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Morphometric Comparison Horned Beetle (*Oryctes rhinoceros* L.) from Location SEAT Ungaran, Banyumas, and Pangandaran

Achmad Himawan[1,*], Agus Prijono[1], Refdika Farid Pradana[1]

Abstract

The rhinoceros beetle *(Oryctes rhinoceros* L.*)* is a major pest of coconut and oil palm in Indonesia. Its attacks can cause up to 25% damage to young palms and reduce fresh fruit bunch production by up to 69%. This study aimed to compare the body morphometrics of male and female O. rhinoceros collected from SEAT Ungaran (oil palm), Banyumas (coconut), and Pangandaran (coconut) in Java. Adult beetles were obtained using pheromone traps (SEAT Ungaran) and manual collection (Banyumas and Pangandaran), then measured for 20 external characters, including body, pronotum, elytra, antennae, scutellum, and leg segments. Morphometric data were analyzed using t-tests to compare sexes within locations and analysis of variance, followed by Duncan's Multiple Range Test (DMRT) at a 5% significance level to compare populations among locations. Several characters, particularly horn length, pronotum size, and hind leg segments, differed significantly between males and females at each site. In addition, body length, pronotum width, elytra length, and hind leg tibia length showed significant differences among populations from SEAT Ungaran, Banyumas, and Pangandaran. These characters are informative for distinguishing local populations of O. rhinoceros and provide baseline morphometric data to support location-specific management strategies for this pest.

Keywords: Female, Male, Morphometrics, *Oryctes rhinoceros*, Population Variation

1. Introduction

Palm oil is a high-value commodity that has been studied by several researchers (Susanti & Harahap, 2024; Fakhrezi et al., 2025; Mahendra et al., 2025). One of the main obstacles to oil palm cultivation is the rhinoceros beetle pest. The coconut rhinoceros beetle, *Oryctes rhinoceros* (Coleoptera: Scarabaeidae), is one of the main pests of coconut and oil palm in tropical Asia and the Pacific, including Indonesia, because the imago attacks the growing point and can significantly reduce plant productivity (Bedford, 2013) ; (Widyanto et al., 2022). The rhinoceros beetle attack is reported to persist across various plant ages and is associated with the availability of breeding sites, including rotting stems and bunches, piles of empty bunches, and poorly managed replanting waste (Widyanto et al., 2022). In addition to ecological and population aspects, information on morphological and morphometric variations of rhinoceros beetle individuals from various locations is potentially important for understanding local adaptation, population dynamics, and their implications for integrated pest management (IPM) strategies (Bedford, 2013; Rosario et al., 2023).

Insect morphometry is a quantitative approach to measure body size and shape traits, such as body length, body width, pronotum size, elytron, antennae, and other structures, which can describe intra- and inter-population variation (Klingenberg, 2016; Manjeri et al., 2013). In rhinoceros beetles, several morphometric studies have shown that body length, body width, pronotum length, pronotum width, and head horn length can be used to assess population variation, the possible presence of biotypes or cryptic species complexes, and sex-related differences (Manjeri et al., 2013; Bedford, 2013). Morphometric analysis combined with multivariate statistical analysis has been applied to rhinoceros beetle populations in various regions of Asia and has been reported to be able to detect morphological variations relevant for pest management, especially in the context of pheromone trap efficiency and other control strategies (Manjeri et al., 2013) ; (Rosario et al., 2023) .

*Correspondence: wawanhimawan2014@gmail.com
1) Institut Pertanian Stiper - Jl. Nangka II, Maguwoharjo, Depok, Sleman, Yogyakarta, Indonesia

At the global level, morphometric studies of rhinoceros beetles from several coconut- and palm-oil-producing countries have shown that although populations vary, they do not always form clearly separated morphological clusters, necessitating more detailed studies at regional and local scales (Manjeri et al., 2013). Studies in Malaysia and other regions have reported stability of certain morphometric characters in some populations, but also indicate differences in body size and structure that may influence interpretations of genetic diversity, adaptive capacity, and response to control programs (Manjeri et al., 2013; Bedford, 2013). On the other hand, morphometric studies of rhinoceros beetles at the local level in Indonesia are still very limited, especially those comparing populations from locations with different agro-ecosystem conditions, capture techniques, and food sources such as SEAT Ungaran, Banyumas, and Pangandaran, even though these environmental variations have the potential to influence the size and body proportions of the beetles (Widyanto et al., 2022) .

Recent research in the Philippines has shown that morphometric variation in rhinoceros beetles between locations can be detected through measurements of several body characteristics and multivariate analysis, including significant differences in body width and hind leg tibia length in certain populations (Rosario et al., 2023) . However, similar studies in Indonesia linking morphometric variation among local populations to differences in habitat conditions and capture methods are still rarely reported, so information on patterns of male and female body size variation between locations is still inadequate to provide a basis for developing location-specific management strategies (Widyanto et al., 2022). This condition raises questions about whether rhinoceros beetle populations from different locations in Java, such as SEAT Ungaran, Banyumas, and Pangandaran, show consistent morphometric differences between sexes and between locations, and which morphological characters are most sensitive for distinguishing these populations in the context of morphometric-based pest management (Manjeri et al., 2013; Rosario et al., 2023).

Based on the description, this study aims to analyze differences in body morphometry between male and female rhinoceros beetles in O. rhinoceros populations from three locations: SEAT Ungaran, Banyumas, and Pangandaran. Specifically, this study aims to: (1) determine the differences in body morphometry of male and female rhinoceros beetles in each location, (2) determine the differences in morphometry of male rhinoceros beetles between locations, and (3) determine the differences in morphometry of female rhinoceros beetles between locations so that key morphometric characters can be identified that have the potential to be used as markers of population variation at the local level.

Previous studies were conducted in Peninsular Malaysia and Medan, Sumatra (Manjeri et al., 2013), and the Philippines (Rosario et al., 2023). The novelty of this study lies in the focus of the study of rhinoceros beetle morphometry from three locations in Java with different sampling methods and agroecosystem conditions, namely the use of pheromone traps in SEAT Ungaran and manual capture in Banyumas and Pangandaran, which have not been widely reported in previous literature in Indonesia (Widyanto et al., 2022). This study measured several more complete body morphometric characters, including the length and width of the pronotum, elytron, scutellum, antennae and leg segments (femur, tibia and tarsus), so it is hoped that it can identify the most informative character combinations to distinguish male and female populations between locations at the regional scale of Java (Manjeri et al., 2013; Rosario et al., 2023). In addition, the use of inferential statistical analysis (t-test, analysis of variance, and DMRT follow-up test) on morphometric data from three local populations is expected to provide new insights into the development of a morphometric database of rhinoceros beetles in Indonesia, which can support the development of more location-specific and effective pest control strategies.

2. Material and Methods

The research was conducted at the Pest and Disease Laboratory, Stiper Agricultural Institute, Yogyakarta, at a latitude of -7.761254 and a longitude of 110.424153, ± 118 masl, from November 2025 to February 2026. The tools used were digital calipers, tweezers, cell phone cameras, and laptops. The materials used were male and female rhinoceros beetles originating from SEAT Ungaran (palm oil commodity) and Banyumas (coconut commodity) in Central Java, and Pangandaran (coconut commodity) in West Java. The research implementation included capturing rhinoceros beetles and measuring the body of rhinoceros beetles (morphometry). Male and female rhinoceros beetles were photographed using a cellphone camera.

Catching rhinoceros beetles in SEAT Ungaran using pheromone traps (attractants). At the Banyumas and Pangandaran locations, rhinoceros beetles were caught manually. The body morphometry of male and female rhinoceros beetles includes body length, body width, head length, horn length, antenna length, pronotum length, pronotum width, scutellum length, scutellum width, elytron length, elytron width, front leg femur length, middle leg femur length, hind leg femur length, front leg tibia length, middle leg tibia length, hind leg tibia length, front leg tarsus length, middle leg tarsus length, and hind leg tarsus length (Rosario et al., 2023). All measurements were taken in millimeters (mm). The data obtained were input into an Excel application on a laptop. Furthermore, the data were analyzed using a t-test with a significance level of 0.05 and an analysis of variance with a significance level of 0.05. If the analysis of variance shows differences between males and females or between locations, further testing is carried out using Duncan's Multiple Range Test (DMRT) at the 0.05 significance level. Statistical analysis was performed using IBM SPSS Statistics 26.

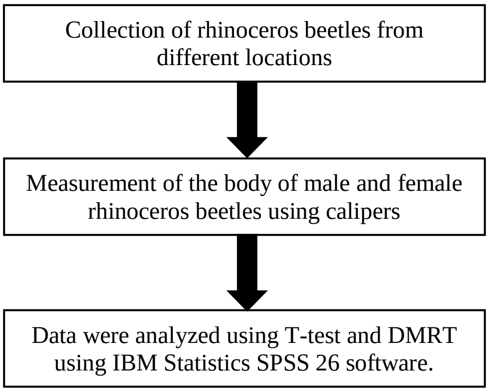

Figure 1. Research flow diagram

3. Results and Discussion

The results of the rhinoceros beetle capture at SEAT Ungaran, Central Java, did not meet expectations. The number of rhinoceros beetles obtained was 3 males and 1 female. In contrast, from Banyumas, 2 males and 12 females were obtained. The rhinoceros beetles obtained from Pangandaran were 13 males and 11 females. The appearance of male and female rhinoceros beetles is presented in Figure 1. The differences in catch results between locations (SEAT Ungaran 3 males + 1 female; Banyumas 2 males + 12 females; Pangandaran 13 males + 11 females) indicate that the data collected does not only reflect the "presence/absence" of the population, but is also influenced by the chance of beetle capture according to the method and environmental conditions during the observation. In field studies, the number of beetles caught in pheromone traps often fluctuates with weather conditions and the observation period, so unequal weeks/days of observation can result in biased comparisons between locations. During periods of heavy rainfall, pheromone trap catches often decrease because beetles tend to reduce their movement/flying activity, so fewer individuals approach the trap even though the pheromone is still in place (Ginting et al., 2025).

The manual collection method does not rely on the beetles' ability to detect attractants and approach the traps, making them more aggressive in capturing individuals present (Pradipta et al., 2020). Consequently, manual collection in Banyumas and Pangandaran potentially yields higher numbers than those obtained with pheromone traps alone, making quantitative comparisons between locations less likely to be completely apple-to-apple (Ginting et al., 2025).

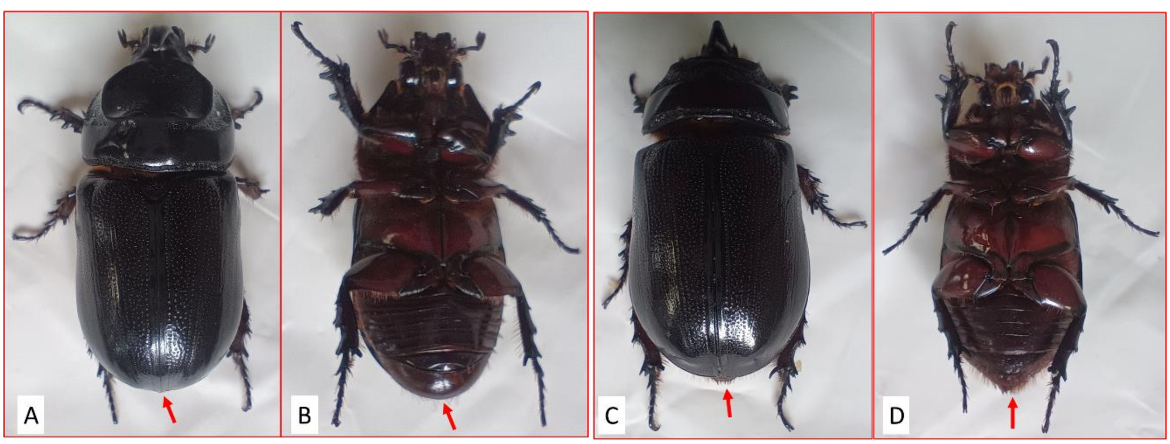

Figure 1. Male and female rhinoceros beetles. Caption: A. Male rhinoceros beetle top view; B. Male rhinoceros beetle bottom view; C. Horned beetle Female top view; D. Female rhinoceros beetle bottom view; The red color arrow indicates the tip of the abdomen. There are no feathers for males, but there are feathers for females.

Statistical analysis of the body morphometry of male and female rhinoceros beetles from SEAT Ungaran could not be performed due to the presence of only one female. However, the morphometry of male and female rhinoceros beetles from Banyumas can be analyzed, as presented in Table 1 below.

Based on Table 1 (Banyumas location), the average body length of males (43.8 ± 2.5 mm) tends to be larger than that of females (40.7 ± 3.3 mm), but the difference is not significant ($p = 0.229$), so the total body size in this sample is not strong enough to distinguish sex (Sahetapy et al., 2018). Clear differences are seen in the secondary sex characters, namely the length of the horns: males 10.3 ± 1.8 mm and females 6.6 ± 2.1 mm, with a significant difference ($p = 0.037$), so that the horn character can be used as the most informative indicator of sexual dimorphism in this data. In addition, the length of the hind leg tarsus also differed significantly between males (8.5 ± 0.3 mm) and females (7.6 ± 0.4 mm) ($p = 0.013$), indicating differences in limb proportions related to male behavior (e.g., competition/holding during mating). However, functional interpretation still requires caution due to the very small sample size of males (n = 2) (McCullough et al., 2015).

Comparison of the morphometry of male and female rhinoceros beetles from Pangandaran is presented in Table 2.

Table 1. Body morphometry of male and female rhinoceros beetles at the Banyumas location

Parameter	Male	Female	P-value
Body length (mm)	43.8 ± 2.5	40.7± 3.3	0.229
Body width (mm)	19.8 ± 1.6	18.4 ± 1.6	0.271
Head length (mm)	19.5 ± 1.5	17.3 ± 2.3	0.229
Horn length (mm)	10.3 ± 1.8	6.6 ± 2.1	0.037
Antenna length (mm)	5.4 ± 0.4	4.7 ± 0.5	0.105
Pronotum length (mm)	13.9 ± 0.9	12.7 ± 1.3	0.261
Pronotum width (mm)	17.9 ± 1.4	16.2 ± 1.5	0.160
Scutellum length (mm)	2.8 ± 0.2	2.5 ± 0.4	0.428
Scutellum width (mm)	2.9 ± 0.3	2.7 ± 0.3	0.237
Elytron length (mm)	25.9 ± 1.2	24.1 ± 1.9	0.231
Elytron width (mm)	12.9 ± 0.6	12.1 ± 1.0	0.317
Length of the front leg femur (mm)	8.4 ± 0.2	7.7 ± 0.7	0.233
Mid-leg femur length (mm)	9.1 ± 0.9	8.3 ± 0.6	0.171
Femur length rear legs (mm)	9.4 ± 1.2	8.7 ± 0.8	0.324
Length of the tibia of the foreleg (mm)	8.5 ± 0.8	7.6 ± 0.8	0.202
Mid-leg tibia length (mm)	6.9 ± 0.7	6.6 ± 0.6	0.513
Length of the hind leg tibia (mm)	9.0 ± 0.9	8.2 ± 0.6	0.130
Length of the forefoot tarsus (mm)	7.3 ± 0.4	6.8 ± 0.7	0.415
Midfoot tarsus length (mm)	8.1 ± 0.2	7.5 ± 0.2	0.180
Length of the tarsus of the hind leg (mm)	8.5 ± 0.3	7.6 ± 0.4	0.013

Description: T-test significance level 0.05; male n = 2; female n = 12

Table 2. Body morphometry of male and female rhinoceros beetles at the Pangandaran location

Parameter	Male	Female	P-value
Body length (mm)	42.9 ± 4.3	42.0 ± 2.1	0.535
Body width (mm)	19.6 ± 1.5	19.5 ± 1.1	0.812
Head length (mm)	18.7 ± 2.1	18.2 ± 1.0	0.407
Horn length (mm)	8.9 ± 2.7	6.1 ± 1.4	0.006
Antenna length (mm)	4.9 ± 0.5	4.9 ± 0.7	0.852
Pronotum length (mm)	13.9 ± 1.5	13.4 ± 0.7	0.334
Pronotum width (mm)	17.6 ± 1.7	17.3 ± 1.0	0.612
Scutellum length (mm)	2.9 ± 0.3	2.8 ± 0.3	0.582
Scutellum width (mm)	3.1 ± 0.3	3.2 ± 0.3	0.313
Elytron length (mm)	25.4 ± 2.1	25.1 ± 1.2	0.699
Elytron width (mm)	12.9 ± 1.2	12.9 ± 0.9	0.905
Length of the front leg femur (mm)	8.2 ± 0.8	8.2 ± 0.4	0.958
Mid-leg femur length (mm)	9.0 ± 0.8	9.0 ± 0.6	0.993
Length of the hind leg femur (mm)	9.3 ± 0.8	9.1 ± 0.5	0.499
Length of the tibia of the foreleg (mm)	8.1 ± 0.7	8.3 ± 0.7	0.375
Middle leg tibia length (mm)	7.4 ± 0.8	7.2 ± 0.5	0.637
Length of the hind leg tibia (mm)	8.6 ± 0.9	8.9 ± 0.5	0.304
Length of the forefoot tarsus (mm)	7.8 ± 0.5	7.7 ± 0.5	0.569
Midfoot tarsus length (mm)	8.4 ± 0.7	8.0 ± 0.5	0.183
Length of the tarsus of the hind leg (mm)	8.5 ± 0.7	7.8 ± 0.5	0.004

Description: T-test significance level 0.05; male n = 13; female n = 11

The body length of the horned beetle in Pangandaran showed that males (42.9 ± 4.3 mm) and females (42.0 ± 2.1 mm) were not significantly different (p = 0.535), as were most other body measurements (body width, head length, pronotum, elytron) which were all p> 0.05, so that the "general body" measurements in this sample were relatively overlapping between sexes (Manjeri et al., 2013). The most consistent difference to distinguish sexes in Table 2 was the length of the horn, where males (8.9 ± 2.7 mm) were longer than females (6.1 ± 1.4 mm) and were very significantly different (p = 0.006), in accordance with the theory that horns in horned beetles act as "weapon" characters that are strongly developed in males due to sexual selection (McCullough et al., 2015).

In addition to the horns, the length of the hind leg tarsus also differed significantly (males 8.5 ± 0.7 mm vs. females 7.8 ± 0.5 mm; p = 0.004), indicating a difference in leg proportions between males and females in the Pangandaran population. This difference is biologically plausible because, in the horned beetle group, differences in supporting structures (including limbs) can align with male behavioral needs during competition or copulation (McCullough et al., 2015). Meanwhile, other variables such as antenna length (p = 0.852) and various femur–tibia–tarsus sizes (except the hind leg tarsus) did not show significant differences, supporting the conclusion that sexual dimorphism in the Pangandaran data is more "concentrated" in certain characters (horns, hind leg tarsus), rather than in all body sizes. In terms of data strength, the Pangandaran sample size (males n=13; females n=11) is more balanced than several small-sample field studies, so that the results of the difference test for horns and hind leg tarsus can be assessed as more reliable in stating the presence of sexual dimorphism in these two parameters (Manjeri et al., 2013).

The practical implication is that if field sex identification is required for sex ratio analysis or population dynamics, the horn length character can be prioritized as the strongest morphological indicator based on the results of Table 2. In contrast, total body size (body length/width) is less informative due to high overlap (McCullough et al., 2015).

Comparison of the morphometry of male rhinoceros beetles from SEAT Ungaran, Banyumas, and Pangandaran is presented in Table 3.

Table 3. Body morphometry of male rhinoceros beetles at the SEAT Ungaran, Banyumas and Pangandaran location.

Parameter	SEAT	Banyumas	Pangandaran	Sig.
Body length (mm)	42.6	44.1	42.9	0.670
Body width (mm)	20.1	20.0	19.6	0.706
Head length (mm)	19.4	19.5	18.7	0.653
Horn length (mm)	10.6	10.5	8.9	0.426
Antenna length (mm)	5.0	5.4	4.9	0.340
Pronotum length (mm)	14.9	13.9	13.9	0.379
Pronotum width (mm)	17.9	17.9	17.6	0.817
Scutellum length (mm)	2.9	2.8	2.9	0.457
Scutellum width (mm)	3.1	2.9	3.1	0.437
Elytron length (mm)	25.7	25.9	25.4	0.791
Elytron width (mm)	13.1	12.9	12.9	0.802
Femur length front legs (mm)	8.2	8.4	8.2	0.778
Mid-leg femur length (mm)	8.9	9.0	9.0	0.853
Length of the hind leg femur (mm)	9.2	9.4	9.3	0.833
Tibia length front legs (mm)	8.6	8.5	8.1	0.395
Mid-leg tibia length (mm)	6.8	6.9	7.4	0.342
Length of the hind leg tibia (mm)	8.5	9.0	8.6	0.472
Length of the forefoot tarsus (mm)	7.4	7.3	7.8	0.161
Midfoot tarsus length (mm)	8.6	8.1	8.4	0.371
Length of the tarsus of the hind leg (mm)	8.6	8.5	8.5	0.803

Description: DMRT real level 0.05; SEAT n = 3; Banyumas n = 2; Pangandaran; n = 13

The body length of male rhinoceros beetles at the three locations ranged from 42.6 to 44.1 mm. It was not statistically significantly different (p>0.05), indicating that body size was relatively uniform across the SEAT, Banyumas, and Pangandaran populations, despite their different locations of origin. This consistency aligns with the findings of morphometric analyses of rhinoceros beetles from several oil palm plantations, which showed no clear morphometric separation between populations and relatively stable size-character variance across a wide geographic range. Biologically, this uniformity in body length indicates that genetic factors and the range of environmental conditions at the three locations were still within the same tolerance range, thus not causing significant body size differentiation.

The body width of male beetles also showed relatively uniform values (19.6–20.1 mm) with no significant differences between locations (p>0.05). This pattern is consistent with reports of morphometric variation in coconut horn beetles in the Philippines, where most body-size characters (including body width) showed variation, but within overlapping ranges between regions, so as not to form a separate morphological group (Rosario et al., 2023). Uniformity of body width is ecologically important because it is related to the beetle's ability to hide in crevices at the base of the leaf sheath and plant tissue, so that too large or too small a size can reduce successful penetration and protection within the host tissue.

The head length of male beetles at the three locations ranged from 18.7 to 19.5 mm, with no significant differences (p>0.05). This relatively uniform head size is related to the primary function of the head in supporting the horn structure and mouthparts for boring into plant tissue. Therefore, this size stability indicates selection pressure maintaining optimal feeding and fighting performance.

Male horn lengths in SEAT and Banyumas were higher (±10.5–10.6 mm) than in Pangandaran (8.9 mm), but remained statistically insignificant ($p>0.05$). Male horns are known to play a role in male competition for mate access, and variation in horn length is generally correlated with larval nutritional conditions and habitat quality during the immature stage. These values, which fall within the same range, indicate that larval food quality and environmental conditions at the three locations are relatively similar, resulting in little difference in horn size. This is in line with the morphological characteristics of horned beetles, which are generally large-bodied and have prominent horns in males (Rahayu et al., 2021).

Antenna lengths ranged from 4.9 to 5.4 mm and showed no significant differences between locations. The horned beetle's antennae play a crucial role in chemical perception, particularly in detecting pheromones and volatile compounds from hosts or traps. Therefore, antenna size stability may be associated with the need to maintain effective olfactory sensitivity across a wide range of habitat conditions. Control using pheromone traps and other attractants also utilizes these antennae so that antenna morphometric information can support the optimization of trap formulation and placement in the field.

The pronotum length ranges from 13.9–14.9 mm, while the pronotum width is around 17.6–17.9 mm, with all values not significantly different ($p>0.05$). The pronotum is the dorsal part of the thorax that protects internal structures and serves as a point of attachment for wing and leg muscles, so the stability of pronotum size across locations indicates that the main mechanical function is maintained even though the beetles come from different environments. Morphometric studies in various countries also use pronotum length and width as important characters for comparing rhinoceros beetle populations, but generally find extensive size overlap and do not show clear morphological separation between locations.

Scutellum length (2.8–2.9 mm) and scutellum width (2.9–3.1 mm) at the three locations also did not differ significantly. The small and relatively constant scutellum supports the aerodynamic body shape and wing base position, so excessively large or small variations in size tend to be disadvantageous for flight or hindwing protection. In morphometric studies in the Philippines, scutellum width was among the characters that showed no significant differences between populations, confirming that this region is relatively evolutionarily conservative (Rosario et al., 2023).

The elytron length of male rhinoceros beetles at the three locations ranged from 25.4 to 25.9 mm, with an elytron width of 12.9 to 13.1 mm, and none of these were significantly different. Elytrons protect the hind wings and help maintain body moisture, so their stable size may reflect the general adaptation of rhinoceros beetles to the humid tropical environment of Southeast Asia. These results align with morphometric studies in oil palm plantations that used elytron length as a main variable and found that, despite interindividual variation, the average elytron size between populations did not differ significantly enough to distinguish populations morphologically.

The average femur length (forelegs, midlegs, and hindlegs) across the three locations ranged from 8.2 to 9.4 mm and was not statistically significantly different. The rhinoceros beetle's legs play crucial roles in burrowing, climbing stems, and clinging to hosts, so the relatively uniform femur size suggests similar biomechanical requirements across populations for burrowing and mobility in similar environments.

Tibia length (forelimb, midlimb, and hindlimb) at the three locations ranged from 6.8 to 9.0 mm, with significance values again indicating no significant differences ($p>0.05$). Morphometric studies in the Philippines indicate that hindlimb tibia length is a distinguishing trait among populations, but this variation falls within overlapping ranges and does not form distinct clusters (Rosario et al., 2023). In the context of the results in Table 3, the lack of differences in tibia length across locations indicates that local selection pressures on locomotion and burrowing are relatively similar across the three habitats.

Tarsus length (forelegs, midlegs, and hindlegs) ranged from 7.3 to 8.6 mm and also showed no significant differences between locations. The tarsus and claws at the tip of the legs help the beetles adhere to plant surfaces and organic media, so a stable size is important for maintaining adhesion and mobility on slippery stem and leaf sheath surfaces. The stability of tarsus size, along with other leg characteristics, supports the conclusion that the beetles' functional adaptation to the substrate and their lifestyle are relatively homogeneous across the three observation locations.

Overall, the absence of significant differences in almost all morphometric parameters (body, head, horns, antennae, pronotum, scutellum, elytron, and legs) indicates that the male rhinoceros beetle populations in SEAT Ungaran, Banyumas, and Pangandaran still belong to a homogeneous morphological group. This finding supports previous reports that rhinoceros beetle populations from various regions often exhibit overlapping sizes and lack clear morphometric separation, even though they originate from distant locations (Rosario et al., 2023).

A comparison of the morphometrics of female rhinoceros beetles from SEAT Ungaran, Banyumas, and Pangandaran could not be performed because there was only one female from SEAT. Therefore, only Banyumas and Pangandaran can be compared, as presented in Table 4.

Table 4. Body morphometry of female rhinoceros beetles at the Banyumas and Pangandaran locations

Parameter	Banyumas	Pangandaran	P-value
Body length (mm)	40.6 ± 3.2	42.0 ± 2.1	0.247
Body width (mm)	18.3 ± 1.5	19.4 ± 1.1	0.068
Head length (mm)	17.2 ± 2.3	18.1 ± 1.0	0.253
Horn length (mm)	6.5 ± 2.0	6.1 ± 1.4	0.593
Antenna length (mm)	4.7 ± 0.4	4.9 ± 0.7	0.379
Pronotum length (mm)	12.7 ± 1.2	13.4 ± 0.7	0.128
Pronotum width (mm)	16.2 ± 1.4	17.3 ± 1.0	0.051
Scutellum length (mm)	2.5 ± 0.3	2.7 ± 0.2	0.065
Scutellum width (mm)	2.6 ± 0.2	3.2 ± 0.2	0,000
Elytron length (mm)	24.0 ± 1.9	25.1 ± 1.1	0.121
Elytron width (mm)	12.0 ± 1.0	12.8 ± 0.9	0.079
Femur length front legs (mm)	7.7 ± 0.6	8.1 ± 0.4	0.072
Femur length midfoot (mm)	8.3 ± 0.6	9.0 ± 0.6	0.015
Femur length rear legs (mm)	8.7 ± 0.7	9.1 ± 0.4	0.115
Length of the tibia of the foreleg (mm)	7.6 ± 0.7	8.3 ± 0.6	0.038
Mid-leg tibia length (mm)	6.5 ± 0.6	7.2 ± 0.4	0.009
Length of the hind leg tibia (mm)	8.2 ± 0.5	8.9 ± 0.4	0.004
Length of the forefoot tarsus (mm)	6.8 ± 0.7	7.7 ± 0.5	0.004
Midfoot tarsus length (mm)	7.4 ± 0.5	8.0 ± 0.5	0.017
Length of the tarsus of the hind leg (mm)	7.5 ± 0.4	7.8 ± 0.4	0.267

Description: T-test results; Banyumas n = 12; Pangandaran n = 11

The average body length and width of females from Pangandaran were higher than those from Banyumas, although the differences were not significant (p>0.05). Ecologically, body size variation in rhinoceros beetles is strongly influenced by larval nutritional quality, population density, and microhabitat conditions.

There were no significant differences in head, horn, and antenna length (p>0.05). In females, horns are shorter and less developed than in males because they do not experience strong sexual selection pressure (Emlen & Nijhout, 2000; McCullough et al., 2015). Evolutionarily, horn variation in Scarabaeidae is more correlated with intrasexual male competition than with female adaptive function (Kijimoto et al., 2012). Therefore, the stability of female horn size across populations is a common pattern. The relatively uniform antennae indicate the absence of differential selection pressure on sensory function, especially in the detection of aggregation pheromones (Hallett et al., 1995).

The width of the scutellum showed a highly significant difference (p=0.000), while the parameters of the pronotum and scutellum length were not significantly different. The structure of the pronotum and scutellum plays a role in protecting the thorax and serves as an attachment point for wing muscles. (Gullan & Cranston, 2005) . Significant differences in scutellum width suggest possible adaptive variation related to wing-movement efficiency or body stability during flight.

The length and width of the elytrons were not significantly different (p>0.05)—the elytra function as protective membranes for the wings and abdominal organs. The stability of elytron size indicates that selection pressures for body protection were relatively uniform across both locations. Most leg parameters showed significant differences. These differences indicate that the locomotor structure is the morphological component most responsive to environmental variations. In Scarabaeidae beetles, the legs play a role in burrowing, copulation, and locomotion on stem or litter substrates.

Most leg parameters showed significant differences, especially mid-leg femur length (p=0.015), foreleg tibia length (p=0.038), mid-leg tibia length (p=0.009), hindleg tibia length (p=0.004), foreleg tarsus length (p=0.004), and mid-leg tarsus length (p=0.017). These differences indicate that the locomotor structure is the morphological part most responsive to environmental variations. In Scarabaeidae beetles, legs play a role in burrowing, copulation, and locomotion on stem or litter substrates.

4. Conclusion

A comparison of the body morphometry of male and female rhinoceros beetles at the Banyumas location reveals clear differences in secondary sexual characteristics, specifically the length of the horns and the hind tarsus. A comparison of the morphometry of male and female rhinoceros beetles from Pangandaran reveals differences in the length of the horns and the tarsus of the hind legs. A comparison of the morphometric measurements of male rhinoceros beetles from SEAT Ungaran, Banyumas, and Pangandaran reveals no significant differences in any of the parameters. A comparison of the morphometry of female rhinoceros beetles from Banyumas and Pangandaran reveals differences in several measurements, including the width of the scutellum, the length of the mid-leg femur, the length of the front leg tibia, the length of the mid-leg tibia, the length of the hind leg tibia, the length of the front leg tarsus, and the length of the mid-leg tarsus.

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