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Morphometric Analysis of Anura in Rajolelo Forest Park Bengkulu Province

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Abstract
Anurans are highly sensitive vertebrates whose morphological variation can reflect ecological adaptation to habitat structure, microclimatic conditions, and locomotor demands. This study aimed to analyze the morphometric characteristics of Anura species in Rajolelo Forest Park, Bengkulu Province, Indonesia, and to interpret their morphological variation in relation to habitat differences. A field survey was conducted from November 2025 to January 2026 using the Visual Encounter Survey method in two habitat types: secondary forest and lakeshore areas. Each individual encountered was identified and measured using 13 morphometric characters, including snout–vent length, head width, head length, tibia length, foot length, hind limb length, whole body length, and body width. The results recorded 20 individuals representing five species from three families: Dicroglossidae, Ranidae, and Rhacophoridae. The species identified were *Fejervarya cancrivora*, *Fejervarya limnocharis*, *Hylarana erythraea*, *Amnirana nicobariensis*, and *Polypedates leucomystax*. Morphometric variation was evident among species, with *F. cancrivora* showing the largest body dimensions, while *A. nicobariensis* displayed relatively smaller body proportions. Species associated with lakeshore habitats tended to have larger and wider bodies, whereas forest-associated species showed limb proportions that support jumping and movement within vegetated habitats. Sexual size variation was also observed in several species, with females generally showing larger body dimensions than males. These findings indicate that morphometric differentiation in Anura reflects ecological adaptation to local habitat conditions and provides baseline information for amphibian biodiversity monitoring and habitat conservation in Bengkulu.

Keywords: Anura; Anura Habitats; Morphometric; Morphological adaptation; VES Method

INTRODUCTION

Indonesia is a country with high biodiversity, including the diversity of Anura species such as frogs and toads in various habitats (Okthari *et al*. 2025). The order of Anura in Indonesia reaches around 450 types, or 11% of the total types of Anura in the world (Prasetyo *et al*. 2015). The Rajolelo Forest Park in central Bengkulu is an area that supports the existence of the Anura species, because it has a variety of habitats, ranging from waters to moist and dry land.

Globally, Anura has become an important taxonomic group in ecological and conservation studies because its members are highly sensitive to microclimatic change, habitat fragmentation, pollution, and hydrological disturbance. Their permeable skin, dependence on moist habitats, and biphasic life cycle make frogs and toads reliable bioindicators for assessing ecosystem quality. In the Indonesian context, studies on Anura are increasingly relevant because tropical forest ecosystems, wetlands, peatlands, and freshwater habitats are experiencing continuous ecological pressure due to land-use change, tourism development, and anthropogenic disturbance. Therefore, documenting Anura diversity and morphology in local conservation areas such as Rajolelo Forest Park is important for strengthening biodiversity databases and supporting habitat-based conservation planning.

Anura is a class of amphibians that includes vertebrate animals, with body temperature depending on the surrounding environment (Hillman, 2018). Anura plays an important role in the ecosystem as a population controller in the food chain (Prasetyo *et al*. 2020). They are carnivorous, feeding on arthropods, worms, insect larvae or other small animals *(Hermanda et al*. 2024). Indirectly, it helps pest control and provides ecological and economic benefits for agriculture (Wanger *et al*. 2023). Anura can be used as an environmental bioindicator because it is sensitive to pollution and habitat damage (Azhari *et al*. 2022). Anura's presence indicates good environmental conditions, while her absence indicates poor environmental conditions (Setiawan *et al*. 2019). However, some species are able to survive in disturbed environments, most of which are vulnerable and difficult to survive (Febriyono *et al*. 2023).

The habitat of the anura is very diverse, ranging from tropical forests, wetlands, swamps, to mountains, and each type has its own unique adaptations (Oussou *et al.* 2022). In general, Anura lives in two habitats, namely aquatic habitats and terrestrial habitats. Aquatic habitat, Anura lives in aqueous environments, while terrestrial includes moist land areas. (Anisa *et al.* 2019). This adaptation reflects morphological characteristics, ranging from body shape, skin surface and body size (Womack & Bell, 2020). Frogs and toads have a clear difference, frogs have four legs with longer hind leg sizes, large eyes, and slippery, slimy skin (Zulaikha *et al*. 2025). On the other hand, rough-skinned toads have shorter hands and feet (Winata *et al*. 2015). For morphometric data, morphological character measurements were used.

The theoretical basis of this study is ecological morphology, particularly the form–function relationship, which explains that morphological traits are closely related to habitat use, locomotor performance, feeding strategy, and adaptation to environmental conditions. In Anura, morphometric characters such as snout–vent length, head width, head length, tibia length, foot length, hind limb length, whole body length, and body width may indicate how species adapt to aquatic, semi-aquatic, terrestrial, or arboreal habitats. For example, species living near water or muddy substrates may require larger and wider body proportions for movement stability, while species inhabiting vegetation may require longer limbs to support jumping and climbing. Thus, morphometric analysis is not only useful for species description but also for interpreting ecological adaptation.

Morphometrics is a method of quantitatively measuring the form (morphology) of organisms to determine variations and differences between species. Measurements include body length, leg length, head diameter, and other parameters, as the basis for comparative morphological analysis (Putri *et al*. 2017). Morphometric analysis of Anura is important for understanding variations in body shape(Castro *et al*. 2021). Furthermore, morphometric analysis can also be used to determine the relationship between Anura morphological characteristics and habitat conditions. Therefore, this study aims to analyze the morphometric characteristics of Anura in Rajolelo Forest Park, Central Bengkulu, to describe the morphology of Anura in the area and to determine the form of Anura morphological adaptation to its habitat.

Recent international studies have shown that morphometric variation in Anura is strongly associated with ecological and evolutionary factors. Womack and Bell (2020) explained that anuran body-size evolution is influenced by geography, ecology, and life-history traits. Castro et al. (2021) demonstrated that water availability can shape allometric patterns in tree frogs, while Bardua et al. (2021) showed that skull size, microhabitat, and feeding-related traits contribute to cranial diversification in frogs. Leavey et al. (2023) further emphasized that locomotor ecology and habitat type influence skeletal proportions in frogs. These studies indicate that morphometric traits can provide meaningful evidence for understanding how Anura species respond to habitat structure and ecological pressure.

In Indonesia, several recent studies have documented Anura diversity and habitat association in different ecosystems. Azhari et al. (2022) reported that amphibian diversity in the Londerang peat protected forest was influenced by habitat condition and environmental quality. Febriyono et al. (2023) found that Anuran communities in the dry karst ecosystem of Central Java were shaped by water availability and habitat heterogeneity. Tambun et al. (2023) also showed that morphological and morphometric identification can support the classification and ecological interpretation of amphibian species in local habitats. However, most Indonesian studies still focus on species inventory, abundance, and habitat distribution, while detailed morphometric analysis that connects body characters with habitat differences remains limited.

Based on this literature, the research gap lies in the limited empirical evidence on the morphometric characteristics of Anura in local forest-park ecosystems, particularly in Bengkulu Province. Previous studies have not sufficiently examined how multiple morphometric characters can explain possible morphological adaptation of Anura species in different habitat types, such as secondary forest and lakeshore environments. In addition, Rajolelo Forest Park remains underrepresented in amphibian morphology research, although the area provides diverse microhabitats that are potentially important for Anura survival.

The novelty of this study lies in its focus on the morphometric analysis of Anura in Rajolelo Forest Park by measuring 13 morphological characters across species found in different habitat types. This approach provides a more comprehensive understanding of body-size variation, head structure, limb proportion, and possible ecological adaptation among local Anura species. Therefore, this study contributes new local evidence to amphibian ecology, strengthens biodiversity documentation in Bengkulu, and provides baseline information for conservation education and habitat management. Specifically, this study aims to identify Anura species found in Rajolelo Forest Park, analyze their morphometric characteristics, compare morphological variation among species, and interpret how these variations may reflect adaptation to different habitat conditions.

METHODS

Time and location of the research

This research was carried out in November 2025- January 2026 at Jaya Rahotelo Forest Park, Tanjung Terdana Village, Pondok Kelapa District, Central Bengkulu Regency, Bengkulu Province. This location was chosen because it has a wide variety of habitat types, such as secondary forests and lake areas, which support the existence of various Anura species.

Tools and Materials

The tools used include a caliper, hand net, camera, bucket, headlamp/lighting device, gloves, plastic bags, stationery, shoes, specimen bottles, labels, tracing paper, cartridges, Autan, sterofoam, tweezers, and thermohygrometer. The materials used are 50% alcohol and 70% to preserve the samples found.

Methodology

This study uses the Visual Encounter Survey (VES) method (Heyer 1994), which is a data collection technique through direct encounters with individuals in the field. Observations were carried out by tracing predetermined paths or areas and recording all species found (Haryanto et al. 2021). The VES method was chosen because it is effective for detecting the presence of Anura in natural habitats, particularly in humid environments with dense vegetation. Furthermore, this method allows for direct observation, allowing the data obtained to more accurately depict the condition of the species in the field.

Observation and sampling procedure

Sampling was carried out in two locations, namely secondary forests and lakeside. These two locations were chosen because they have different ecological characteristics that can affect the existence of the Anura species. Secondary forests have dense vegetation and relatively stable moisture, thus supporting life and shelter for anura (Thompson & Donnelly, 2023). Meanwhile, the edge of the lake with shallow waters, muddy substrate and high humidity is a suitable habitat for Anura to find food, take shelter and reproduce (Tozer et al. 2025). These differences in ecological conditions allow for variations in the type and number of Anura individuals in each habitat.

The study was conducted in the morning and evening for eight consecutive weeks with a frequency of three repetitions in one week. Repetition was carried out to increase the accuracy of the data during the observation. Sampling using a hand net, this technique is effective for capturing anura in various habitats, such as shallow waters and vegetation. Ecological factors measured include air temperature and humidity using a thermohygrometer to determine the relationship between habitat conditions and the presence of Anura. Each species found was documented, the number of individuals in each habitat was recorded, then the species were put into a container and preserved using 50% and 70% alcohol for identification purposes. During the data collection process, sample handling was carried out carefully to minimize stress and damage to the Anura individuals found.

Morphometric identification and measurement

Identification is carried out in the laboratory to obtain more accurate data. Identification refers to books *Pictorial Guide to West Java Amphibian Identification* (Kusrini, 2013) and books *South Sumatran amphibians and reptiles* (Kusrini, 2020) by comparing the morphological characteristics of Anura, such as body color, skin texture, body shape, and other characters. This process also uses several aids such as tweezers, cameras, cardboard and styrofoam to facilitate more thorough and systematic observation of morphological structures. The identification results were recorded based on morphological characteristics, the number of individuals, and the location of the sample.

Morphometric data collection was carried out through morphological measurements on Anura. Measurements are carried out using calipers to obtain accurate and precise results. This morphometric analysis aims to determine the variation in Anura's body shape based on certain size parameters. Through these measurements, quantitative data was obtained regarding various morphological characters, such as body length and other characters, shown in Figure 1.

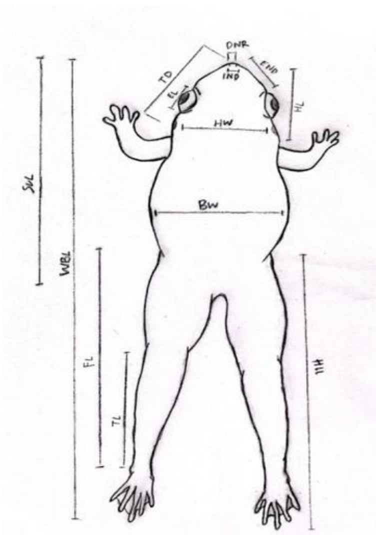

Figure 1. Anura's Morphomeric Character

Figure 1. There are 13 morphometric measurement characters in anura, including Shout-vent length (SVL), Head width (HW), Head lenght (HL), Internarial Distance (IND), Eye-nostril distance (END), Tymphanicum distance (TD), Eye length (EL), Tibia length (TL), Foot length, Distance from the nostril to the most anterior extremity of the rostra (DNR), Hind leg lenght (HLL), and Whole body (WBL), Body width (BW) (Tambun et al.2023).

RESULTS AND DISCUSSION

Result

This study found 3 families of 5 species, namely Dicrogossidae, Ranidae, and Rhacophoridae. The species found are *F. cancrivora*, *F. limnocharis*, *H. erythraea*, *A. nicobariensis*, and *P. leucomystax*, *P. leucomystax*, *A. nicobariensis*, and *H. erythraea* are more commonly found in secondary forests. Meanwhile, *F. cancrivora* and *F. limnocharis* are more commonly found on the shores of lakes.

Table 1. Anura family and species in the Rajolelo Forest Park

Family	Species	Quantity
Dicrogossidae	*Fejervarya cancrivora*	2

	Fejervarya limnocharis	3
Ranidae	*Hylarana erythraea*	3
	Amnirana nicobariensis	7
Rhacophoridae	*Polypedates leucomystax*	5

Table 1. Shows that the Anura community in Rajolelo Forest Park consists of three families, namely Dicroglossidae, Ranidae, and Rhacophoridae with a total of five species and 20 individuals. The Ranidae family has the highest number of individuals, especially A. nicobariensis (7 individuals) and H. erythraea (3 individuals). This high number is related to the conditions of the research habitat which supports Anura's life. The Ranidae group generally lives in aquatic habitats and damp environments (Zhao et al. 2021), so the presence of lakes and dense vegetation in secondary forests are important factors in supporting the distribution of anura species. In secondary forests, air humidity ranges from 70–80% with temperatures of 25–28°C and dense vegetation, creating a humid and stable environment. These environmental conditions really support Anura's activities, especially for finding food, protection and reproduction.

The species *P. leucomystax* (family Rhacophoridae) is an arboreal anuran (Ali *et al*. 2025). This species has a preference for vegetation, especially shrubs and trees. The existence of *P. leucomystax* in secondary forest habitat indicates that the environmental conditions in this ecosystem support the ecological needs of this species. In contrast, the Dicroglossidae family consisting of *F. cancrivora* (2 individuals) and *F. limnocharis* (3 individuals) is more commonly found on lake shores with temperatures of 24–26°C and humidity of 70–78%, smooth water conditions and muddy substrates. These conditions are suitable for the *Fejervarya* genus which lives in open areas near water such as swamps or lake shores. Muddy substrates make it easier for frogs to find food, take shelter and reproduce (Iswandaru *et al*. 2025). Overall, the distribution of species across the two habitat types demonstrates a clear link between environmental characteristics such as humidity, temperature, and vegetation and the ecological preferences of each species. Arboreal species requiring shade tend to be more dominant in secondary forests, while semi-aquatic and open-area-loving species are more common along lakeshores. This difference demonstrates that the variety of habitat types in Rajolelo Grand Forest Park plays a significant role in supporting the diversity and distribution of the Anura community. The different microhabitat conditions at each study site indicate that environmental factors influence the presence and activity of Anura.

Table 2. Results of measuring Anura morphometric characters

Morphometric Characteristics	*Fejervarya cancrivora*	*Fejervarya limnocharis*	*Hylarana erythraea*	*Polypedates leucomystax*	*Amnirana Nicobariensis*
SVL	51,15±5,784	40,723±4,613	42,186±5,985	46,05±1,275	36,038±0,608
HW	18,45±3,073	15,793±1,207	15,446±1,634	16,076±0,174	13,231±0,859
HL	17,15±3,131	13,703±1,441	12,083±2,375	12,326±0,671	9,31±5,200
IND	3,13±0,130	3,076±0,170	3,533±1,251	3,062±0,272	3,028±0,074
END	4,12±0,128	3,403±1,348	3,703±1,002	4,622±0,661	4,02±0,076
TD	13,59±0,530	12,39±1,326	13,043±2,322	13,336±0,181	10,7±1,143
EL	4,25±1,856	3,77±0,737	3,75±0,935	4,066±0,244	3,177±0,175
TL	23,05±2,055	18,74±2,673	18,056±0,414	22,902±0,671	18,411±0,212
FL	53,17±3,218	44,723±3,588	56,166±14,932	54,14±1,715	44,565±1,806
DNR	2,45±1,856	2,083±0,027	2,7±0,952	2,042±0,247	2,015±0,161
HLL	74,85±2,933	66,73±7,932	76,633±12,865	72,872±1,495	63,445±9,797
WBL	126,56±9,266	103,793±10,985	113,133±17,253	115,472±3,683	96,094±1,151

BW	22,55±2,127	18,406±3,359	11,8±0,693	13,222±1,079	9,89±0,313

Table 2. Based on the results of measurements of anura morphometric characters, it shows that there are differences in body size variations found in the Rajolelo Grand Forest Park. This variation can be seen in several main characters such as Snout-Vent Length (SVL), Whole Body Length (WBL), and Body Width (BW). For these three characters, F. cancrivora showed the largest size with SVL values of 51.15 ± 5.784 mm, WBL 126.56 ± 9.266 mm, and BW 22.55 ± 2.127 mm. The smallest size was found in A. nicobariensis with SVL values of 36.038 ± 0.608 mm, WBL 96.094 ± 1.151 mm, and BB 9.89 ± 0.313 mm. This difference in size shows that F. cancrivora has a relatively larger body size compared to other species, while A. nicobariensis is a small group. Anura body size is related to the ability to adapt to the environment, foraging strategies, and reproduction (Acevedo et al. 2022). Apart from that, a larger body can also help maintain stability when moving in muddy or semi-aquatic habitats.

Morphometric characteristics of the head, incl Head Width (HW), Head Length (HL), Internarial Distance (IND), Eye-Nostril Distance (END), Eye Length (EL), Tympanic Distance (TD), and Nostril-to-Rostra Distance (DNR), show clear variations between species. *F. cancrivora* has the largest relative head size, with HW 18.45 ± 3.073 mm, HL 17.15 ± 3.131 mm, EL 4.25 ± 1.856 mm, TD 13.59 ± 0.530 mm, and DNR 2.45 ± 1.856 mm, while *A. nicobariensis* has the largest head size HW 13.231 ± 0.859 mm, HL 9.31 ± 5.200 mm, EL 3.177 ± 0.175 mm, BP 10.7 ± 1.143 mm, DNR 2.015 ± 0.161 mm. The largest IND value was found in *H. erythraea* 3.533 ± 1.251 mm and the smallest in *A. nicobariensis* 3.028 ± 0.074 mm, while the highest END was recorded in *P. leucomystax* 4.622 ± 0.661 mm and the lowest was in *F. limnocharis* 3.403 ± 1.348 mm. This variation reflects differences in snout shape and facial structure that influence the type of food and environmental conditions of each species. Frogs with larger heads have wider mouth openings so they can catch larger prey, while species with smaller heads tend to exploit smaller prey (Bardua *et al*. 2021). The differences in head and body size also indicate the division of ecological niches between species in utilizing food sources and habitats.

In extremity characters, especially Tibia Length (TL), Leg Length (FL), and Hind Leg Length (HLL), it can be seen that *H. erythraea* and *P. leucomystax* have relatively greater values than other species. In *H. erythraea*, the TL value was 18.056 ± 0.414 mm, FL was 56.166 ± 14.932 mm and HLL was 76.633 ± 12.865 mm. Meanwhile, *P. leucomystax* has a TL of 22,902 ± 0.671 mm, FL of 54.14 ± 1,715 mm, and HLL of 72,872 ± 1,495 mm. Longer hind leg length is associated with jumping and swimming skills (Simon *et al.* 2025). Thus, species with longer body sizes and legs tend to be more active in open or aquatic habitats (Leavey *et al*. 2023). In contrast, *A. nicobariensis* has relatively shorter limb sizes, with TL of 18.411 ± 0.212 mm, FL of 44.565 ± 1.806 mm, and HLL of 63.445 ± 9.797 mm, indicating a more limited movement ability. These differences in limb proportions indicate variations in movement and habitat use between Anura species as a form of morphological adaptation to environmental conditions.

These morphometric differences show that the variation in Anura's body size and proportions is a form of adaptation to habitat differences. Species found in aquatic areas or lakesides, such as *F. cancrivora* and *F. limnocharis*, have a relatively larger and wider body size. This body size helps frogs adapt to muddy semi-aquatic habitats and maintain balance while moving. In contrast, species found in secondary forests such as *H. erythraea* and *P. leucomystax* have smaller body sizes with longer hind legs. This condition supports more active movement, making it easier to jump and move places. This difference shows how body morphology plays a direct role in environmental conditions.

Table 3. Comparison of Anura Morphometric Character Measurements in Male and Female Individuals

Character	*F. cancrivora*	*F. limnocharis*		*H. erythraea*		*P. leucomystax*		*A. nicobariensis*	
	Male	Female	Male	Female	Male	Female	Male	Female	Male
SVL	±55.2	±47.6	±37.5	±51.48	±40.4	±48.4	±45.8	±38.3	±36.5

HW	±19.6	±17.22	±15.2	±16.24	±16.6	±16.12	±16.4	±15.4	±13.16
HL	±18.2	±15.3	±13.4	±15.12	±12.6	±13.32	±12.4	±11.5	±9.3
IND	±3.24	±3.4	±3.1	±4.1	±3.4	±3.8	±3.6	±3.08	±3.2
END	±4.22	±4.4	±3.3	±4.5	±4.1	±5.1	±4.4	±4.3	±4.3
TD	±14.12	±14.8	±11.5	±16.7	±12.3	±14.22	±13.3	±12.1	±11.14
EL	±4.4	±4.14	±3.16	±4.7	±4.6	±4.12	±4.4	±4.12	±3.2
TL	±24.6	±22.14	±16.6	±18.7	±18.5	±24.15	±22.8	±19.24	±18.14
FL	±55.28	±49.5	±41.7	±76.24	±48.14	±58.26	±53.6	±46.12	±45.22
DNR	±2.6	±2.12	±2.1	±3.4	±3.2	±2.8	±2.3	±2.3	±2.2
HLL	±76.3	±79.6	±60.5	±96.3	±70.2	±77.4	±72.4	±65.28	±64.22
WBL	±132.7	±121.4	±93.2	±141.3	±105.34	±122.4	±115.1	±101.14	±97.3
BW	±24.4	±23.6	±16.4	±12.2	±12.1	±14.4	±13.1	±10.6	±10.4

Table 3. Comparison of morphometric characters between male and female individuals of the Anura species in Rajolelo Forest Park shows that there are variations in body size between sexes in each species. Comparison of morphometric characters between male and female individuals of the Anura species in Rajolelo Forest Park shows that there are variations in body size between sexes in each species. In the *F. cancrivora* species, only male individuals are found, so it cannot be compared with female individuals. Male individuals have SVL values of 55.2 mm, WBL 132.7 mm, HLL 76.3 mm, and BW 24.4 mm. In *F. limnocharis* species, female individuals have a larger body size than male individuals. The SVL values for females are 47.6 mm and males are 37.5 mm, female WBL is 121.4 mm and males are 93.2 mm, female HLL is 79.6 mm and male is 60.5 mm, and female BW is 23.6 mm and male is 16.4 mm. In *H. erythraea*, females also have a larger body size than males. The SVL value of females is 51.48 mm and males are 40.4 mm, Female WBL is 141.3 mm and male is 105.34 mm, and female HLL is 96.3 mm and male is 70.2 mm. The body width is relatively almost the same, which is 12.2 mm in females and 12.1 mm in males. In *P. leucomystax*, the size difference between males and females is not very noticeable, but females still have a slightly larger size. The SVL values of females are 48.4 mm and males are 45.8 mm, female WBL is 122.4 mm and males are 115.1 mm, female HLL is 77.4 mm and males are 72.4 mm, and 14.4 mm female and 13.1 mm male BW. In *A. nicobariensis* the male size is slightly larger than that of the female. The SVL values of females are 38.3 mm and males are 36.5 mm, female WBL is 101.14 mm and males are 97.3 mm, female HLL is 65.28 mm and male is 64.22 mm, and female BW is 10.6 mm and male is 10.4 mm.

Based on the results of morphometric measurements, it can be seen that there is varying sexual dimorphism in each Anura species found. In F. cancrivora, only male individuals were found so there is no size comparison between males and females. This condition may be influenced by the reproductive season or differences in behavior, where male individuals tend to be more active and easier to find during observations. In the species F. limnocharis, P. leucomystax, H. erythraea, and A. nicobariensis, female individuals generally have a larger body size than males. This pattern indicates sexual dimorphism regarding reproductive function, because larger body size allows females to produce and carry a greater number of eggs (Schlippe et al. 2024). In addition to reproductive factors, differences in body size can also be influenced by environmental conditions. In tropical habitats such as Rajolelo Forest Park, food availability and habitat structure can influence individual growth and reinforce the size differences between males and females. Furthermore, smaller males tend to be more active and agile, making it easier to find mates. This condition shows that sexual dimorphism in Anura is not only influenced by genetic factors, but is also related to reproductive strategies and adaptation to habitat.

Discussion

This study demonstrates that the Anura assemblage in Rajolelo Forest Park, Bengkulu Province, is represented by five species from three families, namely Dicroglossidae, Ranidae, and Rhacophoridae. The total number of individuals recorded was relatively limited, consisting of 20 individuals distributed across secondary forest and lakeshore habitats. The findings indicate that *Amnirana nicobariensis* was the most frequently encountered species, followed by *Polypedates leucomystax*, *Hylarana erythraea*, *Fejervarya limnocharis*, and *Fejervarya cancrivora*. The distribution pattern suggests a clear relationship between habitat type and species occurrence. Arboreal and vegetation-associated species, particularly *P. leucomystax*, *A. nicobariensis*, and *H. erythraea*, were more commonly associated with secondary forest habitats, whereas semi-aquatic species such as *F. cancrivora* and *F. limnocharis* were more frequently observed along lakeshore areas. This finding supports the central objective of the study, namely to describe the morphometric characteristics of Anura and interpret how body-size variation may reflect adaptation to different microhabitats.

The morphometric results further reveal important interspecific variation in body size, head structure, and limb proportions. *Fejervarya cancrivora* showed the largest body dimensions, with higher values in snout–vent length, whole body length, and body width, whereas *A. nicobariensis* displayed the smallest body dimensions. This pattern indicates that larger-bodied species may be more suited to muddy, semi-aquatic, and open-edge habitats, where a wider body may support stability and movement on wet substrates. In contrast, species such as *H. erythraea* and *P. leucomystax* showed relatively longer hind-limb characters, suggesting greater locomotor capacity for jumping, climbing, and movement across vegetation. These findings reinforce the idea that morphometric variation in Anura is not merely taxonomic but also ecological, reflecting functional adaptation to habitat structure, substrate condition, vegetation density, and moisture availability.

The findings of this study are consistent with several global studies published between 2020 and 2026. Womack and Bell (2020) showed that anuran body-size evolution is associated with ecological, geographical, and life-history factors, indicating that body size is shaped by both evolutionary history and environmental adaptation. Similarly, Castro et al. (2021) demonstrated that water availability influences allometric patterns in tree frogs, particularly because body shape can contribute to water conservation under different environmental conditions. In the present study, the occurrence of larger-bodied *F. cancrivora* and *F. limnocharis* near lakeshore habitats may be interpreted as an adaptive response to aquatic or semi-aquatic environments, while the longer limb proportions of forest-associated species may reflect the need for locomotor efficiency in structurally complex vegetation. Thus, the Rajolelo findings support the broader international evidence that amphibian morphology is closely linked to habitat-mediated ecological pressures.

The results also align with global research on form–function relationships in frogs. Leavey et al. (2023) emphasized that skeletal proportions in frogs are influenced by locomotor ecology, habitat type, and phylogenetic history. This is particularly relevant to the present study because hind-limb length, tibia length, and foot length varied noticeably among species. The relatively long hind limbs observed in *H. erythraea* and *P. leucomystax* support the interpretation that limb morphology is connected to jumping and climbing performance. More recent work by Simon et al. (2025) also suggests that relationships between hind-limb traits and locomotor performance may differ within and across species, indicating that morphology should be interpreted cautiously and contextually. Therefore, the present study contributes to the growing understanding that morphometric traits should not be viewed as isolated measurements but as functional indicators of ecological adaptation.

The study also resonates with global evidence on cranial and head-size variation in Anura. Bardua et al. (2021) showed that skull size, microhabitat, and feeding-related factors contribute to cranial diversification in frogs. In the present study, *F. cancrivora* showed relatively larger head dimensions, including head width and head length. This may indicate feeding-related adaptation, since larger head structures may allow species to consume larger prey or exploit different feeding niches. However, because this study did not directly measure diet composition, prey type, or feeding behavior, the relationship between head morphometry and feeding ecology should be treated as an ecological inference rather than a confirmed causal relationship. Future research should therefore integrate stomach content analysis, prey availability, or stable isotope analysis to confirm whether head-size variation is directly related to trophic differentiation.

At the national and local level, the findings are consistent with Indonesian studies showing that Anura distribution is strongly influenced by habitat conditions and microclimatic variation. Azhari et al. (2022) reported that amphibian diversity in the Londerang peat protected forest was associated with habitat quality, humidity, and water availability. Febriyono et al. (2023), in their study of Anuran communities in the dry karst ecosystem of Central Java, also emphasized that water availability and habitat heterogeneity are critical factors determining amphibian occurrence. The Rajolelo Forest Park findings support these local studies by showing that lakeshore and secondary forest habitats support different species composition and morphometric characteristics. This is important because Bengkulu's forest-park ecosystem provides a distinct local context in which aquatic, semi-aquatic, and forest-associated Anura can coexist within a relatively limited spatial area.

The findings also correspond with local morphometric research conducted by Tambun et al. (2023), who showed that morphological and morphometric identification can help distinguish amphibian species and explain variation in body structure. The present study extends this line of evidence by using 13 morphometric characters to compare five Anura species across different habitats. However, compared with broader Indonesian studies on amphibian diversity, the number of individuals in this study remains relatively small. This may reflect limited sampling duration, seasonal effects, detection constraints, or the actual ecological condition of the study site. Since Anura activity is strongly affected by rainfall, temperature, humidity, and breeding season, the low number of individuals should not be interpreted solely as low biodiversity. Instead, it should be read as an initial ecological signal that requires more intensive seasonal monitoring.

Theoretically, this study supports the ecological morphology perspective, which argues that organismal form is shaped by interaction between evolutionary constraints and environmental demands. The observed variation in body size, head morphology, and limb proportions suggests that Anura species in Rajolelo Forest Park exhibit morphological traits that correspond to their preferred habitat. Larger and wider-bodied species appear more associated with semi-aquatic or muddy lakeshore environments, whereas longer-limbed species are more closely associated with forest and vegetation-based habitats. These findings support existing theory on form–function relationships in amphibians while also emphasizing that morphometric adaptation must be interpreted through local ecological context. The study therefore contributes to theoretical refinement by showing that even small-scale habitat differences within a forest park can correspond with measurable morphometric variation among Anura species.

From a pedagogical perspective, the findings have practical value for biology education, particularly in topics related to biodiversity, adaptation, ecology, and conservation. Morphometric data from local amphibians can be used as contextual learning material to help students understand the relationship between organismal structure and environmental function. Field-based learning using local Anura species may strengthen students' scientific literacy, observation skills, ecological reasoning, and awareness of biodiversity conservation. From a policy perspective, the results indicate that Rajolelo Forest Park should be managed not only as a recreational or protected area but also as a living laboratory for biodiversity monitoring. Conservation policy should prioritize the protection of both lakeshore and secondary forest microhabitats, since each supports different ecological groups of Anura. Habitat disturbance, vegetation loss, pollution, and uncontrolled tourism activity may reduce amphibian populations, as amphibians are highly sensitive to environmental changes. Therefore, local conservation programs should integrate habitat restoration, routine amphibian monitoring, environmental education, and community-based biodiversity protection.

The novelty of this study lies in its focus on the morphometric characteristics of Anura in Rajolelo Forest Park, a local ecosystem that remains underrepresented in amphibian research.

While many studies focus primarily on species inventories, this study provides a more detailed morphometric perspective by examining 13 body characters across five species. This approach enables a more nuanced understanding of how morphological variation may relate to habitat preference and ecological adaptation. The study also contributes methodologically by combining Visual Encounter Survey data with morphometric measurement, allowing species occurrence and morphological patterns to be interpreted together. In this sense, the study expands the literature on Indonesian amphibians by providing local evidence that supports broader ecological morphology theory while also offering practical implications for conservation-based biology education.

Nevertheless, this study has several limitations. First, the sample size was relatively small, with only 20 individuals recorded, which limits the generalizability of the morphometric comparisons. Second, the study was conducted only in two habitat types and within a limited temporal period, making it difficult to capture seasonal variation in Anura activity, breeding patterns, and habitat use. Third, the analysis remains descriptive and does not include inferential statistics, multivariate morphometric analysis, or phylogenetic control. Fourth, environmental variables were limited to temperature and humidity, while other important ecological factors such as rainfall, canopy cover, vegetation structure, water quality, prey availability, and anthropogenic disturbance were not measured in detail. Future research should involve larger samples, repeated seasonal surveys, broader habitat coverage, and advanced statistical analyses such as principal component analysis, discriminant function analysis, or geometric morphometrics. Further studies may also integrate ecological, behavioral, acoustic, and genetic data to provide a more comprehensive explanation of Anura adaptation in tropical forest-park ecosystems.

CONCLUSION

This study provides empirical evidence that the Anura community in Rajolelo Forest Park, Bengkulu Province, exhibits measurable morphometric variation across species and habitat types. Five species from three families were recorded, namely *Fejervarya cancrivora*, *Fejervarya limnocharis*, *Hylarana erythraea*, *Amnirana nicobariensis*, and *Polypedates leucomystax*, with a total of 20 individuals. The use of 13 morphometric characters allowed a more detailed interpretation of body-size variation, head morphology, limb proportion, and sexual size differences among the recorded species. The findings show that *F. cancrivora* had the largest overall body dimensions, whereas *A. nicobariensis* showed relatively smaller body proportions. In addition, species found near lakeshore habitats tended to have larger and wider bodies, while species associated with secondary forest habitats displayed morphological traits that support movement across vegetation. These patterns suggest that morphometric variation in Anura is closely related to habitat preference, locomotor function, and ecological adaptation.

The study contributes to amphibian ecology by demonstrating that local habitat heterogeneity within a forest-park ecosystem can correspond with distinct morphological patterns among Anura species. The findings also provide practical implications for biodiversity monitoring, conservation education, and habitat management, particularly in protecting both aquatic and terrestrial microhabitats that support amphibian survival. Nevertheless, the study is limited by its relatively small sample size, restricted habitat coverage, and descriptive analytical approach. Future studies should involve larger samples, longer seasonal observations, broader habitat gradients, and advanced statistical analyses such as multivariate morphometric analysis or geometric morphometrics. Integrating environmental variables, behavioral observations, acoustic data, and genetic analysis would also strengthen future interpretations of Anura adaptation. Overall, this study establishes an important baseline for understanding the morphometric diversity of Anura in Bengkulu and highlights the value of local amphibian research for strengthening biodiversity conservation in tropical forest ecosystems.

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