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Morphometric differentiation of Apis *Cerana Indica* Across Distinct Ecological Zones in Nagpur, Maharashtra

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Abstract
Present study investigates the influence of distinct ecological zones agricultural and urban on the morphometric characteristics of Apis *cerana indica* population and field biology. A total of 120 adult bees, including drones, nurse bees, and foragers, were sampled from both habitats. Ten morphometric traits were measured, encompassing body length, head length, thorax and abdomen dimensions, antennal length, wing lengths, and leg lengths. The data reveal that bees from agricultural areas exhibited slightly larger dimensions across all measured traits compared to their urban counterparts, indicating a possible correlation between habitat quality and bee development. Floral diversity and seasonal pollen analysis further confirmed differential foraging patterns, with agricultural bees visiting a broader spectrum of nectar and pollen sources. These findings underscore the role of environmental factors including floral availability, landscape composition, and climate in shaping the physical development of Apis *cerana indica*, and highlight the importance of habitat conservation in ensuring sustainable pollinator health.

Keywords: *Apis cerana indica*, morphometric differentiation, pollen variability, agriculture vs. urban zones, nagpur

Introduction

Apis cerana indica, often known as 'Satpuda bees' in Maharashtra, serves as an efficient pollinator of regional crops and native plants. Globally, bees contribute to the pollination of over 70% of agricultural crops, with approximately 15% of major cultivated crops relying on domesticated bees for successful pollination (Abrol, 2012) [2]. Due to its adaptability and ecological significance, extensive research has been conducted on this species to evaluate its behavior, ecological preferences, and potential for sustainable apiculture (Abrol, 2009) [1]. The Nagpur district in central India features a variety of agro-climatic zones, urban areas, and industrial regions, supporting both cultivated and wild plant species.

Previous morphometric studies of *Apis cerana* have covered diverse ecological zones across India, from the Himalayas to the southern tip, including the Andaman Islands. Significant contributions include research by Rahman and Singh (1948) [20], Kapil (1956) [14], Deodikar (1962) [9], and Narayanan *et al*. (1961) [17]. However, limited literature addresses seasonal or regional morphometric variation (Alpatov, 1927; Ruttner *et al*., 1978) [21]. The present study investigates the effects of environmental and geographical differences on morphometric traits of *Apis cerana indica* in agricultural and urban zones of Nagpur.

Pollen analysis from bee colonies serves as an indicator of floral preferences during different seasons (Bilisik *et al*., 2008) [7]. Urbanization, habitat fragmentation, and pesticide use are major threats to bee diversity (Spivak *et al*., 2011; Goulson *et al*., 2005; Thompson, 2003; Gels *et al*., 2002; Higes *et al*., 2008; Benaets *et al*., 2017) [5, 11, 12, 13, 22, 23]. This, studies suggest that sustainable practices such as organic farming can positively influence bee foraging behavior and colony health even in urban environments (Czech *et al*., 2000) [8]. This study aims to elucidate the extent to which regional differences in flora and climatic conditions affect the development and physical characteristics of *Apis cerana indica*.

Materials and methods

The present study was carried out to see how differences in pollen and environmental conditions affect the physical traits of *Apis cerana indica* (F.). Two very different sites in Nagpur district, Maharashtra, were chosen for the colonies: an agricultural area in Karanbhad, Parseoni (Latitude: 21.362226, Longitude: 79.106343) and an urban area in Shankar Nagar, Nagpur (Latitude: 21.132188, Longitude: 79.056513).

Pollen samples were collected directly from the hive entrance to identify the floral sources visited by the bees. These samples were preserved in 70% ethanol and analyzed microscopically for floral origin characterization.

A total of 120 adult bees were taken for study, with 10 individuals from each of the three castes drones, nurse bees, and foragers collected from colonies at both sites. The bees were first anesthetized with chloroform and then placed in warm water so their body parts could be fully extended. After this, they were preserved in 70% ethanol for later study. All dissections and measurements were done under controlled laboratory conditions. Ten body characters were measured: body length, head length, thorax length, abdomen length, forewing length, hindwing length, front leg length, middle leg length, and hind leg length. Body length was measured with a digital Vernier caliper, while the other parts were measured with a stereomicroscope, using the method of Mattu and Verma (1984) [15]. The data collected were calculated and presented as mean, standard deviation (SD), and range of variation (RV).

Results and discussion

Tables 1 and 2 present the morphometric data for *Apis cerana indica* collected from different geographical regions, specifically agricultural and urban zones. These areas are characterized by distinct climatic conditions, including variations in temperature, humidity, and the surrounding flora and fauna (Michener, 1974; Velthuis, 1992) [16, 24]. The morphological traits of *Apis cerana* were observed to vary with geographical location (Bhatta & Kumar, 2021) [6], indicating the influence of environmental conditions on the species' development.

Bees from agricultural areas were generally larger than those from urban regions across all castes. Drone, nurse, and worker bees in the agricultural zones had slightly bigger heads, thoraxes, and abdomens, suggesting better overall growth. Their antennae were also longer, which may help them sense and locate flowers more efficiently. Wings, both forewings and hindwings, were consistently longer in agricultural bees, particularly in workers, supporting longer and more effective flights during foraging. Legs of bees from farmland were longer as well, likely allowing them to move more easily and collect nectar and pollen from a wider variety of plants. Among all castes, worker bees showed the most noticeable differences, reflecting their demanding role in foraging and maintaining the colony. These patterns indicate that the environmental conditions in agricultural areas such as richer floral diversity, greater food availability, and more favorable microclimates may contribute to better morphometric development compared to urban habitats. Overall, these findings highlight how habitat quality can directly influence the physical traits and potential performance of *Apis cerana indica*.

All morphometric values observed in this study were cross-checked with previous studies (Ananda, 2000; Patil & Pastagia, 2014; Pal *et al*., 2008; Deodikar, 1962; Kapil, 1956) [4, 9, 14, 18, 19] to ensure accuracy.

Table 1: Quantitative data on significant morphological characters of the three castes of the Indian honey bee, *Apis cerana indica* (F.), collected from an agricultural area

Body characters	Drone		Nurse Bee		Forager Bees	
	Mean±SD	RV	Mean±SD	RV	Mean±SD	RV
Body Length	11.99±0.35	1.10	11.55±0.55	1.50	13.14±0.18	0.60
Head Length	3.40±0.14	0.40	2.92±0.16	0.50	3.50±0.14	0.40
Thorax Length	4.14±0.15	0.40	3.72±0.24	0.80	4.11±0.16	0.50
Abdomen Length	5.50±0.12	0.40	4.18±0.12	0.40	6.20±0.12	0.40
Antenna Length	4.99±0.10	0.30	4.56±0.11	0.30	4.85±0.11	0.30
Fore wings Length	8.73±0.13	0.40	7.75±0.13	0.30	9.71±0.13	0.40
Hind wings Length	6.24±0.10	0.30	5.49±0.12	0.40	6.51±0.09	0.20
Front legs Length	7.44±0.14	0.50	6.20±0.11	0.30	7.53±0.14	0.50
Middle legs Length	8.06±0.13	0.40	7.17±0.09	0.30	8.07±0.13	0.40
Hind legs Length	8.60±0.18	0.60	8.47±0.13	0.40	9.11±0.16	0.50

Table 2: Quantitative data on significant morphological characters of the three castes of the Indian honey bee, *Apis cerana indica* (F.), collected from an urban area

Body characters	Drone		Nurse Bee		Forager Bees	
	Mean±SD	RV	Mean±SD	RV	Mean±SD	RV
Body Length	11.81±0.37	1.10	11.11±0.22	0.60	12.25±0.45	1.30
Head Length	3.30±0.12	0.40	2.78±0.12	0.30	3.11±0.16	0.50
Thorax Length	3.97±0.14	0.30	3.12±0.14	0.40	3.33±0.13	0.40
Abdomen Length	4.09±0.12	0.40	3.67±0.09	0.30	4.55±0.11	0.30
Antenna Length	4.26±0.14	0.50	3.37±0.09	0.30	3.60±0.12	0.40
Fore wings Length	8.41±0.16	0.50	7.66±0.23	0.80	8.98±0.18	0.50
Hind wings Length	5.51±0.17	0.60	4.47±0.13	0.40	6.33±0.13	0.40
Front legs Length	6.47±0.09	0.30	6.07±0.16	0.50	6.85±0.13	0.40
Middle legs Length	7.40±0.12	0.40	6.31±0.16	0.50	7.70±0.12	0.40
Hind legs Length	8.50±0.12	0.40	8.00±0.12	0.40	8.94±0.11	0.30

SD- Standerd Daviation, RV- Range of Variation All the mean values are in mm

Agricultural Zone

In the agricultural area, forager bees exhibited a wide spectrum of floral visitation, suggesting a diverse and seasonally changing floral landscape. During the winter months (January–February), the dominant pollen sources were *Alternanthera sessilis*, *Brassica campestris*, *Lagascea mollis*, and *Azadirachta indica*. Notably, *Azadirachta indica* contributed significantly in February (48.2%), indicating early blooming and high attractiveness due to its abundant nectar and pollen.

The spring months (March–April) reflected a shift in floral preference toward *Citrus sinensis* and *Citrus limetta*, with these species collectively accounting for over 70% of the pollen frequency in April. Their dominance during this period may be attributed to mass flowering and their high quality nectar, which are known to attract forager bees extensively.

In the post-monsoon period (October–December), *Lagascea mollis*, *Parthenium hysterophorus*, *Gossypium*, *Cajanus cajan*, and *Capsicum annuum* emerged as prominent sources. The high frequency of *Gossypium* and *Cajanus cajan* (both ≥32% in November and December) suggests the importance of cultivated crops in sustaining bee populations during periods when wild flora are limited. Interestingly, *Parthenium hysterophorus*, typically regarded as an invasive weed, was regularly foraged in both October and November, indicating its ecological relevance as a fallback floral resource.

Urban Zone

In contrast, the urban site presented a relatively limited but consistent floral spectrum. In the early months (January–March), *Azadirachta indica* consistently dominated (ranging from 40.3% to 48.6%), likely due to its widespread occurrence in urban green spaces and roadside plantations. The presence of *Alternanthera sessilis* and *Tridax procumbens* further complemented the pollen diversity in February and March.

During April, urban foraging patterns diversified significantly, with *Psidium guajava* (38.1%), *Delonix regia*, *Bombax ceiba*, *Poaceae*, and *Cassia fistula* being visited. These ornamental and native species are commonly planted along roads and in parks, providing a transitional source of nectar and pollen between major flowering seasons.

In the post-monsoon period, *Alternanthera sessilis* remained a dominant floral source in October and November, while *Ocimum sanctum* and *Parthenium hysterophorus* also made substantial contributions. In December, *Albizia lebbeck* (45.9%) and *Poaceae* (39.5%) were the major floral resources, showing the significance of late-flowering tree species and grasses in sustaining urban bee foraging.

Conclusion

The present study demonstrates that the morphometric characteristics of *Apis cerana indica* are significantly influenced by environmental variables, particularly the floral diversity and habitat type. Populations from agricultural regions exhibited relatively larger body sizes and more developed morphological traits across all castes indicative of favorable ecological conditions such as diverse floral availability, consistent nectar sources, and relatively stable microclimatic parameters. These results are consistent with previous findings (Free, 1970; Rodionov & Shabarshov, 1986) [10, 21], supporting the notion that *Apis cerana* displays notable phenotypic plasticity in response to both biotic (vegetation type, resource availability) and abiotic (temperature, habitat structure) factors.

Comparative analysis of floral foraging patterns further reinforces this observation. Forager bees in agricultural zones accessed a broader and more seasonally varied array of floral resources, including both cultivated and wild flora. Conversely, urban colonies were limited to a narrower but steady set of ornamental and tree species, reflecting the constrained ecological offerings of urban landscapes.

Collectively, these findings highlight the importance of habitat quality and landscape heterogeneity in shaping both the morphology and foraging ecology of *Apis cerana indica*. Conservation and management strategies aimed at sustaining pollinator populations should therefore prioritize habitat diversification and floral resource enrichment, particularly in rapidly urbanizing regions.

Table 3: Representation of floral resources visited by forager bees in the agricultural zone.

Month	Flora visited by bees	Frequency of pollen
January 2023	Alternanthera sessilis	28.6%
	Brassica campestris	19.4%
	Lagascea mollis	16.5%
	Justicia procumbens	15.8%
	Ocimum basilicum	5.9%
	Sphaeranthus indicus	13.8%
February 2023	Alternanthera sessilis	30.3%
	Azadiracta indica	48.2%
	Brassica compestris	14.2%
	Ocimum basilicum	7.3%
March 2023	Alternanthera sessilis	20.7%
	Brassica sp.	10.4%
	Cipadessa baccifera	5.9%
	Citrus sinensis	29.3%
	Citrus limetta	33.8%
	Solanum lycopersicum	1.9%
April 2023	Solanum lycopersicum	8.7%
	Cipadessa baccifera	12.8%
	Citrus sinensis	38.2%
	Citrus limetta	42.1%
October 2023	Lagascea mollis	41.2%
	Parthenium hysterophorus	30.5%
	Sphaeranthus indicus	12.9%
	Alternanthera sessilis	15.4%
November 2023	Parthenium hysterophorus	16.2%
	Gossypium	35.3%
	Capsicum annuum	19.1%
	Cajanus cajan	29.4%
December 2023	Lagascea mollis	4.8%
	Parthenium hysterophorus	9.4%
	Gossypium	35.5%
	Cajanus cajan	32.4%
	Justicia procumbens	2.8%
	Capsicum annuum	15.1%

Table 4: Representation of floral resources visited by forager bees in the urban zone.

Month	Flora visited by bees	Frequency of pollen
January 2023	Azadiracta indica	48.6%
	Alternanthera sessilis	39.2%
	Lagascea mollis	12.2%
February 2023	Azadiracta indica	40.3%
	Brassica compestris	26.3%
	Tridax procumbens	33.3%
March 2023	Azadiracta indica	41.5%
	Psidium guajava	37.6%
	Prosopis julifera	20.9%
April 2023	Psidium guajava	38.1%
	Delonix regia	20.5%
	Bombax ceiba	16.3%
	Poaceae	10.2%
	Cassia fisfula	14.9%
October 2023	Alernanthera sessilis	40.4%
	Parthenium hysterophrorus	20.2%
	Ocimum santum	31.4%
November 2023	Alernanthera sessilis	38.9%
	Parthenium hysterophrorus	30.5%
	Ocimum santum	30.6%
December 2023	Albizia lebbeck	45.9%
	Poaceae	39.5%
	Chrysanthemum sp.	14.6%

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