

# **Morphometric Characterization of *Apis mellifera* (Italian Honey Bee) Across Different agroclimatic zones of Kumaun Region of Uttarakhand**

## **Abstract**

This study investigated the morphometry of *Apis mellifera* across three diverse locations in Uttarakhand, spanning the Tarai irrigated (Pantnagar), Bhabar Irrigated (Nainital) and High hills (Almora), to explore regional adaptations and environmental influences. Significant regional differences were observed, with populations from high hills exhibiting larger dimensions, whereas populations from Tarai irrigated showed smaller size. The morphological characteristics of *Apis mellifera* worker bees were analyzed. A total of 13 morphological characters were measured using a stereo zoom microscope in combination with VUE software. The results suggest that morphometric variations can potentially distinguish intraspecific groups of honeybee colonies, identifying them as distinct ecotypes. Morphometric analysis of wings and body parts provides valuable insights into honeybee biodiversity studies. To facilitate species identification based on morphometric traits, *Apis mellifera* samples were collected. 40 worker bee samples were analyzed, and 13 morphometric characteristics were measured in the entomology laboratory at G.B. Pant University of Agriculture and Technology (GBPUA&T). The biometric data were analyzed by calculating the mean, range, standard error, and coefficient of variation.

## **1. INTRODUCTION**

Honey bees are social insects that generate vital compounds such as honey, royal jelly, bee wax, propolis, pollen, and bee venom, in addition to playing a major role in agriculture through pollination. India has a varied honey bee fauna, including significant *Apis* species such as *Apis dorsata* Fab., *A. florea* Fab., *A. cerana* Fab., and the well-known exotic *A. mellifera* L. The initial two species are still not hived, whilst the latter two species are hived, therefore used for beekeeping. Honey bee species vary in phenotypic characteristics between climates, and several ecological races are suspected. Previously, the classification of geographical races was only based on the colour and size of honey bees. Alpatov (1929) introduced biometrics to properly define honey bee races. Ruttner et al. (1978) provided a comprehensive discussion of honey bee morphometric research. Following that, these studies were carried out all over the world on

various features to account for differences between species, but precise region-specific characterizations are still required for appropriate identification and suitability. Furthermore, Kekecoglu et al., (2023) emphasized the importance of morphometric research in providing information on the structure, available races, regional and genetic variety, as well as establishing the role and importance of any organism's biometrical characteristics. . In Uttarakhand, apiculture has emerged as a profitable venture. Uttarakhand, an Indian state, is located in the northwestern Himalaya and has a diversified climate that ranges from semi-tropical in the lower hills to semi-arctic in the frigid desert parts. It is situated between Latitude 30°22'40" N to 33°12'20" N and Longitude 75° 45'55" E to 79°04'20" E, with elevations ranging from 350 to 6975 meters above sea level (masl). The current study was designed to investigate the current morphometric state of *A. mellifera*. To assess the current morphometric status of *Apis mellifera* in the Kumaun region of Uttarakhand, the present study was undertaken. To date, no study has provided a comprehensive morphometric characterization of *Apis mellifera* populations across the diverse altitudes of Kashmir. The primary objective of this research was to investigate variations in the morphological traits of *Apis mellifera* across different agroclimatic zones in the region.

## 2. MATERIAL AND METHODS

The morphometric studies on *A. mellifera* was carried out at IBDC Laboratory, Department of Entomology, College of Agriculture, Pantnagar, Uttarakhand in 2023. The materials used and methods employed are as follows.

### 2.1 Collection of *Apis mellifera* species from different altitudes

Worker bees of *A. mellifera* were gathered from natural hives and apiaries in three locations representing distinct agro-climatic zones in Uttarakhand including Tarai irrigated (Pantnagar), Bhabar Irrigated (Nainital) and High hills (Almora), (**Table 1**). At each location, 40 worker bees were collected. The captured bees were placed in a vial containing 70 per cent alcohol and preserved in deep freezer for long time storage at -20°C. This study has facilitated the study of phenotypic traits and the diversification of honey bee populations, revealing variations in body dimensions associated with latitude. Morphometry enables the discrimination of bee populations through precise numerical data obtained from measurements of

morphological traits. These measurements are used to derive colony character means, which are then subjected to statistical analyses (Irshad et al., 2022).

## 2.2 Methodology for Measuring Morphological Traits of *Apis mellifera* L

Thirteen morphological parts of *Apis mellifera* L. were dissected and mounted on glass slides with cover slips for analysis. A stereo zoom microscope equipped with VUE software, calibrated using a micrometer lens, was employed for precise measurements. Key structures, including the head, thorax, abdomen, hindwings, forewings, forelegs, midlegs, and hindlegs, were measured using a measuring scale (mm).

**Table 1: Collection of *Apis mellifera* from different altitudes of Uttarakhand**

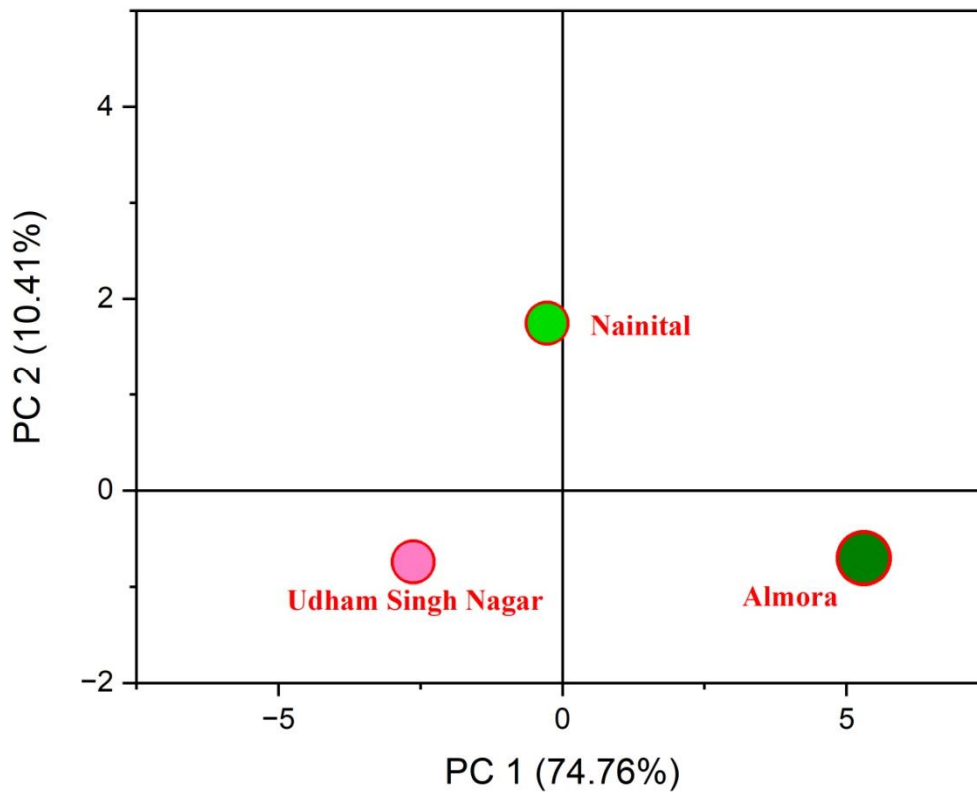
Districts	Agro climatic zones	latitude	longitude	Altitude	Date of collection	Species collected
Pantnagar	Tarai irrigated	29.0222°N	79.4908° E	244 masl	8 August 2023	<i>Apis mellifera</i>
Nainital	Bhabar Irrigated	29.3924° N	79.4534° E	2,084 masl	21 April 2024	<i>Apis mellifera</i>
Almora	High hills	29.5892° N	79.6467° E	2116masl	16 July 2024	<i>Apis mellifera</i>

## 2.3 Statistical Analysis

The morphometric variation of *Apis mellifera* populations across Uttarakhand was analyzed using Principal Component Analysis (fig. 1). These statistical methods were employed to identify patterns and groupings within the dataset, elucidating variations and similarities among populations from diverse geographic and ecological regions. PCA was utilized to reduce

the dimensionality of the dataset while retaining the most significant traits contributing to variability.

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**Fig 1. Component loading of morphometric variables**

### **3. RESULTS**

#### **3.1 Head length, Thorax length ,Abdomen length**

The data on Head length, Thorax length ,Abdomen length of *Apis mellifera* at different altitudes of kumaun region is presented in Table 2. The maximum head length ( $3.280 \pm 0.012$  mm) was observed in the population from Almora, followed by Nainital ( $3.228 \pm 0.012$  mm) and Udham Singh Nagar ( $3.220 \pm 0.013$  mm). The overall mean head length was  $3.270 \pm 0.012$  mm. The highest thorax length ( $4.454 \pm 0.015$  mm) was observed in honey bee samples collected from Almora, which was followed closely by samples from Nainital ( $4.423 \pm 0.023$  mm) and Udham Singh Nagar ( $4.404 \pm 0.023$  mm). The maximum abdomen length ( $6.197 \pm 0.022$  mm)

was recorded at Almora, followed by Nainital ( $6.169 \pm 0.028$  mm) and Udham Singh Nagar ( $6.119 \pm 0.032$  mm), with an overall mean of  $6.174 \pm 0.027$  mm and a coefficient of variance 1.35 per cent.

### **3.2 Total body length**

The data on Total body length of *Apis mellifera* at different altitudes of kumaun region is presented in Table 2. The maximum total body length ( $13.931 \pm 0.006$  mm) was recorded at Almora, followed by Nainital ( $13.821 \pm 0.033$  mm) and Udham Singh Nagar ( $13.743 \pm 0.038$  mm). The overall mean total body length across all locations was  $13.891 \pm 0.020$  mm.

### **3.3 Total antennal length**

The data on Total antennal length of *Apis mellifera* at different altitudes of kumaun region is presented in Table 2. The maximum total antennal length ( $5.133 \pm 0.030$  mm) was recorded at Almora, followed by Nainital ( $5.031 \pm 0.018$  mm) and Udham Singh Nagar ( $4.997 \pm 0.029$  mm).

### **3.4 Proboscis length**

The data on Proboscis length of *Apis mellifera* at different altitudes of kumaun region is presented in Table 2. The maximum proboscis length ( $6.483 \pm 0.023$  mm) was observed at Hawalbagh, followed by Jyolikot ( $6.441 \pm 0.079$  mm) and Pantnagar ( $6.419 \pm 0.024$  mm).

### **3.5 Fore wing length and Fore wing width**

The data on Fore wing length and Fore wing width of *Apis mellifera* at different altitudes of kumaun region is presented in Table 2. The maximum fore wing width ( $3.430 \pm 0.013$  mm) was found at Nainital, followed by Almora ( $3.413 \pm 0.024$  mm) and Udham Singh Nagar ( $3.407 \pm 0.012$  mm). The maximum fore wing length ( $9.312 \pm 0.047$  mm) was recorded at Almora, followed by Nainital ( $9.289 \pm 0.032$  mm) and Udham Singh Nagar ( $9.279 \pm 0.031$  mm).

### **3.6 Hind wing length and hind wing width**

The data on Hind wing length and hind wing width of *Apis mellifera* at different altitudes of kumaun region is presented in Table 2. The maximum hind wing length ( $6.655 \pm 0.028$  mm) was recorded at Almora, followed by Nainital ( $6.648 \pm 0.028$  mm) and Udham Singh Nagar ( $6.633 \pm 0.022$  mm). The maximum hind wing width ( $1.805 \pm 0.012$  mm) was observed at Almora, followed by Nainital ( $1.801 \pm 0.011$  mm) and Udham Singh Nagar ( $1.796 \pm 0.011$  mm).

### 3.7 Cubital index

The data on Cubital index of *Apis mellifera* at different altitudes of kumaun region is presented in Table 2. The maximum cubital index ( $2.120 \pm 0.020$ ) was found at Udham Singh Nagar, followed by Nainital ( $2.090 \pm 0.010$ ) and Almora ( $2.055 \pm 0.007$ ), with an overall mean of  $2.109 \pm 0.013$  and a coefficient of variance of 1.93 per cent.

### 3.8 Total fore leg length

The data on Total fore leg length of *Apis mellifera* at different altitudes of kumaun region is presented in Table 2. The maximum total fore leg length ( $5.748 \pm 0.007$  mm) was observed at Almora followed by Nainital ( $5.687 \pm 0.028$  mm) and Udham Singh Nagar ( $5.650 \pm 0.050$  mm). The overall mean total fore leg length was 5.726 mm, with a coefficient of variance 1.48 per cent.

### 3.9 Total mid leg length

The data on Total mid leg length of *Apis mellifera* at different altitudes of kumaun region is presented in Table 2. The maximum total mid leg length ( $6.083 \pm 0.020$  mm) was recorded at Almora, followed by Nainital ( $6.024 \pm 0.047$  mm) and Udham Singh Nagar ( $5.991 \pm 0.043$  mm). The overall mean total mid leg length across all locations was  $6.063 \pm 0.020$  mm with a coefficient of variance 1.79 per cent.

### 3.10 Total hind leg length

The data on Total hind leg length of *Apis mellifera* at different altitudes of kumaun region is presented in Table 2. The maximum total hind leg length ( $8.859 \pm 0.049$  mm) was recorded at Almora, followed by Nainital ( $8.759 \pm 0.027$  mm) and Udham Singh Nagar ( $8.217 \pm 0.050$  mm). The overall mean total hind leg length across all locations was  $8.690 \pm 0.020$  mm with a coefficient of variance 1.30 per cent.

**Table 2: Morphological characters of *Apis mellifera* collected from different agroclimatic zones of Uttarakhand**

**Table 3. Eigenvalues of the correlation matrix**

Districts	Almora	Nainital	Udham Singh Nagar	CV%
Characters				
Head length	3.280±0.012	3.228±0.012	3.220±0.013	1.19
Thorax length	4.454±0.015	4.423±0.023	4.404±0.023	2.04
Abdomen length	6.197±0.022	6.169±0.028	6.119±0.032	1.35
Total body length	13.931±0.006	13.821±0.033	13.743±0.038	1.65
Proboscis length	6.483±0.023	6.441±0.079	6.419±0.024	2.20
Total antennal length	5.133±0.030	5.031±0.018	4.997±0.029	1.65
Fore wing length	9.312±0.047	9.289±0.032	9.279±0.031	1.22
Fore wing width	3.413±0.024	3.430±0.013	3.407±0.012	1.55
Hind wing length	6.655±0.028	6.648±0.028	6.633±0.022	1.29
Hind wing width	1.805±0.012	1.801±0.011	1.796±0.011	2.25
Cubital index	2.055±0.007	2.090±0.010	2.120±0.020	1.93
Total fore leg length	5.748±0.007	5.687±0.028	5.650±0.050	1.48
Total mid leg length	6.083±0.020	6.024±0.047	5.991±0.043	1.79
Total hind leg length	8.859±0.049	8.759±0.027	8.217±0.050	1.30

Eigenvalue	Percentage of Variance	Cumulative
10.46696	74.76%	74.76%
1.45805	10.41%	85.18%
0.78796	5.63%	90.81%
0.5488	3.92%	94.73%
0.28831	2.06%	96.79%
0.1669	1.19%	97.98%
0.11995	0.86%	98.84%
0.06735	0.48%	99.32%
0.03425	0.24%	99.56%
0.02346	0.17%	99.73%
0.01849	0.13%	99.86%
0.01355	0.10%	99.96%

#### 4. DISCUSSION

Earlier, morphometric studies were conducted by various Indian researchers. For example, Ibrahim et al., (2017) studied *Apis mellifera* populations in Himachal Pradesh, while



Sharma (1990) measured the head length of *A. mellifera* as 3.19 mm, which closely aligns with the average head height observed at Kumaun region of Uttarakhand. The proboscis length of various geographical races of honey bees has shown considerable variation. Ruttner (1988) reported the proboscis length of different *A. mellifera* races, including 6.40 mm in Australia. In the present investigation, the proboscis length observed at high altitudes was  $6.483 \pm 0.023$  mm, closely matching that of *A. mellifera ligustica*. Ajao et al., (2014) reported an average antenna length of *A. mellifera* as  $5.48 \pm 0.015$  mm, which was closer to the average antenna length observed at high altitudes ( $5.133 \pm 0.030$ ) mm in the Kumaun region. Jevtic et al. (2007) recorded forewing lengths ranging from 7.81 to 10.37 mm and widths from 2.12 to 3.75 mm across different parts of Serbia. Additionally, our findings align with those of Bouzeraa et al., (2016), who measured the cubital index of *A. mellifera* at three sites in Algeria as  $2.08 \pm 0.20$ ,  $2.50 \pm 0.34$ , and  $2.53 \pm 0.33$ . Abou-shaara et al., (2012) reported an average Hind wing length and hind wing width of *Apis mellifera* as  $6.13 \pm 0.05$  and  $1.82 \pm 0.08$  mm which was closer to the average Hind wing length ( $6.655 \pm 0.028$ ) and hind wing width ( $1.805 \pm 0.012$ ) observed at high altitude in the Kumaun region.

## 5. CONCLUSION

*Apis mellifera* was collected from different agroclimatic zones of Uttarakhand, and it was found that the individuals of the *Apis mellifera* species belonging to higher altitudes were larger in size compared to those from other regions that means environmental conditions also have an effect on the size and characteristics of the *Apis mellifera* species.

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