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Utilization of Morphological and Morphometric Data of Amphibians from the Silahisabungan Geosite as Content for the Development of an Amphibian Species Diversity Booklet

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Abstrak: Keanekaragaman amfibi merupakan indikator penting kualitas lingkungan, namun pemanfaatan data biodiversitas lokal sebagai sumber belajar masih terbatas sehingga pembelajaran cenderung abstrak. Penelitian ini bertujuan menganalisis variasi morfologi dan morfometrik amfibi di Geosite Silahisabungan-Toba Caldera Unesco Global Geopark ((TCUGGp) serta memanfaatkannya sebagai konten dalam pengembangan booklet keanekaragaman hayati. Metode yang digunakan adalah deskriptif kuantitatif melalui observasi, dokumentasi, dan pengukuran morfometrik terhadap 18 spesies dari 5 famili. Parameter yang diukur meliputi snout-vent length (SVL), *head length* (HL), *head width* (HW), *tibia length* (TL), dan lainnya. Data dianalisis secara deskriptif dan melalui perbandingan morfometrik antar spesies dan famili. Hasil menunjukkan variasi ukuran dan proporsi tubuh yang signifikan dengan nilai SVL berkisar 2,48–11,78 cm. Perbedaan morfometrik antar famili mencerminkan adaptasi terhadap habitat. Data tersebut berpotensi sebagai dasar pengembangan sumber belajar kontekstual biologi.
Kata kunci : Amfibi; Booklet; Keanekaragaman Hayati; Kaldera Toba Taman Bumi Unesco; Morfometrik.

Abstract: Amphibian diversity is an important indicator of environmental quality; however, the utilization of local biodiversity data as a learning resource remains limited, resulting in abstract learning processes. This study aimed to analyze the morphological and morphometric variations of amphibians in the Silahisabungan Geosite-Toba Caldera Unesco Global Geopark (TCUGGp) and to utilize these data as contents for developing a biodiversity booklet. A quantitative descriptive method was employed through observation, documentation, and morphometric measurements of 18 species from five families. The parameters measured included snout-vent length (SVL), head length (HL), head width (HW), tibia length (TL), and others. Data were analyzed descriptively and through morphometric comparisons among species and families. The results showed significant variation in body size and proportions, with SVL ranging from 2.48 to 11.78 cm. Differences in morphometric characteristics among families reflect adaptations to their respective habitats. These findings indicate that morphometric data have strong potential as a basis for developing contextual biology learning resources.

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Keywords: Amphibian; Biodiversity; Booklet; Morphometric; Toba Caldera Unesco Global Geopark (TCUGGp).

1. Introduction

Amphibians are a group of vertebrates that play a significant ecological role, particularly as bioindicators of environmental changes. Their high sensitivity to fluctuations in temperature, humidity, and levels of pollution makes them effective indicators for assessing ecosystem quality [1]. In addition, amphibians contribute to maintaining trophic balance through their roles as both predators and prey within food chains [2]. Therefore, the presence and level of amphibian diversity can reflect the stability of ecosystems within a given area.

Amphibian diversity is influenced by various environmental factors, including habitat conditions, water availability, and anthropogenic pressures [3]. These variations in ecological conditions drive the development of morphological and morphometric adaptations in each species [4]. Morphological characters, such as body shape, color patterns, and limb structure, as well as morphometric traits, including body size and proportions, constitute important parameters in species identification and the analysis of adaptation [5]. Thus, morphological and morphometric studies play a strategic role in understanding the relationship between organisms and their environment.

The morphometric approach provides a quantitative analytical framework for objectively examining variations in body size and proportions of organisms [6]. Parameters such as body length, limb length, and inter-segmental body ratios can be used to distinguish species that exhibit similar morphology visually [7]. Moreover, morphometric variation reflects adaptive responses to environmental pressures as well as the differentiation of ecological niches occupied by each species [8]. Therefore, morphometric analysis represents a relevant approach in biodiversity studies, particularly within amphibian groups.

Nevertheless, the utilization of local biodiversity data in biology education remains suboptimal. The learning process tends to be oriented toward theoretical concepts and has not yet fully integrated the surrounding environment as a learning resource [9];[10]. This condition has implications for students' limited ability to relate biological concepts to real-world phenomena, as well as for the underdevelopment of environmental literacy [11]. Integrating findings from local research into instructional materials is one approach that can enhance the relevance and contextuality of learning [12];[13].

Silahisabungan Geosite, as one of the 16 geosites within the Toba Caldera UNESCO Global Geopark (TCUGGp), represents an area with high biodiversity potential, including amphibian groups. The variation in environmental conditions, such as the presence of aquatic ecosystems, forests, and diverse topography, supports the occurrence of various amphibian species with diverse morphological characteristics [14]. This potential requires systematic scientific investigation to document and analyze the morphological and morphometric characteristics of the species encountered, thereby providing comprehensive information on amphibian diversity in the area.

The development of research-based instructional materials, such as biodiversity booklets, represents a strategic approach to integrating research findings into the teaching and learning process [15]. A booklet is characterized by the concise and systematic presentation of information, supported by visualizations that can enhance understanding [16];[17]. The utilization of amphibian morphological and morphometric data in the development of the booklet is expected to produce instructional materials that are scientific, contextual, and relevant to students' surrounding environment.

Based on the foregoing description, the problem addressed in this study lies in the suboptimal utilization of amphibian morphological and morphometric data as a source of learning based on the local environment. Therefore, this study aims to analyze the morphological and morphometric variations of amphibians in the Silahisabungan Geosite and to utilize these data as a basis for the development of a biodiversity booklet. This research is

expected to contribute to the development of biology instructional materials grounded in local potential and oriented toward enhancing scientific literacy.

2. Research Method

This study employed a quantitative descriptive approach using a field survey method aimed at analyzing the morphological and morphometric characteristics of amphibians as a basis for developing a biodiversity booklet as a local potential–based learning resource. The research was conducted in the Silahisabungan Geosite area, Dairi Regency, North Sumatra, which features diverse habitats, including aquatic environments, forests, and moist areas that support amphibian presence. The study was carried out from early January to early April 2026.

The objects of this study were all amphibian individuals encountered at the research site. Sampling was conducted using a purposive sampling technique, with observation points determined based on habitat characteristics likely to support amphibian life, such as aquatic areas, riverbanks, and moist forest regions. The survey method applied was the Visual Encounter Survey (VES), conducted during the active periods of amphibians, namely from late afternoon to nighttime.

The variables observed in this study included the morphological and morphometric characteristics of amphibians. Morphological variables comprised body shape, skin texture, color patterns, and the presence of specific structures such as webbing and glands. Morphometric variables consisted of quantitative body measurements, including Snout–Vent Length (SVL), head length (HL), limb length (FL), and inter-segmental body ratios such as HL/SVL, FL/SVL, and TL/SVL [18]. Measurements were taken using a digital caliper (KLSOL Mitutoyo 500-151-30, digital caliper) with a precision of 0.01 mm..

Data collection techniques involved direct field observations, documentation, and morphometric measurements of the amphibian individuals encountered. Species identification was conducted by comparing

observed morphological characteristics and referring to amphibian taxonomic literature, including their conservation status [19];[20];[21].

Using a handheld GPS device (Garmin), the coordinate positions where amphibians were encountered were also recorded. Photographic documentation of the observed amphibians was conducted to support the identification process. Data analysis was performed using a quantitative descriptive approach and presented in the form of tables and graphs.

3. Results and Discussion

a. Amphibian Diversity in the Silahisabungan Geosite

The results of the study indicate that at least 18 amphibian species were identified in the Silahisabungan Geosite (Table 1). These amphibians belong to five families, namely Dicroglossidae, Bufonidae, Microhylidae, Ranidae, and Rhacophoridae.

Table 1. Morphological Characteristics of Amphibians in the Silahisabungan Geosite

Family	Local Name	Scientific Name	Key Characteristics	Habitat	Conservation status	Coordinate
(1) Dicroglossidae	(1) Katak Tegalan	*Fejervarya limnocharis*	The body color is grayish, has a middorsal line	Rice fields, swamp, ponds	LC	2.773211⁰, 98.553352⁰
	(2) Bangkok raksasa	*Limnonectes blythii*	Has a cream colored vertebral stripe line	River, forest	NT	2.858642º, 98.523564º
	(3) Bangkong saklon	*Limnonectes paramacrodon*	The body color on the dorsum is golden green	Rocky river	NT	2.772682º, 98.55234º
	(4) Bangkok moncong pendek	*Limnonectes malesianus*	Head with short snout, large eyes, horizontal pupils	Rivers, primary forests	NT	2.772635º 98.552583º
	(5) Katak Shompen	*Limnonectes shompenorum*	The dorsal surface is reddish black, there is a white line on the back-cloaca.	Rivers and humid forests	LC	2.798828º, 98.523552º
	(6) Bangkok tuli	*Limnonectes kuhlii*	Wrinkled skin texture covered with star-shaped bumps spread over the surface of the body.	Wet leaves and mud near water flow	LC	2.798828º, 98.523552º
	(7) Bangkok anak Sungai kecil	*Limnonectes laticeps*	Golden color on the upper body, irregular dark spots, dark brown line between the eyes.	Riparian and leaf-litter forest	LC	2.77359º, 98.553531º

Family	Local Name	Scientific Name	Key Characteristics	Habitat	Conservation status	Coordinate
	(8) Katak sawah	*Fejervarya cancrivora*	The color is like dirty mud with dark asymmetrical spots.	pond, rice field	LC	2.772397°, 98.552303°
(2) Microhylidae	(9) Beletuk-pohon jawa	*Kaloula baleata*	The body color is blackish gray, has two striped patterns, golden in color located on the edge of the back.	Forests, plantations, and settlements	LC	2.788522°, 98.535702°
	(10) Percik bintik hitam	*Microhyla heymonsi*	A wide black band stretches from the tip of the snout to the thighs.	Forest litter, rice fields	LC	2.772397°, 98.552303°
(3) Ranidae	(11) Kongkang gading	*Hylarana erythraea*	On the lateral side it has a striking golden stripe extending from behind the eye - the groin.	Swamps, ponds, calm rivers	LC	2.858426°, 98.522951°
	(12) Kokang jangkrik	*Hylarana nicobariensis*	The body color is brown, has two striking dark lateral lines along the sides of the head to the tympanum.	Damp forest near water	LC	2.798618°, 98.522295°
(4) Rhacophoridae	(13) Katak panjat bergaris	*Polypedates leucomystax*	Has a cream or yellow vertebral stripe that extends from the snout to the cloaca.	Trees, settlements	LC	2.773038°, 98.552883°
	(14) Katak parasut bintik hitam	*Rhacophorus achantharrhena*	Large eyes with horizontal pupils, with deep blue irises.	Primary forest, arboreal life	EN	2.858406°, 98.522965°
(5) Bufonidae	(15) Kodok puru rumah	*Duttaphrynus melanostictus*	The skin is dry, rough, and covered with warts.	Settlements, gardens	LC	2.773253°, 98.553439°
	(16) Kodok sumatra	*Duttaphrynus sumatranus*	It has a brown or dark gray color, with a pattern that is not too striking.	Forest and river	LC	2.72635°, 98.552583°
	(17) Kodok puru raksasa	*Phrynoidis juxtasper*	In males, the sides are reddish.	Big rocky river	LC	2.858355°, 98.523255°
	(18) Kodok puru sungai	*Phrynoidis aspera*	The color is usually grayish brown to dark brown, with a pattern that is not too striking.	Fast flowing river in the forest	LC	2.77306°, 98.552812°

Remarks: LC (Least Concern), NT (Near Threatened), EN (Endangered)

Based on the data presented in Table 1, the family most frequently encountered in the Silahisabungan Geosite is Dicroglossidae, with a higher number of species compared to other families such as Microhylidae, Ranidae, Rhacophoridae, and Bufonidae. Several species belonging to the family Dicroglossidae include *Fejervarya limnocharis*, *Limnonectes blythii*, *Limnonectes paramacrodon*, *Limnonectes malesianus*, and *Limnonectes laticeps*.

The dominance of the family Dicroglossidae indicates that this group possesses a high adaptive capacity to various habitat types, particularly aquatic environments such as rivers, swamps, and rice fields, which are abundant in the Silahisabungan area. In contrast, other families were found in lower numbers, suggesting variation in species abundance as well as more specific habitat preferences among these amphibian groups.

The distribution of species across relatively adjacent habitats, yet exhibiting high variation in characteristics, indicates the presence of microhabitat heterogeneity and niche segregation mechanisms. This is further supported by findings that habitat conditions play a crucial role in determining both the composition and morphological characteristics of amphibians [22], even at a limited landscape scale. Compared to other areas such as Meru Betiri and Lubuklinggau, the Silahisabungan Geosite exhibits higher amphibian morphological complexity, likely due to habitat diversity encompassing arboreal, semi-aquatic, and terrestrial types within a single area [23]. In a global context, such patterns of diversity, abundance, and distribution reflect the characteristics of tropical biodiversity in Southeast Asia, which is recognized as a global hotspot of amphibian diversity [24].

Based on conservation status, fourteen amphibian species recorded in the Silahisabungan Geosite are classified as Least Concern (LC), three species as Near Threatened (NT), and one species as Endangered (EN). The presence of Near Threatened (NT) and Endangered (EN) amphibians in the Silahisabungan Geosite indicates ecological pressures that may potentially affect the sustainability of their populations [25]. The conservation status of amphibians was obtained from the IUCN Red List, which is based on globally recognized scientific criteria. Amphibians that are sensitive to environmental changes tend to respond rapidly to habitat degradation; thus, even minor changes in environmental quality can directly affect community structure [26]. Therefore, ecological pressures, particularly those originating from human activities, should be avoided and minimized as early as possible and to the greatest extent possible.

b. Morphometric Variation of Amphibians

The morphometric data of amphibians recorded in the Silahisabungan Geosite are presented in Table 2.

Table 2. Morphometric Characteristics of Amphibians in the Silahisabungan Geosite

Morphometric Characteristics	Sp. 1	Sp. 2	Sp. 3	Sp. 4	Sp. 5	Sp. 6	Sp. 7	Sp. 8	Sp. 9
Snout-vent length (SVL)	7,8 cm	9,49 cm	11,78 cm	9,45 cm	7,21 cm	6,92 cm	2,79 cm	10,1 cm	4,56 cm
Head width (HW)	3,4 cm	3,6 cm	3,22 cm	2,1 cm	3,21 cm	2,91 cm	0,49 cm	3,52 cm	1,46 cm
Head length (HL)	2,63 cm	3,81 cm	4,4 cm	1,77 cm	2,41 cm	2,24 cm	0,47 cm	4,25 cm	0,93 cm
Internarial distance (IND)	0,32 cm	0,67 cm	0,89 cm	0,56 cm	0,32 cm	0,31 cm	0,13 cm	0,57 cm	0,32 cm
Eye-nostril distance (END)	0,69 cm	0,84 cm	1,13 cm	0,87 cm	0,59 cm	0,57 cm	0,27 cm	0,84 cm	0,36 cm
Tymphanicum distance (TD)	1,99 cm	2,39 cm	0,77 cm	0,43 cm	0,47 cm	0,53 cm	0,04 cm	0,45 cm	0,53 cm
Eye length (EL)	0,47 cm	0,96 cm	0,68 cm	0,52 cm	0,53 cm	0,43 cm	0,07 cm	0,34 cm	0,3 cm
Tibia length (TL)	3,77 cm	3,73 cm	4,45 cm	4,56 cm	3,13 cm	3,5 cm	1,95 cm	4,52 cm	1,23 cm
Foot length (FL)	9,64 cm	13,3	9,44 cm	8,48 cm	8,42 cm	8,19 cm	1,89 cm	10,9 cm	2,63 cm
Distance from the nostril to the most anterior extremity of the rostra (DNR)	0,41 cm	0,48 cm	0,86 cm	0,32 cm	0,39 cm	0,38 cm	0,07 cm	0,45 cm	0,26 cm
Hind leg length (HLL)	6,31 cm	9,12 cm	8,83 cm	7,32 cm	6,31 cm	5,31 cm	1,31 cm	8,4 cm	1,58 cm
Whole body length (WBL)	18 cm	35,8 cm	21,9 cm	15,8 cm	16,23 cm	17 cm	4,21 cm	21,2 cm	7,63 cm

Morphometric Characteristics	Sp. 10	Sp. 11	Sp. 12	Sp. 13	Sp. 14	Sp. 15	Sp. 16	Sp. 17	Sp. 18
Snout-vent length (SVL)	2,48 cm	4,82 cm	4,53 cm	6,26 cm	5,36 cm	7,43 cm	10,9 cm	9,17 cm	7,38 cm
Head width (HW)	0,34 cm	1,32 cm	0,94 cm	1,77 cm	1,25 cm	1,88 cm	3,58 cm	3,11 cm	2,66 cm
Head length (HL)	0,43 cm	1,41 cm	1,48 cm	1,35 cm	1,45 cm	2,09 cm	3,16 cm	3,97 cm	2,87 cm
Internarial distance (IND)	0,09 cm	0,27 cm	0,42 cm	0,36 cm	0,26 cm	0,42 cm	0,63 cm	0,46 cm	0,5 cm
Eye-nostril distance (END)	0,27 cm	0,45 cm	0,41 cm	0,65 cm	0,23 cm	0,5 cm	0,5 cm	0,88 cm	0,43 cm
Tymphanicum distance (TD)	0,05 cm	0,63 cm	0,41 cm	0,28 cm	0,43 cm	0,5 cm	0,54 cm	1,66 cm	1,66 cm
Eye length (EL)	0,06 cm	0,3 cm	0,36 cm	0,33 cm	0,47 cm	0,45 cm	0,61 cm	0,71 cm	0,42 cm
Tibia length (TL)	0,98 cm	1,72 cm	2,41 cm	2,87 cm	2,3 cm	2,69 cm	3,17 cm	3,6 cm	2,46 cm
Foot length (FL)	1,6 cm	4,47 cm	5,14 cm	6,59 cm	5,5 cm	5,39 cm	7,12 cm	10,1 cm	6,61 cm
Distance from the nostril to the most anterior extremity of the rostra (DNR)	0,04 cm	0,31 cm	0,36 cm	0,19 cm	0,27 cm	0,34 cm	0,65 cm	0,28 cm	0,33 cm
Hind leg length (HLL)	1,21 cm	2,44 cm	3,5 cm	5,46 cm	4,14 cm	3,93 cm	5,82 cm	7,4 cm	4,64 cm
whole body length (WBL)	3,87 cm	7,76 cm	9,17 cm	13,9 cm	11,9 cm	10,3 cm	17 cm	20,08 cm	13,35 cm

Remarks: Sp. 1 = *Fejervarya limnocharis*; Sp. 2 = *Limnonectes blythii*; Sp. 3 = *Limnonectes paramacrodon*; Sp. 4 = *Limnonectes malesianus*; Sp. 5 = *Limnonectes shompenorum*; Sp. 6 = *Limnonectes kuhlii*; Sp. 7 = *Limnonectes laticeps*; Sp. 8 = *Fejervarya cancrivora*; Sp. 9 = *Kaloula baleata*; Sp. 10 = *Microhyla heymonsi*; Sp. 11 = *Hylarana erythraea*; Sp. 12 = *Hylarana nicobariensis*; Sp. 13 = *Polypedates leucomystax*; Sp. 14 = *Rhacophorus achantharrhena*; Sp. 15 = *Duttaphrynus melanostictus*; Sp. 16 = *Duttaphrynus sumatranus*; Sp. 17 = *Phrynoidis juxtasper*; Sp. 18 = *Phrynoidis aspera*.

Based on the data presented in Table 2, the morphometric characteristics of amphibians recorded in the Silahisabungan Geosite exhibit considerable variation in body size and morphological proportions among species. The snout–vent length (SVL) ranges from 2.48 cm to 11.78 cm, indicating differences from small- to large-bodied species. Variation is also evident in other parameters such as hind leg length and foot length, which tend to be relatively greater in species with larger SVL, suggesting adaptations related to locomotor abilities such as jumping or swimming. Furthermore, differences in head size (HW and HL) as well as facial distances (IND, END, and DNR) reflect variations in ecological strategies, particularly in terms of feeding habits and interactions with the environment [27]. Overall, this morphometric diversity reinforces the presence of adaptive differentiation among amphibian species in the area as a

response to heterogeneous habitat conditions. Species with larger body sizes tend to be found in permanent aquatic habitats, whereas smaller species are typically associated with microhabitats such as leaf litter.

c. Morphometric Comparison Among Families

Morphometric ratios represent the proportional comparison of specific body parts to the main body length. Ratios such as HL/SVL, TL/SVL, and FL/SVL are used to analyze relative body proportions among species. The analysis of morphometric ratios provides insight into the relationship between body structure and ecological function. [7]. Variations in HL/SVL, TL/SVL, and FL/SVL values reflect species' adaptive strategies to their respective habitats and ecological niches. Comparisons of morphometric ratios among families reveal distinct adaptation patterns that are closely associated with habitat characteristics and the life-history strategies of each group.

Table 3. Average Morphometric Ratios Among Amphibian Families

Family	Number of Species	Mean HL/SVL	Mean TL/SVL	Mean FL/SVL
Dicroglossidae	8	0.32	0.48	1.06
Microhylidae	2	0.19	0.34	0.62
Ranidae	2	0.31	0.45	1.03
Rhacophoridae	2	0.25	0.45	1.04
Bufonidae	4	0.35	0.34	0.85

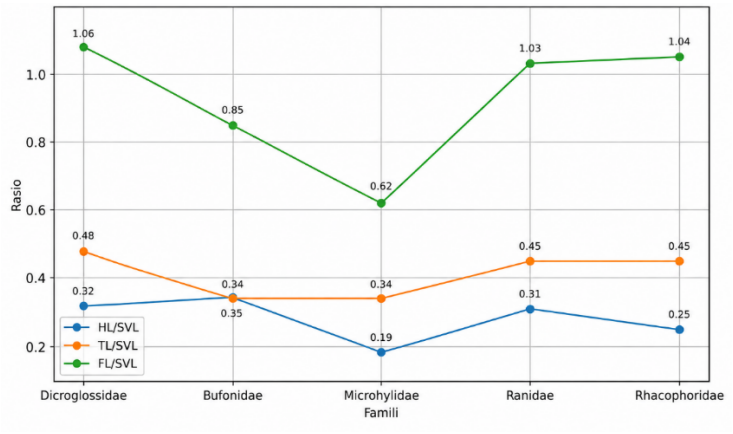


Figure 1. Comparison of Morphometric Ratios Among Amphibian Families

Based on the data presented in Table 3 and Figure 1, there are clear differences in the mean values of morphometric ratios among amphibian

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families, reflecting variation in adaptive strategies to different habitats. The families Dicroglossidae and Ranidae exhibit relatively high FL/SVL values, indicating strong locomotor capabilities, particularly for jumping and swimming in semi-aquatic environments. The proportionally longer limbs in these families reflect adaptations to aquatic habitats that require high mobility for foraging, mating, and predator avoidance.

In contrast, the family Bufonidae exhibits lower ratio values, particularly in TL/SVL and FL/SVL, reflecting adaptation to terrestrial habitats with more limited mobility. A more robust body structure and relatively shorter limbs indicate energy-conserving strategies as well as an enhanced capacity to persist under drier environmental conditions [28].

The family Microhylidae exhibits relatively high TL/SVL ratios compared to its body size, indicating fairly good locomotor ability despite having a small body size. This is associated with adaptive strategies in microhabitats such as leaf litter, where the ability to move quickly within confined spaces is essential for avoiding predators and locating food resources [29].

Meanwhile, the family Rhacophoridae exhibits high FL/SVL values, which are associated with arboreal capabilities. The proportionally longer limbs and feet support climbing activities and movement between vegetation. This adaptation enables species within this family to exploit ecological niches distinct from those of terrestrial and aquatic amphibians.

Overall, the variation in morphometric ratios among families indicates clear differentiation in adaptive strategies, with each family possessing specific morphological characteristics suited to its habitat and ecological function. This underscores that differences in body proportions are not merely descriptive, but also reflect the relationship between structure, function, and environmental pressures in shaping amphibian diversity.

c. Implications as a Learning Resource

The morphological and morphometric data of amphibians obtained in this study have significant potential as a basis for developing biology learning

resources, particularly in the form of a biodiversity booklet. Variations in body size, limb proportions, and morphological characteristics among species and families can be utilized to explain key concepts such as classification, systematics, adaptation, and the relationship between structure and function in a contextual manner [30];[31].

The utilization of local data from the Silahisabungan Geosite enables students to study biodiversity within their surrounding environment, making learning more meaningful and less abstract. Furthermore, the presentation of morphometric data in visual forms such as tables, figures, and scientific descriptions in a booklet can enhance students' analytical thinking skills in interpreting biological data, as well as their science process skills.

Furthermore, the development of a booklet based on the data obtained from this study also supports local wisdom-based learning, which can enhance student engagement in the learning process [32];[33]. Thus, the integration of morphological and morphometric data into learning resources not only enriches instructional content, but also contributes to improving the quality of biology learning that is contextual, scientific, and relevant to real-life situations, while simultaneously fostering students' ecological literacy (ecoliteracy).

4. Conclusion

This study identified 18 amphibian species from five families in the Silahisabungan Geosite. Morphological and morphometric analyses revealed variations reflecting habitat-specific adaptations among families. The findings also provide a scientific basis for developing a contextual biodiversity booklet as a biology learning resource, contributing to improved biology education and students' ecological literacy.

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6. Reference

[1] Agustini, P. L., Ilhamdi, M. L., & Hadiprayitno, G. (2024). Keanekaragaman Spesies Amfibi (Ordo Anura) Di Kawasan Taman Wisata Alam Kerandangan Kabupaten Lombok Barat. *Bioscientist : Jurnal Ilmiah Biologi*, *12*(1), 577–586. https://doi.org/10.33394/bioscientist.v12i1.11030

[2] Hernandez-caballero, I., Garcia-longoria, L., Gomez-mestre, I., & Marzal, A. (2022). The Adaptive Host Manipulation Hypothesis : Parasites Modify the Behaviour , Morphology , and Physiology of Amphibians. *Diversity*, *14*(9), 1–18. https://doi.org/https://doi.org/10.3390/d14090739

[3] Dalkıran, N., & Zünbülgil-Ünsal, B. (2023). Environmental Heterogeneity and Salinity Gradient Impacted the Alpha and Beta Diversities of Diatom Assemblages in a Coastal Delta Wetland. *MDPI*, 1–21. https:/doi.org/10.3390/w15193414

[4] Cantika, M., Larasati, P., & Budijastuti, W. (2022). Morfometri dan Meristik Ikan Bandeng di Pertambakan Sekitar Mangrove Wonorejo Surabaya. *Lentera Bio: Berkala IImiah Biologi*, *11*(2010), 473–492. https://doi.org/10.26740/lenterabio.v11n3.p473-492

[5] Fitzgerald, J. L., Ogilvie, J. E., Caradonna, P. J., & Fitzgerald, J. L. (2025). Intraspecific body size variation across distributional moments reveals trait filtering processes. *Journal of Animal Ecology*, *January 2024*, 394–409. https://doi.org/10.1111/1365-2656.14186

[6] Pranata, D. A., Hadi, I., & Syaputra, M. (2023). Pengukuran Morfometrik Pada Amfibi (Ordo Anura) Di Perbatasan (Terluar) Blok Pemanfaatan Taman Wisata Alam Danau Rawa Taliwang. *Jurnal Edukasi Matematika Dan Sains*, *XII*(1), 29–40.

[7] Uiterwaal, S. F., Squires, A. J., Grappone, B. A., Dillard, B., Castaneda, A., Kim, S. L., & Delong, J. P. (2023). Intraguild predation is increased in areas of low prey diversity in a generalist predator community. *Journal of Animal Ecology*, *November 2022*, 901–912. https://doi.org/10.1111/1365-2656.13901

[8] Rezende, E. L., & Diniz-Filho, J. A. F. (2012). Phylogenetic Analyses : Comparing Species to Infer Adaptations and Physiological Mechanisms. *Comprehensive Physiology*, *2*(January), 639–674. https://doi.org/10.1002/cphy.c100079

[9] Ramadhani, D. O., Afifah, E. N., & Nisak, F. Z. (2025). Pemanfaatan Sumber Daya Lingkungan Lokal Untuk Meningkatkan Hasil Belajar Siswa. *Jurnal Ilmiah Penelitian Mahasiswa*, *3*(1), 677–687. https://doi.org/https://doi.org/10.61722/jipm.v3i1.699

[10] Wulandari, N., & Novinovrita. (2025). Persepsi Siswa Terhadap Pembelajaran Biologi Berorientasi Lingkungan di SMAN 7 Kerinci. *Bioscientist: Jurnal Ilmiah Biologi*, *13*(4), 3242–3253. https://doi.org/https://doi.org/10.33394/bioscientist.v13i4.18871

[11] Kurniawan, S., Sugiarno, Y., & Rahman, M. A. (2025). Analisis kurikulum biologi berbasis konteks lingkungan pendekatan holistik dalam pembelajaran sains di SMA Antartika Sidoarjo. *Science Education and Development Journal Archives*, *3*(1), 27–36.

[12] Lestari, W. Y., & Rahmita. (2025). Penerapan potensi lokal dalam Pembelajaran

IPA di Sekolah Menengah Pertama. *JKPI: Jurnal Kajian Pendidikan IPA*, *5*(2), 200–213. https://doi.org/https://doi.org/10.52434/jkpi.v5i2.41916

[13] Priyatno, O. H., Galih, I., Mardiani, F., & Nadilla, D. F. (2025). Integrasi Nilai-Nilai Kearifan Lokal Suku Osing Dalam Pembelajaran Ips: Studi Analisis Etnopedagogi Di SMP. *Journal of Education Science*, *4*(2), 894–911.

[14] Simatupang, K. (2019). Peran Masyarakat Lokal dalam Pengembangan Geosite Geopark Kaldera Toba Silahisabungan menuju Geopark Global UNESCO. *Jurnal Ekonomi Dan Industri*, *20*(3), 39–48. https://doi.org/10.35137/jei.v20i3.344

[15] Sartika, Anugra, N., & Rahayu, M. (2025). Pengembangan E-Booklet Berbasis Etnobotani pada Upacara Pernikahan Etnis Pattinjo Materi Keanekaragaman Hayati untuk Meningkatkan Hasil Belajar. *Jurnal Pendidikan MIPA*, *15*(2), 569–578.

[16] Sarip, M., Amintarti, S., & Utami, N. H. (2022). Validitas Dan Keterbacaan Media Ajar E-Booklet Untuk Siswa SMA / MA Materi Keanekaragaman Hayati. *Jurnal Pendidikan Dan Ilmu Sosial*, *1*(1), 44–59.

[17] Hafizah, G., & Irianti, R. (2022). Validitas Booklet Sebagai Bahan Ajar Konsep Animalia (Bekantan). *Journal of Science Education and Applied Science*, *2*(1), 13–23.

[18] Tambun, M. L., Hutabarat, L. S., Suri, S., Nuryati, Mardiah, S. R., & Wahyuni, A. (2023). Morphological and Morphometric Identification of Amphibians (Rana) in Meurandeh Dayah Village, Langsa City. *Jurnal Biologi Tropis*, *23*(2), 298–303. https://doi.org/10.29303/jbt.v23i2.6175

[19] Kamsi M, Handayani S, Siregar AJ, Fredriksson G. (2017). BukuPanduan Lapangan Amfibi Reptil Kawasan Hutan Batang Toru. Herpetologer Mania Publishing, Medan.

[20] Kaprawi, F., Alhadi, F., Hamidy, A., Nopandry, B., Kirschey, T. &Permana, J. (2020) *Panduan Lapangan Amfibi di Taman Nasional Batang Gadis Sumatera Utara*. Perkumpulan Amfibi Reptil Sumatra, Sumatra, Indonesia.

[21] Frost, D. R., Grant, T., Faivovich, J., Bain, R. H., Haas, A., Haddad, C. F. B., De Sá, R. O., Channing, A., Wilkinson, M., Donnellan, S. C., Raxworthy, C. J., Campbell, J. A., Blotto, B. L., Moler, P., Drewes, R. C., Nussbaum, R. A., Lynch, J. D., Green, D. M., & Wheeler, W. C. (2006). The amphibian tree of life. Bulletin of the American Museum of Natural History, 297,1–291. https://doi.org/10. 5531/sd.sp.13

[22] Baswedann, B. B., Adifitri, R. D., Fitrih, G. A. Y., Rizdallah, M. A., Djahabiyyah, P. A., Mefida, L. I., Arizki, D. A., & Master, J. (2024). Keanekaragaman Herpetofauna Berdasarkan Karakteristik Mikrohabitat Pada Dua Level Ketinggian Di Taman Nasional Bukit Barisan Selatan. *Biospecies*, *17*(2), 52–59. https://doi.org/10.22437/biospecies.v17i2.31543

[23] Dharma, A. P., & Meitiyani. (2019). inventarisasi amfibi resort cisarua taman nasional gunung gede pangrango berdasarkan musim yang berbeda. *Biosilampari: jurnal biologi*, *2*(1), 1–5. https://doi.org/10.31540/biosilampari.v2i1.585

[24] Arifin, U. (2024). Current knowledge of amphibian diversity in Sumatra, and its significance for conservation. *Cambridge University Press on Behalf of Fauna & Flora International*, *58*(4), 462–467. https://doi.org/10.1017/S0030605323001369

[25] Ulfiyah, M., Hanim, N., Zuraidah, Ahadi, R., & Eriawati. (2024). Status Konservasi Burung Di Kawasan Air Terjun Tingkat Tujuh Kabupaten Aceh Selatan.

Kenanga : Journal of Biological Sciences and Applied Biology, *4*(2), 90–99. https://doi.org/10.22373/kenanga.v4i2.5233

[26] Gardner, T. A., Barlow, J., & Peres, C. A. (2007). Paradox, presumption and pitfalls in conservation biology: The importance of habitat change for amphibians and reptiles. *Journal Elsevier*, 166–179. https://doi.org/10.1016/j.biocon.2007.04.017

[27] Ramadhanu, D., Prananda, M., Wulandari, U. A., Hidayat, R., & Syarif, A. F. (2023). Perbandingan Pola Rasio Morfometrik Dan Karakteristik Habitat Dua Spesies Ikan Cupang Alam (Betta Spp.) Endemik Pulau Bangka. *Jurnal Ilmiah Biologi*, *11*(2), 1501–1508. https://doi.org/10.33394/bioscientist.v11i2.9598

[28] Ismail, F. Y., Rahmawati, S., Sari, N. I., Muhlisa, & Sahribulan. (2024). Thermoregulation as an Adaptation Strategy in Frogs. *IoTeach: Biology Science and Biology Education Journa*, *01*(02), 69–74. https://doi.org/https://doi.org/10.62330/bioteach.v1i02.119

[29] Lennox, R. J., Kambestad, M., Berhe, S., Birnie-gauvin, K., Cooke, S. J., Dahlmo, L. S., Eldøy, S. H., Davidsen, J. G., Hanssen, E. M., Sortland, L. K., Shea, D., Nilsen, C. I., Skoglund, H., Velle, G., Hellström, G., Lundberg, P., Junge, C., Ferter, K., & Vollset, K. W. (2024). The role of habitat in predator – prey dynamics with applications to restoration. *The Journal of the Society for Ecological Restoration*, 1–10. https://doi.org/10.1111/rec.14354

[30] Freudiger, A., Josi, D., Thünken, T., Herder, F., Flury, J. M., Marques, D. A., Taborsky, M., & Frommen, J. G. (2021). Ecological variation drives morphological differentiation in a highly social vertebrate. *Functional Ecology*, *December 2020*, 2266–2281. https://doi.org/10.1111/1365-2435.13857

[31] Fazhan, H., Waiho, K., Quinitio, E., Baylon, J. C., Fujaya, Y., Rukminasari, N., Farhan, M., & Azri, D. (2020). Morphological descriptions and morphometric discriminant function analysis reveal an additional four groups of Scylla spp. *PeerJ*, 1–19. https://doi.org/10.7717/peerj.8066

[32] Susanti, D., Putri, I., & Nabila, S. (2025). TOFEDU : The Future of Education Journal Analysis of the implementation of local wisdom-based learning in the integrated thematic curriculum at MI Pelangi Alam. *TOFEDU: The Future of Education Journal*, *4*(6), 1961–1969. https://doi.org/https://doi.org/10.61445/tofedu.v4i6.701

[33] Lestari, N. C., Mayasari, R., Wulandari, A., & Arifin, M. (2024). Pengenalan Kearifan Lokal Kalimantan Selatan Untuk Siswa Sd Melalui Booklet Sebagai Sumber Belajar Di Sd It Robbani Banjarbaru. *Jurnal Abdimas Widya Dharma*, *03*(02), 69–73. https://doi.org/10.54840/widharma.v3i02.288