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GENETIC AND REPRODUCTIVE DIVERSITIES OF HONEYBEES IN THEIR HABITATS

AIZA PERVEZ and SURMAN ARYA
Department of Zoology, Pt. Lalit Mohan Sharma Campus, Sri Dev Suman Uttarakhand University, Rishikesh – 249201, Uttarakhand, India.

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ABSTRACT

Honeybees are socioeconomic insects embracing numerous colonies originating from a single hive. Years of domestication and studies comprising their behavioral instincts, communal well-being and genetic variation have strengthened the relationship of honeybees with mankind as honeybees are the prime suppliers of crucial byproducts. On observing various areas of Himalayan Uttarakhand, highlighting a qualitative and quantitative study on varieties of honeybees based on their morphological features, adaptation and behavioral differences. Honeybee are haplo-diploid organisms. Males also referred as drones comprise of only one set of chromosomes, viz. 16, whereas females consist of two sets of chromosomes found to be 32 (16 pairs). Queen bee which is the only egg laying member of the colony after mating lays subsequently two kinds of eggs, the unfertilized eggs give rise to drones while the fertilized ones matures into worker bees. On morphologically studying and classifying these patterns between the various species of *Apis mellifera* Linnaeus and *Apis cerana* Fabricius, we observed their essentiality based on the products of their natural resources and acknowledged suitable culturing species underlying its growth, reproduction, and development.

INTRODUCTION

Apis cerana Fabricius, also referred to as the Asian honeybee, is mostly endemic to Asia. It is providing honey for thousands of years and is distributed in both tropical and temperate Asia, i.e. it extends from Afghanistan to Japan (longitudinally), while from Himalayas to Indonesia (latitudinally) (Koetz 2013). It is ecologically plastic and can tolerate extreme climatic (Xu et al. 2009) with long flight duration (Oldroyd and Wongsiri 2007), better hygiene and grooming behaviour (Peng 2011), and cooperative defenses. Its individuals aggregate in the colony during hostile conditions or dangers due to predators or intruders. During this moment, guard honeybees produce alarm pheromones as a defense mechanism (Morse 1967). Furthermore, its high-quality by-products provides large economic benefits to apicultural industry, which may be even more so than its counterpart European honeybee, *Apis mellifera* Linnaeus.

Apis mellifera exist as a European species and is also referred as European honeybee. Morphologically *A. cerana* are generally observed much smaller than *A. mellifera* (Ken 2003). Considerable morphological differences were found between *A. cerana* and *A. mellifera*, with non-tropical honeybees being larger than tropical bees. High altitude bees were larger than the honeybees at low areas. The genetics of *A. cerana japonica* is largely homogeneous in distribution. This enables easy comparison between local genetic diversity with those distributed at other locations. A single allele at a mitochondrial locus in *A. cerana japonica* dominates throughout Japan (Smith 1996; Hisatomo Taki et al. 2016). The complete gene sequence of *A. mellifera* in mitochondrial DNA is 16,343 bp long [Crozier and Crozier 1993). Eleven of t-RNA genes were found in altered positions, while the other genes/ regions were found in the same positions. Predicted protein sequences comparisons indicate tremendous similarity between the honeybee mitochondrial genetic code and that of *Drosophila*. However, the anticodons of two tRNAs significantly vary between the two above insects. The extreme bias base composition of 84.9% AT existed.

Apis mellifera is not so frequently found species occurring at a very wide range of longitudes and latitudes. Evolution has led to the formation of many subspecies in *A. mellifera* due to its distribution at various geographical habitats. Versatility in the climatic and vegetation conditions further favored differentiation, due to which about ten *A. mellifera* subspecies are currently reported based on morphometry and genetics (De la Rúa et al. 2009). Honeybees are super organisms, they live in a colony consisting of three castes, prominently worker bees, drones and queen bee. Queen is the only egg laying member of the colony also known as the mother of the colony. Rarely, more than one queen may be foundt in the hives (Butler, 1957). During favorable seasons a virgin queen naturally mate with drones of same colony or even other apiaries in an open space. The newly mated queen then take period prior to the onset of egg laying that can last up to 5 days or 4 weeks. (Moritz and Kuhnert 1984; Cobey 2007). On completion of this period the queen lay about 1500 to 2000 eggs in peak seasons mostly in spring and autumn. (Al-Ghzawi and Zaitoun 2008) It lays both fertilized and unfertilized eggs consisting of initial one and later two sets of chromosomes respectively that results into following castes of the hives i.e. drones and worker bees. A queen can live normally up to 2.5 to 3 years, in this span of life queen also lay eggs which are rich in health, the worker in later lives prepare a new queen by feeding an optimum amount of royal jelly to the new emerging queen. The emerged queen then engages in conflicts until one queen becomes the mother of the colony. Usually virgin queens attack the prior head by stinging them and sprays her rectal content towards the rival as a defense strategy. (Fletcher 1978). The defeated abscond or swarm to an entirely different hive.

Honeybees reproduce naturally through swarming in spring. The prime swarm with the old queen as a part of the workers and drones forms the continuation of the original colony, with the “old” parasites and the already existing “relationship” between them. After the flight by the old colonies. The remaining colony is now led by a new young queen and can be qualified as “new” or “daughter” colony. After the swarm leaves, the original parasites are still present but the genetic identity of the colony slowly changes as the workforce is replaced. Thus, there is a vertical transmission of the parasite (from mother (-colony) to descendant (colony)). The daughter inherited her mother’s properties (genes), allowing her and her offspring to deal with the parasite that her mother was able to handle (Tjeered and Delphine 2018).

When the breeding selection is concerned, Commercial breeders select against swarming, defensive behavior, and propolis usage, thereby probably compromising colony defense and social immunity (Meunier 2015). The natural reproductive cycle of a colony, incl. hormonal and nutritional aspects, determines timing and development of drones and new queens and often lays outside of the time window for commercial queen rearing. Moreover, during emergency queen rearing, the choice of the bees is not at random; instead, subfamilies, which are rare in the work force, are significantly more likely to end up as queens (Moritz et al., 2010).

MATERIALS AND METHODS

On travelling to various parts in Uttarakhand like Dehradun 30°20′42″N 78°01′44″E, Rishikesh 30°06′30″N 78°17′50″E, Haridwar 29°56′42″N 78°09′47″E, Doiwala 30°10′33″N 78°07′27″E. We conducted studies on different species of honey bees found by the locals that are used in the rearing industries, collecting their bi products in culturing them. In order to compare the performance of each species of bee five colonies of each species were selected and cultured between the span of six months. We collected five colonies each of *Apis cerena indica* and *Apis mellifera*, and cultivated them in 5 frames observing their population surge on onset of each month, their nectar collection, range of flight and ease of culturing. Observations were recorded at monthly intervals for the span of six months from November 2024- March 2025 that can give resultant advice to culturing people in order to understand their areas of apiculture and social behavior of bee in depth.

POPULATION DIFFERENCES

On observing the frames for complete six months we noticed a huge increase in population of *Apis cerana indica* as in the beginning we compelled for a total population of approx. 11000 bees but in the end month of march we noticed a gradual shift to 25000 bees that marks the quantitative growth of honeybees during the given span while for *A. mellifera*, we initially began with 7000 bees and in the end month of march the population rose to 14000 species per five frames that were comparatively much lesser to the species of *indica* (Table-1; Figure-1).

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Table-1: Physiological Differences Between honeybees, *Apis mellifera and Apis cerana indica*.

Characters	***A. cerana***	***A. mellifera***
Labrum - Pigmentation	All yellow or brown	All dark or dark with yellow mark
Tibia of hind leg - Drone	Grove (longitudinal)	Round
Cubital index (mean value)	4.40	2.30
Hooks on hind wing (mean value)	18.28	21.30
Endophallus Chitinous plates Upper cornea Fimbriate lobe	Absent Three pairs Rosette-like	Present Rudimentary Feather-like

RESULTS AND DISCUSSION

On studying the nature of bees for consecutive six months, we saw a clear comparison between the species of bees available in the north hilly areas of Uttarakhand (Tables 2-3). We observed the comparative performance and found *Apis mellifer*a stored more nectar and pollen covered the area of 2560.04 cm² in the month of March as compared to *Apis cerana indica* which was stored nectar being 1361.938 cm² and pollen was found to be 1050 cm² in the same month. However, the species of honey bees exhibited good performance in all aspects from November to March. Although, *Apis mellifera* was found significantly Superior over *Apis cerana indica*. Hence, there was a direct relation between availability of pollen as well as nectar stores in the colony which influence the strength of the colony as evident from the number of frames. We there by concluded that in order to get quality over quantity we preferred apis mellifera but in order to get a significant amount of honey, *Apis cerana indica* is reluctant.

Table-2: Comparative Performance of Honeybee, *Apis cerana indica*, in different areas per month.

Months	**Colony strength (number of frames)**	**Population of bees (1000)**	**Pollen collecting Area in cm^2**	**Nectar collecting area in cm^2**
November	5.0	11.46	720.23	1456
December	5.50	13.87	980.40	1675.30
January	8.50	18.60	1200.45	1980.25
February	11.25	22.67	1560.50	2358.90
March	12.0	25.15	1780.0	2560.04

Table-3: Comparative Performance of Honeybee, *Apis mellifera*, in different areas per month.

Months	**Colony strength (number of frames)**	**Population of bees (1000)**	**Pollen collecting Area in cm^2**	**Nectar collecting area in cm^2**
November	5.0	7.28	340.60	700.5
December	5.50	8.40	590.20	950.20
January	7.50	10.46	750.45	108025
February	8.25	12.45	980.50	1145.34
March	9.0	14.37	1050.0	1367.38

Conclusion

Honeybee is one interesting insect with multiple genomic sequences, colonies, & members playing distinct roles, contributing to their hive and population. Bees have a great understanding of their purpose and spread awareness by communicating among themselves with numerous ways. They stand out and show behavioral changes in accordance of their environment and intruder, In the realm of modern apiculture, honey bee breeding has emerged as a crucial strategy for optimizing their economic performance and ecological contributions. The fusion of molecular techniques into honey bee breeding methodologies promises heightened control over genetic makeup, expedited breeding cycles, and enhanced accuracy and swiftness in pinpointing genetic variations tied to favorable traits in identifying genetic variations. By harnessing the power of selective breeding, we can develop specialized bee varieties optimized for specific ecological niches and agricultural applications. Particularly promising is the development of pollinator-specific strains designed for controlled environment agriculture, such as greenhouse systems, where conventional honey bee populations often demonstrate suboptimal performance, thereby bolstering the sustainability and productivity of modern agriculture.

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