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Biogeography and Diversity of the *Apis* Species of Phek District, Nagaland

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Abstract

Three honey bee species (*Apis cerana*, *Apis dorsata and Apis florea*) were studied in their feral nests and foraging sites in different localities of the study area. Their nests were located in areas with altitudes ranging from 600 to 2426 meters above sea level in mountainous terrain with tropical and sub-tropical evergreen forest type. Moreover, the study area has a very long monsoon season and high amount of rainfall throughout the summer season. The fact that these bees can thrive in these conditions showed an adaptation to a wide range of physical and climatic conditions like altitude, temperature and rainfall.

Keywords: *Apis,* Nests, Diversity, Phek, Nagaland.

Introduction

The state of Nagaland with a geographical area of 16,579 sq. Km has a total forested area of 13,345 sq.km i.e. about 80.48% of the total area (DIPRN, 2010) and lies between the coordinates N25^{0}60.576 and N27^{0}40.833 latitude and E095^{0}20.789 and E097^{0}15.466 longitude. The state offers a veritable Utopia for honey bees in terms of a varied climatic regime i.e., tropical to sub-tropical and bountiful perennial flowering plants through its length and breadth. The multi floral wealth offers the opportunity for the honey bees to produce the finest honey in terms of quality and taste (NBHM, 2012). India and its adjacent regions can be considered to constitute the area of origin and early evolution of the genus *Apis* (Deodikar et al. 1959, 194; Michener, 1974, 214; Deodikar, 1978, 474). These regions have the greatest honey bee diversity, except for *A. Mellifera*.

Much controversy exist with regard to the recognition of honey bee species, for example, the giant honey bee proper, *A. dorsata* Fabricius, 1793, which is wide spread across most of South and Southeast Asia, is considered to have several subspecies, namely, *A. d. binghami* Cockerell, 1906 (Indonesian subspecies), *A. d. breviligula* Maa, 1953 (Luzon and Mintoro, Philippines)

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and A. d. laboriosa Smith, 1871 (the Himalayan rock bee). Before 1980, *A. d. laboriosa* was considered as separate species, but presently it is classified as a subspecies of *Apis dorsata* (Engel, 1999, 165) based on biological species concept. However, others have suggested that it should be a separate species based on genetic species concept (Arias and Sheppard, 2005, 25).

At present, eleven species of honey bee belonging to the genus *Apis* are generally recognized worldwide (Engel, 1999, 165; Arias and Sheppard, 2005, 25). Phylogenetic analysis of the honey bees based on nuclear DNA and mitochondrial DNA (mtDNA) markers strongly support clustering the honey bee species into three distinctive groups: cavity-nesting honey bees (*A. mellifera, A. cerana, A. koschevnikovi, A. nuluensis, A. nigrocincta*), giant honey bees (*A. dorsata, A. laboriosa, A. breviligula, A. binghami,*), and dwarf honey bees (*A. florea, A. andreniformis*) (Willis et al. 1992, 169; Tanaka et al. 2001, 44; Arias and Sheppard, 2005, 25; Raffiudin and Crozier, 2007, 543).

Apis species are classified into two groups based on their nesting habit. The first group that builds a single comb in open-air nests includes *A. dorsata, A. laboriosa, A. breviligula, A. binghami, A. florea and A. andreniformis*. The second groups are those that build their nests inside cavities with multiple combs: *A. cerana, A. mellifera, A. koschevnikovi, A. nigrocincta and A. nuluensis* (Michener, 2000, 166; Hepburn and Radloff, 2011, 669). In recent years, various authors have investigated on the honey bees of the sub-Himalayan and Indian region, however the concrete status of the group of honey bees of this region is still not very well established. However, there are various papers which have significantly contributed on the Indian subcontinent honey bee ecotypes based on multivariate analysis (Mattu and Verma, 1983a, 262; 1983b, 79; 1984a, 3; 1984b, 117; Verma et al. 1989, 458; 1994, 203; Singh et al. 1990, 3; Sihanungtavong et al. 1999, 211). Singh *et al*. (1990, 3) have identified three different biometric groups using multivariate techniques in the eastern Himalayan region and categorized them as - Manipuri honey bees from the state of Manipur, Mizoram and Nagaland. Bramaputra honey bees from the state of Assam and Meghalaya and Himalayan honey bees from the state of Assam, Arunachal Pradesh, Sikkim and West Bengal.

The wide range of geographical and physiological adaptations exhibited by the honey bees to its environment provides one of the richest sources for study and knowledge among all organisms. The geographic variation in honey bee furnishes interesting examples of climatic adaptations within one and the same species, pattern of distribution, isolation and various levels of speciation (Ruttner, 1987, 59).

The present study investigates the diversity of honey bees with regard to the geographical and topographical characteristics such as, altitude, temperature and rainfall experienced by the honey bees in Phek District, Nagaland. Considering its wide range of adaptability to different climatic conditions and the easily available perennial flowering plants, there is a high potential for apicultural activities in this region.

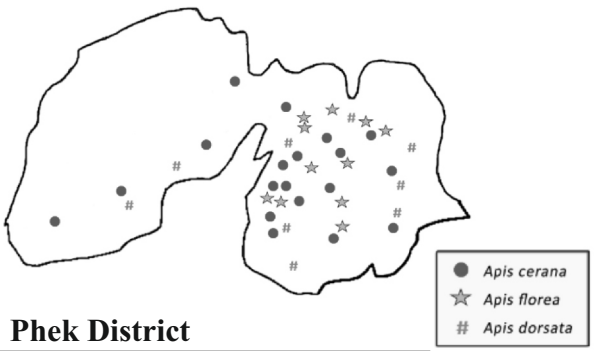
Materials and methods

The study area is comprised of ten areas viz. Kuojile, Liikiipruju, Meluri Town Area,

Mercy Bridge Area, Shatiiza, Sholoju, Tizii River Belt, Weziho, Wujile and Zanibu and covers a total area of 2026 km^2 and lies between the coordinates E094^{0}30.011 Longitude and N25^{0}38.977 Latitude to E94^{0}71.776 Longitude and N25^{0}65.591 Latitude. The climatic condition of Phek District is warm and temperate and is classified as Cwa by K$_{\ddot{o}}$ppen-Geiger system. The average annual rainfall is 1835 mm and the average temperature is 18.3^{0}C. Observations of all the nest sites were personally carried out by the authors from the period June 2017 to May 2018.

Honey bee samples were collected from their feral nests and foraging areas. For collection of *A. dorsata* workers from the feral nest, a tall bamboo rod glued at its tip with a sticky gum was used and for collection at the foraging sites, an insect net was used. *A. cerena* and *A. florea* worker bees were collected directly from their feral nests without much difficulty. The physical and topographical attributes of the areas from where the samples were collected were recorded along with recording of nesting habitats.

The collected specimens were preserved in 80% ethyl alcohol (Smith et al. 2000, 265) while some were deep frozen (Ruttner 1988, 157; Ruttner et al. 1978, 363; Hepburn et al. 1988, 778). The specimens were identified based on the keys and descriptions mentioned by Kshirsagar (1976, 88; 1983, 254), Mattu and Verma (1984, 63), Rutnner (1988, 157), Smith and Hagen (1996, 294), Smith et al. (1999, 60), Michener (2000, 166), Engel (2001, 113) and Lo et al. (2010, 226).



Phek District

Results

All three honey bee species (*A. cerana, A. dorsata* and *A. florea*) were seen to easily adapt to different types of climatic conditions and varying altitudes for building their nests.

The study area is mountainous terrain with tropical and sub-tropical evergreen forests with altitudes ranging from 600 to 2426 meters above sea level. There is a very long monsoon season and high amount of rainfall (average rainfall 1800 mm - 2500 mm) throughout the summer season.

Apis cerana Fabricius, 1793 (The Eastern honey bee)

A. cerana was seen to inhabit warmer areas, and build its nest about 15 to 20 feet on tree trunks with a small longitudinal shaped entrance (Fig.1.A). An exception was seen for one that was found on an oak tree (Fig.1.B). All the entrances faced south. Some nests were seen being built underground, beneath rocks. There were 8 to 9 series of parallel combs in a bee hive. It did not show preference for any specific flower or vegetation - the choices ranged from wild perennial plants to the Agri-based crops (Fig.1.C). Interestingly the intrepid bees thronged and overcrowd the banana flower (also known as banana blossoms).

Fig.1.A: Longitudinal entrance of *A. cerana* hive

Fig.1.B: Circular entrance of *A. cerana* hive

Fig.1.C: *A. cerana* (dorsal view)

Table 1: *A. cerana* feral nests found at different locations with reference to altitude and temperature.

Sl. No.	Location	Altitude in meters	Average Temperature in ^{0}C (June 2017-May 2018)	Coordinates	Number of feral nest(s)
1	Kuojile	1036	19.7	E094^{0}39.179 Longitude and N25^{0}40.445 Latitude	7
2	Wujile	1108	19.3	E094^{0}37.049 Longitude and N25^{0}41.997 Latitude	6
3	Sholoju	1175	18.9	E094^{0}36.367 Longitude and N25^{0}42.624 Latitude	4
4	Zanibu	2426	13.3	E094^{0}30.011 Longitude and N25^{0}57.032 Latitude	2

From the above data, it can be noted that *A. cerana* significantly showed its preference to warmer conditions in building its natural home. The altitudinal average for all the sites was 1436.25 m, lying in the coordinates between E094^{0}30.011 Longitude and N25^{0}40.445 Latitude to E094^{0}39.179 Longitude and N25^{0}57.032 Latitude.

***Apis dorsata* Fabricius, 1793 (The Giant honey bee)**

The nest of *A. dorsata* found in different locations of the study area were built at an average height of 100 feet, but a bivouac colony of *A. dorsata* swarm was sighted at a very low height (8 feet) on the tree trunk near Weziho (Fig.2A and Fig 2 B).

Fig.2.*A*: *dorsata* bivouac hive at Meluri Town.

Fig.2.*B*: *dorsata* (dorsata view)

Table 2: *A. dorsata* feral nests found at different locations with reference to altitude and temperature.

Sl. No.	**Location**	**Altitude in meters**	**Average Temperature in ^{0}C (June 2017-May 2018)**	**Coordinates**	**Total number of feral nest(s)**
1	Tizii River Belt	688	21.4	E094^{0}34.246 Longitude and N25^{0}40.687 Latitude	4
2	Liikiipruju	890	20	E094^{0}35.423 Longitude and N25^{0}42.752 Latitude	3
3	Weziho	1412	16.4	E94^{0}69.107 Longitude and N25^{0}56.244 Latitude	1
4	Shatiiza	1689	15.4	E94^{0}71.776 Longitude and N25^{0}65.591 Latitude	1

It was observed that most of the *A. dorsata* nests were found at low altitude with warmer conditions. However, it was not totally wanting even in higher altitudes. The altitudinal average of the entire site was 1201 m lying between the coordinates of E094^{0}34.246 Longitude and N25^{0}40.687 to E94^{0}71.776 Longitude and N25^{0}65.591 Latitude.

***Apis florea*, Fabricius, 1787 (The Dwarf honey bee)**

A. florea usually builds its nest at a low height with an average of 3 feet from ground and the single comb was built on the twigs of shrubs camouflaged among the bushes. Most nests of the *A. florea* were hung from slender branches of trees and shrubs covered with relatively dense foliage. *A florea* feral nests were sighted on four different altitudinal ranges of the study area i.e., 600 m (at Mercy Bridge), 1036 m (at Kuojile), 1108 m (at Wujile) and 1246 m (at Meluri town) respectively, lying between the coordinates of E094^{0}34.364 Longitude and N25^{0}38.977 Latitude to E094^{0}37.866 Longitude and N25^{0}41.911 Latitude (Fig. 3 A and B, Fig. 4 A and B).

Fig.3.*A*: *florea* hive at Kuojile.

Fig.3.*B*: *florea* (dorsal view)

Fig.4: *A* and *B*. Two A. *florea* hives located within a distance of 5 feet at Mercy Bridge Area, Meluri.

Table 3: *A. florea* feral nests found at different locations with reference to altitude and temperature.

Sl. No.	Location	Altitude in meters	Average Temperature in ^{0}C (June 2017-May 2018)	Coordinates	Number of feral nest(s)
1	Mercy Bridge Area	600	22.5	E094^{0}34.364 Longitude and N25^{0}38.977 Latitude	6
2	Kuojile	1036	19.7	E094^{0}39.179 Longitude and N25^{0}40.445 Latitude	2
3	Wujile	1108	19.3	E094^{0}37.049 Longitude and N25^{0}41.997 Latitude	2
4	Meluri Town Area	1246	18.2	E094^{0}37.866 Longitude and N25^{0}41.911 Latitude	1

The altitudinal factor played an important role for hosting *A. florea* nests as can be seen from the above table. They evidently preferred lower altitudes with slightly warmer temperature. However, they still built their nest even in high altitudes (Meluri Town Area, 1246 m). The altitudinal average of all the locations was 997.5 m.

Discussion and Conclusion

A. cerana or the "Eastern honey bee" (Butler, 1954, 135) or the "Asiatic honey bee" is the most common species found in Southern and South East Asia. The taxonomic name *A. cerana* was first given by Fabricius in 1793 for a honey bee in China and later in 1798, the same author named the honey bees of India as *A. indica.* However, since both the species belong to the same geographic types, the term *A. cerana* is given priority (Lindauer and Kerr, 1960, 29). It is the most wide spread in occurrence than the other honey bee species inhabiting not only tropical and sub-tropical

region of Asia, but also in colder areas of Siberia, Northern China and in the high mountain area of Himalayan region (Koeniger, 1976, 110). It is also widespread in temperate and tropical Asia (Smith et al. 2000, 265). They tend to swarm, abscond and migrate quite frequently (Maa, 1953, 525; Morse and Boch, 1971, 1414; Akratanakul, 1976, 120; Wu and Kuang, 1987, 153; Otis, 1990, 725; Wongsiri et al. 1991, 50; Smith et al. 2000, 265; Richards, 2001, 165). However, among the native bees of Asia, *A. cerana* is exceptionally the most successful beekeeping resources for the bee keepers. In Phek District, *A. cerana* is distributed throughout its length and breadth. However, it showed preference for warmer conditions for building its nest (with an exception for Zanibu having an average temperature of 13.3^{0}C with an altitude of 2426 m).

A. dorsata or the "giant honey bee" is native to South and Southeast Asia. It has the largest individual body size (Michener, 2000, 166) and most spectacular among all the honey bee species: an individual bee of the length of a hornet, living in the open on tall tree branches in singles or in aggregates, up to about 40 to 50 nests on a single tree. The diversity of the giant honey bees has not been studied in detail because of their aggressive and curmudgeon nature and their frequent migratory habit. Most of the *A. dorsata* nests observed were not consistent since they swarm very frequently to different locations within a short a span of time. There was one particular colony which came and stayed in their new home only for three days and after that they swarmed.

A. florea was significantly present in a very dry and hot area where the average temperature throughout the year was 22.5^{0}C as mentioned in table 3. The adaptation by the *A. florea* to far drier climate was also indicated by its successful survival where introduced in Saudi Arabia, Jordan and Sudan (Hepburn et al. 2005, 359; Haddad et al. 2008, 173).

Examining the distribution of the feral nest of the above selected areas, we have a parsimonious explanation that there was a common trend for all the three honey bees (*A. cerana, A. dorsata and A. florea*) where the number of nest increases proportionately with the increase in temperature and decrease in altitude. Natural coexistence within the same geographical area was also observed among the three honey bees.

Although a relatively large amount of work is done on global basis about the honey bee diversity and biogeography, yet only a meager source of information is available on the honey bee diversity of Nagaland. It is observed that the honey bees found in Nagaland can easily adapt to different types of climatic conditions and varied altitudes for building its nest, ranging from 100 m (Dimapur) to 3000 m (Tuensang/Kiphiri). We found out that, *A. florea* preferred warmer environment with higher temperature for building its nest, while *A. cerana* and *A. dorsata* preferred humid and thick forested area.

One of the biggest limitations of the study was the difficulty in lining the honey bees due to the region's mountainous terrain and steep landscape. The present study extends only to a restricted geographical area within Nagaland and the work is done in a limited time period. Thus, further work on the biodiversity and

biogeography of the honey bee species covering entire geographical area of Nagaland needs to be continued. As Nagaland has rich perennial vegetations, the practice of beekeeping among the rural community should be encouraged both in small and large scale basis.

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