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Diversity and Abundance of Bees and Wasps (Hymenoptera: Aculeata) in North Central Bhutan

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Abstract

Bees and wasps (Aculeata: Hymenoptera) are group of insects which plays important roles in agriculture and are economically valuable species. The occurrence of these species depends on the climatic and non-climatic factors. This paper documents the bee and wasp diversity and their distribution based on the altitudinal gradient and land use in the Bumthang and Trongsa *dzongkhags*. The data were collected using opportunistic visual encounter and transect walk method over a period of eight months from September, 2015 to May, 2016. The research documented 12 species of bees and 22 species of wasps that belong to four and eight different sub-families respectively. Species diversity and richness were higher in the altitudinal range of 1501-2000 m asl. This study is expected to serve as a baseline data for future research and reflects on the importance of habitat conservation of these important taxa.

Keywords: abundance, bees, diversity, elevation, land use, richness, wasps

Introduction

Bees (super family Apoidea) and Wasps (super family Vespoidaea) make a diverse group of insects and belong to the third largest order Hymenoptera of the class Insecta (Bingham, 1897; Das and Gupta, 1989). Bees and wasps are considered the most developed group of insects and are widely distributed around the world (Moron *et al.,* 2008; Moisset and Buchman, 2011). Their distribution is affected by various factors such as elevation, aspects, temperature, the type of land use, and the ecosystems (Rajkumari *et al.,* 2012).

It is estimated that there are 25,000-30,000 bee species distributed in different regions of the world (Loyola and Martins, 2006; Michener, 2007; Gupta, 2014). In India, more than 10,000 species of bees and wasps fauna are found and in Sikkim alone, one of the states of India, about 505 species of bees and wasps are recorded (Chandra, n.d.). Similarly, in Arunachal Pradesh, another state of India, about 118 species of bees and wasps were recorded (Ramakrishna and Alfred, 2006) while in Nepal, about 165 species of bees and wasps were recorded (Thapa, 2000). In Bhutan, nine species of wasps (Dorji *et al.,* 2016), seven species of carpenter bees (Dorji *et al.,* 2016), and seven species of potter wasps (Nidup *et al.,* 2016; Nidup and Dorji, 2016) are recorded.

The objective of this paper is therefore to document the bees and wasps fauna of Bumthang and Trongsa *Dzongkhags* (districts).

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The two dzongkhags have diverse ecosystems with high altitudinal variation, where the diversity of bees and wasps were assumed to be highest. This study is expected to provide baseline information for the future research and highlight the importance of the habitats to protect these important fauna.

Materials and Method

Study area

Bumthang and Trongsa Dzongkhags, covering different land use types and diverse ecosystems, were selected purposively for this study. The study was done within the altitudinal range of 1000-3000 m asl (Figure 1). Bumthang Dzongkhag is located at 27°42'00.0"N 90°46'58.8"E with an altitudinal range of 2400-7500 m asl. It has warm summer and cold winter with annual average temperature ranging from 5 °C to 18 °C and annual average rainfall of over 598 mm (NSB, 2013). Two *Gewogs* (sub-districts) under Bumthang Dzongkhag were selected for the study.

Trongsa Dzongkhag is located at 27° 26'47.4"N 90°30'14.5"E in central Bhutan with an altitudinal range of 800-4800 m asl (NSB, 2012). It has annual average temperature ranging from 8 °C to 19 °C and annual average rainfall of over 869 mm (NSB, 2013). From Trongsa Dzongkhag, Gewogs selected are Tangsibji, Drakteng, Nubi and Langthel.

Data collection and analysis

The study site is located within the altitudinal range of 1000-3000 m asl which is divided into four categories for this study. This was done to compare the species richness and diversity among altitudinal gradient. Furthermore, land use types were categorised as Agricultural land, Settlement, Orchard, Kitchen garden, Forest, and Grasslands.

The data were collected using opportunistic visual encounter and transect walk methods. The former method employs random search and collection of bees and wasps opportunistically whenever encountered (Oppold, 2005; Dorji, 2014; Russo et al., 2015). Transect walk method employs a systematic walk along a defined path and motor road within and across the research area. In addition, visual surveillance was also followed and the encountered species were captured using sweeping insect net (Elpino-Campos et al., 2007). Various types of baits such as food, meat, overripe fruits, fermented foods, sugary foods, or oil were used wherever applicable following the method explained by Sutherland, (2006). Field coordinates were recorded using hand held GPS.

The diversity and richness of insects collected were compared between various altitudinal categories. The collected specimens were identified using published keys, reference books, pictorial guides, taxonomic literatures on bees and wasps (Bingham, 1897; Das and Gupta, 1989; Michener, 1990; Goulet and Huber, 1993; Carpenter and Nguyen, 2003; Michener, 2007 and Williams et al., 2010). In case of taxonomically difficult species, experts were consulted for further identification. Measurements of the insects were done as per the method described by Spengler et al. (2011). Correlational analyses were performed between altitudinal categories, land use types, species diversity, and richness.

Results and Discussion

Diversity of aculeates

In this study, 12 species of bees belonging to four sub-families and 22 species of wasps belonging to eight families were recorded (Table 1). Among these, 29 were identified up to species level, two to genus level and three to family level. Among total individuals of 204 aculeate fauna observed, 74 were male and 130 were female. Vespidae was the most dominant family with 15 species followed by family Apidae with 11 species (Table 1).

Distribution pattern of aculeates in relation to altitudes

Species diversity and richness of bees were found to be highest at altitudinal range of 2501-

Table 1: Different species of bees and wasps collected from north-central Bhutan

Species	Subfamily	Family
[cf] *Hemistephanus* sp.	-	Stephanidae
Apis cerana (Fabricius, 1793)	Apinae	Apidae
Apis dorsata (Fabricius, 1793)	Apinae	Apidae
Apis florea (Fribicius, 1787)	Apinae	Apidae
Apis laboriosa (Smith, 1871)	Apinae	Apidae
Apis mellifera (Linnaeus, 1758)	Apinae	Apidae
Bombus breviceps (Smith, 1852)	Bombinae	Apidae
Bombus festivus (Smith, 1861)	Bombinae	Apidae
Bombus haemorrhoidalis (Smith, 1852)	Bombinae	Apidae
Bombus parthenius (Richards, 1934)	Bombinae	Apidae
Chrysis [cf] *inaequalis* (Dahlbom, 1845)	Chrysidinae	Chrysididae
Eumenes gibbosus (Nguyen, 2015)	Eumeninae	Vespidae
Parapolybia nodosa (van der Vecht, 1966)	Polistinae	Vespidae
Parapolybia varia (Fabricius, 1787)	Polistinae	Vespidae
Polistes (Gyrostoma) olivaceus (De Geer, 1773)	Polistinae	Vespidae
Polistes (Gyrostoma) rothneyi (Cameron, 1900)	Polistinae	Vespidae
Polistes (Gyrostoma) tenebricosus (Lepeletier, 1836)	Polistinae	Vespidae
Polistes (Polistella) adustus (Bingham, 1897)	Polistinae	Vespidae
Polistes (Polistella) santoshae (Das and Gupta,1989)	Polistinae	Vespidae
Ropalidia fasciata (Fabricius, 1804)	Polistinae	Vespidae
Sceliphron curvatum (Smith, 1870)	Sceliphrinae	Specidae
Sceliphron destillatorium (Illeger, 1807)	Sceliphrinae	Specidae
Trypoxylon sp.	Craboninae	Crabonidae
Unidentified 1	Craboninae	Crabonidae
Unidentified 2	Phompilinae	Phopilidae
Unidentified 3	Halictinae	Halictidae
Vespa basalis (Smith, 1852)	Vespinae	Vespidae
Vespa binghami (Buysson, 1905)	Vespinae	Vespidae
Vespa mandarinia (Smith, 1852)	Vespinae	Vespidae
Vespa velutina (Lepeletier, 1836)	Vespinae	Vespidae
Vespa vivax (Smith, 1870)	Vespinae	Vespidae
Vespula [cf] *rufa* (Linnaeus, 1758)	Vespinae	Vespidae
Xylocopa aestuans (Linnaeus, 1758)	Xylocopinae	Apidae
Xylocopa latipes (Drury, 1773)	Xylocopinae	Apidae

3000 m asl (H = 0.365; 11 species) and lowest at 1000-1500 m asl (H = 0.244; 3 species) (Table 2). The result was similar to the observation reported by Oppold (2005) and this may be due to the presence of temperate fruiting plants such as apple and peach (Hoehn *et al.,* 2008). Evenness of bee fauna was highest (E = 0.511) at altitudinal range of 1000-1500 m asl and lowest (E = 0.351) at 2501-3000 m asl. The diversity of wasps differed with that of bees except in the elevation range of 1000-1500 m asl. This study supports the results of Hanson and Gauld (2000) who considered that Hymenopterans decrease in species diversity and richness as elevation increases. Our findings were consistent with the argument of Russo *et al.* (2015) and Michener (2000) who stated that altitude could play important role in abundance and diversity of bees and wasps. Species richness and the number of individuals for both the taxa varied with different altitudinal ranges having relatively high species overlap for bees.

There was negative correlation between altitudinal range and species richness (r = -.286, p > .05) and species diversity (r = -.315, p > .05). However, there was positive correlation between species evenness and altitudinal range (r = .294, p > .05). These finding supports Oppold (2005) who stated that the shorter altitudinal range is not large enough to detect changes in species diversity. So, studies are needed on distribution of bees and wasps along a larger elevational array.

Table 2: Species diversity, richness and evenness of bees and wasps

Altitude (m)	*No. of species*	*No. of individuals*	*H*	*E*
1000-1500	3	16	0.244	0.511
1501-2000	8	36	0.36	0.399
2001-2500	5	28	0.312	0.446
2501-3000	11	33	0.365	0.351
1000-1500	5*	22	0.326	0.467
1501-2000	10*	37	0.364	0.364
2001-2500	4*	12	0.298	0.496
2501-3000	5*	20	0.326	0.467

*H = Species diversity; E = Species evenness, * = wasps*

Distribution and abundance of aculeates in relation to land use type

Species diversity and richness of bees were higher in agriculture land (H = 0.361 with 10 species) followed by grass land (H = 0.328 and 7 species) (Table 3). However, the species evenness was higher in forested area (E = 0.456) and lower in agriculture land (E = 0.3618). These findings were in conformity with that of Raju and Rao (2006) who reported that there is mutual relationship between bees and flowering plants – bees for food and plants for pollination. The study was conducted coinciding with the flowering season of buckwheat, apple, and peach. The same bee species are seen foraging in different land use types because of the dietary and resources overlap (Steffan-Dewenter and Tscharntke, 2000; Carvalho *et al.,* 2014). Bees were found in the forest edges, meadows, and grass land foraging wild flowers. The result supports Williams *et al.* (2001) who reported that wild bees play key roles in maintaining the diversity of wild plant communities.

Species diversity and richness of wasps were higher in forested land (H = 0.359, 7 species) followed by settlements (H = 0.346 with 6 species) (Table 3). However, the species evenness was higher in agriculture land and kitchen garden (E = 0.687 each) and lower in forested area (E = 0.425). Most of the social wasps

Table 3: Diversity, richness and evenness of aculeate species from different land use types

Land use type	*No. of species*	*No. of individuals*	*H*	*E*
Agriculture	10	31	0.361	0.361
Forest	3	16	0.21	0.456
Grassland	7	18	0.328	0.389
Settlement	4	12	0.255	0.424
Orchard	5	31	0.285	0.409
Kitchen garden	4	20	0.255	0.424
Agriculture	2*	10	0.207	0.687
Forest	7*	20	0.359	0.425
Grassland	3*	8	0.259	0.544
Settlement	6*	18	0.346	0.445
Orchard	4*	7	0.298	0.49
Kitchen garden	2*	13	0.207	0.687

*H= Species diversity; E= Species evenness, * = wasps*

(wasps that live in colonies) were found foraging and building their nests in tree canopies in forested areas and settlements. This result supports Yamane and Yamane (1979) who observed that wasps usually live in the covered and unexposed areas, mostly adjacent to forests. Somavilla *et al.* (2014) noted that the social wasps are highly territorial insects, showing species concentration and clustering in the same location. In this study, we observed that the paper wasps and vespid wasps were usually found preparing their nest (Figure 1A) in the settlements areas.

Queen wasps were found taking care of their nests and laying eggs (Figure 1B). Rajkumari (2012) and Spengler *et al.* (2011) asserted that queen does all the work including taking care of nest at the beginning and later hand over these tasks to the workers and drones. The *Vespa* species (hornets) were seen flying in the forest, supporting the observation noted by Archer (1989.

Figure 1: Queen *Polistes tenebricosus* constructing nest (A), Queen *Polistes olivaceus* laying eggs (B)

Conclusions

This paper documented important species of bees and wasps from the selected ecosystems of Bumthang and Trongsa. There were 34 species of aculeate belonging to eight families out of which more than 80% of the families were social insects. The Vespidae is the dominant family noted in the study areas. Species diversity and richness were higher at the altitudinal range of 1000-2000 m asl. This paper however lacks data covering different seasons and ecosystems other than the elevation range described in this manuscript. Therefore, the study has to expand across different seasons and diverse altitudes.

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