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Non-volant mammals in the central Andes Yungas: the Pampa Hermosa National Sanctuary

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The Pampa Hermosa National Sanctuary (SNPH) is a Natural Protected Area (11,543 ha) that encompasses a large extension of central Yungas; however, despite its high priority status for the conservation of biodiversity, the non-volant mammals have been poorly documented. This study reports the non-volant mammals from the Yungas of the SNPH and its buffer zone, for the first time. We sampled four localities: Podocarpus (1,900 m), Los Cedros (1,600 m), Santa Isabel (1,450 m), and Nueva Italia (1,370 m), which encompass very humid premontane and montane forests. We used capture methods for small mammals; and direct and indirect records for medium and large-sized mammals. The capture effort was 6,860 traps-night (Sherman and Victor traps) and 490 buckets-night (pitfall traps). We recorded 31 native species: six marsupials, one cingulate, two primates, 18 rodents, two carnivores, and two artiodactyls, including the threatened species *Lagothrix lagotricha tschudii* and two endemic rodents. The most diverse orders were rodents and marsupials (77 %). The analysis of true diversity (^qD) showed that the montane forests of SNPH (1,600 to 1,900 m) had the highest values: Los Cedros ($^0D = 18.80$) when order q = 0; and Podocarpus ($^1D = 6.34$; $^2D = 4.99$) when order q = 1, 2. The rank-abundance curves indicated the same taxa group (*Hylaeamys yunganus*, *Akodon* cf. *A. aerosus*, and species of *Neacomys*) as the most abundant at all localities. The species *Marmosa* (*Micoureus*) *constantiae*, *Hylaeamys yunganus*, *Rhipidomys gardneri*, *Euryoryzomys nitidus*, *Oligoryzomys microtis*, and *Neacomys macedoruizi* are the first records for the region of Junín. One species of *Neacomys* and another of *Oecomys* might be new species to science. A beta diversity analysis showed that the Yungas of SNPH are more similar to the Manu National Park (21 %) and the Tingo María National Park (20 %); highlighting that dissimilarity is high even between relatively close communities. Our study indicates that the SNPH allow connectivity with other nearby Yungas, especially for medium and large-sized mammals that need pristine and preserved forests. Nevertheless, the real diversity of the region is still far from being completely inventoried; additional evaluations with a diverse array of methods are needed toward that goal. In addition, the local and regional governments should get involved in conserving these fragile forests where the changes in land use may affect many key and endemic species.

El Santuario Nacional Pampa Hermosa (SNPH) es un área natural protegida (11,543 ha) que abarca una gran extensión de yungas centrales; sin embargo, a pesar de su estatus de alta prioridad para la conservación de la biodiversidad, los mamíferos no voladores han sido poco documentados. Este trabajo reporta por primera vez a los mamíferos no voladores de las Yungas del SNPH y su zona de amortiguamiento. Muestreamos cuatro localidades: Podocarpus (1,900 m), Los Cedros (1,600 m), Santa Isabel (1,450 m) y Nueva Italia (1,370 m), que abarcan bosques muy húmedos premontanos y montanos. Utilizamos métodos de captura para mamíferos pequeños; y registros directos e indirectos para mamíferos medianos y grandes. El esfuerzo de captura fue de 6.860 trampas-noche (trampas Sherman y Victor) y 490 baldes-noche (trampas pitfall). Registramos 31 especies nativas: seis marsupiales, un cingulado, dos primates, 18 roedores, dos carnívoros y dos artiodáctilos, incluyendo a la especie amenazada *Lagothrix lagotricha tschudii* y dos roedores endémicos. Los órdenes más diversos fueron los roedores y marsupiales (77 %). El análisis de diversidad verdadera (^qD) mostró que los bosques montanos del SNPH (1,600 a 1,900 m) presentaron los valores más altos: Los Cedros ($^0D = 18.80$) cuando el orden q = 0; y Podocarpus ($^1D = 6.34$; $^2D = 4.99$) cuando el orden q = 1, 2. Las curvas de rango-abundancia indicaron el mismo grupo de taxones (*Hylaeamys yunganus*, *Akodon* cf. *A. aerosus* y especies de *Neacomys*) como los más abundantes para todas las localidades. Las especies *Marmosa* (*Micoureus*) *constantiae*, *Hylaeamys yunganus*, *Rhipidomys gardneri*, *Euryoryzomys nitidus*, *Olygoryzomys microtis* y *Neacomys macedoruizi* son los primeros registros para la región de Junín. Una especie de *Neacomys* y otra de *Oecomys* serían nuevas para la ciencia. Un análisis de diversidad beta mostró que las Yungas del SNPH son más similares con el Parque Nacional del Manu (21 %) y el Parque Nacional Tingo María (20 %), destacando que la disimilitud es alta incluso entre comunidades cercanas. Nuestro estudio indica que el SNPH permite la conectividad con otras Yungas cercanas, especialmente para los mamíferos medianos y grandes los cuales requieren bosques prístinos y conservados. Sin embargo, la diversidad real de la región aún está lejos de ser completamente inventariada, por lo que se necesitan evaluaciones adicionales con diversos métodos para lograr ese objetivo. Además, los gobiernos locales y regionales deben involucrarse en conservar estos bosques frágiles donde los cambios en el uso del suelo pueden afectar a muchas especies claves y endémicas.

Keywords: Conservation status; diversity; endemic species; new records; non-volant mammals; central Yungas.

Introduction

The Peruvian Yungas is one of the most diverse ecosystems where a great number of endemism occur (Young and León 1999; Myers *et al.* 2000; Pacheco 2002; Antón and Reynel 2004; Young 2007; Pacheco *et al.* 2009; Tovar *et al.* 2010). These ecosystems occupy 14 of the 24 political regions of Perú along the eastern and western slopes of the Andean Cordillera from Amazonas to Puno. They cover a total area of 12'765'993 ha, which represents 9.9 % of the total area of Perú (MINAM 2009). Moreover, there are three natural terrestrial ecoregions within the Yungas: Very Humid Pre-Montane Forests, Very Humid Montane Forests, and Montane Rain Forests (Britto 2017). In addition, the Yungas present a complex and steep orography with a great variety of altitudinal gradients and climates where high humidity conditions prevail, which favor a high diversity of flora and fauna. However, there are few studies documenting the diversity and endemism of various taxa throughout the Yungas, especially the non-volant mammals.

Protected Natural Areas (ANPs) have been recognized as places of protection of biological and genetic diversity (Joppa and Pfaff 2009), and almost a third of the total ANPs in Perú is located in the Yungas ecoregions (CDC-UNALM and TNC 2006). Peruvian laws have determined the scientific and cultural importance of ANPs, where their knowledge contributes to the country's sustainable development (Law No. 26834, DS 038-2001-AG, 2001). In the central Yungas, there are at least 11 ANPs with premontane and montane forest areas located in the regions Huánuco, Junín, Pasco, and Ucayali: The National Parks (NP) Otishi, Tingo María, Yanachaga-Chemillen, and Cordillera Azul; the Communal Reserves (CR) Ashaninka, Yanesha, "El Sira", and Amarakaeri; the Protection Forests Pui Pui and San Matias-San Carlos; and the Pampa Hermosa National Sanctuary (Tovar *et al.* 2010; Tovar 2021).

The Yungas of Ucayali, Huánuco, Junín, and Pasco are the regions with more than 70,000 hectares of deforested rainforest. Although the ANPs are places with intangibility categories, the diversity of these areas and their surroundings are strongly threatened by the change in land use for agricultural activities, mainly (SERFOR 2015; MINAM 2016). In this context, knowledge of diversity is highly urgent for the future conservation of species. Vivar (2006) evaluated the small volant and non-volant mammals' diversity in the central Yungas ANPs at the Yanachaga Chemillen NP; whereas Arias *et al.* (2016) evaluated the volant mammals' diversity at the Pampa Hermosa National Sanctuary. Likewise, Cossios and Ricra-Zevallos (2019), and Pillco Huarcaya *et al.* (2020) addressed the medium and large-sized mammals' diversity at "El Sira" CR and Tingo María NP. On the other hand, outside of ANPs, there are studies on small, medium, and large-sized mammals in various central regions (Pacheco *et al.* 2007; Medina *et al.* 2012; Pacheco and Noblecilla 2019; Cossios and Ricra-Zevallos 2019; Pillco Huarcaya *et al.* 2020; Aquino *et al.* 2022). Although Junín has ten ANPs, this region is one of the least studied (MINAM 2016).

The Pampa Hermosa National Sanctuary (SNPH) is a Natural Protected Area located precisely in the Central Yungas in the Region of Junín. To date, only one study assessed the diversity of non-volant mammals from SNPH but focused exclusively on medium and large species in the high-Andean regions (3,200 to 3,700 m; Melo-Dias *et al.* 2022). These authors recorded 11 species through camera traps, searching mammal tracks (*e. g.*, feces, footprints, food consumed, marks on trees), and direct visualizations. Despite the importance of the Yungas of SNPH, which shelters and protects relict cedar forests *Cedrela* spp. in the central jungle of Perú, studies on the diversity of all groups of mammals are scarce. Considering that the central Yungas are priority conservation areas (Tovar *et al.* 2010) and that they function as an essential biological corridor between high Andean and Amazon forests (SERNANP 2012; Arias *et al.* 2016), the diversity of non-volant mammals is still poorly known.

For all the reasons mentioned above, this study aims: 1) Describe the alpha diversity and the composition of non-volant mammals in the Yungas of SNPH between 1,370 and 1,900 m. 2) Evaluate the beta diversity of mammals in SNPH with other montane Peruvian forests in elevation ranges between 1,000 and 2,000 m. 3) Assess the conservation status and endemicity of the reported mammals.

Material and methods

Study area. We conducted the study in the Pampa Hermosa National Sanctuary (SNPH) and its buffer zone both near the Ulcumayo river basin, province of Chanchamayo, region of Junín, Perú (Figure 1). The area with a total extension of 11,543 ha is within the Yungas ecoregion (Brack-Egg 1986), also known as Montane Forests on the eastern slope of the Andes (Tovar *et al.* 2010), or as Very Humid Premontane and Montane Forests (Britto 2017). Four localities were evaluated: Podocarpus (1,900 m), Los Cedros (1,600 m), Santa Isabel (1,450 m), and Nueva Italia (1,370 m; Figure 1). Podocarpus and Los Cedros are located within the Pampa Hermosa National Sanctuary in the ecoregion named as "Very Humid Low Montane Tropical Forest" (Britto 2017). A primary forest with trees between 15 to 20 m high is present in both localities. The families Podocarpaceae and Clusiaceae are common in Podocarpus, whereas Meliaceae (mainly *Cedrela* spp.), Moraceae, Lauraceae, and arboreal ferns are commonly seen in Los Cedros. The localities Nueva Italia and Santa Isabel are in the buffer zone less than 1 km away from the SNPH and separated by Ulcumayo River in the ecoregion named as "Very Humid Premontane Forest" (Britto 2017). A dense understory with secondary forests is present in these localities, with trees and shrubs of the families Piperaceae, Solanaceae, and Cecropiaceae (Table 1). A detailed habitat description of all localities is found in Arias *et al.* (2016).

Mammals sampling. The localities of Podocarpus, Los Cedros, and Nueva Italia were evaluated during May and October 2011, whereas Santa Isabel was evaluated in May and June 2012. The sampling was carried out in two seasons, established by the presence of precipitation: the first in

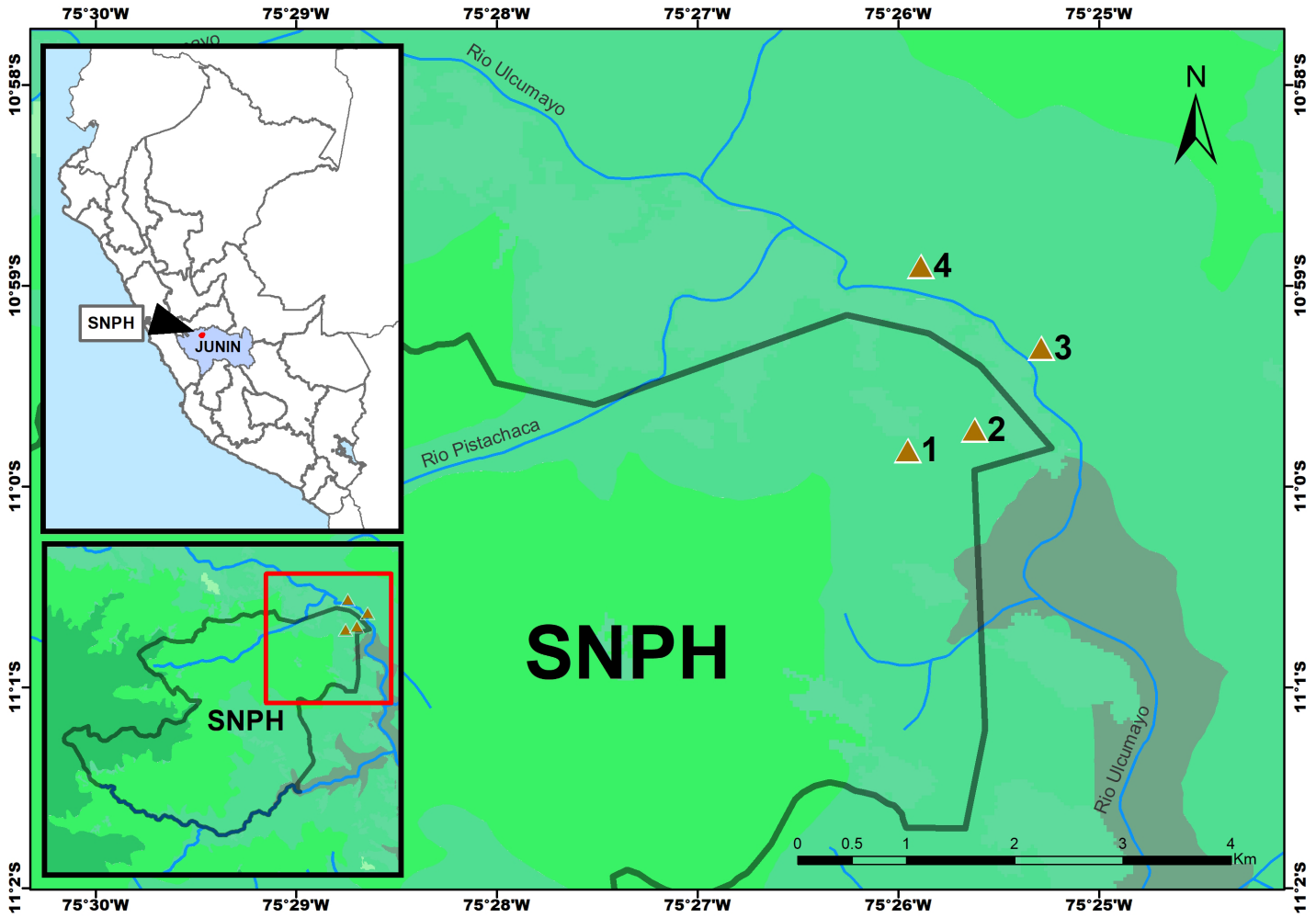

Figure 1. Sampling localities in the Pampa Hermosa National Sanctuary (SNPH) and its Buffer Zone: 1) Podocarpus, 2) Los Cedros, 3) Nueva Italia, 4) Santa Isabel. See Table 1 for complete locality information.

May-June (wet season) and the second in October (dry season). The methodology consisted of using live (Sherman), snap (Victor), and pitfall traps to capture small mammals and records of direct and indirect evidence for medium and large mammals. All trapping methods were used following some modifications from the methods detailed by Jones *et al.* (1996), Voss and Emmons (1996), Woodman *et al.* (1996), and Sikes *et al.* (2011).

In each locality, two transects of 35 trapping stations separated by 10 m were set. Each trapping station consisted of one Sherman and one Victor trap; then, 140 traps were active each night. The bait for all traps was made of oatmeal, peanut butter, raisins, honey, vanilla essence, and unviable canary seeds. All traps were baited and activated during the morning and reviewed and re-baited the following day. In addition, a 90 m pitfall trap was installed in each locality (Voss and Emmons 1996), where 10 buckets of eight liters of capacity were buried and separated by about 10 m. The total trapping effort was calculated by multiplying the number of traps or buckets for the nights evaluated (Table 1).

The captured specimens were measured (total, tail, ear, and hind foot length), weighted, sexed (including reproductive condition), aged, and preliminary taxonomically identified in the field. All specimens were collected, except for some lactating or pregnant females that were released (making sure we already had a voucher for the species). The captured specimens were preserved as skins, skulls, and carcasses or complete bodies, fixed in 10 % formaldehyde for 10 days, and afterward preserved in 70 % alcohol. All specimens were identified, cataloged, and deposited in the scientific collection of the Mammalogy Department in the Museum of Natural History of the Universidad Nacional Mayor de San Marcos (MUSM).

The presence of medium and large-sized mammals was recorded through occasional records of direct and indirect traces. A direct record consisted of the observation of an individual (or a skull); meanwhile, indirect ones were feces, footprints, smell traces, or diggings. Furthermore, we surveyed the local people living near the sampling localities. In the interviews, people were presented with photos or illustrations of potential species and asked to confirm if they were familiar with some. Species, local names, and dates of observation were recorded. Because data of medium and large-sized mammals was qualitative, it was only used to update the list of species richness and beta diversity analyses.

Analysis of data. Alpha diversity analyses were assessed only with quantitative data from small mammals and localities with dry and wet season sampling. Santa Isabel was sampled only once (in the wet season) and its results added to the overall richness. In addition, a rank abundance curve was constructed to measure the community structure of small mammals, calculating the base logarithm 10 of the relative abundance of species in each locality. This method lets us know the species richness and dominance or rareness in each sampled site or habitat (Feinsinger 2001).

The diversity of localities was estimated using the true diversity (^{q}D) proposed by Jost (2006). This measure is defined as the effective number of species ($^{q}sp_{E}$), which is a virtual species that is equally abundant as the species recorded on average (Tuomisto 2013). Hence, ^{q}D has properties intuitively of the diversity concept as the duplication property (Jost 2006). The superscript q is the order of the true diversity and indicates its sensitivity to rare and common species when q is less or greater than unity, respectively. To estimate ^{q}D, the order value "q" and the diversity estimators are considered (Moreno *et al.* 2011). The values of order "q" used in this study were: the diversity of order zero (^{0}D) that is equivalent to species richness; the diversity of order one (^{1}D), equal to the exponential of Shannon's entropy index; and the diversity of order two (^{2}D), the inverse of Simpson's index (Tuomisto 2013). The richness estimators used consider the sample coverage as a measure of the completeness of the inventories, which represents the fraction of the total abundance of the community represented in the sample (Chao and Shen 2003). Thus, Moreno *et al.* (2011) recommend the following diversity estimators according to the value of "q": the non-parametric estimator ACE (Abundance-based coverage estimator) for ^{0}D; Bias-corrected Shannon diversity estimator for ^{1}D; and the MVUE estimator (Minimum variance unbiased estimator) for ^{2}D. These analyses and their 95 % confidence intervals (CI) were calculated with the online program SpadeR (Chao *et al.* 2015).

Beta diversity was analyzed to assess the species' turnover of SNPH with other central and southern Peruvian Yungas in the elevation range of 1,000 to 2,000 m using qualitative data of the richness of small, medium, and large-sized mammals based on presence-absence (Wilson and Shmida 1984; Magurran 1988; Villareal *et al.* 2006; Magurran 2011). This species' turnover was performed through a cluster analysis using Jaccard's similitude coefficient (I_j; Magurran 1988, 2004; Baev and Penev 1995; Samo *et al.* 2008). Data was compiled from similar forests such as the Manu National Park (Solari *et al.* 2006; Medina *et al.* 2012), the Yanachaga-Chemillén National Park (Vivar 2006), the Apurímac River Basin (Pacheco *et al.* 2007), Pozuzo Forests (Mena and Medellín 2010), the Middle Basin of the River Tambopata (Pacheco *et al.* 2011), Carpish Forests (Pacheco and Noblecilla 2019), the Yungas of Huánuco (Aquino *et al.* 2022), the Sira Communal Reserve (Pillco Huarcaya *et al.* 2020), the Tingo María National Park (Cossios and Ricra-Zevallos 2019), and Fundo La Genova in Chanchamayo (Guevara-Torres *et al.* 2021). This analysis was executed using PAST program 3.0.

Finally, the conservation status and endemism of all species recorded in all localities were reviewed following IUCN (2023), DS 004-2014-MINAGRI (2014), and CITES (2023). In addition, including all species data from previous studies and the current from SNPH, their conservation status, and endemism, a list of potential mammal species in the central and southern Peruvian Yungas between 1,000-2,000 m was elaborated (see Supplementary material 1).

Results

Species composition. A total of 31 species of small, medium, and large-sized mammals were recorded in the four sampled localities in the SNPH and its buffer zone: six opossums (order Didelphimorphia), one armadillo (order Cingulata), two monkeys (order Primates), 18 rodents (order Rodentia), two carnivores (order Carnivora), and two even-toed ungulates (order Artiodactyla). According to size, 17 species were classified as small mammals: five opossums and 12 rodents. The remaining 14 species belong to the group of medium and large-sized mammals: the Andean White-eared Opossum, *Didelphis pernigra*; the Nine-banded Armadillo, *Dasypus novemcinctus*; the Tschudi's Woolly Monkey, *Lagothrix lagothricha tschudii* and the Black-headed Night Monkey, *Aotus nigriceps*; the Grey-headed Tayra, *Eira barbara* and the South American Coati, *Nasua nasua*; the Collared Peccary, *Dycotiles tajacu* and the Red Brocket, *Mazama americana*; and six large rodents (Table 2). An introduced small rodent,

Table 1. Sampling localities in the Pampa Hermosa National Sanctuary and its Buffer Zone. VHMF: Very Humid Montane Forest, VHPF: Very Humid Premontane Forest, TN (traps-night), BN (buckets-night).

Sampling Locality	Ecoregion	Elevation (m)	Geographical coordinates		Live and Snap Traps (Sherman/Victor)		Pitfall traps	
			South	West	Number of nights	Capture effort (TN)	Number of nights	Capture effort (BN)
Podocarpus	VHMF	1,900	10° 59' 49.2"	75° 25' 57.1"	14	1,960	14	140
Los Cedros	VHMF	1,600	10° 59' 43.1"	75° 25' 37.2"	14	1,960	14	140
Nueva Italia	VHPF	1,370	10° 59' 18.6"	75° 25' 17.3"	14	1,960	14	140
Santa Isabel	VHPF	1,450	10° 58' 54.1"	75° 25' 53.3"	7	980	7	70
Total Effort Capture						**6,860**		**490**

the Black Rat *Rattus rattus* (Muridae), was also recorded. For the nomenclature of the species, we follow the latest updated list of mammals from Perú (Pacheco *et al.* 2021).

The order Rodentia (18 species) and Didelphimorphia (six species) were the most diverse, reaching 77 % of the total richness. Within these taxonomic orders, the families Didelphidae and Cricetidae were the most representative, with six and 12 species, respectively. Other recorded orders accumulated seven species composing 23 % of the total richness, being Cingulata with a single species the least diverse. The records of these orders were mainly observations (individuals or skulls), vocalizations, feces, and footprints. In addition, the interviews conducted with park rangers were also considered reliable indirect records (see Table 2).

Species richness was different across localities and elevations. Nueva Italia (1,370 m) accumulated the highest richness with 17 species, followed by Podocarpus (1,900 m), Los Cedros (1,600 m), and Santa Isabel (1,370) each with 14 species. Analyzing by size, the richness of small mammals was very alike at all elevations. Medium and large-sized species were more frequently recorded at lower elevations mainly in Nueva Italia (Table 2).

Small mammals. We recorded 248 individuals from two orders, three families, 11 genera, and 18 species in the four sampled localities. Rodentia was the order with the greatest number of species (72.2 %) and number of records (87.1 %). Cricetidae, with 12 species and 215 individuals (86.7 %), was the most diverse family. In addition, six species were recorded with one single individual.

Noteworthy records. Several records are worth mentioning as it is the first report on the non-volant small mammals from the Yungas of the SNPH. Among our findings, new regional records and new species are revealed.

The new records for the region of Junín are the following: the marsupial *Marmosa* (*Micoureus*) *constantiae* and the rodents *Hylaeamys yunganus*, *Rhipidomys gardneri*, *Euryoryzomys nitidus*, *Oligoryzomys microtis*, and *Neacomys macedoruizi* (Figure 5). Furthermore, *O. microtis* is captured for the first time in the habitats of Yungas. Previous studies only reported it in low forests (Patton *et al.* 2000; Pacheco *et al.* 2007; Patton *et al.* 2015; Medina *et al.* 2016).

The spiny rodent *Neacomys macedoruizi* highlights since it was described as a new species endemic to the region of Huánuco (Sánchez-Vendizú *et al.* 2018). Our record in Junín is represented by a single adult male (voucher number MUSM 45889) captured in the locality of Santa Isabel. Diagnostic characters observed on the specimen, that agree with the description of the species made by Sánchez-Vendizú *et al.* (2018) include a bicolored ventral fur with a gray basal area and the skull with: the anterior region of the nasal protruding sharply from the maxilla; the supraorbital region markedly divergent with slightly protruding ridges; a conspicuous and large subsquamosal fenestra; the petrosal bones (close to the auditory bulla) less exposed; the incisive foramina subrectangular and almost reaching the first upper molar; and the anterocone divided (Figure 2).

A probable new species of *Neacomys* captured in the four localities was also recorded in this study. After a thorough morphological examination of all specimens, a series of characters suggests that this might represent a new species, referred here to as *Neacomys* sp. "Junín". A relevant diagnostic character is the white ventral fur, not bicolored. A dorsal view of the skull shows a short rostrum; nasal with a width interorbital region, and the dorsal border of the foramen magnum usually rounded. Ventrally, the incisive foramina extend quite far from the plane of the first upper molar; the anterocone in the first upper molar is conspicu-

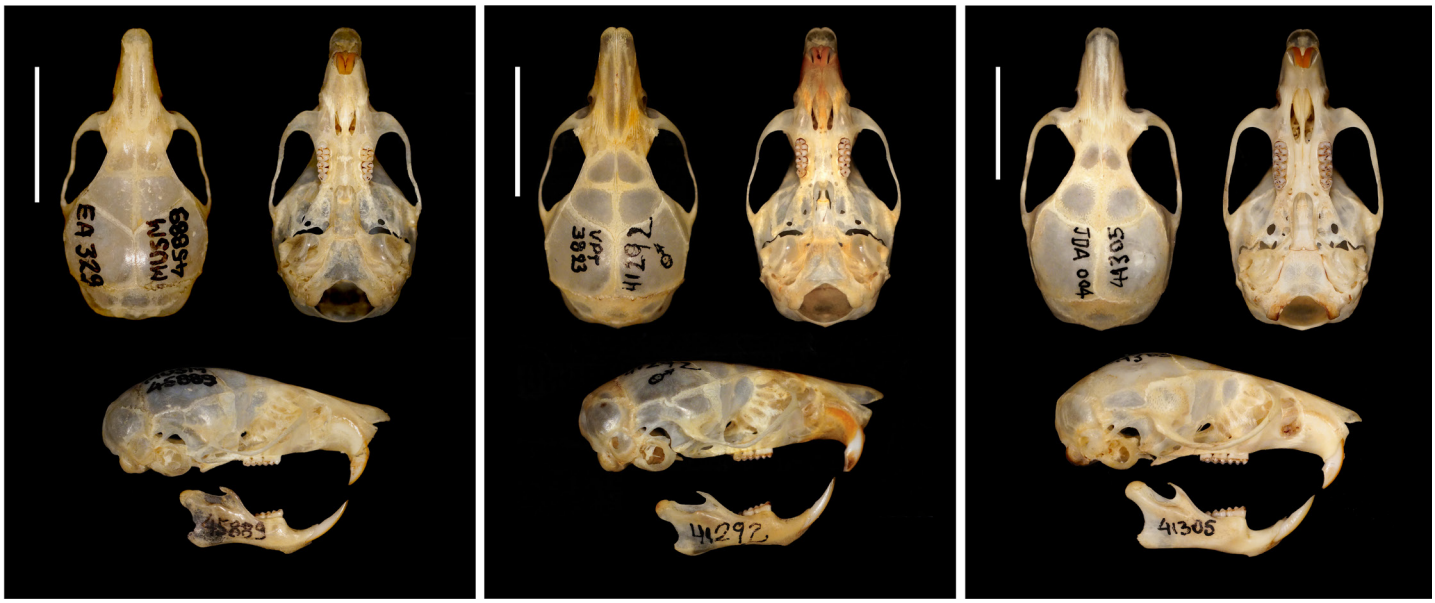

Figure 2. Dorsal, ventral, and lateral views of cranium and mandible of *Neacomys macedoruizi* MUSM 45889 (left), *Neacomys* sp. "Junín" MUSM 41292 (middle), and *Oecomys* sp. "Junín" MUSM 41305 (right). Bar = 10 mm.

Table 2. List of non-volant mammal species recorded by locality in the Pampa Hermosa National Sanctuary and its Buffer Zone. The number of captured individuals of small mammals and the type of record for medium and large-sized mammals is presented (O: observation, F: footprint, Fe: feces, and I: interviews with local people). [a] small, [b] medium, [c] large

Species	Common name	Locality			
		Podocarpus (1,900 m)	Los Cedros (1,600 m)	Nueva Italia (1,370 m)	Santa Isabel (1,450 m)
ORDER DIDELPHIMORPHIA					
Family Didelphidae					
Didelphis pernigra [b]	Andean White-eared Opossum	-	-	-	O
Marmosa macrotarsus [a]	Macrotarsus' Mouse Opossum	-	-	1	1
Marmosa constantiae [a]	Woolly Mouse Opossum	5	-	4	5
Marmosops bishopi [a]	Bishop's Slender Opossum	3	-	-	-
Marmosops caucae [a]	Cauca's Slender Opossum	4	1	-	-
Marmosops noctivagus [a]	White-bellied Slender Mouse Opossum	1	4	1	2
ORDER CINGULATA					
Family Dasypodidae					
Dasypus novemcinctus [c]	Nine-banded Armadillo	I	I	-	-
ORDER PRIMATES					
Family Cebidae					
Aotus nigriceps [c]	Black-headed Night Monkey	I	O, I	-	-
Family Atelidae					
Lagothrix lagothricha tschudii[c]	Tschudi's Woolly Monkey	O	O	-	-
ORDER RODENTIA					
Family Sciuridae					
Hadrosciurus pyrrhinus [b]	Junín Red Squirrel	-	O	-	-
Family Cricetidae [a]					
Akodon cf. *A. aerosus*	Grass Mouse	6	5	26	38
Euryoryzomys nitidus	Elegant Rice Rat	-	-	-	1
Hylaeamys yunganus	Yungas Rice Rat	17	21	22	9
Neacomys amoenus	"Northern" Ameno's Spiny Mouse	-	4	12	-
Neacomys macedoruizi	Macedo Ruiz' Spiny Mouse	-	-	-	1
Neacomys sp. "Junín"	Spiny Mouse	10	3	6	12
Nephelomys keaysi	Keays's Nephelomys	2	1	4	-
Oecomys sp. "Junín"	White-bellied Oecomys	1	1	1	1
Oligoryzomys destructor	Destructor Colilargo	-	-	-	8
Oligoryzomys microtis	Smell-eared Colilargo	-	-	1	-
Rhipidomys gardneri	Gardner's Rhipidomys	-	1	-	-
Rhipidomys leucodactylus	Great Rhipidomys	-	1	-	-
Family Erethizontidae					
Coendou bicolor [c]	Bicolor-spined Porcupine	-	-	-	O
Family Dinomyidae					
Dinomys branickii [c]	Pacarana	-	-	-	O
Family Caviidae					
Hydrochoerus hydrochaeris [c]	Capybara	-	-	O	-
Family Dasyproctidae					
Dasyprocta cf. *D. kalinowskii* [b]	Kalinowski Agouti	O	-	O	-
Family Cuniculidae					
Cuniculus paca [c]	Agouti, Spotted Paca	-	-	O	-
ORDER CARNIVORA					
Family Mustelidae					
Eira barbara [c]	Tayra, Greyheaded Tayra	-	-	I	I
Family Procyonidae					
Nasua nasua [c]	South American Coati	-	-	O	-
ORDER ARTIODACTYLA					
Family Tayassuidae					
Dicotyles tajacu [c]	Collared Pecari	-	-	O	-
Family Cervidae					
Mazama americana [c]	Red Brocket	I	-	F, Fe	-
Total: 31 species		**14**	**14**	**17**	**14**

We follow the latest updated list of mammals from Perú for the species names (Pacheco *et al.* 2021). Some species are shown in figures 2, 5, and 6.

ously divided, and the third upper molar has a distinct and conspicuous hypoflexus (Figure 2). A complete taxonomic review will be developed in a forthcoming manuscript.

Oecomys sp. "Junín" is probably another new species revealed in this study and recorded in the four localities. Our specimens were compared with all the species of the genus, and show many notable differences. *Oecomys* sp. "Junín" shows a small size and protruding hairs at the tip of the tail. In a dorsal view of the skull, the interorbital region is narrow and widely divergent, not beaded. Laterally, the postglenoid foramen is quite open; and the subsquamosal fenestra is greatly reduced. Ventrally, the incisive foramina are long and wide, reaching the anterior plane of the first upper molar or slightly posterior to it (Figure 2). Like the previous species reported as new, *Oecomys* sp. "Junín" will also be formally described in a forthcoming manuscript.

The grass mouse *Akodon* cf. *A. aerosus* was identified to this level due to some differences found when comparing it with the species *aerosus*. Our specimens differ from *aerosus* by exhibiting a narrower interorbital region; narrower incisive foramina that extend to the protocone of the first upper molar (versus extending to the anterocone); anterior edges of zygomatic-plates concave (versus straight); thicker hamular process; and upper incisors orthodont (versus slightly opisthodont). The anterior edges of zygomatic plates are concave (versus straight to slightly concave in *aerosus*, according to the description of Pardiñas *et al.* 2015). The complex taxonomy of *Akodon aerosus* was mentioned by Jiménez and Pacheco (2016), recommending more studies in the Peruvian Yungas, given that it could encompass more than one species.

Alpha diversity. For this analysis, the three localities sampled twice recorded 170 individuals and 14 species. Species richness (s) and number of individuals (n) were distributed as follows: Podocarpus (s = 9, *n* = 49), Los Cedros (s = 11, *n* = 43), and Nueva Italia (s = 10, *n* = 78).

The three localities had the same set of most abundant species according to the range-abundance curves: *Hylaeamys yunganus*, *Akodon* cf. *A. aerosus,* and *Neacomys* spp. Likewise, the curves of Los Cedros and Nueva Italia were similar, with few abundant species and many less abundant species. Furthermore, both localities showed at least one slope fall, meaning greater inequality between species. In contrast, Podocarpus showed a gradual decay indicating a greater diversity than the previous localities. On the other hand, species with one single individual (singletons) were placed in the base of curves, highlighting Los Cedros with the highest value (six singletons). *Oecomys* sp. "Junín" was the only singleton species recorded in each locality (Figure 3).

Results of true diversity analysis showed a decreasing pattern according to the increase in the number of order (^{q}D); however, the magnitude of that decrease was variable in the three sampled localities. Comparing the values of ^{0}D that indicate the estimated species richness, Los Cedros showed the highest value. Since ^{2}D focuses on abundance, a more considerable difference between ^{2}D and ^{0}D means that locality is influenced by the dominance of one or more species. Thus, this difference was greater in Los Cedros, followed by Nueva Italia and Podocarpus with values of 15, 11, and 5 effective species ($^{q}sp_{E}$), respectively. On the other hand, considering the values of ^{1}D (which includes common, dominant, and even rare species) and ^{2}D (focused mainly on dominant species), Podocarpus was ranked as the most diverse locality. Nevertheless, for each ^{1}D and ^{2}D, the three localities differ by less than 1.5 $^{q}sp_{E}$, in which we can assert these localities are relatively equally diverse. In addition, the completeness of each sampled locality was measured through the divide between the richness (S) and ^{0}D, ranking the localities in descending order as follows: Podocarpus (87 %), Nueva Italia (67 %) and Los Cedros (59 %) (Table 3).

Beta diversity. Using the Jaccard similarity index (I_j) to compare Yungas communities between 1,000 to 2,000 m, a low similarity was observed showing the highest values when comparing SNPH with the Manu National Park "PNM" (*Ij* = 21 %) and the Tingo María National Park "PNTM" (*Ij* =

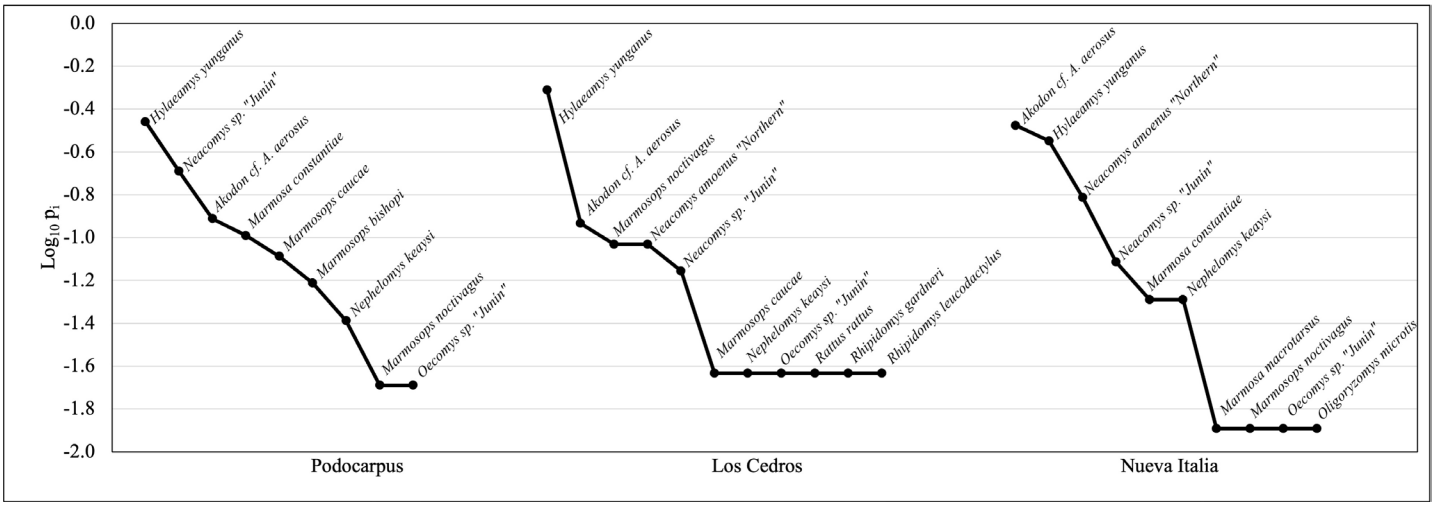

Figure 3. Rank abundance curves for small mammals from localities sampled during two seasons in the Pampa Hermosa National Sanctuary and its Buffer Zone.

Table 3. True diversity analysis performed in localities sampled during two seasons in the Pampa Hermosa National Sanctuary and its Buffer Zone. N: number of individuals, S: species richness, ^{q}D: true diversity of order q = 0, 1, 2.

Locality	N	S	True diversity (estimated)					
			^{0}D		^{1}D		^{2}D	
Podocarpus	49	9	10.30	(9.20-19.60)	6.34	(4.79-7.91)	4.99	(3.47-6.51)
Los Cedros	43	11	18.80	(12.50-50.70)	5.77	(4.63-6.91)	3.60	(2.56-4.65)
Nueva Italia	78	10	15.00	(10.80-42.10)	5.68	(4.91-6.44)	4.42	(3.66-5.18)

20 %) sharing 16 and eight species, respectively. With the Yungas of Huánuco "YuHUA" and Sira Communal Reserve "SCR" the similarity values were the same (I_j = 18 %) sharing 10 species, while with the other communities, the values were less than 14 %. On the other hand, the Yanachaga-Chemillén National Park, and the forests of Carpish and Pozuzo formed a separate group (Figure 4). Species shared between SNPH, PNM, and PNTM included five orders, whilst between SNPH, YuHUA, and SCR shared six orders. The PNM is one of the communities with the most complete and detailed studies on the richness of mammals (Solari *et al.* 2006; Medina *et al.* 2012). For this reason, its complementarity with SNPH is one of the lowest among all the communities analyzed. In addition, the greatest similarity between these two communities occurs mainly between the species of rodents and marsupials sharing 11 species (Table 4, Figure 4).

It is important to mention that in PNYCh (Vivar 2006) and in Pozuzo (Mena and Medellín 2010) only small mammals were evaluated. In contrast, in the Yungas of Huánuco

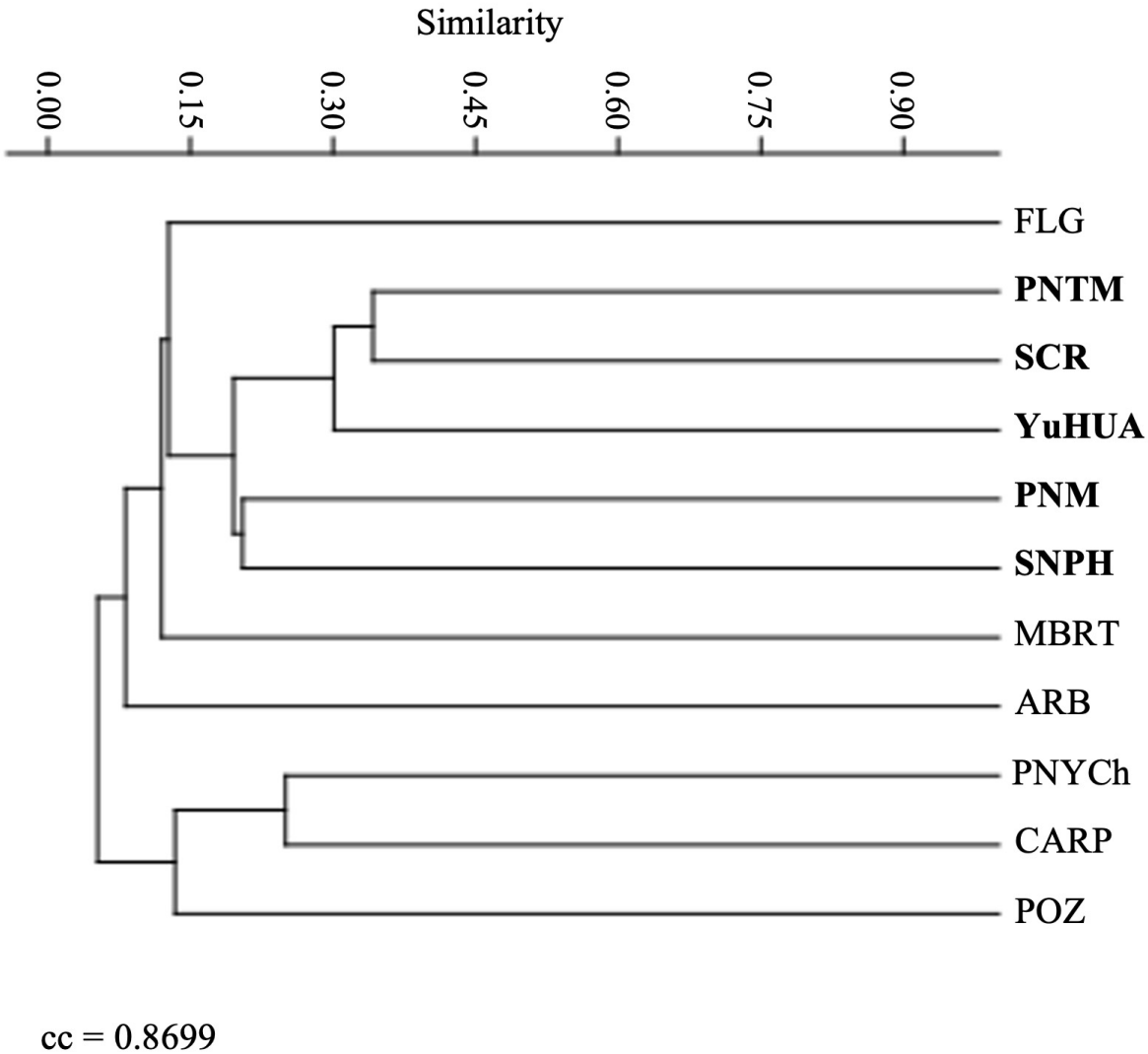

Figure 4. Cluster analysis using the Jaccard similarity coefficient and Unweighted Pair Group Method with Arithmetic Mean (UPGMA) of eleven communities with 'Yungas' habitats in the elevation rank of 1,000 to 2,000 m in the central and south of Perú. Localities that share more similarities with SNPH are in bold. cc=cophenetic correlation. The acronyms are detailed in Table 4.

Table 4. Jaccard similarity index (I_j) and complementarity values (C) of 11 study areas with Yungas in the elevation rank of 1,000-2,000 m in the central and south of Perú: SNPH (the Pampa Hermosa National Sanctuary), PNM (the Manu National Park), PNTM (the Tingo María National Park), SCR (the Sira Communal Reserve), YuHUA (the Yungas of Huánuco), MBRT (Middle Basin of the River Tambopata), ARB (the Apurímac River Basin), PNYCh (the Yanachaga-Chemillén National Park), CARP (Carpish Forests), POZ (Pozuzo Forests), and FLG (Fundo La Genova). Values in bold represent I_j (decimals) and C (integers in %) between the SNPH and the other study areas.

Study Area	SNPH	PNM	PNTM	SCR	YuHUA	MBRT	ARB	PNYCh	CARP	POZ	FLG
SNPH	**1**	**79**	**80**	**82**	**82**	**86**	**87**	**87**	**88**	**89**	**92**
PNM	**0.21**	1	84	74	80	83	93	87	96	90	91
PNTM	**0.20**	0.16	1	66	70	95	93	97	100	100	81
SCR	**0.18**	0.26	0.34	1	70	85	90	96	100	100	83
YuHUA	**0.18**	0.20	0.30	0.30	1	89	91	96	98	100	90
MBRT	**0.14**	0.17	0.05	0.15	0.11	1	94	85	90	91	90
ARB	**0.13**	0.07	0.07	0.10	0.09	0.06	1	100	100	90	95
PNYCh	**0.13**	0.13	0.03	0.04	0.04	0.15	0.00	1	75	86	95
CARP	**0.12**	0.04	0.00	0.00	0.02	0.10	0.00	0.25	1	87	100
POZ	**0.11**	0.10	0.00	0.00	0.00	0.09	0.10	0.14	0.13	1	100
FLG	**0.08**	0.09	0.19	0.17	0.10	0.10	0.05	0.05	0.00	0.00	1

(Aquino *et al.* 2022), Sira Communal Reserve (Pillco Huarcaya *et al.* 2020), and The Tingo María National Park (Cossios and Ricra-Zevallos 2019), only medium and large-sized mammals were considered. However, all these studies were considered to assess the similarity between communities and elaborate a list of potential mammals in Yungas' habitats in central and southern Perú between 1,000 and 2,000 m (see Supplementary material 1).

Medium and large-sized mammals. We recorded 14 medium and large mammal species in all sampling localities (Table 2). Order Rodentia was the most diverse group, with six taxonomic families and six species. Orders Primates, Carnivora, and Artiodactyla each presented two families and species. Didelphimorphia and Cingulata orders each had only one species (Table 2).

One of the most noteworthy records was the sightings of the Tschudi's Woolly Monkey, *Lagothrix lagothricha tschudii*. Their troops were observed in the first hours of the morning, almost during all trapping sampling for small mammals into the SNPH, in both Los Cedros y Podocarpus (Figure 6). Furthermore, the Black-headed Night Monkey, *Aotus nigriceps* was listened to, observed, and confirmed by local people in interviews.

Among the large rodents, we highlight the agouti *Dasyprocta* cf. *D. kalinowskii*. Our records included the sighting of an individual and a skull that was thoroughly reviewed to be identified at this taxonomic level (Figure 6). After analyzing specimens from Junín which included *D. variegata* reviewed by Teta and Reyes-Amaya (2021) and one specimen of *D. kalinowskii* (MUSM 38533), a series of characters suggests that our record might represent *D. kalinowskii*. Our specimen is close to *D. kalinowskii* and differs from *D. variegata* (characters in parenthesis) by exhibiting in a dorsal view of the skull, a short and thin sagittal crest (versus elongated and thickened). Laterally, the maxillary foramen is rounded rectangular (versus oval and shorter). Ventrally, the septum in the maxilla is thick and the mesopterygoid fossa has a spine (versus thin septum and mesopterygoid fossa without a spine). According to these characters and added to the fact that it was only contrasted with a single specimen of *D. kalinowskii* from the MUSM, we decided to identify our specimen as *Dasyprocta* cf. *D. kalinowskii*.

Other groups also recorded by sightings were, the Andean White-eared Opossum *Didelphis pernigra*, the South American Coati *Nasua nasua*, and the Collared Peccary *Dicotyles tajacu*. Footprints and feces of the Red Brocket *Mazama americana* were recorded. The Nine-banded Armadillo *Dasypus variegatus*, and the Grey-headed Tayra *Eira barbara* were the only records by interviews with local people.

Endemic species. Two rodent species were recorded as endemic to Perú: The Macedo 'Ruiz' Spiny Mouse *Neacomys macedoruizi* and the Kalinowski Agouti *Dasyprocta* cf. *D. kalinowskii*. One single specimen of *N. macedoruizi* was captured in the premontane forests of Santa Isabel and is a range extension of 185 km south from the previous report from Huánuco (Sanchez-Vendizú *et al.* 2018). On the other hand, *Dasyprocta* cf. *D. kalinowskii* was sighted in the montane forests of Los Cedros and in the premontane forests of Nueva Italia. Records of this large rodent are significant, because if future studies confirm that it is indeed *D. kalinowskii*, new records and information about this poorly-known species will be added.

Conservation status. Seven species recorded in this study are included in some conservation category according to Peruvian (DS 004-2014-MINAGRI 2014) or international legislation (IUCN 2023, CITES 2023).

The Tschudi's Woolly Monkey *Lagothrix lagothricha tschudii* is the most threatened species, listed as Endangered (EN) by Peruvian legislation (DS 004-2014-MINAGRI 2014), Vulnerable (VU) by IUCN (2023), and included together with the Black-headed Night Monkey *Aotus nigriceps* into the Appendix II of CITES (2023). Three rodents are also species with some threat status: the Pacarana *Dinomys branickii,* listed as VU by Peruvian legislation; the Kalinowskii Agouti *Dasyprocta* cf. *D. kalinowskii*, and the Junín Red Squirrel *Hadrosciurus pyrrhinus,* both listed as Data Deficient (DD) by IUCN and Peruvian legislation. Both IUCN and Peruvian legislation also list the Red Brocket *Mazama*

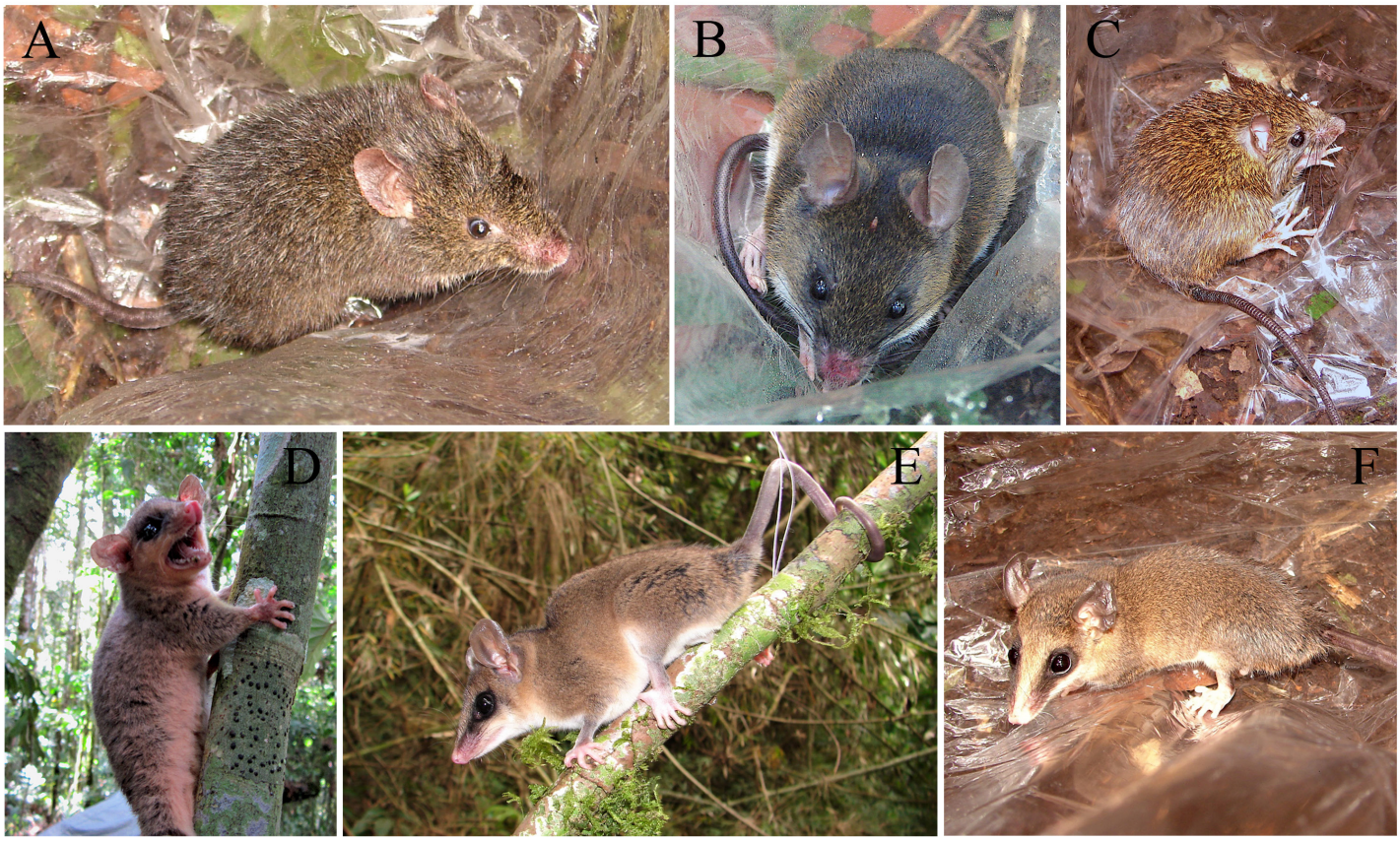

Figure 5. Small mammals in the Yungas of Pampa Hermosa National Sanctuary, Junín-Perú. (A) *Akodon* cf. *A. aerosus*; (B) *Hylaeamys yunganus*; (C) *Neacomys amoenus* "Northern"; (D) *Marmosa* (*Micoureus*) *constantiae*; (E) *Marmosops* (*Marmosops*) *noctivagus*; and (F) *Marmosops* (*Sciophanes*) *bishopi*. Photos by V. Pacheco.

americana as DD, and Appendix II of CITES includes the Collared Peccary *Dicotyles tajacu*. Appendix II lists species that are not necessarily currently threatened with extinction, but that may become so unless trade is closely controlled (CITES 2023). The remaining medium and large-sized mammals, and all small-sized mammals are not included in some threat status. However, the population trend of almost all medium and large mammals except the Collared Peccary is decreasing or unknown, and more studies are needed to know their actual conservation status of threat (IUCN 2023).

In addition, we surveyed the local people and asked them about the uses of many mammals that live there. Thus, the Spotted Paca *Cuniculus paca*, the Pacarana *Dinomys branickii*, the Kalinowskii Agouti *Dasyprocta* cf. *D. kalinowskii*, and the Red Brocket *Mazama americana* were reported as animals hunted for food. Some people stated that medium and large-sized mammals could affect their coffee crops. Since most of the records of these mammals were in the buffer zone of SNPH, it would be essential to inform local people about the conservation status and importance of mammals for the maintenance of the Yungas where they live.

Discussion

We document for the first time the non-volant small, medium, and large-sized mammals in the central Yungas of the Pampa Hermosa National Sanctuary (SNPH). This assessment reports a high diversity of species composed of six marsupials, one cingulate, two primates, 18 rodents, two carnivores, and two artiodactyls, which supports the recognition of the area as protected for the government (MINAM 2009) and highlights the biogeographic, ecological, systematic, and conservation value of the mammals of the central Yungas of Perú.

Our report provides several new records of the presence and range extension of rodents such as *Neacomys macedoruizi, Oligoryzomys microtis*, and *Euryoryzomys nitidus*, which were previously reported only in the lowland forests of the departments of Loreto and Pasco (Patton *et al.* 2000; Pacheco *et al.* 2009; Patton *et al.* 2015). The record of the marsupial *Marmosa* (*Micoureus*) *constantiae*, previously known for Perú as *M.* (*Micoureus*) *demerarae* (Silva *et al.* 2019), is also the first for the region of Junín (Pacheco *et al.* 2020). In addition, the species *Neacomys* sp. "Junín" and *Oecomys* sp. "Junín" are likely new species for science. These new records indicate that the diversity of the Yungas is still poorly known.

The SNPH and natural areas with habitats of Yungas have an ecological interest, because they promote faunal connectivity between remaining pristine forests, which are also influenced by changes in land use due to agricultural and livestock activities (SERFOR 2015; MINAM 2016). La Torre-Cuadros *et al.* (2007), in their study of tree flora in SNPH, mention that the preserved forests can function as

biological corridors due to the great diversity and tree density. Likewise, studies of tree flora in the Yanachaga Chemillén National Park "PNYCH" and further south in the Manu National Park "PMN" (MINAM 2012); Farfan-Rios *et al.* 2015), report a great diversity, biomass, and tree volume, being indicators of a good condition of the forests in Yungas. Considering our records in common with close forests such as Chanchamayo Forests, 12 km away from SNPH (Guevara-Torres *et al.* 2021), the PNYCh, 78 km away (Vivar 2006), and Yungas of Huánuco, 140 km away (Aquino *et al.* 2022), the species recorded in these Yungas require large extensions of forests both in upper strata (*e. g.*, *Lagothrix lagothricha tschudii*, *Aotus* spp.) and in lower strata (i.e. *Dasypus novemcinctus*, *Dinomys branickii*, *Cuniculus paca*, *Eira barbara*, *Nasua nasua*, *Dicotyles tajacu*). These records support the statement of La Torre-Cuadros *et al.* (2007), that connectivity between forests promotes gene flow in mammalian populations. In addition, the SNPH, being a natural protected area, allows the maintenance of suitable ecosystems for various species of arboreal habitats. Hence, our study reveals how meaningful is the close relationship between mammal diversity and the good condition of the Yungas.

Besides the importance of connectivity between forests, it is crucial to know each species' ecological role in the ecosystem to propose feasible conservation plans. For example, the species of the genus *Lagothrix* have a frugivorous diet which makes them responsible for maintaining the balance and complexity of the tropical forest (Luna 2013; López 2020). Large rodents such as *Dasyprocta* and *Cuniculus* also show frugivorous diets mainly of arboreal species (Dubost and Henry 2006; McWilliams 2009; Martínez 2017). Small rodents of the genera *Akodon* and *Oligoryzomys* may also include some fruits and seeds in their diets, and together with species of the tribu Thomasomyini, they may disperse viable seeds that can potentially regenerate forests (Cervantes 2014; Sahley *et al.* 2015). Although this study does not include a diet analysis, it is likely that *Akodon* cf. *A. aerosus*, two species of *Oligoryzomys*, and two species of *Rhipidomys* (tribu Thomasomyini), reported here in SNPH, could also be fruit consumers and seed dispersers. Since a frugivorous diet appears to be prevalent, the 17 species of small mammals recorded in SNPH likely have different food habits, including fruits, to avoid competition (Cervantes 2014). For this reason, future studies on the diet

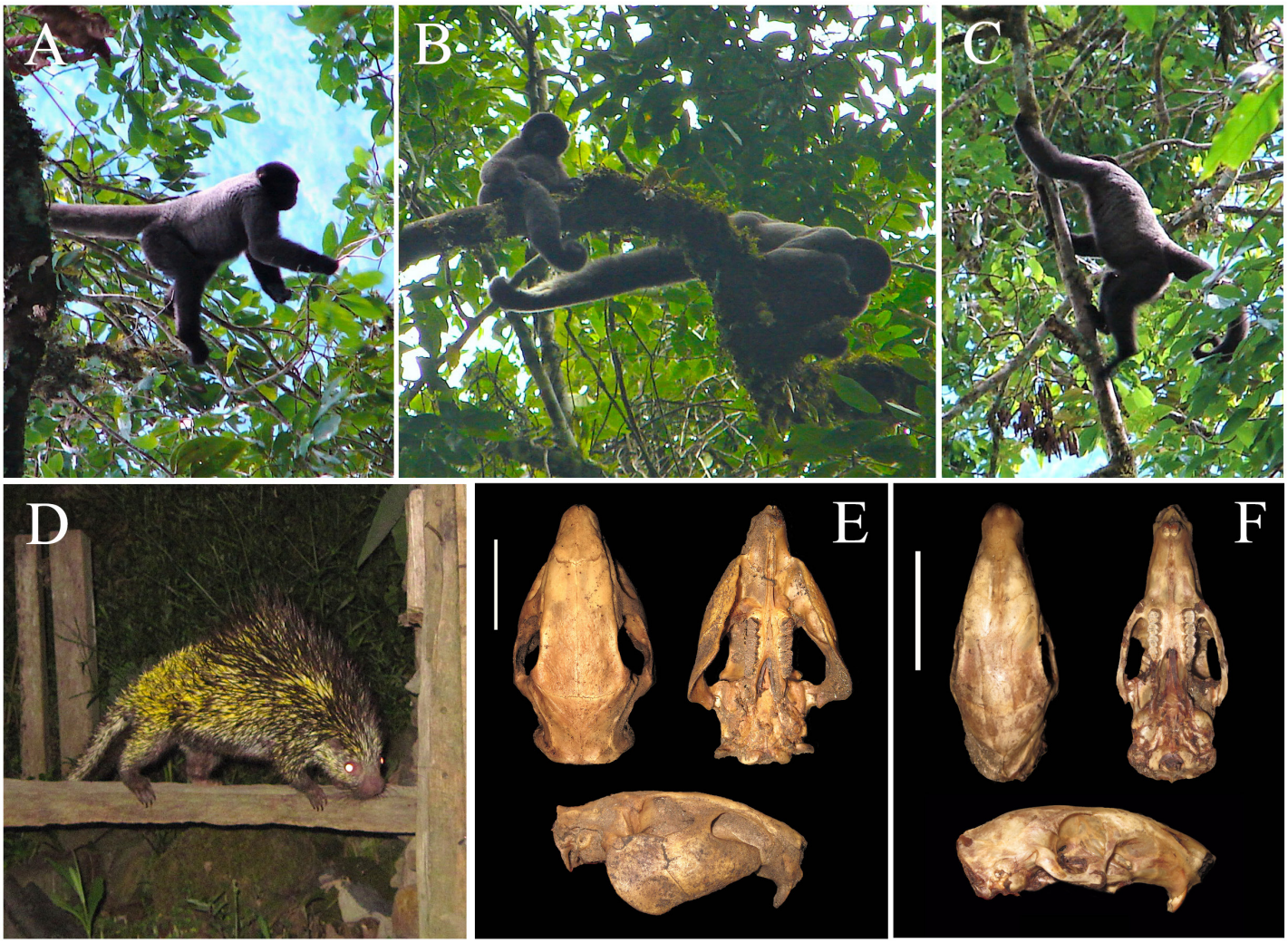

Figure 6. Medium and large-sized mammals recorded in the Yungas of Pampa Hermosa National Sanctuary. (A, B, C) *Lagothrix lagothricha tschudii*; (D) *Coendu bicolor*; (E) dorsal, ventral, and lateral views of skulls of *Cuniculus paca*; and (F) *Dasyprocta* cf. *D. kalinowskii*. Skulls belonging to the local people.

of these mammals are recommended to know the ecological roles they play and the functional group they take part (Córdova-Tapia and Zambrano 2015).

Abundance. The abundance range curve allowed us to differentiate the dominance or rarity of one single species or a group of species (Feinsinger 2001). Thus, a set of abundant species was observed, including *Hylaeamys yunganus*, *Akodon* cf. *A. aerosus*, and *Neacomys* spp. in an elevational range <1,370 to 1,900 m> in SNPH. This same species complex is also noticed in Yungas of Valley of Pozuzo (Pasco) at 1,200 m with high relative abundance (Mena and Medellín 2010). Other studies in Yungas show variable relative abundances of similar species, such as *Hylaeamys perenensis*, *Akodon aerosus*, and *Neacomys spinosus* in the Apurimac River basin at 805 m and in Cusco at 1,050 m (Pacheco *et al.* 2007). Likewise, in the middle basin of the Tambopata River, between 1,200 and 1,985 m in Puno, the set of species *H. perenensis*, *Akodon baliolus*, and *Neacomys spinosus* was also reported (Pacheco *et al.* 2011). All these results suggest a species pattern, including genera *Hylaeamys*, *Akodon*, and *Neacomys* in Yungas below 2,000 m. Among these three genera, *Akodon* had the highest frequency in most sampled localities in Yungas, mainly recorded at ground level (Pacheco *et al.* 2007; Mena and Medellín 2010; Pacheco *et al.* 2011; Pacheco and Noblecilla 2019). Furthermore, it should be noted that *H. yunganus* lives in sympatry with *H. perenensis* (Percequillo 2015), and both have been recorded at ground level (Voss *et al.* 2001).

Regarding the species with the lowest abundances, such as *Marmosops* (*Marmosops*) *noctivagus*, *Nephelomys keaysi* y *Oecomys* sp. "Junín", similar records were observed between 950 and 1,600 m in the middle basin of the Tambopata River in Puno (Pacheco *et al.* 2011) and at 1,200 m in the Pozuzo valley in Pasco (Mena and Medellín 2010). It is prevailing for *M.* (*Marmosops*) *noctivagus* to be recorded at ground level (Patton *et al.* 2000; Voss *et al.* 2001; Hice and Velazco 2012) and its habits are associated with primary, secondary, and disturbed forests (Tirira 2007). Similarly, *Nephelomys keaysi* exhibits these same habits and tolerates disturbed areas such as cattle pastures (Mena and Medellín 2010). In contrast, *Oecomys* is rarely found in disturbed areas (Hice and Velazco 2012) and is primarily recorded in canopy traps (Carleton and Musser 2015). Therefore, for greater representativeness in future research, it is recommended to equate the effort in installing traps at ground level and in specific heights in the trees or bushes.

Alpha diversity. Alpha diversity indicates a reduction in ${}^{q}D_{\alpha}$ as "q" increases for each locality, revealing a high degree of dominance (Jost 2006). This ${}^{q}D_{\alpha}$ reduction agrees with the range-abundance curves' results, especially for Los Cedros and Nueva Italia, which have steep slopes. Jost (2007) recommends using ${}^{1}D_{\alpha}$ when abundances are somewhat relevant and in compliance with the fifth property of alpha diversity ($D_{\alpha} < D_{\gamma}$). It would be affirmed that Nueva Italia is the least diverse locality with 4.90 ${}^{1}sp_{E}$ compared to Podocarpus and Los Cedros with 6.34 ${}^{1}sp_{E}$ and 5.34 ${}^{1}sp_{E}$, respectively. This difference may be because more than 80 % of the small mammal individuals in Nueva Italia belong to the three most abundant species (*Hylaeamys yunganus*, *Akodon* cf. *A. aerosus*, and *Neacomys* spp.). Another factor that affects diversity is the type of habitat and the geographical location within the SNPH. The montane forests of Los Cedros and Podocarpus located in higher elevations (1,600 to 1,900 m) and far from anthropic influence, are related to a greater species diversity. On the other hand, the proximity of human activities and the presence of local people in the lower areas of Nueva Italia (1,370 m) confirm that the first effects of tropical defaunation are the reduction of the richness and local diversity of wild vertebrate communities (Mendoza and Camargo-Sanabria 2019).

Beta diversity. The similitude method of Jaccard to compare diversity in Yungas between 1,000 to 2,000 m shows a low similarity between communities. Despite these low values, the cluster analysis indicates that the SNPH is more similar to three Natural Protected Areas. Regarding species richness, SNPH was slightly similar to the Manu National Park (PNM) sharing 16 species, contrasting with communities out of natural protected areas that form an aggrupation (see Figure 4). Since the National Parks and Sanctuaries are intangible protected areas with high diversity, the pairwise comparisons were closer between SNPH with PNM and PNTM. This moderate beta diversity has also been noted when contrasting other studies of non-volant mammals in Yungas, but above 3,000 m (Pacheco *et al.* 2013). Although nearby communities were dissimilar in this research, the greatest similarity was observed when comparing it with the PNM (Pacheco *et al.* 2013). Moreover, in the study of the diversity of bats in the same SNPH, a high beta diversity is also observed (Arias *et al.* 2016). The great richness of species in these Yungas, many even endemic (Young and Valencia 1992; Pacheco 2002), only confirms these habitats' tremendous relevance in biodiversity conservation.

One of the most noticeable records was Tschudi's Woolly Monkey, *Lagothrix lagothricha tschudii* due to recent studies that differentiate its distribution from *L. lagothricha cana* (Ruiz-García *et al.* 2019). Fooden (1963), in the first and the most comprehensive taxonomic revision of the genus *Lagothrix*, recognized three subspecies of *L. lagothricha*, with only *L. l. cana* inhabiting in Perú. Grooves (2001) and Pacheco *et al.* (2009) considered *L. cana* a full species. Nonetheless, molecular studies suggest that *L. lagothricha* would be composed of five different subspecies, with *L. lagothricha cana* and *L. lagothricha tschudii* distributed in center and southern Perú respectively (Aquino *et al.* 2019; Ruiz-García *et al.* 2019). Recent studies have recorded *L. l. tschudii* to the north of SNPH, in the montane forests of Ucayali, Pasco, and Huánuco (Aquino *et al.* 2019, 2022), and to the south in the cloud forests and low jungles of the Manu National Park (Solari *et al.* 2006). Regarding large rodents, the agouti *Dasyprocta kalinowskii* is a poorly known endemic species

of Yungas (Teta and Reyes-Amaya 2021). This species is distributed between 1,000 and 2,000 m (Patton *et al.* 2015) and is nearly sympatric with *D. variegata* which inhabits mainly lowland rainforest, but also reaches upper forest up to 1,800 m (Tschudi 1845; Teta and Reyes-Amaya 2021). Although our record of a skull in Nueva Italia suggests that could be *D. kalinowskii*, the cranial morphology of the few specimens in scientific collections is quite variable. Teta and Reyes-Amaya (2021) assert that individuals of *D. kalinowskii* stored at the AMNH (the American Museum of Natural History) present mostly indistinguishable characters from *D. variegata*. Hence, an adequate characterization of *D. kalinowskii* is needed to differentiate it from the other sympatric species such as *D. variegata* and even *D. fuliginosa* (Teta and Reyes-Amaya 2021).

Conservation status. Yungas is one of the most fragile ecosystems where a great diversity of ecotones and forest patches can be found (Pacheco 2002), and where fragmentation due to deforestation by agriculture and grazing is one of the major threats (Tovar *et al.* 2010, Tejedor *et al.* 2012). Yungas of SNPH is not exempt from this issue because the forests could suffer this threat mainly in their buffer zone, close to human settlements. This issue was observed in Nueva Italia and Santa Isabel, areas surrounding the sanctuary that are currently being affected by crops, mainly coffee. Although this crop is one of the primary sources of income for the inhabitants, it is also among the five most important in causing the highest rates of deforestation in Perú (SERFOR 2015). This issue directly affects the conservation status of many species, as revealed by the current decreasing trends of the population of medium and large-sized mammals recorded in this study (IUCN 2023). For this reason, local and regional governments must initiate sustainable management that includes the conservation of Yungas forests and the species of mammals and other vertebrates they keep in these central jungle regions. In addition, the knowledge and diffusion of the key species for conservation play a relevant role in the care, protection, and conservation of the species in the SNPH.

Although we managed to record the non-volant mammals in this Yungas poorly known, the number of mammalian species of SNPH is likely to be much larger than that recorded in this study, and further assessments will be needed to better understand the real diversity. In addition, a more exhaustive statistical analysis will be necessary to know if there may be changes in diversity on a temporal and spatial scale.

Finally, we urge future researchers and all decision stakeholders of the SNPH itself to encourage more research in this area. Future studies on mammals living in SNPH should focus on 1) functional diversity, 2) the ecological role of each species, 3) the current conservation status of the species, and 4) the population trends and habitat requirements of each species. These are key questions to produce conservation plans for the species and the area.

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Supplementary material 1

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