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ANURAN DIVERSITY IN KARST AREAS, GERANTUNG AS AN ENVIRONMENTAL BIOINDICATOR

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Abstract: The purpose of this study was to determine the diversity of anura types in the karst area, especially the conservation area of Gerantung, Central Lombok. This study uses the Visual Encounter Survey (VES) method combined with the patch and time search methods. Patches were selected based on representative areas for anura habitat with a size of 100 m^2. A total of 6 patches (plots) were used. The time search method was used by determining the observation time: afternoon and evening, with an observation duration of 2-3 hours per day. Sample data analysis using the frequency calculation and the Shannon-Wiener diverse index. There are 9 species of Anura found in Gerantung karst area: *Duttaphrynus melanostictus, Iningerophrynus biporcatus, Fejryvarya limnocharis, Kaloula baleata, Occidozyga lima, Occidozyga sumatrana, Microhyla orientalis, Microhyla palmipes,* and *Polypedates leucomystax*. The two most abundant species are *Ingerophrynus biporcatus* and *Fejervarya limnocharis*. Meanwhile, the species with the highest frequency are *Ingerophrynus biporcatus* and *Leucomystax polypedates*, which is shows that the distribution of *Ingerophrynus biporcatus* and *Leucomystax polypedates* is even. Anura diversity found in the Karst area is classified as medium, which shows that the stability of the ecosystem is moderate.

Keywords: Anura, Diversity, Karst Area

INTRODUCTION

Biodiversity has a crucial role in maintaining ecosystem stability [1] [2]. Biodiversity functions to maintain ecosystem balance, provide biological resources, maintain climate stability, and increase ecosystem resilience to disturbances [3] [4]. Anuras are a group of animals that are very sensitive to environmental changes, so they are often used as ecological indicators to assess habitat quality [5]. The order Anura consists of Bufonidae, Ranidae, Dicroglossidae, Rhacophoridae, Microhylidae, and Megophryidae [6] [7].

Anura undergoes metamorphosis from larvae (tadpoles) that live in water to adult forms that can live on the land [8]. Anura skin is quite variable; frogs are generally smooth and moist, while toads have rough and bumpy skin [9] [10]. Anura skin has mucus glands that secrete mucus to keep the skin moist [11] [12]. Some anuran species even have skin that can produce poison for self-defense from predators [13]. Naturally, anuras like humid habitats, bushes, standing water, and canopies [14] [15]. However, Anura can be found in a variety of habitats, including tropical rainforests, deserts, mountains, and wetlands [16].

The presence and diversity of Anura not only reflect ecosystem conditions [17], but are also important in nutrient cycles and as a natural controller of insect pests [18] [19]. Frogs and toads are effective insect predators [20] [21]. They help control insect populations, including those of pests such as mosquitoes, flies, and agricultural insects. Anuras are an important food source for a variety of predators, including birds, mammals, reptiles, and fish [22]. Tadpoles (anura larvae) play a role in the nutrient cycle in aquatic ecosystems [23]. They help break down organic materials, converting them into simpler forms that can be used by other organisms. Tadpoles help control algal growth, which can reduce eutrophication and maintain water quality [24]. Some species of toad dig in the ground for shelter or to find food, which helps aerate the soil. Due to their permeable skin and a life cycle that includes both aquatic and terrestrial phases, anura are highly sensitive to environmental changes such as water pollution, climate change, and habitat degradation [25] [26]. A decline in Anura populations can be an early indication that the ecosystem is experiencing stress or damage [27]. Research and monitoring of anura populations can provide important data about pollution, climate change, habitat degradation, and other ecosystem problems.

Karst areas, such as those in Gerantung Village, Central Lombok Regency, have a unique ecology with limestone formations and caves, often providing habitat for various endemic species [28] [29] [30] [31]. However, research on anuran diversity in this karst area is still very limited [32]. The lack of data and information regarding herpetofauna in Indonesia's karst regions, especially in Lombok, creates a significant knowledge gap. Without a deep understanding of existing species and their habitat conditions, conservation, and environmental management efforts will be less effective [33] [34]. Based on this, it is necessary to carry out an inventory and documentation of anura diversity in the karst area of Gerantung Village. Through an ecological approach and field surveys, this research will identify existing anuran species and analyze their density and diversity. This research not only

aims to increase scientific information about the herpetofauna in the region but also to provide a strong basis for conservation efforts and sustainable habitat management.

RESEARCH METHOD

The specimens studied were all types of amphibians belonging to the Anura order, which live in the karst area of Gerantung Village, Central Lombok Regency. The tools and materials used in this research are: a Global Positioning System (GPS), a camera, specimen bags, a net, and headlamps. The research was conducted for six days, from May 5 to 10, 2023. The method used was the Visual Encounter Survey (VES) method combined with patch and time search methods. The Visual Encounter Survey (VES) method uses survey lines (transects) based on the area being studied (following natural features such as rivers or rice fields). Patches were selected based on representative areas for anura habitat with a size of 100 m^2. A total of six patches (plots) were used.

Data collection on anuran diversity was carried out in a total of six plots in the Gerantung area: plots 136, 137, 138, 139, 140, and 141. Plot 136 represents an area with high human activity because it is close to the road. Plot 136 represents an area with high human activity because it is close to the road. Plot 137 represents an area with low human activity, such as grasslands and water bodies (ponds) with riparian vegetation, which is a potential habitat for anuran. Plots 138 and 139 are rice fields with tall trees and a dense canopy, but without standing water. Plot 140 is an open forest area, with some human activity around the area. Plot 141 is an open area with a small lake in it and lots of bushes and herbs around the irrigation.

The time search method was used by determining the observation time: afternoon and evening, with an observation duration of 2-3 hours per day. All specimens (order Anura) had their discovery coordinates recorded, documented, captured, and identified. Anura identification refers to [35], [36], and [37]. The data obtained was analyzed using the Shannon-Wiener diversity index and frequency of species occurrence.

$$H' = -\sum (\mathbf{Pi\ ln\ Pi})$$

While Pi= Ni/N
H': Diversity Index
Ni: Number of individuals of each species
N : Total number of individuals of all species

Criteria:
0 <H'<1 = very low diversity
1<H'<1.5 = low diversity
1.5<H'< 2.0 = medium diversity
H'>2.0 = high diversity.

RESULTS AND DISCUSSION

There were 9 types of anurans found in the Gerantung karst area; *Duttaphrynus melanostictus, Ingerophrynus biporcatus, Fejervarya limnocharis, Kaloula baleata, Occidozyga lima, Occidozyga sumatrana, Microhyla orientalis, Microhyla palmipes*, and *Polypedates leucomystax* (Table 1). *Ingerophrynus biporcatus* and *Fejervarya limnocharis* are the most abundant anura in Gerantung karst area. The appearance of the two types can be seen in Figure 1

Table 1. Anura Diversity in The Gerantung Karst Area

Class	Order	Familia	Species	Numbers
Amphibia	Anura	Bufonidae	*Duttaphrynus melanostictus*	9
		Bufonidae	*Ingerophrynus biporcatus*	76
		Dicroglossidae	*Fejervarya limnocharis*	39
		Dicroglossidae	*Kaloula baleata*	5
		Dicroglossidae	*Occidozyga lima*	2
		Dicroglossidae	*Occidozyga sumatrana*	8
		Microhylidae	*Microhyla orientalis*	2
		Microhylidae	*Microhyla palmipes*	3
		Rhacophoridae	*Polypedates leucomystax*	8

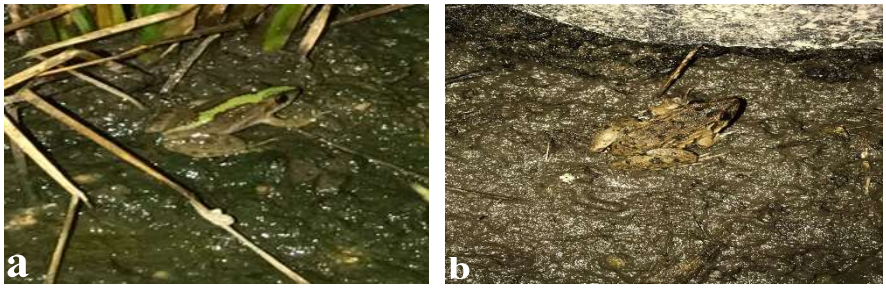

Figure 1. The most abundant types of frogs and toads in karst area, Gerantung (a) *Ingerophrynus biporcatus*; and (b) *Fejervarya limnocharis*.

Table 2 shows the frequency of anura species found in the karst area, Gerantung. The species *Fejervarya limnocharis* and *Polypedates leucomystax* are the species most frequently found in Gerantung.

Table 2. Frequency of Species of The Anura Order in Karst Areas, Gerantung

Familia	Species	Frequency
Bufonidae	*Duttaphrynus melanostictus*	50%
Bufonidae	*Ingerophrynus biporcatus*	50%
Dicroglossidae	*Fejervarya limnocharis*	100%
Dicroglossidae	*Kaloula baleata*	50%
Dicroglossidae	*Occidozyga lima*	16.70%
Dicroglossidae	*Occidozyga sumatrana*	50%
Microhylidae	*Microhyla orientalis*	16.70%
Microhylidae	*Microhyla palmipes*	33.30%
Rhacophoridae	*Polypedates leucomystax*	83.30%

Analysis of the Shannon-Wiener diversity index (H') (Table 3) shows that the level of anuran diversity in the karst area of Gerantung is included in the medium level. This illustrates the diversity of species of the anura order in karst areas; gerantung is not too low or too high.

Table 3. Number of Individuals and Diversity Index of Anura in Karst Area, Gerantung

Location	Plots						Total individuals	Shannon-Wiener Diversity Index
	136	137	138	139	140	141		
Number	5	7	3	6	3	3	27	1.43

Ingerophrynus biporcatus is generally found in primary and secondary forests that have water flow and fairly dense vegetation [38]. *Ingerophrynus biporcatus* has habitat preferences such as river areas with standing water, forests, or areas with dense vegetation [39]. The abundance of the *Ingerophrynus biporcatus* species indicates that the physico-chemical factors in Gerantung's environment are suitable for the life of this species. This species prefers temperatures around 30 °C, a humidity of 76%, and a neutral pH of 6 [40]. Based on measurements, the temperature in Gerantung ranges between 24 and 31 °C (air temperature), while the water temperature ranges between 23 and 30 °C. This temperature is ideal for the reproduction of *Ingerophrynus biporcatus*. Although primary forests are their main habitat, *Ingerophrynus biporcatus* also shows tolerance to habitat disturbance and can be found in secondary forests and areas experiencing moderate changes due to human activities [41]. Therefore, even though the research location is dominated by rice fields, the population is quite high.

Meanwhile, *Fejervarya limnocharis* has a habitat preference in the form of open areas such as wet habitat types, including river floods, wet agricultural areas such as rice fields, ditches, swamps, parks, gardens, and other habitats covered by forest canopies. Stagnant water provides a suitable environment for their reproduction [41]. *Fejervarya limnocharis* shows high tolerance to habitats affected by human activities [42] [43]. Therefore, even though the study location is close to residential areas, the population is also quite high.

Even though the numbers are less abundant, the *Polypedates leucomystax* species apparently has a fairly high frequency of findings. This means that the population of this species has a fairly even distribution. This condition can be caused by its high adaptability to various environments [43]. As a tree frog, *Polypedates leucomystax* can use these trees and bushes for resting, hunting, and shelter from predators. Trees, shrubs, and herbs in damp areas and close to standing water are the preferred habitat for *Polypedates leucomystax* [44]. This species is also easily found in irrigation canals and ditches, which provide sufficient water and vegetation to meet its living needs. *Polypedates leucomystax* is easy to find at night, especially when resting on the trunks and stems of trees and shrubs [45] [46]. All *Polypedates leucomystax* found during the research were adults.

Duttaphrynus melanostictus, known as the common toad, is a very common anuran species found in various parts of Asia [47]. This toad has a medium-to-large body with rough, black-spotted skin [48]. *Duttaphrynus melanostictus* prefers terrestrial habitats such as gardens, rice fields, city parks, and areas close to human settlements. They are often found in humid areas and have direct access to air for breeding. This species is very adaptable and can be found in urban and suburban areas [32]. Although it can adapt to various environments, *Duttaphrynus melanostictus* is rarely found in dense forests or far from human settlements. *Duttaphrynus melanostictus* is a very adaptable species and can live in various habitats, including karst areas. However, they prefer areas that have direct access to the air surface and moderate humidity. This is in accordance with the findings [49]. Dry karst or with little surface water may not support its digestion.

Kaloula baleata is a small toad with a round body and smooth skin [50]. This species can be found in Southeast Asia, including Indonesia and the Philippines. They prefer forest habitats with high humidity and lots of vegetation that offer shelter and food sources. This species can also be found in gardens and agricultural lands, especially in areas with lots of shelter [51]. This frog is rarely found in densely populated urban areas that are inhabited by humans. They need a humid environment, so dry habitats are not suitable. *Kaloula baleata* is a species that likes to take shelter in humid and sheltered places [52], which are often found in caves or karst

crevices. They can utilize karst habitats that have lots of natural shelter. However, this species is less suitable for living in dry or open karst areas [53]. This is in accordance with research findings because the research location is dominated by an open era that is heavily influenced by human activities.

Occidozyga lima, known as the ringed frog, is a species that is often found in Southeast Asia. This frog has a small and slender body with a greenish brown color and a ring pattern on its body. *Occidozyga lima* is often found in swamps, ponds, and rice fields where there is a pool of still air. This species also prefers habitats such as riverbanks with calm air and stable vegetation [54]. In contrast, *Occidozyga lima* is difficult to find in dense forests or far from air sources. This species has difficulty surviving in karst areas that do not have surface water, such as rivers or lakes. This is in accordance with research findings [55]. This species is very rarely found in Gerantung village because the vegetation in the area is relatively changeable and dominated by rice fields.

Occidozyga sumatrana is a species similar to *Occidozyga lima* but has a more limited geographical distribution. Commonly found in Sumatra and several parts of Southeast Asia. Just like *Occidozyga lima, Occidozyga sumatrana* prefers wet habitats such as swamps, ponds, and rice fields. This species is also found in areas of thick, humid vegetation, including forests that have air communities [56] [57]. This frog is not suitable for habitats that lack air [57]. Therefore, they will rarely be found in dry karst areas. They will be difficult to find in environments where humans have intervened or in urban areas.

Microhyla orientalis is a species of small frog found in Southeast Asia, including Indonesia. They have small bodies and are often brown or gray in color. *Microhyla palmipes* is another small species in the genus *Microhyla*, found in Southeast Asia. These frogs are known for their long, slender legs and their preference for humid environments. Both species are often found in humid rainforests, especially in areas with lots of fallen leaves and plant debris. They can also be found in rice fields or in other wetlands that provide high humidity [58][59]. However, they are less suited to habitats that are too open and dry and are rarely found in urban areas [60]. Karst covered by vegetation can provide suitable habitat for this species. Gerantung Village is a karst area that tends to be open and heavily influenced by human activities. This makes both species difficult to find.

Plants in rice fields include trees, bushes, and herbs. The variations in microhabitat available include open areas with bushes and grass, lake areas with riparian vegetation, and forest areas with tall trees and dense canopies. Diversity analysis shows a moderate level of diversity among anuran species. This may be caused by several factors. First, there is limited water availability. Karst areas have rapid drainage, where surface water quickly flows into the soil through soil cracks [61]. This reduces the amount of surface water habitat required by many Anura species to reproduce and survive. Second, Karst areas tend to experience quite extreme fluctuations in temperature and humidity [62] [63]. Many Anura species require stable, moist environmental conditions to reproduce and survive. Third, some Anura species in karst areas may be specialist species that can only live in very specific environmental conditions. This limits the number of species that can live in this area. Fourth, fragmented microhabitats. Suitable habitat for Anura in karst areas is scattered and fragmented, making it difficult for the species to find suitable places to breed and shelter.

Rice fields, on the other hand, also have conditions that can inhibit the reproduction of anuras. Rice fields often experience seasonal changes in water availability, from waterlogged during the growing season to dry at harvest. This creates an environment that is not always stable for many anura species [64]. Additionally, rice fields are generally fairly homogeneous habitats with little variation in vegetation structure [65]. This could limit the number of microhabitats available to support the diversity of Anura species. The use of pesticides and other chemicals in agriculture has a negative impact on Anura populations, thereby reducing species diversity [66] [67]. Activities such as tillage and harvesting can disrupt Anura habitat and reduce shelter and breeding areas [68].

CONCLUSION

Anuras found in the Gerantung karst area consist of 9 species: *Duttaphrynus melanostictus, Iningerophrynus biporcatus, Fejryvarya limnocharis, Kaloula baleata, Occidozyga lima, Occidozyga sumatrana, Microhyla orientalis, Microhyla palmipes*, and *Polypedates leucomystax*. The highest species abundance was found in the species *Ingerophrynus biporcatus* and *Fejervarya limnocharis*. This illustrates the species' ability to adapt to ecosystem disturbances. Meanwhile, the highest frequency of occurrence was found in the species *Ingerophrynus biporcatus* and *Leucomystax polypedates*. This shows that the distribution of the two species is even. The diversity of anurans found in the Karst area is classified as moderate. Data on the abundance, frequency, and diversity of anurans in the Gerantung karst area shows that ecosystem stability is at a moderate level.

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