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# Exploring amphibian wealth: An inventory of anuran species in Lake Cuipari, Loreto, Peru

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**ABSTRACT.** This study aimed to document the diversity of amphibians in Lake Cuipari, Loreto, Peru, as baseline information to support conservation strategies and promote sustainable ecotourism. Fieldwork was conducted between August and October using the visual encounter survey method with day and night sampling periods. Each species was photographed (10–20 images) and identified based on morphological traits, consultation with local experts, and validation via AmphibiaWeb and iNaturalist. A total of 17 species were recorded, comprising 13 frogs and three toads from six families of the order Anura, as well as one caecilian (*Siphonops annulatus*) from the order Gymnophiona. Noteworthy species such as the South American Common Toad (*Rhinella margaritifera*), the South American Cane Toad (*Rhinella marina*), and poison frogs (*Allobates femoralis, Ameerega trivittata, A. hahneli*) highlight the ecological and medical significance of this assemblage, with most taxa classified as "Least Concern" by the International Union for Conservation of Nature and Natural Resources [IUCN] Red List. These findings reveal the exceptional amphibian richness of Lake Cuipari, provide critical baseline data for long-term monitoring, and emphasize the potential of amphibian-focused ecotourism to integrate biodiversity conservation with sustainable community development.

**Keywords:** Biology; conservation; ecotourism; endemic species; sustainable; tourism.

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## Introduction

Peru is the fourth country with the greatest wealth of amphibians (Amphibian Specialist Group, 2023). This biological phenomenon finds its maximum expression in the Loreto region, where the concentration of species reaches significant numbers, and its biodiversity emerges as a specialized study area of considerable interest (Aguilar et al., 2021). The complexity and diversity of the ecosystems in this region have sparked growing scientific interest (Metcalf et al., 2023) and even more so from specialized tourism (Rios-Alva et al., 2022).

Thus, to the southwest of Loreto, specifically in the province of Alto Amazonas, some interventions have been carried out in Lake Cuipari, such as those of Ruiz Camus et al. (2022), with the intention of highlighting this ecosystem and promoting it as an attraction for tourism specialized in bird watching and anuran amphibians. However, some studies have also discussed the negative impact generated, affecting the ecosystem and the species within it (Buckley et al., 2012).

The growing attention to the biodiversity of anurans in Loreto, together with interventions aimed at the conservation and valorization of Lake Cuipari, constitutes an invaluable contribution to both scientific research and the promotion of sustainable tourism in the province. This perspective is supported by Morrison et al. (2012), who argue that these actions not only serve as a mechanism to encourage and finance conservation (Steven et al., 2013), but also as a comprehensive strategy to balance the preservation of the natural environment with the promotion of responsible and sustainable tourism.

To fulfill its potential as a conservation tool, ecotourism requires detailed inventories of the species present in an area. These inventories provide essential data on local biodiversity, enabling the identification of endangered species and the monitoring of population changes. A comprehensive inventory of amphibians can reveal the presence of rare or endemic species, which is crucial for designing effective conservation

strategies (Moravec et al., 2014). Additionally, inventories generate a knowledge base that is useful for educating tourists and communities and increasing awareness and support for conservation. Without precise and updated data, ecotourism and conservation efforts lack clear direction, thereby endangering the species and ecosystems intended for protection.

Despite advances in the identification of anurans in the Loreto region (Metcalf et al., 2020; Rivera-Gonzáles et al., 2006), Lake Cuipari remains relatively unexplored in terms of comprehensive inventories. This initiative represents a milestone in scientific research in the Alto Amazonas Province, as it addresses this gap by systematically and comprehensively documenting the biological wealth of the area. The inventory not only contributes new data to the study of amphibians but also provides a valuable tool for the management and conservation of the Lake Cuipari ecosystem.

The results of this study are expected to expand our understanding of local biodiversity and foster greater awareness of the importance of preserving these unique ecosystems. By documenting the species present, this study establishes a foundation for future research and long-term conservation actions that respect and promote environmental sustainability. In doing so, it aligns scientific knowledge with practical strategies to safeguard biodiversity while supporting sustainable development in the region.

### Theoretical framework

Ecotourism has emerged as a key strategy for biodiversity conservation, providing a sustainable source of income while promoting natural ecosystem protection (Habibulloev et al., 2024). In this context, amphibian observation represents a unique opportunity to diversify tourism offerings and attract a niche of travelers interested in herpetology and biodiversity in the region.

### Relevance of amphibian biodiversity

Amphibians, particularly frogs, play crucial ecological roles as indicators of environmental health, pest controllers, and essential components of food webs (Mailho-Fontana et al., 2014). Additionally, their diversity and distribution reflect changes in the ecosystem, making them ideal subjects for conservation studies (Lehr et al., 2021). In the context of Loreto, Peru, a region rich in biodiversity, documenting these species is vital for understanding and preserving the ecosystems.

### Importance of species inventory

Detailed inventories are fundamental to effective biodiversity conservation. These inventories enable the identification of endangered species and monitoring of population changes, providing essential data for designing conservation strategies (Heyer et al., 1994). In amphibians, inventories can reveal the presence of rare or endemic species, which is crucial for prioritizing conservation actions (Luyt & Van der Merwe, 2022).

### Ecotourism and conservation

Ecotourism focused on amphibian observation can be a powerful tool for conservation as it generates income that can be reinvested in habitat protection and educational programs (Tozer et al., 2018). Additionally, educating tourists about the importance of amphibians and their ecological roles can increase awareness and support conservation efforts (Morrison et al., 2012). This approach not only helps conserve biodiversity but also benefits local communities by providing a sustainable income.

Our study will not only contribute to biodiversity preservation in Lake Cuipari, but also strengthen sustainable ecotourism initiatives. Species inventories have the potential to provide significant benefits for conservation and public health. This inventory represents a significant milestone in scientific research in the region, serving as a vital resource to promote sustainable tourism initiatives and highlight the potential of frog-watching as an ecotourism product, as emphasized by Luyt and Van der Merwe (2022). Additionally, it underscores the importance of increasing awareness of the urgent need to protect these unique habitats, thus promoting the preservation of biological diversity in the region.

## Materials and methods

Lake Cuipari (5°57' 34.9” S; 75° 57' 52.8” W), located in the Teniente Cesar López Rojas District, Province of Alto Amazonas, Department of Loreto, is a meander that has preserved its original shape, a product of a change in the course of the Huallaga River that occurred approximately 50 years ago. This rainy tropical body

of water experiences warm daytime temperatures ranging between 32 and 38°C, while nighttime temperatures are mild, with temperatures hovering between 22 and 25°C. Figure 1 shows the geographical location of Lake Cuipari and the distribution of the sampling transects in the lake. The study area encompassed a linear range of approximately 4 km around the lake, covering both the margins and adjacent habitats.

To carry out an inventory of anurans in Lake Cuipari, a comprehensive methodology was implemented from August to October, covering various research phases and highlighting the uniqueness and ecological relevance of this aquatic environment. Sampling was conducted over 18 effective field days, accumulating approximately 324 man-hours (3 observers × 6 hours/day × 18 days).


**Figure 1**. Location of Lake Cuipari and distribution of amphibian sampling transects.

### Review and preliminary analysis

It began with an exhaustive review of previous studies, allowing amphibian biodiversity in the region to be contextualized (Crnobrna et al., 2023; Molina et al., 2009; Schlüter et al., 2004). Subsequently, a detailed analysis of the genetic diversity of local anurans was conducted to understand the existing variability based on Pacheco Torres et al. (2021).

### Visual encounter method

Data and image collection was primarily performed using the visual encounter method, following the protocol established by Heyer et al. (1994). This approach involves a thorough search with slow and constant movement through various microhabitats, including vegetation, bodies of water, stones, and rocks (Doan, 2003). Special attention was paid to any material that could serve as a shelter for the specimens. Subsequently, between 10 and 20 images were captured for each identified species to carry out its nomenclature and taxonomy in the office.

### Day and night sampling

The visual encounter technique was implemented both during the day and at night, following the methodology proposed by Córdova et al. (2009). This approach allowed the identification of diurnal species resting in low vegetation, in accordance with previous studies (Doan, 2003; Schlüter et al., 2004).

### Taxonomy and nomenclature of the species found

Each set of 10–20 images per species was carefully examined to identify key characteristics, such as color patterns, body morphology, and size. Online platforms, such as iNaturalist (https://www.inaturalist.org/) and AmphibiaWeb (https://amphibiaweb.org/), were used to validate the observations, and the (2022) was used to identify the risks to the species. Locals were consulted, and advice from local herpetologists was sought in challenging cases. This methodology, supported by extensive sets of available images, ensured a more accurate and informed identification of frog species, considering both morphological details and scientific community feedback.

### Ethical considerations and conservation

We ensured an ethical approach in all phases of the study, minimizing any negative impact on amphibians and their habitats. The information collected contributes to the scientific knowledge of amphibian biodiversity and provides crucial data for the management and conservation of these ecosystems, especially given their growing tourist interest.

## Results and discussions

Below, we show the inventory carried out in Lake Cuipari in Table 1, which highlights a varied collection of amphibians belonging to the Anura order, covering representatives from multiple families. Likewise, a detailed analysis of the most relevant species identified in the study area is provided.

**Table 1.** List of Amphibian species present in Lake Cuipari.

| Order/Family/Species | Name | [IUCN]/CITES | N/E/M/I | Local Name |
|---|---|---|---|---|
| Order Anura: Family Bufonidae | | | | |
| *Rhinella margaritifera* | South American Common Toad | LC | N | Toad |
| *Rhinella marina* | South American Cane Toad | LC | N | Toad |
| *Rhinella poeppigii* | Gray Toad | LC | N | Toad |
| Orden Anura: Familia Aromobatidae | | | | |
| *Allobates femoralis* | Brilliant-thighed Poison Frog | LC-II | N | Toad |
| Order Anura: Family Dendrobatidae | | | | |
| *Ameerega trivittata* | Three-striped Poison Frog | LC-II | N | Toad |
| *Ameerega hahneli* | Yurimaguas Poison Frog | LC-II | N | Toad |
| Order Anura: Family Hylidae | | | | |
| *Boana lanciformis* | Basin Treefrog | LC | N | Cortasho |
| *Boana punctata* | Polka-dot Treefrog | LC | N | Cortasho |
| *Boana cinerascens* | DemeraraFalls Treefrog | LC | N | |
| *Scinax ruber* | Two-striped Snouted Treefrog | LC | N | Cortasho |
| *Sphaenorhynchus carneus* | Napo Lime Treefrog | LC | N | |
| *Sphaenorhynchus lacteus* | Ghost Frog | LC | N | |
| Order Anura: Family Leptodactylidae | | | | |
| *Leptodactylus knudseni* | Knudsen's Thin-toed Frog | LC | N | Hualo |
| *Leptodactylus pentadactylus* | Smoky Jungle Frog | LC | N | Hualo |
| Order Anura: Family Pipidae | | | | |
| *Pipa pipa* | Star-fingered Frog | LC | N | |
| Order Anura: Familia Strabomantidae | | | | |
| *Oreobates quixensis* | | LC | N | |
| Orden Gymnophiona: Familia Siphonopidae | | | | |
| *Siphonops annulatus* | The ringed caecilian | LC | N | |

IUCN: International Union for Conservation of Nature. CITES: International Trade in Endangered Species of Wild Fauna and Flora. N: Native Species. E: Endemic Species. M: Migratory Species. I: Introduced Species.

According to the detailed inventory presented in Table 1, 17 amphibian species were identified in Lake Cuipari, belonging to two orders, seven families, and 17 species. This assemblage includes 13 species of frogs (order Anura, families Dendrobatidae, Hylidae, Leptodactylidae, Pipidae, and Strabomantidae*)*, three species of toads (order Anura, family *Bufonidae*), and one species of caecilian (*Siphonops annulatus*, order *Gymnophiona*, family Siphonopidae). Thus, amphibian diversity is represented by multiple taxonomic groups that reflect the ecological complexity of the area. Notable findings include the South American Common Toad (*Rhinella margaritifera*), first described in Peru by Moravec et al. (2014), and the South American Cane Toad (*Rhinella marina*), whose toxins have been investigated for their potential antiproliferative effects in cancer research (Schmeda-Hirschmann et al., 2016). Both species are currently classified as "Least Concern" on the IUCN Red List (2022).

Poisonous toads, such as *Allobates femoralis*, *Ameerega trivittata*, and *Ameerega hahneli,* underscore the importance of ongoing research to understand these subspecies and their implications for conservation and public health. Their potent toxins not only play crucial ecological roles but also offer potential insights into medical research and treatment (Bégué et al., 2024). Recent studies have revealed new compounds that can be used for pain management and other therapeutic areas (Souvannasing et al., 2007). Continued investigation is essential to uncover the full scope of their biological and medicinal potentials (Mailho-Fontana et al., 2014). The diversity in the families Hylidae, Leptodactylidae, Pipidae, and Strabomantidae and the presence of the ringed caecilian (*Siphonops annulatus*) in the *Siphonopidae* family contribute significantly

to amphibian richness in the region. Despite the limited information on *Oreobates quixensis*, its presence adds to the general understanding of biodiversity in the Lake Cuipari area.

The results obtained offer a detailed vision of the biological richness in the Lake Cuipari region, highlighting the need to continue specialized studies and conservation measures to safeguard the valuable ecosystems identified as (Tozer et al., 2018) in their study affirm that these strategies may benefit frog and toad species. This inventory represents a significant milestone in scientific research for the region and serves as a vital resource for promoting sustainable tourism initiatives. This underscores the potential of frog-watching as an ecotourism product, as highlighted by Luyt and Van der Merwe (2022). Furthermore, it highlights the importance of raising awareness of the prevailing need to protect these unique habitats, thus promoting the preservation of biological diversity in the region. Promoting ecotourism focused on amphibian observation can diversify tourism offerings and attract a specific segment of travelers interested in herpetology and biodiversity.

## Conclusion

The inventory conducted in Lake Cuipari demonstrates the ecological importance and biological richness of this ecosystem, consolidating it as a priority area for biodiversity conservation. The study confirms the presence of emblematic amphibian species that act as indicators of ecosystem health and possess potential relevance for scientific and even medical research. The use of complementary methodologies, combining visual encounter surveys with day and night sampling, proved effective in characterizing the diversity of habitats and activity patterns of the species. Beyond its scientific contribution, this research provides a solid foundation for integrating conservation efforts with sustainable ecotourism, highlighting amphibian observation as an opportunity to raise awareness, strengthen environmental stewardship, and promote local development. In this sense, the findings emphasize the urgency of continuing long-term studies to address knowledge gaps and ensure the preservation of these unique ecosystems for future generations.

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