Original Research

Evaluation of Morphometric Characters of the *Pieris canidia* and *Danaus chrysippus* Butterflies in different geographical area in Uttar Pradesh and Uttarakhand

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Abstract
The purpose of this study was to describe the morphometric features of the butterflies Pieris canidia and Danaus chrysippus, such as their morphometric lengths. Butterflies were collected at random from the Sohagi Barwa Wildlife Sanctuary in the Maharajganj and the Himalaya Botanical Garden in Nainital, Uttarakhand. We used a Canon 750D DSLR camera to take the pictures of the butterflies. We used ImageJ software (1.48v) to measure seven different morphometric lengths from the Body length (BL), Antenna length (AL), Forewing length (FL), Hindwing length (HL), Foreleg length (FL), Midleg length (ML), and Hindleg length (HLL). The measurement of morphometric length of two butterfly species *Pieris canidia* and *Danaus chrysippus*. The mean length was recorded as 22.15 ± 1.52 mm, 12.2 ± 0.55 mm, 23.6 ± 0.88 23.2 ± 0.65, 6.8 ± 0.35 mm, 8.85 ± 0.32 and 11.05 ±0.38 mm in Body length (BL), Antenna length (AL), Forewing length (FL), Hindwing length (HL), Foreleg length (FL), Midleg length (ML), and Hindleg length (HLL) respectively, in the *P. canidia* butterfly. The mean length was recorded as 11.05±1.60 mm, 13.305±0.60 mm, 32.115±1.49mm, 27.700±0.68 mm, 8.75±0.88 mm, 11.1±1.00 mm in Body length (BL), Antenna length (AL), Forewing length (FL), Hindwing length (HL), Foreleg length (FL), Midleg length (ML), and Hindleg length (HLL) respectively, in *D. rysippus* the butterfly.

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Statement of Sustainability: Morphometric analysis of butterfly wings providing a sustainable way to track the population changes and understand the adaptation to environmental changes without affecting the endangered species by using eco-friendly sampling methods.

1. Introduction

Butterflies (Lepidoptera: Papilionoidea) are a significant element of biodiversity in natural ecosystems due to their complex interconnections within the food web (Bonebrake *et al.*, 2010). The techniques of morphometric have been engaged to facilitate quantitative measurement and morphometric variation study in the size and shape of the butterfly species (Digo *et al.*, 2015). Morphometric traits, such as body length, proboscis, antenna, wings, and legs, are what most people use to classify butterflies.

Morphological traits of diverse butterflies exhibit specific correlations with their evolutionary context and the natural selection (Azrizal-Wahid *et al.*, 2015). Morphometrics are essential to entomology because they offer important insights into the systematics, ecology, and taxonomy of insects (Azrizal-Wahid *et al.*, 2023). This field identifies and analyzes insect body parts' shape, size, and proportions, identifying species, differentiating populations or subspecies, and understanding evolutionary relationships (Baylac *et al.*, 2003; Aytekin *et al.*, 2007). *P. canidia* is belongs to the Pieridae family, this is known the Indian cabbage white, is a serious pest of crucifer plants in numerous countries in Asia (Evans, 1926). *D. chrysippus* known as the African monarch, African queen or plain tiger, is belongs to the Nymphalidae family. These pollinators which is play a crucial role in the biodiversity and maintenance of ecosystem but butterfly populations have experienced significant declines in recent decades as a result of anthropogenic activity (Zattara and Aizen, 2021).

Changes and fluctuations in the environment exert selective pressures on the population due to the finite nature of both the environment and the energy fixation within any specific ecosystem (Bashar, 2016). Insects are good model organisms for finding small changes in the environment that can change where they live (Forister *et al.*, 2019). High temperatures and harsh weather conditions can cause physiological stress in butterflies, affecting their growth, development, and overall well-being. (Hill *et al.*, 2021; Bonifacino *et al.*, 2022). The temperature of 32°C was chosen to ensure the species' survival throughout the pupal stage (Von *et al.*, 2023). Butterfly wing morphology commonly varies among species and populations and even between the two sexes. Genetic, epigenetic, and environmental variability are considered to interact complexly to cause variation in wing shape (Watt, 2003; Nosil, 2012). The present study highlights the task of morphometric analysis such as body length (BL), antenna length (AL), forewing length (FL), hindwing length (HL), foreleg length (FL), midleg length (ML), and hindleg length (HLL) from different area of Uttar Pradesh and Uttarakhand.

2. Materials and methods

2.1. Butterflies species

The butterfly *P. canidia* and *D. chrysippus* were collected from Himalaya botanical garden (HBG), Uttarakhand and Sohagi Barwa Wildlife Sanctuary Maharajganj District Uttar Pradesh, India. The species was recognized using the features reported by Kunte (2000) and Butterflies of India.

2.2. Sampling sites

Sohagi Barwa Wildlife Sanctuary, Maharajganj District, Uttar Pradesh area spread across the sub montane area of Terai in Uttar Pradesh, India. The temperature ranges between 0°C to 40°C. The average annual rainfall is >1,500 mm. The earth surface is almost plain and the altitude varies between 95–103 m above mean sea level. Geographical coordinates 26° 50- 27° 30 N and 27°30 and 83°10 - 83°50 N. Himalaya botanical garden (HBG) Nainital, Uttarakhand, India area sample collection was done by different sites located in Nainital region**.** The average annual rainfall 1903 mm, temperature reaches up to 27°C in summer and 1.1-10.4°C in winters and altitude ranging from 1,940–2,100 m above sea level. It is located at 29.38°N 79.45°E (Figure 1).

2.3. Sampling and preservation

The samples were collected using a random sampling technique. Specimens were collected using sweep nets and handpicking methods. The specimens were narcotized with ethyl acetate and then air dried for preservation at the Department of Zoology, Kamla Nehru Institute of Physical and Social Sciences, Sultanpur, Uttar Pradesh.

2.4. Photography

For morphometric measurements, photos of the preserved specimens were taken with a DSLR camera (Canon 750D). According to (Mahdi *et al.*, 2021) photographs are obtained by placing various portions of the butterfly on a scale.

2.5. Morphometric analysis

Morphometric measures were taken with electronic digital Vernier callipers in mm scale. Data was evaluated for mean ± standard deviation (n = 10). The morphometric study used Image J software to measure the collected images. For morphometric analysis, 7 characters that represented the butterfly's wings and body parts were measured. The following characteristics are used: Body length (BL), Antenna length (AL), Forewing length (FL), Hind wing length (HL), Fore leg length (FL), Mid leg length, Hind leg length (HL). Figures 2 ,3 and 4 shows a thorough description of each character along with an image of each measurement.

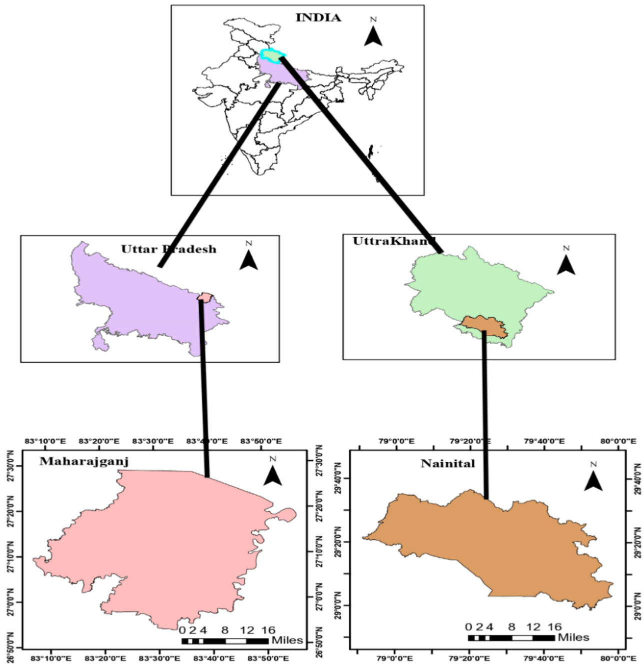

Figure 1. Study map of different site of geographical area of Uttar Pradesh and Uttarakhand.

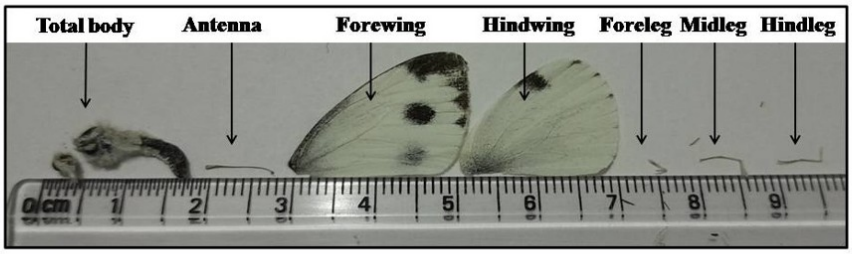

Figure 2. Morphological study of distinct parts of the *P. canidia*.

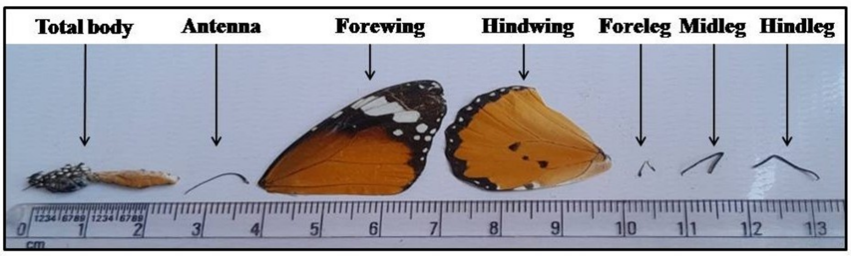

Figure 3. Morphological study of different parts of the *D. chrysippus*

2.6. Data Analysis

Descriptive statistical analyses, including mean, standard deviation, minimum, and maximum values, were carried out for the morphometric parameters of butterflies using Microsoft Excel 2013.

3. Results and discussion

Morphometric analysis of 7 parameters of Pieriscanidia and Danauschrysippus was evaluated. We examined the body length (BL), antenna length (AL), forewing length (FL), hindwing length (HL), foreleg length (FL), midleg length (ML), and hindleg length (HLL) (Table 1 and 2).

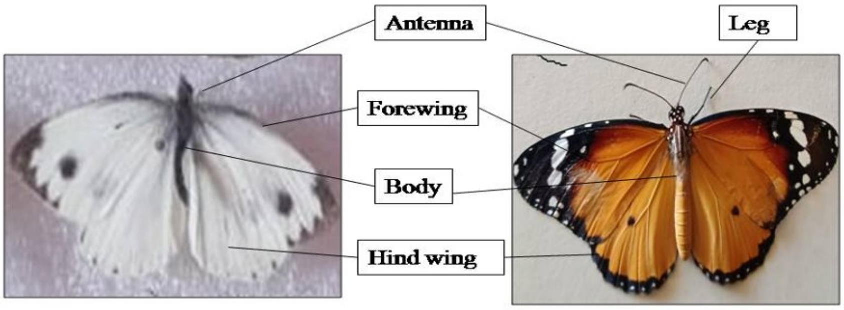

Figure 4. The morphological study of butterfly species *P. canidia* and *D. chrysippus*.

3.1. Analysis of morphometric characters in P. canidia

The morphometric analysis of *P. canidia* (n = 10) revealed moderate variation across all measured characters (Table 1). Body length ranged from 19.11 to 25.2 mm, with a mean of 22.15 ± 1.52 mm, indicating relatively low variability within the sampled population. Antenna length showed minimal variation (11.10–13.3 mm; mean 12.2 ± 0.55 mm), suggesting consistency in sensory appendage size. Wings measurements demonstrated slightly higher uniformity. The forewing length ranged from 22.0 to 25.2 mm (mean 23.6 ± 0.88 mm), while hindwing length varied between 21.9 and 24.5 mm (mean 23.2 ± 0.65 mm). These results indicate proportional development of forewings and hind wings. Leg measurements showed gradual increases from forelegs to hindlegs. Foreleg length ranged from 6.11 to 7.51 mm (mean 6.8 ± 0.35 mm), midleg length from 8.21 to 9.5 mm (mean 8.85 ± 0.32 mm), and hindleg length from 10.3 to 11.8 mm (mean 11.05 ± 0.38 mm). This pattern reflects functional adaptation in locomotion. The total body length varied between 98.73 and 117.01 mm, with a mean of 107.85 ± 2.04 mm, showing overall size consistency among individuals. Median values for all parameters were very close to their respective means, indicating a symmetrical distribution of data without significant skewness.

Table 1. Measurements of different morphometric characters of the *P. canidia* (*n* =10).

Parameters	Min (mm)	Max (mm)	Mean ±SD	Median
Body length (BL)	19.11	25.2	22.15 ± 1.52	22.16
Antenna length (AL)	11.10	13.3	12.2 ± 0.55	12.20
Forewing length (FL)	22	25.2	23.6 ± 0.88	23.60
Hindwing length (HL)	21.9	24.5	23.2 ± 0.65	23.20
Foreleg length (FL)	6.11	7.51	6.8 ± 0.35	6.81
Midleg length (ML)	8.21	9.5	8.85 ± 0.32	8.86
Hindleg length (HLL)	10.3	11.8	11.05 ± 0.38	11.05
Total length	**98.73**	**117.01**	**107.85 ± 2.04**	**107.88**

The present morphometric analysis of *P. canidia* demonstrates measurable variation in body size and appendage dimensions, reflecting both intra-specific variability and environmental influence. According to our data, it is stated that the morphometric characters viz. pattern, length, width and venation of wings, body length, forewing, hindwing could be used as a guide for taxonomic discrimination (Azrizal-Wahid *et al.*, 2016; Akand *et al.*, 2018; Mahdi *et al.*, 2018). The recorded range in body length, wing size, and leg measurements indicates that even within a small sample population (n=10), individuals exhibit noticeable morphological differences. Such variation is commonly associated with ecological factors including temperature, altitude, and host plant quality, which directly affect larval development and adult morphology (Ashton *et al.*, 2009). The relatively low standard deviation observed in wing dimensions (forewing and hindwing length) suggests structural consistency, which is essential for maintaining effective flight performance. Wing morphology in butterflies is strongly linked to dispersal ability and habitat utilization, and stable wing traits often indicate adaptation to a specific ecological niche (Le Roy *et al.*, 2019). In contrast, moderate variation in body length and total length suggests phenotypic flexibility, allowing individuals to respond to environmental variability. Mahdi *et al.* (2021) was reported that the mean of total length of the body was recorded as 16.10 ± 2.55 mm for E. hecabe. Results shown the total body length of *P. canidia* noted that 19.2 ± 0.98 mm. Many authors were found that same results (Akand *at al.*, 2017; Mahdi *et al*., 2018). Antenna and leg measurements showed comparatively smaller variation, indicating their conserved functional roles in sensory perception and locomotion. These traits are less influenced by external environmental conditions and are more tightly regulated genetically (Moradinour *et al.,* 2021). The close agreement between mean and median values across most parameters further supports the presence of a relatively homogeneous population with limited skewness, although minor deviations point to phenotypic plasticity.

3.2. Analysis of morphometric characters in D. chrysippus

The morphometric analysis of *D. chrysippus* (n = 10) showed noticeable variation across measured characters (Table 2). Body length ranged from 21.10 to 27.50 mm, with a median value of 24.30 mm. Although the reported mean ± SD appears inconsistent (11.05 ± 1.60 mm), the median and range suggest that the average body length lies around the mid-20 mm range, indicating moderate variability among individuals. Antenna length varied from 12.10 to 14.51 mm, with a mean of 13.305 ± 0.60 mm, reflecting low variability and structural consistency. Wing measurements showed comparatively higher values than body size. Forewing length ranged from 29.13 to 35.10 mm (mean 32.115 ± 1.49 mm), while hindwing length ranged from 26.30 to 29.01 mm (mean 27.700 ± 0.68 mm), indicating well-developed wings with relatively low dispersion. Leg measurements showed progressive increase from forelegs to hindlegs. Foreleg length ranged from 7.00 to 10.50 mm (mean 8.75 ± 0.88 mm), midleg length from 9.10 to 13.10 mm (mean 11.1 ± 1.00 mm), and hindleg length from 9.50 to 14.50 mm (mean 12.00 ± 1.25 mm). This gradient reflects functional differentiation in locomotory appendages. Total length varied from 114.23 to 144.22 mm, with a mean of 129.23 ± 2.78 mm, suggesting overall size uniformity within the population. Median values were very close to the means for most parameters, indicating a fairly symmetrical distribution of measurements.

Table 2. Measurements of different morphometric characters of the *D. chrysippus* (*n* =10).

Parameters	Min (mm)	Max (mm)	Mean ±SD	Median
Body length (BL)	21.10	27.50	11.05±1.60	24.30
Antenna length (AL)	12.1	14.51	13.305±0.60	13.31
Forewing length (FL)	29.13	35.10	32.115±1.49	32.12
Hindwing length (HL)	26.30	29.01	27.700±0.68	27.66
Foreleg length (FL)	7.00	10.50	8.75±0.88	8.75
Midleg length (ML)	9.10	13.10	11.1±1.00	11.10
Hindleg length (HLL)	9.50	14.50	12.00± 1.25	12.00
Total length	**114.23**	**144.22**	**129.23±2.78**	**129.23**

The morphometric analysis of *D. chrysippus* revealed measurable variation across all studied parameters, indicating intra-specific variability and environmental influence. The observed differences in body length, wing dimensions, and appendage sizes suggest adaptive responses to ecological factors such as temperature, humidity, and host plant availability. In particular, the relatively low standard deviation in forewing and hindwing lengths highlights structural stability, which is essential for efficient flight and survival (DeVrise *et al.*, 2010). Body size variation in butterflies is strongly associated with geographic gradients and environmental stressors. Larger wing spans may improve dispersal ability, while smaller body sizes can be advantageous under resource-limited conditions (Ashton *et al.*, 2009). The moderate variation observed in antenna and leg lengths reflects their specialized roles in sensory perception and locomotion, which are generally less influenced by environmental fluctuations compared to overall body size (Moradinour *et al.*, 2021). The close agreement between mean and median values across most morphometric traits indicates a relatively homogeneous population. However, slight deviations suggest the presence of phenotypic plasticity, a common feature in butterflies influenced by larval nutrition and climatic conditions (Kingsolver & Buckley, 2018). Such plasticity allows individuals to adjust their morphology in response to environmental variability, thereby enhancing survival and reproductive success. Recent study highlights the importance of morphometric analysis in understanding ecological adaptation, biodiversity assessment, and conservation planning. Variations in wing morphology are closely linked with flight performance and habitat fragmentation, making them useful indicators of environmental change (Le Roy *et al.*, 2019). Additionally, morphometric traits play a key role in taxonomic identification and differentiation among closely related species (Singh *et al.*, 2020).

4. Conclusion

The present study highlights the effectiveness of morphometric analysis in understanding species-specific variations in butterflies. Both *Pieris canidia* and *Danaus chrysippus* exhibited relatively low intraspecific variability, indicating stable morphological traits within the studied populations. The close alignment between mean and median values further confirms uniform distribution of morphometric characters. Comparative analysis revealed that *D. chrysippus* possesses larger body size, wing dimensions, and overall length than *P. canidia*, suggesting better adaptation for stronger flight and wider dispersal. In contrast, the smaller size of *P. canidia* may be associated with localized movement and different ecological preferences. The consistent increase in leg length from forelegs to hindlegs in both species reflects functional specialization in locomotion. Overall, these findings demonstrate that morphometric parameters provide valuable insights into species differentiation, ecological adaptation, and evolutionary significance of butterflies.

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Author Contributions

Suresh Kumar: Performed and analyzed the study and wrote the original draft; Ram Pher and Chandra Bhushan: Writing-review & editing. Roshan Lal Gautam: Reviewed the data; Sanjay Kumar: Conceptualized the study and critically reviewed the experiments during the entire study.

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Conflicts of Interest

The authors declare no competing interests.

Institutional/Ethical Approval

Not applicable.

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