a.
- state 3. Diverging between 2-2.6x length of cu-a.
- state 4. Diverging at 3x length of cu-a.

F. Tergites.

- state 1. I-III with fasciae.
- state 2. I-IV with fasciae.

G. Apical spines on pygidium.

- state 1. Absent.
- state 2. Two.
- state 3. Five.
- state 4. Six.

H. Propodeal sculpture.

- state 1. Rugose with transverse striae on edges.
- state 2. Striato-rugose.
- state 3. Transversely striate with rugose interspaces.
- state 4. Rugose to striato-rugose.

I. Pygidium vestiture.

- state 1. Absent.
- state 2. Stiff appressed setae.
- state 3. Apical half with appressed setae.
- state 4. Appressed setae except U shaped basal portion.

TABLE 3 CHARACTER STATE MATRIX OF TEN SPECIES OF GENUS <i>LIRIS</i> FABRICIUS										
Sl.No.	Name of species	A	B	C	D	E	F	G	H	I
1.	<i>L. anupamas</i>	1	2	1	1	2	1	4	3	4
2.	<i>L. arcuatus</i>	5	2	3	2	4	1	2	1	1
3.	<i>L. aurulentus</i>	2	4	1	3	1	2	4	3	2
4.	<i>L. narendrani</i>	2	3	2	2	1	1	4	2	2
5.	<i>L. pentaspinosus</i>	5	1	3	2	3	2	3	1	1
6.	<i>L. simony</i>	3	3	2	2	2	1	3	4	2
7.	<i>L. sinuatus</i>	4	2	3	2	4	2	2	1	1
8.	<i>L. subtessellatus</i>	1	2	1	1	3	2	3	3	4
9.	<i>L. thenmalaensis</i>	1	3	2	3	2	1	4	2	3
10.	<i>L. wayanadensis</i>	5	1	2	3	1	1	1	1	1

Chapter 5 DISCUSSION

Insects are the most dominant creatures on Earth and also the most economically important organisms from the human point of view. Being the oldest and most successful creatures, they have always fascinated and challenged the human race. They have influenced us directly or indirectly through their way of life and action. Hymenoptera forms one of the most diverse among insect orders and is responsible for sustaining diversity in other groups. Without the action of Hymenopterans, pest resurgence, decrease in plant diversity and secondary pest outbreaks may result and homeostasis of nature will be disrupted.

The sphecids is one of the largest and important groups of Hymenoptera. By their habit sphecids wasps destroy large number of insects injurious to agriculture and forestry, thus forming a major factor preventing undue increase of noxious species. A few species has been tried for biological control, but a great majority remains unexplored due to inadequate knowledge on their taxonomy and biology. In spite of their economic importance, not much detailed work has been done in India on the biology and behavior of this group. The present investigation attempted to assess the diversity of sphecid fauna of Kerala.

5.1. Collection.

The collection method mainly employed in the present study was Sweep net. This was found to be the most successful and reliable method for collecting these conspicuous, brightly coloured wasps. In addition to this Rearing was also employed in which the mud nests collected were kept undisturbed in the lab. This method allows the study of larval development, days of hatching, prey species etc. But one disadvantage with this method was that the emerging adults showed incomplete development, may be due to the stress at the time of nest removal. Yellow pan trap was not very successful for collecting these fast fliers, with dipterans, spiders and ants forming the majority of the

collection. Food bait (honey) was also not successful, since these attracted ants faster than any other insects. Malaise trap yielded the most common species namely *Chalybion bengalense* Dahlbom.

5.2. Habit and Habitat Diversity.

The collections were carried out during day time from 8 A.M to 5 P.M. It was observed that these wasps heightened their activity from 9 A.M. to 12 P.M. and from 3 P.M. to 5 P.M. Only one specimen of *Liris narendrani* sp. nov. was collected during night at 9 P.M. The collection time pointed to the diurnal nature of these wasps and that the sphecid activity was high during the morning hours.

Sphecids are solitary wasps and occupy diverse niches from natural habitats to manmade dwellings. The wasps collected were grouped into four habitat categories namely nurseries and vegetable gardens, rubber plantations and semi forest areas, open area with shrubs and indoors of houses (Table 9).

Ampulex compressa (Fabricius), *Trirogma caerulea* Westwood and *Pison punctifrons* Shuckard were caught exclusively from the inside of houses. *Sceliphron coromandelicum* (Lepeletier), *S. madraspatanum* (Fabricius) and *Chalybion bengalense* (Dahlbom) were collected both from inside of buildings as well as from gardens. This may be correlated with the availability of mud pools for nest construction as well as the abundance of prey species. The members of the genus *Sphex* Linnaeus were caught from open areas, as well as from gardens. Their fossorial habit accounts for their occurrence in open areas with sparse vegetation. Members of the family Crabronidae were collected mainly from rubber plantations and semi forest areas. These were mainly shade lovers and were observed hopping in shady areas with patches of light. Members of the genus *Trypoxylon* Latreille were collected from open areas as well as from gardens with bamboo plants. Paddy fields were not found to be a suitable habitat and did not yield any species. The habitat diversity correlates with the fact that the occurrence of Spheciformes in a habitat is conditioned by moisture, the soil exposure, soil type and prey abundance (Gayubo *et.al*, 2000). Another interesting

aspect emerged from the study was that diversity of sphecids was found to be abundant in areas of human interaction and that each species occupied more than one functional niche. Two types of nest construction were observed during the collection- aerial mud nests and ground nests. Ground nests consisted of holes of varying diameter. *Sphex sericeus* (Fabricius) was observed to be digging four holes simultaneously.

Seasonal and climatic variations also influenced the occurrence of these wasps. These wasps were mainly collected from the pre-monsoon months of February to April. This time also marked heightened nesting activity. Daily temperature variations also influenced their occurrence, as these were not collected from noon to about 3 P.M. All though sphecids were solitary, *Chalybion bengalense* (Dahlbom) showed a unique behavior of aggregation at dusk.

5.3. FLORISTIC RELATIONS.

As adults are nectar feeders, many species were collected from flowers (Table 8). The main families of plants visited by these wasps were Rubiaceae, Euphorbiaceae, Lamiaceae, Asteraceae and Rutaceae. *Trypoxylon bicolor* F. Smith was collected from the stems of *Dendrocalamus strictus* (Roxb.) Nees., probably its nesting area (Plate 4).

5.4. FAUNAL DIVERSITY.

In the present investigation 49 species of sphecids under 19 genera and three families- Ampulicidae, Sphecidae and Crabronidae were studied. Crabronidae represented the most diverse family with 31 species, forming 63% of the total species studied. Family Sphecidae contributed 29% of sphecid population with 14 species. Family Ampulicidae were represented by 4 species and formed 8% of the total sphecid population (Graph 1).

5.4.1. Family Ampulicidae

In India family Ampulicidae were represented by two subfamilies- Dolichurinae and

Ampulicinae. In the present study only subfamily Ampulicinae were recorded from Kerala with two genus *Ampulex* Jurine and *Trirogma* Westwood (Graph 2). Genus *Ampulex* was represented by two species- *Ampulex aenea* Spinola and *Ampulex compressa* (Fabricius). *A. compressa* (Fabricius) can be distinguished from *A. aenea* Spinola in having seven longitudinal carina along the propodeum. Genus *Trirogma* Westwood was represented by two species- *Trirogma caerulea* Westwood and *Trirogma narendrani* Madhavikutty. *T. caerulea* Westwood differed from *T. narendrani* Madhavikutty in having body metallic blue with smooth metasoma, while in *T. narendrani* Madhavikutty body was metallic blue-green with a coarsely punctate metasoma.

5.4.2. Family Sphecidae.

Family Sphecidae were represented by four subfamilies- Ammophilinae, Sceliphriini, Chloriontinae and Sphecinae and seven genera. Subfamily Ammophilinae were represented by two genera *Ammophila* Kirby and *Parapsammophila* Taschenberg. Genus *Ammophila* can be distinguished from *Parapsammophila* in having tarsal claws simple, while in *Parapsammophila* tarsal claws were bidentate. *Ammophila* was represented by two species- *A. clavus* (Fabricius) and *A. laevigata* F. Smith. In *A. clavus* (Fabricius) pronotum and scutum striate, while in *A. laevigata* F. Smith pronotum and scutum was punctate. Only *Parapsammophila erythrocephala* Fabricius was reported from Kerala (Graph 3).

Subfamily Chloriontinae included a single genus *Chlorion* Latreille and this was recorded in Kerala. *Chlorion lobatum* Fabricius was the only species recorded. They were beautiful insects, brilliantly coloured with metallic blue. Subfamily Sceliphriinae recorded two genera- *Sceliphron* Klug and *Chalybion* Dahlbom. Genus *Sceliphron* was represented by three species. *Sceliphron javanum nalandicum* Strand had black hairs and pronotum black without any yellow markings. *Sceliphron madraspatanum* (Fabricius) had the legs variegated with yellow and black, while in *Sceliphron coromandelicum* (Lepelletier) legs were yellow brown. Genus *Chalybion* recorded two species with one new species *Chalybion keralensis* sp. nov. and the most common

species *Chalybion bengalense* Dahlbom. *Chalybion keralensis* sp. nov. showed affinity to genus *Sceliphron* in colour pattern, while *C. bengalense* Dahlbom was metallic blue coloured.

Subfamily Sphecinae recorded two genera *Sphex* Linnaeus and *Isodontia* Patton. Genus *Sphex* recorded four species with one new species record *Sphex neosericeus* sp. nov.. This species showed close resemblance to *S. sericeus* (Fabricius) in body colour and propodeal sculpture. In *Sphex neosericeus* sp. nov freemargin of clypeus was more sharp with median emargination bounded by lateral lobes, while in *S. sericeus* median emargination of the clypeus was without lateral lobes. Also in *S. sericeus* the male and female were differently coloured. *Sphex argentatus* Fabricius differed from *S. praedator* F. Smith in having clypeal freemargin bilobed and body black, while in *S. praedator* F. Smith clypeal freemargin was with single median lobe and the mid and hind femora red black. Genus *Isodontia* was represented by single species *Isodontia diodon* (Kohl) and was rare in collection.

5.4.3. Family Crabronidae.

This was represented by a single subfamily Crabroninae with ten genera and thirty one species (Graph 4).

Genus *Tachysphex* Kohl, *Gastrosericus* Spinola and *Tachytes* Panzer showed common characters like midocelli placed in transverse depression and hindocellar scars forming an angle of less than 140°. This may point to their evolutionary relationship. However, *Gastrosericus* differed from *Tachysphex* and *Tachytes* in having only two SMC's in the forewing. This genus was represented by single species, *Gastrosericus siamensis* Tsuneki. Genus *Tachytes* was separated from *Tachysphex* by the long tailed hindocellar scars, while in *Tachysphex* hindocellar scars were oval. *Tachytes* recorded two species- *T. modestus* F. Smith and *T. nitidulus* (Fabricius). Genus *Tachysphex* recorded six species, out of which *Tachysphex panzeri* (Vander Linden) was a new record to the state. *Tachysphex indicus* Pulawski could easily be separated by the unique feature of fore basitarsus laterally expanded. *T. morosus* (F.Smith) was

identified by the sinuate clypeal free margin, tergites I-III with silver fasciae and fore basitarsus with five rake spines. *T. gryllivorus* Pulawski had clypeal freemargin arcuate with two lateral incisions on each side and tergites I-IV with silver fasciae. In *T. changi* Tsuneki tarsomere V swollen with minute spines ventrally and on lateral margins, while in *T. bengalensis* Cameron tarsomere V not swollen and ventrally with median cluster of spines.

Genus *Liris* Fabricius and *Larra* Fabricius showed structural similarity, pointing to their origin from a common Larrine ancestor. They were primarily separated based on the propodeal sculpture. In *Liris*, the sculpture on the propodeal side was dull and smooth, while in *Larra* propodeal side was smooth, shining and densely punctate, resembling pinpricks. Genus *Liris* recorded the largest number of species in this study. Out of the ten species recorded eight species viz., *Liris anupamus* sp. nov., *Liris arcuatus* sp. nov., *Liris narendrani* sp. nov., *Liris pentaspinosus* sp. nov., *Liris simoni* sp. nov., *Liris sinuatus* sp. nov., *Liris thenmalaensis* sp. nov. and *Liris wayanadensis* sp. nov. were new to science. *L. aurulentus* Fabricius showed close resemblance to *L. wayanadensis* sp. nov., but differed in having pygidium with stiff appressed setae, while pygidial setae were absent in *L. wayanadensis*. *L. subtessellatus* (F. Smith) and *L. anupamus* sp. nov. were similar except for the hind femora red and wings pale yellow in *L. subtessellatus* (F. Smith) while in *L. anupamus* wings deep yellow with hind femora black. Genus *Larra* was represented by two species *Larra Vechti* Sudheendrakumar and Narendran and *Larra stom* sp. nov. *L. Vechti* Sudheendrakumar and Narendran differed from *L. stom* sp. nov. in having body black with hind femora red and propodeum reticulate, while in *L. stom* sp. nov. basal segments of metasoma red, legs black and propodeum punctate.

Genera *Solierella* Spinola, *Lyroda* Say and *Miscophus* Jurine were obviously closely allied with features like normal hindocelli, simple hind femoral apex and femur tapering apically. But in *Miscophus* two SMC's were present in forewing, with SMC II petiolate and clypeal freemargin laterally excised. Genus *Miscophus* was new record to Kerala with a new species *Miscophus apoorvus* sp. nov. Genus *Solierella* represented by a single species, *Solierella turneri* Dutt.

Genus *Trypoxylon* Latreille and *Pison* Jurine showed close resemblance in having emarginate inner orbits and propleura with lamellate projection. However, *Trypoxylon* differed from *Pison* in having forewing with with one SMC and metasoma clavate or petiolate, while in *Pison* metasoma sessile and forewing with three SMC's. Genus *Trypoxylon* recorded six species. Out of this *Trypoxylon pileatum* Smith and *T. bicolor* Smith was new records to Kerala. *T. pileatum* Smith could be easily recognized by the presence of head shield absent in all other species. *T. bicolor* Smith could be separated from *T. errans* Saussure by the absence of lateral carina on propodeum and basal metasomal segments red with black markings.

Genus *Liris* Fabricius was found to be the most diverse with 10 recorded species. Out of these 8 species were new to science. The second most diverse genera were *Tachysphex* Kohl and *Trypoxylon* Latreille with records of 6 species each. Genera *Pison* Jurine, *Solierella* Spinola, *Lyroda* Say, *Miscophus* Jurine, *Isodontia* Patton, *Chlorion* Latreille and *Parapsammophila* Taschenberg were represented by single species each.

5.5. DISTRIBUTION PATTERNS.

Chalybion bengalense Dahlbom showed an even distribution pattern, with records in all the fourteen districts surveyed. Their successful establishment may be attributed to the prey abundance. *Sceliphron madraspatanum* (Fabricius) and *Sphex sericeus* (Fabricius) was the second most abundant species with records from nine districts. The third most abundant species was *Sceliphron coromandelicum* (Lepeletier) with collection records from seven districts. *Sphex neosericeus* sp. nov. was recorded only from Thrissur district, *Liris pentaspinosus* sp. nov. from Malappuram and *Liris wayanadensis* sp. nov. from Wayanad. *Miscophus apoorvus* sp. nov. was collected from Aluva, Ernakulam and *Chalybion keralensis* sp. nov. from Wayanad. The new species recorded for the state *Tachysphex panzeri* (Vander Linden) was collected from Wayanad and Ernakulam districts, while both *Trypoxylon pileatum* Smith and *T.*

bicolor Smith were recorded from Malappuram and Kollam districts. *Isodontia diodon* (Kohl) was rare in collection.

The highest species diversity was shown by Palakkad district with records of nineteen species. This was followed by Ernakulam and Malappuram with records of eighteen species each and Thrissur with sixteen species. Idukki and Kannur was the least diverse with records of two species only.

The distribution pattern of all the species collected represented in Table 5, 6, 7 and Map 2-6. The species diversity under each zone of Kerala namely South, Central and North Kerala were plotted as bar diagram (Graph 5, 6, 7).

5.6. AFFINITES.

The distribution data of sphecid wasps collected from Kerala demonstrated that it was not isolated from the Oriental fauna. The wasps showed greater relationship to the island fauna of SriLanka. Out of 49 species recorded in this study 17 species occurred in SriLanka. Faunal similarity of sphecids with other regions of India was also striking. *Ampulex compressa* (Fabricius), *Tirogma caerulea* Westwood, *Ammophila clavus* (Fabricius), *Ammophila laevigata* F. Smith, *Parapsammophila erythrocephala* (Fabricius), *Chlorion lobatum* (Fabricius), *Sceliphron coromandelicum* (Lepeletier), *S. javanum nalandicum* Strand, *S. madraspatanum* (Fabricius), *Chalybion bengalense* (Dahlbom), *Sphex praedator* F.Smith, *S. sericeus* (Fabricius), *Liris subtessellatus* (F.Smith), *Lyroda formosa* (F.Smith), *Pison punctifrons* Shuckard, *Trypoxylon bicolor* F. Smith, *T. errans* Saussure and *T. pileatum* F.Smith were recorded both for WestBengal and Kerala.

In the present study 49 species of sphecid wasps belonging to three families were recorded. Out of this 12 were new species to science and 3 new records to Kerala. The taxonomy of all the three families was discussed. Significant efforts were made to record all the known species of sphecid wasps from Kerala through collection as well from literature records. Taxonomic redescriptions and descriptions were provided to remove ambiguity and also to bring together scattered information. Details on the

available biology of the species were provided. The limitations in the study were primarily due to difficulty in specimen collection. These wasps are quick fliers and collecting needs expertise and luck. A total of 92 places were visited for specimen collection and random sampling method was adopted. But, overall the whole study had been successful in bringing out the taxonomic information on these lesser known groups of Kerala. The current study also brought out the abundance and diversity of these wasps in the state. The present study may help in future undertaking of any experiments involving their use as bioindicators, biological control agents and any studies related to the biology of these wasps. The physio-geographical and climatic conditions of Kerala promises high species diversity and any future taxonomic survey may bring new species to light.

CHECKLIST OF SPHECIFORMES IN KERALA

In this list, the species name, author, year, synonyms and distribution are given. The question mark in front of a synonym indicates that the status of the taxon within the genus is not clear.

I. FAMILY AMPULICIDAE

Distribution

SUBFAMILY AMPULICINAE

Genus 1 *Ampulex* Jurine, 1807

- 1 *Ampulex aenea* Spinola, 1841..... India.

- 2 *Ampulex compressa* (Fabricius), 1781..... Africa, Bangladesh, China, Hawaii, Indonesia, Mauritius, Philippines, Singapore, Sri Lanka, India.
[= *Sphex compressus* Fabricius, 1781
= *Chlorium compressum* (Fabricius) Billberg, 1820
= *Chlorampulex compressa* (Fabricius) Saussure, 1892
= *Ampulex compressa* (Fabricius) Jurine, 1807
= *Chlorampulex striolata* de Saussure, 1892

Genus 2 *Trirogma* Westwood, 1841

- 3 *Trirogma caerulea* Westwood, 1841..... Singapore, Indonesia, China, Taiwan, Iraq, Sri Lanka, Iran and India
[= *Trirogma caerulea* Westwood, 1841a
= *Trirogma caerulea* Westwood, 1841b
= *Trirhogma caerulea* Westwood, 1842]

- 4 *Trirogma narendrani* Madhavikutty, 2004..... India.

II FAMILY SPHECIDAE

SUBFAMILY AMMOPHILINAE

Genus 3 *Ammophila* W.Kirby, 1798

- 5 *Ammophila clavus* (Fabricius), 1775..... Australia, China, Japan,
South East Asia,
SriLanka, India.
[= *Sphex clavus* Fabricius, 1775
= *Ammophila clavus* (Fabricius) F. Smith, 1856
= *Ammophila atripes* F. Smith, 1852a
= *Ammophila clavus atripes* Tsuneki, 1957j
= *Ammophila basalis* F. Smith, 1856
= *Ammophila nigripes* F. Smith, 1856
= *Ammophila dimidiata* F. Smith, 1856
= *Ammophila simillima* F. Smith, 1856
= *Ammophila pulchella* F. Smith, 1856
= *Ammophila longiventris* de Saussure, 1867
= *Ammophila humbertiana* de Saussure, 1867
= *Ammophila spinosa* F. Smith, 1873a
= *Ammophila orientalis* Cameron, 1889c
= *Ammophila buddha* Cameron, 1889c]
- 6 *Ammophila laevigata* F.Smith, 1856..... China, Madagascar,
Nepal, SriLanka,
Thailand, Vietnam, India.
[= *Ammophila laevigata* ab. *bicellularis* Strand,
1915]

Genus 4 *Parapsammophila* Taschenberg, 1869

- 7 *Parapsammophila erythrocephala* (Fabricius),
1781..... Iran, India
[= *Sphex erythrocephalus* Fabricius, 1781
= *Pelopoeus erithrocephalus* (Fabricius)
Fabricius, 1804
= *Ammophila erythrocephala* (Fabricius)
Lepeletier 1845
= *Podalonia erythrocephala* (Fabricius)
Ebrahimi, 1993
= *Parapsammophila erythrocephala*
(Fabricius) Menke, 1966a
= *Ammophila fuscipennis* F. Smith, 1870
= *Ammophila violaceipennis* Cameron, 1889c
= *Ammophila indica* Dalla Torre, 1897]

SUBFAMILY CHLORIONTINAE

Genus 5 *Chlorion* Latreille, 1802

- 8 *Chlorion lobatum* (Fabricius), 1775..... Bangladesh, China,
Egypt, Indonesia,
[= *Sphex lobatus* Fabricius, 1775 Malaysia, Philippines,
= *Chlorion lobatum* (Fabricius) Fabricius, 1804 SriLanka, Vietnam, West
= *Sphex semiauratus viridis* Barbut, 1781 Indies, India.
= ? *Sphex ferus* Drury, 1782
= *Sphex chrysis* Christ, 1791
= ? *Sphex smaragdinus* Christ, 1791
= *Chlorion azureum* Lepeletier, 1828]

SUBFAMILY SCELIPHRINAE

Genus 6 *Sceliphron* Klug, 1801

- 9 *Sceliphron coromandelicum* (Lepeletier), Bangladesh, Malaysia, Sri
1845..... Lanka, Thailand, India
[= *Pelopaeus coromandelicus* Lepeletier, 1845
= *Ammophila coromandelica* (Lepeletier)
Casolari and Casolari Moreno, 1980
= *Sceliphron coromandelicum* (Lepeletier)
Bingham, 1897]
- 10 *Sceliphron javanum nalandicum* Strand, 1915... SriLanka, India
[= *Pelopoeus spinolae*: F. Smith, 1856
= *Sceliphron javanum* var. *nalandicum* Strand,
1915
= *Sceliphron javanum nalandicum* van der
Vecht and van Breugel, 1968]
- 11 *Sceliphron madraspatanum* (Fabricius), 1781... Afghanistan, China,
Egypt, France, Japan,
[= *Sphex madraspatanus* Fabricius, 1781 Kazakhstan, Maldives,
= *Pelopaeus madraspatanus* (Fabricius) Saudi Arabia, South East
Fabricius, 1804 Asia, SriLanka, Syria,
= *Sceliphron madraspatanum* (Fabricius) Tajikistan, Tibet, Turkey,
Moscáry, 1892 Ukraine, India
= ? *Sphex lugubris* Christ, 1791
= *Pelopoeus interruptus* Palisot de Beauvois,
1806
= *Sceliphron interruptum* (Palisot de Beauvois)

Dalla Torre, 1897
 = *Pelopaeus bilineatus* F. Smith, 1852a
 = *Sceliphron blineatum* (F. Smith) Bingham,
 1897
 = *Pelopoeus separatus* F. Smith, 1852
 = *Sceliphron separatum* (F. Smith): Dalla
 Torre, 1897]

Genus 7 *Chalybion* Dahlbom, 1843

- 12 *Chalybion bengalense* (Dahlbom), 1845..... Bangladesh, China,
 Eritria, Ethiopia, Japan,
 Madagascar, Malay,
 Maldives, Mozambique,
 Seychelles, Singapore,
 South Africa, South East
 Asia, SriLanka, Tanzania,
 Timor, Yemen, India
 [= *Sphex violaceus* Fabricius, 1775
 = *Pepsis violacea* (Fabricius) Fabricius, 1804
 = *Pelopaeus violaceus* (Fabricius) Billberg,
 1820
 = *Sceliphron violaceum*(Fabricius) de
 Saussure, 1892
 = *Sceliphron bengalensis* (Dahlbom): Kohl,
 1894
 = *Chalybion bengalense* (Dahlbom): F. Smith,
 1871a
 = *Pelopoeus convexus* F. Smith, 1876a
 = *Sceliphron convexus* (F. Smith): Dalla
 Torre, 1897
 = *Chalybion convexus* ((F. Smith) Bohart and
 Menke, 1976]

- 13 *Chalybion keralensis* sp. nov.

SUBFAMILY SPHECINAE.

Genus 8 *Sphex* Linnaeus, 1758.

- 14 *Sphex argentatus* Fabricius, 1787..... Africa, Australia, China,
 Dubai, Israel, Japan,
 Kazakhstan, Korea,
 Kuwait, Seychelles
 Islands, South East Asia,
 Spain, SriLanka, Taiwan,
 India
 [= *unicolor* Fabricius, 1787
 = *umbrosus* Christ, 1791
 = *argenteus* Turton, 1800
 = *argentifrons* Lepeletier, 1845
 = *plumifer* A. Costa, 1864b
 = *umbrosus* var. *nanulus* Strand, 1913]
- 15 *Sphex praedator* F. Smith, 1858..... China, Egypt, India,
 Indonesia, Malaysia,
 Philippines, South Africa,
 Srilanka, Taiwan,

- = *nigripes* var. *calopterus* Kohl, 1890b
 = *melanopodus* Strand, 1915] Tanzania, Zambia,
 Zimbabwe, India
- 16 *Sphex sericeus* (Fabricius), 1793..... Australia, China, Japan,
 Madagascar, Papua New
 Guinea, Philippines,
 SriLanka, South East
 Asia, Yemen, India.
 [= *Sphex aurulentus* Fabricius, 1793
 = *Pepsis sericeus* Fabricius, 1804
 = *Sphex fabricii* Dahlbom, 1843
 = *Sphex lineolus* Lepeletier, 1845
 = *Sphex ferrugineus* Lepeletier, 1845
 = *Sphex ferox* F. Smith, 1862
 = *Sphex lepeletierii* de Saussure, 1867
 = *Sphex godeffroyi* de Saussure, 1869
 = *Sphex aurifex* F. Smith, 1873d
 = *Sphex aurulentus* var. *pallidehirtus* Kohl,
 1890b
 = *Sphex rugosus* Matsumura, 1912
 = *Sphex lineolus wegneri* van der Vecht and
 Krombein, 1955
 = *Sphex sericeus nigrescens* van der Vecht and
 Krombein, 1955
 = *Sphex sericeus ferocior* van der Vecht and
 Krombein, 1955
 = *Sphex stueberi* van der Vecht and Krombein,
 1955]
- 17 *Sphex neosericeus* sp. nov.

Genus 9 *Isodontia* Patton, 1880

- 18 *Isodontia diodon* (Kohl), 1890..... China, Indonesia,
 Malaysia, Nepal,
 Thailand, India
 [= *Sphex diodon* Kohl, 1890
 = *Sphex maia* Bingham, 1893]

III. FAMILY CRABRONIDAE.

SUBFAMILY CRABRONINAE

Genus 10 *Gastrosericus* Spinola, 1839

- 19 *Gastrosericus siamensis* Tsuneki, 1985..... Thailand, SriLanka, India
 [= *binghami*: Tsuneki, 1963c
 = *menoni* Sudheendrakumar and Narendran,
 1985

Genus 11 *Tachysphex* Kohl 1883

- 20 *Tachysphex bengalensis* Cameron, 1889..... China, SriLanka, India
[= *brevitarsis* Kohl, 1901c]
- 21 *Tachysphex changi* Tsuneki, 1967..... Japan, South East Asia,
SriLanka, India.
[= *nambui* Tsuneki, 1973a
= *changi luzonicus* Tsuneki, 1983a]
- 22 *Tachysphex gryllivorus* Pulawski, 1994..... SriLanka, Nepal, India
- 23 *Tachysphex indicus* Pulawski, 1994..... Africa, Israel, Jordan,
Syria, Yemen, Tajikistan,
Turkmenistan,
Uzbekistan, Pakistan and
India
- 24 *Tachysphex morosus* (F.Smith), 1858..... SriLanka, Nepal, China,
Fiji, Hawaii, Papua New
Guinea, Pacific ocean
Islands, South East Asia,
India
[= *Tachytes morosus* F. Smith, 1858b
= *Tachysphex tinctipennis* Cameron, 1904f
= *Tachysphex lihyuetanus* Tsuneki, 1971h]
- 25 *Tachysphex panzeri* (Vander Linden), 1829..... Pakistan, SriLanka,
Thailand, North Europe,
North Africa, Russia,
Kazakhstan, Iran, Turkey,
Ukraine, India
[= *Lyrops rufiventris* Spinola, 1839
= *Larrada rufiventris* (Spinola): F. Smith, 1856
= *Tachytes rufiventris* (Spinola) Costa, 1867b
= *Lyrops haemorrhoea* Spinola, 1843b
= *Tachytes oraniensis* Lepeletier, 1845
= *Tachytes aurifrons* Lucas, 1849
= *Tachytes discolor* Frivaldszky, 1877
= *Tachytes pulverosus* Radoszkowski, 1886a
= *Tachytes ceylonicus* Cameron, 1900a
= *Tachytes aurifrons* Cameron, 1900a
= *Tachysphex ablatas* Nurse, 1909
= *Tachysphex panzeri fortunatus* de Beaumont,
1968a
= *Tachysphex panzeri cyprius* Pulawski, 1971
= *Tachysphex panzeri sareptanus* Pulawski,
1971
= *Tachysphex auriceps*: Giner Mari, 1945c]

Genus 12 *Tachytes* Panzer, 1806.

- 26 *Tachytes modestus* F. Smith, 1856..... China, Japan, Korea,
[= *maculipennis* Cameron, 1904] South East Asia and India
- 27 *Tachytes nitidulus* (Fabricius), 1793..... Borneo, India
[= *Crabro nitidulus* Fabricius, 1793
= *Tachytes nitidulus* (Fabricius) Dahlbom,
1845]

Genus 13 *Larra* Fabricius, 1793.

- 28 *Larra stom* sp. nov.
- 29 *Larra Vechti* Sudheendrakumar and Narendran,
1985..... India

Genus 14 *Liris* Fabricius, 1804

- 30 *Liris anupamus* sp. nov.
- 31 *Liris arcuatus* sp. nov.
- 32 *Liris aurulentus* (Fabricius), 1787..... China, Eritrea, Indonesia,
Japan, Korea, Malaya,
[= *Sphex aurulentus* Fabricius, 1787 Papua New Guinea,
= *Larrada aurulenta* (Fabricius) F. Smith, Phillipines, SriLanka,
1856 Sulawesi, Taiwan, India
= *Tachytes aurulenta* (Fabricius): Lepeletier,
1845
= *Larra aurulenta* (Fabricius) Cresson, 1862
= *Liris aurulenta* (Fabricius) Van der Vecht,
1961a
= *Liris aurulentus* (Fabricius) Yamane,
Ikudome, and Terayama, 1999
= *Sphex auratus* Fabricius, 1787
= *Pompilus auratus* (Fabricius) Fabricius, 1798
= *Lyrops auratus* (Fabricius) Guérin-
Méneville, 1844
= *Larra aurata* (Fabricius): Jurine, 1807
= *Notogonia aurata* (Fabricius) Rothney, 1903

= *Tachytes opulentus* Lepeletier, 1845
 = *Tachytes auropilosus* Rohwer, 1911a
 = *Tachytes sinensis* var *purpureipennis*
 Matsumura and Uchida, 1926]

33 *Liris narendrani* sp. nov.

34 *Liris pentaspinosus* sp. nov.

35 *Liris simoni* sp. nov.

36 *Liris sinuatus* sp. nov.

37 *Liris subtessellatus* (F. Smith), 1856..... Afghanistan, Bangladesh,
 [= *Larrada exilipes* F. Smith, 1856 Burma, China, Fiji, Iran,
 = *Larrada docilis* F. Smith, 1873a Iraq, Japan, Papua New
 = *Larrada tisiphone* F. Smith, 1873a Guinea, Philippines,
 = *Larra tisiphonoides* Dalla Torre, 1897 Sri Lanka, Thailand, India
 = *Notogonidea manilensis* Rohwer, 1910c
 = *Notogonia insularis* Cameron, 1913b
 = *Notogonidea luzonensis* Rohwer, 1919
 = *Liris vortex* Tsuneki, 1966g]

38 *Liris thenmalaensis* sp. nov.

39 *Liris wayanadensis* sp. nov.

Genus 15 *Lyroda* Say, 1837

40 *Lyroda formosa* (F. Smith), 1858..... China, Indonesia, New
 [= *Morphota formosa* F. Smith, 1858b Guinea, Oman,
 = *Lyroda Formosa* (F. Smith): Kohl, 1885a Philippines, Thailand,
 = *Odontolarra rufiventris* Cameron, 1900a India
 = *Lyroda rufiventris* (Cameron): Turner, 1914]

Genus 16 *Miscophus* Jurine, 1807

41 *Miscophus apoorvus* sp. nov.

Genus 17 *Solierella* Spinola, 1851

42 *Solierella turneri* Dutt, 1917..... India

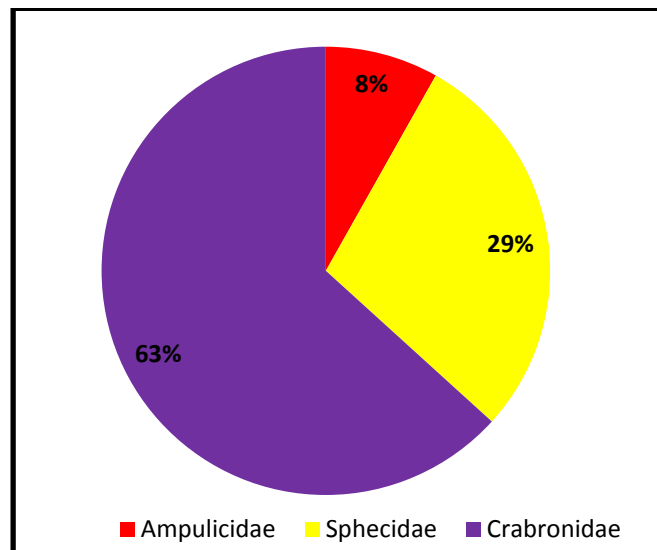
Genus 18 *Pison* Jurine, 1808

- 43 *Pison punctifrons* Shuckard, 1838..... China, Japan, Korea,
SouthEast Asia , India
[= *suspiciosum* F. Smith, 1858a
= *fabricator* F. Smith, 1869a
= *striolatum* Cameron, 1897a
= *lagunae* Ashmead, 1904d
= *javanus* Cameron, 1905k
= *japonicum* Gussakovskij, 1937]

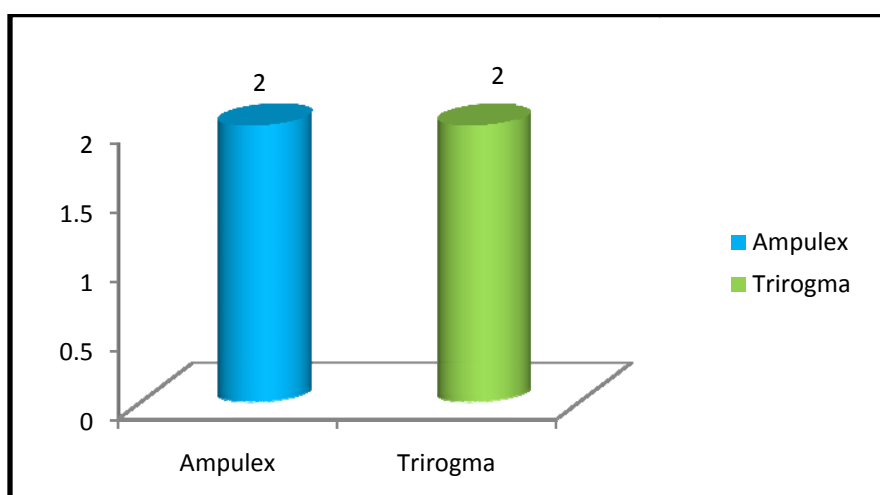
Genus 19 *Trypoxylon* Latreille, 1796

- 44 *Trypoxylon bicolour* F.Smith, 1856..... China, Hawaii, Malaya,
Maldives, South East
Asia, SriLanka and India
[= *bicolor marginatum* Tsuneki, 1976b
= *bicolor dorsale* Tsuneki, 1977i]
- 45 *Trypoxylon errans* de Saussure, 1867..... Bangladesh, China, Japan,
Madagascar, Malaya,
Mauritius, Myanmar,
Nepal, South East Asia,
SriLanka, Seychelles,
Tanzania, India
[= *intrudens* F. Smith, 1870
= *canaliculatum* Cameron, 1889c
= *geniculatum* Cameron, 1902f
= *philippinense* Ashmead, 1904c
= *gardineri* Cameron, 1907e
= *ornatipes* Cameron, 1913
= *pulawskii* Tsuneki, 1956g
= *tanoi* Tsuneki, 1967d
= *saitamaense* Tsuneki, 1973a]
- 46 *Trypoxylon lamellatum* Tsuneki, 1979..... India
- 47 *Trypoxylon nishidai* Tsuneki, 1979..... Laos, India
- 48 *Trypoxylon pileatum* F.Smith, 1856..... Bangladesh, China,
SriLanka, India
- 49 *Trypoxylon vardyi* Tsuneki, 1979a..... Malaya, Indonesia, India

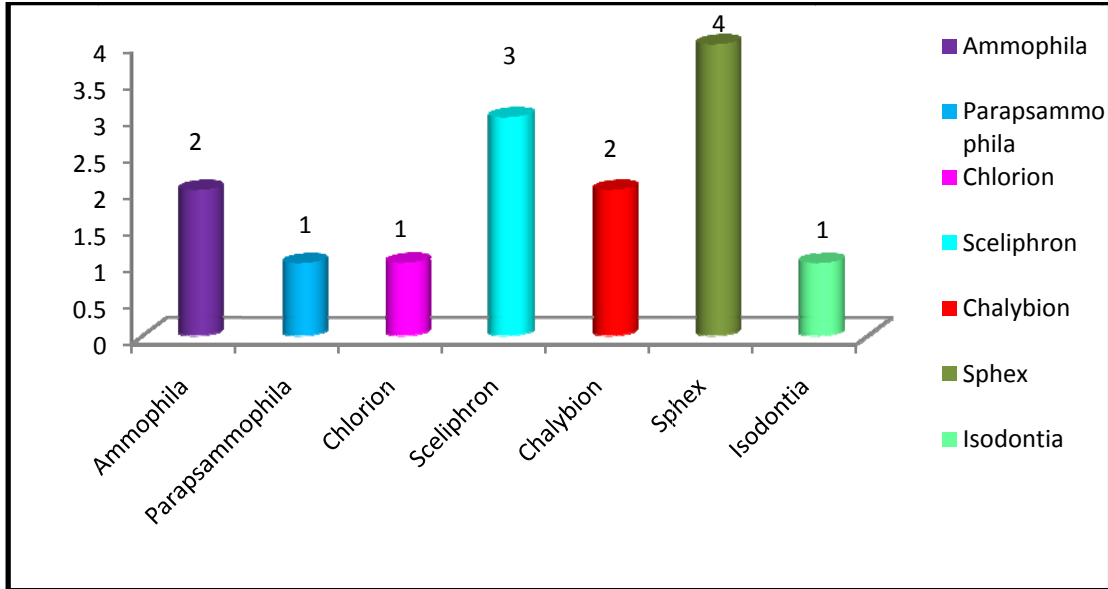
GRAPH 1 PERCENTAGE COMPOSITION OF THREE FAMILIES OF SPHECID FAUNA OF KERALA DEALT WITH THIS STUDY



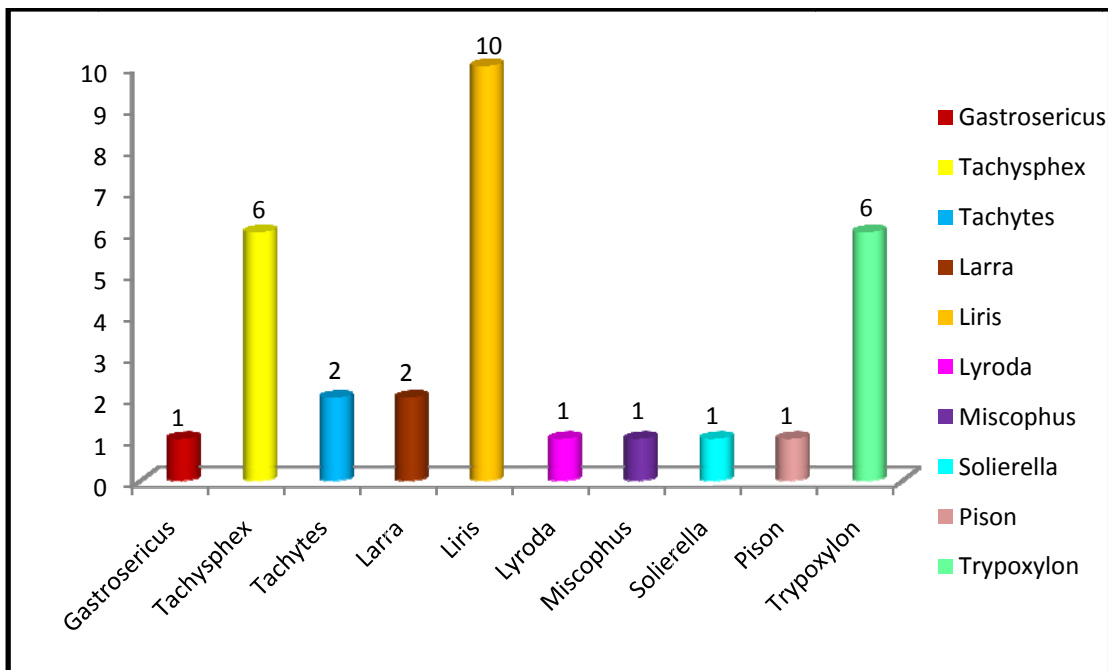
GRAPH 2 GENERIC AND SPECIES ABUNDANCE OF FAMILY AMPULICIDAE



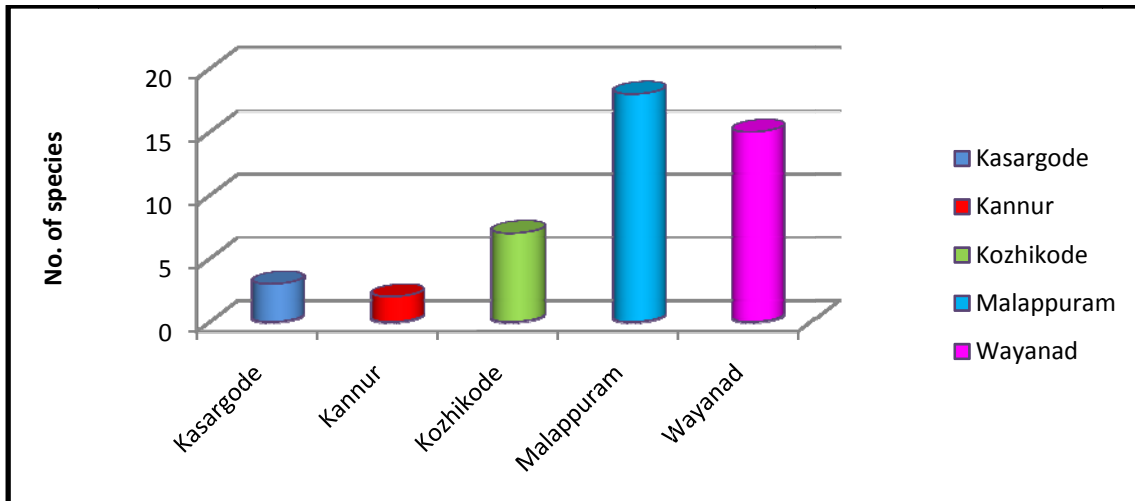
GRAPH 3 GENERIC AND SPECIES ABUNDANCE OF FAMILY SPHECIDAE



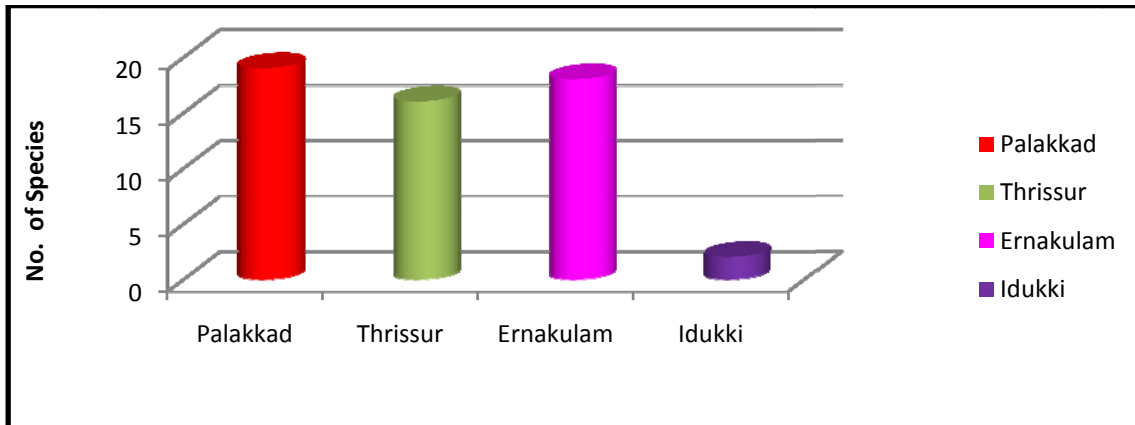
GRAPH 4 GENERIC AND SPECIES ABUNDANCE OF FAMILY CRABRONIDAE



GRAPH 5 SPECIES DIVERSITY OF WASPS IN NORTH KERALA



GRAPH 6 SPECIES DIVERSITY OF WASPS IN CENTRAL KERALA



GRAPH 7 SPECIES DIVERSITY OF WASPS IN SOUTH KERALA

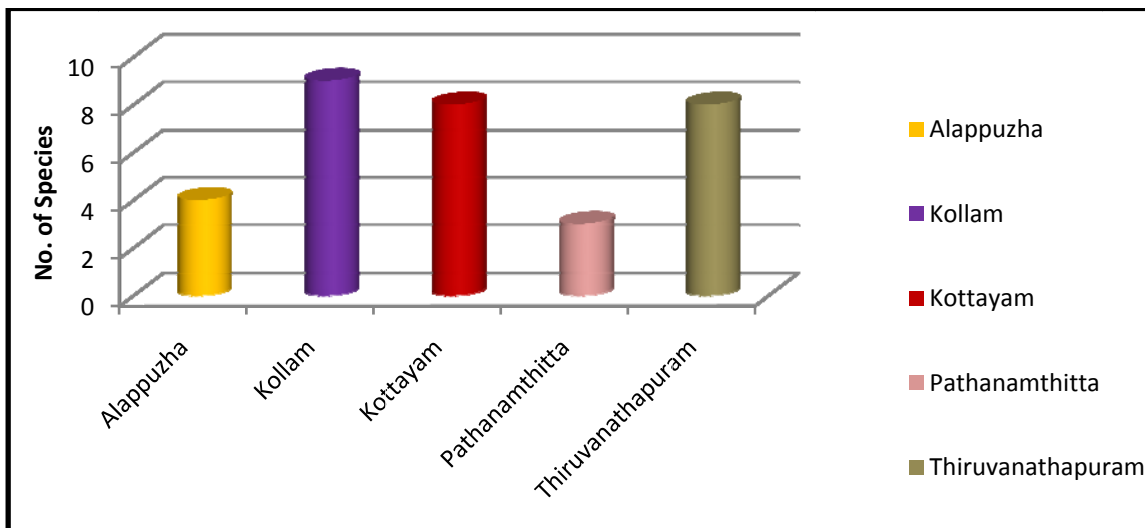


TABLE 4 PLACES VISITED FOR SPECIMEN COLLECTION

NORTH KERALA		CENTRAL KERALA		SOUTH KERALA	
KASARGODE	Padanakkadu. Parappa. C.P.C.R.I. BekalFort, Pallikere. Cheruvathur	PALAKKAD	Chalissery Koottupatha Malampuzha Manarkadu Paalana, Kannadi Pattambi Tippu's fort	ALAPPUZHA	Arthungal Chungam Kuttanad Pathiramanal Thiruvambady
KANNUR	Dharmadom Pallikkunnu Payyambalam. Sree Narayana Park St.Angelo Fort. Thalassery.	THRISSUR	Ayyanthole Chelakkottukara Eravu K.F.R.I. Butterfly Park Kunnamkulam Peechi Thumburmuzhi Park Vazhani Kanimangalam	KOLLAM	Ottakkal Puthiyarur Urukkunnu Thenmala deer Park Thenmala Butterfly Park Kulathupuzha Kottarrakkara Munroethuruthu Punalur
KOZHIKODE	Feroke Mahe. Mankavu Mavur. Ramanattukara.	ERNAKULAM	Aluva Kanjiramala Karimugal Koothattukulam Vytilla	KOTTAYAM	Chempu Edamattom Kozha Layikad Munnakkal Ramapuram Rubber board
MALAPPURAM	Chamramattom. Kondotty. Manjeri. Nilambur teak Museum Thavanoor. Thunchanparambu, Tiroor Valanchery Vazhikadavu	IDUKKI	Cheppukulam Kunjimala Munnar Thekkadi Thodupuzha Thomannkuthu	PATHANAMTHI TTA	Ayiroor Pazhavangadi Perumthuruthy Ranni Thiruvella
WAYANAD	Ambalavayal Boy's Town Kambamala Kottiyoor Kottiyur Kuruva. Kuzhinilam. Mannanthavady Park Thirunelli Tholpetty	92 places were visited for specimen collection		THIRUVANANTHA PURAM	Kanakkunnu Mannathala Shangumugam T.B.G.R.I. Palode Vellayani

**TABLE 5 DISTRIBUTION PATTERNS OF SPECIES OF THE FAMILY
AMPULICIDAE IN KERALA**

SI No.	Name of the Species*	Name of Districts													
		Kasargode	Kannur	Kozhikode	Malappuram	Wayanad	Palakkad	Thrissur	Ernakulam	Idukki	Alappuzha	Kollam	Kottayam	Pathanamthitta	Thiruvananthapuram
1	<i>Ampulex compressa</i> (Fabricius)	+	-	-	+	-	+	+	+	-	-	-	-	-	-
2.	<i>Trirogma caerulea</i> Westwood	-	-	-	+	-	+	+	-	-	-	-	-	-	-
3.	<i>Trirogma narendrani</i> Madhavikutty	-	-	-	-	+	-	-	-	-	-	-	-	-	-
* <i>A. aenea</i> Spinola not included due to want of literature ‘+’ indicates presence of the species ‘-’ indicates the absence of species															

**TABLE 6 DISTRIBUTION PATTERNS OF SPECIES OF THE FAMILY
SPHECIDAE IN KERALA**

Sl. No.	Name of the Species*	Name of Districts												
		Kasargode	Kannur	Kozhikode	Malappuram	Wayanad	Palakkad	Thrissur	Ernakulam	Idukki	Alappuzha	Kollam	Kottayam	Pathanamthitt ^a
1	<i>Ammophila clavus</i> (Fabricius)	-	-	-	+	-	+	+	-	-	-	-	-	+
2.	<i>Ammophila laevigata</i> F. Smith,	-	-	-	+	+	+	+	-	+	-	+	-	-
3.	<i>Chlorion lobatum</i> (Fabricius)	-	-	+	-	+	+	+	-	-	-	-	-	-
4.	<i>Sceliphron coromandelicum</i> (Lepeletier)	-	-	-	+	+	+	+	-	+	-	+	-	+
5.	<i>Sceliphron javanum nalandicum</i> Strand	-	-	+	+	+	+	+	-	-	-	-	-	-
6.	<i>Sceliphron madraspatanum</i> (Fabricius)	-	+	+	+	-	+	+	+	-	-	-	+	+
7.	<i>Chalybion bengalense</i> (Dahlbom)	+	+	+	+	+	+	+	+	+	+	+	+	+
8.	<i>Chalybion keralensis</i> sp. nov.	-	-	-	-	+	-	-	-	-	-	-	-	-
9.	<i>Sphex argentatus</i> Fabricius	-	-	+	+	-	+	+	-	-	-	-	-	+
10	<i>Sphex praedator</i> F. Smith	-	-	-	+	-	-	-	-	-	-	-	-	-
11	<i>Sphex sericeus</i> (Fabricius)	-	-	+	+	+	+	+	+	-	-	+	+	-
12	<i>Sphex neosericeus</i> sp. nov.	-	-	-	-	-	-	+	-	-	-	-	-	-
13	<i>Isodontia diodon</i> (Kohl)	-	-	-	-	-	-	-	+	-	-	+	-	-

* *Parapsammophila erthrocephala* (Fabricius) not included due to want of literature
 ‘+’ indicates presence of the species ‘-’ indicates the absence of species

**TABLE 7 DISTRIBUTION PATTERNS OF SPECIES OF THE FAMILY
CRABRONIDAE IN KERALA**

SI No.	Name of the Species*	Name of Districts													
		Kasargode	Kannur	Kozhikode	Malappuram	Wayanad	Palakkad	Thrissur	Ernakulam	Idukki	Alappuzha	Kollam	Kottayam	Pathanamthitta	Thiruvnanthapuram
1	<i>Gastrosericus siamensis</i> Tsuneki	-	-	+	-	-	-	-	-	-	-	-	-	-	-
2.	<i>Tachysphex bengalensis</i> Cameron	-	-	-	-	-	-	-	+	-	-	+	-	-	-
3.	<i>T. changi</i> Tsuneki	-	-	-	-	-	+	-	-	-	-	-	-	-	-
4.	<i>T. gryllivorus</i> Pulawski	-	-	-	-	-	+	-	-	-	-	-	-	-	-
5.	<i>T. indicus</i> Pulawski	-	-	-	-	+	+	-	-	-	-	-	-	-	-
6.	<i>T. morosus</i> (F.Smith)	-	-	-	-	+	+	-	-	-	-	-	-	+	-
7.	<i>T. panzeri</i> (Vander Linden)	-	-	-	-	+	-	-	+	-	-	-	-	-	-
8.	<i>Larra Stom</i> sp. nov.	-	-	-	-	-	-	-	+	-	-	-	-	-	-
9.	<i>Larra Vechti</i> Sudheendrakumar and Narendran	-	-	-	+	-	-	-	-	-	-	-	-	-	-
10	<i>Liris aurulentus</i> (Fabricius)	-	-	-	+	+	-	+	+	-	-	-	-	-	-
11	<i>Liris subtessellatus</i> (F.Smith)	-	-	-	-	+	-	-	+	-	+	-	+	-	-
12	<i>Liris narendrani</i> sp. nov.	-	-	-	-	-	-	-	+	+	-	-	+	-	-
13	<i>Liris thenmalaensis</i> sp. nov.	-	-	-	-	-	-	+	+	-	-	+	-	-	-
14	<i>Liris simoni</i> sp. nov.	-	-	-	-	-	-	+	+	-	-	-	+	-	-
15	<i>Liris sinuatus</i> sp. nov.	-	-	-	-	-	-	-	+	-	-	-	-	-	-

* *Tachytes modestus* F. Smith, and *Tachytes nitidulus* (Fabricius) not included due to want of literature
‘+’ indicates presence of the species ‘-’ indicates the absence of species

continued

Sl. No.	Name of the Species*	Name of Districts													
		Kasargode	Kannur	Kozhikode	Malappuram	Wayanad	Palakkad	Thrissur	Ernakulam	Idukki	Alappuzha	Kollam	Kottayam	Pathanamthitta	Thiruvnanthappuram
16	<i>Liris arcuatus</i> sp. nov.	-	-	-	-	+	-	-	-	-	-	+	-	-	
17	<i>Liris pentaspinosus</i> sp. nov.	-	-	-	+	-	-	-	-	-	-	-	-	-	
18	<i>Liris wayanadensis</i> sp. nov.	-	-	-	-	+	-	-	-	-	-	-	-	-	
19	<i>Liris anupamus</i> sp. nov.	-	-	-	+	-	-	-	+	-	-	-	-	+	
20	<i>Miscophus apoorvus</i> sp. nov.	-	-	-	-	-	-	-	+	-	-	-	-	-	
21	<i>Pison punctifrons</i> Shuckard	-	-	-	-	-	-	+	-	-	-	+	-	+	
22	<i>Trypoxylon bicolor</i> F.Smith	-	-	-	+	-	-	-	-	-	-	+	-	-	
23	<i>T. errans</i> de Saussure	+	-	-	+	-	+	-	-	-	-	-	-	-	
24	<i>T. lamellatum</i> Tsuneki	-	-	-	-	-	+	-	-	-	-	-	-	-	
25	<i>T. nishidai</i> Tsuneki	-	-	-	-	-	+	-	-	-	-	-	-	-	
26	<i>T. pileatum</i> F.Smith	-	-	-	+	-	-	-	-	-	-	+	-	-	
27	<i>T. vardyi</i> Tsuneki	-	-	-	-	-	+	-	-	-	-	-	-	-	

* *Solierella turneri* Dutt and *Lyroda formosa* (F.Smith) not included due to want of literature
‘+’ indicates presence of the species ‘-’ indicates the absence of species

**TABLE 8 FLORISTIC RELATIONS: ADULT SPHECIDS COLLECTED
FROM FLOWERS**

Name of plant species	Family	Name of sphecid wasp
<i>Ixora dufii</i> Moore	Rubiaceae	<i>Sceliphron coromandelicum</i> (Lepeletier), 1845
<i>Euphorbia milli</i> Des.Moul	Euphorbiaceae	<i>Chalybion bengalense</i> (Dahlbom), 1845.
<i>Mikania micrantha</i> Kunth	Asteraceae	
<i>Murraya Koenigii</i> (L) Sprengel	Rutaceae	<i>Sphex sericeus</i> (Fabricius), 1793.
<i>Clerodendrum</i> sp	Lamiaceae	<i>Sphex argentatus</i> Fabricius, 1787.

TABLE 9 HABITAT DIVERSITY OF SPHECIDS

Habitat	Name of the species.
Nurseries and vegetable gardens	<i>Sceliphron coromandelicum</i> (Lepeletier) <i>S.madraspatanum</i> (Fabricius) <i>Chalybion bengalense</i> (Dahlbom) <i>Sphex argentatus</i> Fabricius <i>Sphex sericeus</i> (Fabricius) <i>Liris subtessellatus</i> (F.Smith) <i>Ammophila clavus</i> (Fabricius) <i>T. pileatum</i> F.Smith <i>T. errans</i> de Saussure
Indoors of Houses and Buildings	<i>Sceliphron coromandelicum</i> (Lepeletier) <i>S.madraspatanum</i> (Fabricius) <i>Chalybion bengalense</i> (Dahlbom) <i>Chalybion keralensis</i> sp. nov. <i>Tirogma caerulea</i> Westwood <i>Ampulex compressa</i> (Fabricius) <i>Pison punctifrons</i> Shuckard
Rubber plantations and Semiforest areas	<i>Ammophila laevigata</i> F.Smith <i>Liris anupamus</i> sp. nov. <i>Liris arcuatus</i> sp. nov. <i>Liris aurulentus</i> (Fabricius) <i>Liris narendrani</i> sp. nov. <i>Liris pentaspinosus</i> sp. nov. <i>Liris simoni</i> sp. nov. <i>Liris sinuatus</i> sp. nov. <i>Liris subtessellatus</i> (F.Smith) <i>Liris thenmalaensis</i> sp. nov. <i>Liriswayanadensis</i> sp. nov. <i>Tachysphex bengalensis</i> Cameron <i>T. indicus</i> Pulawski <i>T. morosus</i> (F.Smith) <i>T. panzeri</i> (Vander Linden) <i>Larra stom</i> sp. nov.
Open areas with shrubs	<i>Ammophila laevigata</i> F.Smith <i>Sceliphron javanum nalandicum</i> Strand <i>Sphex argentatus</i> Fabricius <i>Sphex sericeus</i> (Fabricius) <i>Sphex praedator</i> F.Smith <i>Sphex neosericeus</i> sp. nov. <i>Isodontia diodon</i> (Kohl) <i>Trypoxylon bicolour</i> F.Smith <i>T. errans</i> de Saussure <i>Miscophus apoorvus</i> sp. nov.

Chapter 6 SUMMARY

- Sphecid wasps or Spheciformes derive their name from the Greek word Sphêkos means wasp. The spheciformes includes 9716 described species coming under 318 genera and four families. These wasps are large (30mm) to minute (1.8mm) with a worldwide distribution and a focus in arid and semi arid areas. Female hunt other insects or spiders for larval nutrition, a few species develop as cleptoparasites of other sphecids. Adults feed on nectar and honeydew.
- In the current system of classification being followed, sphecid wasps come under the Order Hymenoptera, Suborder Apocrita, Super family Apoidea with five included families- Heterogynaidae, Ampulicidae, Sphecidae and Crabronidae, together with Apoidea, the bees (Pulawski,2013).
- These wasps are quite harmless and beneficial because of their prey diversity. They can be utilized as pest management and biocontrol agents as well as bioindicator tools. They are part of several functional niches (predators, cleptoparasites and pollinators), have economic importance (pollinators and pest management) and they reflect the patterns of other taxa in a given habitat.
- Sphecid wasps are mainly active during daylight and prefer high temperatures (30°- 38°C). The most successful method for their collection is the use of sweep nets. Collection of these quick flying wasps is not easy and needs some experience and luck. Specimens can be mainly found on flowers as well as on nesting sites.
- The present work provides a comprehensive account of Spheciformes in the state of Kerala. It includes 49 species spread over 19 genera coming under 3

families- Ampulicidae, Sphecidae and Crabronidae. 35 species were collected from different districts of Kerala, while diagnoses of 14 species were compiled from literature records. The species within each genus is arranged alphabetically.

- ❖ Family Ampulicidae- 4 species under 2 genera viz. *Ampulex* Jurine and *Tirogma* Westwood.
- ❖ Family Sphecidae- 14 species under 7 genera viz. *Ammophila* Kirby, *Parapsammophila* Taschenberg, *Chlorion* Latreille, *Sceliphron* Klug, *Chalybion* Dahlbom, *Sphex* Linnaeus and *Isodontia* Patton.
- ❖ Family Crabronidae- 31 species under 10 genera viz. *Gastrosericus* Spinola, *Tachysphex* Kohl, *Tachytes* Panzer, *Larra* Fabricius, *Liris* Fabricius, *Lyroda* Say, *Miscophus* Jurine, *Solierella* Spinola, *Pison* Jurine and *Trypoxylon* Latreille. The sphecids form a monophyletic assemblage of wasps.
- Genus *Liris* Fabricius is the most diverse with 10 recorded species. Genera *Pison* Jurine, *Solierella* Spinola, *Lyroda* Say, *Miscophus* Jurine, *Isodontia* Patton, *Chlorion* Latreille and *Parapsammophila* Taschenberg is represented by single species each.
- Out of 35 species collected, 3 are new records for Kerala and 12 new species to science.
 - New records for Kerala
 - *Tachysphex panzeri* (Vander Linden)
 - *Trypoxylon bicolor* F.Smith
 - *Trypoxylon pileatum* F.Smith
 - New species recorded
 - *Sphex neosericeus* sp. nov.
 - *Chalybion keralensis* sp.nov.

- *Liris anupamus* sp. nov.
 - *Liris arcuatus* sp. nov.
 - *Liris narendrani* sp. nov.
 - *Liris pentaspinosus* sp. nov.
 - *Liris simoni* sp. nov.
 - *Liris sinuatus* sp. nov..
 - *Liris thenmalaensis* sp. nov.
 - *Liris wayanadensis* sp. nov.
 - *Larra stom* sp. nov.
 - *Miscophus apoorvus* sp. nov.
- In the present study collections have been made from 92 localities, covering all the 14 districts of Kerala. The places of collection chosen randomly and comprise of human habitats, open areas, forest, nurseries and vegetable gardens, paddy fields, rubber plantations and hilly areas.
- The collection data regarding name of country in capital letters, state, district, exact collection locality, latitude and longitude, collector's name and date of collection with month in Roman numerals has been mentioned for all the specimens examined for each species. All the specimens collected are stored in the research lab, Department of Zoology, St. Thomas College, Thrissur, which will be transferred to Zoological Survey of India Western Ghat Regional Centre, Calicut (ZSIWGRC).
- In the review of literature previous taxonomic studies done in India have been included, with the taxonomic work done in Kerala mentioned separately.
- All relevant morphological structures of taxonomic importance of species are represented through drawings and photographs, supplemented by detailed descriptions.

- The distribution patterns of all the species described has been provided. The floral relationships, affinities, habit and habitat diversity has been briefly discussed. A checklist of the sphecid wasps as well as character state matrix of three genera which recorded the highest number of species was prepared.
- *Chalybion bengalense* (Dahlbom) is the most common species. Palakkad is the most species rich district with records of 19 species, while Kannur and Idukki represents the least species rich with 2 species each.
- Significant efforts were made to record all the known species of sphecid wasps from Kerala through collection as well from literature records. Overall the whole study had been successful in bringing out the taxonomic information on these lesser known groups of Kerala. The present study will be reference to future wokers for undertaking any experiments involving the use of these wasps as bioindicators, biological control agents and any studies related to the biology.

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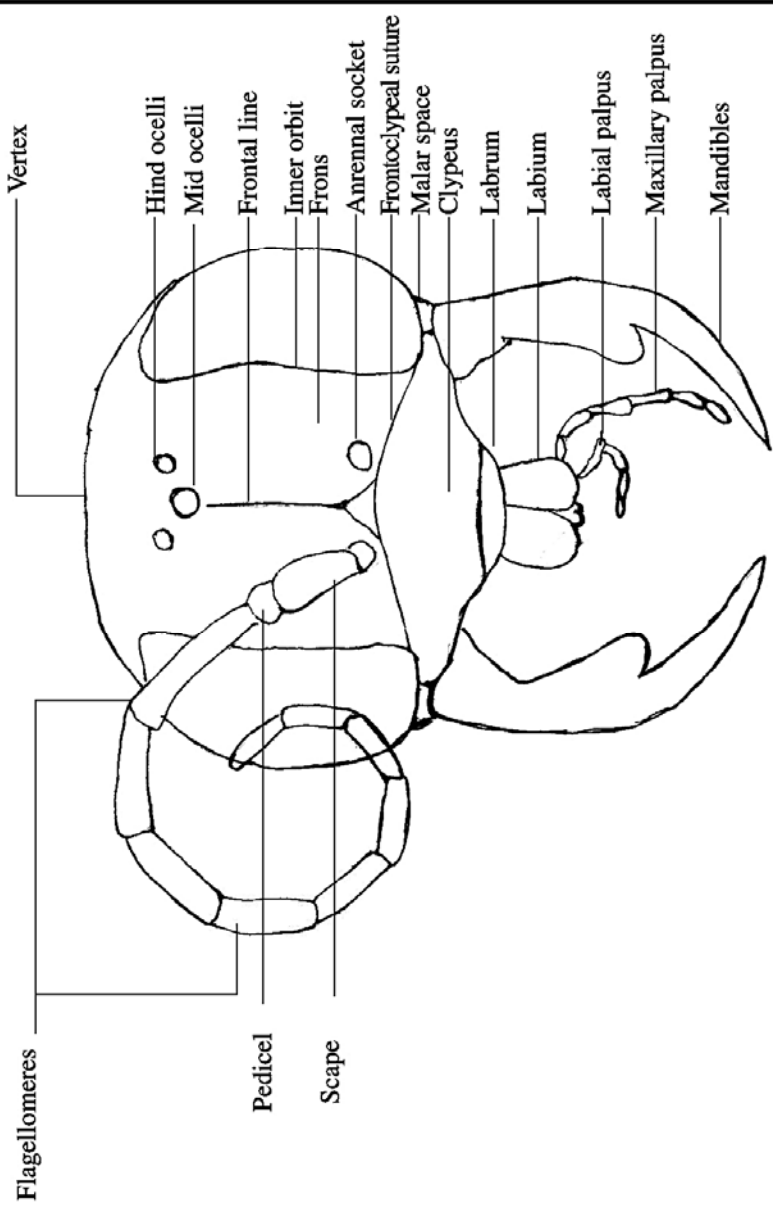
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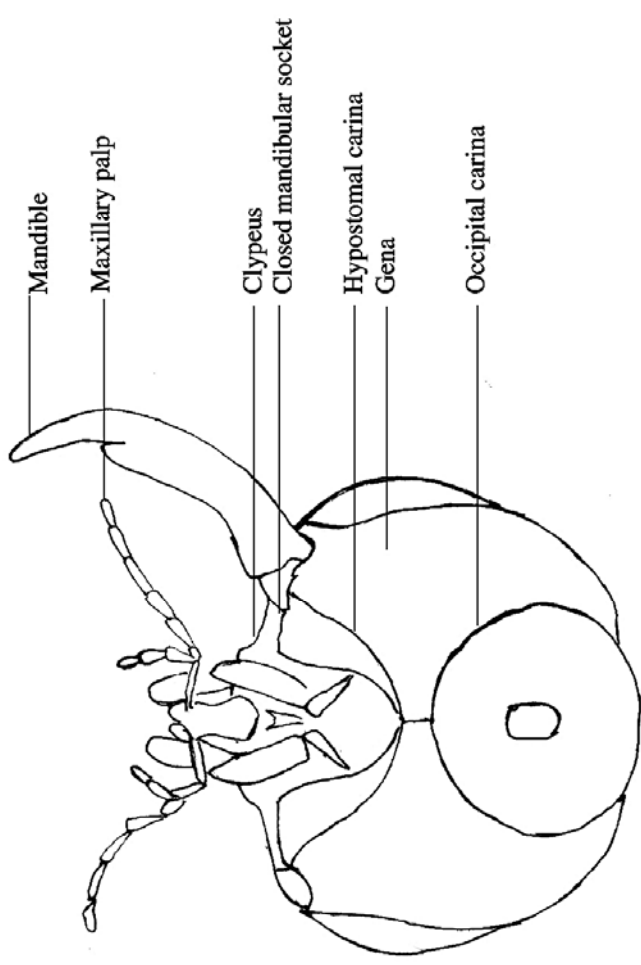
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Figure - 1

Morphology



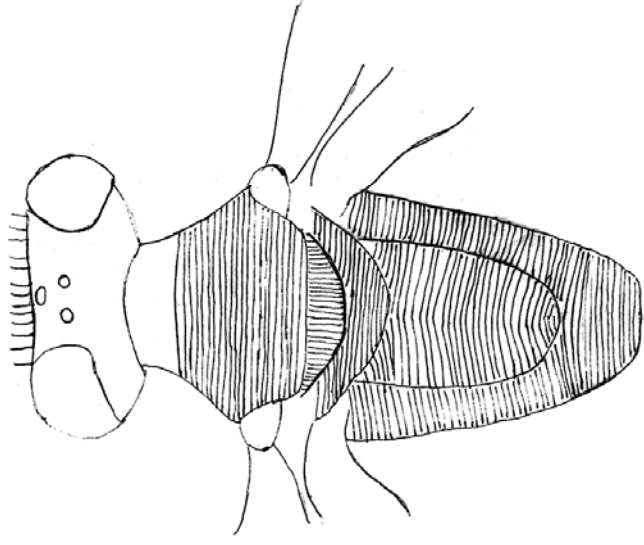
a: Head Dorsal View



b: Head Ventral View

Figure - 10

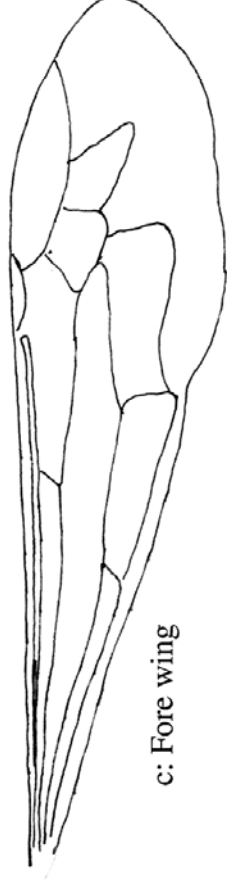
Sceliphron coromandelicum (Lepeletier)



b: Head & Mesosoma



a: Head Ventral view



c: Fore wing



d: Hind wing



e: Petiole lateral view

Figure - 11

Sceliphron javanum nalandicum Strand

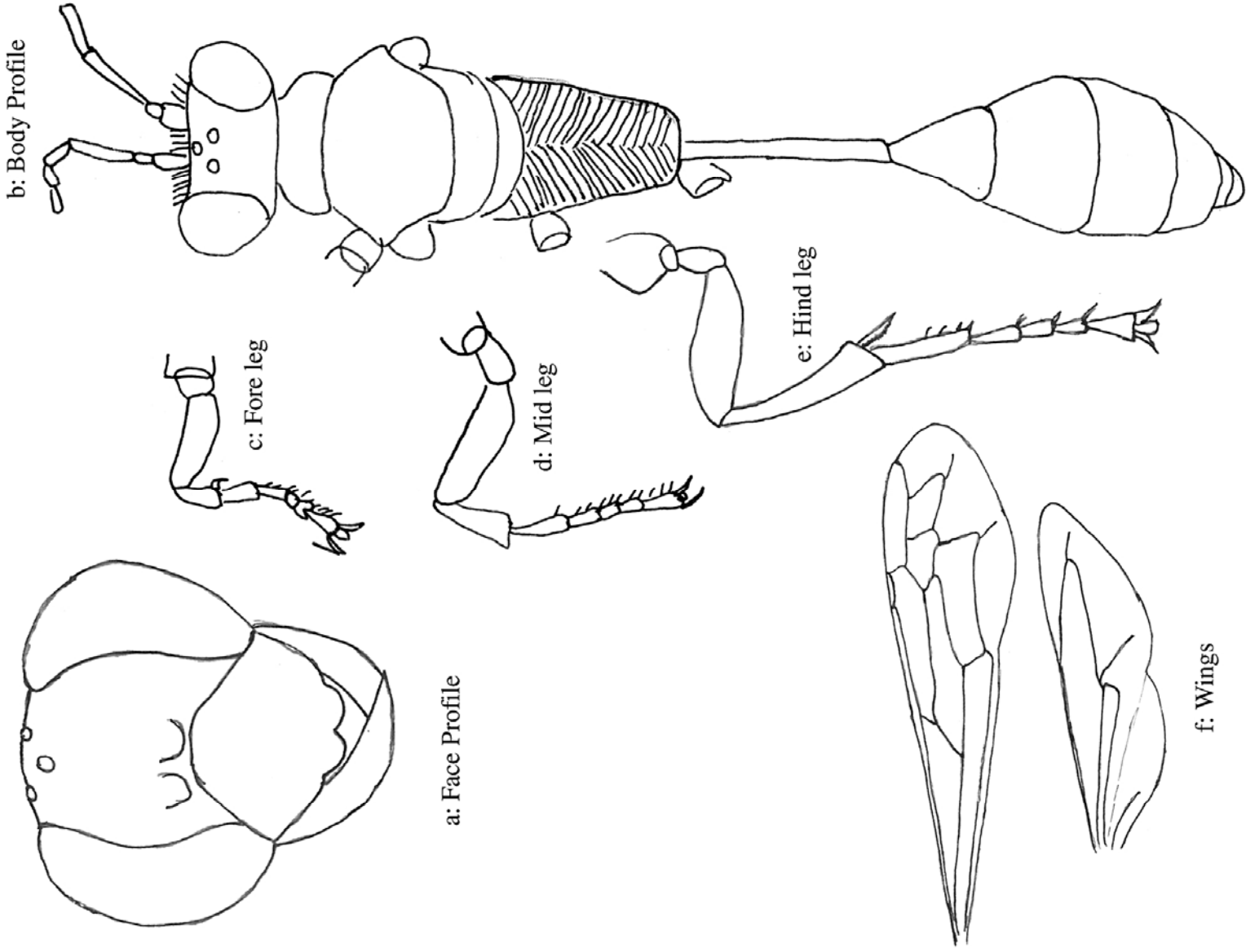
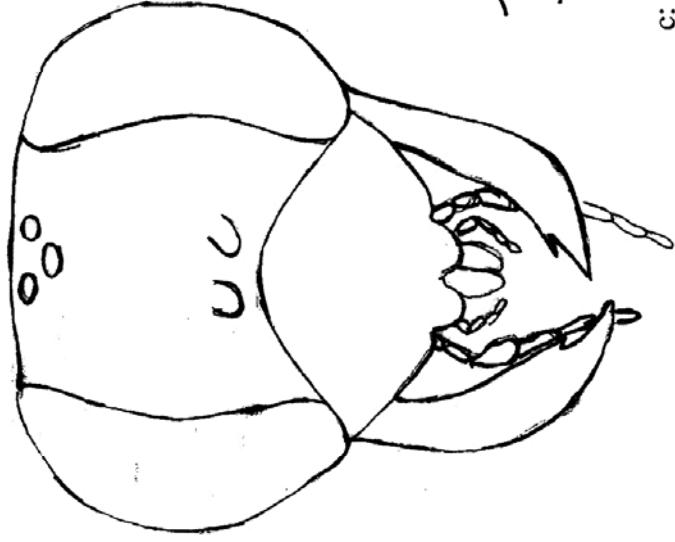


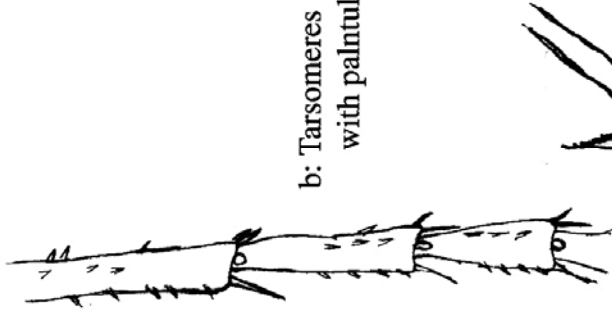
Figure - 12

Sceliphron madraspatanum (Fabricius)

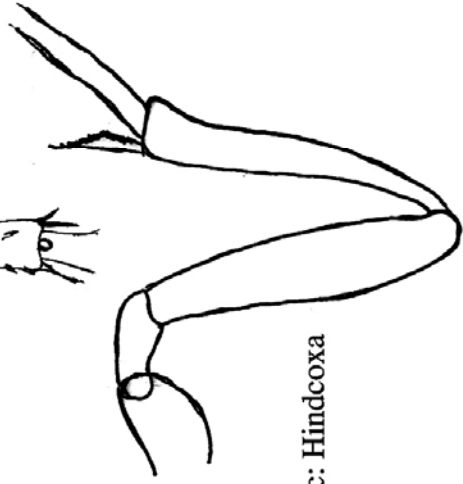
a: Face Profile



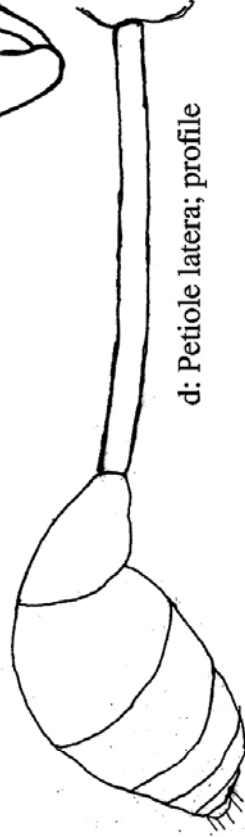
b: Tarsomeres with palintulae



c: Hindcoxa



d: Petiole latera; profile

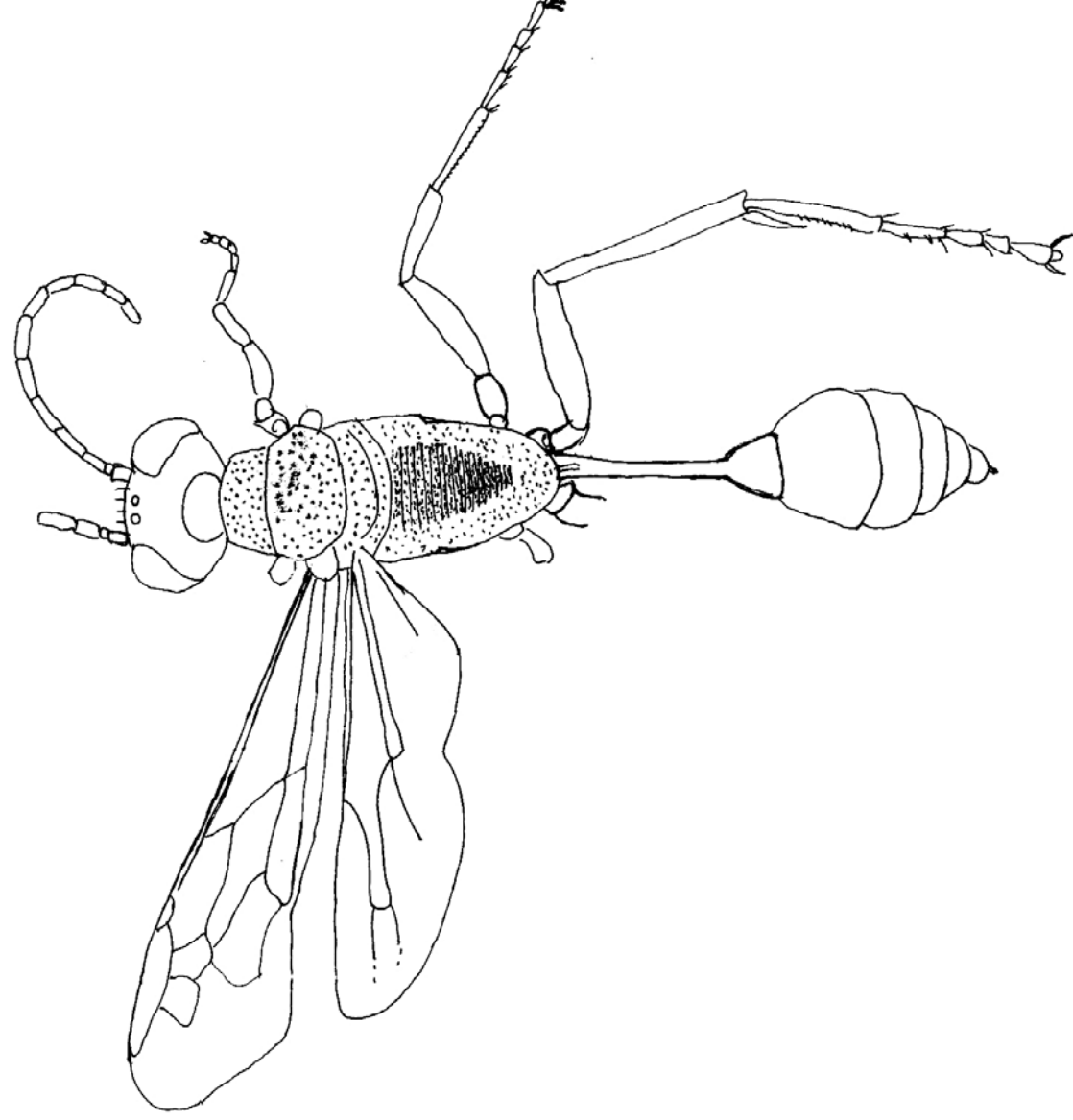


e: Wings



Figure - 13

Chalybion bengalense (Dahlbom)



a: Body profile

Figure - 14

Chalybion keralensis sp. nov.

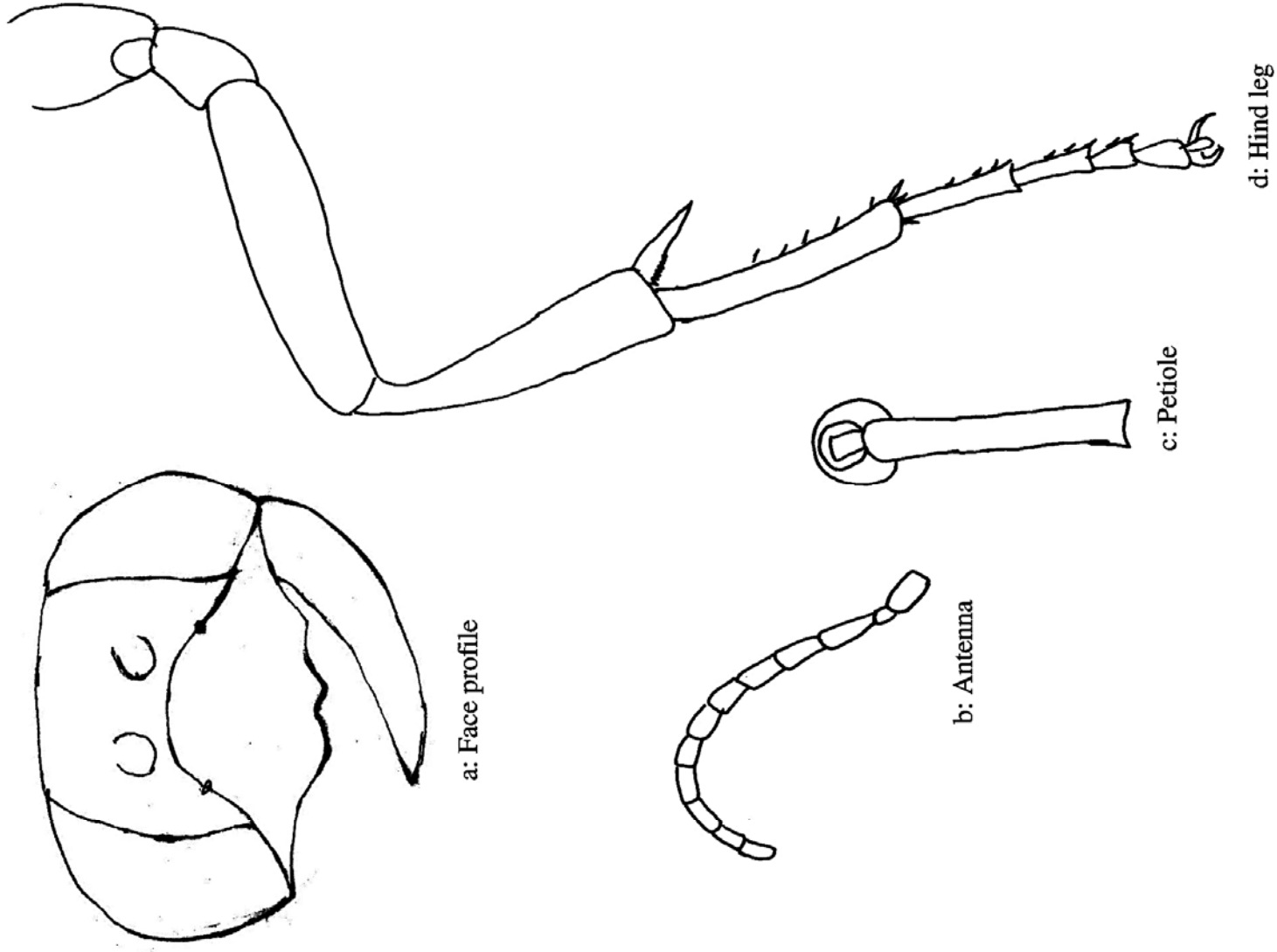
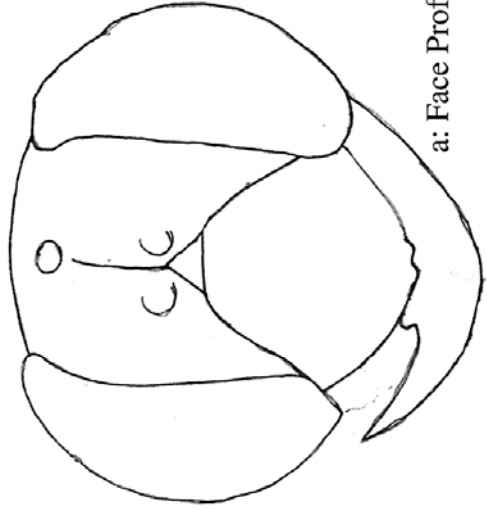
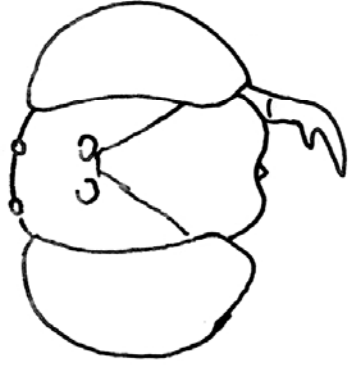


Figure - 15

Sphex argentatus Fabricius



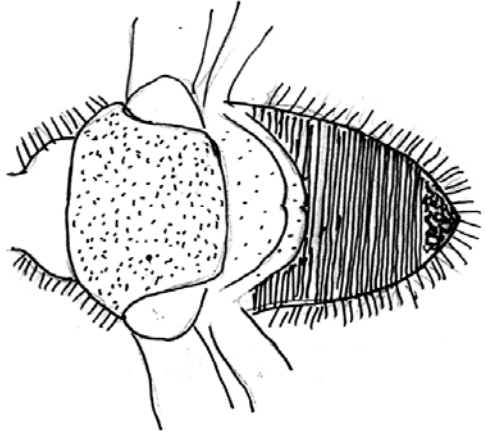
a: Face Profile Female



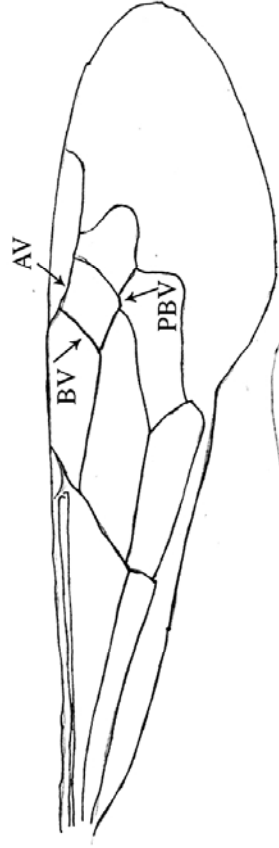
b: Face profile Male



c: Propodeum lateral profile with spiracular groove (sg)



d: Propodeum



e: Wings



f: Foretarsomeres female

Figure - 16

Sphex neosericeus sp. nov.

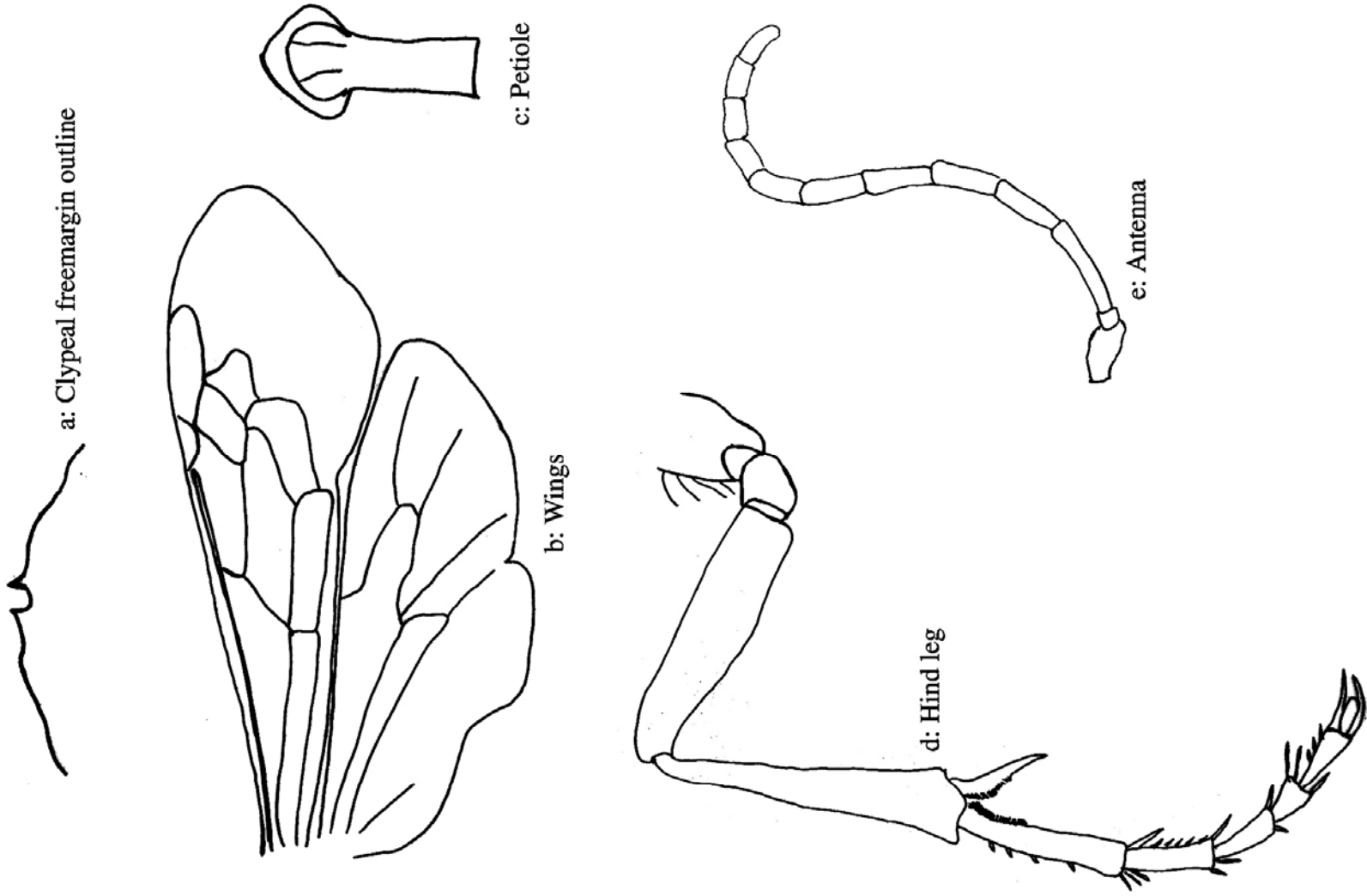
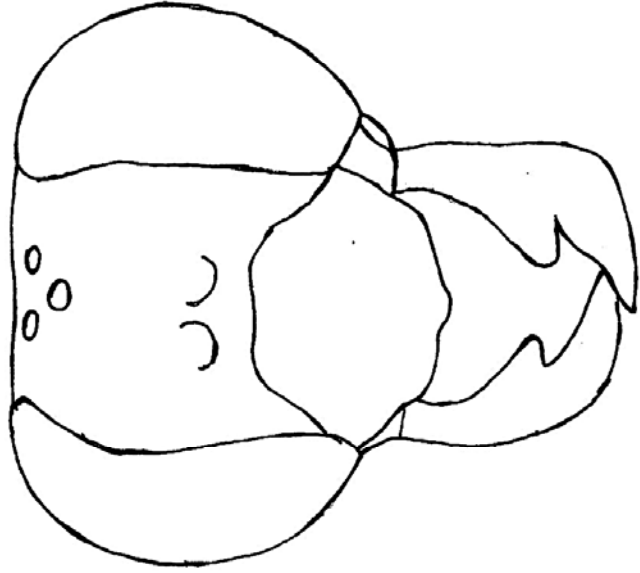
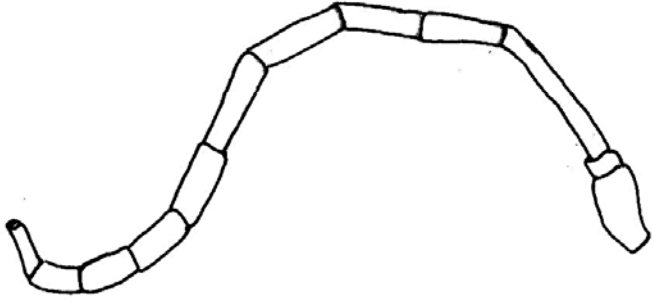


Figure - 17

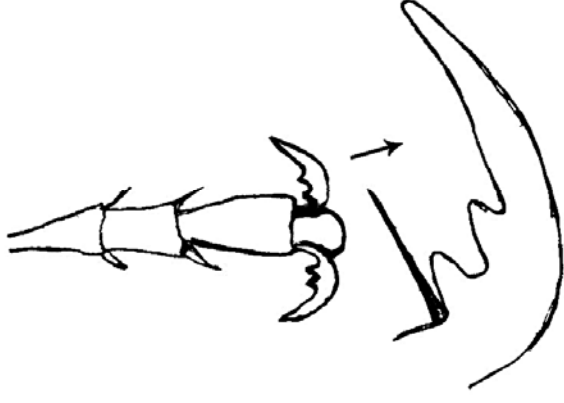
Sphex praedator F. Smith



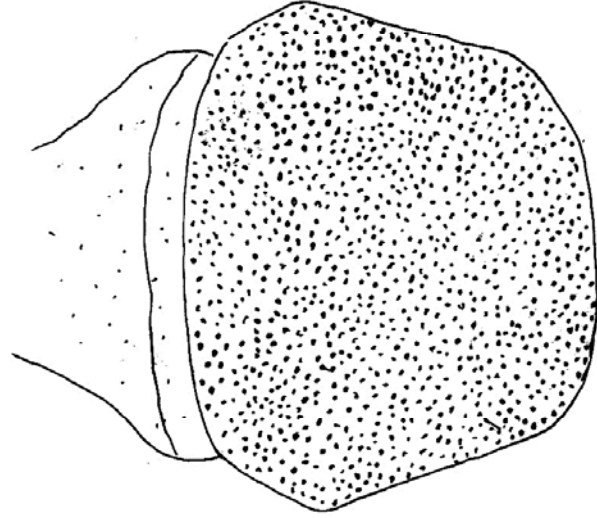
a: Face profile



b: Antenna



d: Tarsomeres with claws



c: Scutum

Figure - 18

Sphex sericeus (Fabricius)

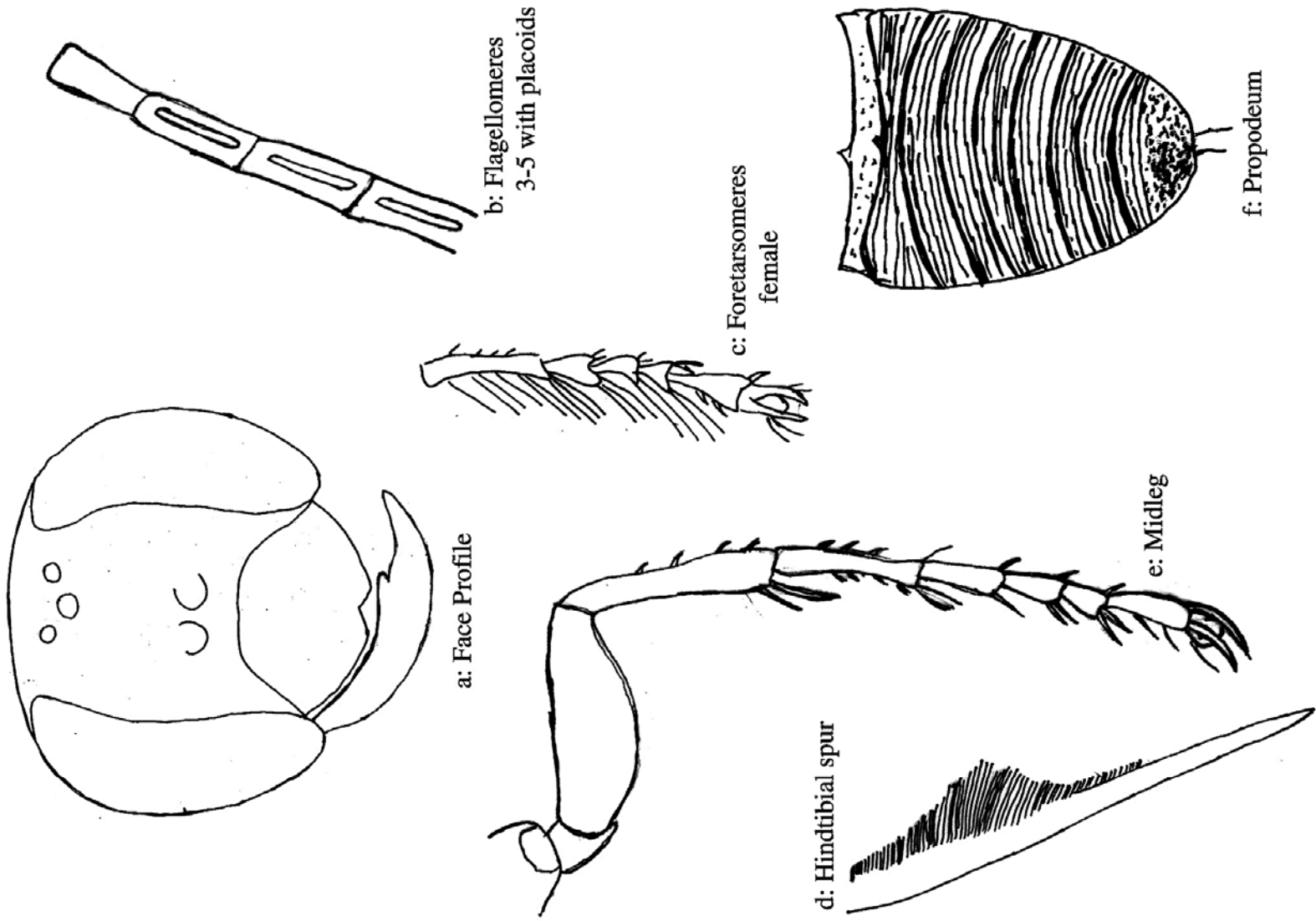
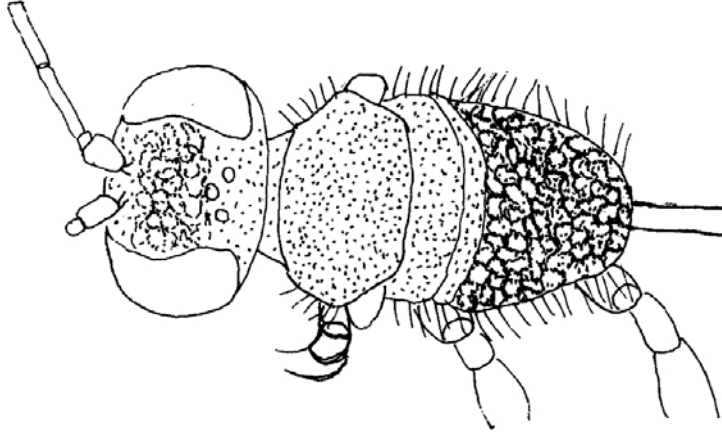
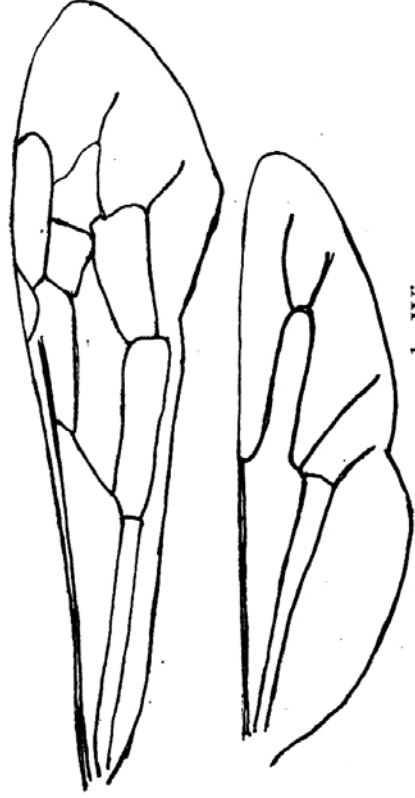


Figure - 19

Isodontia diodon (Kohl)



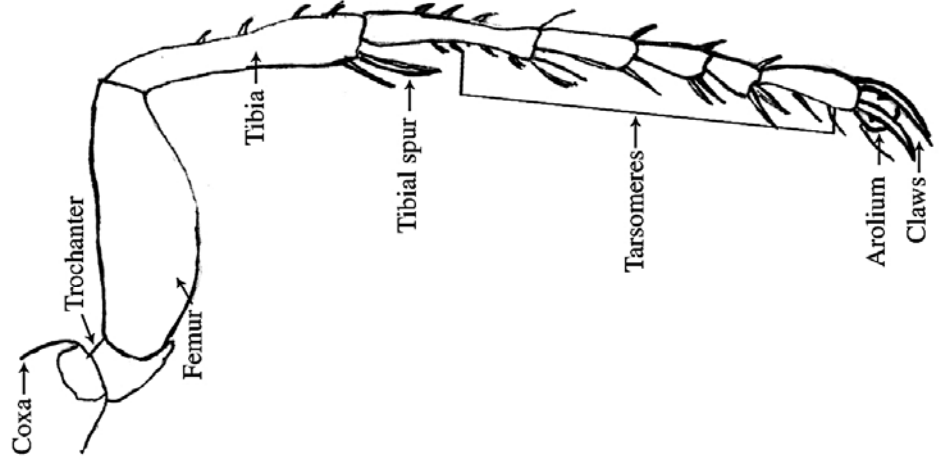
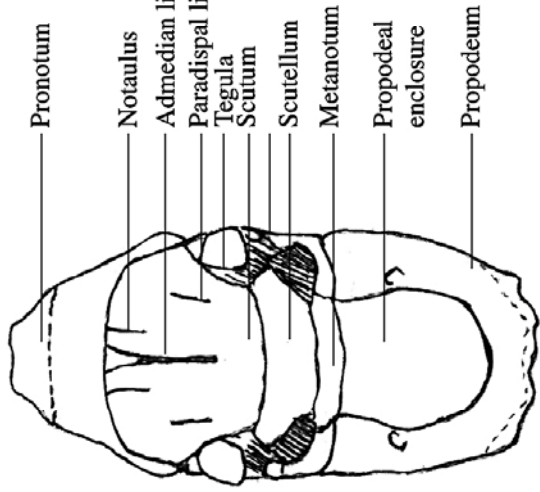
a: Body Profile



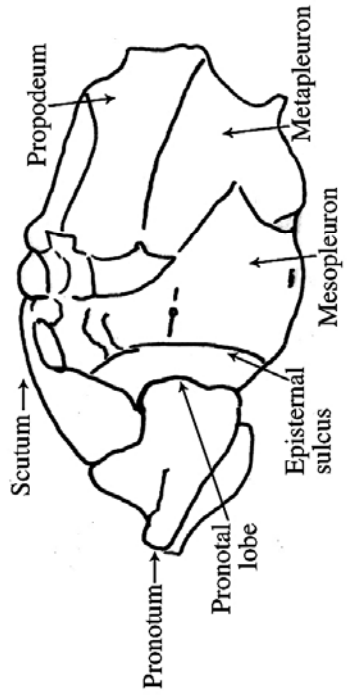
b: Wings

Figure - 2

Morphology Body



a: Mesosoma



b: Mesosoma Lateral Profile



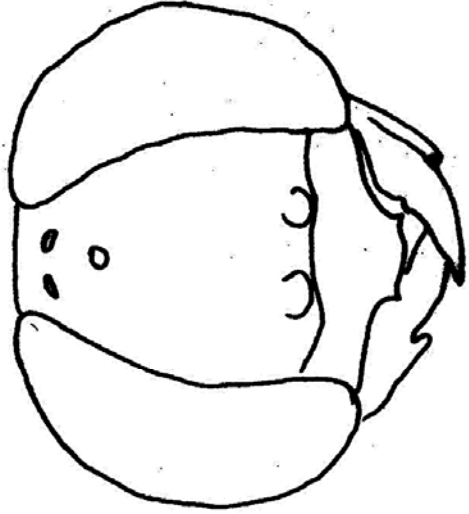
d: Plumose hairs



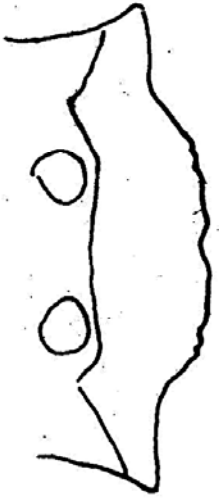
e: Simple hairs

c: Leg

Tachysphex bengalensis Cameron



a: Clypeal margin male



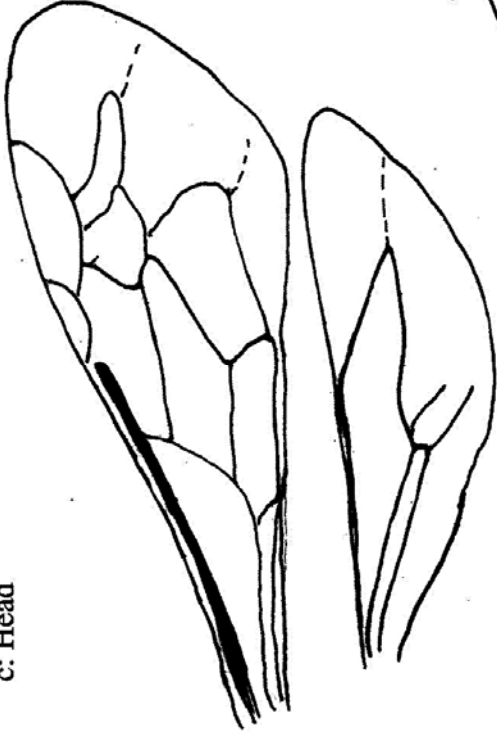
b: Clypeal margin female



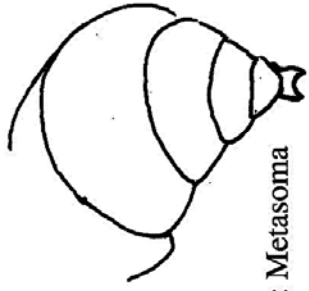
c: Head



d: Foretarsomeres



e: Wings



f: Metasoma

Figure - 21

Tachysphex indicus Pulawski

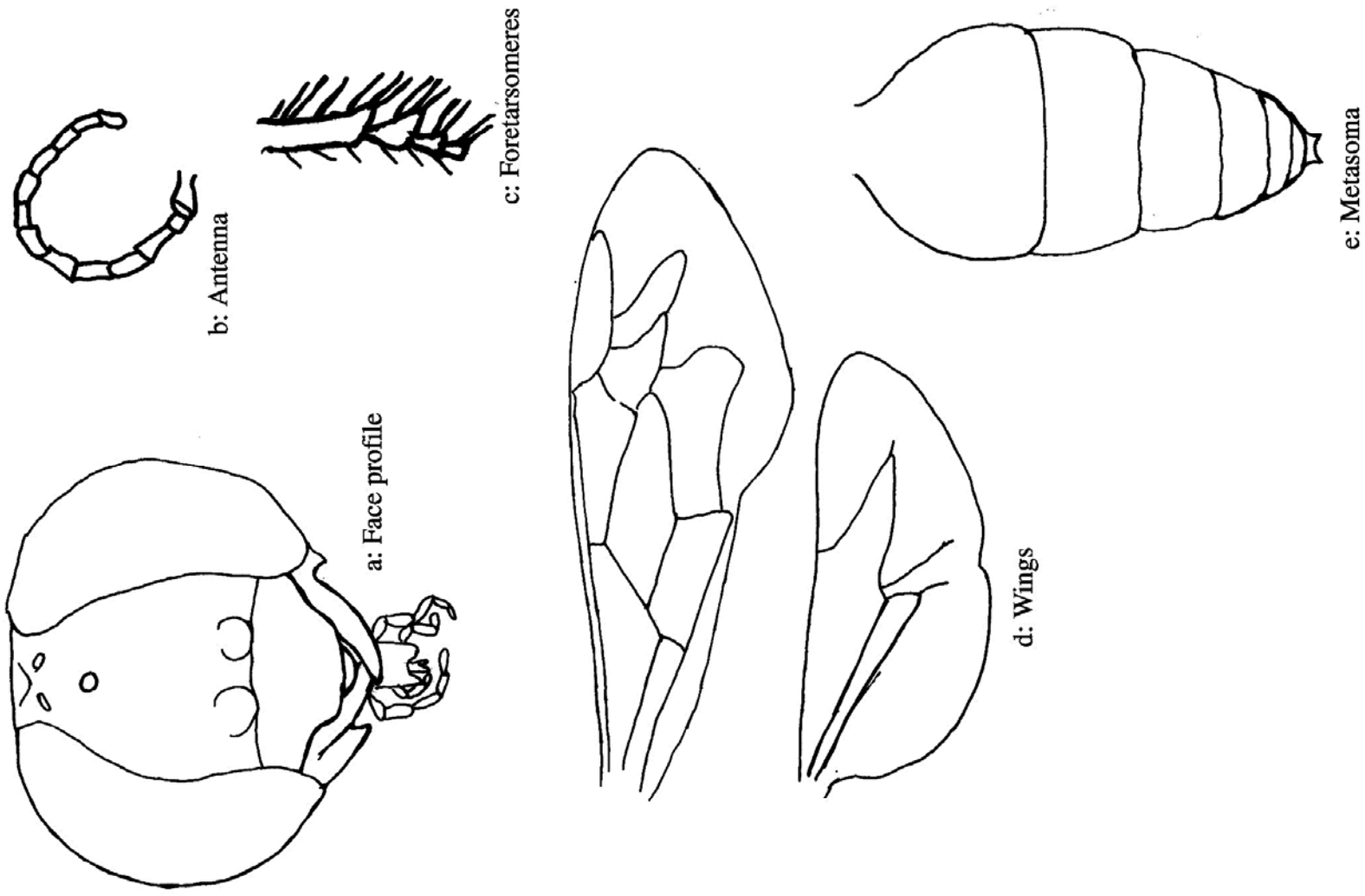
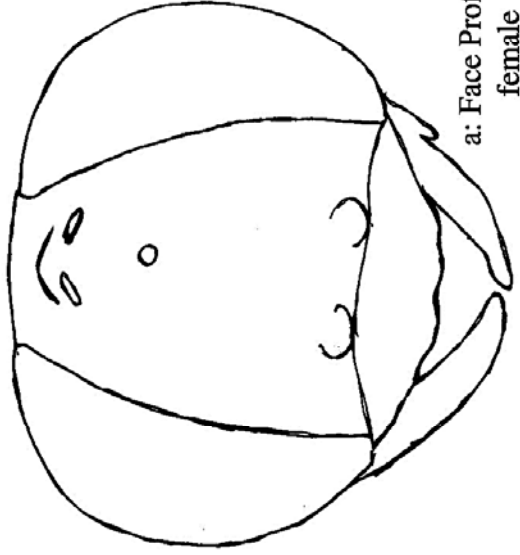


Figure - 22

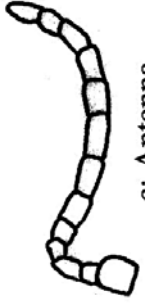
Tachysphex morosus (F. Smith)



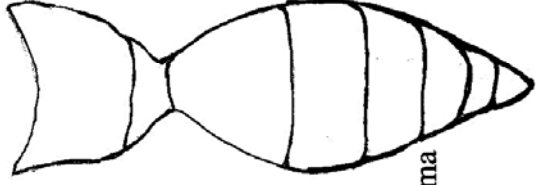
a: Face Profile
female



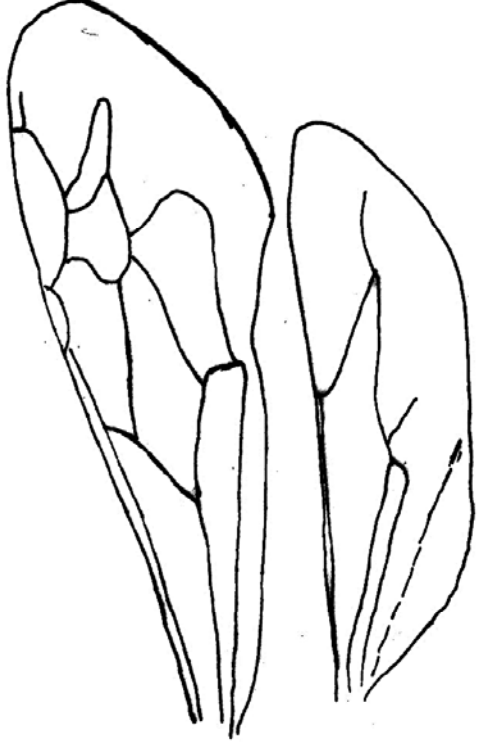
b: Face Profile
male



c: Antenna



d: Metasoma



e: Wings



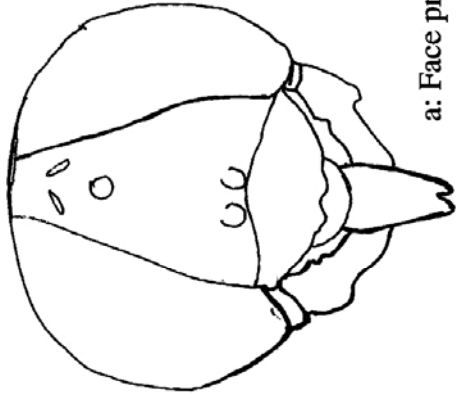
f: Pygidium



g: Sternum VIII

Figure - 23

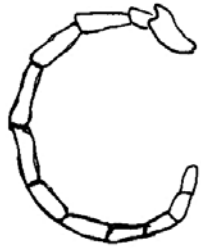
Tachysphex panzeri (Vander Linden)



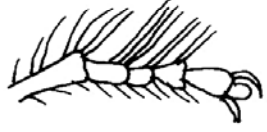
a: Face profile



b: Clypeal margin outline



c: Antenna

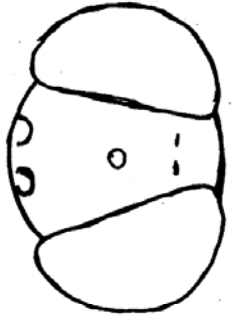


d: Foretarsomeres



e: Wings

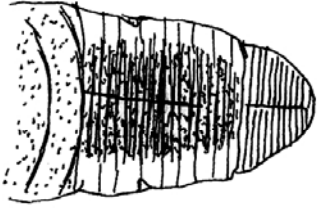
Liris anupamus sp. nov.



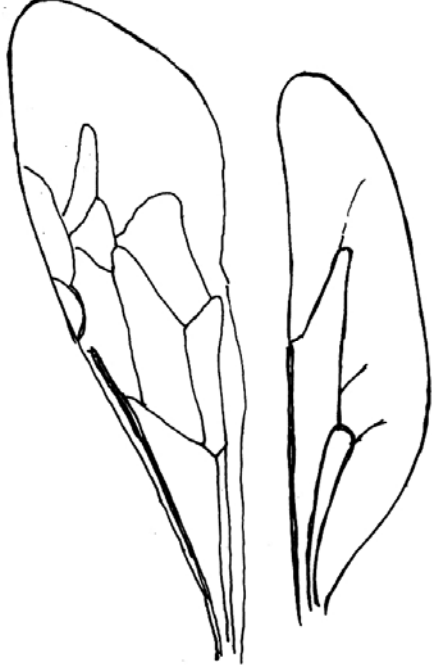
a: Head Dorsal View



b: Antenna



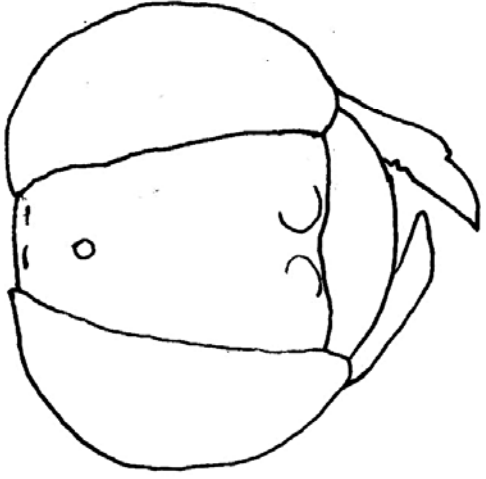
c: Propodeum



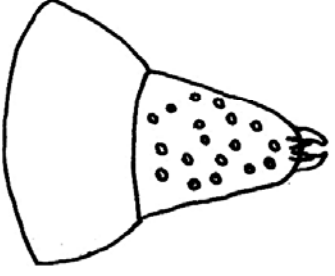
d: Wings

Figure - 25

Liris arcuatus sp. nov.



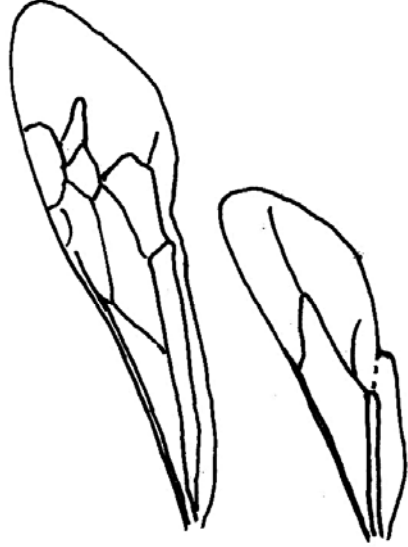
a: Face Profile



b: Pygidium



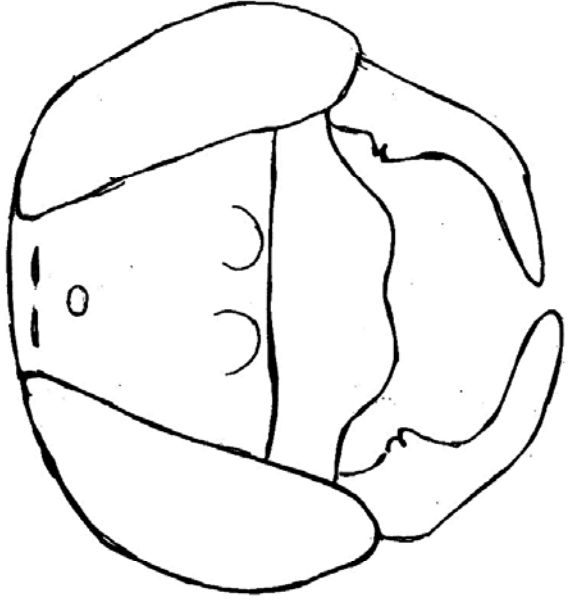
c: Foretarsomeres



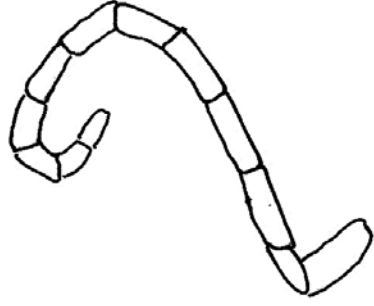
d: Wings

Figure - 26

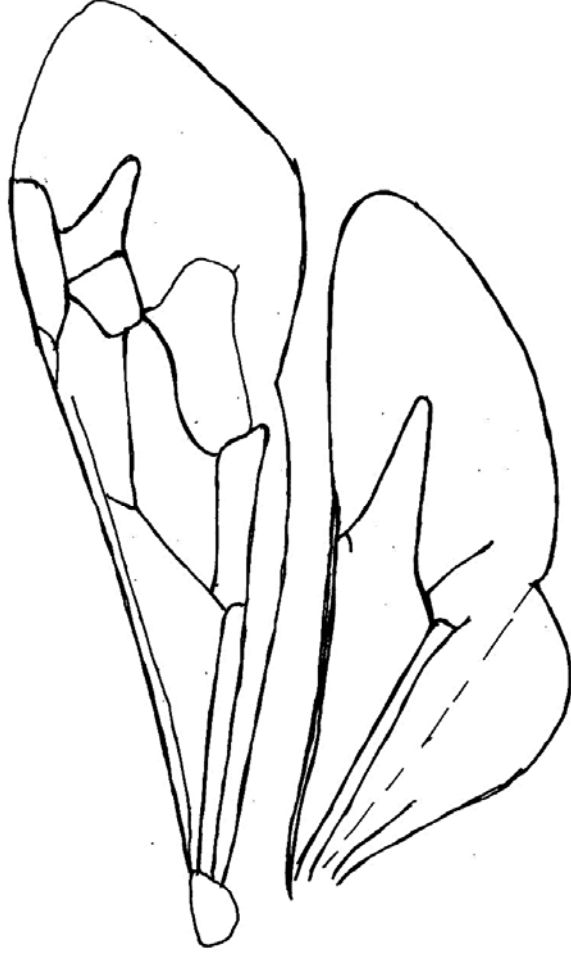
Liris aurulentus (Fabricius)



a: Face Profile



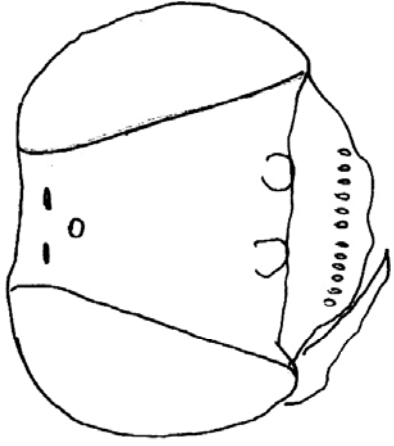
b: Antenna



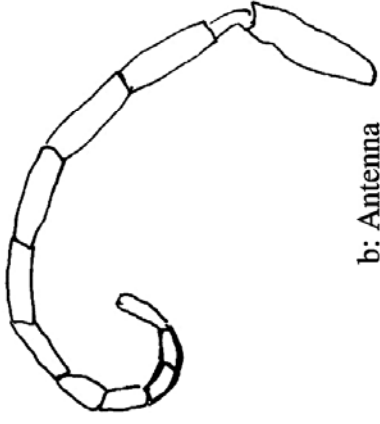
c: Wings

Figure - 27

Liris narendrani sp. nov.



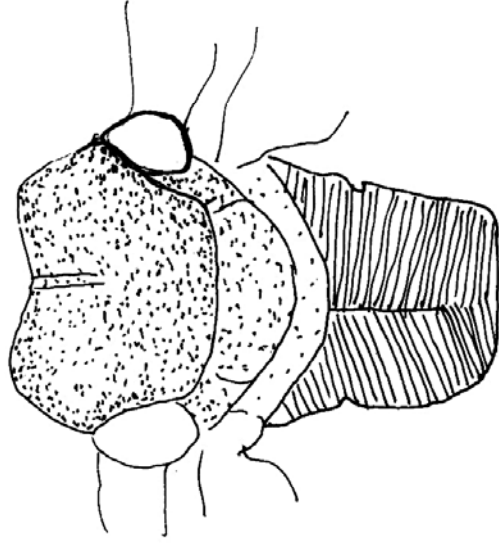
a: Face profile



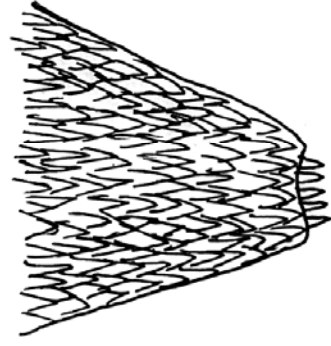
b: Antenna



c: Pronotum



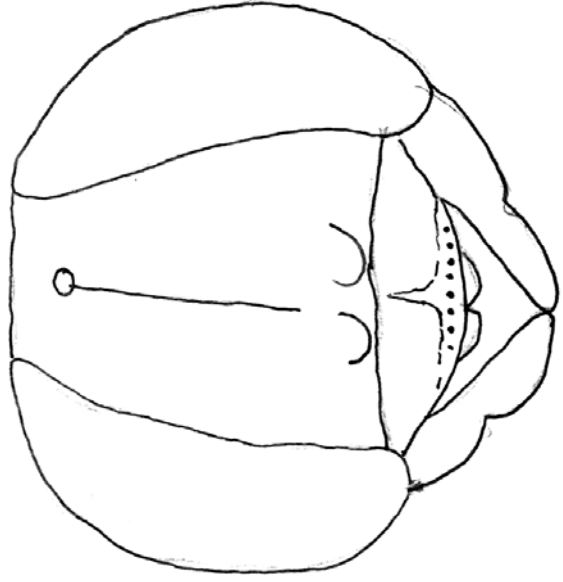
d: Mesosoma



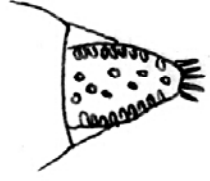
e: Pygidium

Figure - 28

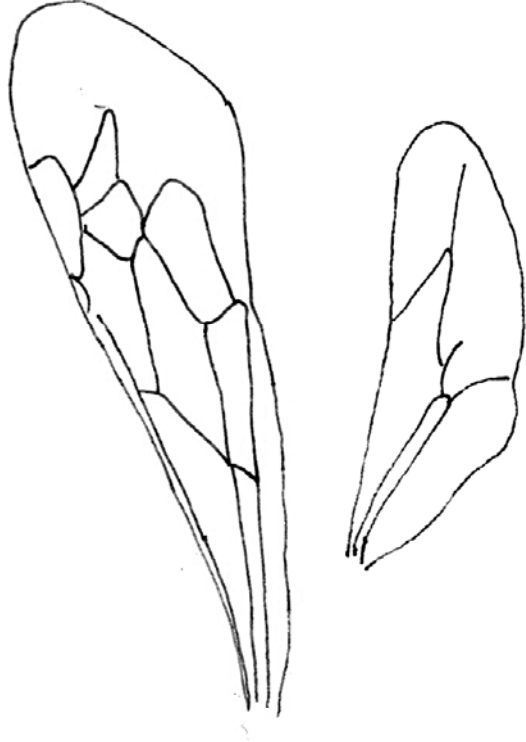
Liris pentaspinosus sp. nov.



a: Face profile



b: Pygidium



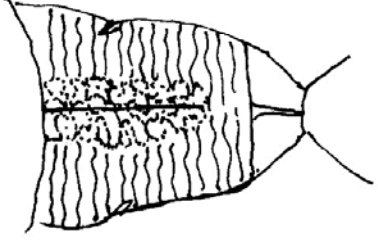
c: Wings

Figure - 29

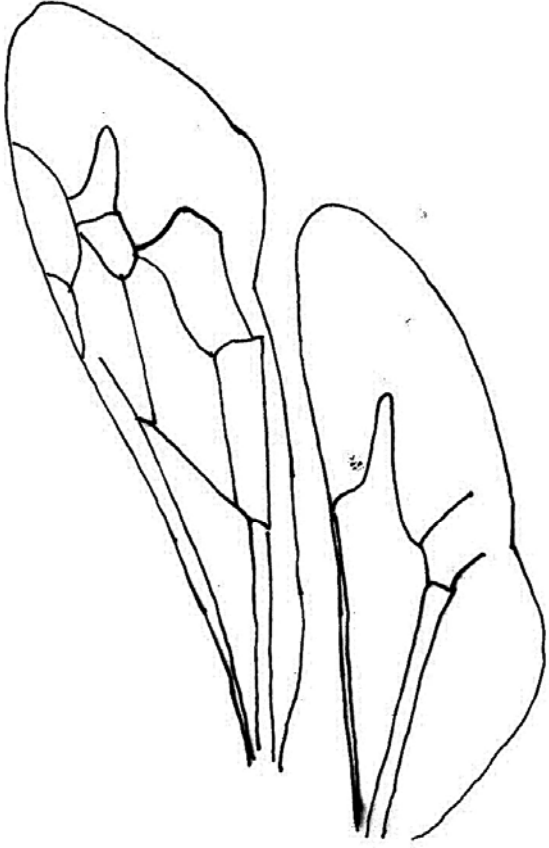
Liris simoni sp. nov.



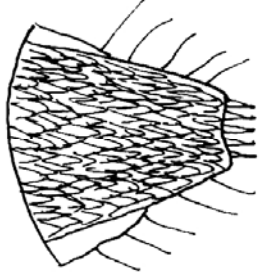
a: Clypeal freemargin outline



b: Propodeum



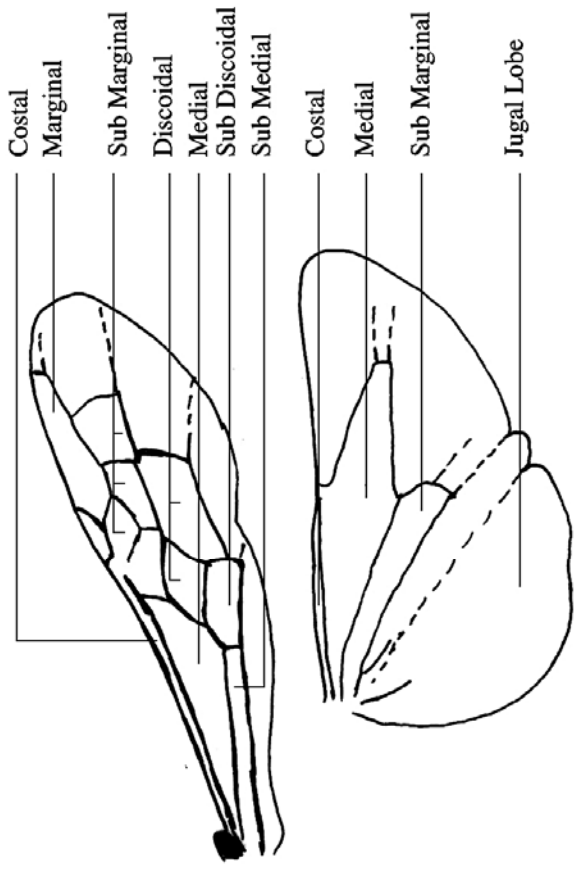
c: Wings



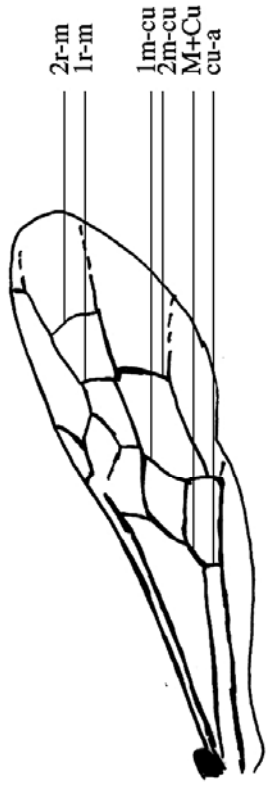
d: Pygidium

Figure - 3

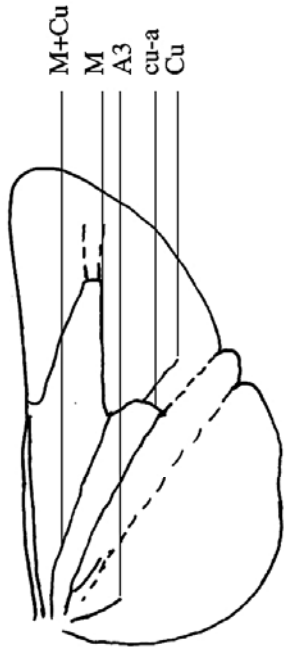
Morphology - Wings



a: Wing Cells



b: Wing veins



Cu: Cubitus
cu-a : crossvein connecting the cubitus and the first anal vein
M: Media
A: Anal
r-m: crossvein connecting the radius and media
m-cu: crossvein connecting the media and cubitus
C: Costa

Figure - 30

Liris sinuatus sp. nov.

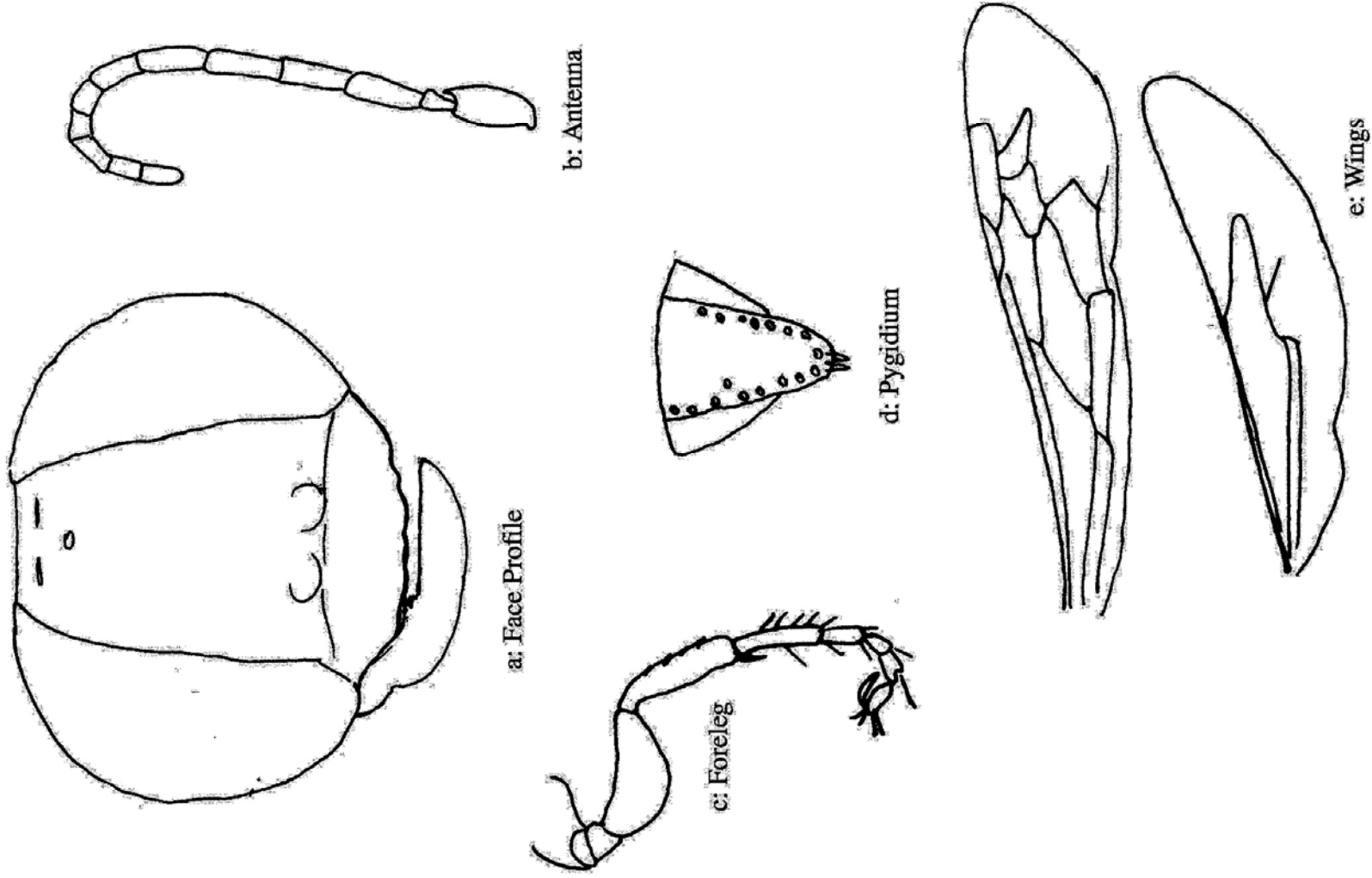
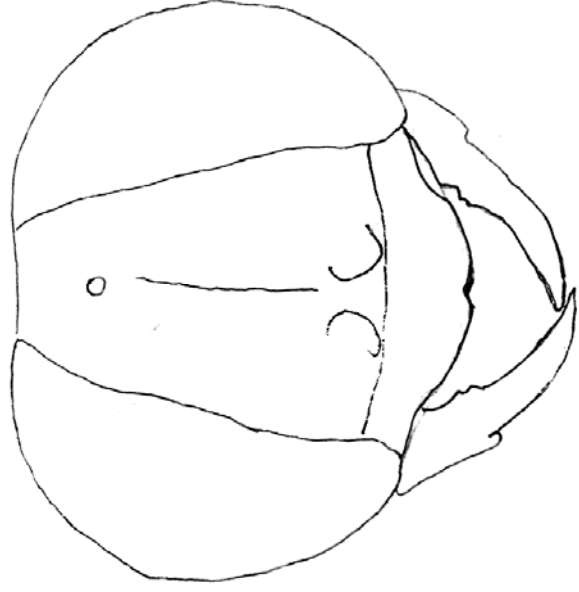


Figure - 31

Liris subtesselatus (F. Smith)



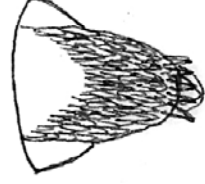
a: Face Profile



b: Wings

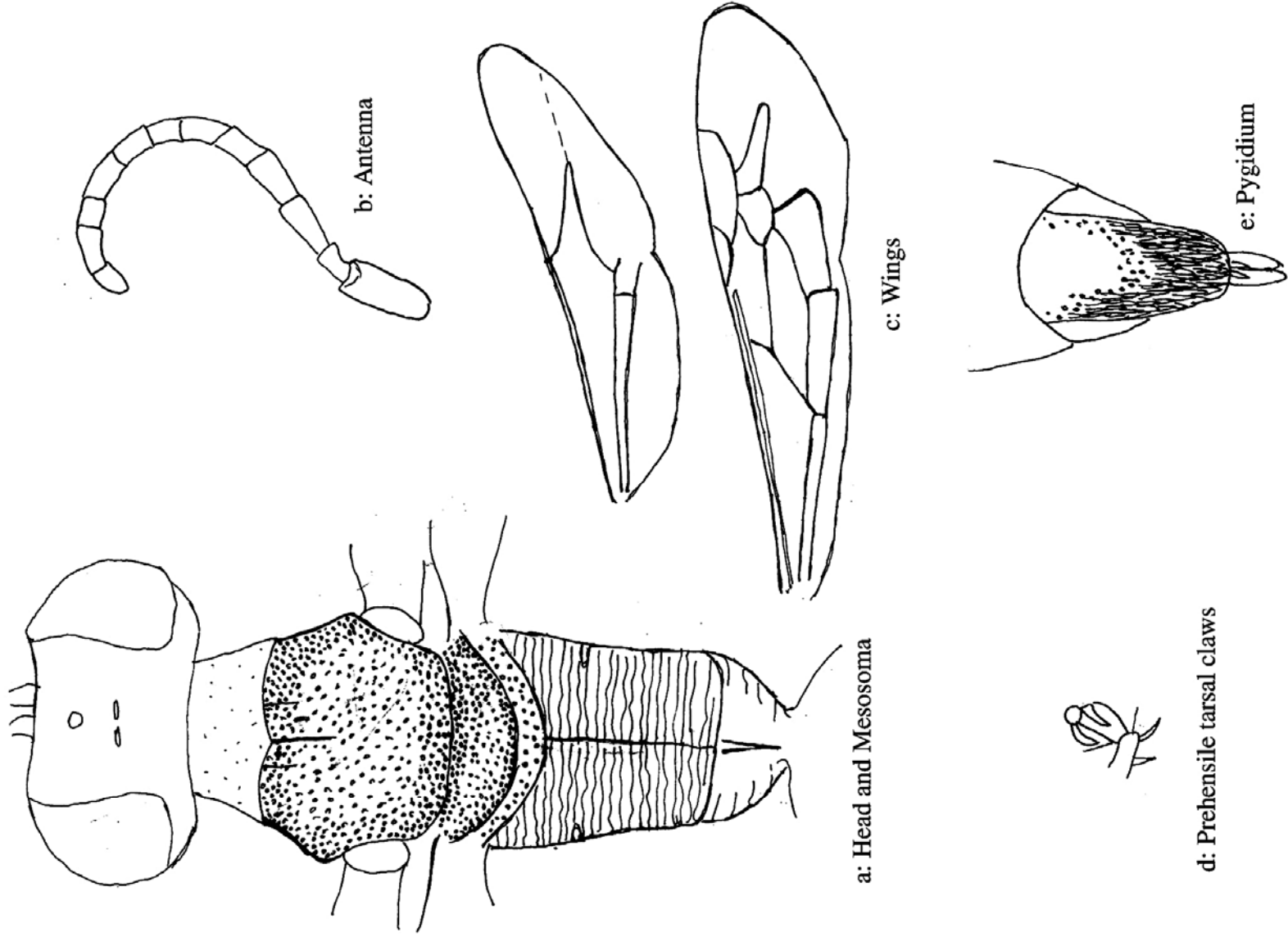


c: Hindleg



d: Pygidium

Liris thenmalaensis sp. nov.



b: Antenna

a: Head and Mesosoma

c: Wings

d: Prehensile tarsal claws

e: Pygidium

Figure - 33

Liris wayanadensis sp. nov.

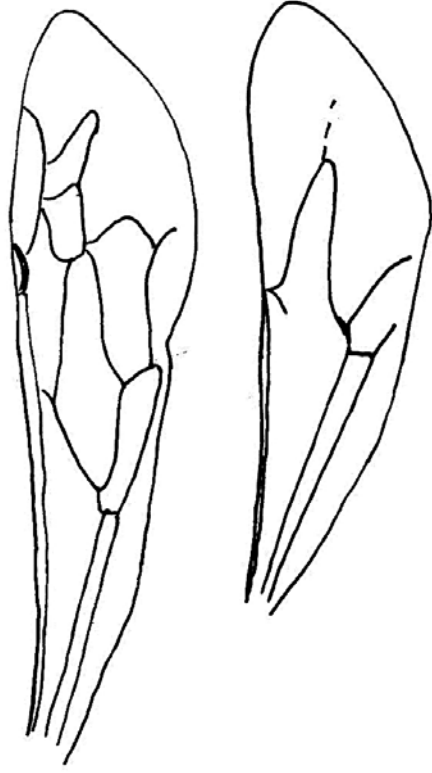
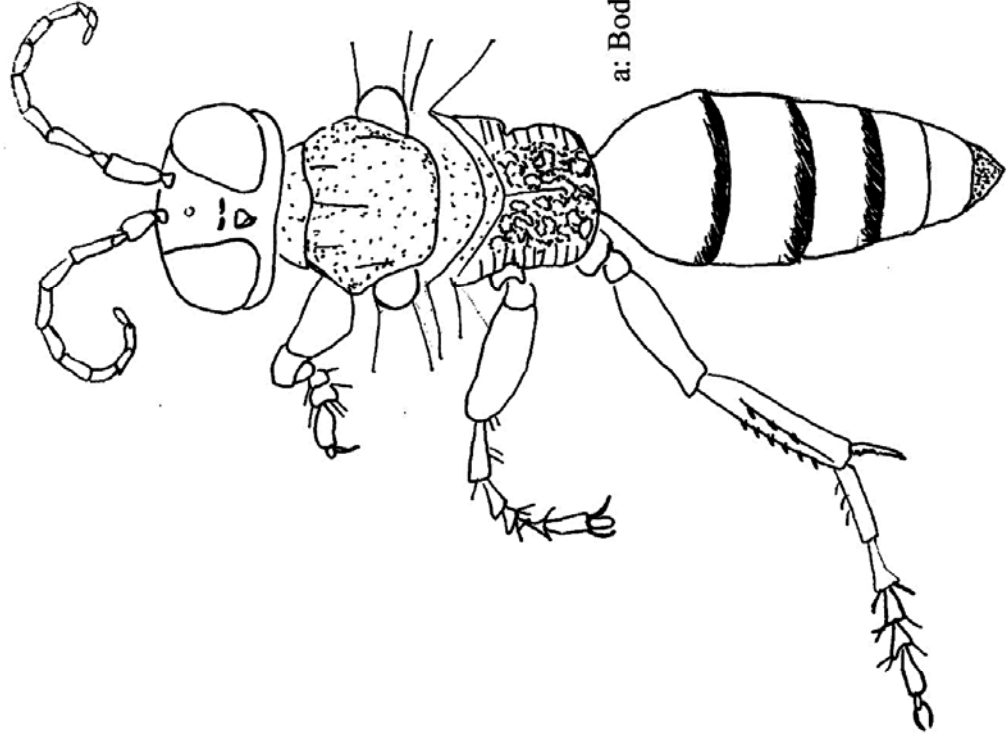
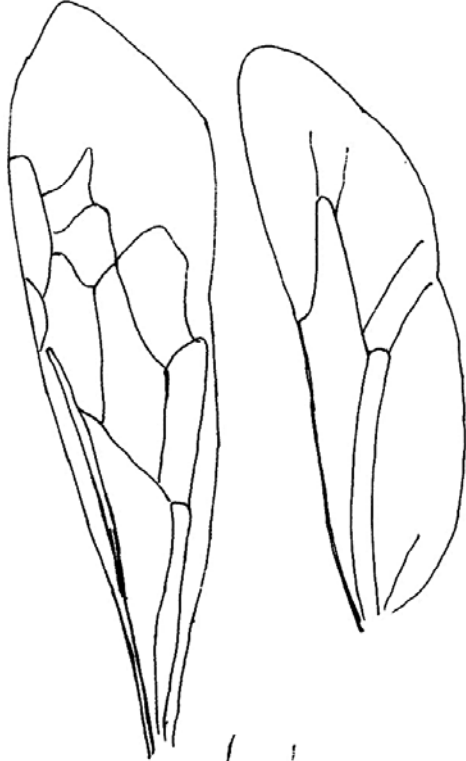
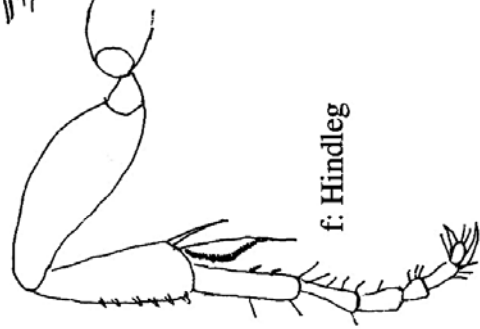
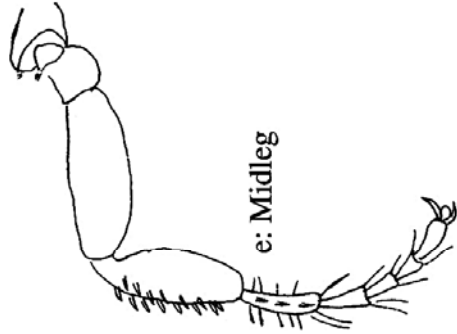
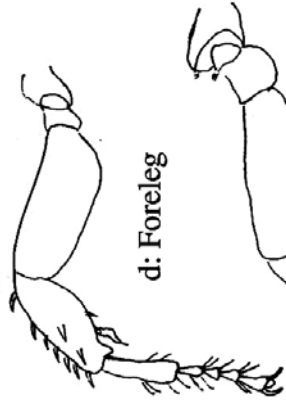
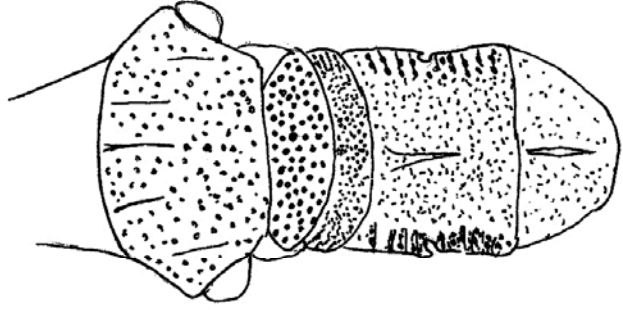
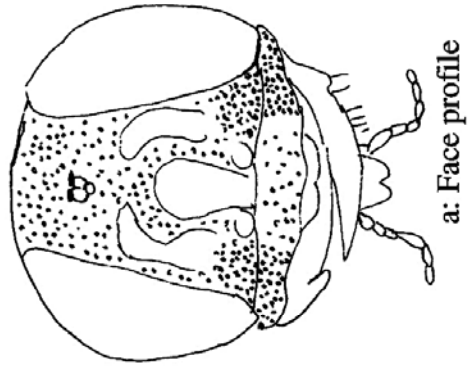


Figure - 34

Larra stom sp. nov.



Miscophus apoorvus sp. nov.

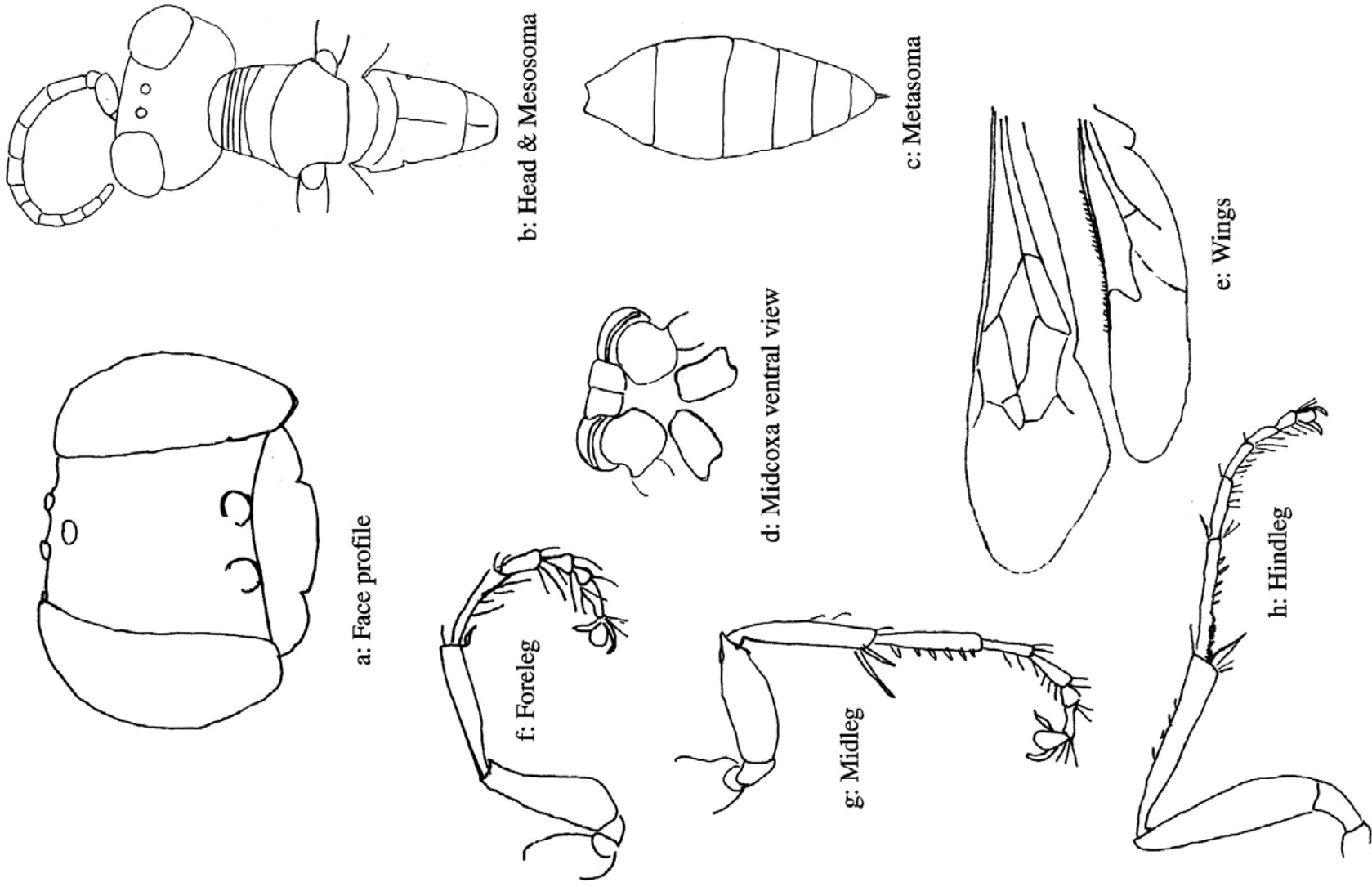
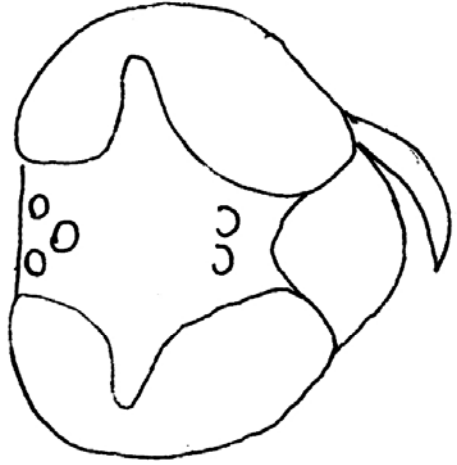


Figure - 36

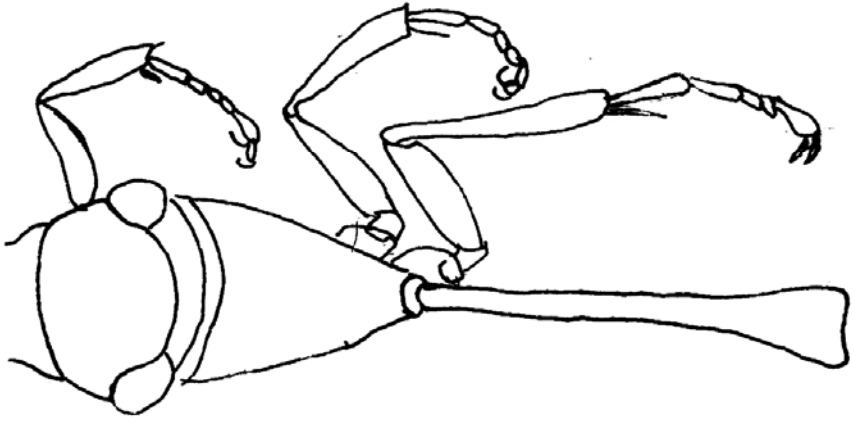
Trypoxylon bicolor F. Smith



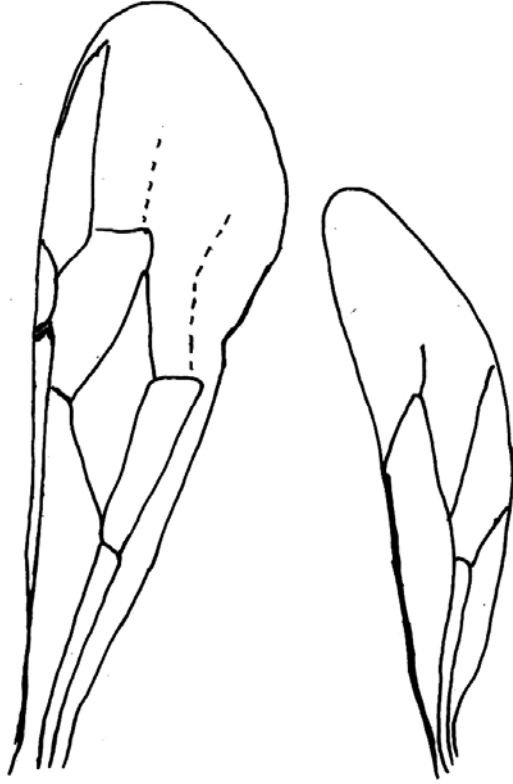
a: Face Profile



b: Antenna



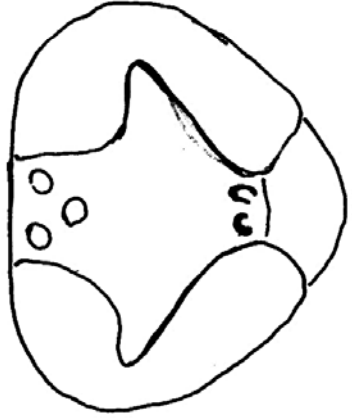
c: Mesosoma



d: Wings

Figure - 37

Trypoxylon errans Saussure



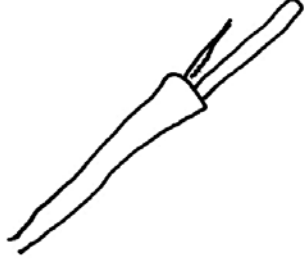
a: Face Profile



b: Clypeal margin outline



c: Antenna

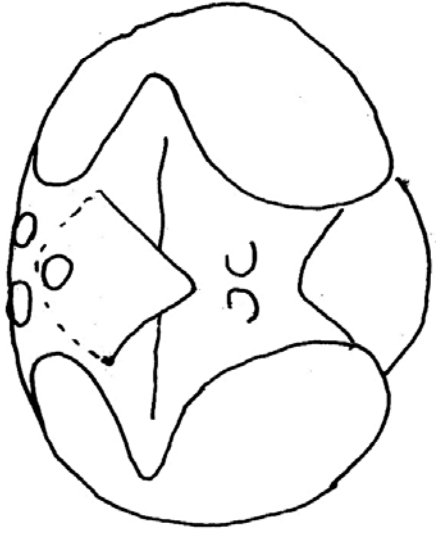


d: Hind tibia and basitarsus



e: Fore wing

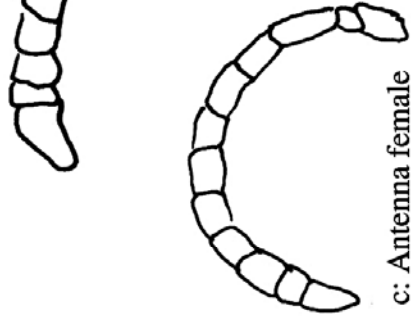
Trypoxylon pileatum F. Smith



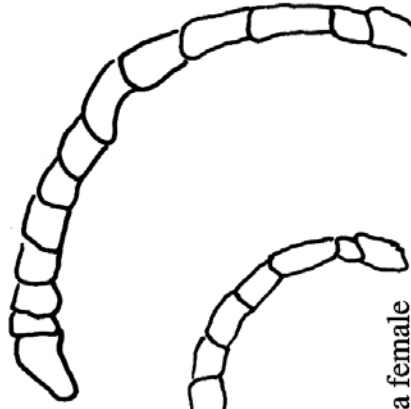
a: Face profile female



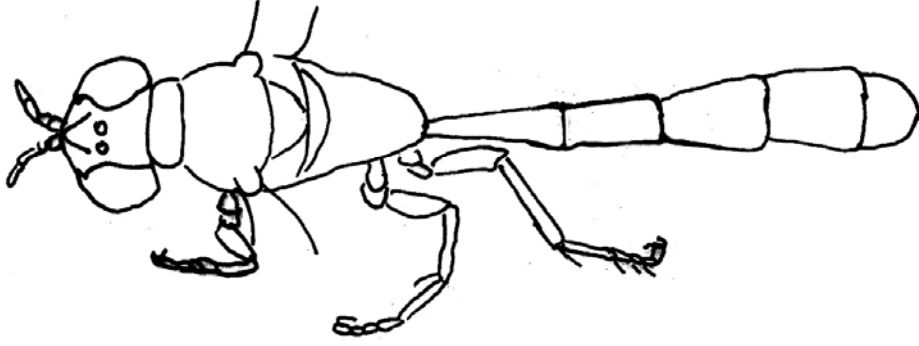
b: Face profile male



c: Antenna female



d: Antenna male



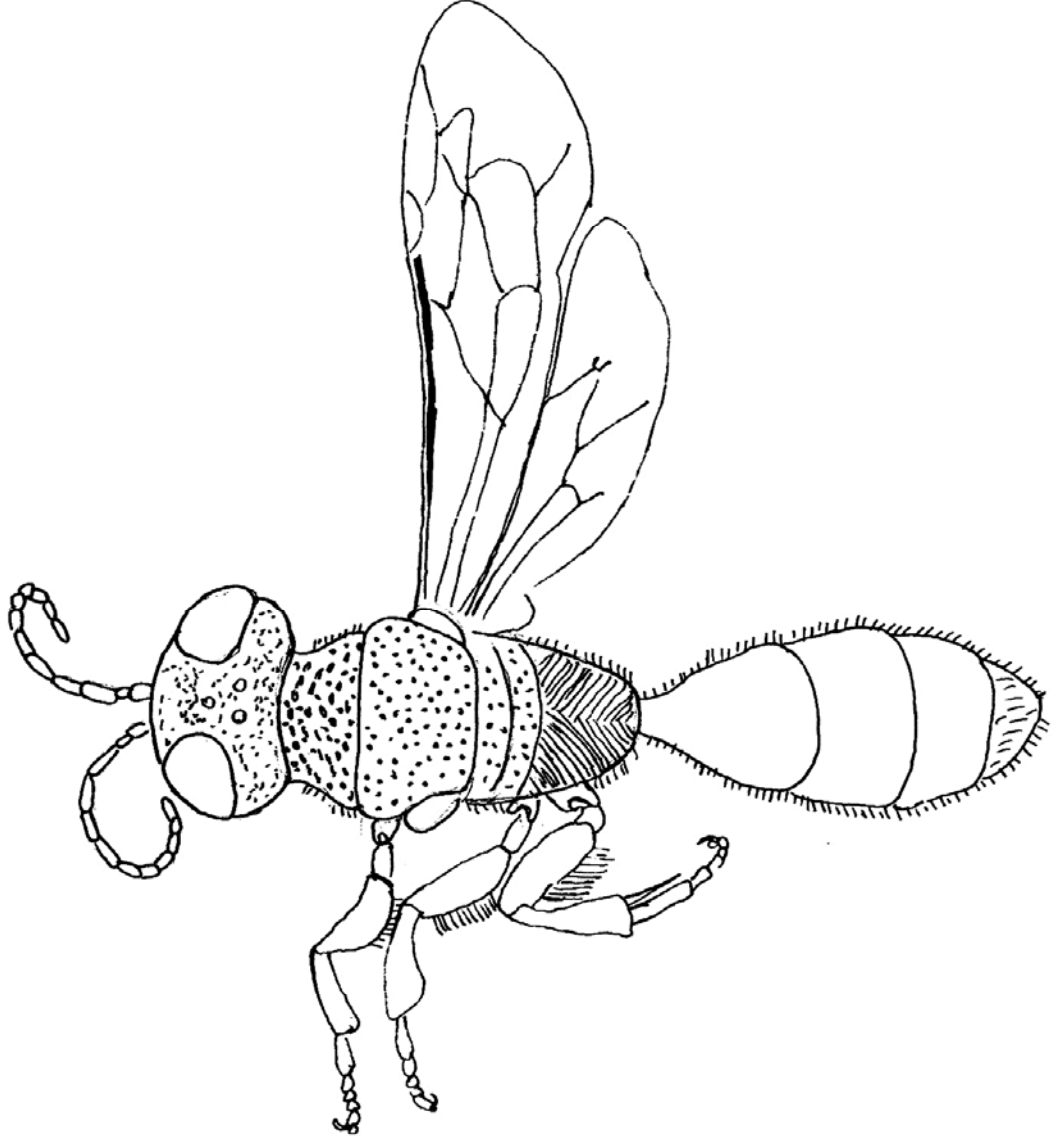
e: Body profile



f: Wings

Figure - 39

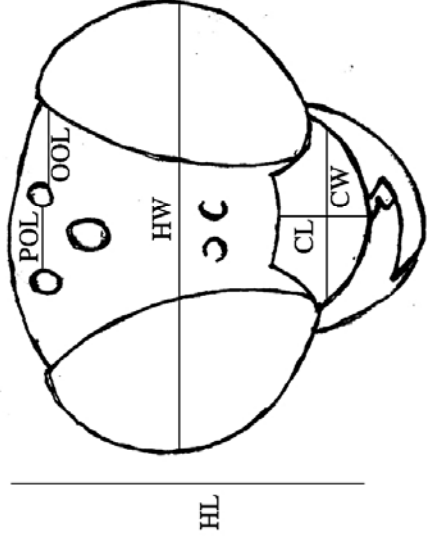
Pison punctifrons Shuckard



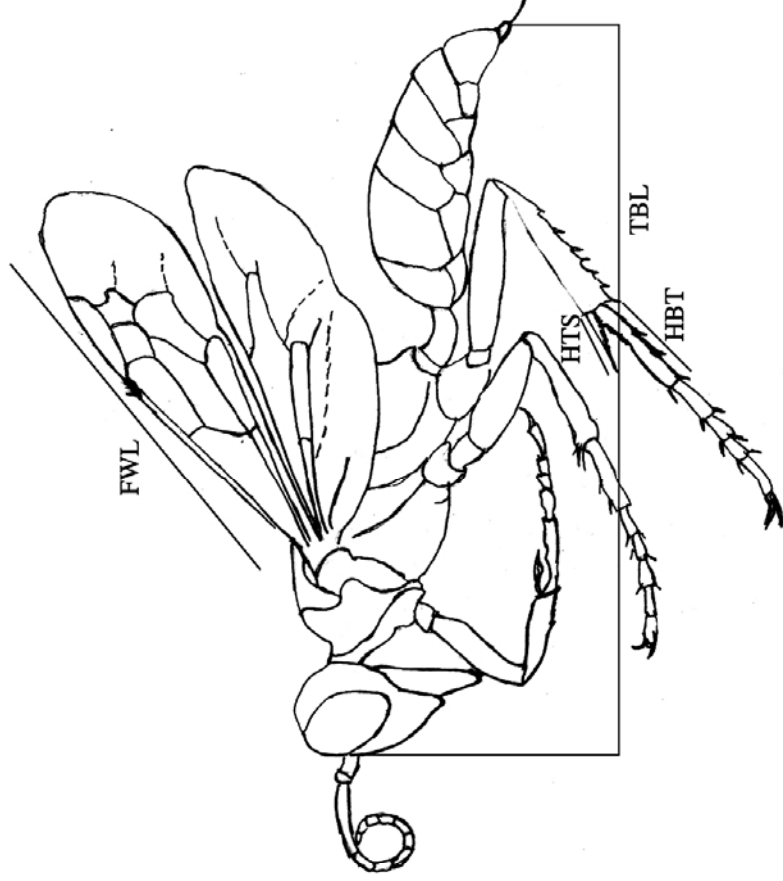
a: Full Profile

Figure - 4

Measurements



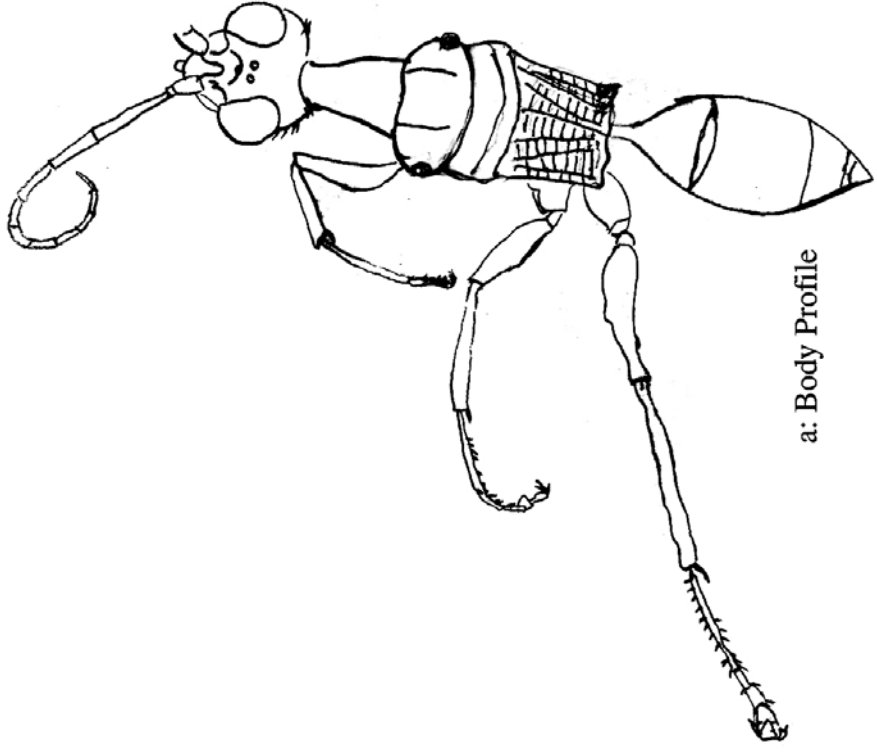
a: Head



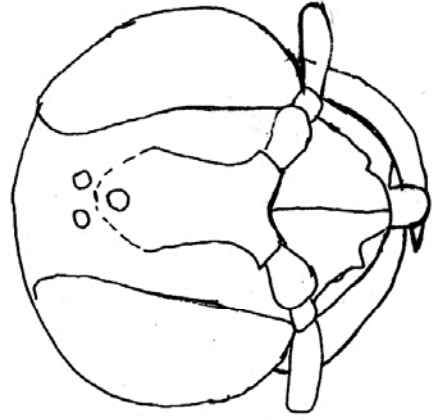
b: Body

Figure - 5

Ampulex compressa (Fabricius)



a: Body Profile



b: Face Profile



c: Wings

Figure - 6

Trirogma caerulea Westwood

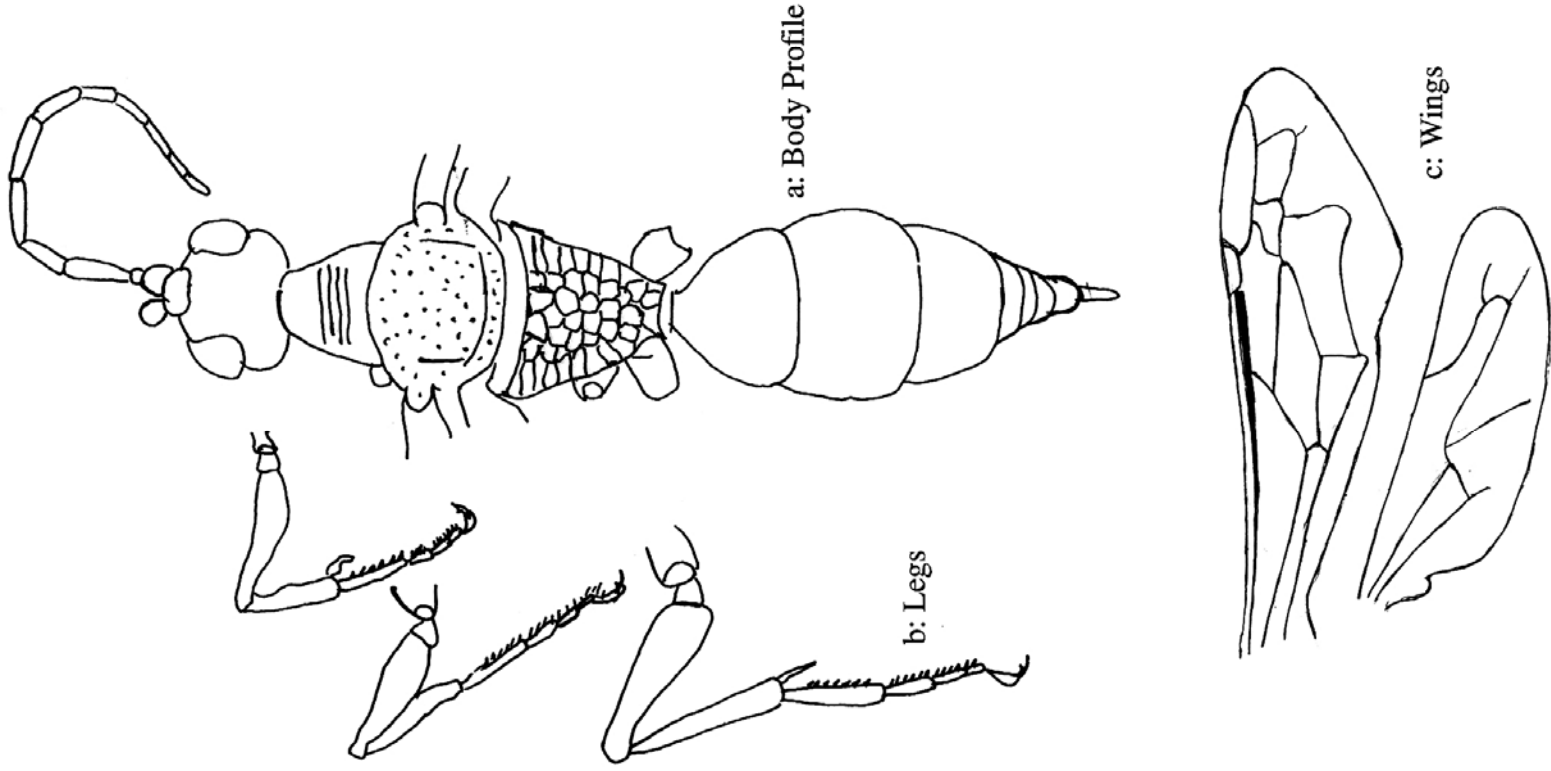


Figure - 7

Ammophila clavus (Fabricius)

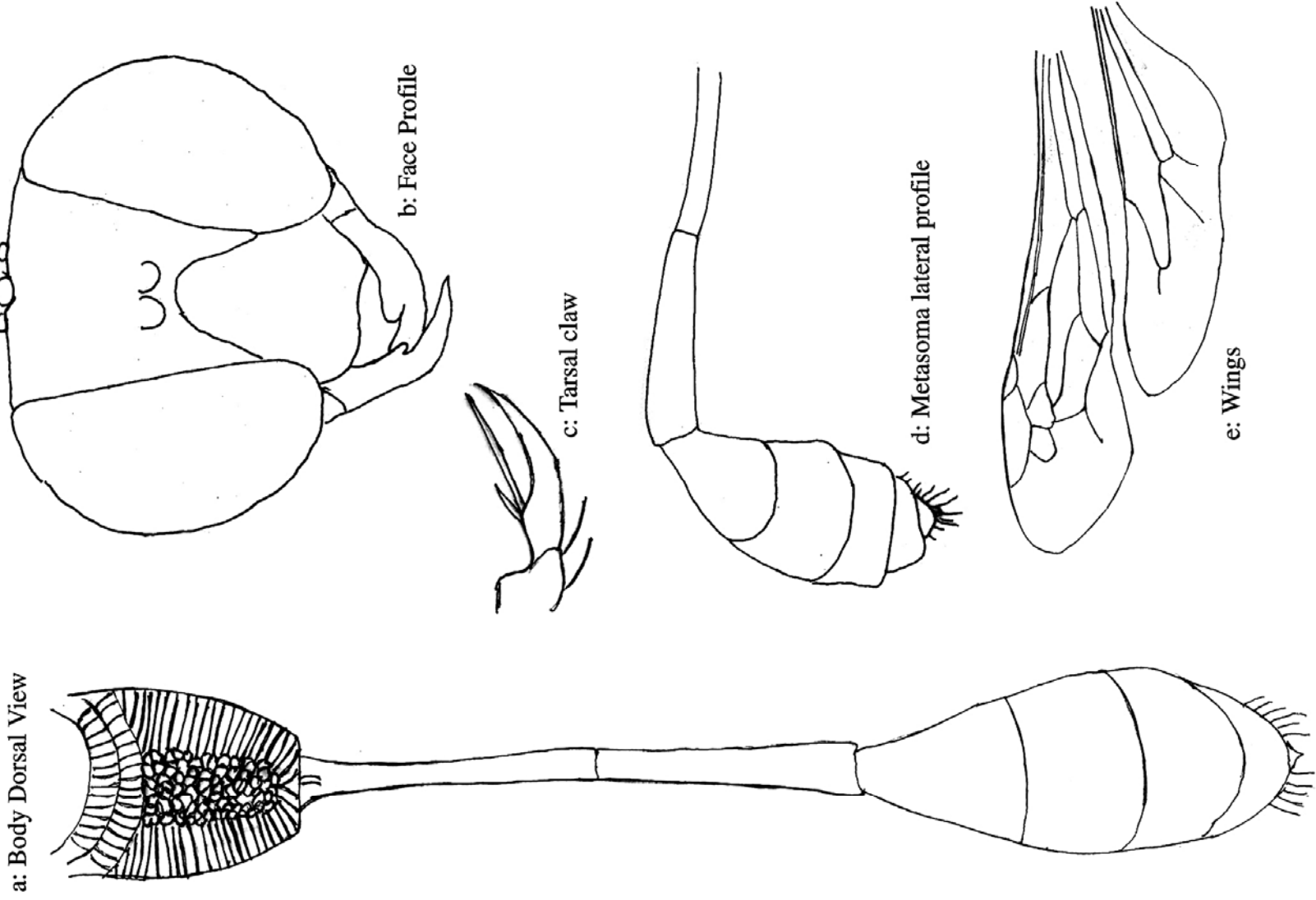


Figure - 8

Ammophila laevigata F.Smith

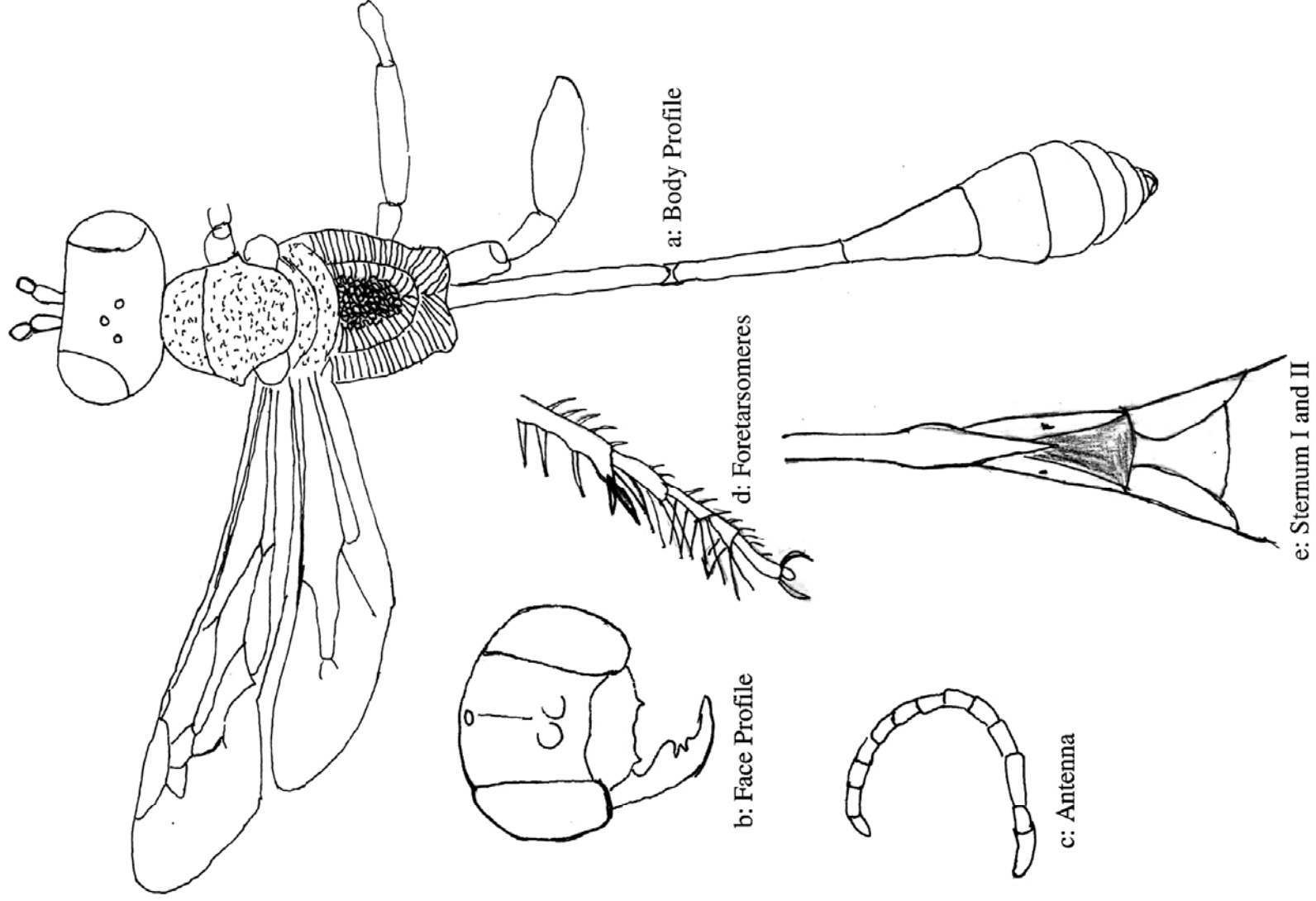
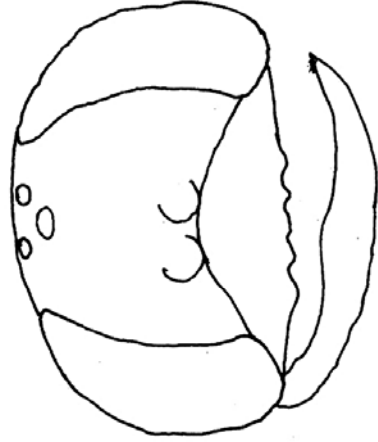
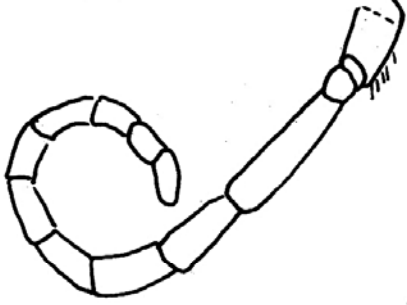


Figure - 9

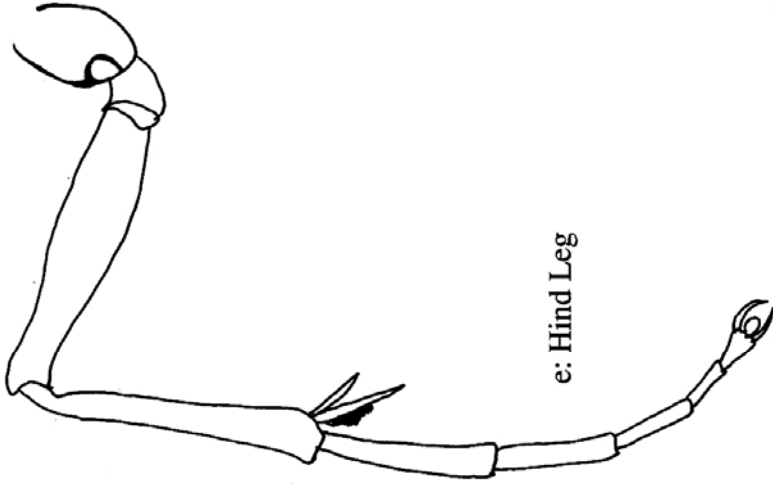
Chlorion lobatum (Fabricius)



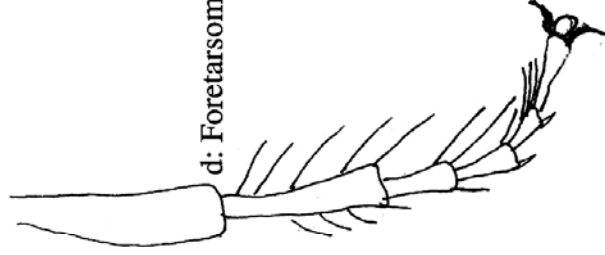
a: Face profile



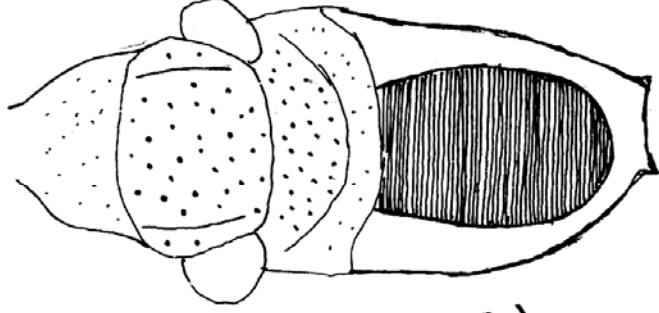
b. Antenna



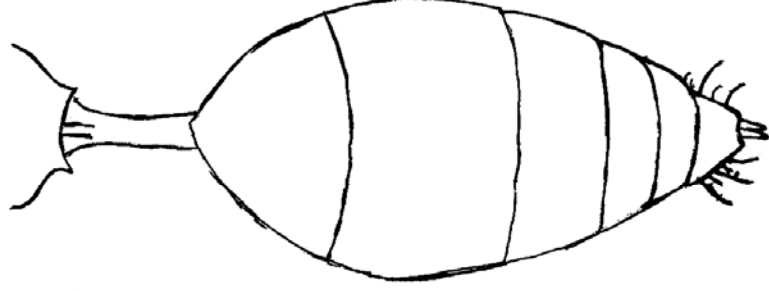
e: Hind Leg



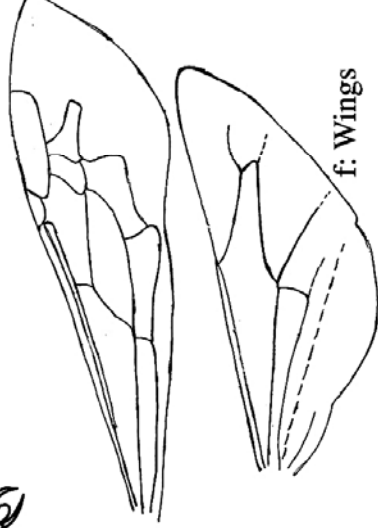
d: Foretarsomere



c: Mesosoma



g: Metasoma



f: Wings

Insects Collected



a: *Ammophila clavus* (Fabricius)



b: *Ammophila laevigata* F. Smith



c: *Chlorion lobatum* (Fabricius)



d: *Sceliphron coromandelicum* (Lepeletier)

Insects Collected



a: *Sceliphron javanum nalandicum* Strand



b: *Sceliphron madraspatanum* (Fabricius)



c: *Chalybion bengalense* (Dahlbom)



d: *Chalybion keralensis* sp. nov.

Collection Methods



a: Sweep net



b: Yellow Pan trap



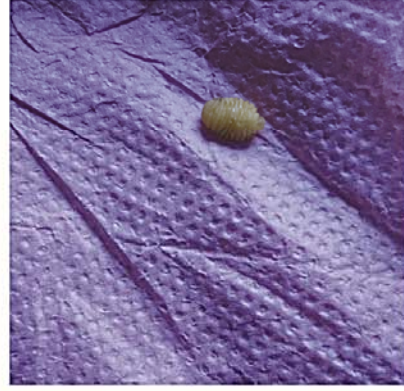
c: Food bait



d: Malaise trap



e: Rearing



f: Larva of *Chalybion bengalense* (Dahlbom)

Insects Collected



a: *Sphex argentatus* Fabricius



b: *Sphex neosericeus* sp. nov.



c: *Sphex praedator* F. Smith



d: *Sphex sericeus* (Fabricius)

Insects Collected



a: *Tachysphex bengalensis* Cameron



b: *Tachysphex indicus* Pulawski



c: *Tachysphex morosus* (F. Smith)



d: *Tachysphex panzeri* (Vander Linden)

Insects Collected



a: *Liris anupamus* sp. nov.



b: *Liris arcuatus* sp. nov.



c: *Liris aurulentus* (Fabricius)



d: *Liris narendrani* sp. nov.

Insects Collected



a: *Liris simoni* sp. nov.



b: *Liris sinuatus* sp. nov.



c: *Liris subtessellatus* (F. Smith)



d: *Liris pentaspinosus* sp. nov.

Insects Collected



a: *Liris thenmalaensis* sp. nov.



b: *Liris wayanadensis* sp. nov.



c: *Larra stom* sp. nov.



d: *Trypoxylon errans* Saussure

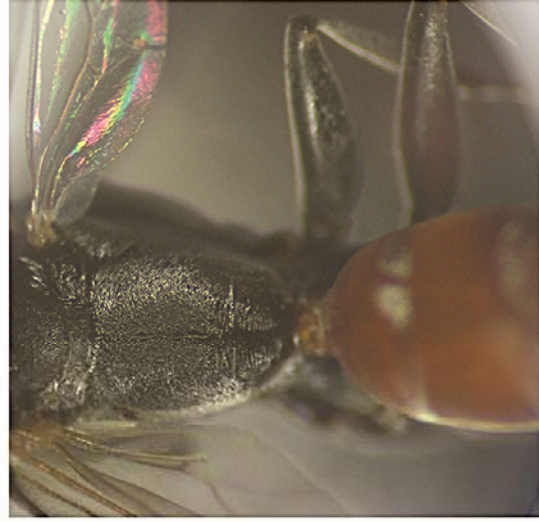
Insects Collected



a: *Trypoxylon bicolor* F. Smith



b: *Trypoxylon pileatum* F. Smith



c: *Miscophus apoorvus* sp. nov.
Propodeum



d: *Miscophus apoorvus* sp. nov.

Insects Collected



a: *Ampulex compressa* (Fabricius)



b: *Trirogma caerulea* Westwood



c: *Pison punctifrons* Shuckard

Methods



a: Leica MZ 6 stereozoom microscope



b: Insect collection

Collection Places



a: Pallikkunnu, Kannur



b: Koothattukulam, Ernakulam



c: Nilambur teak museum, Malappuram



d: Hydel Park, Munnar, Idukki



e: Kuruva, Wayanad



f: Chungam, Alappuzha

Collection Places



a: Perumthuruthy, Pathanamthitta



b: Punalur, Kollam



c: Parappa, Kasargode



d: Palode, Thiruvananthapuram

Collection Places



a: Tippu fort, Palakkad



b: Ramanattukara, Kozhikode



c: Rubber Board, Kottayam



d: Thumburmuzhi, Thrissur

Floristic Relations



a: *Euphorbia milli* Des. Moul



b: *Mikania micrantha* Kunth



c: *Ixora duffii* Moore



d: *Murraya koenigii* (L.) Sprengel

Types of Nests



a: *Sceliphron madraspatanum* (Fabricius)



b: *Sphex sericeus* (Fabricius)

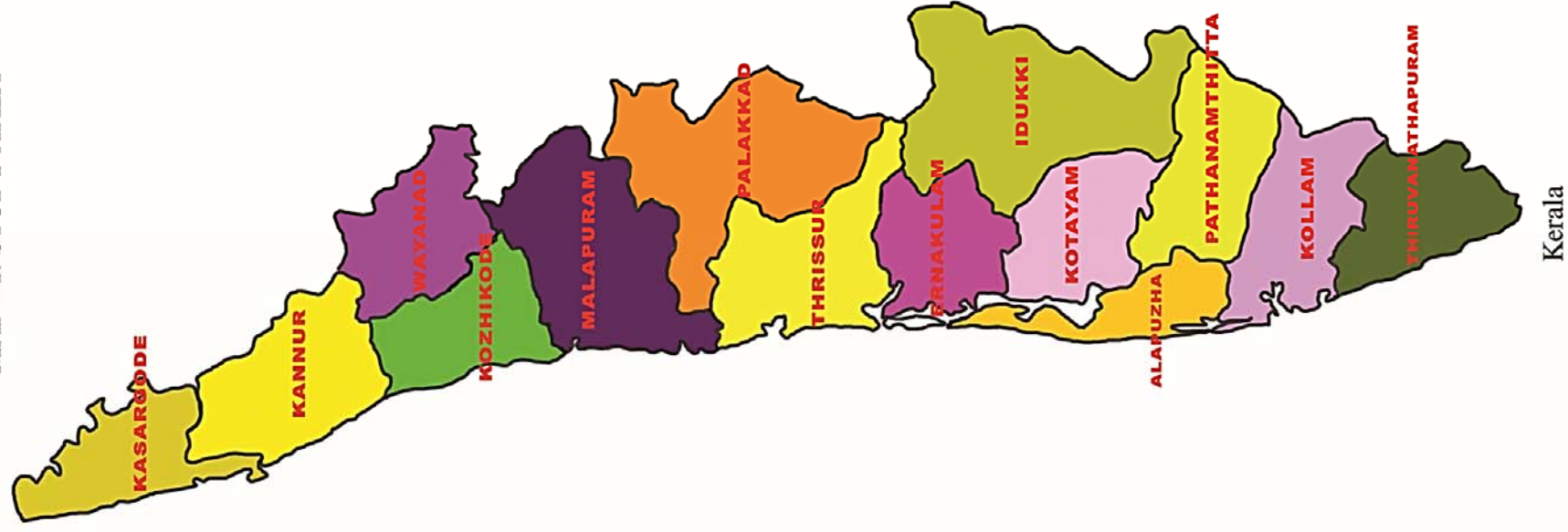


c: *Sceliphron coromandelicum* (Lepeletier)

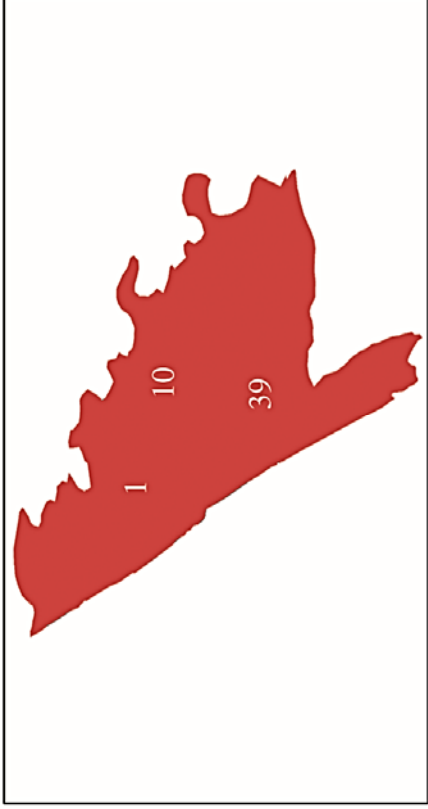


d: *Sphex argentatus* Fabricius

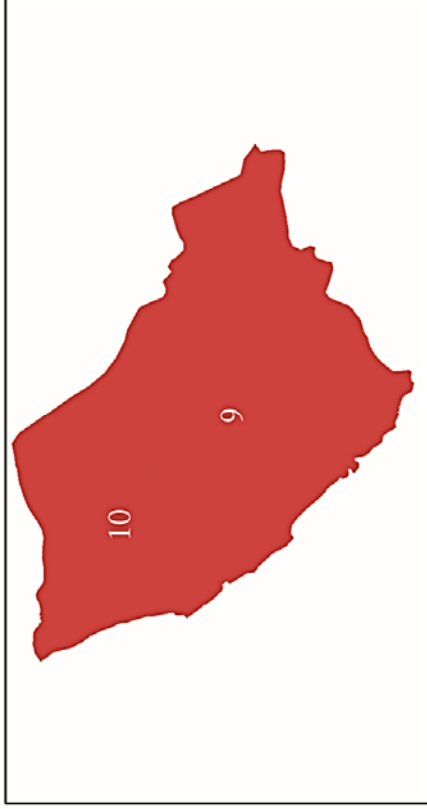
MAP - 1: STUDY AREA



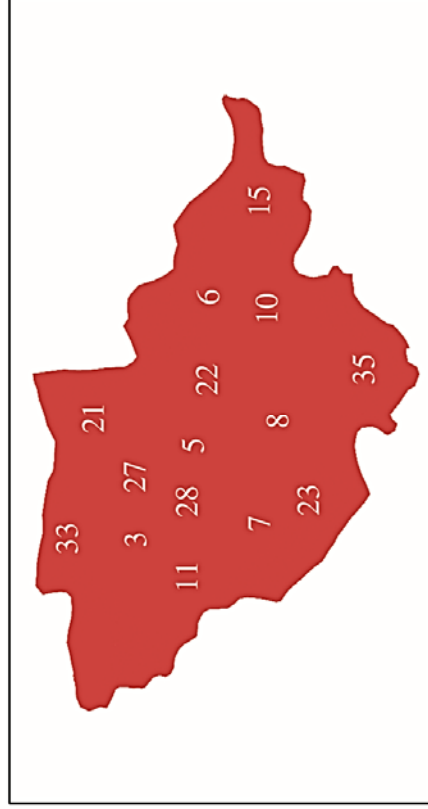
MAP-2: Distribution Pattern of Sphecid wasps



a: Kasargode

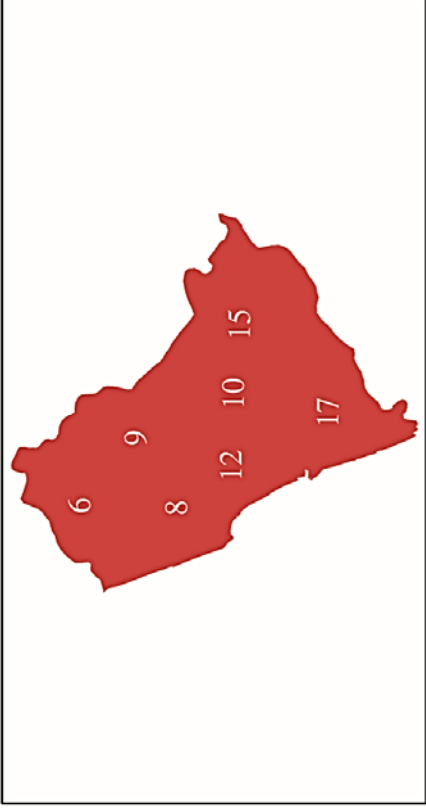


b: Kannur



c: Wayanad

MAP-3: Distribution Pattern of Sphecid wasps



a: Kozhikode

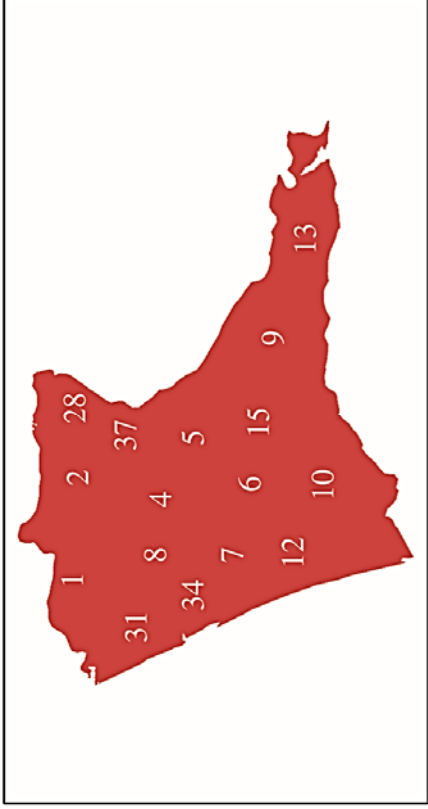


b: Malappuram

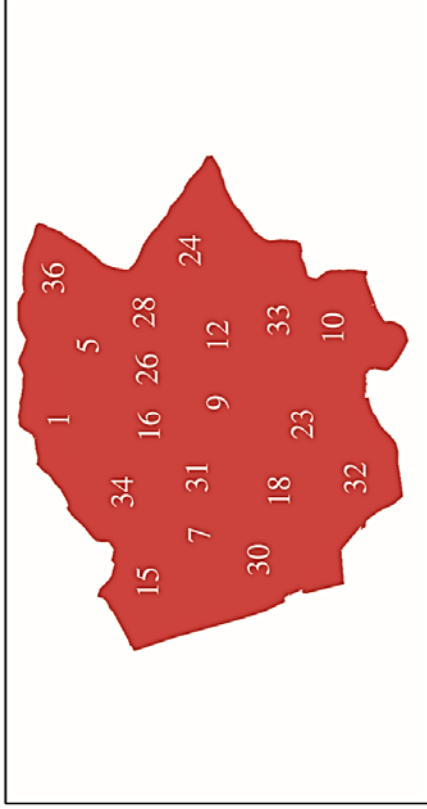


c: Palakkad

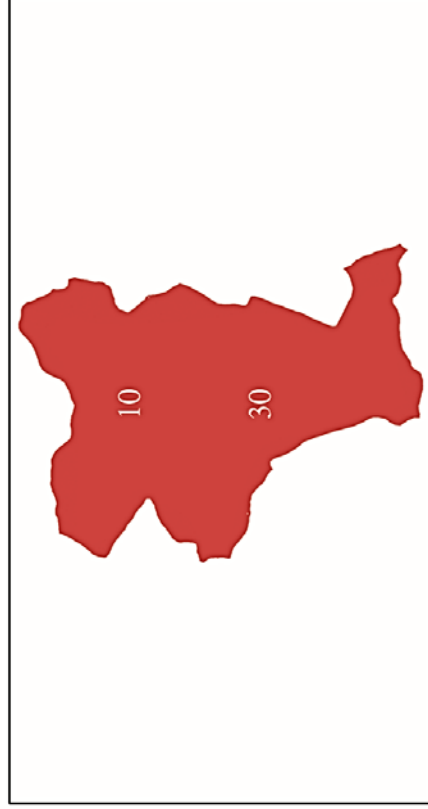
MAP-4: Distribution Pattern of Sphecid wasps



a: Thrissur

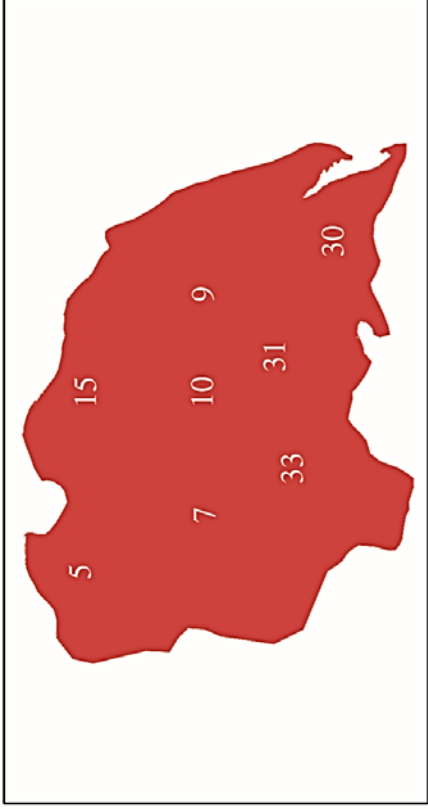


b: Ernakulam

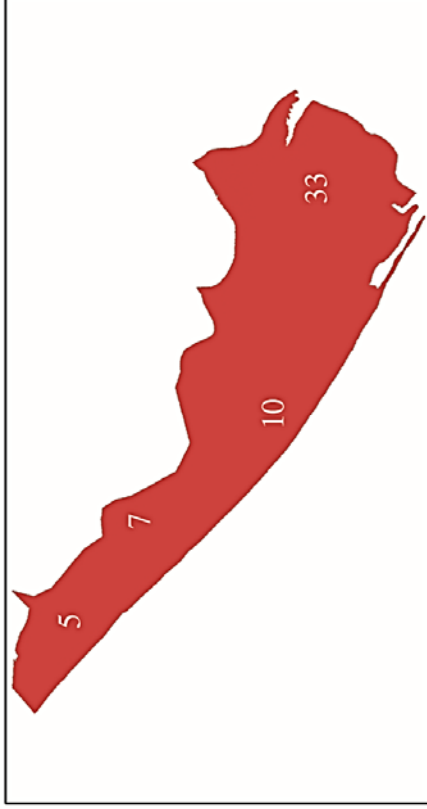


c: Idukki

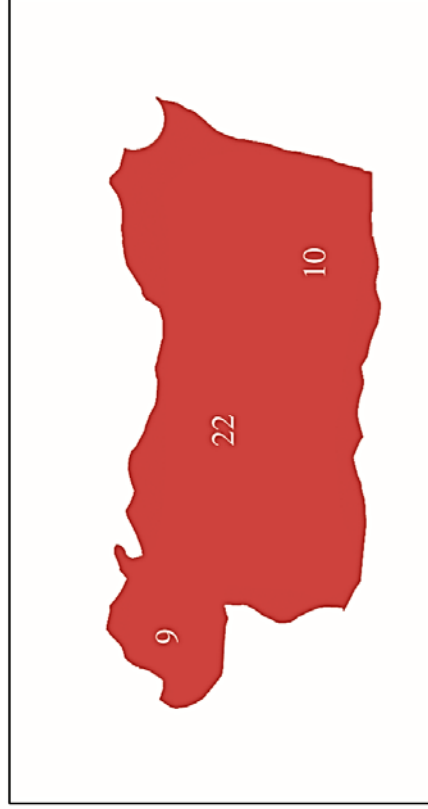
MAP-5: Distribution Pattern of Sphecid wasps



a: Kottayam

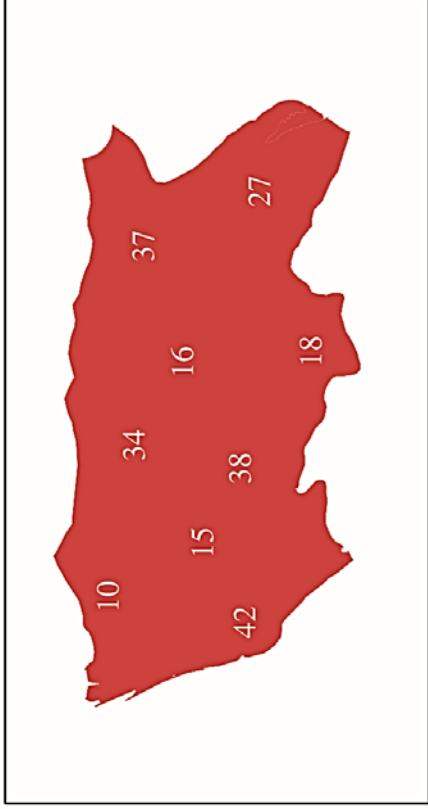


b: Alappuzha

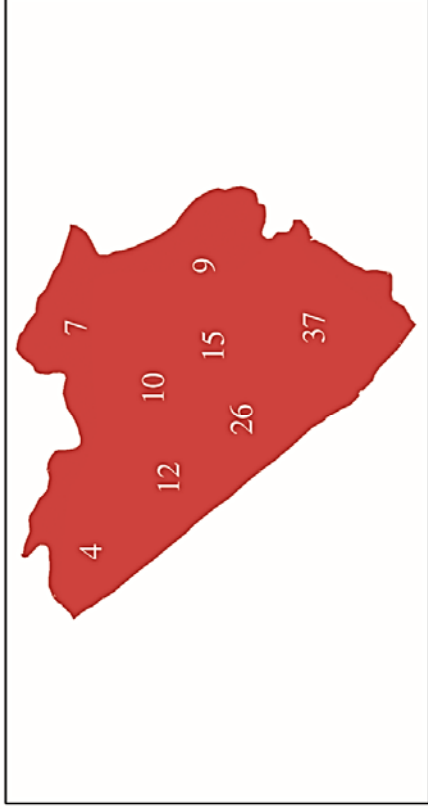


c: Pathanamthitta

MAP-6: Distribution Pattern of Sphecid wasps



a: Kollam



b: Thiruvananthapuram

A Study on the Diversity and Distribution of Sphecoid fauna in Thrissur District, Kerala, INDIA.

Baaby Job¹, Joseph Louis Olakkengil²
(Department of Zoology, St.Thomas College, Thrissur).

Abstract: Sphecoid wasps comes under the Superfamily Apoidea, with species distributed throughout the world. They are mainly beneficial and relatively harmless to man. This paper provides a report on Sphecoid wasps collected from six localities in and around Thrissur district, Kerala. The wasps were collected using hand nets. Ten species belonging to two subfamilies- Ampulicinae and Sphecinae were identified. Of the ten species, *Chalybion bengalense* Dahlbom showed highest distribution. The dominant genus was *Sceliphron* Klug (3species), while *Ampulex* Jurine and *Trirogma* Westwood were represented by one species each. A short note on biology is provided. A comparative analysis of species reported from Kerala and India is also provided.

Keywords: Ampulicinae, Distribution, Sphecidae, Sphecinae, Thrissur.

I. Introduction

Sphecidae (Latreille, 1802) is a cosmopolitan family of wasps with 9716 described species coming under 318 genera [1]. They are represented in all bio geographical regions and show great diversity in morphological and biological characters. Adult sphecids feed on a variety of food from nectar and honeydew to spiders and insects belonging to several orders. Prey paralysis and provisioning of nest is a common feature. Nests are constructed in soil, wood, plant stems, twigs and crevices or holes in rocks, stones, walls etc. Mating strategies include prenuptial flights, territorial defenses and courtship activities [2, 3].

The sphecid wasps can be readily distinguished from their closest relatives, bees by the presence of simple unbranched hairs, pronotal lobe not touching tegulae and presence of cleaning pectan on inner side of hind basitarsus opposed to inner tibial spur. These wasps are associated with mankind in the field of agriculture and general ecology, acting as predators, pollinators, parasites and parasitoids. They are valuable bio indicators and biocontrol agents [4, 5]. The relationship of these insects with man has been unfriendly due to fear from their over rated stinging powers.

Though most species of Spheciformes have been collected and described from Central and Northern parts of India, the sphecoid fauna of the country is still imperfectly known. The pioneer studies of Indian Spheciformes were done by Fabricius [6]. Bingham [7] has recorded as many as one sixty eight species of Sphecoid wasps as occurring in the Indian Sub Continent. Later Cameron [8], Turner[9] has published on the Indian fauna. Bohart and Menke[3]published generic revision on the world fauna. The recent works on Indian sphecidae is by Gupta [10], Jonathan et.al [11,12] and Kundu et.al[13]. In Kerala 47 species of sphecoid wasps has been listed [14,15,16].The Sphecidae has been treated as a single family with 11 subfamilies [3] or as Superfamily with the subfamilies raised to family status[17].But later cladistic treatment has divided the sphecoid wasps in four monophyletic families [18, 19].This paper follows the classification proposed by Bohart and Menke[3], as it is an authenticated revision on world Sphecidae, even till date.

The present papers aim to generate valuable information about the diversity and distribution of Sphecoid wasps belonging to Subfamilies Ampulicinae and Sphecinae in Thrissur District of Kerala, as of now research on the sphecoid wasp diversity has not been available for this area.

II. Materials And Methods

2.1. STUDY AREA: The study area includes six locations around Thrissur district-Ayyanthole, Chelakkottukara, Eravu, Peechi, Thumburmuzhi and Vazhani (Fig:1). Thrissur district lies at central part of kerala at sea level (10.52°N and 76.21°E). The district is bounded on east by Western Ghats and consists of three natural divisions-highlands, plains and sea shore. The district has tropical humid climate with average temperature of 31°C and annual rain fall 3000mm.



Figure1: Collection areas in Thrissur District

2.2. COLLECTION AND PRESERVATION: The insects were collected using hand nets, killed with Acetone, pinned with No. 3 Entomological pins and preserved in insect boxes for identification studies. The insects were collected random between 9 AM and 5 PM from August 2009 to February 2012.

2.3. IDENTIFICATION: The collected specimens were identified using Leica MZ6 Stereozoom microscope with camera lucida with the help of literature [3,7,11,12,14]

III. Results

A total of ten species belonging to six genera under two subfamilies- Ampulicinae and Sphecini, were collected from Thrissur district (TABLE 1).

Subfamily Ampulicinae

Tribe Ampulicini

Genus *Ampulex* Jurine, 1807

1. *Ampulex compressa* (Fabricius, 1781)

Sphex compressus Fabricius, 1781

Material Examined: 3♀, Ayyanthole (10°32'12"N, 76°11'8"E), 02.VI.2010, 11.II.2011 and 04.VI.2011.

Kerala records: Fabricius, 1781 (Malabar)[20]; Sudheendrakumar and Narendran, 1989(Malabar).

Tribe Dolichurini

Genus *Trirogma* Westwood, 1841

2. *Trirogma caerulea* (Westwood, 1841)

Trirogma caerulea Westwood, 1841

Material Examined: 3♀, Ayyanthole (10°32'12"N, 76°11'8"E), 05.II.2010 and 15.I.2011.

Kerala records: Sudheendrakumar and Narendran, 1989(Malabar); Sudheendrakumar and Mathew, 1999 (Parambikulam Wildlife Sanctuary).

Subfamily Sphecinae

Tribe Ammophilini

Genus *Ammopila* W.Kirby, 1798.

3. *Ammophila clavus* (Fabricius, 1775)

Sphex clavus Fabricius, 1775

Material Examined: 1♀, Ayyanthole, 03.III.2009; 1♀, Vazhani, 03.01.2010.

Kerala Records: Sudheendrakumar and Narendran, 1989(Malabar); Sudheendrakumar and Mathew, 1999 (Parambikulam Wildlife Sanctuary).

4. *Ammophila laevigata* (F.Smith, 1856).

Ammophila laevigata (F.Smith, 1856).

Material Examined: 1♀, Ayyanthole (10°32'12"N, 76°11'8"E), 07.VII.2009; 1♀, Eravu (10°47'N, 76°15'E), 11.III.2011.

Kerala Records: Sudheendrakumar and Narendran, 1989(Malabar); Sudheendrakumar and Mathew, 1999 (Parambikulam Wildlife Sanctuary).

Tribe Sceliphriini

Genus *Sceliphron* Klug, 1801

5. *Sceliphron coromandelicum* (Lepeletier, 1845)

Pelopaeus coromandelicus Lepeletier de Saint Fargeau, 1845.

Material Examined: 1♀, Peechi (10°31'47"N, 76°22'13"E), 12.II.2012.

Kerala Records: Sudheendrakumar and Narendran, 1989(Malabar); Sudheendrakumar and Mathew, 1999 (Parambikulam Wildlife Sanctuary).

6. *Sceliphron javanum nalandicum* (Strand, 1915)

Pelopeus spinolae: F. Smith, 1856.

Material Examined: 1♀, Thumburmuzhi (10°29' N, 76°46' E), 05.V.2012.

Kerala Records: Sudheendrakumar and Narendran, 1989(Malabar); Sudheendrakumar and Mathew, 1999 (Parambikulam Wildlife Sanctuary).

7. *Sceliphron madraspatanum* (Fabricius, 1781)

Sphex madraspatanus Fabricius, 1781

Materials examined: 3♀, Ayyanthole(10°32'12"N, 76°11'8"E), 02.I.2010 and 13.IV.2010.

Kerala Records: Fabricius, 1781(Malabar); Sudheendrakumar and Narendran, 1989(Malabar); Sudheendrakumar and Mathew, 1999 (Parambikulam Wildlife Sanctuary).

Genus *Chalybion* Dahlbom, 1843.

8. *Chalybion bengalense* (Dahlbom, 1845)

Sphex violaceus Fabricius, 1775.

Materials examined: 2♀, Ayyanthole(10°32'12"N, 76°11'8"E), 02.I.2010; 1♀, Eravu (10°47'N, 76°15'E), 11.III.2011; 2♀, Chelakkottukara (10°39'57" N, 76°21'4"E). 30. VI.2011; 1♀, Thumburmuzhi(10°29' N, 76°46' E), 05.II.2012.

Kerala Records: Sudheendrakumar and Narendran, 1989(Malabar); Sudheendrakumar and Mathew, 1999 (Parambikulam Wildlife Sanctuary).

Tribe Sphecini

Genus *Sphex* Linnaeus, 1758.

9. *Sphex argentatus* (Fabricius, 1787)

Sphex argentatus Fabricius, 1787

Materials examined: 3♂, Peechi(10°31'47"N 76°22'13"E), 12.II.2012.

Kerala Records: Sudheendrakumar and Narendran, 1989(Malabar); Sudheendrakumar and Mathew, 1999 (Parambikulam Wildlife Sanctuary).

10. *Sphex sericeus* (Fabricius, 1793)

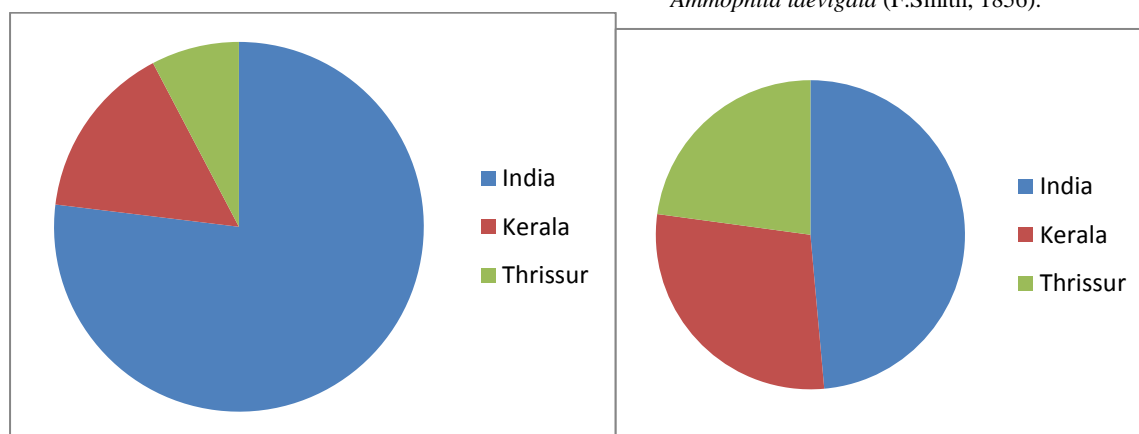
Sphex aurulentus Fabricius, 1793

Materials examined: 1♀, Thumburmuzhi(10°29' N, 76°46' E), 05.V.2012; 4♂, Chelakkottukara (10°39'57" N, 76°21'4"E). 30. VI.2011 and 18.VII.2011.

Kerala Records: Sudheendrakumar and Narendran, 1989(Malabar); Sudheendrakumar and Mathew, 1999 (Parambikulam Wildlife Sanctuary).

Table: 1 Systematic position of Sphecoid wasps in Thrissur District, Kerala.

Subfamily	Genus	Species collected.
Ampulicinae	<i>Ampulex</i> Jurine, 1807	<i>Ampulex compressa</i> (Fabricius, 1781)
	<i>Trirogma</i> Westwood, 1841	<i>Trirogma caerulea</i> (Westwood, 1841)
Sphecinae	<i>Sphex</i> Linnaeus, 1758	<i>Sphex sericeus</i> (Fabricius, 1793)
		<i>Sphex argentatus</i> (Fabricius, 1787)
	<i>Sceliphron</i> Klug, 1801	<i>Sceliphron javanum nalandicum</i> (Strand, 1915)
		<i>Sceliphron coromanandelicum</i> (Lepletier, 1845)
		<i>Sceliphron madraspatanum</i> (Fabricius, 1781)
	<i>Chalybion</i> Dahlbom, 1843	<i>Chalybion bengalense</i> (Dahlbom, 1845)
<i>Ammophila</i> W. Kirby, 1798	<i>Ammophila clavus</i> (Fabricius, 1775)	
	<i>Ammophila laevigata</i> (F. Smith, 1856).	



a: Subfamily Ampulicinae

b: Subfamily Sphecinae

Figure 2: Pie diagram comparing number of Species reported from Thrissur to Kerala and India.

IV. Discussions

In the present study ten species of sphecoid wasps in six genera representing two subfamilies were recorded. The subfamily Sphecinae recorded eight species under four genera, while subfamily Ampulicinae represented two species under two genera.

Among the genus *Sceliphron* Klug recorded the most number of species. These together with *Chalybion bengalense* Dahlbom are called mud-dauber wasps, on account of their habit of building multicellular mud nests. These can be readily recognized in the fields by their black and yellow body, while *C.bengalense* has metallic blue body. They mass provision their nests with spiders. Among the species *C.bengalense* was the most represented with collections recorded from four of the six localities, a possible outcome of prey abundance. *Sceliphron javanum nalandicum* Strand was recorded only from Thumburmuzhy area.

Sphex Linnaeus are fossorial wasps, their nests are holes dug in soil and provisioned with Acrididae. *Sphex sericeus* Fabricius females are readily recognized by their golden yellow body, while males have black and red body with white hairs. The males were collected feeding from flowers of *Murraya koenigii* (L) Spreng. *Sphex argentatus* Fabricius are robust black species. Ammophilini are called thread waisted wasps, with slender, black and red body. Their petiole is two segmented. These are solitary nesters feeding on lepidopteran larva. They were the most difficult to catch usually escaping from the nests while sweeping.

Ampulex compressa Fabricius and *Trirogma caerulea* Westwood were collected from Ayyanthole locality only. *A.compressa* are metallic green blue body and were collected from trunks of *Coccus nucifera* Linnaeus, possibly in search of their prey, *Periplaneta americana* Linnaeus.

A pie diagram showing the comparison between the number of species reported from Thrissur to species recorded from the above genus' in Kerala and India is given for both subfamilies. In India, the number of species reported from the four genus of Subfamily Sphecinae is 17 and from Kerala is 10 (Fig.2a), while the number of species reported from Subfamily Ampulicinae in India is 20 and in Kerala is 4 (Fig 2b).

V. Conclusions

The occurrence of Spheciformes in a habitat is conditioned by moisture, the soil exposure, soil type and prey abundance [21]. The collection of these wasps are a tedious process, yet they have to be catalogued because of their economic importance. In determining the fauna of a country, faunistic studies on small regions is very important because individual habitats and the micro climate in a small region plays an important role on the distribution of insects [21]. These wasps are mainly feared by humans due to their overrated stinging powers and their close association with human habitats results in the destructions of nests by humans. These wasps perform many ecological roles as predators, pollinators, bio control agents and biodiversity indicators [22]. Present study has revealed valuable information on the wasps of Thrissur region and future studies may result in further elaboration of these wasp species. Also studies on the ecology of these diverse wasps need to be carried out.

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Koothattukulam (Ernakulam Dist.) : A hotspot for Sphecoid fauna

*Baaby Job and Joseph Louis Olakkengil

Department of Zoology, St. Thomas College, Thrissur, Kerala, India - 680001

*E mail: baabyjobc@yahoo.com

Abstract

This paper reports on the Sphecoid fauna collected from the Koothattukulam area of Ernakulam district in Kerala State [9° 49' 45.02"N & 76° 36' 25.71" E, elevation 47m. (area 1.25 hectares)]. The area seemed to be a preferred nesting site for *Sceliphoron coromandelicum* Lepeletier, *Chalybion bengalense* Dahlbom and Dolichurini. Of the 40 specimens collected the following families were represented. Family Sphecidae: Tribe Sphecini – Genus *Sphex* Linnaeus, Tribe Sceliphronini – Genus *Chalybion* Dahlbom, *Sceliphron* Klug; Tribe Ammophilini – Genus *Ammophila* Kirby; Family Ampulcidae :Tribe Dolichurini, and Family Crabronidae : Tribe Trypoxylonini and Tribe Larrini.

Key words: Spheciformes, Hotspot, Biodiversity

Introduction

The Sphecoid wasps lack a single common name but include groups such as digger wasps, sand wasp, thread waisted wasps and mud dauber wasps. Many are brightly coloured, conspicuous and fast moving³. Sphecoid wasps come under the Super family Apoidea, Series Spheciformes and comprises 318 genera and almost 10,000 described species in the world, treated as a single family by some authors or as a series of 9 families⁷.

Sphecoids are easily distinguished from bees by the presence of gold and silvery hairs on the lower face, causing the face to glitter in the light. They are also quite different from true wasps of Vespoidea both in their morphology and behaviour. The diagnostic features of Spheciformes include antennae with 10 – 11 flagellomeres, pronotum with posterolateral lobe strongly convex, hind wing with 2 closed cells, jugal lobe usually present, and presence of petiole and ovipositor concealed at rest and modified as sting³.

Bingham² in his work on the Indian Hymenoptera recorded as many as 168 species of Sphecoid wasps as occurring in the Indian Sub Continent. Sudheendrakumar and Dr. Narendran published papers on Spheciformes of Kerala¹⁰. Madhavikutty⁹ listed 42 species of Spheciformes from Kerala.

Adult Sphecoids feed on a variety of food, from nectar and honey dew to spiders and insects belonging to several orders. The majority of Sphecoids are parasitic but some are cleptoparasitic. Prey paralysis is a common feature among these wasps. Nests can be underground and above ground types and usually associated with human dwellings. These wasps are associated with mankind in the field of agriculture and general ecology, acting as predators, pollinators, parasites and parasitoids. The relationship of these insects with man has been unfriendly due to fear from their over rated stinging powers.

Collection Area

The study area involved 1.25 hectares of land (9° 49' 45.02"N & 76° 36' 25.71" E, elevation 47m), surrounded by rubber plantation, of Koothattukulam Panchayat located in the Muvattupuzha Taluk, towards South East corner of Ernakulam District in Kerala State, India (Fig 1-c). Soil texture was found to be Loamy and pH as 6.7



Methods of Collection

The specimens were collected in the pre monsoon months of March and April 2011, during day time between 8am and 5pm. The insects were collected using sweep net and killed with Acetone as agent. The specimens were mounted using No.3 entomological pins and preserved for identification studies.

Results and Discussions

The collected specimens represented 3 families, 6 tribes and 8 genera of Spheciformes, with *Chalybion bengalense* Dahlbom and *Sceliphoron coromandelicum* Lepeletier forming the major share (Table 1). The area also seemed to be their preferred nesting sites with as many as 10 *Sceliphoron* nests in a single wall. They were seen to be collecting mud from adjoining puddles and constructing nests, the activity heightening around noon. The *Chalybion* was seen carrying their spider prey to their nests in the crevices of walls and ceilings. Their nets were sealed with an outer layer of white material. Dolichurus was caught red handed with its prey in a partially paralyzed condition. The *Sphex* was caught in the act of constructing a ground nest with hole being almost one and a half inches.

The occurrence of Spheciformes in a habitat is conditioned by the moisture, but other factors like the soil exposure also seem to be the determinant, relating to their nesting requirements⁵. The Sphecidae is a cosmopolitan family of mud-dauber wasps and thread-waisted wasps. Soil type and prey abundance is very important for the settlement of this family^{5, 7}. They are essentially predators of Araneae, Orthopteroids or Lepidopteron larvae, abundant in the particular area, making them potential tools as bio control agents⁴. (Table-2) Members of the genus *Sphex* dig their nests in soil with gravel and provision their nests with their prey- Acrididae and Locustidae, an agricultural pest¹. *Ammophila* are generally solitary nesters, feeding on lepidopteran larvae.

India, one of the mega diversity countries in the world harbours a high level of biodiversity. Kerala has also a share in being one of the global biodiversity hotspot-the Western Ghats. This biodiversity is now being depleted at an alarming rate, our precious natural resources are vanishing, and these have to be conserved before they vanish. The creation of Protected Areas was one of the first measures taken for the protection of biodiversity and is still the most widely used¹¹. Aculeate Hymenopterans, especially Spheciformes and Apiformes gather exceptional characteristics as bio indicators: are a part of several functional niches (predators, cleptoparasites and pollinators), have economic importance (pollinators and pest management) and proven to be good bio indicators (predicting the diversity of other groups of animals and for all the species of a given area)^{6,8}. In England, the ISIS [Invertebrate Species Habitat Information System], a classification system for conservation based on invertebrate communities and their relation with habitats, is already being developed¹¹.

Hotspots of biodiversity are regions harbouring great diversity of endemic species and at the same time significantly altered and impacted by human activities. Most of our conservation strategies are centred around hotspots but little known niches like these also has tremendous value in biodiversity conservation. So the establishment of systems to evaluate the effectiveness of management of these areas are crucial to validate their importance for conservation and guide the managers towards their conservation goals.



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Table. 1 List of spheciformes showing family,tribe & genus

Series	Family	Tribe	Genus	Species
SPHECIFORMES	Sphecidae	Sphecini	<i>Sphex</i> <i>Linnaeus</i>	<i>Sphex argentatus</i> Fabricius
		Sceliphronini	<i>Chalybion</i> <i>Dahlbom</i> <i>Sceliphron</i> <i>Klug</i>	<i>Chalybion bengalense</i> Dahlbom <i>Sceliphron coromandelicum</i> Lepeletier <i>Sceliphron</i> (s) <i>madraspatanum</i> Fabricius.
		Ammophilini	<i>Ammophila</i> <i>Kirby</i>	<i>Ammophila laevigata</i> Smith
	Ampulicidae	Dolichurini	<i>Dolichurus</i> <i>Latrielle</i>	
	Crabronidae	Trypoxylonini	<i>Trypoxylon</i> <i>Latrielle</i>	
		Larrini	<i>Larra</i> <i>Fabricius</i>	

Table 2. Prey records for Spheciformes

	spiders	Orthoptera	Lepidoptera	Coleoptera	Hymenoptera	Hemiptera	Homoptera
Sceliphronini	✓	✓					
Sphecini		✓					
Ammophilini		✓	✓	✓	✓		
Larrini		✓	✓			✓	✓
Trypoxylonini	✓						
Dolichurini		✓					

Figure 1- A,B, D-nests of *Sceliphron* & *Sphex*, C- Collection Area



A
B



C



D