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Hymenopteran Fauna of Andanan Watershed Forest Reserve in Caraga Region, Philippines

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A B S T R A C T

The hymenopteran fauna plays a crucial role in the ecosystem, serving as primary pollinators and acting as biological controls essential in the interrelationships in the community. This study assessed various groups of Hymenoptera occurring in Andanan Watershed Forest Reserve from collected samples through sweeping, light trapping, and opportunistic sampling. A total of 36 species of hymenopterans were identified, belonging to 30 genera, 20 subfamilies, 11 families, and four superfamilies. One genus of Scoliidae – *Phalerimeris*, with one species, *P. aurulenta*, and a single species of *Liacos* – *L. semperi,* are reported in the Philippines for the first time, while the sphecine wasp *Isodontia* is a new record to Mindanao island. Formicidae is the most abundant family comprising 40% of all the collected individuals. Other groups with significant numbers include the families Apidae and Vespidae. Additional families present in the area include social apoid bees Halictidae and solitary bees Megachilidae. Predatory apoid wasps Crabronidae and Sphecidae, predatory vespoid wasps Pompilidae, Mutillidae, Scoliidae, and the parasitoid wasps Ichneumonidae were also reported. Anthropogenic activities and human interventions are also observed in the area, which may pose threats to the diversity of hymenopteran fauna in the forest reserve.

Keywords: *bees, wasps, ants, new records, checklist, Philippines*

1 Introduction

Hymenoptera is one of the largest insect taxa that include certain groups that are social and consist of several well-organized family units engaging in a variety of complex tasks within the colony, while others are solitary in habit, and some have evolved to be parasitoid to other insects (Sharkey et al. 2012). Hymenopterans play various roles in the ecosystem, serving as primary insect pollinators for flowering plants, fruit-bearing trees, and agricultural crops. In the food web, they are important components for the diet of birds, fishes, and other small animals. According to Choate & Drummond (2011), hymenopterans also serve as biological control agents by feeding on phytophagous arthropods, and have shown that some species are used in ecological studies due to their complexity and suitability in habitat requirements (Dauber et al. 2003). Favorably occurring in tropical forests, hymenopterans have been recorded to tolerate anthropogenic activities (Sobrinho & Schoereder 2007; Mondal & Rojo 2017). However, despite their tolerance, certain groups are still experiencing global declines (Uno et al. 2010) as their nesting behaviors and development are significantly altered due to forest degradation (Samejima et al. 2004).

The Philippines has been studied for hymenopteran diversity in the past decade due to its wide range of possible habitats (General & Alpert 2012). New research has also contributed to the knowledge of Philippine Hymenoptera by describing new species (Kojima 1982; Fernandez

2006; Sorger & Zettel 2011; General 2018; Zettel et al. 2018; and Koch & General 2019), implying the diverse community of this group in the archipelago.

The Andanan Watershed Forest Reserve is a protected forested area under Proclamation No. 734, S. 1991 (PENRO Agusan del Sur 2020), situated in Sibagat and Bayugan in the Caraga region of northeastern Mindanao. There is limited information on the insect fauna of this area, such as lepidopterans (Domine & dela Cruz 2020) and odonatans (Guerzon et al. 2023). There is no information yet on hymenopterans that can inform the area's need for forest management and conservation practices. The result of this study will serve as a preliminary report of hymenopteran fauna for species inventory and ecological monitoring in the future.

2 Materials and Methods

The Andanan Watershed Forest Reserve is a secondary forest that spans alternating lowland and mountainous areas in the Caraga region of northeastern Mindanao. The forested section is characterized by slopes and ridges along its riparian area. Fruit-bearing trees such as *Lansium parasiticum* (Osbeck), Sahni & Bennet (lanzones), and *Artocarpus odoratissimus* Blanco (marang) are observed in certain parts of the area. Flowering plants like *Wedelia, Odontonema, Areca, Ficus,* and *Nauclea* are scattered around the area. The forest reserve boasts a moderately dense canopy cover. The ground is also covered with leaf litter, fallen twigs, and decaying logs. Large to medium boulders are observed alongside the river, and various types of soils, ranging from clay to loam, play a vital role for certain species of bees and wasps. The riparian zone features a dense combination of shrubs, ferns, and grasses. Pebbles and cobbles can be found in some areas along the stream, with rocks covered by moss and algae. Arthropods and other insects, such as spiders and larvae of lepidopterans, coleopterans, and hemipterans, were also observed in the Andanan Watershed Forest Reserve.

The Andanan Watershed Forest Reserve also contains patches of cultivated lands. Certain areas within the reserve have been dedicated to agricultural crops. Furthermore, a few residential areas have been observed near the riparian zone, featuring ornamental flowering shrubs that attract some pollinators to these plants.

One collection site each was established in three different barangays – Calaitan (8.7927°N, 125.7789°E; 209.1 masl), Berseba (8.8552°N, 125.8007° E; 219.7 masl), and Santo Niño (8.8451°N, 125.7871°E; 261.7 masl) (Fig. 1) of Bayugan City, Agusan del Sur. Various tributaries along the Andanan River interconnect the riparian zones along the three sites. Ocular habitat observations were documented using a digital camera for photos and videos, while the coordinates were recorded using a Global Positioning System (GPS) receiver.

The specimens were collected by sweeping and handpicking for an eight-hour sampling effort. During nighttime, light trapping was also utilized. Moderately large samples were placed in specimen boxes with phenol and then pinned and labeled properly, while smaller individuals were placed in ethyl alcohol. All taxa were identified and validated by hymenopterists specializing in certain taxonomic groups. The field collection took place from July to September 2019.

This study was granted with the gratuitous permit number R13-2021-33 issued by DENR Region XIII Butuan City.

3 Results and Discussion

Table 1 lists all hymenopteran groups collected in Andanan Watershed Forest Reserve. A total of 36 species were identified, representing 30 genera, 20 subfamilies, 11 families, and four superfamilies.

The superfamily Apoidea (Fig. 2, species composition: 39%) comprises a large group of hymenopterans, generally including bees and apoid wasps. This group is behaviorally diverse, encompassing both eusocial species (Apidae and Halictidae) and solitary bees (Megachilidae), along with specific groups of apoid wasps (Sphecidae and Crabronidae). Eusocial bees, mostly pollenivores, are valuable pollinators in natural habitats for flowering plants and agricultural crops. On the other hand, sphecoid and digger wasps are obligate predators and kleptoparasites of other wasps (Schmid-Egger 2011).

Another cosmopolitan superfamily, Vespoidea (Fig. 2, species composition: 19%), is also present in Andanan Watershed Forest Reserve. This group includes a wide range of both eusocial

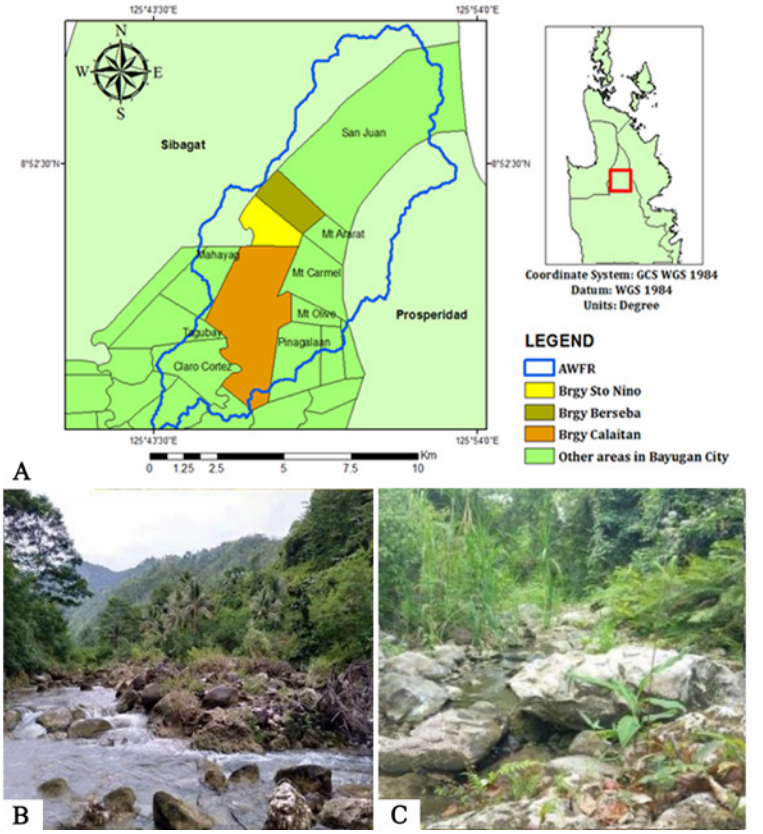

Figure 1. (A) Location map delineating the Andanan Watershed Forest Reserve boundary (in blue: AWFR) and the three collections sites of the study (Calaitan, Berseba, and Sto. Niño); (B–C) tributaries of Andanan River showing the riparian system and vegetation of the area close to forest margin

wasps (vespine wasps and paper wasps) and solitary wasps (potter wasps, scoliid wasps, and spider wasps). Most members of vespine wasps are essential pollinators for various fruits and crops, while some are employed as biological agents to control larvae pests such as caterpillars (Mahmood et al. 2012). Other members of this large group, such as scoliid wasps, act as parasitoids to beetle larvae (Augul, 2016), while pompilid wasps are predators of spiders (Waichert et al. 2012).

Obligate parasitoid wasps belonging to the superfamily Ichneumonoidea (Fig. 2, species composition: 2%) have been observed in the area. This group is obligate endoparasitic, inserting their eggs directly into the host larva through their sharp ovipositors. This evolutionary behavior has proven successful, turning them into effective bio-control agents against insect pests. Lastly, the largest group, Formicoidea (Fig. 2, species composition: 40%), includes an abundant community of ants recorded in Andanan Watershed Forest Reserve. This group comprises diverse genera of ants and is primarily observed near their nest sites, contributing to their prevalence in the collection. Since ants are the most successful social insects, they have become the most species-rich and ecologically dominant among all social insects (Johnson et al. 2013). They can perform vital functions in many terrestrial environments (Chen et al. 2013).

A total of 195 hymenopteran individuals were recorded in Andanan Watershed Forest Reserve. Seventy-eight belong to Formicoidea, and 77 are Apoidea, making these two superfamilies the most abundant groups in the area, constituting 40% and 39%, respectively. On the other hand, Vespoidea accounted for 37 individuals, comprising 19% of the total numbers, while Ichneumonoidea was the

Table 1. Checklist of Hymenoptera in Andanan Watershed Forest Reserve. New records indicated: *genus in the Philippines; **species in the Philippines; ***genus in Mindanao

Superfamily	Family	Subfamily	Species
Apoidea	Apidae		*Amegilla* sp.
		Apinae	*Apis breviligula*
			Apis nigrocincta
			Thyreus wallacei
		Xylocopinae	*Xylocopa ghilianii*
			Xylocopa flavonigrescens
	Crabronidae	Crabroninae	*Larra* sp.
	Halictidae	Nomiinae	*Nomia (Curvinomia) iridescens*
			Nomia (Maculonomia) sp.
	Megachilidae	Megachilinae	*Megachile* sp.
	Sphecidae	Sphecinae	*Isodontia* sp. ***
			Sphex sp.
		Sceliphrinae	*Sceliphron caementarium*
			Sceliphron laetum
Formicoidea	Formicidae	Ectatomminae	Genus undetermined
		Formicinae	*Camponotus* sp.
			Colobopsis sp.
			Polyrhachis bihamata
			Polyrhachis ignota
			Polyrhachis sp.
			Carebara diversa
		Myrmicinae	*Myrmicaria* sp.
			Solenopsis geminata
		Ponerinae	*Odontomachus* sp.
Ichneumonoidea	Ichneumonidae	Ophioninae	*Enicospilus* sp.
Vespoidea	Mutillidae	Mutillinae	*Trogaspidia* sp.
	Pompilidae	Ceropalinae	*Irenangelus* sp.
		Pepsinae	*Hemipepsis* sp.
	Scoliidae	Scoliinae	*Liacos semperi* **
			Phalerimeris aurulenta *
	Vespidae	Eumeninae	*Delta pyriforme*
			Phimenes curvatus
			Rhynchium atrissimum
		Polistinae	*Ropalidia flavobrunnea*
		Stenogastrinae	*Eustenogaster spinicauda*
		Vespinae	*Vespa tropica*

fewest, with only three individuals collected. The family Formicidae is the most observed group due to the area's diverse vegetation and leaf litter covering the ground, providing an ideal habitat for ant colonies. Apoid bees of the family Apidae, including honeybees and related groups, show a significant number in the area. Since pollination is a key component in the integrity of terrestrial ecosystems, hymenopteran pollinators, including bees (Kremen et al. 2007), play crucial roles in plant reproduction (Potts et al. 2009).

Similarly, the numbers of vespid wasps (Vespidae) were relatively high. Eusocial wasps, particularly certain groups of Polistinae and

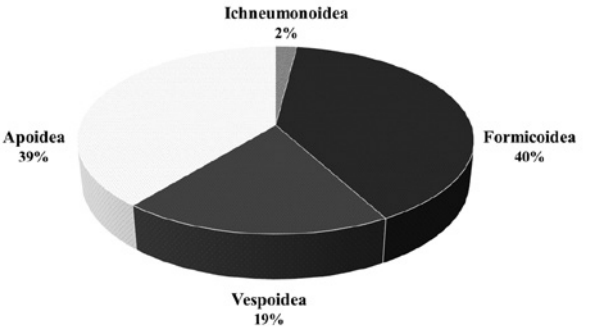

Figure 2. Superfamily composition and relative abundance of hymenopterans recorded in Andanan Watershed Forest Reserve, comprising 11 families

Vespinae, thrive as colonies, while others like Eumeninae and Stenogastrinae are solitary in nature. Although most vespid species are predatory, their occurrence is usually associated with specific arthropods in the area, serving as their prey. Some studies have reported that vespid wasps prefer tropical forests with extreme canopy shades (Bawa 1990; Steffan-Dewenter et al. 2006), a characteristic of certain sections in the forest reserve.

The superfamily Apoidea comprises one of the largest groups of hymenopterans. Apidae, one of the most common groups, includes honeybees, carpenter bees, and bumblebees plays a vital role as a key pollinator for fruit trees and flowering plants. Some groups within Apidae are utilized worldwide for honey production (Van Klink 2016). In Andanan Watershed Forest Reserve, two subfamilies are reported: Apinae and Xylocopinae. One notable group is the genus *Thyreus* (Fig. 3G), known as a kleptoparasite to *Amegilla* (Fig. 3F) (Lieftinck 1968). Two species of honeybees from the genus *Apis* were also reported (Figs. 3A and 3B). Solitary bees, such as carpenter bees from the genus *Xylocopa* (Figs. 3H and 3I), are also recorded in the area. These large bees typically build their nests in burrows and dead wood and are considered essential pollinators for several cultivated and wild plant species (Prashanta & Belavadi 2017). Family Halictidae, including *Nomia* (Figs. 3D and 3E), a typical sweat bee common in the Philippines (Cockerell 1919), and the leaf-cutter bees *Megachile* (Fig. 3C) of family Megachilidae are also documented. According to Baltazar (1996), most species of *Megachile* are parasites of larvae and pupae of other insects. However, it is not certain whether the individual collected from the area is parasitic or non-parasitic. Sphecoid groups of Apidae are also collected in the Andanan Watershed Forest Reserve, including sphecid wasps (Sphecidae) and sand wasps (Crabronidae). One notable crabronid wasp, *Larra* (Fig. 3J), is a predator of a wide range of insects and spiders (Bohart & Menke 1976). On the other hand, *Isodontia, Sphex,* and *Sceliphron* exhibit diverse nesting habits in the ground and use various insects as food for their offspring. *Isodontia* (Fig. 3K) is a new record in Mindanao, while digger wasp *Sphex* (Fig. 3N) and mud daubers *Sceliphron* (Figs. 3L and 3M) are commonly found and considered invasive species, particularly in Europe (Ćetković. al. 2011). Certain species of these wasps even prefer nesting near anthropogenic disturbances (Fateryga & Kovblyuk 2014).

Formicoidea comprises the largest and most diverse hymenopterans in Andanan Watershed Forest Reserve, encompassing various ant groups and widely distributed across tropical ecosystems (Coleman & Wall 2015). In the Philippines, the taxonomy of this group has been developed by several hymenopterists (Baltazar 1996; Calilung 2000; General & Alpert 2012; General & Buenavente 2017; and Mondejar & Nuñeza 2022). Four subfamilies are recorded in the area: Ectatomminae, with one individual with an undetermined genus (Fig. 4D); Formicinae; Myrmicinae; and Ponerinae. Three genera of formicine ants were collected in the area: *Camponotus* (Fig. 4G), *Colobopsis* (Fig. 4A), and *Polyrhachis* (Figs. 4H, 4I and 4J). *Polyrhachis*, distinguished by spines on its pronotal and mesonotal areas, generally includes one of the largest species of Philippine ants. Myrmicine ants of the genera *Carebara* (Fig. 4F), *Myrmicaria* (Fig. 4B), and *Solenopsis* (Fig. 4C) were also

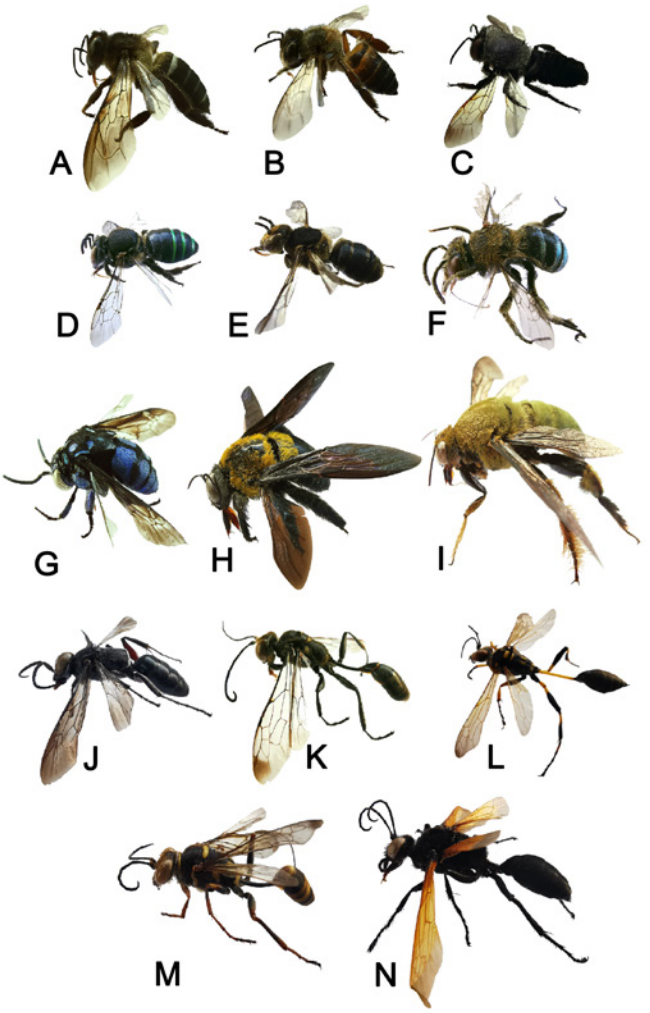

Figure 3. Superfamily Apoidea including apoid bees (A) *Apis breviligula*; (B) *Apis nigrocincta*; (C) *Megachile* sp.; (D) *Nomia (Curvinomia) iridescens*; (E) *Nomia (Maculonomia)* sp.; (F) *Amegilla* sp.; (G) *Thyreus wallacei*; (H) *Xylocopa ghilianii*; (I) *Xylocopa flavonigrescens*; and apoid wasps (J) *Larra* sp.; (K) *Isodontia* sp.; (L) *Sceliphron caementarium*; (M) *Sceliphron laetum*; (N) *Sphex* sp.

collected and are the most abundant among all ants in the area. The genus *Odontomachus* (Fig. 4E) is a ponerine ant remarkable for its long head and strong, elongated jaws, used for grasping prey. This group, locally known as "hantik", is mainly found in the ground or climbs on plant foliage to hunt prey (General & Alpert 2012).

One genus of ichneumonoid wasp from the superfamily Ichneumonoidea is reported in the Andanan Watershed Forest Reserve. Members of *Enicospilus* (Fig. 4K) are parasitoid wasps targeting other insect taxa, usually at their larval stages.

In the superfamily Vespoidea, four families are reported in the area. A species of velvet ant, *Trogaspidia*, belonging to the family Mutillidae, was collected and represented by male (Fig. 5A) and female (Fig. 5B) individuals. Pompilidae, commonly known as spider wasps, are also recorded with two genera – *Irenangelus* (Fig. 5G), known as a kleptoparasite of other pompilid wasps (Barthelemy, 2014), and *Hemipepsis* (Fig. 5F), known to feed on tarantula spiders in the tropics. One genus of Scoliidae – *Phalerimeris*, with one

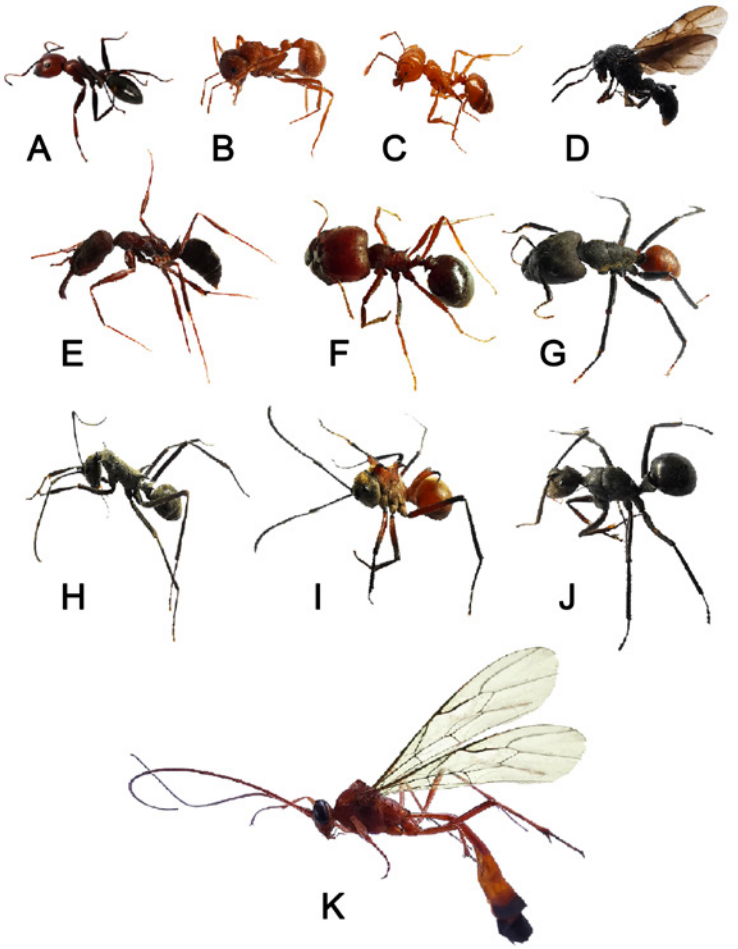

Figure 4. Superfamilies Formicoidea (A) *Colobopsis* sp.; (B) *Myrmicaria* sp.; (C) *Solenopsis geminata*; (D) Ectatomminae Undetermined Genus; (E) *Odontomachus* sp.; (F) *Carebara diversa*; (G) *Camponotus* sp.; (H) *Polyrhachis ignota*; (I) *Polyrhachis bihamata*; (J) *Polyrhachis* sp.; and Ichneumonoidea (K) *Enicospilus* sp.

species *P. aurulenta* (Fig. 5C: male) and (Fig. 5D: female), and a single species of *Liacos – L. semperi* (Fig. 5E), are reported in the Philippines for the first time. Vespidae is the most diverse group with eusocial and solitary representative subfamilies among all the vespoid families. In Andanan Watershed Forest Reserve, Eumeninae, Polistinae, Stenogastrinae, and Vespinae were recorded. Three genera of subfamily Eumeninae, also known as potter wasps, are identified. These include *Delta* (Fig. 5H), whose nests are often found attached to building walls using mud (Yamane 1990), as well as *Phimenes* (Fig. 5J) and *Rhynchium* (Fig. 5I). Polistine wasps, also known as paper wasps, are the only eusocial vespid wasps recognized in the area. One genus is *Ropalidia* (Fig. 5K), the most diverse social wasps in the tropics. Another subfamily is Stenogastrinae, also known as hover wasps, with one species, *Eustenogaster – E. spinicauda* (Fig. 5L), observed in the area. This species was described by Saito & Kojima (2007) using various specimen types from Samar, Leyte, Surigao and Bukidnon. Lastly, the genus *Vespa* of the subfamily Vespinae are true hornets distributed in the Oriental region. The species *V. tropica* (Fig. 5M) was first recorded in Sulu by Bequaert (1936), suggesting its dispersal route from the Indonesian archipelago through Borneo.

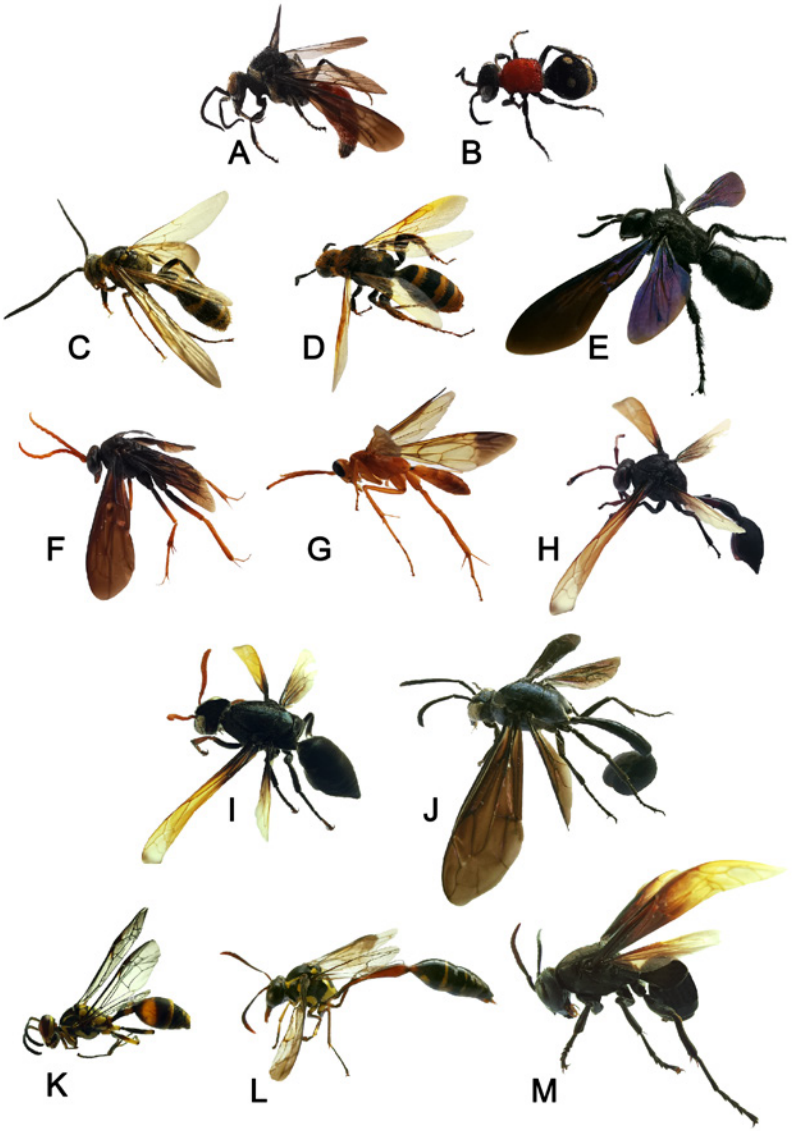

Figure 5. Superfamily Vespoidea (A) *Trogaspidia* sp. [male]; (B) *Trogaspidia* sp. [female]; (C) *Phalerimeris aurulenta* [male]; (D) *Phalerimeris aurulenta* [female]; (E) *Liacos semperi*; (F) *Hemipepsis* sp.; (G) *Irenangelus* sp.; (H) *Delta pyriforme*; (I) *Rhynchium atrissimum*; (J) *Phimenes curvatus*; (K) *Ropalidia flavobrunnea*; (L) *Eustenogaster spinicauda*; (M) *Vespa tropica.*

4 Conclusion and Recommendations

Various techniques have inherent biases that favor different species of hymenopterans. For example, certain active groups at night may be more effectively captured through light trapping, while ground-dwelling hymenopterans are better sampled using pitfall traps, and active flyers are more advantageously captured with Malaise traps. Using all of these collecting methods is encouraged to capture an area's wider spectrum of hymenopteran biodiversity. Research on insect fauna, particularly this large and diverse group of Hymenoptera, encourages future researchers to delve into the taxonomy and ecological studies, potentially discovering new records in protected

areas with high demands for conservation. The hymenopteran checklist in Andanan Watershed Forest Reserve is the first inventory study in the area, serving as a guide for future ecological assessment and biomonitoring in the forest reserve.

Andanan Watershed Forest Reserve listed 36 species of hymenopterans belonging to 11 families. The hymenopteran community in this area is supported by forested and riparian ecosystems, which may also pose threats, such as potential deforestation and agricultural expansion, that lead to habitat fragmentation. Nevertheless, actively working to preserve the forested and riparian sections is highly encouraged. Furthermore, a more comprehensive and standardized collection effort is recommended to generate more panoramic baseline information on hymenopterans in the forest reserve.

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Statement of Conflict of Interest

The authors declare no conflict of interest associated with the submission and publication of this manuscript.

Author Contribution

Geneva Sabuero contributed to the conceptualization, collection of resource materials, and the original drafting of the manuscript. Nick Anthony Burias was involved in the conceptualization and contributed to the writing through review and editing. Ian Niel dela Cruz participated in the conceptualization, collection of resource materials, and writing through review and editing, as well as providing supervision. All authors approved the final version of the manuscript.

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