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Diversity and Temporal Frequency of Records of the Herpetofauna of the Equatorial Seasonally Dry Tropical Forest in the Rural Community of Lucarqui, Piura, Northwestern Peru

Juan Carlos Soto Quispe[1], Armando Fortunato Ugaz Cherre[1,4], Angel Enrique Llompart Navarro[2], Irwing Smith Saldaña Ugaz[3], José Manuel Marchena Dioses[1,4]†, Mariana Alexandra Montero Silva[1,4] and Robert Barrionuevo García[1,4]

[1]Universidad Nacional de Piura. Urb. Miraflores s/n, Castilla, Piura, Perú

[2]Centro de Investigación en Biología Tropical y Conservación (*CYNBIOTIC*)), Cal. Néstor Martos Mza. E lote 16 A.H. Almirante Miguel Grau, II etapa Piura, Piura, Perú

[3]Instituto Peruano de Biología Integrativa (IPBI), Lambayeque, Perú

[4]Laboratorio de investigación en Zoología, Facultad de Ciencias, Universidad Nacional de Piura, Urb. Miraflores s/n, Castilla, Piura, Perú

†Corresponding author: José Manuel Marchena Dioses; jmarchenad@unp.gob.pe

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ABSTRACT

Reptile and amphibian species in the Equatorial BTES face threats such as fragmentation, habitat loss, and climate change. Between 2019 and 2021, the richness and abundance of herpetofauna species was evaluated in the Lucarqui peasant community in Piura, northwest Peru. The objective of this research is to provide a preliminary list of species and understand their temporal frequency patterns. The study area was divided into specific zones: with anthropogenic activity, “crops” and “population centers”, where incidental catches and visual surveys were carried out, and without anthropogenic activity, “forests” and “ravines”, where transects of variable length and fixed width (2 m), the biological data obtained were analyzed with the iNEXT statistical tool, and a standardized methodology was provided for the calculation of the temporal frequency of recordings (FRT). The study identified 26 species: 7 amphibians and 19 reptiles. Amphibians dominated in abundance, while reptiles were rare. 85.71% (6) of amphibians and 47.36% (9) of registered reptiles are restricted to the Equatorial BTES. FRT patterns varied by habitat and time. These, along with wealth and abundance, were altered and reduced in areas influenced by human activity, crops, and population centers. It was found that there were still more species to be reported, especially reptiles. The study highlights the richness and vulnerability of the herpetofauna in the Equatorial BTES, reaffirming the urgent need for conservation strategies and continued research to ensure the protection and deep understanding of this valuable, fragile ecosystem.

INTRODUCTION

The fragile ecosystem of the Equatorial Seasonally Dry Tropical Forests (hereinafter referred to as ESDT Forests) has been recognized as a biogeographic area of exceptional interest due to its high level of biodiversity and endemism (Linares-Palomino et al. 2011, Rivas et al. 2021). For the herpetofauna, this biome can pose a double challenge. On the one hand, reptiles are influenced by high levels of solar radiation, which promotes their diversification in arid environments (Laurencio & Fitzgerald 2010, McCain 2010), on the other hand, amphibians must adapt to conditions of constant desiccation and marked seasonality (Armijos-Ojeda et al. 2021, Laurencio & Fitzgerald, 2010). Additionally, both groups must survive and thrive in a fragmented environment, exposed to marked changes in land use, and vulnerable to climate change (Cordier et al. 2021, Linares-Palomino et al. 2010).

Despite its relevance, a preliminary or complete list of reptile diversity in the Equatorial Seasonally Dry Tropical Forests (ESDT Forests) has not been published. However, the literature suggests that remnants of native vegetation along the equatorial Pacific coast and northern Peru are essential for the conservation of unique and regionally threatened species, such as *Boa constrictor ortonii* (EN), *Bothrops barnetti* (VU), *Polychrus femoralis* (VU), and *Callopistes flavipunctatus* (NT). Greater efforts are needed to unify reptile information from this region.

On the one hand, the amphibians of the Equatorial ESDT have received particular attention, and their conservation status and diversity are better understood (Armijos-Ojeda et al. 2021, Catenazzi & von May 2014). To date, 30 amphibian species have been reported (Armijos-Ojeda et al. 2021), of which the following are considered threatened in Peru: *Ceratophrys stolzmanni* (VU), *Hyloxalus elachyistus* (EN), *Lithobates bwana* (VU), *Pristimantis ceuthospilus* (VU), *Pristimantis sternothylax* (VU), *Pristimantis wiensi* (VU), *Epipedobates anthonyi* (NT), due to habitat loss and chytridiomycosis.

Conservation initiatives for the herpetofauna are based on assessments of species richness and knowledge about the natural history of the species, mainly derived from publications describing each species. Additional information on diet, ecology (including thermoecology), ethology, seasonality, and activity patterns for most species is scarce. This study aims to provide a preliminary list of amphibian and reptile species that contribute to the general understanding of species richness in the Equatorial ESDT and to identify daily activity patterns at both community and species-specific levels. To provide useful information for species conservation, the study area was subdivided into natural zones: forests and ravines and anthropized zones, populated centers, and crops. The necessity of this study lies in its potential to positively influence conservation strategies, ensuring the survival and prosperity of the herpetofauna in an ecosystem under constant change and threat.

MATERIALS AND METHODS

Study Area

The peasant community of Pampas de Lucarqui is located in the vicinity of the urban center of Lucarqui, in the district of Ayabaca, province of Ayabaca, Piura region, northwest Peru. This locality is situated within the Equatorial ESDT. For the present investigation, samplings were conducted in an area ranging from 1125 to 2220 meters above sea level (Fig. 1). These samplings were distributed across four well-differentiated zones of the forest in the peasant community

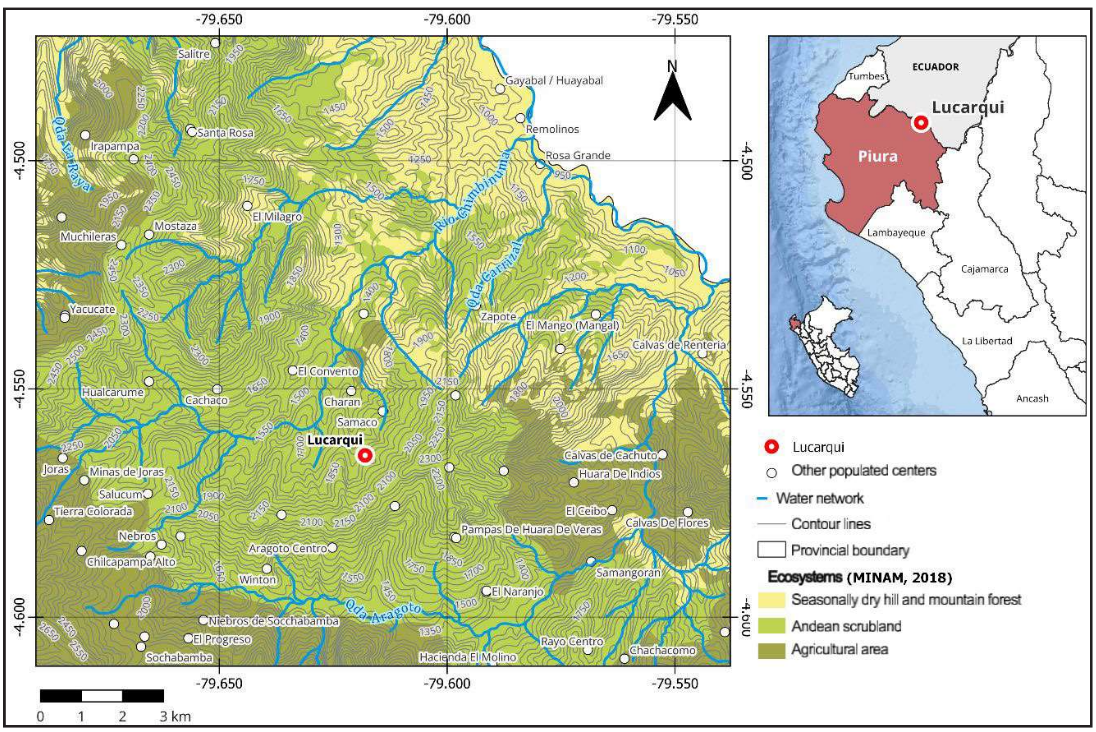

Fig. 1: Location map of the study area, Lucarqui Population Center, Ayabaca District, Ayabaca Province, Piura Region, Northwestern Peru.

of Lucarqui. Two of them are areas with low intervention, forests, and ravines, while the remaining two exhibit a high degree of anthropization, urban centers, and crops. Below, we describe the main physiographic and vegetative cover characteristics of these four zones:

- **Forests (ZB)**: lush and open areas featuring low forest density. It is possible to find plant species such as *Colicodendron scabridum, Loxopterigium huasango, Erythrina smithiana, Bursera graveolens, Neltuma sp., Acacia sp., Guadua angustifolia, Gynerium sagittatum, Pennisetum purpureum, Bidens pilosa, Heliotropium sp.*, among others.
- **Ravind (ZQ):** the streams in the study area can be either seasonal or permanent. They are characterized by rocky areas, partly covered by moss, and riparian vegetation with the presence of *Arundo donax, Acacia sp., and Pennisetum purpureum,* among others.
- **Crop (ZC)**: these are anthropized areas with productive purposes, featuring bare rocky soil and scattered vegetation, mainly composed of *Acacia sp*. Local crops in this area include *Zea mays, Vicia faba, Cajanus cajan, Arachis hypogaea, Cucumis sativus, Pisum sativum, Manihot esculenta, Cucurbita maxima, Phaseolus lunatus, Ph. vulgaris*. Two types of cultivation zones are recognized: permanent ones, hosting year-round plantations, and seasonal ones, which have irrigation systems via ditches and depend on water from the rainy season (December to April).
- **Village (ZP)**: the hamlets in the area consist of scattered houses situated on bare, rocky soil accompanied by herbaceous vegetation and scarce trees such as *Acacia sp*., *Erythrina smithiana*, and *Bougainvillea pachyphylla*. Most houses have small orchards with permanent irrigation.

Data Collection

To assess the richness and abundance of amphibian and reptile species, nine samplings were conducted between August and December 2019, January, February, November, and December 2020, and January 2021. Each sampling consisted of 30 effective hours of assessment, accumulating a total of 270 person-hours of sampling effort. Both diurnal, from 7:00 am to 6:00 pm, and nocturnal samplings, from 6:00 pm to 12:00 am, were conducted using both incidental captures and Visual Encounter Surveys (VES) (Aguirre-León 2011). These methodologies were applied along sampling transects with differentiated measurements for the different evaluated zones. In populated areas and cultivated lands, where vegetation was sparse, species detectability was higher. Hence, fixed-width transects of 50 × 2m were employed in rugged and less accessible areas, and 100 × 2m transects in more accessible areas with lower slopes. For forests and streams, where vegetation was denser, transects of variable length and fixed 2m width were used (Aguirre-León 2011). Each transect was assessed at a slow pace, searching in holes and under stones for 30 to 45 minutes.

Species Determination

Species were determined to the lowest possible taxonomic level (genus or species), following the literature (Catenazzi & von May 2014, de Espinoza & Icochea 1995, Duellman & Wild 1993, Minam 2018). Photographs were taken of captured individuals and of the majority of individuals observed exhibiting unusual characteristics. All captured individuals were promptly released to minimize stress.

Data Analysis

With the data of abundance and richness obtained by zone for the registered amphibians and reptiles, three analyses were performed:

Temporal Frequency of Records (TFR)

Here, a new methodology for the analysis of temporal frequency of records (TFR) is proposed. TFR was considered as the sum of records per family for each hour of the day, reported as individuals per hour (ind./hour). In the present study, the hourly range from 7:00 am to 11:59 pm of the same day was considered. Since it is a methodology with a high level of wear, it requires a team of at least two people with similar levels of experience to take turns to maintain continuous sampling during the evaluation period. Using these data, bar graphs were generated to identify TFR patterns throughout the day. The patterns were analyzed for the entire study area (Fig. 2) and by grouping the records for each evaluated zone (forest, stream, crop, and town, Figs. 3 and 4). It was considered pertinent to perform this analysis by summing the records by family rather than by species due to the scarce number of records for some of them.

To standardize this methodology (TFR) for future uses, the following detailed algorithm is proposed:

- *Step 1*: In the field, record each encounter, noting the sampling zone, date and time, species, and the number of individuals seen in that encounter. This latter ensures the accurate collection of abundance information, particularly for species with gregarious habits that may be hidden together.
- *Step 2:* In the office, filter the database for the group of interest (order, family, or species, depending on the study's purposes).

- *Step 3*: Standardize the time. If the data of "hour and minute" or "hour, minute, and second" were recorded in the field, proceed to only consider the hour value for further use. If only the hour were noted without minutes, proceed without any modification. This step enables grouping the data by hour, disregarding other temporal divisions, which is crucial for generating the final bar graph grouped by hours.
- *Step 4:* Create the final bar graph, considering the horizontal axis as the evaluation hours (categorical variable) and the vertical axis as the sum of abundances from all records for each group of interest within the specific hour (TFR).
- *Step 5*: During the data visualization process, it is recommended to subdivide the bars in a "stacked" manner based on the groups of interest, aiming to have a single bar per hour.

Since the methodology covers continuous sampling during the evaluation period, it is possible to use it to identify peaks of higher activity of a species or taxonomic group as a homologous characteristic to having a higher TFR value (ind./hour).

Rarefaction and Extrapolation of Alpha Richness and Diversity

To analyze biological diversity, the iNEXT package (Hsieh et al. 2016) in RStudio (RStudio Team 2023) was employed, which utilizes rarefaction and extrapolation to perform comparisons between communities or habitats with different sample sizes or sampling areas. Through rarefaction, it estimates species diversity for a standardized sample size or area, while extrapolation predicts how diversity would be in a larger sample size or broader area. iNEXT provides precise and reliable diversity estimates, even with incomplete sampling data, and allows for the standardization of species accumulation curves. Shannon-Wiener, Simpson, and species richness indices were projected to assess diversity from different perspectives (evenness, dominance, and species richness, respectively).

Sampling Completeness

A sampling coverage analysis was conducted using iNEXT (Hsieh et al. 2016) to assess the completeness of the samplings. This analysis evaluates the sufficiency of sampling in biodiversity studies, allowing us to determine if the collected samples are representative of the studied community and estimate what proportion of the total diversity has been captured in the samples. This enables us to compare diversity between non-identical sites or where there was no equitable sampling effort, as is the case with the four zones in the study area being evaluated here.

RESULTS

Description of Recorded Richness and Abundance

Between August 2019 and January 2021, 1054 observations

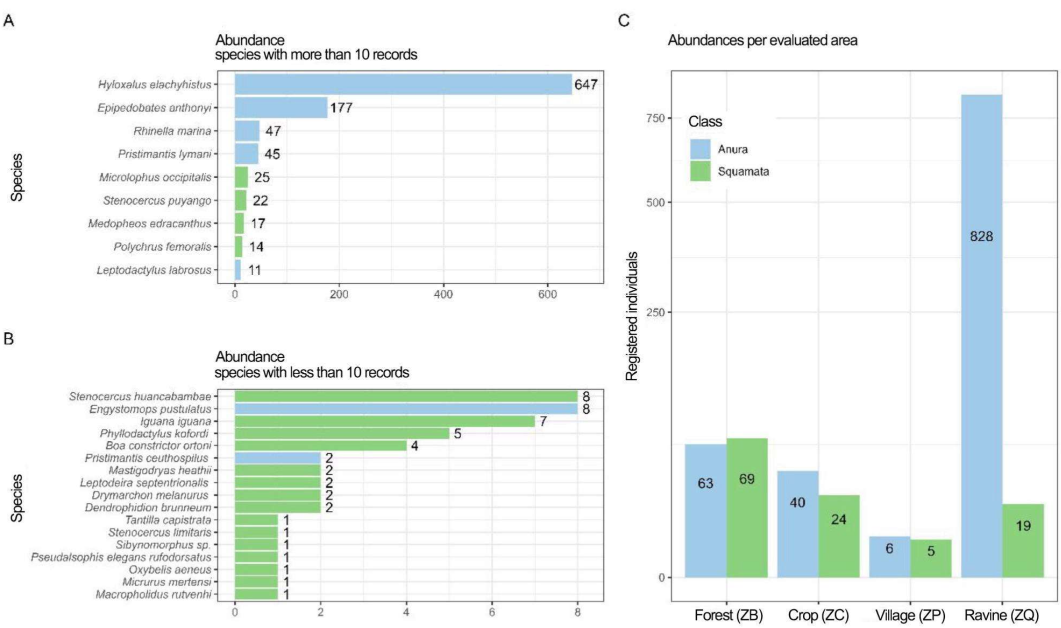

Fig. 2: Abundance of Anura species (blue) and Squamata species (green) reported in the rural community of Lucarqui, Piura, northwest Peru, categorized by (A) species with more than 10 records, (B) species with fewer than 10 records, and (C) by evaluated zone.

Table 1: Taxonomic list of amphibian and reptile species recorded in the Equatorial ESDT of the Lucarqui peasant community, Piura, northwest Peru. Abundances (Abund.) per zone are shown for each species. The highest abundances are highlighted in bold. Threat categories, according to the IUCN (2022), are shown in bold, according to the Peruvian state (Serfor 2018) are underscored, and in bold and underscored when both categorizations coincide. NT: Near Threatened, VU: Vulnerable, EN: Endangered, II: Appendix II of CITES (MINAM 2018).

Class	Order	Family	Species	Zone	Abund.
Amphibia	Anura	Bufonidae	*Rhinella marina*	ZB	26
				ZC	1
				ZP	1
				ZQ	19
		Craugastoridae	*Pristimantis ceuthospilus* (VU)	ZQ	2
			Pristimantis lymani	ZB	1
				ZC	7
				ZP	3
				ZQ	34
		Dendrobatidae	*Epipedobates anthonyi* (NT, II)	ZC	22
				ZQ	**155**
			Hyloxalus elachyhistus (EN)	ZB	35
				ZC	5
				ZP	1
				ZQ	**606**
		Leptodactylidae	*Engystomops pustulatus*	ZB	1
				ZQ	7
			Leptodactylus labrosus	ZC	5
				ZP	1
				ZQ	5
Reptilia	Squamata	Boidae	*Boa constrictor ortoni* (EN, II)	ZB	2
				ZC	2
		Colubridae	*Dendrophidion brunneum*	ZQ	2
				ZP	1
			Drymarchon melanurus	ZQ	1
				ZB	1
			Mastigodryas heathii	ZP	1
			Oxybelis aeneus	ZB	1
			Pseudalsophis elegans rufodorsatus	ZB	1
			Sibynomorphus sp.	ZB	1
			Tantilla capistrata	ZB	1
		Dipsadidae	*Leptodeira septentrionalis*	ZB	1
				ZC	1
		Elapidae	*Micrurus mertensi*	ZB	1
		Gymnophthalmidae	*Macropholidus ruthveni*	ZB	1
		Iguanidae	*Iguana iguana* (II)	ZB	4
				ZQ	3
		Phyllodactylidae	*Phyllodactylus kofordi*	ZB	5
		Polychrotidae	*Polychrus femoralis* (VU)	ZB	5
				ZC	6
				ZQ	3

Table Cont....

Class	Order	Family	Species	Zone	Abund.
		Teiidae	*Medopheos edracantha*	ZB	15
				ZP	1
				ZQ	1
		Tropiduridae	*Microlophus occipitalis*	ZB	21
				ZP	1
				ZQ	3
			Stenocercus huancabambae	ZB	4
				ZC	4
			Stenocercus limitaris (VU)	ZQ	1
			Stenocercus puyango	ZB	5
				ZC	11
				ZP	1
				ZQ	5

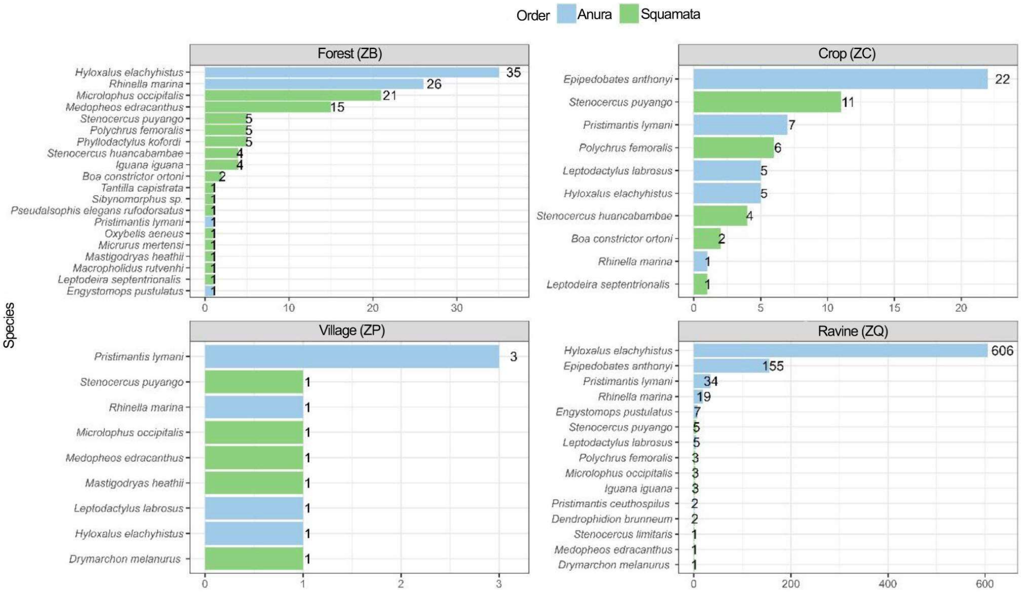

Fig. 3: Species abundance of Anura (blue) and Squamata (green) was reported in each evaluation zone within the peasant community of Lucarqui, Piura, northwest Peru.

were conducted, documenting 26 species of herpetofauna, distributed into two classes: Amphibia, with seven recorded species (26.9%) and 937 individuals (88.9%), and Reptilia, with 19 species (73.1%) and 117 individuals (11.1%). Taxonomically, four families of amphibians and 10 families of reptiles were reported (Table 1). The family Colubridae exhibited the highest diversity (seven species), followed by Tropiduridae (four species) (Table 1, Fig. 7, Fig. 8, Fig. 9).

The most common amphibian was *Hyloxalus elachyhistus,* with 647 individuals, and the most common reptile was Microlophus occipitalis, with 25 individuals (Table 1, Fig. 2A). Considering the evaluation area (Fig. 2C), amphibians were more abundant in the streams (828 individuals), while reptiles were more abundant in forests (69 individuals). Differentiating the most abundant amphibians and reptiles (Fig. 3), in forests, *Hyloxalus elachyhistus* and *Microlophus occipitalis* dominated. In crops, *Epipedobathes anthonyi* and *Stenocercus puyango*, in populated centers, *Pristimantis lymani* and S. puyango, whereas, in streams, *H. elachyhistus and S. puyango* prevailed.

With regard to their conservation (Table 1), three globally threatened species were recorded (IUCN 2022): *Pristimantis ceuthospilus* (VU), *Epipedobates anthonyi* (NT), and *Stenocercus limitaris* (VU), and four regionally threatened species for Peru: *E. anthonyi* (NT), *Hyloxalus elachyhistus* (EN), *Boa constrictor ortoni* (EN), *Polychrus femoralis*

(VU). Additionally, three species protected by CITES under Appendix II have been recorded: Iguana iguana, B. c. ortoni, and E. anthonyi.

Regarding the biogeographical importance of these species, according to IUCN (2022), 85.71% (6 species) of amphibians are restricted to the Equatorial ESDT: *Pristimantis ceuthospilus, Pristimantis lymani, Epipedobates anthonyi, Hyloxalus elachyhistus,* and *Engystomops pustulatus*, as well as 47.36% (9 species) of reptiles: *Dendrophidion brunneum, Tantilla capistrata, Micrurus mertensi, Macropholidus ruthveni, Phyllodactylus kofordi, Polychrus femoralis, Stenocercus huancabambae, Stenocercus limitaris,* and *Stenocercus puyango*.

Rarefaction and Extrapolation of Diversity

The iNEXT algorithm did not generate extrapolations for richness and alpha diversity indices in forests, crops, and populated centers for Anura and in populated centers for Squamata (Fig. 4). At the order level, Anura richness was higher in streams, reaching an asymptote with the seven amphibian species recorded. However, alpha diversity values were low due to the high dominance of a few species, such as *Hyloxalus elachyhistus* or *Epipedobathes anthonyi*. Squamata richness was higher in forested areas, not reaching asymptotes with 17 reptile species, two fewer than reported. Additionally, a higher species richness of reptiles is expected in this area. Alpha diversity was high, attributed to the relatively uniform number of records. It is expected that the entirety of reptile species has been recorded in crops.

Analysis of Temporal Frequency of Records

Temporal frequency of records (TFR) patterns were obtained for the orders Anura and Squamata considering the entire study area (Fig. 2), as well as for each evaluated zone for Anura (Fig. 3) and Squamata (Fig. 4). The activity peaks for each order (Fig. 2) showed a higher number of diurnal records for Squamata, mainly between 11:00 and 13:00 hours, whereas for Anura, a bimodal distribution was obtained with a peak of diurnal records at 10:00 hours, and a nocturnal one at 22:00 hours. The families that contributed the most to these patterns at the taxonomic order level were Dendrobatidae (Anura) and Tropiduridae (Squamata).

Considering the grouping of abundance data for each evaluated zone, a different pattern is observed for Anura (Fig. 3). The highest abundance of records per hour was observed in the streams (maximum of 160 ind./hour), followed by forests (17 ind./hour), crops (15 ind./hour), and populated centers (3 ind./hour). In forests, the presence of Dendrobatidae was observed in the early morning hours (8:00 to 10:00 hours), while at night, they completely

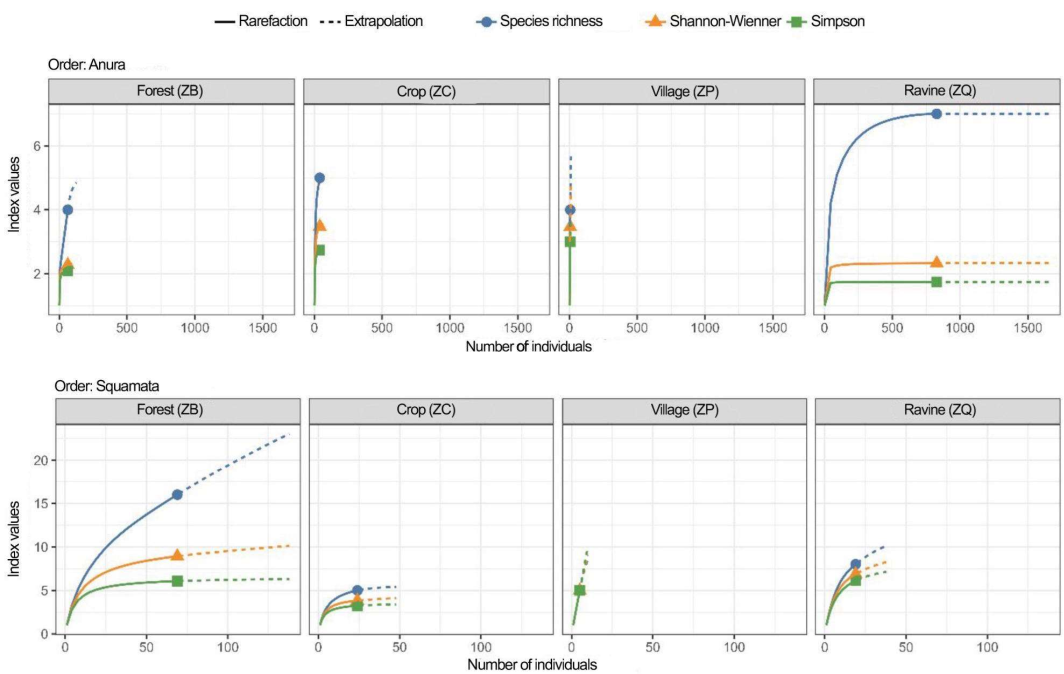

Fig. 4: Estimates with iNEXT on rarefaction of Hill's numbers (solid lines) and extrapolation of data (dashed lines) for species richness (blue), Shannon-Wiener index (yellow), and Simpson index (green) for amphibians (Anura) and reptiles (Squamata). The information was divided by sampling zone in the ESDT Equatorial of the peasant community of Lucarqui, Piura, northwest Peru.

disappeared to give way to a dominance of Bufonidae. It is noteworthy that the highest concentration of Dendrobatidae (*Epipedobates anthonyi* and H*yloxalus elachyhistus*) is observed in streams, where they can be found throughout the day. During the day, records obtained in more anthropized areas, such as crops and populated centers, were scarce.

Regarding the data grouped by zone for Squamata (Fig. 4), the abundance values were much lower. The highest abundance of records per hour was observed in forests (with a maximum of 20 ind./hour), followed by crops and streams (4 ind./hour each), and populated centers (1 ind./hour). In forests, the presence of Dendrobatidae was observed in the early morning hours (8:00 to 10:00 hours), while at night, they completely disappeared to give way to Bufonidae. Notably, eight out of ten Squamata families were recorded in forests. Throughout the four study zones, Tropiduridae

Table 2: Maximum Temporal Recording Frequency (TRF), expressed as the maximum number of individuals per hour (ind./hour), for all amphibian and reptile species recorded in the Equatorial ESDT of the Lucarqui peasant community, Piura, northwest Peru. The zone and time (in 24-hour format) of the peak of maximum activity are shown.

Order	Specie	Zone	Peak of activity	Max. Ind./hour
Anura	Engystomops pustulatus	ZQ	23:00	3
	Epipedobates anthonyi	ZQ	22:00	33
	Hyloxalus elachyhistus	ZQ	22:00	118
	Leptodactylus labrosus	ZC	19:00	3
	Pristimantis ceuthospilus	ZQ	21:00	1
		ZQ	23:00	1
	Pristimantis lymani	ZQ	20:00	10
	Rhinella marina	ZB	20:00	14
Squamata	Boa constrictor ortoni	ZB	0:00	1
		ZB	15:00	1
		ZC	13:00	1
		ZC	17:00	1
	Dendrophidion brunneum	ZQ	11:00	1
		ZQ	12:00	1
	Drymarchon melanurus	ZP	12:00	1
		ZQ	12:00	1
	Iguana iguana	ZQ	16:00	3
	Leptodeira septentrionalis	ZC	7:00	1
	Macropholidus rutvenhi	ZB	11:00	1
	Mastigodryas heathii	ZB	13:00	1
		ZP	15:00	1
	Medopheos edracanthus	ZB	11:00	4
		ZB	12:00	4
		ZB	13:00	4
	Microlophus occipitalis	ZB	12:00	10
	Micrurus mertensi	ZB	16:00	1
	Oxybelis aeneus	ZB	18:00	1
	Phyllodactylus kofordi	ZB	12:00	3
	Polychrus femoralis	ZB	16:00	2
		ZC	8:00	2
		ZC	22:00	2
		ZQ	20:00	2
	Pseudalsophis elegans rufodorsatus	ZB	9:00	1
	Sibynomorphus sp.	ZB	16:00	1
	Stenocercus huancabambae	ZB	13:00	3
	Stenocercus limitaris	ZQ	11:00	1
	Stenocercus puyango	ZC	13:00	3
		ZC	16:00	3
	Tantilla capistrata	ZB	8:00	1

(*Stenocercus huancabambae, S. limitaris, S. puyango, Microlophus occipitalis*) is the family with the highest number of records and the one that covers the most hours during the day.

The results of individuals per hour (ind./hour) maximum and hour of highest activity for each Anura and Squamata species are shown in Table 2.

Completeness of the Study

The completeness analysis (Fig. 5) for Anura showed that no further species are expected in forests and crops, whereas in populated areas, the number of recorded individuals was low, resulting in an incomplete species record. Regarding Squamata, something similar occurred in populated areas, and it is expected to find more species in forests, crops, and streams. The effort required to obtain a complete sampling is expected to be higher in forests than in crops and streams. The iNEXT algorithm indicated that amphibian species from the stream area and reptiles from crop areas were virtually covered 100%.

DISCUSSION

This study aimed to enhance the understanding of diversity patterns and temporal frequency records of herpetofauna in an Equatorial ESDT located in hilly and mountainous areas at altitudes between 1125 and 2220 meters above sea level in northwest Peru. From our research, a preliminary list of amphibian and reptile species present in this region is provided.

Seven species of amphibians were identified, representing 23.3% of the species reported for the Equatorial ESDT of Peru and Ecuador (Armijos-Ojeda et al. 2021). Regarding reptiles, no preliminary or complete list of species has been published for the Equatorial ESDT. However, a detailed approximation for northern Peru, covering the regions from La Libertad to Tumbes, conducted by Venegas (2005), documented 33 reptile species in the region. In the present study, 19 reptile species were found, representing 57.6% of the figure published by Venegas (2005). However, when comparing the species list, our findings add three new species: Stenocercus huancabambae, *S. limitaris*, and *Sibynomorphus* sp., thus expanding the recognized richness for the region to 36 reptile species. In contrast to the Marañón ESDT located on the eastern slope of the Andes, between Peru and Ecuador —with which the Equatorial ESDT shares geographical, climatic, and evolutionary characteristics—, Koch et al. (2018) reported 14 amphibian species and 49 reptile species. It is anticipated that the herpetofauna richness for the Equatorial ESDT will be higher than reported in this study.

Regarding the distribution patterns of diversity in the different evaluated zones, these reflect the influence of environmental factors and anthropogenic changes on the landscape. The heterogeneity of microhabitats fosters a

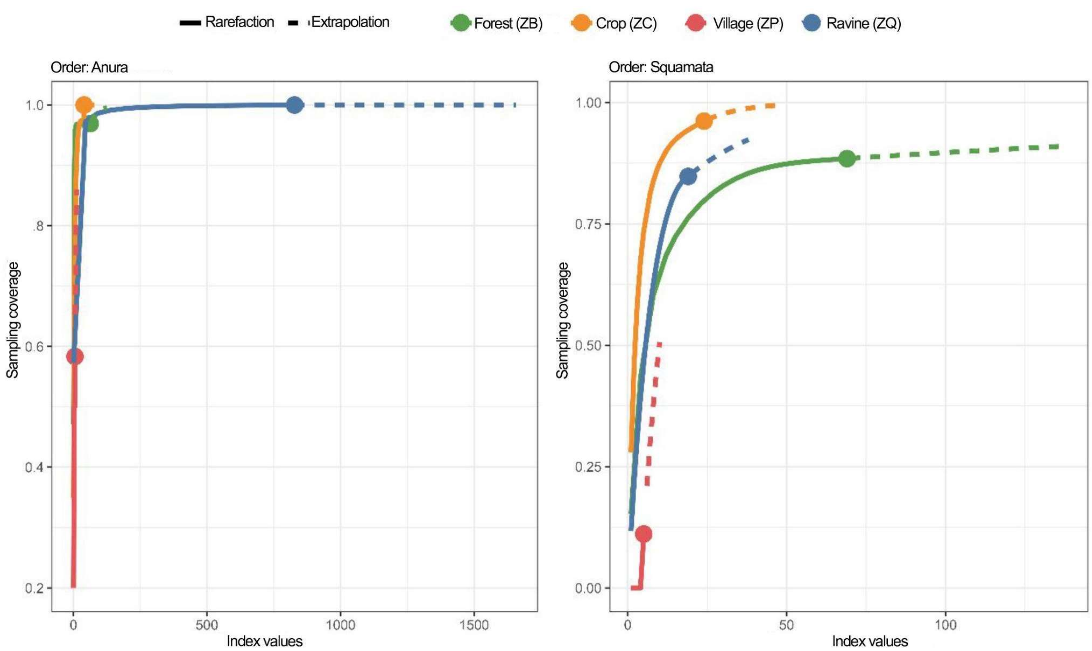

Fig. 5: Coverage curves (or completeness) of the evaluated areas for amphibians (Anura) and reptiles (Squamata) recorded in the ESDT Equatorial of the peasant community of Lucarqui, Piura, northwest Peru. The solid lines represent sampling completeness based on the number of individuals recorded, while the dashed lines depict extrapolated curves by iNEXT on the completeness trend.

greater diversity of amphibians and reptiles (Bucher 2019). These variations are linked to fluctuations in temperature, moisture content, and interspecific trophic interactions, among others (Ravkin & Bogomolova 2018). Additionally, anthropogenic landscape changes play a significantly more determining role in local extinctions of herpetofauna on a global scale (Cordier et al. 2021). The lowest diversity of amphibian and reptile species was found in crops (ZC) and populated areas (ZP), which is due to habitat alteration and the decrease in the availability of shelters and resources. On the other hand, the highest diversity was found in forests (ZB) and streams (ZQ). This pattern suggests that the conservation of larger forested areas and riparian forests is crucial for the protection of herpetofauna. Furthermore, it is essential to consider that the size and shape of forest patches, and the composition of the landscape matrix affect each species uniquely (Russildi et al. 2016). Understanding these effects is of vital importance for biodiversity conservation.

The analysis of temporal frequency records (TFR) allowed us to infer peaks of activity and fluctuations in the abundance of Equatorial ESDT herpetofauna. These patterns showed differences depending on habitat characteristics. At the community level in the evaluated Equatorial ESDT, reptiles exhibited multimodal activity patterns. For reptiles (Squamata, Fig. 5), the first peak of diurnal activity occurred at 9:00 am, with a homologous but greater peak towards sunset at 4:00 pm. This closely resembles older studies on reptile thermoecology that demonstrated bimodal activity patterns in some subtropical species (Judd 1975). The highest activity of the reptile community was at 12:00 noon when maximum radiation occurred in the ESTD near the Equator. Some species of the families Polychrotidae and Colubridae were active during the night, with a peak of activity around 10:00 pm. Tropiduridae were the dominant family throughout the day, probably because they are better adapted to anthropogenic disturbances (Dávila & Cisneros-Heredia 2017).

For the amphibian community (Anura, Fig. 6), the TFR indicated a clear bimodal pattern throughout the day, with a peak of diurnal activity (10:00 hrs) and a nocturnal one (22:00 hrs), where *Epipedobates anthonyi* was overwhelmingly dominant. Species of Bufonidae, Craugastoridae, and Leptodactylidae exhibit predominantly nocturnal activity, associated with reduced dehydration rates and avoidance of diurnal predators, although juveniles can also be found during the day (Arroyo et al. 2008, Maia-Carneiro et al. 2013, 2021). Dehydration is minimized in these individuals due to their lower surface-to-volume ratio (Kühsel et al. 2017). This same reason would account for species of the family Dendrobatidae, with small aposematic frogs being active throughout the day.

Observing activity patterns in relation to the evaluated zone revealed interesting findings. Dendrobatidae was the most abundant family in streams, only visiting forested areas in the early morning hours and also occurring in crops toward the evening. Bufonidae showed widespread adaptation to inhabit all zones during the night, with higher abundance toward the forest. Regarding reptiles, the hypothesis that daytime activity differs from a conserved state in forests to erratic patterns in areas with higher human influence is reinforced (Cordier et al. 2021).

CONCLUSIONS

A total of 26 species of herpetofauna were recorded,

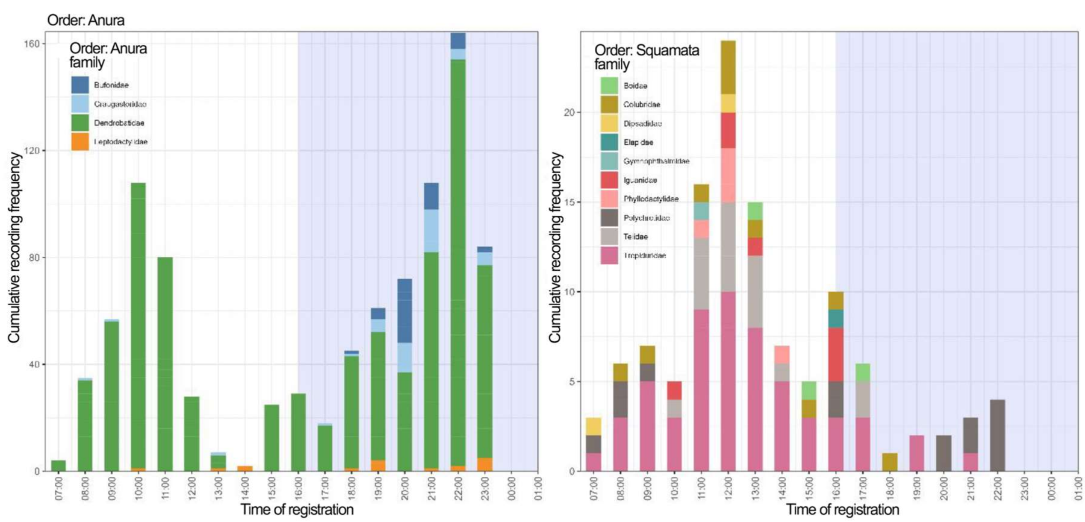

Fig. 6: Cumulative frequency of records for families belonging to the orders Anura and Squamata reported, grouped for each sampling hour (daytime: white background, nighttime: blue shaded background).

distributed into two classes: Amphibia, with seven recorded species (26.9%) and 937 individuals (88.9%), and Reptilia, with 19 species (73.1%) and 117 individuals (11.1%). At the taxonomic level, four families of amphibians and 10 families of reptiles were reported.

The most frequent amphibian was *Hyloxalus elachyhistus,* with 647 individuals, and the most frequent reptile was *Microlophus occipitalis,* with 25 individuals. Amphibians were more abundant in streams (828 individuals), while reptiles were more abundant in forests (69 individuals). Differentiating the most abundant amphibians and reptiles, *Hyloxalus elachyhistus* and *Microlophus occipitalis* dominated in forests, *Epipedobates anthonyi* and *Stenocercus puyango* in cultivated areas, Pristimantis lymani and S. puyango in populated centers, while *H. elachyhistus* and *S. puyango* were prevalent in streams.

Three globally threatened species were recorded (IUCN, 2022): *Pristimantis ceuthospilus* (VU), *Epipedobates*

Fig. 7: Anura species recorded in the BTES Equatorial of the Lucarqui farming community, Piura, northwest Peru. (A) *Rhinella marina,* (B) *Pristimantis ceuthospilus,* (C) *Pristimantis lymani,* (D) *Epipedobates anthonyi,* (E) *Hyloxalus elachyhistus,* (F) *Engystomops pustulatus,* (G) *Leptodactylus labrosus,* (H) *Leptodactylus labrosus dark dorsum.*

Fig. 8: Some of the Squamata species from the suborder Ophidia recorded in the Equatorial Seasonally Dry Tropical Forest (BTES) of the Lucarqui peasant community, Piura, northwestern Peru. (A) *Boa constrictor ortoni*, (B) *Dendrophidion brunneum*, (C) *Mastigodryas heathii*, (D) *Pseudalsophis elegans rufodorsatus*, (E) *Tantilla capistrata*, (F) *Leptodeira septentrionalis*, (G) *Oxybelis aeneus*, (H) *Sibynomorphus sp*., (I) *Micrurus mertensi*

Fig. 9: Some of the non-snake Squamata species recorded in the BTES Ecuatorial of the Lucarqui farming community, Piura, northwestern Peru. (A) *Macropholidus rutvenhi*, (B) *Iguana iguana*, (C) *Phyllodactylus kofordi*, (D) *Polychrus femoralis*, (E) *Medopheos edracanthus*, (F) *Stenocercus huancabambae*, (G) *Stenocercus limitaris*, (H) *Stenocercus puyango*

anthonyi (NT), and *Stenocercus limitaris* (VU), and four species regionally threatened in Peru: *E. anthonyi* (NT), *Hyloxalus elachyhistus* (EN), *Boa constrictor* ortoni (EN), and *Polychrus femoralis* (VU). Additionally, three species protected by CITES under Appendix II have been recorded: *Iguana iguana, B. c. ortoni,* and *E. anthonyi*.

Regarding the biogeographical importance of the species, according to the IUCN (2022), 85.71% (6 species) of the amphibians are restricted to the Equatorial BTES: *Pristimantis ceuthospilus, Pristimantis lymani, Epipedobates anthonyi, Hyloxalus elachyhistus,* and *Engystomops pustulatus*, as well as 47.36% (9 species) of the reptiles: *Dendrophidion brunneum, Tantilla capistrata, Micrurus mertensi, Macropholidus ruthveni, Phyllodactylus kofordi, Polychrus femoralis, Stenocercus huancabambae, Stenocercus limitaris,* and *Stenocercus puyango*.

CONSERVATION

The Equatorial ESDT, spanning extensive areas west of the Andes between Peru and Ecuador, is highly significant for its endemism and high level of biodiversity. Remnants and fragments of these forests have become crucial for the herpetofauna due to increasing human pressure and climate change threatening the availability and quality of their habitats. Findings from this study not only highlight how herpetofauna can be considerably diverse in a specific locality within the Equatorial ESDT but also emphasize the need to consider landscape structure as a key component for the conservation of amphibian and reptile species.

The presence of four threatened species and four with restricted ranges indicates that these forests can harbor key populations for conservation at a regional level. Protecting these species in one locality can have a domino effect, safeguarding populations in other areas of the forest and food webs.

Throughout the Equatorial ESDT, the relationship between humans and, amphibians, and reptiles is complex, shaped by culture, fear, and economy (Ríos-Orjuela et al. 2020). Hunting, trade, or mortality of these species are widespread phenomena. It is imperative to develop education and awareness programs to conserve the herpetofauna and maintain the ecological integrity of the Equatorial ESDT.

Increasing sampling efforts (e.g., person-hours) in future research will be crucial for finding less common species in the Equatorial ESDT. Other studies in dry forests have shown a positive trend between effort and reported herpetofauna diversity (Koch et al. 2018). It is recommended to expand assessments in unexplored regions of the Equatorial ESDT, with greater sampling effort, to increase knowledge of the natural history, ethology, diet, thermoecology, and other important characteristics of amphibian and reptile species that inform their conservation status and propose action plans accordingly.

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