



MORPHOMETRICS OF *APIS CERANA* FROM AGROCLIMATIC ZONES OF HIMACHAL PRADESH

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ABSTRACT

Study on morphometrics of *Apis cerana* was conducted for 13 characters in order to examine the variability and comparison with earlier reports. Samples of worker bees were collected from the apiaries at different locations namely, Bajaura (Kullu), Bharmour (Chamba), Nagrota Bagwan, Palampur (Kangra) and Sangla (Kinnaur) representing different zones. Results showed that head height x width, proboscis length, thorax length, abdomen length, fore wing length x width, cubital index, hind wing length x width, number of hamuli, coxa length, trochanter length, femur length, tibia length and metatarsus length x width were varied from 2.87- 3.07 x 3.49- 3.78 mm, 5.35- 5.46 mm, 3.97- 4.39 mm, 5.18- 6.01 mm, 8.46- 8.93 x 2.86- 3.03 mm, 2.70- 3.38, 5.97- 6.37 x 1.62- 1.72 mm, 18.64- 19.90, 0.91- 1.08 mm, 0.63- 0.76 mm, 2.29- 2.42 mm, 2.72- 2.95 mm and 1.83- 1.97 x 0.98- 1.07 mm, respectively. Present findings on morphometrics of three important characters viz., proboscis length, fore wing length and cubital index were compared with the earlier reports wherein the mean proboscis length (5.41 mm) and forewing length (8.67 mm) were found to be close to *A. cerana cerana*. However, cubital index value (3.01) was at wide variance from *A. cerana cerana*.

Keywords: *Apis cerana*, Himachal Pradesh, worker bees, proboscis length, fore wing length, cubital index, thorax, abdomen, legs

Honey bees are social insects and play an important role in pollination of agricultural and horticultural crops besides being considered as productive insect. India has diverse honey bee fauna with major *Apis* spp., like, *Apis dorsata* F., *A. florea* F., *A. cerana* F., and well-established exotic *A. mellifera* L. The former two species are still not hived while rest are hived and suitable for beekeeping. *A. cerana* though is well adapted to the extremes of environmental conditions, especially colder zones but its commercial rearing is declining in the state (Verma and Attri, 2008). A honey bee colony comprises of a queen, hundreds of drones and thousands of worker bees. The workers are the dedicated individuals and perform different duties including nectar and pollen collection. The collection of pollen and production of honey not only depend upon the floral abundance of the area but also on the morphological characters of workers such as body size, proboscis length, corbicula, etc. (Alburaki and Alburaki, 2008).

The length of proboscis of a particular species of worker bee plays a vital role for honey production as

it has positive correlation with foraging (Mostajeran et al., 2006). Body size and hind leg length affect pollen carrying capacity of honey bees (Morimoto, 1968). Corbicula size, fore and hind wing areas have the direct correlation with the production potential of the honey (Szabo, 1990). Wing morphometry is important for classification of races and their size affects the flight ability of worker honey bees (Horowitz, 1983). It is likely that *A. cerana* in India might have undergone certain morphological changes or degeneration in its characters during ecological adaptation to different climatic conditions and excessive inbreeding. It is also speculated to have different geographical races of *A. cerana* in the Himachal Pradesh as there is wide variability in climatic conditions. The present study was carried out to investigate the morphometrics of *A. cerana* workers samples from different locations of the state.

MATERIALS AND METHODS

The study was carried out at the Department of Entomology, CSK Himachal Pradesh Krishi

Vishvavidyalaya, Palampur during 2012. Worker bees of *A. cerana* were collected from six apiaries representing different zones of Himachal Pradesh as below:

At each location, 50 workers were collected from each apiary (three colonies/apiary). For the collection of bees, hive entrance was closed and the worker bees were handpicked gently one by one. The collected bees were killed in boiling water and further preserved in 75% alcohol. The bees were brought to lab at Palampur and dissected for different body parts/appendages in laboratory under stereozoom microscope. Characters including head height, head width, proboscis length, thorax length, abdomen length, fore wing length, fore wing width, cubital index, hind wing length and width, number of hamuli on hind wing, length of coxa, trochanter, femur, tibia, and metatarsus length and width on hind leg were used to study the morphometrics.

The cubital index was calculated after measuring the length of vein A - B and B - C, according to Goetze (1930): $CI = BC/AB$, where, BC = Distance between points B to C, and AB = Distance between points A to B. Measurements were taken using stereozoom microscope (Nikon SMZ 745 T) equipped with Image Analysis System (NIS elements D 3.1). Data thus obtained were analyzed following standard statistical procedures suggested by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Head: Among the populations of *A. cerana*, the minimum head height (2.87 mm) was recorded from Bajaura population which was significantly different from the populations of Palampur (3.00 mm), Sangla (3.02 mm) and Bharmour (3.07 mm). There was no significant difference among the populations of Bajaura and Nagrota Bagwan. The data with regard to head width *A. cerana* is given in Table 1. The mean head width varied from 3.49-3.78 mm among the populations of *A. cerana*. Significant differences were also observed among the population of *A. cerana* which were collected

from Bajaura (being at par with Nagrota Bagwan and Palampur), Bharmour and Sangla. The parameters of the head as examined in the present investigations have not been studied earlier in the bee species.

Proboscis length: Proboscis length is of extreme importance in honey production. In the present studies, the mean proboscis length of *A. cerana* exhibited significant variations between the population of Palampur (at par with Bajaura and Sangla) and Bharmour (at par with Nagrota Bagwan) (Table 1). The proboscis length was maximum in Nagrota Bagwan population (5.46 mm) and minimum in Palampur population (5.35 mm). Overall mean of proboscis length in different locations of *A. cerana* was 5.41 mm. Measurement of proboscis length of various geographical races of honey bees has shown considerable variations. The present observations on the proboscis length agree with (Atwal and Sharma 1968) and the variations in proboscis length can be due to the geographical races.

Thorax length: Data on thorax length of *A. cerana* collected from different locations is presented in Table 1. Among the different populations *A. cerana*, the minimum thorax length (3.97 mm) was recorded in the population of Bajaura which was at par with Palampur (4.03 mm) but differed significantly from the populations of rest of locations. Maximum thorax length of 4.39 mm was recorded from Sangla which was at par with the Bharmour population. The population of Palampur and Nagrota Bagwan were significantly different with Sangla. Mean thorax length of different locations of *A. cerana* was (4.16 mm). Information on variability of thorax length of honey bees is not available in the literature.

Abdomen length: Data in respect of abdomen length of *A. cerana* are given in Table 1. The abdomen length of *A. cerana* collected from Palampur (6.01 mm) was significantly different from the population of other locations i.e., Bajaura (5.31 mm), Bharmour (5.29 mm), Nagrota Bagwan (5.18 mm) and Sangla (5.46 mm) which were statistically at par. The minimum abdomen

Location	District	Agro-climatic zone	Latitude (°N)	Longitude (°E)	Altitude (masl)
Nagrota Bagwan	Kangra	Sub-Montane and Low Hills Sub-Tropical	32° 06' 22.35"	76° 22' 46.72"	861
Bajaura	Kullu	Mid Hills Sub-Humid Zone	31° 50' 54.25"	77° 09' 51.60"	1087
Palampur	Kangra	-do-	32° 06' 39.10"	76° 32' 10.51"	1268
Bharmour	Chamba	High Hills Temperate Wet Zone	32° 26' 34.26"	76° 31' 58.54"	2076
Sangla	Kinnour	High Hills Temperate Dry Zone	31° 25' 31.75"	78° 15' 53.99"	2650

Table 1. Morphometrics- length of head, thorax and abdomen of *A. cerana* from Himachal Pradesh

Location	Head height (mm)	Head width (mm)	Proboscis length (mm)	Throax length (mm)	Abdomen length (mm)
Bajaura	2.87±0.04	3.49±0.05	5.38±0.04	3.97±0.10	5.31±0.41
Bharmour	3.07±0.04	3.57±0.07	5.45±0.04	4.33±0.06	5.29±0.24
Nagrota Bagwan	2.90±0.04	3.51±0.03	5.46±0.04	4.10±0.09	5.18±0.29
Palampur	3.00±0.03	3.56±0.04	5.35±0.04	4.03±0.12	6.01±0.46
Sangla	3.02±0.04	3.78±0.04	5.39±0.04	4.39±0.06	5.46±0.15
Mean	2.97	3.58	5.41	4.16	5.45
LSD (P=0.005)	0.08	0.07	0.05	0.12	0.45
MSS (E)	0.021	0.013	0.009	0.048	0.654

N= 25; Mean± Standard Error; NS = Non-significant

length was recorded in Nagrota Bagwan population (5.18 mm) and maximum in Palampur population (6.01 mm). Mean abdomen length of *A. cerana* of different locations was found to be 5.45 mm. Information on variability in abdomen length either of *A. cerana* is not available in the literature.

Fore wings: Data on fore wing length, width and cubital index of *A. cerana*, collected from honey bees of different locations are given in Table 2. It can be seen from the data that maximum length in *A. cerana* was observed to be in the Sangla (8.93 mm) population followed by Bharmour (8.77 mm), Palampur (8.69 mm), Nagrota Bagwan (8.50 mm) and Bajaura (8.46 mm). The mean wing length of population from different locations was recorded to be 8.67 mm. The population of Bajaura (being at par with Nagrota Bagwan) was significantly different from the populations of Palampur,

Sangla and Bharmour. The population of Palampur was statistically at par with Sangla (2.99 mm) in fore wing width and this was further found to be at par with Bharmour.

Earlier, the fore wing length and width have been reported to be variable (Ruttner 1988; Jevtic et al., 2007; Adl et al., 2007) which can be attributed to altitude or geographical races. In *A. cerana*, the maximum length and width has been reported as 8.662±0.021 and 2.855±0.19 mm which is in proximity of the present findings.

Cubital index is one of the important parameters taken to discriminate honey bee subspecies. The population of *A. cerana* from Bajaura recorded minimum cubital index (2.70) which was at par with Nagrota Bagwan (2.74) and Palampur (2.89) but

Table 2. Morphometrics- fore and hind wing, cubital index and hamuli of *A. cerana* from Himachal Pradesh

Location	Fore wing length (mm)	Fore wing width (mm)	Cubital index	Hind wing length (mm)	Hind wing width (mm)	No. of hamuli
Bajaura	8.46±0.07	2.86±0.02	2.70±0.12	5.97±0.05	1.63±0.02	18.96±0.60
Bharmour	8.77±0.09	3.03±0.09	3.33±0.18	6.28±0.07	1.72±0.03	19.90±0.43
Nagrota Bagwan	8.50±0.09	2.86±0.03	2.74±0.16	6.04±0.07	1.62±0.03	18.64±0.58
Palampur	8.69±0.08	2.95±0.04	2.89±0.18	6.10±0.10	1.65±0.03	18.64±0.59
Sangla	8.93±0.05	2.99±0.01	3.38±0.21	6.37±0.03	1.72±0.02	19.06±0.46
Mean	8.67	2.94	3.01	6.15	1.67	19.04
LSD (P=0.005)	0.10	0.06	0.24	0.09	0.04	0.73
MSS (E)	0.034	0.012	0.179	0.026	0.004	1.701

N= 25; Mean± Standard Error; NS = Non-significant

differed significantly from Bharmour (3.33) and Sangla (3.38) both being at par. The variable cubital index has been calculated by different authors by (Ruttner 1988; Szabo 1990; Niem and Trung 1999).

Hind wings: The data on the length and width of hind wing and number of hamuli were taken in account and presented in Table 2. However, the minimum of hind wing length was recorded from the population of Bajaura (5.97 mm) and it was statistically at par with population of Nagrota Bagwan (6.04 mm) but differed statistically from Palampur (6.10 mm), Bharmour (6.28 mm) and Sangla (6.37 mm). The population from Sangla showed maximum hind wing length which was being at par with Bharmour population. Both of these locations fall under the snow bound regions during winters.

The hind wing width varied from 1.62 to 1.72 mm among different population of *A. cerana*. The population of *A. cerana* from Nagrota Bagwan showed minimum hind wing width which was statistically at par with Bajaura and Palampur but differed significantly from Bharmour and Sangla. Like wing length, wing width was also found maximum in the bees from Sangla and Bharmour. The mean wing length and width of different location was found to be significantly varied. The wing length (mm) and width (mm) of *A. cerana* was found to be 6.15 and 1.67 mm. In Himachal Pradesh, Mattu and Verma (1984b) reported smaller length (5.937±0.031) of hind wing in *A. c. indica* as compared to the present study. Elsewhere in the world, variable morphometrics of hind wings has been reported by (Szabo 1990; Mattu and Verma 1984b).

The *A. cerana* population of Nagrota Bagwan and Palampur exhibited minimum number (18.64) of hamuli (both being statistically at par with Bajaura and Sangla.

The mean number hamuli in *A. cerana* population were counted to be 19.04 mm. Work on the hamuli count in *A. cerana*, number has been reported to be 18.09 (Hepburn and Radloff 2004) and 18.96±0.347 mm (Mattu and Verma 1984b). Information on number of hamuli from some states of India is also available i.e., 19.44, 19.36 and 17.72 for Kashmir, Himachal Pradesh and Uttar Pradesh populations, respectively. The number of hamuli as recorded in the current study is close to both Kashmir and Himachal population, but considerably low in Uttar Pradesh population (Hepburn et al. 2001a). Tan et al. (2008) reported 18.57 hamuli/wing in *A. cerana* of China.

Hind legs: The various parts of hind legs of *A. cerana* were studied included length of coxa, trochanter, femur and tibia. Beside, length and width of metatarsus were also taken up. The data on length of coxa, trochanter, femur, tibia, metatarsus and their width are presented in Table 3.

The mean coxa length in *A. cerana*, corresponded to the bees collected from Bajaura and Sangla, respectively which were significantly different from other populations whereas, the bees from Palampur (0.98 mm), Bharmour (0.99 mm) and Nagrota Bagwan (1.01 mm) were statistically at par. On basis of overall mean, the population of *A. cerana* was (0.99 mm).

The population of *A. cerana* from different places showed significant differences in trochanter length which varied from 0.63 to 0.76 mm. The minimum length of 0.63 mm was recorded from Bajaura (being at par with Palampur and Nagrota Bagwan) but differed significantly from the population of Sangla and Bharmour. The population from Bharmour revealed maximum trochanter length and was at par with the

Table 3. Morphometrics- legs of *A. cerana* from Himachal Pradesh

Location	Coxa length (mm)	Trochanter length (mm)	Femur length (mm)	Tibia length (mm)	Metatarsus length (mm)	Metatarsus width (mm)
Bajaura	0.91± 0.05	0.63±0.04	2.29±0.06	2.72±0.09	1.83±0.06	0.98±0.04
Bharmour	0.99±0.03	0.76±0.04	2.31±0.03	2.82±0.03	1.89±0.03	1.07±0.03
Nagrota Bagwan	1.01±0.03	0.67±0.03	2.29±0.04	2.80±0.03	1.85±0.03	0.99±0.02
Palampur	0.98±0.03	0.65±0.03	2.35±0.05	2.90±0.05	1.96±0.05	1.06±0.02
Sangla	1.08±0.02	0.73±0.03	2.42±0.03	2.95±0.03	1.97±0.03	1.07±0.02
Mean	0.99	0.69	2.33	2.84	1.90	1.03
LSD _(P=0.005)	0.05	0.05	0.06	0.07	0.06	0.04
MSS (E)	0.007	0.007	0.012	0.017	0.011	0.004

population of Sangla. Samples from Nagrota Bagwan and Sangla were also found to be statistically different. The mean of trochanter length was (0.69 mm).

The data on *A. cerana* from Sangla revealed greater femur length (2.42 mm) which was significantly different. The samples from Bajaura and Nagrota Bagwan recorded minimum femur length (2.29 mm) and were statistically at par with those of Bharmour and Palampur. On the basis of overall mean, it measured 2.33 mm. Earlier, (Tan et al., 2008) reported that length in *A. cerana*, 3.02-3.22 mm in China. Greater femur length ranging from 2.34- 2.58 mm had been reported for Indian population compared to the present findings (Hepburn et al., 2001a), whereas it was 2.10- 2.17 mm in Sri Lanka (Szabo 1990).

Different populations of *A. cerana* showed significant differences in tibia length and varied from 2.72 (Bajaura) to 2.95 mm (Sangla). The samples from Bharmour and Nagrota Bagwan were statistically at par in their tibia length, but were significantly different from that of Sangla (2.95 mm) and Palampur (2.90 mm) (both at par). Indian population of *A. cerana*, tibial length has been reported as 3.097 to 3.147 mm (Mattu and Verma 1984b) and 2.88 to 3.20 mm (Hepburn et al., 2001a) which is higher compared to the present findings. The tibial length has been reported as 1.90 to 2.30 mm in China (Tan et al., 2008), 2.46 to 2.65 mm in Sri Lanka (Szabo 1990), 2.87 mm in Thailand and 2.86 mm in Vietnam (Niem and Trung 1999).

The data on the measurement (length and width) of metatarsus reveal that among the different population of *A. cerana*, the minimum (1.83 mm) and maximum (1.97 mm) metatarsus length were recorded from Bajaura (statistically at par with those of Nagrota Bagwan and Bharmour) and Sangla (being at par with Palampur), respectively and differed significantly from each other. *A. cerana*, shows maximum metatarsus width (1.07

mm) was recorded from Sangla and Bharmour (being at par with Palampur) and minimum (0.98 mm) from Bajaura (statistically at par with Nagrota Bagwan). The metatarsus length and width were found to be 1.90 and 1.03 mm in *A. cerana*. Metatarsus length was measured to be 1.82 to 2.00 mm for India population (Hepburn et al., 2001a) and 1.07 to 1.12 mm for China population (Tan et al., 2008) length x width have been measured as 1.53-1.72 x 0.90-0.96 in Sri Lanka (Szabo 1990), 1.32 x 1.03 mm in Vietnam and 1.72 x 1.00 mm in Thailand (Niem and Trung 1999).

A. cerana is found practically throughout India. There are several races of this bee species. Generally plain and hill races have been recognised. Ruttner (1988) examined the morphometrics of different subspecies of *A. cerana* for a number of characters. Morphometrics of three characters of honey bee races which were common in his studies and in the present investigations are presented in Table 4. In the present investigations, proboscis length, cubital index and fore wing length of *A. cerana*, the mean proboscis length, fore wing length and cubital index was measured as 5.41mm (range: 5.35 to 5.46 mm), 8.67 mm (range: 8.46 to 8.92 mm) and 3.01 (range: 2.70 to 3.33), respectively. Out of these, the morphometrics of proboscis and fore wing length are very close to that of *cerana* race. However, the cubital index value is at wide variance of *cerana*. The present observations can be considered in line to those of Ruttner (1988) to some extent.

Thus there are variations with the data available in the literature. It can be attributed to many factors such as varying geographical conditions and presence of different races. Besides, bee samples collected during different seasons even at the same place also have remarkable effect on the biometry of honey bees (Mattu and Verma 1984b).

Table 4. Selected morphometric data of *A. cerana* races as reported by Ruttner (1988)

Subspecies	Distribution	Proboscis length	Cubital index	Fore wing length
<i>cerana</i>	Asia	5.28	4.19	8.63
<i>indica</i>	Asia	4.79	3.96	7.90
<i>himalaya</i>	Asia	5.15	3.71	8.04
<i>philippines</i>	Philippine	4.58	3.18	7.43
<i>japonica</i>	Japan	5.18	6.40	8.69

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