Akshay Kumar Chakravarthy
Shakunthala Sridhara *Editors*

Arthropod Diversity and Conservation in the Tropics and Sub-tropics

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Diversity and Distribution of Sphecoid Wasps in Kerala, India: Bioindicators of Habitat Quality

12

Baaby Job and J.L. Olakkengill

Abstract

Sphecoid wasps, superfamily Apoidea, series Spheciformes with 9706 species in the world come under 318 genera. The life histories of Spheciformes include hunting strategies and solitary to communal nesting to eusociality. They are mainly beneficial and relatively harmless to man. The diversity and distribution of sphecoid wasps at the genus level, with 9 subfamilies and 74 genera, are being reported in India, out of which 8 subfamilies and 35 genera occur in Kerala. A comprehensive analysis of these wasps in Kerala is provided. The food items and habitat patches the wasps prefer are specific so that the changes in the population of wasps can be related to changes in the food and habitat.

Keywords

Apoidea • Eusociality • Sphecoid • Spheciformes

12.1 Introduction

The vast group of Apocrita of Hymenoptera, despite their importance, remain unexplored, especially Spheciformes which has been greatly neglected. The Spheciformes are a highly diverse assemblage of solitary hunting wasps, most of which are brightly colored and fast moving. It comprises 9706 described species under 318 genera (Pulawski 2012) with representations in all biogeographical regions and shows great diversity in morphological and biological characteristics. The oldest known record of sphecoid wasps is from the early Cretaceous, 135 million years ago. The sphecoid wasps can be distinguished from the other hymenopteran groups

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by the presence of a pronotum with a lateral lobe separated from the tegula, the presence of a cleaning pecten on the inner side of hind basitarsus, and simple unbranched setae (Roche and Gadallah 1999). Adult sphecids feed on a variety of food from nectar and honeydew to spiders and insects across 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 (Ashmead 1894; Bohart and Menke 1976; Capinera 2003).

12.1.1 Economic Importance

Spheciformes are natural control agents of pests such as aphids, biting flies, cutworms, grasshoppers, and leafhoppers and are used as biocontrol agents in the cultivated fields and act as predators, pollinators, parasites, and parasitoids (Borror and Delong 1988). They are valuable bioindicators responding to environmental disturbances and environmental variations and reflect the diversity patterns of other taxa. They are regarded as nuisance by the people who cannot abide by the presence of wasps, together with the fear of their overrated stinging power, and two species have been reported to be pests in apiaries (Capinera 2003).

12.1.2 Sphecoid Wasps in India and Kerala

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 (1781). Bingham (1897) recorded as many as 168 species of sphecoid wasps as occurring in the Indian subcontinent. Bohart and Menke (1976) published on the world fauna. In Kerala, Sudheendra kumar and Narendran (1989, 1985) and Madhavikutty (2004) worked on the sphecoid wasps. Some authors treat Spheciformes as a single family Sphecidae (Bohart and Menke 1976; Gauld and Bolton 1988) or as a series of nine families (Finnamore et al. 1993), giving family status to subfamilies and their tribes being treated as subfamilies. This paper uses the classification set up by Bohart and Menke (1976).

In determining the fauna of a country, faunistical studies on small regions are important because individual habitats and the microclimate in a small region play an important role on the distribution of insects (Gulmez and Tuzum 2005). The present paper aims to provide data toward complete knowledge of the Indian fauna by analyzing the diversity and distribution of these wasps in Kerala.

12.2 Materials and Methods

The insects were collected from urban and semi-urban areas of Kerala from 2010 to 2012. The insects were caught using sweep net and were killed with 10 % acetone analytical grade as agent. Field studies were carried out from 9:00 am to 17:00 pm. The specimens were mounted using no. 3 entomological pins and identified according to Bohart and Menke (1976) using Leica MZ6 Stereo Zoom microscope.

12.2.1 Study Area

Kerala is one of the smallest states in India with an area of 38,863 km^2, contributing 1.3 % of total area of India. Kerala is located between north latitude 8°18′ and 12°48′ and east longitude 74°52′ and 77°22′.

(a) *Topography*
The topography consists of eastern highlands comprising Western Ghats, covered with dense forests and high mountains with tea and coffee plantations, midlands along the Central Kerala with paddy fields, pepper and tapioca fields to a flat coastal belt of coconut trees; interconnected with canals and rivers.

(b) *Climate*
Kerala lies in the tropics and is subjected to humid tropical wet climate. It receives an average rainfall of 3107 mm. Average daily temperature is around 36.7 °C with minimum 19.8 °C. The state enjoys four climatic seasons—summers (from March to June), southwest monsoon (from June to August), northeast monsoon (from September to October) and the winter season with a chilly climate from December to February.

12.3 Results

Out of the nine subfamilies and 74 genera reported in India (Bohart and Menke 1976), Kerala has recorded eight subfamilies and 35 genera (Sudheendra kumar and Narendran 1989; Suresh et al. 1999) (Table 12.1). A total of 175 specimens belonging to 15 genera were collected from the state and listed in Table 12.2 and Fig. 12.1. The genus *Chalybion* Dahlbom showed the widest range of distribution suggesting the ability of this group to exist in varied environmental conditions, provided with their food sources.

12.4 Discussion

The collected specimens were represented in four subfamilies—Ampulicinae, Sphecinae, Larrinae, and Nyssoninae—and 15 genera. Subfamily Sphecinae were the most represented with six genera and showed almost cosmopolitan distribution.

Table 12.1 Diversity of sphecoid wasps in Kerala, India

Sl. no.	Genus	India	Kerala
Subfamily Ampulicinae (Fig. 12.2)			
1	*Ampulex* Jurine	P	P
2	*Dolichurus* Latreille	P	P
3	*Trirogma* Westwood	P	P
Subfamily Sphecinae (Fig. 12.3)			
4	*Sceliphron* Klug	P	P
5	*Chlorion* Latreille	P	P
6	*Chalybion* Dahlbom	P	P
7	*Sphex* Linnaeus	P	P
8	*Isodontia* Patton	P	P
9	*Prionyx* Vander Linden	P	P
10	*Podalonia* Fernald	P	P
11	*Ammophila* W. Kirby	P	P
12	*Parapsammophila* Taschenberg	P	P
Subfamily Pemphredoninae (Fig. 12.4)			
13	*Mimumesa* Malloch	P	A
14	*Psen* Latreille	P	A
15	*Psenulus* Kohl	P	P
16	*Diodondus* Curtis	P	A
17	*Pemphredon* Latreille	P	A
18	*Polemistus* Saussure	P	P
19	*Stigmus* Panzer	P	A
20	*Carinostigmus* Tsuneki	P	P
21	*Spilomena* Shuckard	P	A
22	*Ammoplanellus* Gussakovskij	P	P
Subfamily Astatinae (Fig. 12.5)			
23	*Astata* Latreille	P	P
24	*Dryudella* Spinola	P	A
25	*Dinetus* Panzer	P	A
Subfamily Laphyragoginae			
26	*Laphyrogogus* Kohl	P	A
Subfamily Larrinae (Fig. 12.6)			
27	*Larra* Fabricius	P	P
28	*Liris* Fabricius	P	P
29	*Paraliris* Kohl	P	A
30	*Dicranorhina* Shuckard	P	A
31	*Gastrosericus* Spinola	P	P
32	*Tachytes* Panzer	P	P
33	*Tachysphex* Kohl	P	P
34	*Parapiagetia* Kohl	P	A
35	*Holotachysphex* de Beaumont	P	A
36	*Prosopigastra* A. Costa	P	P
37	*Palarus* Latreille	P	A

(continued)

Table 12.1 (continued)

Sl. no.	Genus	India	Kerala
38	Lyroda Say	P	P
39	*Paranysson* Guérin-Méneville	P	A
40	*Solierella* Spinola	P	P
41	*Miscophus* Jurine	P	A
42	*Nitela* Latreille	P	A
43	*Pison* Jurine	P	P
44	*Trypoxylon* Latreille	P	P
Subfamily Crabroninae (Fig. 12.7)			
45	*Oxybelus* Latreille	P	P
46	*Encopognathus* Kohl	P	A
47	*Entomognathus* Dahlbom	P	A
48	*Lindenius* Lepeletier and Brulle	P	A
49	*Rhopalum* Stephens	P	A
50	*Isorhopalum* Leclercq	P	A
51	*Crossocerus* Lepeletier and Brulle	P	A
52	*Crabro* Fabricius	P	A
53	*Piyuma* Pate	P	P
54	*Vechita* Pate	P	A
55	*Hingstoniola* Turner and Waterson	P	A
56	*Dasyproctus* Lepeletier and Brulle	P	P
57	*Ectemnius* Dahlbom	P	A
58	*Lestica* Billberg	P	A
Subfamily Nyssoninae (Fig. 12.9)			
59	*Alysson* Panzer	P	A
60	*Nursera* Cameron	P	A
61	*Nysson* Latreille	P	A
62	*Synnevrus* A. Costa	P	A
63	*Brachystegus* A. Costa	P	A
64	*Dienoplus* W. Pax	P	A
65	*Gorytes* Latreille	P	A
66	*Lestiphorus* Lepeletier	P	A
67	*Ammatonius* A. Costa	P	P
68	*Hoplisoides* Gribodo	P	A
69	*Stizus* Latreille	P	P
70	*Stizoides* Guerin-Meneville	P	A
71	*Bembecinus* A. Costa	P	P
72	*Bembix* Fabricius	P	P
Subfamily Philanthinae (Fig. 12.8)			
73	*Philanthus* Fabricius	P	A
74	*Cerceris* Latreille	P	P

P Present, *A* Absent

Table 12.2 Genera of sphecoid wasps collected from Kerala, India, 2010–2012

Sl. no.	Genus	Kasargod	Kannur	Wayanad	Kozhikode	Malappuram	Palakkad	Thrissur	Ernakulam	Kottayam	Idukki	Pathanamthitta	Kollam	Trivandrum
1	*Ampulex* Jurine	X						X	X					
2	*Dolichurus* Latreille								X					
3	*Trirogma* Westwood													
4	*Sceliphron* Klug	X	X	X	X	X	X	X	X	X	X	X	X	X
5	*Chlorion* Latreille			X										
6	*Chalybion* Dahlbom	X	X	X	X	X	X	X	X	X	X	X	X	X
7	*Sphex* Linnaeus			X				X	X	X		X	X	X
8	*Isodontia* Patton								X					
9	*Ammophila* W. Kirby	X	X	X		X	X	X	X		X			
10	*Larra* Fabricius					X		X						
11	*Liris* Fabricius	X		X					X	X	X			X
12	*Tachysphex* Kohl													
13	*Pison* Jurine							X						
14	*Trypoxylon* Latreille	X				X								
15	*Bembix* Fabricius					X		X						

Fig. 12.1 Distribution patterns of sphecoid wasps (Based on Table 12.2)

Most of the collected specimens showed marked variations at the times of their collections. All of the specimens were collected in the morning, the insect's activity increasing with temperature, but collections were less after around 1:00 pm and increased toward around 4–5:00 pm in the evening, displaying their diurnal nature. The wasps also showed variations in the areas collected. While most of the Sphecinae and Ampulicinae were collected from open areas, *Liris* Fabricius and *Larra* Fabricius were collected from shady areas with patches of light, while *Bembix* Fabricius was collected from sandy areas. *Chalybion* Dahlbom and *Sceliphron* Klug were collected mainly from areas with loamy soil. Subfamily Laphyragoginae, although reported in most other parts of India, has not been reported yet in Kerala (Table 12.1).

Ampulex spp (http://ispeakforthefleas.blogspot.in)

Dolichurus spp (http://www.padil.gov.au)

Fig. 12.2 Sphecoid wasps: subfamily Ampulicinae

12.4.1 Subfamily Ampulicinae

These wasps are called as "cockroach wasps" because of their prey choice; one cockroach prey is provided in each cell as food for the larvae. These wasps represented in six genera, out of which three, *Ampulex* Jurine, *Dolichurus* Latreille, and *Trirogma* Westwood are reported from Kerala (Fig. 12.2). *Ampulex* Jurine is readily identified in the field by metallic blue or black and red integument. *Trirogma* Westwood is medium to large sized wasps, with white mandibles in males. *Dolichurus* Latreille are small black wasps, often with red terminal abdominal segments. They run or skip over leaf litter, occasionally disappearing beneath the fallen leaves to search prey. Among the three genera collected, *Ampulex* Jurine was the most common, being collected from three Kerala districts: Ernakulam, Thrissur, and Kasargod.

12.4.2 Subfamily Sphecinae

These are called 'thread-waisted wasps' on account of their cylindrical petiole. They are cosmopolitan wasps, with large size and bright colors. They are common inhabitants of fields, forests, and even garage lots. The genera *Chalybion* Dahlbom and *Sceliphron* Klug were the most common specimens collected followed by *Sphex* Linnaeus and *Ammophila* W. Kirby. *Isodontia* Patton was collected from the Koothattukulam area in Ernakulam, Kerala (Figs. 12.3, 12.4, and 12.5). These display a variety of nesting habits from fossorial to nesting in preexisting cavities in twigs and woods to social behavior. Preys include spiders, cockroaches, crickets, grasshoppers, etc.

Chlorion Latreille: Length ranging from 16 to 37 mm, metallic green or blue wasps. They can be identified from their well-developed foretarsal rake, spiracular groove, and second submarginal cell receiving the first recurrent vein. Prey species are crickets belonging to Gryllidae.

Sceliphron Klug: Cosmopolitan wasps with two subgenus—*Scelipheron* and *Proscelipheron*. These are medium-sized wasps with lengths ranging from 12 to 32 mm and black body with yellow markings and are closely associated with human habitations. They are called "mud dauber wasps" with reference to their habit of

Sceliphron spp. (http://www.pestnet.org) *Sphex* Linnaeus (http://www.waspweb.org)

Ammophila spp. (http://napamosquito.org) *Prionyx spp.*(http://www.pbase.com)

Fig. 12.3 Sphecoid wasps: subfamily Sphecinae

Stigmus spp (http://www.bwars.com) *Carinostigmus* spp (http://fukker666.blog32.fc2.com)

Fig. 12.4 Sphecoid wasps: subfamily Pemphredoninae

building nests with mud collected from a moist spot. They can be identified from other groups of the subfamily by expanded third maxillary palpal segment. In subgenus *Scelipheron*, the hypostomal carina ends near the mandible socket, while this is evanescent about halfway to the socket in *Proscelipheron*. Each mud nest consists of six to seven cells of mud, each cell provisioned with spiders.

Astata spp. (http://www.natureconservationimaging.com) *Dryudella* spp.(http://bugguide.net)

Fig. 12.5 Sphecoid wasps: subfamily Astatinae

Chalybion Dahlbom: These are cosmopolitan metallic blue wasps with lengths ranging from 11 to 32 mm. They are the most common wasps, associated with human dwellings and habitats. They are characterized by the absence of propodeal enclosure and submarginal cell, one receiving both recurrent veins. These wasps mass provision their mud nests with spiders, which is then sealed with a white cementing substance.

Sphex Linnaeus: These are cosmopolitan and moderate to large wasps, with black or golden yellow colors. They are identified with the length of petiole as measured along dorsum less than the combined lengths of hind tarsomeres II–IV and complete spiracular groove on the propodeal side. Members of the genus *Sphex* dig nests in soil with gravel and provision their nests with prey—Acrididae and Locustidae, agricultural pests.

Isodontia Patton: "Grass carrier wasps." These are moderate to large wasps, 11–33 mm, mostly black. These wasps use preexisting cavities like hollow plant stems and crevices between stones for nesting. They are identified by the absence of a complete spiracular groove and the anterior veinlet of the third submarginal cell exceeding the length of posterobasal veinlet. They are nonfossorial; hence, either the females lack a fore tarsal rake or the rake is poorly developed. Preys include Gryllidae and Tettigoniidae.

Ammophila W. Kirby: These wasps range in length from 8 to 37 mm. They are easily diagnosed by partly or all-red gaster, and the legs are commonly partly red, with the legs and thorax covered with appressed silver hairs. They are characterized by the presence of a long petiole, appearing two segmented; apex of sternum I does not reach the base of II, with a long intervening space connected by ligaments. *Ammophila* are generally solitary nesters, feeding on lepidopteran larvae.

12.4.3 Subfamily Larrinae

These are the largest subfamily with 18 genera reported in India, often dark-colored wasps, sessile or petiolate. Most species are fossorial and are commonly known as "digger wasps." The most abundant in the collection was *Liris* Fabricius, followed by *Larra* Fabricius and *Trypoxylon* Latreille. *Pison* Jurine was collected from

Chelakkottukara area of Thrissur district, Kerala, and *Tachysphex* Kohl from Ramapuram in Kottayam district, Kerala (Figs. 12.6, 12.7, and 12.8). Prey species range from spiders, Orthoptera, Hemiptera, Dipterans, and hymenopterous adults to lepidopterous larva. *Larra* Fabricius: These are small to large wasps, 6–25 mm long, black wasps with a shiny gaster. Hind-ocellar scars are very small and obscure. They are identified by the last tarsomere evenly arcuate, propodeal side punctate, and pronotal collar flat or arcuate in front view. The subgenus *Crotolarra* is distinguished from the subgenus *Larra* by the absence of spine rows on the outer face of

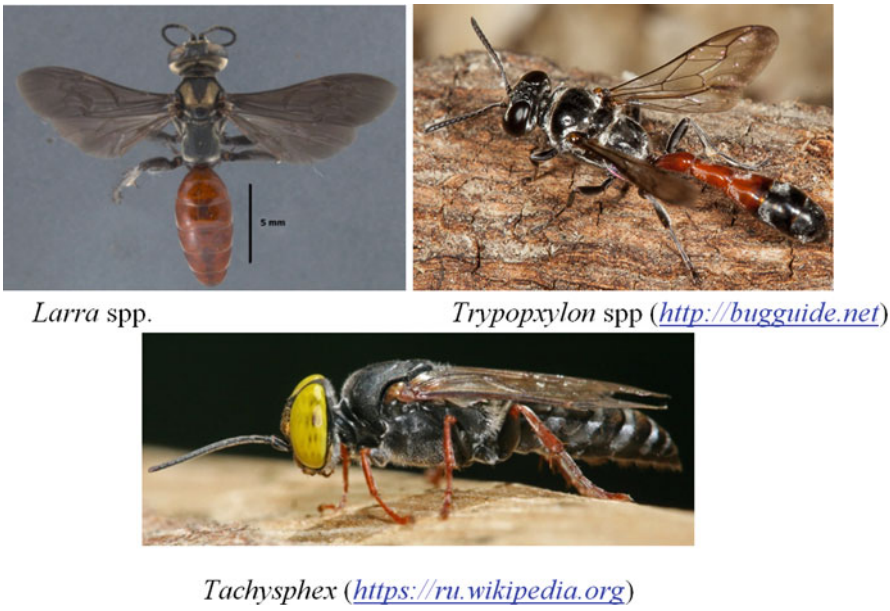

Fig. 12.6 Sphecoid wasps: subfamily Larrinae

Fig. 12.7 Sphecoid wasps: subfamily Crabroninae

Fig. 12.8 Sphecoid wasps: subfamily Philanthinae

foretibia. *Larra* females don't construct their own nests and prey paralysis is temporary, the prey being mole crickets (Gryllotalpidae).

Liris Fabricius: These are dull black wasps with a fine appressed vestiture on the abdomen. They range in length from 5 to 30 mm. They have a hind tibia with a sharp polished carina, propodeum converging posteriorly from above, and reduced hind ocellus and dentate mandibles. Prey species include crickets from the family Gryllidae.

Tachysphex Kohl: These are 4–18-mm-long black wasps with the abdomen and legs often partly or all red. Diagnostic features include inner orbits converging above, hind-ocellar scars oval or oblong or accent marked, and long axes forming an angle of 80°–130°. They have a pair of polished prominences just above the antennal sockets. Prey consists of Orthoptera and nest is constructed in open sandy or vegetated areas.

Pison Jurine: Black wasps with two or three submarginal cells in the fore wing, entire mandible, emarginate eyes, and sessile abdomen. Prey species include a variety of spiders.

Trypoxylon Latreille: They are distinguished by single submarginal cell, emarginate eyes, and slender clavate abdomen. Most of these exist in preexisting cavities and are called "keyhole wasps," with prey mainly being spiders.

12.4.4 Subfamily Nyssoninae

The second largest family is called "sand wasps" as the majority of these are found in sandy habitats. The only genus collected was *Bembix* Fabricius; these were collected from sandy mounds in parks from Nilambur area of Malappuram district and

Fig. 12.9 Sphecoid wasps: subfamily Nyssoninae

Thumburmuzhi in Thrissur, Kerala (Fig. 12.9). They are identified by totally reduced anterior ocelli and reduced palpal segments and long labrum. They nest gregariously and prey consists of Diptera. The digger wasps focus predominantly on habitats influenced by anthropogenic disturbance, to allow burrowing activity and subsequent nesting (Srba and Heneberg 2012).

The abiotic factors driving the presence and nesting of solitary hymenopterans include light intensity, moisture, and soil (Schrimer et al. 2008; Hranitz et al. 2009; Murray et al. 2009), and the biotic variables include floral abundance (Banaszak 1996), availability of pollen and nectar sources (Petanidou and Votou 1990), changes in the availability of the preferred prey (O'Neill 2001; Polidori et al. 2007), or these factors combined (Potts et al. 2005). In addition to specialization at different sizes or types of prey, variability in the abiotic factors of the microhabitat conditions like temperature, moisture, soil type, vegetation cover, and ground inclination was found both necessary and sufficient to allow the parallel presence of viable populations of several closely related sphecoid wasps (Srba and Heneberg 2012).

12.5 Conclusion

The occurrence of Spheciformes in a habitat is conditioned by moisture, but other factors like the soil exposure also seem to be the determinant, relating to nesting requirements. Soil type and prey abundance are important for the settlement of these wasps (Gayubo et al. 2000). The collections of these wasps are a tedious process, yet they have to be catalogued because of economic importance, especially in being bioindicators of habitat quality and ecological disturbance (Gayubo et al. 2005). The richness of wasp species has been shown to correlate with landscape complexity and habitat diversity (Steffan Dewanter 2005).

The creations of protected areas were one of the first measures taken for the protection of biodiversity and are still the most widely used approach (Vieira et al. 2011). Aculeate hymenopterans, especially Spheciformes and Apiformes, gather

exceptional characteristics as bioindicators, are a part of several functional niches (predators, kleptoparasites, and pollinators), have economic importance (pollinators and pest management), and are proven to be good bioindicators (predicting the diversity of other groups of animals and for all the species of a given area (Klein et al. 2002). In England, the Invertebrate Species-Habitat Information System [ISIS], a classification system for conservation based on invertebrate communities and their relation with habitats, is already being developed (Webb and Lott 2006).

Most of our conservation strategies are centered around hotspots, but little known niches like these also have tremendous value in biodiversity conservation. Hence the establishment of systems to evaluate the effectiveness of management of these areas is crucial to validate their importance for conservation and guide the managers towards conservation goals. Our current knowledge of these wasps is still imperfect, and a proper understanding of their habitat requirements is a key prerequisite to allow efficient conservation of individual species, before they are lost.

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