Jurnal Biologi Tropis

Original Research Paper

Morphometric Characterization Study of *Apis cerana* Worker Bees in North Lombok Regency

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Article History
Received : Desember 18th, 2024
Revised : January 17th, 2025
Accepted : February 07th, 2025

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Abstract: Honeybees (Apis cerana) are one of the indigenous honeybee species of Asia. They serve a crucial function in ecosystems, mostly as pollinators. This study investigates the morphometric characteristics of *Apis cerana* worker bees in North Lombok Regency, focusing on two beekeeping groups: Harapan Keluarga and Tunas Muda, located in Salut village, Kayangan District North Lombok Regency. Morphometric analysis was conducted on 40 colonies, with measurements taken from eight key body traits: body length, abdomen length, femur length, tibia length, metatarsus length, forewing length, hindwing length, and body weight. Results revealed significant differences between the two locations. Tunas Muda bees exhibited larger morphometric traits with lower coefficient variations, indicating higher population uniformity. Correlation and regression analyses showed that body length, forewing length, and abdomen length strongly influence body weight, with body length having the highest correlation (r = 0.85) and determination coefficient (R^2 = 0.722). The study highlights the impact of environmental factors, management practices, and nutritional conditions on bee morphology. These findings provide critical insights for enhancing beekeeping practices, supporting honeybee conservation efforts, and exploring genetic and physiological adaptations in *Apis cerana*. This research underscores the importance of integrating morphometric analysis into sustainable apiculture and biodiversity conservation strategies in North Lombok.

Keywords: *Apis cerana*; Honeybee conservation; Morphometric characteristics; North Lombok apiculture

Introduction

Honeybees (*Apis cerana*) are one of Asia's native honeybee species. They play a vital role in ecosystems, primarily as pollinators. Their contributions extend beyond ecological benefits to economic importance, particularly in agriculture and livestock. Research on honeybee morphometrics is essential for understanding the morphological variations contributing to their environmental adaptations, including in the North Lombok Regency, which features diverse geography and ecology.

Previous studies indicate that factors such as environment, ecosystems, and farming practices influence honeybee morphometric characteristics. For instance, Widiawati et al. (2020) identified morphometric differences in *Apis cerana* worker bees across agricultural, forest, and urban ecosystems, emphasizing the significance of local environmental adaptations in shaping honeybee morphology. This observation is relevant to North Lombok Regency, encompassing ecosystems from lowlands to mountainous regions.

Frunze et al. (2022) highlighted that morphometric variations could distinguish

honeybee populations based on habitat. They found that bees in wild habitats exhibit larger body sizes compared to urban or rural areas due to physiological adaptations to extreme environmental conditions. Morphometric traits thus reflect environmental influences and adaptive survival strategies.

In addition to environmental factors, farming practices significantly impact honeybee morphology. Mattiello et al. (2022) revealed that techniques like queen cell size influence worker bee morphometrics. These practices, prevalent in North Lombok Regency's traditional beekeeping methods, warrant further exploration.

Morphometric methods are widely employed to identify honeybee species and subspecies and study population diversity. As Bouga et al. (2010) noted, multivariate morphometric analysis reveals significant differences between bee populations in various regions, underscoring the importance of quantitative approaches in understanding population structure.

Altitude is another factor influencing honeybee morphometric traits. Lozier et al. (2021) found that worker bees in mountainous areas exhibit larger body sizes, a physiological adaptation to lower temperatures and oxygen levels at higher altitudes. North Lombok Regency's geographical diversity, encompassing lowlands and mountains, makes it an ideal location for such studies.

Morphometric studies have crucial implications for honeybee conservation. Prastiyo et al. (2024) emphasized that understanding morphometric variations aids in managing and conserving honeybee populations. Identifying locally adapted subspecies or strains can enhance sustainable beekeeping. This is particularly relevant in North Lombok, where honeybee population sustainability is critical for supporting agriculture and local ecosystems.

Furthermore, Jasmi (2022) demonstrated that honeybee farming at different altitudes results in significant morphometric variations among worker bees. This insight applies to North Lombok, where elevation varies from coastal areas to mountains, highlighting the need to consider local environmental conditions in beekeeping management (Erwan & Agussalim, 2022).

This study examines the morphometric characteristics of *Apis cerana* worker bees in North Lombok Regency. It seeks to provide insights into how environmental factors and farming practices influence honeybee morphology, paving the way for better conservation and management strategies. North Lombok's unique geographical and ecological features, including diverse ecosystems and traditional beekeeping practices, make it an ideal study area (Erwan et al., 2021).

The findings of this study are expected to contribute to honeybee conservation and management efforts in North Lombok. Moreover, they aim to serve as a foundation for future research focusing on the genetic diversity and physiological adaptations of honeybees in the region. This research sheds light on the species' local adaptations by understanding the morphometric variations of *Apis cerana* worker bees. It contributes to developing more effective conservation strategies that support ecosystem sustainability and agricultural productivity. This research marks an important step toward better honeybee management in North Lombok Regency.

Material and Method

Materials

Morphometric analysis was performed at the Laboratory of Animal Breeding and Genetics, Faculty of Animal Science, University of Mataram. The observed population consisted of *Apis cerana* worker bees from 40 colonies, including 20 from Harapan Keluarga and 20 from Tunas Muda. Randomly selected worker bee samples represented each colony. Morphometric measurements were conducted on eight key body traits: body length, abdomen length, femur length of the hind leg, tibia length of the hind leg, metatarsus length, forewing length, hindwing length, and body weight.

Methods

Research Location and Duration

This study was conducted in Salut village, Kayangan District, North Lombok Regency. Bee

samples were collected from the Harapan Keluarga and Tunas Muda groups. Data collection and morphometric measurements were performed over three months, from July to September 2024. Data analysis was conducted at the Laboratory of Animal Breeding and Genetics, Faculty of Animal Science, University of Mataram.

Research Design

A descriptive quantitative design was used to describe the morphometric variations of *Apis cerana* worker bees. Data were obtained through direct measurements using high-precision tools.

Sample Collection

Samples were selected using purposive sampling based on active and healthy colonies. Each group provided 20 colonies, making a total of 40 colonies observed. From each colony, 10 worker bees were randomly selected, resulting in 400 worker bees analyzed.

Morphometric Measurement Procedure

Worker bees selected as samples were humanely euthanized using a 70% ethanol solution. The bees were then stored in sealed containers until measurement. Measurements were conducted using a stereo microscope and digital caliper with a precision of 0.01 mm. The morphometric traits measured included:

1. Body Length: Measured from the head to the end of the abdomen.
2. Abdomen Length: Measured from the base to the tip of the abdomen.
3. Femur Length of the Hind Leg: Measured from the base to the tip of the femur on the hind leg.
4. Tibia Length of the Hind Leg: Measured from the base to the tip of the tibia on the hind leg.
5. Metatarsus Length: Measured from the base to the tip of the metatarsus.
6. Forewing Length: Measured from the base to the tip of the forewing.
7. Hindwing Length: Measured from the base to the tip of the hindwing.
8. Body Weight: Measured using a digital scale with a precision of 0.001 grams.

Data Analysis

The data obtained were statistically analyzed using the latest version of SPSS software. The parameters studied included means, standard deviations, and coefficients of variation for each morphometric characteristic. Comparisons between the two beekeeping groups were analyzed using an independent two-sample t-test to determine significant differences between Harapan Keluarga and Tunas Muda. Correlation and regression analyses were conducted to assess the strength and direction of linear relationships between body weight and each morphometric characteristic. Correlation results were presented as correlation coefficients (r) with values ranging from -1 to 1, interpreted as follows: 0.00–0.30: Very weak relationship; 0.31–0.50: Weak relationship; 0.51–0.70: Moderate relationship; 0.71–0.90: Strong relationship; 0.91–1.00: Very strong relationship. A simple linear regression model was used for each characteristic, with body weight as the dependent variable (Y) and morphometric characteristics as the independent variable (X). The general regression equation was as follows:

$$Y = \beta_0 + \beta_1 X + \epsilon$$

Y	=	Body weight
X	=	Morphometric characteristic
β_0	=	Intercept
β_1	=	Regression coefficient (indicating the magnitude of change in Y for a one-unit change in X)
ϵ	=	Error term

Results and Discussion

Morphometric Characteristics of *Apis cerana* Worker Bees

The results presented in Table 1 reveal the morphometric characteristics of *Apis cerana* worker bees from two locations in Salut Village, Kayangan District, North Lombok Regency: Location 1 (Harapan Keluarga Group) and Location 2 (Tunas Muda Group). The averages and coefficients of variation (CV) of the morphometric characteristics, including body length, abdomen length, hind femur length, hind tibia length, metatarsus length, forewing length, hindwing length, and body weight, were analyzed.

Table 1. Morphometric characteristics of *Apis cerana* worker bees from Salut village, Kayangan District, North Lombok Regency.

No	Morphometric Characteristics of *Apis cerana* Worker Bees	Location 1		Location 2	
		Average ± SD	CV (%)	Average ± SD	CV (%)
1	Body Length	10.09±0.17	1.69	10.14±0.20	1.99
2	Abdomen Length	5.28±0.24	4.47	5.35±0.19	3.60
3	Femur Length (Hind Leg)	2.59±0.03	1.06	2.61±0.03	1.04
4	Tibia Length (Hind Leg)	2.61±0.02	0.82	2.62±0.02	0.73
5	Metatarsus Length	2.00±0.02	0.94	2.01±0.01	0.65
6	Forewing Length	7.71±0.11	1.41	7.71±0.10	1.31
7	Hindwing Length	5.18±0.05	0.97	5.20±0.09	1.73
8	Body Weight	0.06±0.01	9.93	0.07±0.01	7.66

CV: Coefficient of Variation

The average body length was slightly higher at Location 2 (10.14 mm) compared to Location 1 (10.09 mm). The coefficient of variation (CV) at Location 1 (1.69%) was lower than at Location 2 (1.99%), indicating a smaller variation at Location 1. Location 2 exhibited a greater abdomen length (5.35 mm) compared to Location 1 (5.28 mm), with a lower CV at Location 2 (3.60%) than at Location 1 (4.47%). The average difference between the two locations was very small, reflecting high consistency in this characteristic. The lower CV at Location 2 indicates better uniformity. Location 2 also had a slightly higher average metatarsus length (2.01 mm) compared to Location 1 (2.00 mm), with a lower CV at Location 2 (0.65%). The forewing length had the same average in both locations (7.71 mm), while the hindwing length was slightly higher at Location 2 (5.20 mm). The CV for both these characteristics was lower at Location 2. Location 2 also showed a higher average body weight (0.07 g) compared to Location 1 (0.06 g), with a lower CV (7.66% at Location 2 vs. 9.93% at Location 1), indicating a more uniform population at Location 2.

The study results demonstrate that worker bees at Location 2 exhibit slightly larger morphometric traits with lower variation coefficients than Location 1. This may be attributed to environmental factors, colony management, and the availability of food resources. Morphometric differences can be associated with microclimate variations, such as temperature, humidity, and food resource availability (Bhatta & A, 2022; Novita et al., 2013). Location 2 likely provides more favorable environmental conditions for the growth of worker bees. Better management practices at Location 2 may contribute to increased body size and weight in worker bees (Dziechciarz et al., 2021). Optimal colony conditions, including sufficient food availability, support more uniform morphometric development. Larger body size, particularly longer abdomen and wings, is associated with flight efficiency and the working capacity of bees (Araújo et al., 2004; Grula et al., 2021). The higher body weight observed at Location 2 reflects better nutritional conditions.

Comparison of *Apis cerana* Morphometry with Previous Studies

Table 2 compares the morphometric characteristics of *Apis cerana* from various locations in Indonesia, including findings from the North Lombok Regency, Kepahiang, Bengkulu City, Gunung Kidul, and Kulonprogo. The comparison is based on several morphometric traits: body length, abdomen length, hind leg femur length, hind leg tibia length, metatarsus length, forewing length, hindwing length, and body weight.

Table 2. Comparison of Morphometric Characteristics of *Apis cerana* with Previous Studies Based on Different Locations in Indonesia

No	Morphometric Characteristics of *Apis cerana*	[1]North Lombok	[2]Kepahiang	[2]Bengkulu City	[3]Gunung Kidul	[3]Kulonprogo
1	Body Length (mm)	10.12 ± 0.19	-	-	9.89 ± 0.51	10.26 ± 0.96
2	Abdomen Length (mm)	5.32 ± 0.22	-	-	-	-
3	Hind Leg Femur Length (mm)	2.60 ± 0.03	2.10 ± 0.01	2.07 ± 0.12	2.41 ± 0.17	2.00 ± 0.14
4	Hind Leg Tibia Length (mm)	2.62 ± 0.02	2.50 ± 0.09	2.52 ± 0.09	2.49 ± 0.15	2.51 ± 0.12
5	Metatarsus Length (mm)	2.01 ± 0.02	2.01 ± 0.12	2.02 ± 0.06	1.79 ± 0.16	1.63 ± 0.08
6	Forewing Length (mm)	7.71 ± 0.10	7.68 ± 0.19	7.56 ± 0.12	7.59 ± 0.30	7.45 ± 0.25
7	Hindwing Length (mm)	5.19 ± 0.07	-	-	-	-
8	Body Weight (g)	0.06 ± 0.01	0.07 ± 0.00	0.06 ± 0.01	0.04 ± 0.05	0.04 ± 0.07

Notes: [1]Current Study Results; [2]Novita et al., (2013); [3]Widiawati et al., (2020)

The bees in North Lombok have an average body length of 10.12 mm. Meanwhile, the average body lengths in Gunung Kidul and Kulonprogo are 9.895 mm and 10.262 mm, respectively. This indicates variations in body length across different locations. Data on abdomen length is only available from North Lombok, with an average of 5.32 mm. No data from other places is available. The bees from North Lombok have an average hind femur length of 2.60 mm, slightly longer than those in Kepahiang (2.10 mm) and Bengkulu City (2.07 mm). However, the hind femur width is larger in Gunung Kidul (2.42 mm) than North Lombok's.

The bees in North Lombok have an average hind tibia length of 2.62 mm, slightly longer than in other locations such as Kepahiang, Bengkulu City, and Kulonprogo, where the lengths range around 2.50 mm. The metatarsus length in North Lombok is 2.01 mm, slightly longer than in Gunung Kidul (1.79 mm) and Kulonprogo (1.64 mm). The forewing length in North Lombok (7.71 mm) is relatively similar to the findings in Kepahiang (7.68 mm) and Bengkulu City (7.57 mm) but slightly longer than in Kulonprogo (7.46 mm). Data on hindwing length is only available from North Lombok (5.19 mm). The body weight of bees from North Lombok (0.06 ± 0.01 g) is similar to that in Bengkulu City but higher than in Gunung Kidul and Kulonprogo.

The differences in body length of *Apis cerana* bees across various locations might be influenced by genetic factors, environmental conditions, and resource availability. The findings in North Lombok are relatively comparable to those in Gunung Kidul and Kulonprogo, although slightly shorter than in Kulonprogo. This suggests that environmental factors, such as food availability or local climate, could influence the bees' body development (Czekońska et al., 2023; Gajger & Mutinelli, 2024). Only data from North Lombok shows an average abdomen length of 5.32 mm, which is relatively longer compared to other areas where no data is available. Variations in abdomen length might be influenced by the level of food supply and colony management (Shawer et al., 2021).

Differences in hind femur length might be related to the bees' morphological adaptations to terrain or flower shapes available for foraging. Bees in Gunung Kidul have longer femurs, which may enhance their nectar-collecting abilities (Wei et al., 2023). Differences in tibia length might reflect variations in adaptation or morphology governed by genetic or environmental factors, such as altitude or microclimate. Bees in North Lombok and other locations exhibit small variations in tibia length, possibly linked to functional needs during food collection (Sauthier et al., 2016). The body weight of bees in North Lombok (0.06 ± 0.01 g) is higher than in Gunung Kidul and Kulonprogo.

This could be associated with better food availability in North Lombok, as explained by Slater et al. (2020), who noted that the quality and quantity of food affect the body size and weight of bees.

Correlation and Regression Analysis Between the Body Weight of *Apis cerana* Bees

Table 3 presents the correlation and regression analysis between the body weight of *Apis cerana* bees and various other morphometric characteristics. Each characteristic was tested for a linear relationship with body weight using the correlation coefficient (r), significance test, regression equation, and coefficient of determination (R^2).

Table 3. Correlation and Regression Analysis Between Body Weight of *Apis cerana* and Other Morphometric Characteristics

No	Characteristic	Correlation Coefficient (r)	Significance	Regression Equation	Coefficient of Determination (R^2)
1	Body Length	0.85	Significant	Y = 0.002 + 0.005X	0.722
2	Abdomen Length	0.78	Significant	Y = 0.001 + 0.006X	0.608
3	Femur Length of Hind Leg	0.67	Significant	Y = 0.004 + 0.008X	0.448
4	Tibia Length of Hind Leg	0.65	Significant	Y = 0.003 + 0.009X	0.422
5	Metatarsus Length	0.60	Significant	Y = 0.005 + 0.010X	0.360
6	Forewing Length	0.82	Significant	Y = 0.001 + 0.004X	0.672
7	Hindwing Length	0.74	Significant	Y = 0.002 + 0.007X	0.548

The body length exhibited the highest correlation with body weight (r = 0.85), followed by forewing length (r = 0.82) and abdomen length (r = 0.78). The lowest correlation was observed in metatarsus length (r = 0.60). All variables demonstrated a significant relationship with body weight. The regression equations illustrate how changes in morphometric characteristics influence body weight. For instance, body length has the equation Y = 0.002 + 0.005X, indicating that every 1 mm increase in body length contributes to a 0.005 g increase in body weight. The highest R^2 value was found in body length (R^2 = 0.722), suggesting that 72.2% of the variation in body weight can be explained by body length. Metatarsus length had the lowest R^2 value (R^2 = 0.360), indicating a smaller contribution to body weight.

The analysis results indicate that body length, forewing length, and abdomen length are the most significant morphometric characteristics influencing the body weight of *Apis cerana* bees. The strong relationship between body length and body weight (r = 0.85, R^2 = 0.722) suggests that overall body size is key in determining the bee's weight. These findings align with the study by Pudasaini et al. (2020), which identified body length as a primary indicator of bee nutritional status and health.

Forewing length (r = 0.82) and hindwing length (r = 0.74) showed a significant relationship with body weight. This supports the findings of Grula et al. (2021), which demonstrated that wing length contributes to flight capability and foraging efficiency, influencing body weight. The bee's abdomen (r = 0.78) also strongly correlated with body weight. The abdomen is a storage site for food and metabolic organs, so its size reflects the bee's energy capacity. Dziechciarz et al. (2021) also reported a significant relationship between abdomen length and body weight in worker bees. Although the correlation was lower (r ranging from 0.60 to 0.67), these characteristics influence body weight significantly. This supports the findings of Mountcastle et al. (2015), which indicated that the size of the hind legs plays a role in the bee's ability to carry nectar or pollen loads. The highest R^2 values were observed in body length and forewing length, indicating that these characteristics are dominant factors in predicting bee body weight. Conversely, lower R^2 values in

metatarsus length suggest that this characteristic has a limited influence on body weight.

Conclusion

This study reveals the morphometric characteristics of worker bees (*Apis cerana*) in the North Lombok Regency, highlighting significant differences between the two research locations. Location 2 exhibited larger and more homogeneous morphometric traits than Location 1, reflecting the influence of environmental factors and management practices. The analysis identified body length, forewing length, and abdomen length as the main characteristics influencing body weight, with body length showing the strongest correlation and contribution ($r = 0.85$, $R^2 = 0.722$). These findings emphasize the importance of environmental and nutritional factors on bee morphology. This study provides valuable insights for honeybee management, supports conservation programs, and opens opportunities for further research on the genetic adaptation of honeybees in North Lombok.

Acknowledgments

The authors thank the Faculty of Animal Science, University of Mataram, for providing laboratory facilities and support throughout this research. Special thanks to the Harapan Keluarga and Tunas Muda beekeeping groups in Salut village, Kayangan district, North Lombok Regency, for their cooperation and assistance in collecting samples.

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