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Peruvian Mammals Collected by the Andrews University. Department of Biology : Expeditions & Patterns of Diversity

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ABSTRACT

PERUVIAN MAMMALS COLLECTED BY THE ANDREWS UNIVERSITY DEPARTMENT OF BIOLOGY: EXPEDITIONS & PATTERNS OF DIVERSITY

by

Kieran M. Taylor

Chair: Daniel Gonzalez-Socoloske, Ph.D.

ABSTRACT OF GRADUATE STUDENT RESEARCH

Thesis

Andrews University

College of Arts and Sciences

Title: PERUVIAN MAMMALS COLLECTED BY THE ANDREWS UNIVERSITY DEPARTMENT OF BIOLOGY: EXPEDITIONS & PATTERNS OF DIVERSITY

Name of researcher: Kieran M. Taylor

Name and degree of faculty chair: Daniel Gonzalez-Socoloske, Ph.D.

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The Department of Biology at Andrews University conducted three expeditions to Peru in 1964, 1965, and 1968. During the expeditions, thousands of specimens were collected of several taxa, including mammals. As far as we know, no complete summary of the expeditions and the mammals collected has been created. Knowledge of the expeditions and evaluation of the mammals collected compared to current literature could have conservation implications. My purpose was to recreate the story of the expeditions and use this contextual information to catalog and identify the number of mammal species collected and evaluate the mammal diversity collected according to current literature. This was done by analyzing available specimen lists, field notes, and interviews conducted with surviving participants to create a comprehensive database of

all the mammals collected during the expeditions. I determined that nearly 2,900 mammals were collected during the expeditions representing 130 species within 7 orders, 23 families, and 86 genera. Specimens were collected within the ecoregions Puna, Yungas, and Selva Baja. Several species were either not reported in Peru at present or had some of their specimens collected in an unexpected ecoregion according to current literature. Further work is required to improve the accuracy and completeness of the reconstruction of the expeditions and improve the analysis of the mammals collected by completing the mammal identifications and increasing the accuracy of location data. This thesis describes the mammal diversity collected during the expeditions, yet thousands of birds, reptiles, amphibians, and insects were additionally collected. Future research could aim to summarize the specimens collected of these additional taxonomic groups.

Andrews University

College of Arts and Sciences

PERUVIAN MAMMALS COLLECTED BY THE ANDREWS UNIVERSITY DEPARTMENT OF BIOLOGY: EXPEDITIONS & PATTERNS OF DIVERSITY

A Thesis

Presented in Partial Fulfillment

of the Requirements for the Degree

Master of Science

by

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APPROVAL BY THE COMMITTEE:

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Daniel Gonzalez-Socoloske, Ph.D., Chair

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H. Thomas Goodwin, Ph.D.

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James L. Hayward, Ph.D. Date approved

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LIST OF ABBREVIATIONS

AMNH	American Museum of Natural History
AUMNH	Andrews University Museum of Natural History
ESRI	Environmental Systems Research Institute
FMNH	Field Museum of Natural History
KU	University of Kansas
MCZ	Museum of Comparative Zoology
QGIS	Quantum Geographic Information System
SDA	Seventh-day Adventist
TA	Tropical Andes
UMMZ	University of Michigan Museum of Zoology
USNM	United States National Museum

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Thank you to everyone who provided insightful revisions of my thesis drafts. Thank you to my thesis committee members, Dr. Gonzalez-Socoloske, Dr. Goodwin, and Dr. James L. Hayward, for pushing me to strive for excellence in my writing. Special thanks go to Roshelle and Kenley Hall. You not only have provided feedback on my writing, but you have also always been willing to lend a kind and supportive ear. I would not have completed my master's thesis without your mental, emotional, and spiritual support. Thank you to my fellow graduate student, Dana Husana, for help editing my maps and formatting my thesis. You are a true friend! I have no doubt that you will finish your degree just as I did.

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CHAPTER 1

INTRODUCTION

Global biodiversity and endemism are not equally distributed across our globe but are centered around regions that due to temperature, precipitation, elevation, and other factors are especially conducive to speciation (Gaston, 2000; Hillebrand, 2004). Many such regions are coastal, near the equator, and/or at high elevation, and harbor substantially more plant and animal species than expected in relation to their size (Ceballos & Ehrlich, 2006; Schipper et al., 2008). Currently, 25 such biodiversity "hotspots" have been described, which combined represent 1.4% of global land surface area yet comprise 44% of all known species of vascular plants and 35% of all species of birds, mammals, reptiles, and amphibians (Myers et al., 2000).

The Tropical Andes (TA) is a biodiversity hotspot stretching along the entire extent of the Andes mountain range along the western margins of northern South America in Venezuela, Columbia, Ecuador, Peru, Bolivia, Chile, and Argentina (Bax & Francesconi, 2019) (Figure 1A). The TA ranks number one in endemism with 6.7% and 5.7% of global endemic plant and vertebrate species, respectively (Myers et al., 2000). This biodiversity and endemism are due to the steep elevation gradients caused by the Andes and the rain shadow effect whereby trade winds carry humid air from the Amazon basin and condensate into precipitation on the eastern slopes of the Andes (Sher & Molles, 2022).

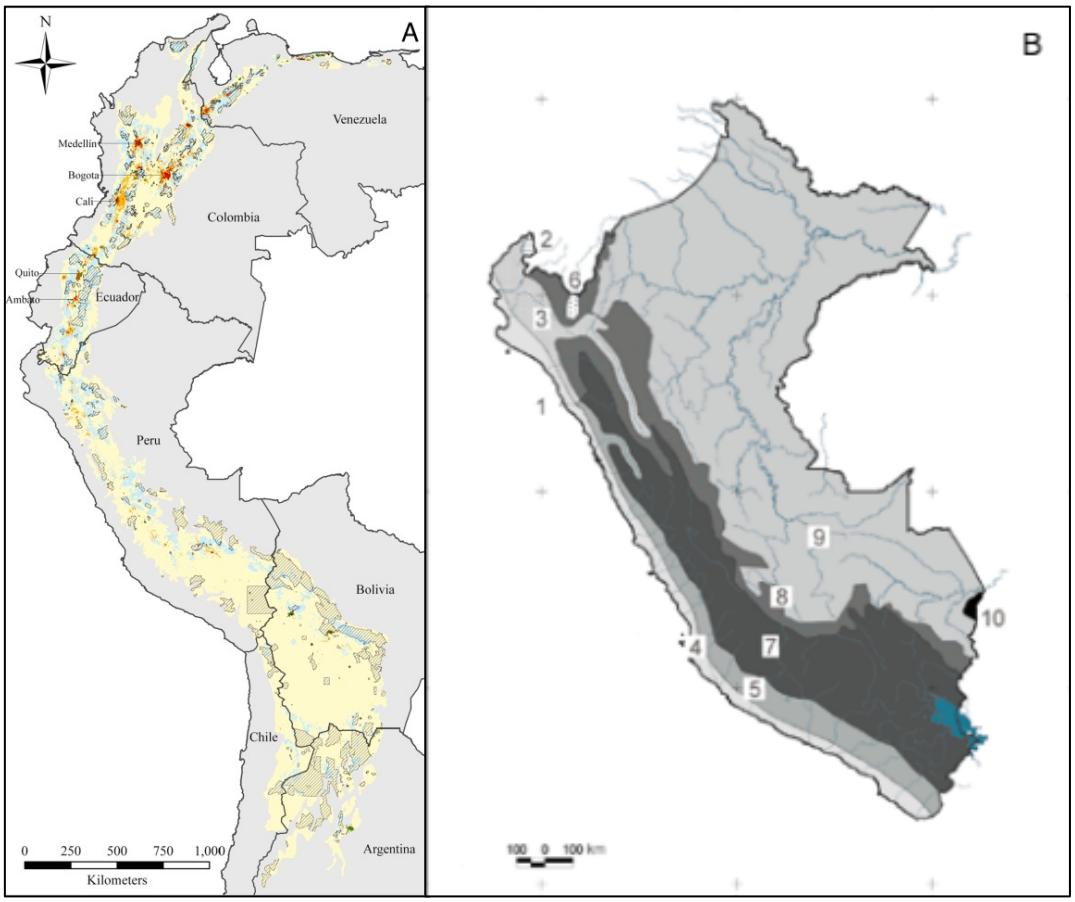

Figure 1. Ecological Regions of South America and Peru. **A**. Extent of the Tropical Andes (TA) in South America. Modified from Bax and Francesconi (2019). **B**. Ecoregions of Peru as described by Brack-Egg (1986). 1 = Oceánica, 2 = Bosque Pluvial del Pacífico, 3 = Bosque Seco Ecuatorial, 4 = Desierto Costero, 5 = Serranía Esteparia, 6 = Páramo, 7 = Puno, 8 = Yungas, 9 = Selva Baja, 10 = Sabana de Palmera. Modified from Pacheco et al. (2009).

Biodiversity of Peru

The central range of the TA is located in Peru, which primarily owes its biodiversity to the Andes which creates large expanses of tropical biomes on the eastern slopes (Rodríguez & Young, 2000) (Figure 1B). Peru is designated as a megadiverse country, defined as a country that contains a large proportion of known global flora and fauna diversity (McNeely et al., 1990). The main criteria for designation as a megadiverse country is that the country must harbor at least 5,000 endemic species and contain endemism at the level of family and genus (McNeely et al., 1990). One study

found that a single ecoregion on the eastern slopes of the Andes, Yungas (montane pluvial forest), comprised 1.7% of the given study area yet housed 36% of Peru's total plant and animal endemic species (Swenson et al., 2012).

Mammals are especially diverse in Peru. Pacheco et al. (2021) documented 573 mammal species in the country making it the second most diverse country for mammals in the Americas and third in the world. In contrast, Kays and Wilson (2009) document 462 mammal species in the United States and Canada combined, constituting 20% less mammal species diversity than Peru. Approximately 6,600 mammal species have been documented worldwide (*Mammal Diversity Database*, 2022), so Peru houses almost 10% of the world's mammalian diversity. Of these 573 species, documented by ecoregion and conservation status, members of the mammalian orders Chiroptera (bats) and Rodentia (rodents) dominate, with approximately two-thirds of the documented mammalian species belonging to these two groups. Furthermore, the ecoregions of Yungas and Selva Baja are the most diverse of all ecoregions within Peru, housing 256 and 320 mammal species (non-mutually exclusive), respectively (Pacheco et al., 2021).

Conservation Issues & Potential Solutions

Contrary to what might be expected of ecoregions with such species richness, large parts of Yungas and Selva Baja in the TA of Peru have yet to be surveyed extensively and/or are inadequately protected (Bax & Francesconi, 2019; Rodríguez & Young, 2000; Swenson et al., 2012; Young & León, 2000). In addition, surveyed areas in these ecoregions exhibit high relative irreplaceability and/or vulnerability (Swenson et al., 2012), terms that define areas of critical importance for multiple species' survival

(irreplaceability) and areas especially vulnerable to man-made and/or natural change (vulnerability).

Creating taxonomic lists of the biodiversity present within restricted areas in the TA is one strategy that can help resolve these issues (Pacheco et al., 2021). Collection expeditions can provide valuable taxonomic lists on multiple taxa within restricted study areas. The Andrews University Department of Biology made three expeditions to Peru in the 1960s. Careful description of these expeditions, along with the identification and cataloging of the mammals collected during the expeditions, could provide information important for the protection of the mammals of Peru.

Introduction to Research

The objectives of this study were to: (1) investigate and document the Andrews University Department of Biology expeditions to Peru in the 1960s, (2) catalog and identify the mammals collected during the expeditions, and (3) evaluate the diversity of mammals collected compared to current literature (Pacheco et al., 2021).

In Chapter 2, I provide an overview of the expeditions by investigating who, when, why, and where they went, what they did during the expeditions, and how the expeditions were organized. I provide a timeline of each expedition and a map of localities visited. This chapter offers contextual information necessary to understand Chapter 3.

In Chapter 3, I catalog and identify the mammal species collected within each ecoregion visited during the expeditions, the number of specimens collected, and where they are currently housed. I evaluate the mammal diversity collected and relate it to our current understanding of the mammal diversity within the visited ecoregions according to

the current literature (Pacheco et al., 2021). In addition, I comment on species not presently reported in Peru and species collected outside their expected ecoregions.

In my final chapter (Chapter 4), I summarize the previous two chapters and present recommendations for future research regarding both the reconstruction of the expeditions and the mammals collected.

CHAPTER 2

EXPEDITIONS TO PERU

Introduction

Members of the Department of Biology at Andrews University conducted three expeditions to Peru in 1964, 1965, and 1968. However, the understanding of the expeditions within the department is largely anecdotal since no complete summary of the expeditions was completed and no one that participated in those expeditions has been active in the department for more than half a century.

A summary of these three expeditions will be a valuable contribution to the scientific literature on small-scale biological and educational expeditions within South America (particularly Peru) during the 1960s. In addition, these expeditions have value to our department's history.

To that end, my research objectives are to investigate and document for each of the expeditions (1) the purpose and funding, (2) who participated, (3) the timeline of when and where the participants went, and (4) what activities they conducted.

Methodology

To accomplish all objectives, I first located all available documents related to the expeditions. This included an extensive search of the Department of Biology at Andrews University and contacting the staff at various museums where some of the collected

mammals are currently located, as determined by searches on VertNet.org (Chapter 3). This resulted in a trip to the American Museum of Natural History (AMNH) in May 2022, where I was able to obtain several specimen lists and field notes[1] from the 1964 expedition, and scans of a specimen list and field notes belonging to one individual from the 1964 expedition sent from the University of Kansas (KU). Specimen lists and field notes that I located were evaluated according to established guidelines (Appendix B).

I analyzed the specimen lists, field notes, and other associated expedition related documents[2] to reconstruct the expeditions and supplemented knowledge of the expeditions by reviewing interviews conducted by Dr. Gonzalez-Socoloske with surviving expedition participants. Determination of which participants were deceased, and the contact information of surviving participants was done through the Office of Alumni Services at Andrews University. I created a timeline for each expedition using Microsoft PowerPoint to summarize elements of the expeditions and a map of the localities visited during each expedition using Quantum Geographic Information System (QGIS) 3.26 and shapefiles from the Environmental Systems Research Institute (ESRI). All retrieved original expedition documents can be accessed through the Department of Biology at Andrews University.

[1] Specimen lists were kept by each expedition participant and document their collected specimens. Field notes likewise were kept by each participant and provide scientific and personal observations organized in daily entries. An example of a specimen list and field notes page can be found in Appendix A, exhibit 1 and 2, respectively.
[2] Select documents relevant to the expeditions can be found in Appendix A, exhibits 1–5.

Results

Origination of the Expeditions

During the summer of 1963, Merlin D. Tuttle, undergraduate student in the Department of Biology at Andrews University, completed a solo trip to Peru. With logistical support from his personal mentor Ernest S. Booth, professor at Loma Linda University, he visited several localities in central Peru. The purpose of his trip was to collect mammals for Booth, some of which are currently located at the AMNH (amongst other institutions), as determined through VertNet.org.

Following Tuttle's return to Andrews University for the 1963-1964 academic school year, Asa C. Thoresen, chairman of the Department of Biology at Andrews University at that time, heard about Tuttle's travels to Peru during the summer and was inspired to organize an expedition to Peru during the summer of 1964. Tuttle greatly assisted in planning this expedition, helped determine which localities to visit, and connected Thoresen with local Peruvian contacts established during his 1963 experiences in Peru. Donald R. Seidel, professor in the Department of Biology at Andrews University, accompanied Thoresen during the 1964 expedition in addition to being instrumental in the detailed logistical planning. Following the success of the 1964 expedition, two additional expeditions occurred in 1965 and 1968.

1964 Expedition

Purpose and Funding

The purpose of the 1964 expedition was threefold: (1) collect birds and mammals (especially rodents and bats), (2) collect blood samples and testes material from birds and ectoparasites from mammals, and (3) take print-quality photographs. The various

elements of the 1964 expedition purpose were informed by the funding. Robert Traub, a former colonel in the United States Army who had an interest in parasites, provided funding in exchange for the collection of mammal ectoparasites, and the National Geographic Society provided funding in exchange for photographs taken during the expedition. The remainder of the funding was provided by the Department of Biology at Andrews University.

Participants

The 1964 expedition consisted of two faculty members and 10 students (Table 1). In addition, Carlos R. Perez, an indigenous person, accompanied the participants during some of the expedition. Thoresen was one of the faculty members and served as the primary expedition leader. He was responsible for collecting birds and associated blood/testes samples in addition to taking the print-quality photographs for the National Geographic Society. Seidel was the second faculty member and served as the associate expedition leader. In addition, Tuttle served as an assistant expedition leader. Seidel and Tuttle oversaw collecting small mammals and associated ectoparasites, and Tuttle oversaw collecting bats.

All 10 students were undergraduates majoring or minoring in biology and participation in the expedition provided academic credits counted towards their degrees (Table 1). The nine remaining students (besides Tuttle), in addition to Perez, assisted Thoresen, Seidel, and Tuttle with their collection goals. I was able to retrieve specimen lists and field notes for each participant except Perez, whose field notes were not found. All specimen lists were complete except the specimen list belonging to Perez and John C. Kelley, where a few pages were retrieved and a single page was missing, respectively.

Table 1

1964 Expedition Participants

Group	Participant	Specimen Lists			Field Notes				Interviewed
		Present	Complete[a]	Number of Missing Pages	Present	First/Last Entry	Continuous	Number of Missing Entries	
1[b]	Buck, E. L.	Y[c]	Y		Y	May 28/July 31	Y		N
	Kelley, J. C.	Y	N	1	Y	June 1/July 29	Y		N
	Knowlton, D. L.	Y	Y		Y	June 1/August 3	Y		N
	Perez, C. R. †	Y	N/A		N	N/A	N/A		N
	Stringer, K. R.	Y	Y		Y	June 1/July 23	Y		N
	Tuttle, A. L.	Y	Y		Y	May 28/July 27[d] August 10/September 3	Y		N
	Tuttle, M. D.*	Y	Y		Y	June 6/July 25	Y		Y
2	Castanon, G.	Y	Y		Y	June 1/August 1	N	3	N
	Coon, N. E.	Y	Y		Y	June 3/August 1	N	3	N
	Myers, F. J.	Y	Y		Y	June 1/August 2	Y		N
	Seidel, D. R.*	Y	Y		Y	June 1/August 8	Y		N
	Seifert, T. B.	Y	Y		Y	June 3/August 2	Y		N
N/A[e]	Thoresen, A. C.*	Y	Y		Y	June 3/August 10	N	4	N

[a] This column indicates if the located specimen list is complete regarding the mammals collected. See Appendix B for specimen list and field notes evaluation guidelines.

[b] Perez accompanied group 1 for some of the expedition.

[c] Y = Yes, N = No, and N/A = Not Applicable.

[d] First set of field notes was received from the AMNH and the second from KU.

[e] Thoresen accompanied both groups at separate times.

* Expedition leader.

† Indigenous person.

Timeline

All 12 participants traveled independently to Miami, Florida, where they together boarded a flight to Lima, Peru, and arrived on June 3, 1964 (Figures 2 & 3). Following arrival, they spent the first few days in Lima purchasing supplies including food, cookware, mammal traps, materials for the preparation of mammal specimens (cotton, Borax, formaldehyde, etc.), and weapons/ammunition, and arranging for transport over the Andes. While in Lima, they received lodging, food, and transportation from staff of a local Seventh-day Adventist (SDA) church union office.

On June 5, they loaded a camper van, which they had rented, with their supplies and began the drive from Lima toward San Ramon (elev. 820 m), approximately 300 km from Lima. San Ramon served as their entry and exit point to the jungle (Figures 2 & 3). Thoresen drove the camper but there was not sufficient space in the camper for the supplies and all the participants, so while travelling from Lima to San Ramon over the Andes between various camps, the group mainly traveled in two different ways: (1) half of the students rode in the camper with Thoresen and half hitch-hiked on trucks or (2) half of the group drove with Thoresen while the rest of the group stayed behind and waited to be picked up later. During this nearly two-week phase of the expedition (June 5-17) (Figure 3), participants collected rodents and birds and explored the high-elevation habitats on the western slopes of the Andes at Camp 1, 2, & 3 (elev. 3,810 m, 4,755 m, and 3,962 m, respectively) (Figure 2).

Once they had crossed the Andes and were near San Ramon, the participants split into two groups (Table 1), and they remained in these groups for the rest of the expedition (Figures 2 & 3). The groups spent almost two weeks (June 17-30) collecting

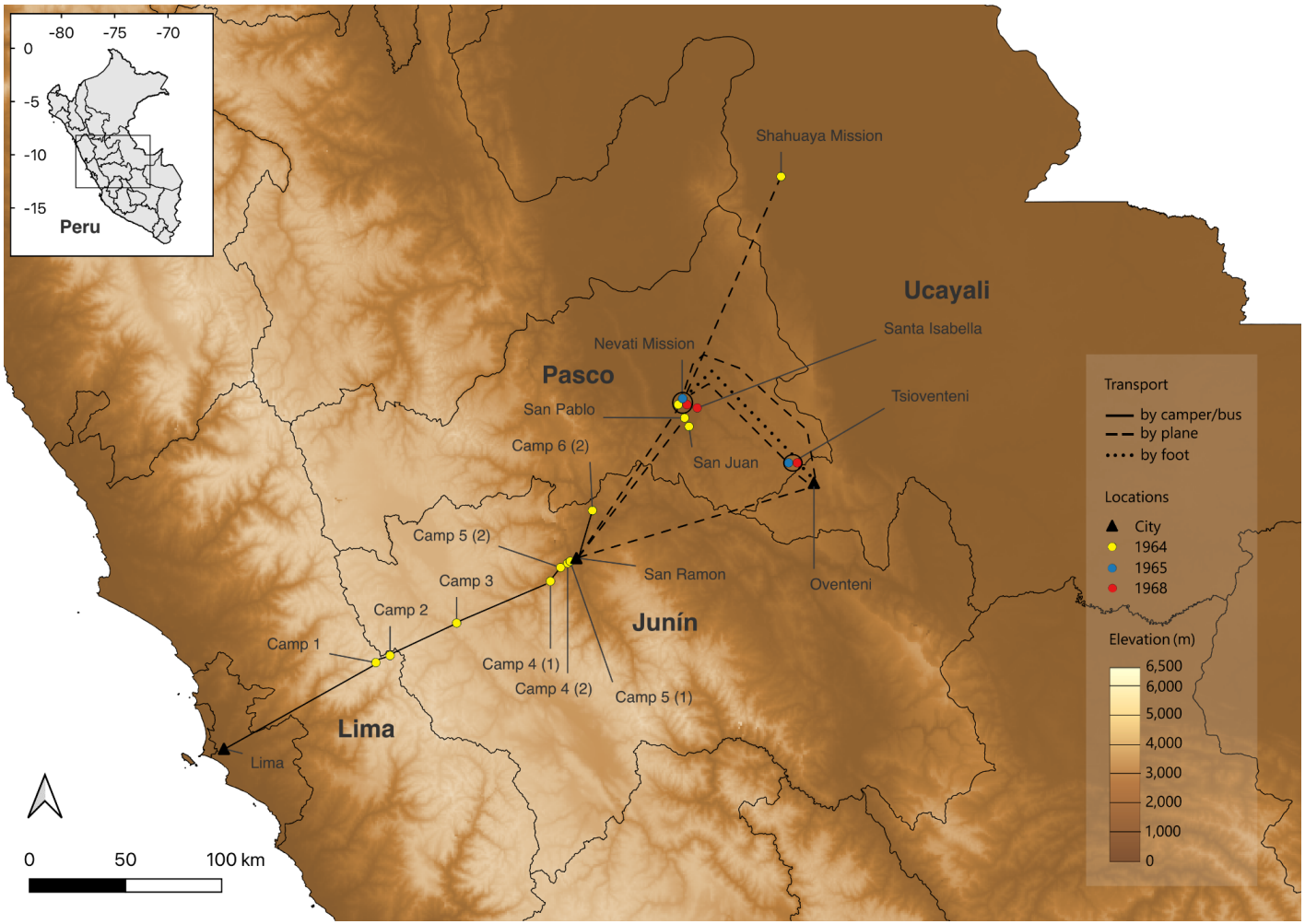

Figure 2. Map of localities visited during the expeditions. Departments of Peru are outlined and labelled as appropriate. Lines between localities do not show exact routes taken but modes of transportation. Travel by river is not depicted due to the large map scale. Two localities were visited multiple times across the expeditions (Nevati Mission and Tsioventeni) and three localities were traveled between by two modes of transportation at various stages during the expeditions (Nevati Mission, Oventeni, and Tsioventeni).

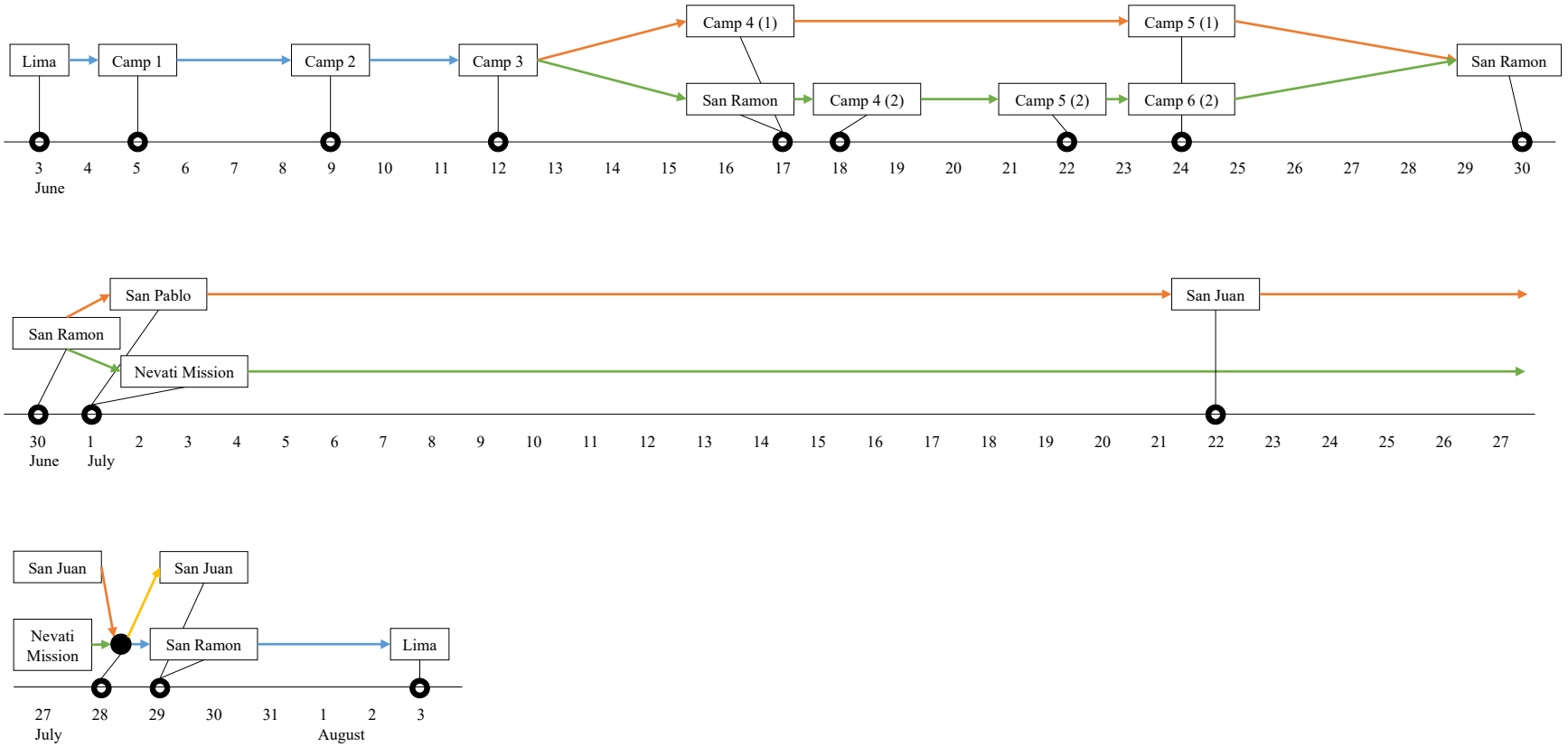

Figure 3. 1964 expedition timeline. Dates for anchored locations on the axis denote arrival. Blue arrows represent all participants (except Perez, A. Tuttle, and M. Tuttle for some of the expedition, see text). Orange and green arrows represent group 1 & 2 participants, respectively (Table 1). The yellow arrow represents the Tuttle brothers (A. & M. Tuttle). Thoresen spent time with both groups throughout the expedition. Perez joined group 1 in San Pablo (elev. 274 m) and continued with them until they left San Juan (elev. 274 m) for Nevati Mission (elev. 274 m). When A. & M. Tuttle returned from Nevati Mission to San Juan, Perez rejoined for the remainder of their stay.

mammals and birds and exploring the habitats of the immediate eastern slopes of the Andes near San Ramon. Thoresen spent time with each group and facilitated transport for the groups using the camper van, except from June 24-30 when the camper van was out of commission due to mechanical issues. Group 1 visited two locations (Camp 4 (1) and Camp 5 (1) at elev. 2,225 m and 884 m, respectively) and group 2 visited three locations (Camp 4 (2), Camp 5 (2), and Camp 6 (2) at elev. 845 m, 845 m, and 724 m, respectively) in addition to an initial overnight in San Ramon from June 17-18.

All 12 participants reconvened in San Ramon on June 30 and spent the night at the small airport in town in one of the airplane hangars (Figures 2 & 3). The next morning, on July 1, Clyde Peters, an SDA mission pilot based in the area, used a small mission plane to fly group 1 90 km to San Pablo (elev. 274 m), an indigenous settlement, and group 2 100 km to Nevati Mission (elev. 274 m) (Figure 2), an SDA mission outpost. Group 1 stayed in San Pablo for three weeks collecting hundreds of mammals, after which they used a dugout canoe, provided by members of the local indigenous settlement, to travel 5 km to San Juan (elev. 274 m), another indigenous settlement, on July 22. They stayed there for about a week until they returned to Nevati Mission (15 km) by mission plane on July 28, in preparation to leave the jungle for San Ramon on July 29. M. Tuttle met Perez in San Pablo and convinced him to remain with group 1 to help guide them around and collect mammals until they left San Juan for Nevati Mission. Group 2 stayed mostly at Nevati Mission for the duration of the stay except for several short trips. One of these occurred from July 9-14 when Thoresen, Castanon, and Thomas B. Seifert flew to another mission outpost called Shahuaya Mission (elev. 177 m), located approximately 115 km NNE of Nevati Mission (Figure 2). In general, Thoresen spent

most of his time with group 2 in Nevati Mission and only managed to spend a few days with group 1 in San Juan towards the end of their stay there.

The participants usually camped on the outskirts of the settlements while at San Pablo, San Juan, and Nevati Mission. On occasion several of the participants were hosted by some of the indigenous people or SDA missionaries in their private residences. Food was provided for them by indigenous people and/or SDA missionaries.

When all 12 participants had been flown back to San Ramon on July 30, Thoresen went to pick up the camper van from the mechanic (Figures 2 & 3). The repairs dried up the expedition funds. Therefore, the participants decided to make their way back to Lima on their own. All but the Tuttle brothers arrived in Lima on August 3 and again were provided lodging, food, and transport by a local SDA church union office. They spent a few days arranging for transportation of specimens they collected back to the United States in addition to a few other errands. They flew back to Miami, Florida, on August 9, which concluded the 1964 expedition.

The Tuttle brothers did not return to San Ramon and ultimately the United States with the other participants on July 30 (Figures 2 & 3). After arriving in Nevati Mission by mission plane on July 28, they returned to San Juan the following day and continued collecting with Perez. M. Tuttle stayed in San Juan until August 10 and A. Tuttle stayed until August 30.

Activities Conducted

At each location during the expedition, the participants daily set out mammal traps and mist nets, checked them for captured mammals, prepared voucher skins, cleaned skulls, collected ectoparasites of captured mammals, rebaited traps, and

cataloged all collected mammals using their specimen lists. In addition, while in San Pablo, San Juan, and Nevati Mission, they frequently made day trips into the surrounding jungle to capture larger mammals, including primates, marsupials, sloths, and artiodactyls, either alone or in small groups. On these day trips, they would usually be guided by an indigenous person from the given locality they were staying at. They would bring their rifles and shoot animals of interest that the guide spotted and bring them back to camp to skin. In addition, once group 2 reached Nevati Mission, they gave their mammal traps to the local school children and paid the children to capture mammals for them to increase the number of mammals that were collected. Lastly, some large mammals such as primates and ocelots would be shot and brought in by indigenous people, purchased by the participants, and skinned.

1965 Expedition

Purpose and Funding

In contrast to the 1964 expedition, the purpose of the 1965 expedition was to serve as partial requirement for two college courses: Biogeography and Jungle Ethology. Due to the changed focus, fewer mammals were collected. Funding was provided by the National Geographic Society and the Department of Biology at Andrews University.

Participants

The 1965 expedition consisted of two faculty members and 10 students (Table 2). Both Thoresen and Seidel reprised their roles as expedition leaders. Nine of 10 students were undergraduates majoring or minoring in biology and the last student, Floyd M. Murdoch, was a biology graduate student. Specimen lists and field notes were retrieved

for nine of the 10 students and were not for both faculty members. All available specimen lists are complete. Don J. Grosse and Keith I. Messersmith are both missing a single entry in their field notes.

Timeline

All 12 expedition participants traveled independently to Miami, Florida, where they together boarded a flight to Lima, Peru, and arrived on June 8, 1965 (Figures 2 & 4). Following arrival, they spent a few days preparing for the field portion of the expedition and they received lodging, food, and transportation from members of a local SDA church union office, as during the 1964 expedition. The 1965 expedition participants did not plan on collecting or engaging in other major expedition activities while travelling over the Andes, so they took a commercial bus from Lima to San Ramon on June 10. San Ramon again served as their entry and exit point to the jungle.

Following arrival in San Ramon on June 10, they stayed the night in one of the airplane hangars at the same airport in town as during the 1964 expedition (Figures 2 & 4). The next morning, they were informed that Peters, the same pilot as during the 1964 expedition, would not make it that day so they chose to move, and they camped beside the road 5 km SW of San Ramon on June 11. They spent a few days there and on June 13 they were informed early in the morning that Peters would be flying them into the jungle that day, so they packed up camp and traveled back to the San Ramon airport. They were flown to Nevati Mission that same day, where they stayed the night, and then the following morning on June 14 they were flown 65 km to Tsioventeni (elev. 1,280 m) (Figure 2), an indigenous settlement. Here they spent the next week studying the local environment and having lectures and presentations.

Table 2

1965 Expedition Participants

Participant	Specimen Lists		Field Notes				Interviewed
	Present	Complete[a]	Present	First/Last Entry	Continuous	Number of Missing Entries	
Esham, W. T.	Y[b]	Y	Y	June 8/July 22	Y		N
Grosse, D. J.	Y	Y	Y	June 11/July 15	N	1	N
Hoag, J. B.	Y	Y	Y	June 14/July 22	Y		N
Kleinert, T. R.	N	N/A	N	N/A	N/A		N
Martsching, P. W.	Y	Y	Y	June 10/July 22	Y		N
Medley, M. E.	Y	Y	Y	June 8/July 27	Y		N
Messersmith, K. I.	Y	Y	Y	June 14/July 16	N	1	Y
Murdoch, F. M.**	Y	Y	Y	June 8/July 21	Y		Y
Radomsky, J. W.	Y	Y	Y	June 10/July 20	Y		Y
Seidel, D. R.*	N	N/A	N	N/A	N/A		N
Seland, R. N.	Y	Y	Y	June 10/July 25	Y		Y
Thoresen, A. C.*	N	N/A	N	N/A	N/A		N

[a] This column indicates if the located specimen list is complete regarding the mammals collected. See Appendix B for specimen list and field notes evaluation guidelines.
[b] Y = Yes, N = No, and N/A = Not Applicable.

* Expedition leader.
** Graduate student.

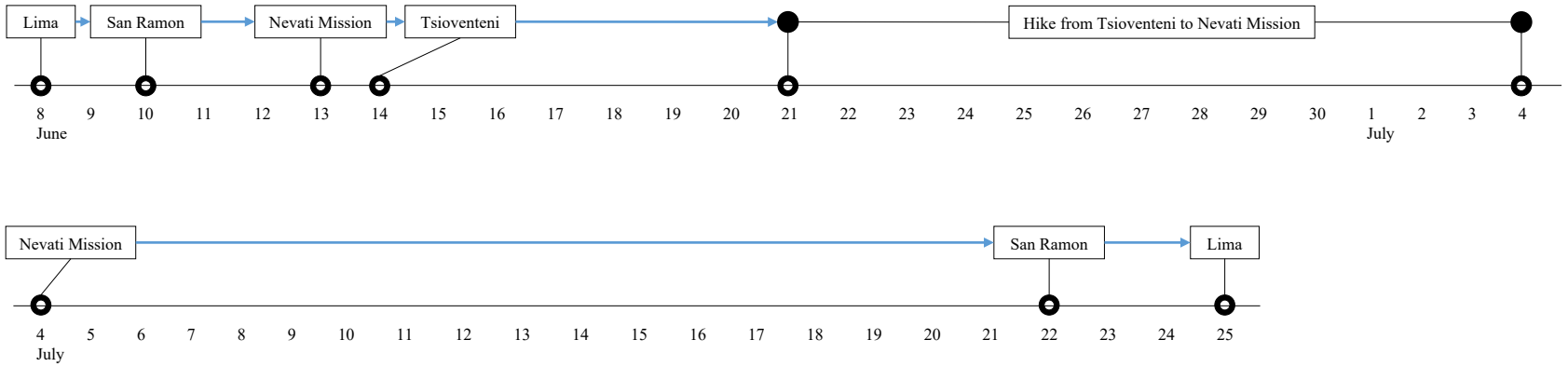

Figure 4. 1965 expedition timeline. Dates for anchored locations on the axis denote arrival or, for the case of the trek from Tsioventeni (elev. 1,280 m) to Nevati Mission (elev. 274 m), departure and arrival. All participants traveled together throughout the expedition.

On June 21, they embarked on the return trek from Tsioventeni to Nevati Mission (Figures 2 & 4). They hired several indigenous people to guide them through the jungle and to help them carry their gear. During the 14-day trek, from June 21 to July 4, they averaged 15 km per day. They camped directly on the trail or at various indigenous settlements along the trail if they were fortunate to encounter them. They rested for a few days after their fourth and seventh days of hiking. On July 4, they reached a larger village on the riverbank, where they were able to hire several indigenous people to take them the remaining few kilometers to Nevati Mission by dugout canoe, arriving in the afternoon on that same day.

The trek through the jungle was a monumental feat for a few reasons. Firstly, most of the indigenous people assisting them by carrying their packs decided to go back on June 28, leaving the expedition participants with only two indigenous persons to guide them the remainder of the trek and no one to help them carry their equipment. Secondly, the expedition participants failed to plan adequately for the trek resulting in several days where they had little food/water and in general they ate far less protein than necessary to sustain them through the trip. Thus, they had to rest more often than anticipated and they traveled less than they hoped each day. Lastly, the indigenous people that they had hired to guide them did not know the trail sufficiently well which led the whole group to take long detours, wasting both time and energy. Due to this, in addition to the convoluted and hilly nature of the trails they took, they trekked approximately 160[3] km through the jungle before reaching Nevati Mission.

[3] One of the participants kept track of his number of steps using a pedometer and, using the length of his stride, could estimate the distance traveled.

After arriving in Nevati Mission on July 4, they spent the remainder of the expedition there until they were flown back to San Ramon on July 22, where they spent a few days recuperating (Figures 2 & 4). They took the commercial bus from San Ramon to Lima on July 25 and then ultimately left for the United States on July 27. This concluded the 1965 expedition.

The expedition participants usually camped on the outskirts of the settlements while at Tsioventeni and Nevati Mission, as during the 1964 expedition, and, in addition, food and occasional lodging were likewise provided by indigenous people or SDA missionaries.

Activities Conducted

During the expedition, the students typically had designated time for lectures and individual or group presentations in the mornings and then spent the afternoons working on completing their assignments to fulfill their course requirements. This included collecting animals such as mammals, birds, insects, and reptiles, writing detailed species accounts regarding certain ecological interactions that they encountered, and analyzing the plant composition of adjacent sections of the rainforest by completing plant transects. Specimen collecting happened on a smaller scale compared to the 1964 expedition due to the increased focus on coursework. They prepared voucher skins and cleaned skulls of captured mammals, rebaited traps, and cataloged all mammals that they collected using their specimen lists. In addition, as during the 1964 expedition, while at Nevati Mission, they occasionally made day trips into the surrounding jungle to capture larger mammals, including primates, marsupials, sloths, and artiodactyls, either alone or in small groups. They were usually guided by an indigenous person from Nevati Mission or Tsioventeni.

They would bring their rifles and shoot animals of interest that the guide spotted and bring back to camp to skin. Lastly, some large mammals such as primates and ocelots would be shot and brought in by indigenous people, purchased by participants, and skinned, as during the 1964 expedition.

1968 Expedition

Purpose and Funding

Like the 1965 expedition, the 1968 expedition was designed to serve as partial requirement for two college courses: Biogeography and Animal Behavior. Therefore, the participants also collected fewer mammals than during the 1964 expedition. Funding was provided by the Department of Biology at Andrews University.

Participants

The 1968 expedition consisted of one faculty member, one assistant leader not directly affiliated with Andrews University, and 16 students (Table 3). Asa C. Thoresen again reprised his role as the expedition leader, but this year Seidel did not accompany him. Instead, Clive Thoresen, A. Thoresen's brother, served as the assistant leader. Five of the participants were SDA high school science teachers, who participated in the expedition to supplement and strengthen their biology knowledge to better perform their duties as teachers. Eight of the remaining participants were undergraduate students majoring or minoring in biology and the last few were graduate students. Specimen lists and field notes were retrieved from 14 of the 16 students and not retrieved for both expedition leaders. All available specimen lists are complete. Field notes belonging to four participants are missing entries. David B. Ekkens is missing 12 field note entries.

Table 3

1968 Expedition Participants

Participant	Status	Specimen Lists		Field Notes				Interviewed
		Present	Complete[a]	Present	First/Last Entry	Continuous	Number of Missing Entries	
Ashdon, R. R. Jr.	U[b]	Y[c]	Y	Y	June 12/August 12	N	3	N
Brown, F. B.	U	Y	Y	Y	June 13/August 9	Y		N
Chilson, R. A.	U	N	N/A	N	N/A	N/A		N
Day, R. A.	U	Y	Y	Y	June 12/August 9	Y		N
Ekkens, D. B.	G	Y	Y	Y	June 12/August 12	N	12	Y
Ellison, W. L.	U	Y	Y	Y	June 12/August 12	Y		Y
Farenick, A. D.	H	Y	Y	Y	June 11/August 12	Y		N
Gibbs, D. L.	U	Y	Y	Y	June 12/August 12	Y		N
Jacques, R. L.	N/A	Y	Y	Y	June 12/August 11	N	1	N
Johns, G. E.	U	Y	Y	Y	June 13/August 11	Y		Y
Johnson, A. N.	G	Y	Y	Y	June 11/August 9	Y		N
Noonan, G. R.	H	Y	Y	Y	June 11/August 12	N	5	N
Penrod, C. L.	H	N	N/A	N	N/A	N/A		N
Saber, J. M.	U	Y	Y	Y	June 13/August 11	Y		N
Streidl, H. R.	H	Y	Y	Y	June 12/August 12	Y		N
Thoresen, A. C.	E	N	N/A	N	N/A	N/A		N
Thoresen, C.	E	N	N/A	N	N/A	N/A		N
Trefz, K. R.	H	Y	Y	Y	June 11/August 10	Y		N

[a] This column determines if the located specimen list is complete regarding the mammals collected. See Appendix B for specimen list and field notes evaluation guidelines.

[b] U = Undergraduate student, G = Graduate student, H = High school teacher, E = Expedition leader.

[c] Y = Yes, N = No, and N/A = Not Applicable.

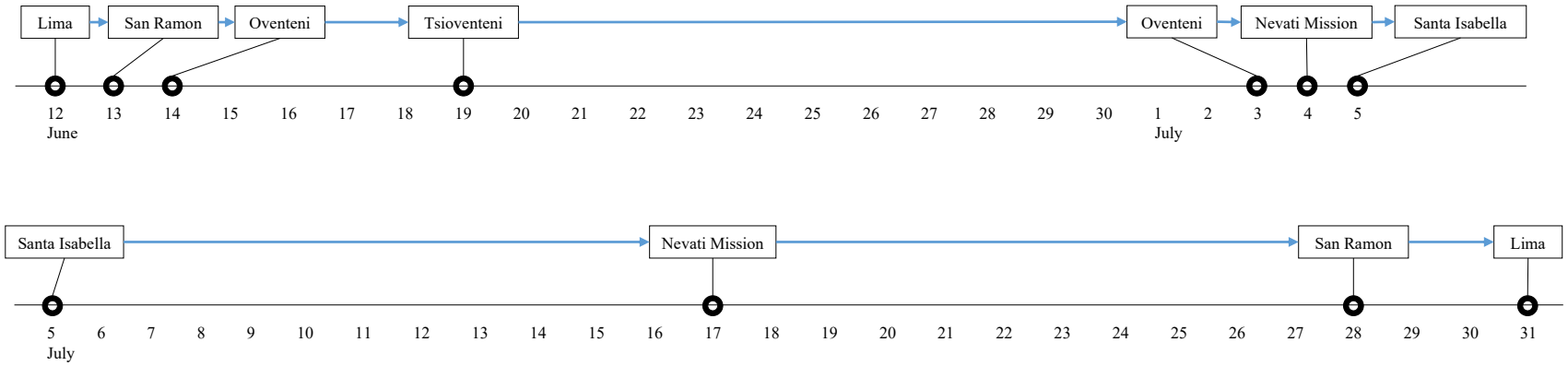

Figure 5. 1968 expedition timeline. Dates for anchored locations on the axis denote arrival. All participants traveled together throughout the expedition.

Timeline

The 1968 expedition participants traveled independently to Miami, Florida, where they flew as a group to Lima on June 12, 1968 (Figures 2 & 5). Upon arrival, as with the previous two expeditions, they spent time in Lima preparing for the expedition and they again received lodging, food, and transportation from members of a local SDA church union office. This year they only spent one day in Lima and on June 13, they took the commercial bus over the Andes to San Ramon, as during the 1965 expedition. San Ramon again served as their entry and exit point to the jungle.

When they arrived at San Ramon, Peters, the same pilot who assisted during both previous expeditions, immediately flew a few members of the group 130 km to Oventeni (elev. 975 m), a Catholic mission outpost with a small on-site military base (Figures 2 & 5). The rest of the group flew to Oventeni the following day, on June 14, staying overnight in an airplane hangar at the same airport in San Ramon as during the previous two expeditions. They set up camp close to the jungle at the Oventeni mission and stayed there for a few days until they left for Tsioventeni on June 19. They initially attempted to trek to Tsioventeni, approximately 25-30 km, on both June 16 and 17 but weather and objections from the military commander at Oventeni prohibited this, citing concerns for the group's safety due to communist guerrillas in the area and unfriendly indigenous people. Finally, on June 19, Cline Johnson, a second SDA mission pilot based in the area, flew most of the group to Tsioventeni instead of hiking to avoid the issue with the military commander. Four individuals (Ekkens, Kenneth R. Trefz, Robert A. Chilson, and Robert L. Jacques) managed to trek the distance accompanied by indigenous people from Tsioventeni.

Once the group had reached Tsioventeni, they stayed there for two weeks until they trekked back to Oventeni on July 3 (Figures 2 & 5). On July 4, they were flown 85 km to Nevati Mission in preparation to leave for Santa Isabella (elev. 457 m), another indigenous settlement. To facilitate quicker travel, the group decided to leave most of their gear in Oventeni and have it flown to them at Santa Isabella over the next few days. Harold R. Streidl stayed behind with the equipment to guard it.

Once the group reached Nevati Mission, they stayed the night and then on July 5, they traveled 10 km by dugout canoe to a camp site approximately 1.5 km E of Santa Isabella (Figures 2 & 5). The surrounding area was composed of multiple acres of planted crops and fruit trees and was managed by the SDA missionaries at Nevati Mission. It served as an ideal site for the group to study and they stayed there for almost two weeks. During that time, Streidl joined them on July 8, with a portion of the equipment, and the rest was flown in later that same week.

Unfortunately, during that first weekend at the campsite near Santa Isabella, they did not have enough supplies to last them until they expected Streidl to join them since they had left most of the cookware with him and their food supplies were lower than expected. Therefore, C. Thoresen went by dugout canoe to Nevati Mission in the morning on July 7 to bring food. Later that day, he flew over the campsite with Johnson, and he was able to drop some food for the group mid-flight. Once he landed in Santa Isabella, he took a dugout canoe and returned to the group that same evening. On July 18, the group traveled back to Nevati Mission via dugout canoes. They stayed in Nevati Mission for the remainder of the expedition.

The participants usually camped on the outskirts of the settlements while at Oventeni, Tsioventeni, and Nevati Mission, as during the two previous expeditions, and, in addition, indigenous people or SDA missionaries provided food and occasional lodging.

On July 28, the group was flown back to San Ramon from Nevati Mission (Figures 2 & 5). The group spent a few days in San Ramon before they took a commercial bus back to Lima on July 31. Following arrival in Lima and in contrast to the 1964 and 1965 expedition participants, the 1968 expedition participants spent about a week as tourists in Peru. They flew with commercial airlines to multiple places including Machu-Pichu and Lake Titicaca. They returned to Lima on August 9 and ultimately to the United States on August 12. This concluded the 1968 expedition.

Activities Conducted

Activities conducted during the 1968 expedition were identical to the 1965 expedition.

Discussion

Evaluating the Retrieved Documents & Interviews Conducted

Seven sets of specimen lists and field notes from the expeditions have not been located, three of these from students during the 1965 and 1968 expeditions and four from the expedition leaders during the 1965 and 1968 expeditions (Tables 1, 2, & 3). The expedition leaders likely did not have time to collect animals and therefore did not maintain a specimen list. In addition, since the focus of the 1965 and 1968 expeditions had changed, the expedition leaders now had to prepare and organize lectures during the

expeditions, a primary reason why they likely did not maintain field notes. The three students for whom no specimen lists and field notes were retrieved likely did create these documents since there is no circumstantial evidence to suggest otherwise.

All specimen lists from the expeditions that we obtained were complete regarding the mammals collected except those belonging to Perez and Kelley during the 1964 expedition (Tables 1, 2, & 3). Despite the singular missing page from Kelley's specimen list, I was able to reconstruct the page by reading through his field notes and locating his specimens at the AMNH (Chapter 3). Therefore, Kelley's single missing specimen list page has no effect on the products of this thesis. In contrast, only a few specimen list pages from Perez have been retrieved and these are only related to his specimens located at the Andrews University Museum of Natural History (AUMNH). No specimen lists have been found related to Perez's specimens located at other institutions (Chapter 3). We cannot be sure if the specimen list pages found belonging to Perez were written by him since we are not sure if he could write in English/Spanish, which are the languages used in his specimen list pages. A. Tuttle potentially completed the specimen list pages on Perez' behalf to document as much metadata as possible since we know that A. Tuttle and Perez spent time together collecting specimens after M. Tuttle had left on August 10, 1964. Considering this, we are fortunate to have the few specimen list pages attributed to Perez that we have, but it is unlikely that we will retrieve any more.

Of the recovered field notes during the expeditions, most of the field notes entries are continuous except for nine participants (Tables 1, 2, & 3). Of these, most are missing a few entries; however, Ekkens is missing 12 entries from his field notes during the 1968 expedition. In most cases, it seems that the missing field notes entries are not due to any

pages being missing but because the participants did not create the entry. Due to the small number of field notes entries being missing, other field notes belonging to the remaining participants can fill in the knowledge gaps. Therefore, the missing field notes entries have little effect on the overall reconstruction of the expeditions.

Due to the difficulty of contacting and arranging interviews with surviving participants, only eight interviews were conducted with surviving participants from the expeditions (Tables 1, 2, & 3). Nevertheless, this constitutes 30% of the surviving participants. More details are likely to be extracted from future interviews. In addition, since interviews were conducted with surviving participants from all three expeditions, some anecdotal knowledge has been documented for each expedition.

Despite the knowledge discovered from the specimen lists, field notes, and interviews, it is likely that some aspects of the reconstruction of the expeditions are lacking detail or completely absent due to the few specimen lists and field notes not being located and/or the remainder of the surviving participants having not been interviewed. The likelihood of a crucial part of the reconstruction of the expeditions being completely absent seems low but is possible. Future research should aim to locate and retrieve additional documents and contact and interview the remaining surviving participants.

Conclusion

The Department of Biology at Andrews University conducted three expeditions to Peru in 1964, 1965, and 1968. Each expedition consisted of two leaders and 10–16 students, most of whom were undergraduates majoring or minoring in biology. However, approximately half of the 1968 expedition participants were graduate students studying biology or SDA high school teachers attempting to strengthen their biology knowledge to

improve their teaching skills. The primary focus of the 1964 expedition was to collect birds and mammals; the primary focus of the two latter expeditions was to serve as partial requirement for several college courses and therefore, fewer specimens were collected, especially mammals.

The expeditions arrived and departed Peru from Lima, and San Ramon served as the point from which they would be flown into the jungle. All three expeditions visited Nevati Mission; and during the latter two expeditions, they additionally visited Tsioventeni. Several unique locations were only visited during the 1964 expedition due to this expedition's unique focus. Throughout the expeditions, the participants relied heavily on local SDA contacts and indigenous people for lodging, transportation, and food.

Most of the potentially available specimen lists and field notes for the expeditions were located. The few specimen lists and field notes not retrieved in addition to missing specimen list pages and field notes entries for located documents do not severely affect the reconstruction of the three expeditions. Approximately 30% of surviving participants were interviewed. In summary, analysis of the expedition documents that we located has allowed robust reconstruction of these expeditions. Future research may improve this reconstruction by locating additional expedition documents and interviewing additional surviving participants.

CHAPTER 3

MAMMALS COLLECTED IN PERU

Introduction

The Department of Biology expeditions to Peru collected several thousand animal specimens including mammals, birds, amphibians, reptiles, fish, and insects, in addition to ectoparasites from several of these taxa. The focus of each expedition and the relative collection effort within these taxonomic groups varied by expedition (Chapter 2). In particular, the primary and nearly entire objective of the 1964 expedition was to collect birds and small mammals (especially bats and rodents) according to the expertise of the expedition leaders (Appendix A, exhibit 3). Despite this collection effort, few scientific publications have summarized the taxa that were collected.

To our knowledge, only one paper has been published and a few departmental unpublished summaries have been created regarding the mammals collected during the expeditions. Firstly, Tuttle (1970) summarized in his doctoral dissertation the entire bat diversity for Peru and commented on their natural history. He examined bat specimens collected during his own personal expedition to Peru in 1963, the Department of Biology expedition to Peru in 1964, and museum specimens from the AMNH, Field Museum of Natural History (FMNH), and United States National Museum (USNM). Three genera and 13 species of bats collected during the 1964 expedition were first records from Peru, and several additional species previously known only from a few Peruvian localities were

documented to occur more widely (Tuttle, 1970). Secondly, Seidel compiled a list of mammals collected during the 1964 expedition, including for each collection locality the number of mammals collected, their associated preparation types, and preliminary identification (Appendix A, exhibit 4). Lastly, A. Thoresen wrote an abstract for the National Geographic Society that summarized the key results from the 1964 and 1965 expeditions. This summary included the number of mammals collected, the museums housing the mammals, and ecological notes on several of the collection localities (Appendix A, exhibit 5).

Despite these efforts, no complete review has summarized all mammals collected during the three expeditions and compared the diversity of mammal species they collected to that which is documented in the current literature. Creating such a review will provide a sample of the Peruvian biodiversity present at the collection localities studied in the mid-1960s, providing historical context to Peruvian mammal diversity trends, and could ultimately inform conservation initiatives. To that end, my research objectives were to (1) catalog the mammal specimens collected, (2) identify the mammal species collected, and (3) evaluate the patterns of species collected by ecoregion and compared to expected taxa based on the current literature (Pacheco et al., 2021).

Methodology

Mammal Specimens Collected

To create a comprehensive list of the mammals collected during the three expeditions, I used the specimen lists and field notes created by each individual participant (Chapter 2), specimen tags of Peruvian mammals in the AUMNH mammal collection, and data obtained from VertNet.org for all mammals collected by known

participants during the study period. For each specimen, I incorporated information including collector and collector number; institution where the specimen is located and institution specimen number; specimen preparation(s); taxonomic identification; collection locality, elevation, ecoregion, and date; specimen gender; and morphometric measurements. I determined the ecoregion of each collection locality by using descriptions from participant field notes to identify the latitude and longitude coordinates of the locality using Google Maps, and then overlaid the coordinates onto a map of the ecoregions of Peru from Brack-Egg (1986). A map visualizing the mammal collection localities within their respective ecoregions was created using QGIS 3.26 and shapefiles from ESRI. Summary tables of the mammals collected at each collection locality can be found in Appendix D.

Mammal Species Identified

For specimens housed in museums outside of the AUMNH, I usually followed the taxonomic identification provided by the institution; however, in some cases, I implemented taxonomic adjustments based on current literature (Appendix C). For specimens housed in the AUMNH collection, I revised or made identifications to genus and species using dichotomous keys for the mammals of South America (Gardner, 2008; Patton et al., 2015) or, for specimens not covered in the dichotomous keys, a textbook that provided species descriptions (Eisenberg & Redford, 1999) or review articles (Marsh, 2014; Rylands et al., 2016). Several unidentified bat and rodent specimens at the AUMNH required direct specimen comparison to identify, which I was able to do at the University of Michigan Museum of Zoology (UMMZ) in Ann Arbor, Michigan, during March 2022.

Patterns Evaluated

I calculated the Richness Index (R) (defined as the number of species collected at a given collection locality divided by the number of sampling days at the locality), Shannon Diversity Index (H), and Shannon Equitability Index (E_H) for the localities within each ecoregion. Diversity relates species richness to abundance in a community and equitability (evenness) compares the abundances of species within a community (Sher & Molles, 2022). Kruskal-Wallis H Test with *post hoc* pairwise comparisons was performed using IBSM SPSS Statistics 29 to determine whether the ecoregions differed significantly for the number of specimens collected, number of species collected, number of sampling days, and the indices R, H, and E_H. Sample size for the comparisons was the number of collection localities within each ecoregion. Specimens not identified to species, the introduced species *Rattus rattus*, and specimens without a collection locality were not included in the analyses.

I compared the proportion of collected mammal diversity to total mammal diversity in each ecoregion by ordinal level according to current literature (Pacheco et al., 2021). In addition, I determined which species are reported in Peru at present and of these, which species were collected in their expected ecoregions. For species not reported in Peru at present, I searched the scientific literature to analyze and determine the likely cause. For species collected in an unexpected ecoregion, I determined the number of specimens and the nearest distance between the unexpected and expected ecoregion.

Results

Mammal Specimens Collected

Nearly 2,900 mammals were collected during the three expeditions. Most of these (~90%) were collected during the first expedition in 1964 (Table 4) with only 275 mammals collected during the 1965 and 1968 expeditions combined (Table 5). About 96% of mammals referenced in specimen lists were located in museums, but 108 specimens were unaccounted for (107 from 1964, 1 from 1968).

Mammals collected during the 1964 expedition are distributed across four museums with nearly three-quarters housed at the AMNH (72%) (Table 4). Several mammals have their preparations split between two institutions, e.g., the skin is located at

Table 4

Number of Mammal Specimens Collected during the 1964 Expedition and their Location

	Location						
Participant	AMNH	AUMNH	KU	USNM	Other	Unknown	TOTAL
Buck, E. L.	176	10				5	191
Castanon, G.	104	10				5	119
Coon, N. E.	160	2			1[a]	30	193
Kelley, J. C.	168	2				3	173
Knowlton, D. L.	210	4				13	227
Myers, F. J.	144	2			1[b]	5	152
Perez, C. R. †	14	49	4	31	15[c]	N/A[d]	113
Seidel, D. R.*	61	6			2[a]	1	70
Seifert, T. B.	152	4				1	157
Stringer, K. R.	130	3				4	137
Thoresen, A. C.*	3						3
Tuttle, A. L.	333	12	120	302		39	806
Tuttle, M. D.*	223	4		21	4[a]	1	253
Unknown	20	5			1[a]		26
TOTAL	1,898	113	124	354	24	107	2,620

[a] Specimen preparations split between the AMNH and the AUMNH.
[b] Museum of Comparative Zoology (MCZ).
[c] Specimen preparations split between the AMNH and KU.
[d] N/A = Not Applicable. We are not in possession of a complete specimen list for Perez (Chapter 2).

* Expedition leader.
† Indigenous person.

Table 5

Number of Mammal Specimens Collected during the 1965 & 1968 Expeditions Located at the AUMNH

1965 Expedition		1968 Expedition	
Participant	Number of Specimens	Participant	Number of Specimens
Esham, W. T.	33	Ashdon, R. R. Jr.	3
Grosse, D. J.	36	Brown, F. B.	18
Hoag, J. B.	17	Chilson, R. A.	N/A[a]
Kleinert, T. R.	4	Day, R. A.	14
Martsching, P. W.	6	Ekkens, D. B.	0
Medley, M. E.	10	Ellison, W. L.	24
Messersmith, K. I.	15	Farenick, A. D.	1
Murdoch, F. M.	20	Gibbs, D. L.	3
Radomsky, J. W.	18	Jacques, R. L.	3
Seidel, D. R.*	N/A	Johns, G. E.	1
Seland, R. N.	7	Johnson, A. N.	11
Thoresen, A. C.*	N/A	Noonan, G. R.	0
		Penrod, C. L.	N/A
		Saber, J. M.	14 (1)[b]
		Streidl, H. R.	5
		Thoresen, A. C.*	N/A
		Thoresen, C.*	N/A
		Trefz, K. R.	0
TOTAL[c]	166		97 (1)

[a] N/A = Not Applicable. We are not in possession of specimen lists for six participants for the 1965 and 1968 expeditions combined (Chapter 2).
[b] Numbers denoted by a parenthesis indicate specimens not located.
[c] Combined total for both expeditions equals 275. Includes 12 specimens with an unknown collector and expedition.

* Expedition leader.

one museum and the skull at another. Most mammals located at other institutions besides the AMNH and AUMNH were collected by Perez, A. Tuttle, and M. Tuttle. In contrast, all mammals collected during the 1965 and 1968 expeditions are housed at the AUMNH (Table 5).

Mammal Species Identified

One hundred and thirty species of mammals representing 7 orders, 23 families, and 86 genera were collected during the three expeditions (Table 6). Bats (Chiroptera) and rodents (Rodentia) together constituted 75% of mammal species. Most species (~80%) were represented by fewer than 20 specimens, but 16 bat, 11 rodent, and one primate species were collected more frequently (Figure 6). Seven species endemic to Peru were collected including one bat (*Eptesicus brasiliensis*), one didelphid (*Marmosops juninensis*) (Didelphimorphia), and five rodents (*Akodon juninensis*, *Akodon orophilus*, *Calomys sorellus*, *Dasyprocta kalinowskii*, and *Neacomys spinosus*). Eighty-seven percent of specimens that were located to museum were identified to species (Table 7) and 60% of the specimens not identified to species were rodents identified to genus and in the collection at the AMNH (Table 8), with the remaining specimens at the AUMNH.

Bats and rodents dominated mammal diversity sampled during the expeditions and two families stood out. The bat family Phyllostomidae and the rodent family Cricetidae represented 75% and 80% of total bat and rodent species diversity, respectively (Table 9). Additionally, the bat subfamilies Stenodermatinae and Phyllostominae represented 42% and 25% of phyllostomid diversity, respectively. Despite the large diversity of Phyllostomidae, the one endemic bat species was within the family Vespertilionidae. Four of the five endemic rodent species were within Cricetidae.

Table 6

Number of Collected Mammal Specimens & Taxa Within Each Order

Order	Specimens	Families	Genera	Species
Artiodactyla	6	2	2	2
Carnivora	26	3	6	6
Chiroptera	1,363	5	35	64 (1)[a]
Didelphimorphia	66	1	8	12 (1)
Pilosa	7	3	3	3
Primates	84	3	7	9
Rodentia	1,235	6	25	34 (5)
TOTAL	2,787	23	86	130 (7)

[a] Numbers in parenthesis denote endemic species.

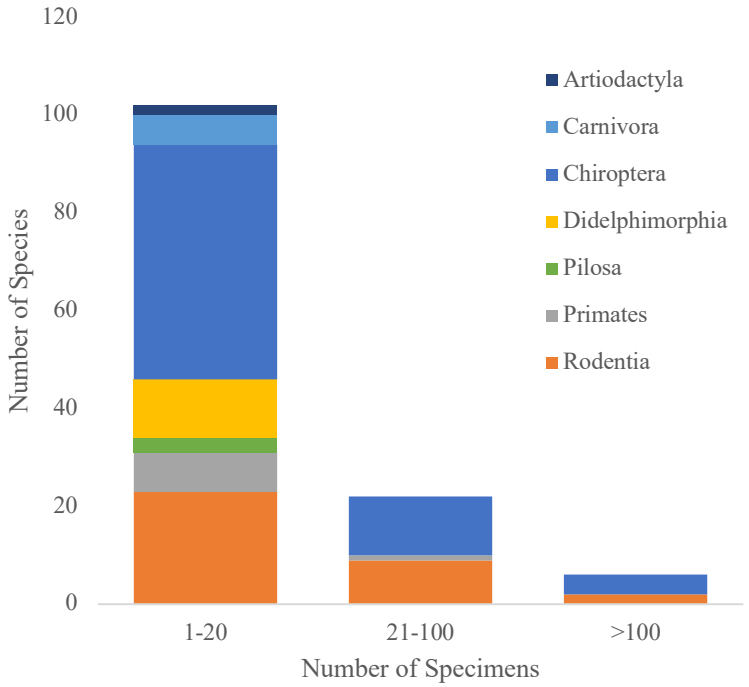

Figure 6. Relative abundance of species collected. Most species were represented by less than 20 specimens. One primate species (*Saimiri boliviensis*) was represented by over 20 specimens; the remaining species with over 20 specimens were bats (Chiroptera) and rodents (Rodentia).

Table 7

Number of Specimens Identified Down to Select Taxonomic Level and No Further

	Identified down to				
Order	Order	Family	Genus	Species	TOTAL
Artiodactyla			3	3	6
Carnivora				26	26
Chiroptera			40	1,323	1,363
Didelphimorphia			1	65	66
Pilosa				7	7
Primates			2	82	84
Rodentia	61	11	253	910	1,235
TOTAL	61	11	299	2,416	2,787

Table 8

Number of Specimens Identified Down to Order, Family, or Genus and their Location

		Location			
Order	Identified to	AMNH	AUMNH	AMNH/KU[a]	TOTAL
Artiodactyla	Genus	2	1		3
Chiroptera	Genus		39	1	40
Didelphimorphia	Genus		1		1
Primates	Genus		2		2
Rodentia	Order		61		61
	Family		11		11
	Genus	227	26		253
TOTAL		229	141	1	371

[a] Specimen preparation between the AMNH and KU.

Table 9

Number of Chiropteran & Rodent Species by Family/Subfamily

Order	Family/Subfamily	Number of Species
Chiroptera	Emballonuridae	6
	Molossidae	2
	Noctilionidae	2
	Phyllostomidae	48
	Carolliinae	5
	Desmodontinae	2
	Glossophaginae	5
	Lonchophyllinae	4
	Phyllostominae	12
	Stenodermatinae	20
	Vespertilionidae	6 (1)[a]
Rodentia	Cricetidae	26 (4)
	Cuniculidae	1
	Dasyproctidae	2 (1)
	Echimyidae	2
	Sciuridae	2

[a] Numbers in parenthesis denote endemic species.

Patterns Evaluated

The participants collected mammals from 14 localities ranging from 177 to 4,755 m elevation and representing three ecoregions (Table 10, Figure 8). Selva Baja was sampled the most in terms of number of specimens and was represented by approximately 60% of specimens collected with Puna and Yungas each representing approximately 20%. Mean number of species and sampling days increased from Puna to Selva Baja (following the expedition progression, see Chapter 2), but mean number of specimens did not follow this trend, with Puna averaging more specimens per locality than Yungas (Figure 7). Mean richness peaked in Yungas (2.65), mean diversity peaked in Selva Baja (2.82), and mean evenness did not vary notably across ecoregions. All comparisons were not significantly different, as determined by Kruskal Wallis H Test, except mammal diversity ($H(2) = 6.897$, $p=0.032$), specifically between Puna and Selva Baja ($p=0.014$) (Table 11).

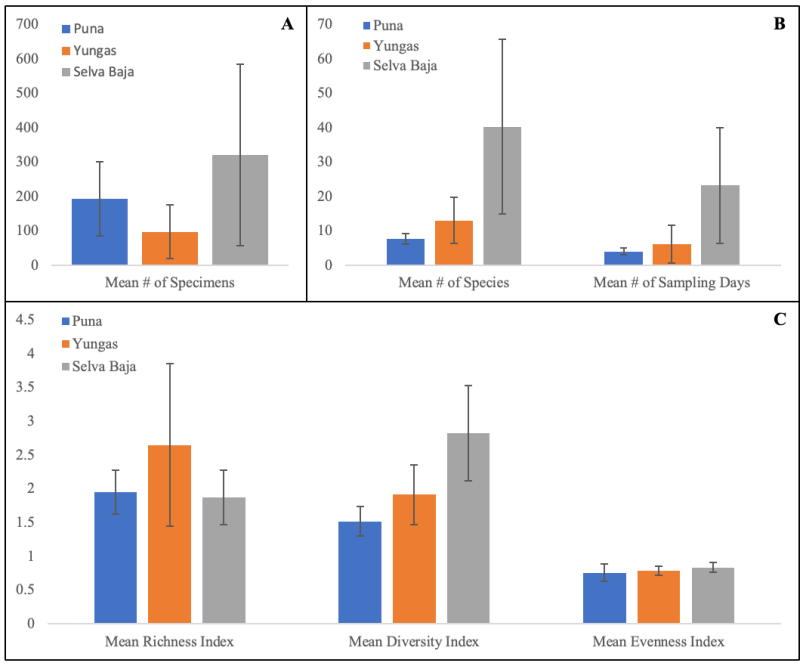

Figure 7. Mean descriptive variables and indices for Puna (n=3), Yungas (n=6), and Selva Baja (n=5). Error bars indicate standard deviations. **A**. Mean number of specimens. **B**. Mean number of species and sampling days. **C**. Mean richness (R), diversity (H), and evenness (E_H) indices.

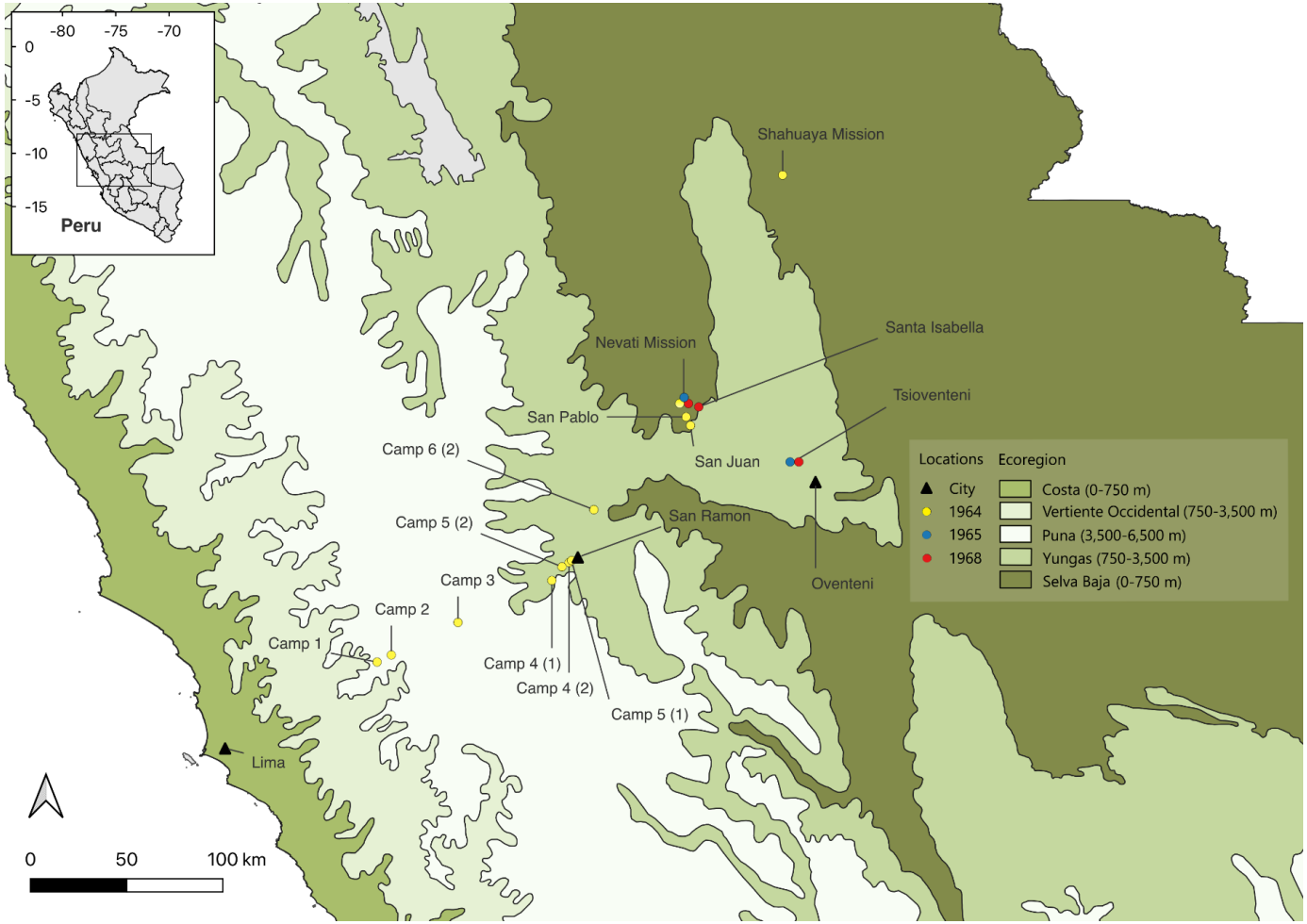

Figure 8. Map of mammal collection localities visited during the expeditions. Ecoregions in the legend go from west to east. The darker color the ecoregion, the lower the elevation. Two localities were collected from at multiple times across the expeditions (Nevati Mission (elev. 274 m) and Tsioventeni (elev. 1,280 m)).

Table 10

Mean Descriptive Variables & Indices by Ecoregion with Standard Deviations

Ecoregion (n)[b]	Average Elevation of Localities (m)	Descriptive Variables ($\bar{x} \pm SD$[a]) Number of Specimens	Number of Species	Number of Sampling Days	Indices ($\bar{x} \pm SD$) Richness Index (R)[c]	Diversity (H)[d]	Evenness (E_H)[e]
Puna (3)	4,176	192.3 ± 107.5	7.7 ± 1.5	4.0 ± 1.0	1.95 ± 0.33	1.51 ± 0.22	0.754 ± 0.127
Yungas (6)	1,134	97.2 ± 77.2	13.0 ± 6.7	6.2 ± 5.5	2.65 ± 1.20	1.91 ± 0.44	0.782 ± 0.067
Selva Baja (5)	291	320.2 ± 263.0	40.2 ± 25.4	23.2 ± 16.8	1.87 ± 0.41	2.82 ± 0.70	0.835 ± 0.071

[a] SD = Standard Deviation.
[b] Sample size (n) equals number of collection localities within each ecoregion.
[c] Richness index calculated as number of species divided by number of sampling days.
[d] Shannon Diversity Index.
[e] Shannon Equitability Index.

Table 11

Kruskal-Wallis H Test with Pairwise Comparisons between Ecoregions

Analysis	Test Statistic (H)	p-value[a]
Mean # of Specimens	2.821	0.244
Mean # of Species	4.530	0.104
Mean # of Sampling Days	5.020	0.081
Mean Richness Index (R)	1.672	0.433
Mean Diversity Index (H)	6.897	0.032
Puna – Yungas	-2.667	0.367
Puna – Selva Baja	-7.533	0.014
Yungas – Selva Baja	-4.867	0.055
Mean Evenness Index (E_H)	1.960	0.375

[a] $\alpha = 0.05$.

Within orders, species diversity was sampled least well from Puna, with 15% of reported species diversity being collected from only one order (Rodentia) (Table 12, Figure 9). Approximately 20% of mammal species currently reported from Yungas were sampled, representing six orders; and Selva Baja was sampled best with approximately 33% of reported mammal species being sampled, representing seven orders. Within each order, the diversity of collected species increased as expected from Puna through Yungas to Selva Baja.

Nine of 130 species collected during the expeditions are not reported in Peru at present (Table 13). Seven of the nine species are within recently revised genera and are either invalid species names as determined by revision, or valid species that after revision do not occur in Peru. The two remaining species are not within recently revised genera.

Table 12

Number of Mammal Species Per Order within Ecoregions Compared to Literature

	Puna[a]		Yungas		Selva Baja	
Order	Expeditions	Literature[b]	Expeditions	Literature	Expeditions	Literature
Artiodactyla		6		7	2	8
Carnivora		9	2	19	5	18
Chiroptera		4	26	87 (2)	59 (1)	140 (3)
Cingulata				2 (1)		4
Didelphimorphia		2 (1)[c]	6 (1)	22 (5)	9	33 (4)
Eulipotyphla				3 (2)		
Lagomorpha				1		1
Paucituberculata				2		
Perissodactyla				2		1
Pilosa			1	4	3	7
Primates			2	13 (4)	9	40 (8)
Rodentia	11 (3)	50 (13)	13 (3)	94 (34)	16 (2)	67 (4)
Sirenia						1
TOTAL	11 (3)	71 (14)	50 (4)	256 (48)	103 (3)	320 (19)

[a] Numbers of species within each order between ecoregions are non-mutually exclusive.
[b] Pacheco et al., 2021.
[c] Numbers in parenthesis denote endemic species.

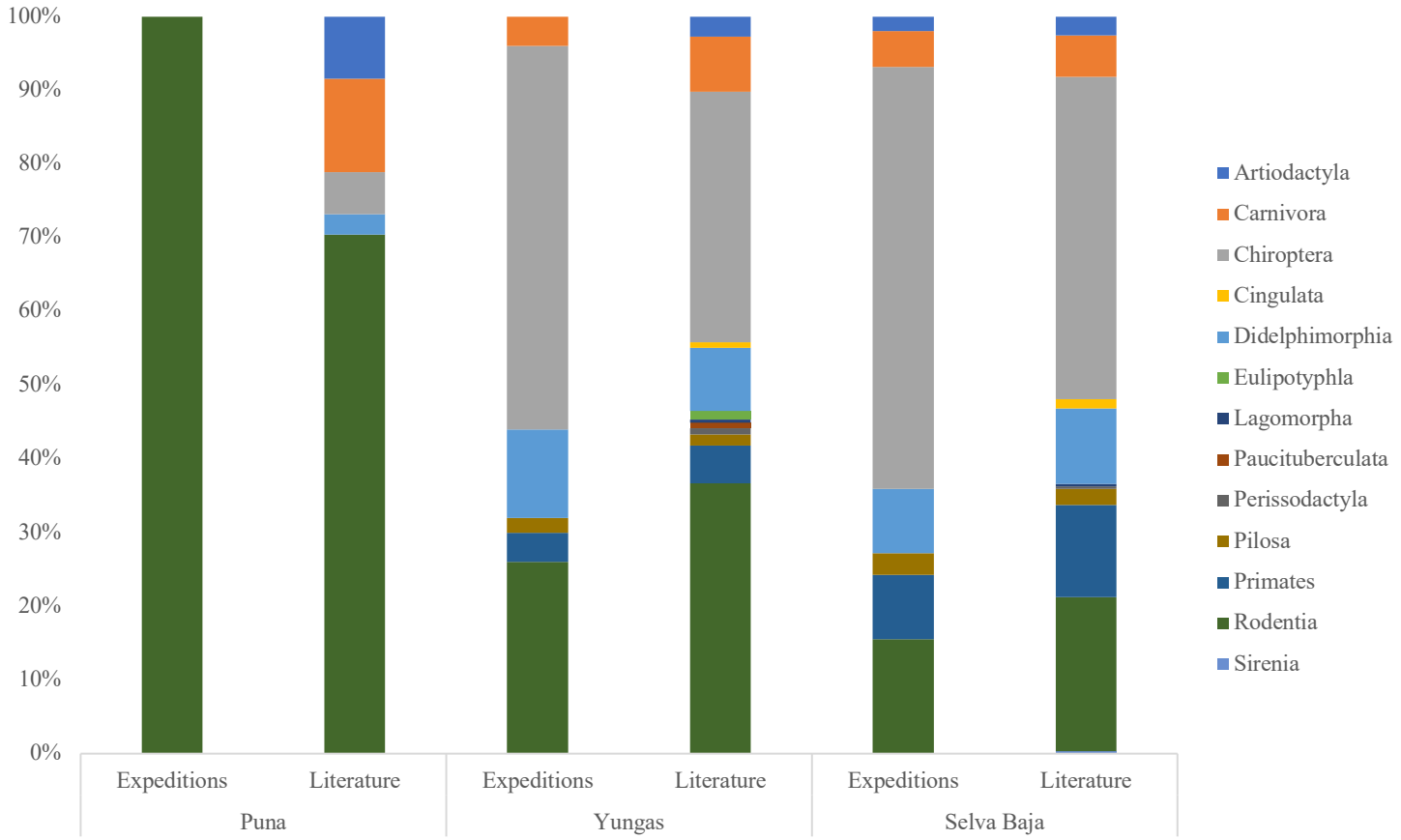

Figure 9. Proportion of mammal species collected by order and ecoregion during the expeditions compared to current literature (Pacheco et al., 2021). Numbers of species within each order between ecoregions are non-mutually exclusive.

Table 13

Collected Species Reportedly Absent from Peru According to Current Literature

Species	Reason for Absence	Comment	Reference
Marmosa murina	Genus revised	1[a]	(Voss, 2022)
Micoeureus regina			(Voss, 2022)
Cyclopes didactylus		2	(Miranda et al., 2018)
Nectomys squamipes			(Patton et al., 2015)
Pithecia inusta			(Marsh, 2014)
Sturnira lilium			(Velazco & Patterson, 2013)
Sturnira ludovici			(Velazco & Patterson, 2013)
Oecomys concolor	Unknown	N/A[b]	N/A
Oligoryzomys flavescens			N/A

[a] 1 = Species name no longer valid. 2 = Species name valid but range no longer in Peru.
[b] N/A = Not Applicable.

Of the species presently reported in Peru, 13 species had one or more specimens that were collected from an unexpected ecoregion (Table 14), usually representing unexpected presence in Yungas versus Selva Baja or vice versa. Two species were collected >75 km from an expected ecoregion (one bat and one rodent), six species 25-45 km from an expected ecoregion (five bats and one didelphid), and five species <10 km from an expected ecoregion (four rodents and one didelphid). The weighted mean distance to nearest expected ecoregion was 39.6 km/species with a range from one to 200 km. Most were represented by less than 10 specimens; however, 61 specimens of *Anoura geoffroyi* were collected from Camp 4 (1) (elev. 2,225 m) in Yungas.

Discussion

Mammal Specimens Collected

The number of mammals collected during the expeditions reported here is likely an accurate estimate (Tables 4 & 5) despite several specimen lists having not been retrieved from the 1965 and 1968 expeditions (Chapter 2). This is due to three factors:

Table 14

Species Collected from Unexpected Ecoregion

Species	Number of Specimens	Collection		Expected Ecoregion	Distance (km) & Direction to Nearest Expected Ecoregion
		Locality	Ecoregion		
Sturnira bogotensis	1	Nevati Mission	SB	VOC[a]	200 km WSW
	5	Camp 5 (1)	YUN		102 km WSW
	1	Camp 4 (1)	YUN		88 km WSW
Akodon orophilus[E]	1	Camp 1	PUN	YUN	75 km ENE
Anoura geoffroyi	61	Camp 4 (1)	YUN	SB	45 km NE
	2	Camp 5 (1)	YUN		30 km NE
Saccopteryx bilineata	1	Camp 5 (1)	YUN	BPP, SB, SP	30 km NE
Vampyrodes caraccioli	6	Camp 5 (1)	YUN	SB	30 km NE
Carollia castanea	2	Camp 5 (1)	YUN	SB	30 km NE
Artibeus gnomus	1	Tsioventeni	YUN	SB, SP	25 km E
Glironia venustra	1	Tsioventeni	YUN	SB	25 km E
Neacomys spinosus[E]	1	Shahuaya Mission	SB	YUN	16.5 km W
	2	Nevati Mission	SB		10 km SW
	3	San Pablo	SB		3.5 km SE
Dasyprocta kalinowskii[E]	1	Nevati Mission	SB	YUN	10 km SW
	1	San Juan	SB		1 km E
Hylaeamys perenensis	1	Camp 6 (2)	YUN	SB, SP	7.5 km E
Oligoryzomys microtis	13	Camp 6 (2)	YUN	SB, SP	7.5 km E
Didelphis pernigra	1	San Juan	SB	COS, VOC, YUN	1 km E

[a]BPP, Bosque Pluvial del Pacífico; COS, Costa; SB, Selva Baja; SP, Sabana de Palmera; VOC, Vertiente Occidental; YUN, Yungas (Pacheco et al., 2009; Pacheco et al., 2021).

[E] Endemic species.

(1) the 1965 and 1968 expeditions collected fewer mammals than the 1964 expedition, (2) there were some participants during the 1968 expedition that did not collect any mammals, and (3) A. Thoresen, Seidel, and C. Thoresen were expedition leaders and likely did not have time to collect many mammals. However, we are aware that at least one of the participants collected a few mammals and brought them back to his own collection (Murdoch, pers. comm.), so potentially this could be the case for other participants.

Considering that the three expeditions occurred almost 60 years ago, a 96% recovery rate with only 108 specimens missing indicates that we have accessed most of the relevant data (Tables 4 & 5). The 107 missing specimens from the 1964 expedition are likely present at the AMNH or have been traded to other institutions, because we know that these specimens were sold to the AMNH following the 1964 expedition according to correspondence we discovered. The missing specimens from A. and M. Tuttle could potentially be uncataloged and located at the USNM or KU, given that large portions of their collected specimens are housed at these two locations. There is a chance that a few of the 107 missing specimens from the 1964 expedition could be found at the AUMNH, because a collection of 60 fluid rodent specimens from the 1964 expedition was discovered at the AUMNH during early 2022. The one missing specimen from the 1968 expedition is Joseph M. Saber's number 11, a bat fetus retrieved from his specimen number 10. Considering the delicate nature of the specimen, it was probably preserved in fluid in a small vial. It is likely that the specimen was brought back to Andrews University since we have other similar delicate specimens in our collection, but it is impossible to say what might have happened to it since.

The mammals collected by Perez during the 1964 expedition deserve comment (Table 4). He was not an expedition participant from Andrews University but rather an indigenous person who assisted with collection efforts, but his specimens returned with the participants following the expedition. We are in possession of a partial specimen list from him, but his field notes have not been found (Chapter 2) or were not created. Of the 113 mammals attributed to Perez that have been located, it seems that his partial specimen list only references the mammals at the AUMNH. However, according to data from VertNet.org, mammals collected by Perez and housed in other museums have overlapping collector numbers, something which is only possible if Perez reused numbers while out in the field. In addition, we do not know whether the specimen list we found was completed by Perez himself, by A. Tuttle (who Perez accompanied for all of August 1964, Chapter 2), or completed in the United States by a third individual. Perez' 49 mammals at the AUMNH have therefore not been adequately cataloged, a task that will require direct inspection of his specimens at other museums.

Mammal Species Identified

Thirteen percent of almost 2,800 mammals that have been located from the expeditions have not been identified to species (Tables 7 & 8). Most of the mammals not identified to species are rodents, which makes sense since rodents are highly diverse in South America and significant major taxonomic revisions are currently underway (Patton et al., 2015). Most of the specimens not identified to species could be further identified by specialists in the respective taxa. Since the AMNH and AUMNH house all the specimens not identified to species, a second trip to the AMNH with all specimens not

identified to species at the AUMNH would facilitate direct comparison and further identification.

The distribution of mammal specimens per species (Figure 6) probably reflects an opportunistic collection style. Even though the participants specifically set up mist nets and traps to collect rodents and bats (Chapter 2), they did so indiscriminately. Even though several species were represented with over a hundred specimens, we have no reason to believe, based on the specimen lists and field notes, that they specifically sought out these species and exclusively chose to collect them. Instead, it seems that these species were especially common at their respective collection localities. Larger mammal species such as primates and carnivores were additionally sampled less than bats and rodents, likely due to the increased effort required to, say, collect a primate compared to a bat, as well as their lower population densities.

Bats represent almost twice the diversity as that of the rodents in the collection even though nearly equal numbers of specimens were collected (Tables 6 & 9). This probably reflected biases associated with trapping methods. The participants mainly used Sherman traps to collect rodents and mist nets to collect bats. The Sherman traps would be baited and then checked once or twice a day. Each Sherman trap could only capture one rodent at a time and once a trap had been triggered, it could not be used to capture another rodent until the captured rodent had been removed by a participant and the trap rebaited. Even under the best of conditions, the success rate for each Sherman trap was highly variable due to several factors, including the highly cryptic nature of many rodent species and the sensitivity of the spring-loaded trap. As such, hundreds of Sherman traps had to be set up at each mammal collection locality to collect a significant number of

rodents. In contrast, each mist net could capture multiple bats at a time and continuously capture bats from when the mist net was set up until the mist net was checked by a participant. Bats are also less cryptic than rodents and many species swarm at night in large numbers in pursuit of food. Placing mist nets at strategic places outside roost sites at dawn and dusk would have been productive and guaranteed a higher rate of capture than for rodents.

Patterns Evaluated

Considering the few collection days in Puna, the participants collected significant numbers of specimens and species, which leads to a high richness score of 1.95. Richness at Puna was higher than at Selva Baja (1.87) even though Selva Baja had a higher average number of specimens and species collected than Puna (Table 10, Figure 7). However, average number of sampling days in Selva Baja was >5 times that of Puna. Yungas had the highest average richness index (2.65) but also the highest standard deviation, indicating high interlocking variation in richness. Yungas is known to harbor high biodiversity (Pacheco et al., 2021) so it makes sense that richness of the collection was greatest there.

The higher diversity index in Selva Baja is likely due to the increased time participants spent in that ecoregion. The more time spent collecting, the more specimens per species can be collected, and the higher chance there is to collect an increased number of species. According to Pacheco et al. (2021), Selva Baja is also the ecoregion in Peru with the most number of species, meaning the data align well with expected. However, despite the relative differences between the indices, our statistical analyses only showed significant difference between Puna and Selva Baja in mammal species diversity

(p=0.014) (Table 11). The lack of significant difference in other comparisons may relate, in part, to small sample of localities in the ecoregions.

Participants sampled the three ecoregions differently in terms of ordinal diversity (Table 12, Figure 9). The participants only sought to collect small terrestrial mammals while in Puna since they did not use mist nets or shoot large mammals. In Yungas, the participants usually set up Sherman traps and mist nets, and caught mostly rodents and bats, with the occasional didelphid. They started hunting for larger mammals once they had been flown to the jungle, where they collected several carnivores and primates, primarily from Tsioventeni (elev. 1,280 m). Once the participants reached Selva Baja, they launched multiple extended excursions with indigenous guides (Chapter 2), which increased their sampling of larger mammals; and, since Selva Baja has a higher mammal diversity, they were able to collect more species.

Seven of the nine species not reported in Peru at present are within recently revised genera (Table 13). Specimens from all seven species likely belong to a current species that is presently reported from Peru. Voss (2022) recently revised extant didelphids, and the species *Marmosa murina* and *Micoeureus regina* were determined to no longer be valid species names. In addition, the four remaining genera previously only contained a few species, yet these species had multiple subspecies. One of the major accomplishments of the revisions of these genera was to elevate subspecies to species status (Marsh, 2014; Miranda et al., 2018; Patton et al., 2015; Velazco & Patterson, 2013). Direct comparison of the specimens within these seven species would likely reveal a different and more current taxonomic identification in line with the literature and reported in Peru at present. The remaining two species not reported in Peru are both

rodent species. These could potentially represent previous ranges of these species that have subsequently shifted and are no longer present in Peru. More likely, however, is that these specimens were misidentified, given that I found no recent revision of these two genera. Direct inspection of these specimens could rectify these potential misidentifications.

The specimens of the 13 species collected from a different ecoregion than expected likely are due to multiple non-mutually exclusive causes (Table 14). Species collected <10 km from expected ecoregion are likely due to inaccurate location coordinates. Locations were determined by using distance and direction indicators from the field notes and attempting to determine the coordinates on Google Maps as accurately as possible. Since the borders between the three ecoregions are convoluted in the study area, it is plausible that the collection locality actually was located inj the neighboring ecoregion. Several of the species with a medium distance to the nearest expected ecoregion (25-45 km) are bats, which can travel extensively during feeding forays. Depending on if the bats were collected at a roost site or by using mist nets at a feeding locality, the interpretation of the results could differ. Lastly, several species were collected >75 km from their nearest expected ecoregion. In some cases, this could result from taxonomic revisions. The bat genus *Sturnira* has recently been revised (Velazco & Patterson, 2013), thus the seven specimens identified as *S. bogotensis* may plausibly represent a different species in the current taxonomy. In addition, misidentification of the specimens is possible. In particular, the one *Akodon orophilus* specimen collected in Puna may be a misidentification, especially because the specimen's skin is not present (as determined through VertNet.org). Rodent identifications (indeed all mammal

identifications) are most accurate when both a skin and skull are inspected (Patton et al., 2015).

Sources of Error

It is important to note potential sources of error when creating the comprehensive dataset of mammals. Firstly, several duplicate numbers were discovered at the AMNH where the collector and collector number were the same for two specimens. In these cases, the two specimens were easily distinguished as being separate specimens due to differences in morphometric measurements, identification, collection date, or collection locality. In some instances, however, duplicate numbers represented different preparations of the same specimen, that is, the specimen skin and skull had been separated and given different numbers. Secondly, a curatorial error affecting at least half a dozen specimens was discovered while importing data from the AMNH. Because of the way the database at the AMNH is set up, each digital collection number entry has attached a scanned image of the physical catalog that corresponds to the given collection number. On several occasions, I discovered that the AMNH number and collector/collector number were mismatched, and it was only when I viewed the scanned image of the physical catalog that I discovered the error. Often it was a simple case of data being entered incorrectly from the catalog to the database. Whoever had typed in the data would have typed the data from the row immediately above or below instead of the relevant row. Future work should aim to systematically go through the specimen records at the institutions where the specimens are located and correct these errors.

Conclusion

Nearly 2,900 mammals were collected during the Andrews University Department of Biology expeditions to Peru in 1964, 1965, and 1968. Of these, nearly three-quarters of the 1964 specimens are housed at the AMNH. All the 1965 and 1968 specimens are housed at the AUMNH. The mammals collected represent 130 species within 7 orders, 23 families, and 86 genera. Eighty-seven percent of specimens that I located were identified to species with only 371 specimens not identified down to species. Specimens were collected from the ecoregions Puna, Yungas, and Selva Baja, with nearly 60% of mammals being collected from Selva Baja. Yungas had the highest mean richness index (2.65) and Selva Baja had the highest mean diversity index (2.82), both in line with the current literature. However, statistical analyses showed no difference for all comparisons except mammal diversity between Puna and Selva Baja ($p=0.014$).

Nine of 130 species collected are not reported in Peru at present. In addition, 13 species reported in Peru had specimens collected from an unexpected ecoregion, mostly representing unexpected presence in Yungas versus Selva Baja. Likely explanations are specimen misidentification, genus revisions, and location coordinate inaccuracies. Further work is required to advance our understanding of these species not reported in Peru or in their expected ecoregion. Completing the identification of the remaining specimens not identified to species, increasing the location data accuracy, and analyzing the data with different more advanced metrics could assist with this objective.

CHAPTER 4

CONCLUSION

The overall objectives of this research were to: (1) investigate and document the Andrews University Department of Biology expeditions to Peru in the 1960s, (2) catalog and identify the mammals collected during the expeditions, and (3) evaluate the collected mammal diversity patterns compared to current literature (Pacheco et al., 2021).

Members of the Department of Biology at Andrews University conducted three expeditions to Peru in 1964, 1965, and 1968. However, no complete summary of the expeditions had been completed prior to this study, which will contribute to the scientific literature on small-scale biological and educational expeditions within South America (particularly Peru) during the 1960s. My research provided the first complete summary of the expeditions by investigating and determining who, when, why, and where they went, what they did during the expeditions, and how the expeditions were organized.

Each expedition consisted of two expedition leaders and 10–16 students, most of whom were undergraduates majoring or minoring in biology; however, approximately half of the 1968 expedition participants were graduate students studying biology or Seventh-day Adventist high school teachers attempting to strengthen their biology knowledge to improve their teaching skills. The primary focus of the 1964 expedition was to collect birds and mammals; the primary focus of the two latter expeditions was to serve as partial requirement for several college courses. The expeditions arrived and

departed Peru from Lima, and San Ramon served as the point from which they flew into the jungle. All three expeditions visited Nevati Mission, and during the latter two expeditions they additionally visited Tsioventeni. Several unique locations were only visited during the 1964 expedition due to this expedition's unique focus. Throughout the expeditions, the participants relied heavily on local Seventh-day Adventist contacts and indigenous people for lodging, transportation, and food.

Most of the available specimen lists and field notes for the expeditions were retrieved. The few specimen lists and field notes not retrieved in addition to missing specimen list pages and field notes entries for located documents do not severely affect the reconstruction of the three expeditions. Approximately 30% of surviving participants were interviewed. Analysis of the expedition documents that were located and interviews conducted allowed me to reconstruct key features of the expeditions, which future research can attempt to improve by locating additional expedition documents and interviewing the remaining surviving participants.

Mammal diversity in Peru is especially rich with 573 species (Pacheco et al., 2021) documented by ecoregion making it the third most mammal diverse country in the world. Creating taxonomic lists of the biodiversity present within restricted areas of especially diverse yet not surveyed extensively and/or are inadequately protected habitats (Bax & Francesconi, 2019; Rodríguez & Young, 2000; Swenson et al., 2012; Young & León, 2000) is one strategy that can aim to resolve conservation issues (Pacheco et al., 2021). The mammals collected during the Department of Biology at Andrews University expeditions to Peru can provide such taxonomic lists. However, to our knowledge no complete summary of the mammals collected during these expeditions has been created.

My research provided the first complete summary by cataloging and identifying the mammal species collected within each visited ecoregion during the expeditions and evaluating the mammal diversity collected compared to current literature (Pacheco et al., 2021).

Nearly 2,900 mammals were collected during the Andrews University Department of Biology expeditions to Peru in 1964, 1965, and 1968. Of these, nearly three-quarters of the 1964 specimens are housed at the AMNH. All the 1965 and 1968 specimens are housed at the AUMNH. The mammals collected represent 130 species within 7 orders, 23 families, and 86 genera. Eighty-seven percent of specimens that I located were identified to species with only 371 specimens not identified down to species. Specimens were collected from the ecoregions Puna, Yungas, and Selva Baja, with nearly 60% of mammals being collected from Selva Baja. Yungas had the highest mean richness index (2.65) and Selva Baja had the highest mean diversity index (2.82), both in line with the current literature. However, all comparisons were not significantly different except mammal diversity ($H(2) = 6.897$, $p=0.032$), specifically between Puna and Selva Baja ($p=0.014$).

Nine of 130 species collected are not reported in Peru at present. In addition, 13 species reported in Peru had specimens collected from an unexpected ecoregion, mostly representing unexpected presence in Yungas versus Selva Baja or vice versa. Likely explanations are specimen misidentification, genus revisions, and location coordinate inaccuracies. Further work is required to advance our understanding of these species not reported in Peru or in their expected ecoregion. Completing the identification of the

remaining specimens not identified to species, increasing the location data accuracy, and analyzing the data with different more advanced metrics could assist with this objective.

The primary objective of this thesis was to describe the mammal diversity collected during the expeditions, yet thousands of birds, reptiles, amphibians, and insects were additionally collected. Future research should aim to summarize the specimens collected of these additional taxonomic groups. The knowledge attained from these expeditions can and should be more fundamentally cemented into our department consciousness and utilized for inspiration and teaching. Hopefully, awareness of these expeditions and the mammals collected can inspire a new and deepened appreciation of biological field work in our students in the Department of Biology and this thesis may serve as the foundation for further studies of these expeditions and the taxa collected.

APPENDIX A

EXPEDITION RELATED DOCUMENTS

EXHIBIT 1

Example of a Specimen List Page (anonymous)

FIELD NUMBER	SEX	NAME	LOCALITY	ALTITUDE	DATE	TOTAL LENGTH	TAIL	HIND FOOT	EAR	FORE ARM	WEIGHT	REMARKS
1	♂	Mouse	Peru, Dept Pasco, Prov. Oxapampa, Tsioventeni	4300'	17 Jun, '65	218 mm	120 mm	29 mm	15 mm	—	28 gr.	No skull
2	♂	Bat, Carollia	½ mi – SW from Tsioventeni – Peru, Dept. Pasco, Prov. Oxapampa, Tsioventeni	4200'	19 Jun, '65	75	16	14	TR-8 mm 19	39	17 gr.	NONE
3	♀	Bat	1 mi NE of union of Rio Neguachi and Mandarague. Peru, Dept Pasco, Prov. Oxapampa, Nevati: "	900'	7 Jul, '65	48	NONE	9	TR-6.5 14	31.5	8 gr.	
4	♀	Bat	"	900'	8 Jul, '65	49	NONE	8	TR-5 15	32	8 gr.	
5	♀	Bat	"	900'	8 Jul, '65	85	29	7	TR-5 13	36	8 gr.	
6	♂	Bat	"	900'	9 Jul, '65	49	NONE	10	TR-6.5 16	34	17 gr.	
7	♂	Bat	"	900'	9 Jul, '65	40	NONE	8.5	TR-6 15	36	9 gr.	
8	♂	Bat, Phyllostomus	"	900'	10 Jul, '65	137	25	20	TR-9 29	88.5	120 gr.	
9	♀	Rat, Proechimys	East side of "Neguachi River	900'	11 Jul, '65	323	108	48	21	—	279 gr.	
10	♂	Bat, Molossus	3 mi NE of union of Rios Neguachi & Mandarague. Peru, Dept Pasco, Prov. Oxapampa, Nevati "	900'	11 Jul, '65	110 mm	43 mm	9 mm	TR-8 mm 12 mm	40 mm	16 gr.	NONE
11	♀	Rat, Oryzomys	"	"	12 Jul, '65	330 mm	165 mm	41 mm	21 mm	—	134 gr.	NONE
12	♀	Bird, Hen bird	"	"	13 Jul, '65	278	131	closed wing – 134	culmen – 23	tarsus – 39	– 82 gr.	
13	♀	Bird, Smooth-billed Ani	" NE of Nevati on Rio Neguachi	"	13 Jul, '65	324	190	C.W. 139	TAR. 34	Cul. 24	—	
14	♀	Bird, hummingbird	" NE of Nevati on Rio Neguachi	"	13 Jul, '65	120	38	C.W. 56	TAR. 7	Cul. 30	—	
15	♂	Bat	Peru, Dept Pasco, Prov. Oxapampa, Rio Manpaisiani 3 mi NE of Nevati Mission	"	14 Jul, '65	80	33	8.5	TR-7 14	37	8 gr.	Belly rotted before I could stuff it, so the fur and hide of belly are absent.
16	♀	Bat, fish eating	"	"	14 Jul, '65	116	27	29	TR-6.5 27.5	85	60 gr.	
17	♀	Bird, tyrant flycatcher	"		15 Jul, '65	139	60	C.W. 74	TAR. 17	Cul. 18	—	
18	♂	Bird, Oven bird	Peru, Dept Pasco, Prov. Oxapampa, Rio Neguachi – approx. 3 mi NE of Nevati Mission	"	15 Jul, '65	177	59	C.W. 87	TAR. 31.5	Cul. 20	—	
19	♂	Bird, Silver-beaked Tanager	½ mi East. Peru, Dept Pasco, Prov. Oxapampa, Nevati –	"	16 Jul, '65	160	80	C.W. 77	TAR. 21	Cul. 15	—	beak silver color.
20	♀	Bird, lineated woodpecker	East side of Neguachi River. Peru, Dept Pasco, Prov. Oxapampa, Nevati,	"	15 Jul, '65	298.5	143	C.W. 193	TAR. 27	Cul. 40	—	
21	♀	Bat	1 mi NE of confluence of Rios Neguachi and Mandarague. Peru, Dept Pasco, Prov. Oxapampa, Nevati,	900'	19 Jul, '65	72	15	14	TR-9 20.5	43	15 gr.	
22	♂	Bat	"	"	19 Jul, '65	48	NONE	7.5	TR-6 15	35	8 gr.	
23	♀	Bat	"	"	19 Jul, '65	46	NONE	9	TR-6.5 15.5	31	6 gr.	
24	♂	Bat	"	"	20 Jul, '65	71	NONE	14.5	TR-7 19	48.5	24 gr.	
25	♂	Bird	"	"	19 Jul, '65	130	36	C.W.– 68	TAR.– 20	Cul. 9	—	
26	♂	Bird, hummingbird.	"	"	20 Jul, '65	110	41	C.W.– 43	TAR.– 5	Cul. 26	—	
27	♂	Bird, hummingbird.	"	"	20 Jul, '65	100	31.5	C.W.– 57	TAR.– 5	Cul.– 20	—	
8												
9												
0												

EXHIBIT 2

Example of a Field Notes Page (anonymous)

Peru, Dept. Pasco, Pozo. Oxapampa, Iscozacin, 4000 ft.

JUN 15 We rose about 5:45 am today to meet with Indians at their morning assembly. Just after breakfast Max and I went to check some "M.S."s which he had set out the night before. The results were such that only one trap was sprung. Since it had rained the night before, I don't know if the oatmeal used as bait was good or not. Afterwards we observed many (~~many~~) paradise tanager in a small clump of trees just south and east of the south end of the airstrip - In the same area we found a collared trogon (♂) at about 40 ft from the ground. Also located in that area, we saw a long-tailed tyrant catching insects in a dead tree about 50ft in height.

Shortly after a two hour lecture period given to us by both Dr. Seidel and Dr. Thorson, we, Dr. Thorson, Bill Esham, John Radomsky, Max Medley, two native guides, our guide - Cesar, and myself went for a 13 mile (approx by pedometer) hike into the tropical rain forest. Our direction to start was about South & West. We noticed that the majority of trees had lichens and moss growing along their trunks, and that the floor of the forest was covered with dead leaves and quite wet overall. We able to shoot a male and female trogon (about 8 in height) as our first specimens for the day. We came across a clearing of about one hundred ft in diameter with GUAVA trees - good to eat - and a PACHA tree - not a good thing to eat by Campa standards (yellow and pear-shaped). We identified by our Campa guide the name of a blue berry-like flower located near the floor of the earth - hoja de monte. As we neared our second sandy area - pasional -, I noticed that

EXHIBIT 3

A Proposal for a Biological Expedition to Peru, South America

Personal Copy

A PROPOSAL FOR A BIOLOGICAL EXPEDITION TO PERU, SOUTH AMERICA

Expedition Leaders:

1. Asa C. Thoresen, Ph.D., Chairman, Department of Biological Sciences, Andrews University, Berrien Springs, Michigan, Ornithologist and Coordinator of the Expedition.

2. Associate Leader - Donald R. Seidel, Ph.D. Assistant Professor of Biology, Andrews University, Mammalogist.

3. Assistant Leader - Merlin D. Tuttle, Museum Curator, Andrews University, Mammalogist.

Activity Period: June 1, 1964 - August 20, 1964

Objectives: The expedition will persue three main objectives.

1. Research in areas pertaining to the specialty of each investigator.

2. The general collection of small animal specimens and their parasites.

3. Biological and general nature photography.

Details of the objectives:

1. Research. Each of the expedition leaders will persue a line of investigation associated with his special interests. Each will contribute to the overall study of the ecological settings at various altitudes of the Andes down into the eastern jungle areas of Peru. The leaders are convinced that there is need for more interspecialty communication and cooperative field observations. The party will operate as three separate units, but will compare the extensive material and field notes accumulated.

Asa C. Thoresen will make a careful study of the Tanagers and prepare blood smears and preserve testes material for future study back in the United States of the chromosome patterns in this group of birds. It is important that studies such as these be correlated with diligent field observations by the investigator in order to be sure that correct data is recorded throughout the investigations. It is hoped that such studies will be extremely valuable in determining the true relationships of the group. It is possible also that the expedition will be able to collect more specimens of the new Genus of Tanagers found recently in Peru and represented by one specimen only.

Donald R. Seidel will study the ecological distribution of the mammals with special emphasis on comparing the population densities of

arboreal animals in the various ecological settings. Careful attention will be paid to comparing arboreal populations on the two sides of river systems. Dr. Seidel will also make collections of ectoparasites infesting the animals.

Merlin Tuttle has long been interested in Bat populations and will collect extensively of these creatures for taxonomic purposes. It is believed that new species are likely to show up in careful collections such as planned. Modern methods of collecting, such as mist netting, has not been used extensively in this area especially over the waterways, and it is believed that several species have been missed in previous collections. It is hoped that our initial expedition will provide the experience and the ground work for future trips to make complete life history studies of several species in the natural environment. Practically nothing is known in the literature of the habits of many of the creatures inhabiting many areas in South America.

2. The three areas of emphasis as outlined above will all require extensive collecting of specimens to be prepared as study skins and skeletons and brought back to North America for the benefit of all interested in Taxonomy. The American Museum of Natural History, the United States National Museum, and the Chicago Museum of Natural History have expressed interest and enthusiasm in our projects and emphasize the need for more complete collections and data from Peru. The collections will be deposited in one of the above museums, or in the Andrews University Museum of Natural History, depending upon financial outcomes, for the availability to investigators who may wish to study the specimens.

3. Biological Photography. Asa C. Thoresen is an accomplished photographer with the 35mm and 16mm cameras. He has had considerable experience in macrophotography of biological specimens and plans to photograph all the interesting and unusual findings and occurrences as the expedition progresses. It is planned to produce picture articles that will interest the editors and readers of the National Geographic magazine.

Personnel:

The party will consist of the three men listed as expedition leaders and seven carefully selected students who are trained field collectors and assistants, who are majors in biology at Andrews University. This will make a complete party of ten people on the expedition, and will facilitate the division of the party into the three research groups. Background sketches of the expedition leaders are attached. The seven student assistants are named as follows:

1. Arden Tuttle: Experienced field collector of mammals, Mexico June-September 1962. These specimens were prepared for the American Museum.

2. John Kelley: Trained in field biology techniques at Andrews University 1963. Fluent in speaking Spanish. Experienced jungle guid in Chiapas, Mexico.

3. Delbert Knowlton: Trained in museum field collecting at Andrews University 1963.

4. Edwin Buck: Trained in museum field collecting at Andrews University 1963. Has travelled in Asia, Africa, Europe and Central America. Fluent in speaking Spanish.

5. Fred Meyers: Trained in field and museum methods at Andrews University. Teaching assistant at Andrews University 1961-present. Honor student in zoology.

6. Thomas Seifert: Trained in field and museum methods at Andrews University 1963. Has studied Spanish and communicates well.

7. Robert Stringer: Trained in field and museum methods at Andrews University 1963-1964. Honor student in zoology.

Academic credit will be allowed for these student assistants because we feel that the tropical area will give them valuable additional experience. It is emphasized that these men are already skilled personnel.

Methods of Travel:

The least expensive means of travel to Peru is by Peruvian Airlines from Miami to Lima. Most of the travel between Lima and San Ramon will be by motor vehicle provided by local missionaries of the Adventist missions with whom Andrews University is affiliated. Bus and rail travel in the Andes area is also available. Jungle headquarters will be at the Nevati mission station on the Pachitea River. Access to the station will be by light plane which will fly out of San Ramon and Pulcallpa to various other jungle points. We can hire the plane and pilot for $12.00 per hour. Canoes and outboard motors are available at the mission station for travel to various positions along the river system. Short hiking trips with Campa Indian guides are planned.

Plans and Itinerary:

We will leave Michigan May 31, and arrive in Lima, Peru, June 5, 1964. Supplies will be purchased at our order and will be ready to pick up upon arrival in Lima. Some will be shipped ahead to the Nevati mission, and the essentials carried with us to the various study areas in the Andes previously picked out by Mr. Merlin Tuttle during the summer of 1963.

The expedition should begin study at various altitudes in the Andes by June 8. It is planned to spend up to one week in each location, depending upon the terrain and density of animal population. Each week will provide enough time for about 6000 trap nights for small mammals. After five weeks of gradually working down to lower altitudes on the Eastern side of the Andes, we plan on moving into the Nevati Mission station area where we will remain until August 15.

Specimens and personnel will be flown back to Miami after that date. Some heavier materials will be shipped by surface transport back to the United States.

Because Mission's personnel are willing to help to facilitate our expedition in Peru, little time should be lost from the planned itinerary. All permits will be arranged for before our arrival in Lima.

Estimated Budget:

1.	Personnel Transportation	$ 3,800
2.	Food, lodging, etc. (10 persons, 3 months)	1,200
3.	Traps, weapons, and nets	400
4.	Collection supplies	300
5.	Photographic equipment and supplies	1,000
6.	Insurance	250
7.	Freight on Collections back to United States	500
8.	Fellowships for research assistants	2,000
9.	Salaries for leaders	paid by University
10.	Emergency fund for unexpected expenses	750
11.	Post expedition care, study, distribution, and housing of specimens	paid by University
	Total	$10,200

Financial Support:

1.	Furnished by Andrews University	3,700
2.	Private contributions	3,000
3.	Research grant requested from National Geographical Society	3,500
	Total	$10,200

Biographies of the Expedition Leaders:

1. Asa C. Thoresen

Born September 9, 1930, Blenheim, New Zealand, University Entrance 1948, Auckland, New Zealand; B.A. 1954 Emmanuel College, Michigan; M.A. in Zoology 1958 Walla Walla College, Washington; Ph.D. in Zoology 1960 Oregon State University. Teaching fellow Oregon State University 1957-1960. Research assistant, U.S. Fish and Wildlife Service, Portland Oregon, Summer 1959; Studied population dynamic's and ecology of the Sea birds on the Farallon Islands, California. Visiting professor biology, Walla Walla College Marine Station, Anacortes, Washington, Summer 1960. Assistant professor biology, Andrews University 1960-1963. Associate professor and Chairman Department of Biology, Andrews University 1963-present.

Military Service: 1954-1956 Instructor, Army Medical Service, Fort Sam Houston, Texas.

Foreign Travel: New Zealand, Fiji Islands, throughout U.S., Canada and Mexico.

Expeditions: Confined to the U.S. Leader of short collecting trips to Texas, Florida, Olympic Mountains, Gaspe Peninsula. Population studies of nesting seabirds in the San Juan Island area, Summer.

Publications:

1. Breeding Behavior of the Pigeon Guillemot Cepphus columba (Pallas) 1958 Walla Walla College Publications of the Department of Biological Sciences and the Biological Station.

2. Notes on the Winter and Early Spring Bird Activity on the Farallon Islands 1960 Condor

3. Popular style article Gulls, auklets and guillemots, at Press Audubon's Magazine.

4. At Press, Breeding Behavior and Growth Rates in Cassin's Auklet Ptychoramphus aleutica (Pallas) Condor.

Memberships: Sigma Xi, Phi Sigma, A.A.A.S., American Ornithological Union, Cooper Ornithological Society, Listed in Leaders in American Science, and Who's Who in American Education.

2. Donald R. Seidel

Born January 14, 1926, Reading, Pennsylvania, Graduated 1944 from Lebanon, Penna. High School B.A. 1952, M.A. 1954, Zoology, Walla Walla

College, Washington. Ph.D. 1960, Vertebrate Zoology, Cornell University.

Academic Positions Held: Teaching assistant, Walla Walla College 1951 to 1954. Assistant professor of biology, Solusi Missionary College, Southern Rhodesia, Africa 1954-1957. Graduate Research Assistant, Cornell University, 1957-1960. Research Assistant, University of California at Davis, 1960-1963. Assistant Professor Biology Andrews University 1963-present.

Military Service: U.S. Marine Corps, 1944-1947. Aviation Electrician and Automatic Pilot Technician.

Publications:

1. Biology and breeding habits of the meadow mouse, Microtus montanus, in eastern Washington. No. 29 1960 Walla Walla College Publications of the Department of Biological Sciences and the Biological Station.

2. Observations on a captive short-tailed weasel, Journal of Mammalogy 40(4), 1959.

3. Homing in the eastern chipmunk, Journal of Mammalogy 42(2), 1961.

4. Series of popular articles on African mammals. The Naturalist. Assoc. Nat. Clubs of America., College Place, Washington. 19(2), 1959; 19(4), 1959; 20(2), 1960.

Memberships: Sigma Xi, The American Society of Mammalogists, American Institute of Biological Sciences.

3. Merlin D. Tuttle

Born August 26, 1941, Honolulu, Hawaii, University of Tennessee 1961. B.A. 1964 Andrews University, Curator, Museum of Natural History Andrews University 1963-present. Has been an active collector of mammals since 10 years of age.

Expeditions: Mexico 1954, one month; 1955, one month; June-September 1962. In 1962 Mr. Tuttle and his brother Arden, collected in Mexico for the Summer and returned with an outstanding collection of 2,000 mammals, 100 birds, 400 amphibians and reptiles, and 4,000 ectoparasites. Member of the American Museum of Natural History Expedition to Uraguay, December 1962-May 1963. Travelled and collected in Argentina, Paraguay, Bolivia, Peru, Equador, Galapagos Islands, Columbia, Venezuela, Trinidad, Barbados, St. Vincent, Martinique, Quadelupe, and Antigua, June 1963-August 1963.

Research experience: Migratory movements of the bat Myotis grisescen in Tennessee.

Purpose: To determine migratory routes, summer and winter distribution, ecological requirements, environmental factors related to movements. Mr. Tuttle has banded 7,000 bats and plans to continue his study in future years. He has travelled extensively visiting known colonies and searching for new ones in Tennessee. He has made extensive notes on sex ratios also.

In addition Mr. Tuttle has been active making a complete Ecological study of mammals on Roan Mountain, Tennessee, the specimens of which have been donated to the U.S. National Museum in Washington D.C. where his work is well known.

Publications:

At Press: Journal of Mammalogy.
1. First Record of Myotis subulatus in Tennessee.

2. Observations on Sorex cinereus.

3. The occurrence of Sorex longinostris in Tennessee.

EXHIBIT 4

List of Mammals Collected During the 1964 Andrews University
National Geographic Society Expeditions to Peru

List of Mammals Collected During the
1964 Andrews University
National Geographic Society
Expedition to Peru

Compiled by

D. R. Seidel

1964 PERUVIAN EXPEDITION

Peru, Dept. Lima, Prov. Huarochiri, 6.3 mi. W. Casapalca. 12,500 ft.

Rodentia
- Cricetidae
  - Oryzomys - 11
  - Akodon jelskii - 2
  - Akodon sp. - 86
  - Calomys sorella - 73
  - Phyllotis - 24

Alcoholic
- Akodon sp. - 3
- Calomys sorella - 10
- Oryzomys sp. - 1
- Phyllotis sp. - 4
- Oxymycterus sp. - 1

Skulls Only - 48
Skeleton Only - 1
Skeleton (with skin & skull)-2

Peru, Dept. Lima, Prov. Huarochiri, 1.2 mi. N.W. Chinchan. 15,600 ft.

Rodentia
- Cricetidae
  - Akodon jelskii - 2
  - Akodon sp. - 15
  - Calomys lepidus - 7
  - Calomys sorella - 13
  - Phyllotis - 25
  - Neotomys - 6
  - Oryzomys - 1

Skull Only - 13
Skeletons - 6

Peru, Dept. Junin, Prov. Yauli, 9.5 mi. N. La Oroya. 13,000 ft.

Rodentia
- Cricetidae
  - Oryzomys - 18
  - Akodon jelskii - 9
  - ? Akodon sp. - 2
  - Calomys sorella - 31
  - Akodon sp. - 31
  - Phyllotis - 26
  - Neotomys - 28

Alcoholic
- Akodon sp. - 6
- Oryzomys sp. - 3
- Phyllotis sp. - 6
- Calomys sorella - 1
- Neotomys sp. - 3

Skulls Only - 27
Skeletons - 2

Peru, Dept. Junin, Prov. Tarma, 20 mi. E. Tarma. 7,900 ft.

Marsupialia
- Didelphidae
  - Marmosa - 3
  - Didelphis - 1 (skin lost)

Chiroptera
- Phyllostomidae
  - Anoura - 53
  - Sturnira - 2

Rodentia
- Cricetidae
  - Oryzomys - 77
  - Oxymycterus - 26
- Muridae
  - Rattus rattus - 2

Alcoholic
- Anoura geoffroyi - 4
- Oryzomys sp. - 6
- Oxymycterus sp. - 3

Skull Only - 10
Skeleton Only - 3
Skeletons - 3

Peru, Dept. Junin, Prov. Tarma, 2km. NW San Ramon. 2,900 ft.

Marsupialia — Skull Only - 5
- Didelphidae — Alcoholic
  - Marmosa - 4
  - Marmosa sp. - 1

Chiroptera — Glossophaginae - 2; Artibeus lituratus - 1
- Emballonuridae
  - Saccopteryx bilineata - 1
- Phyllostomidae — Carollia perspicillata - 1; Eptesicus sp. - 1
  - Anoura - 2
  - Carollia perspicillats - 11
  - C. castanea - 2
  - Sturnira - 35
  - Artibeus lituratus - 34
  - A. jamaicensis - 2
  - White-lined bats - 14
- Desmodontidae
  - Desmodus rotundus - 4
- Vespertilionidae
  - Myotis nigricans - 1

Rodentia
- Sciuridae
  - Sciurus - 1
- Cricetidae
  - Oryzomys - 11
  - Neacomys - 1
  - Nectomys (Holochilus?) - 3
  - Oxymycterus (aerosus?) - 15
- Muridae
  - Rattus rattus - 1

Peru, Dept. Junin, Prov. Tarma, 3 mi. S. San Ramon, E. side Tulamayo R., 2772 ft.

Marspialia — Skulls Only - 4; Skeleton - 1
- Didelphidae
  - Marmosa - 3
  - Metachirus - 1

Chiroptera
- Phyllostomidae
  - Carollia perspicillata - 1
  - Artibeus lituratus - 1 — Alcoholic

Rodentia — Nectomys (Holochilus?) - 1
- Cricetidae
  - Oryzomys - 1
  - Neacomys - 3
  - Nectomys (Holochilus?) - 5
  - Oxymycterus (aerosus?) - 11

Peru, Dept. Junin, Prov. Tarma, 6 mi. S. San Ramon, E. side Tulamayo R., 2772 ft.

Marsupialia — Skull Only - 1
- Didelphidae
  - Metachirus - 1 — Alcoholic

Chiroptera — Micronycteris sp. - 1
- Phyllostomidae
  - Carollia perspicillata - 2

Rodentia
Cricetidae
Oryzomys - 6
Neacomys - 3
Oxymycterus (aerosus?) - 4

Peru, Dept. Junin, Prov. Tarma, 20 km. NE La Merced.

Edentata
Bradypodidae
Choloepus - 1

Peru, Dept. Junin, Prov. 13 mi., N. La Merced, Rio Seco Alto.

Marsupialia — Skulls Only - 3
Didelphidae
Marmosa - 1
Chiroptera
Phyllostomidae
Carollia perspicillata - 2 — Alcoholic
White-lined bat - 1
Rodentia — Oryzomys sp. - 2
Cricetidae
Oryzomys - 14
Neacomys - 1
Nectomys - 6
Rhipidomys - 1
Oxymycterus iris - 18

Peru, Dept. of Pasco, Prov. Oxapampa, Nevati.

Marsupialia — Skull Only - 32; Skeleton Only - 2; Skeletons - 9
Didelphidae
Caluromys lanatus - 1
Philander opossum - 2
Metachirus - 2
Didelphis - 3
Chiroptera
Phyllostomidae
Phyllostomus hastatus - 21
Carollia perspicillata - 38
Rhinophylla pumilio - 1 — Alcoholic
Sturnira - 12
Artibeus cinereus - 1 — Carollia perspicillata - 1
A. lituratus - 6 — Molossus sp. - 1
White-lined bat - 1
Desmodontidae
Desmodus rotundus - 1
Vespertilionidae
Myotis albescens - 7
M. nigricans - 6
Molossidae
Molossus - 6
Primates
Cebidae
Aotus - 4

Pithecia - 6
Alouatta - 1
Cebus - 4
Saimiri - 4
Callithricidae
Saguinus - 2
Edentata
Bradypodidae
Bradypus - 1
Rodentia
Cricetidae
Oryzomys sp. - 59
Neacomys sp. - 2
Nectomys (Holochilus?) - 14
Dasyproctidae
Dasyprocta - 1
Echimyidae
Proechimys sp. - 30
Mesomys sp. - 1
Isothrix sp. - 1
Carnivora
Procyonidae
Nasua - 1
Potos flavus - 2
Mustelidae
Tayra (Eira) - 1
Felidae
Felis - 1

Peru, Dept. Pasco, Prov. Oxapampa, 10 mi., E. Nevati, Puerto Madrid, N. side Rio Nevati.

Chiroptera
Tonatia - 2
Phyllostomus hastatus - 1
Rodentia
Sciuridae
Microsciurus - 1
Primates
Cebidae
Lagothrix - 1
Artiodactyla
Cervidae
Fawn - 1

Peru, Dept. Pasco, Prov. Oxapampa, San Pablo.

Marsupialia
Didelphidae
Caluromys lanatus - 1
Marmosa - 7
Philander opossum - 5
Metachirus - 1
Didelphis - 2
Chiroptera
Emballonuridae

Skull Only - 12
Skeleton Only - 10
Skeletons - 21

Alcoholic

Saccopteryx sp. - 1

- Rhynchonycteris - 4
- Saccopteryx - 25
- Peropteryx - 1
- Cormura or Peropteryx - 1

Noctilionidae
- Noctilio leporinus - 3
- N. labialis - 2

Phyllostomidae
- Tonatia - 4
- Mimon - 7
- Phyllostomus hastatus - 4
- P. ebngatus - 15
- Carollia perspicillata - 60
- C. castanea - 1
- Rhinophylla pumilio - 12
- Sturnira - 21
- Artibeus cinereus - 15
- A. liturstus - 13
- White-lined bats - 3

Desmodontidae
- Desmodus rotundus - 5

Vespertilionidae
- Myotis nigricans - 3
- M. simus - 1

Rodentia

Sciuridae
- Sciurus - 1

Cricetidae
- Oryzomys - 23
- Neacomys - 2
- Nectomys (Holochilus?) - 13
- Thomasomys (Rhipidomys) - 3

Hydrochoeridae
- Hydrochoerus - 1

Dasyproctidae
- Dasyprocta - 2

Echimyidae
- Proechimys - 26

Primates

Cebidae
- Aotus - 2
- Alouatta - 5
- Cebus - 2
- Saimiri - 9

Carnivora

Procyonidae
- Potos - 3

Mustelidae
- Tayra (Eira) - 1

Artiodactyla

Cervidae
- Mazama - 2

Peru, Dept. Pasco, Prov. Oxapampa, San Juan.

Chiroptera
- Emballonuridae
  - Rhynchonycteris - 4
  - Saccopteryx bilineata - 2
- Noctilionidae
  - Noctilio leporinus - 4
  - N. labialis - 5
- Phyllostomidae
  - Phyllostomas hastatus - 4
  - P. elongatus - 5
  - Trachops cirrhosus - 1
  - Lonchorhina aurita - 1
- Carollia perspicillata - 44
  - C. castanea - 9
- Rhinophylla pumilio - 7
  - Sturnira - 15
  - Artibeus cinereus - 3
  - A. lituratus - 2
  - A. jamaicensis - 3
  - White-lined bats - 4
- Desmodontidae
  - Desmodus rotundus - 1
- Vespertilionidae
  - Myotis albescens - 4
  - M. simus - 1

Rodentia
- Sciuridae
  - Sciurus - 1
- Dasyproctidae
  - Dasyprocta - 1
- Echimyidae
  - Proechimys - 3

Carnivora
- Mustelidae
  - Tayra (Eira) - 1

Skull Only - 1
Skeleton Only - 1
Skeletons - 17

Peru, Dept. Loreto, Prov. Coronel Portillo, Shahuaya.

Chiroptera
- Phyllostomidae
  - Carollia perspicillata - 6
  - Sturnira - 3

Rodentia
- Cricetidae
  - Oryzomys - 16
  - Nesoomys - 1
- Echimyidae
  - Proechimys - 14

Skull Only - 3

Specimens still at National Museum - To be returned later.

Noctilio labialis - 1
Micronycteris minuta - 3
Micronycteris hirsuta - 3
Lonchophylla sp. - 1
Anoura geoffroyi - 1
Tonatia silvicola - 1
Carollia castanea - 3
Sturnira large,hairy species - 3
Sturnira medium, hairy sp. - 1
Sturnira small, hairy sp. - 3
Sturnira medium, short-haired sp. - 2
Sturnira small, short-haired sp. - 2
Vampyodes ornatus - 1
Myotis nigricans - 1
Molossus sp. - 1

EXHIBIT 5

Abstract of Data Collected on the Andrews University
National Geographic Expeditions to Peru
in 1964 and 1965

— 1 copy —

Abstract of Data Collected on

the Andrews University - National Geographic

Expeditions to Peru in 1964 and 1965.

1¼ margin

Double Space

Investigators: Asa C. Thoresen, Ph.D., Chairman, Department of Biology, Andrews University, Berrien Springs, Michigan, Ornithologist, Project leader.

Donald R. Seidel, Ph.D., Associate Professor of Biology, Andrews University, Mammalogist. Associate leader.

Merlin D. Tuttle, Museum Curator, Andrews University, Mammalogist. (Now in graduate work at University of Kansas), Associate Leader 1964.

Other personnel assisting in the field during the expeditions were as follows: 1964: Arden Tuttle, John Kelley, Delbert Knowlton, Edwin Buck, Fred Meyers, Thomas Seifert, Robert Stringer; 1965: William Esham, Donald Grosse, Joel Hoag, Paul Martsching, Max Medley, Keith Messersmith, Eugene Morrison, Floyd Murdoch, John Radomsky, and Ralph Seland.

Objectives:

The objectives of the expeditions were to extend our present knowledge of the distribution of birds and small mammals of Peru and to make a collection of blood smears and parasites. Special emphasis was to be given to the ecology and distribution of bat populations. Mist nets were used extensively for collecting both small birds and bats. Future trips to the same localities are planned to follow up the initial investigations with efforts to record behavior and life history data of birds and bats. Camps were located at various elevations in the Andes from 5,000 meters to 300 meters in the Amazon Headwaters and Gran Pajonal.

Summary of the Results:

From June to August 1964 and 1965 the group studied the ecology of mammals and birds from 5,000 meters altitude in the Andes and at several points bordering the Gran Pajonal territory, Oxapampa Province, Pasco Department, Peru. We also covered, by trail, a distance of 115 miles between the remote

village Tsioventeni to Nevati.

Botanical transects one meter wide and twenty meters long, made at Tsioventeni (1,300 meters elevation) indicated 66.6% chamaeophytes, 19% phaenerophytes and 14.4% geophytes. At Nevati (300 meters elevation) our figures indicate 58% chamaeophytes, 28% phaenerophytes and 14% geophytes.

Approximately 2100 mammals were collected, 1500 of which have been deposited in the American Museum in New York. The remainder are housed at Andrews University. Bats were collected from very conceivable niche and habitat that we could get into. We shot them from the roofs of caves, netted them in forest and village and crawled into hollow trees to extricate them. Our methods were highly successful. Eighteen species, not previously recorded from Peru, were collected. Two of these were known before only from Trinidad. A new Genus concurrently collected in Surinam is in the collection and a new species from Peru was included.

Details of the study are to be published by Merlin D. Tuttle in the Proceedings of the United States National Museum under the title: "Annotated Checklist of Bats of Peru with Biological Data."

Parasites are being identified by specialists for each type pending the accurate determination of the host species. Dr. Robert Traub of the Microbiology Department, University of Maryland, is ~~presently~~ in charge of the parasites collected.

Two hundred and twenty bird species (780 specimens) collected are deposited in the Andrews University museum with the exception of one colinga which was a new record for Peru, (Lipaugus subalaris). Two of this species were taken at Tsioventeni in the forest bordering the Gran Pajonal. One which has been deposited in the museum of the University of Louisiana, Baton Rouge.

A paper entitled "Ecological Notes on Birds Collected in Central Peru," has been submitted for publication to the Auk journal authored by Asa C.

Thoresen. His report is confined to observations of birds collected in the low forest areas since the ecology of birds in the High Andes is fairly well known.

Of the 154 species collected, 77 were taken from the lower stratum of the forest up to three meters from the ground, 60 from the middle, to 15 meters, and 17 from the highest stratum up to 50 or 60 meters high. The figures are an indication of our collecting and do not necessarily represent the true ecological situation. The investigators believe that nest location is a better ecological indicator although there is some merit in collection data.

Many 35 mm photographs were taken while in Peru, and sixty-five transparencies have been retained in the National Geographic Society files.

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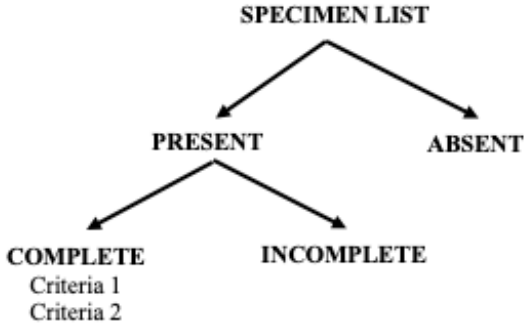
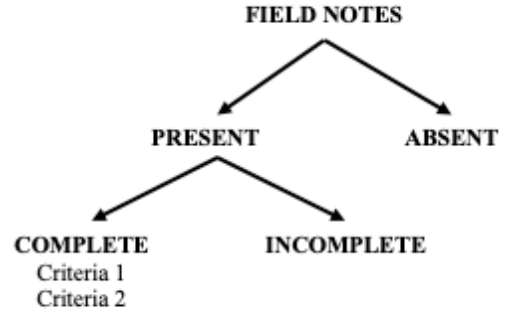
APPENDIX B

SPECIMEN LIST & FIELD NOTES EVALUATION GUIDELINES



1: Specimen numbers continuous. If non-continuous, missing specimen numbers determined to be non-mammalian/non-existent.

2: First and last recorded mammal specimen determined to be the first/last collected mammal specimen based on first/last collection day for the given participant as described in the field notes.



1: Field note entries continuous.

2: First and last field note entries correspond to dates of arrival and departure from Lima, Peru, respectively.

APPENDIX C

TAXONOMIC ADJUSTMENTS IMPLEMENTED

Previous name	Current name	Reference
Aotus trivirgatus	*Aotus vociferans*	Hershkovitz (1983)
Artibeus jamaicensis	*Artibeus planirostris*	Larsen et al. (2010)
Isothrix villosa	*Isothrix bistriata*	Patterson and Velazco (2006)
Marmosops impavidus	*Marmosops caucae*	Voss (2022)
Metachirus nudicaudatus	*Metachirus myosuros*	Voss et al. (2019)
Mimon crenulatum	*Gardnerycteris crenulata*	Hurtado and D'Elía (2018)
Oryzomys megacephalus	*Hylaeamys perenensis*	Weksler et al. (2006)
Oryzomys yunganus	*Hylaeamys yunganus*	Weksler et al. (2006)
Philander opossum	*Philander canus*	Voss et al. (2018)
Platyrrhinus helleri	*Platyrrhinus incarum*	Velazco et al. (2010)
Sciurus spadiceus	*Hadrosciurus spadiceus*	de Abreu-Jr et al. (2020)

APPENDIX D

MAMMAL SPECIMENS COLLECTED BY LOCALITY

Ecoregion - Puna					
Camp 1 – elev. 3,810 m		Camp 2 – elev. 4,755 m		Camp 3 – elev. 3,962 m	
Rodentia	279	Rodentia	72	Rodentia	226
Cricetidae	270	Cricetidae	71	Cricetidae	213
Abrothrix jelskii	2	*Abrothrix jelskii*	2	*Abrothrix jelskii*	12
Akodon juninensis[E]	109	*Akodon juninensis*[E]	14	*Akodon boliviensis*	1
Akodon orophilus[E]	1	*Auliscomys pictus*	27	*Akodon juninensis*[E]	48
Akodon sp	4	*Calomys lepidus*	7	*Akodon sp*	6
Auliscomys pictus	2	*Calomys sorellus*[E]	14	*Auliscomys pictus*	37
Calomys lepidus	3	*Neotomys ebriosus*	6	*Calomys lepidus*	2
Calomys sorellus[E]	102	*Oryzomys sp*	1	*Calomys sorellus*[E]	32
Oligoryzomys andinus	11	BLANK	1	*Calomys sp*	2
Phyllotis andium	36			*Neotomys ebriosus*	47
BLANK	9			*Oligoryzomys flavescens*	4
				Oligoryzomys sp	20
				Phyllotis andium	2
				BLANK	13
TOTAL	279	TOTAL	72	TOTAL	226

[E] Endemic species.

Ecoregion - Yungas							
Camp 4 (1) – elev. 2,225 m		Camp 4 (2) – elev. 845 m		5 (1) – elev. 884 m			
Chiroptera	66	Chiroptera	2	ɔtera	124	Rodentia cont.	
Phyllostomidae	66	Phyllostomidae	2	Emballonuridae	1	Muridae	2
Anoura geoffroyi	61	*Artibeus planirostris*	1	*Saccopteryx bilineata*	1	*Rattus rattus*	2
Sturnira bogotensis	1	*Carollia perspicillata*	1	Phyllostomidae	121	Sciuridae	1
Sturnira erythromos	4	Didelphimorphia	4	*Anoura geoffroyi*	2	*Sciurus sp*	1
Didelphimorphia	3	Didelphidae	4	*Anoura latidens*	1	BLANK	5
Didelphidae	3	*Marmosops noctivagus*	2	*Artibeus planirostris*	37		
Marmosops juninensis[E]	3	*Metachirus myosuros*	2	*Carollia brevicauda*	3		
Rodentia	142	Rodentia	28	*Carollia castanea*	2		
Cricetidae	126	Cricetidae	24	*Carollia perspicillata*	10		
Akodon aerosus	1	*Akodon aerosus*	12	*Desmodus rotundus*	4		
Akodon orophilus[E]	34	*Neacomys spinosus*[E]	4	*Glossophaga soricina*	7		
Akodon sp	3	*Nectomys squamipes*	6	*Lonchophylla handleyi*	1		
Calomys sorellus[E]	1	*Oryzomys sp*	2	*Micronycteris megalotis*	1		
Microryzomys altissimus	8	BLANK	4	*Platyrrhinus infuscus*	9		
Microryzomys minutus	5			*Sturnira bogotensis*	5		
Oligoryzomys destructor	69			*Sturnira lilium*	32		
Oryzomys sp	1			*Sturnira ludovici*	1		
Rhipidomys sp	1			*Vampyrodes caraccioli*	6		
Thomasomys aureus	3			Vespertilionidae	2		
Muridae	3			*Eptesicus andinus*	1		
Rattus rattus	3			*Myotis nigricans*	1		
BLANK	13			Didelphimorphia	6		
				Didelphidae	6		
				Marmosops noctivagus	6		
				Rodentia	43		
				Cricetidae	35		
				Akodon aerosus	19		
				Neacomys spinosus[E]	1		
				Nectomys squamipes	3		
				Oligoryzomys destructor	10		
				Oryzomys sp	2		
TOTAL	211	TOTAL	34	TOTAL			173

[E] Endemic species.

Ecoregion – Yungas cont.					
Camp 5 (2) – elev. 845 m		Camp 6 (2)[a] – elev. 724 m		Tsioventeni[b] – elev. 1,280 m	
Chiroptera	3	Chiroptera	4	Carnivora	2
Phyllostomidae	3	Phyllostomidae	4	Mustelidae	1
Carollia brevicauda	1	*Carollia perspicillata*	2	*Eira barbara*	1
Carollia perspicillata	1	*Lonchophylla handleyi*	1	Procyonidae	1
Micronycteris megalotis	1	*Platyrrhinus incarum*	1	*Nasua nasua*	1
Rodentia	20	Didelphimorphia	3	Chiroptera	52
Cricetidae	20	Didelphidae	3	Phyllostomidae	52
Akodon aerosus	7	*Marmosa murina*	2	*Artibeus gnomus*	1
Neacomys spinosus[E]	6	*Marmosops noctivagus*	1	*Carollia sp*	16
Oligoryzomys destructor	5	Pilosa	1	*Chiroderma trinitatum*	1
Oryzomys sp	2	Choloepodidae	1	*Diphylla ecaudata*	3
		Choloepus hoffmanni	1	*Lonchorhina aurita*	1
		Rodentia	52	*Platyrrhinus incarum*	1
		Cricetidae	50	*Platyrrhinus infuscus*	14
		Hylaeamys perenensis	1	*Platyrrhinus sp*	2
		Neacomys spinosus[E]	1	*Sturnira erythromos*	1
		Nectomys squamipes	8	*Sturnira lilium*	1
		Oligoryzomys destructor	2	*Sturnira magna*	2
		Oligoryzomys microtis	13	*Trachops cirrhosis*	9
		Oryzomys sp	1	Didelphimorphia	2
		Oxymycterus inca	14	Didelphidae	2
		Oxymycterus sp	9	*Caluromys lanatus*	1
		Rhipidomys sp	1	*Glironia venusta*	1
		BLANK	2	Primates	6
				Cebidae	4
				Aotus nigriceps	4
				Pitheciidae	2
				Pithecia inusta	2
				Rodentia	20
				Cricetidae	18
				Akodon aerosus	4
				Nectomys sp	1
				Oligoryzomys destructor	13
				Sciuridae	2
				Hadrosciurus pyrrhinus	2
TOTAL	23	TOTAL	60	TOTAL	82

[a] Includes one specimen donated to Merlin by a truck driver and collected near Camp 6 (2).

[b] Includes four specimens collected at elev. 610–914 m on the trek from Tsioventeni to Nevati during the 1965 expedition (Chapter 2).

[E] Endemic species.

Ecoregion – Selva Baja					
Nevati Mission[c] – elev. 274 m		San Juan – elev. 274 m		San Pablo[d] – elev. 274 m	
Artiodactyla	3	Carnivora	6	Artiodactyla	2
Cervidae	2	Mustelidae	2	Cervidae	2
Mazama sp	2	*Eira barbara*	2	*Mazama americana*	1
Tayassuidae	1	Procyonidae	4	*Mazama sp*	1
Dicotyles tajacu	1	*Potos flavus*	4	Carnivora	4
Carnivora	10	Chiroptera	595	Mustelidae	1
Felidae	3	Emballonuridae	98	*Eira barbara*	1
Leopardus pardalis	3	*Cormura brevirostris*	2	Procyonidae	3
Mustelidae	2	*Peropteryx kappleri*	1	*Potos flavus*	3
Eira barbara	1	*Peropteryx macrotis*	12	Chiroptera	260
Lontra longicaudis	1	*Rhynchonycteris naso*	10	Emballonuridae	37
Procyonidae	5	*Saccopteryx bilineata*	69	*Peropteryx macrotis*	1
Nasua nasua	1	*Saccopteryx leptura*	4	*Rhynchonycteris naso*	6
Potos flavus	4	Molossidae	2	*Saccopteryx bilineata*	30
Chiroptera	211	*Molossops neglectus*	2	Molossidae	3
Emballonuridae	1	Noctilionidae	8	*Molossus molossus*	3
Saccopteryx leptura	1	*Noctilio albiventris*	2	Noctilionidae	9
Molossidae	14	*Noctilio leporinus*	6	*Noctilio albiventris*	6
Molossops neglectus	1	Phyllostomidae	438	*Noctilio leporinus*	3
Molossus molossus	13	*Artibeus anderseni*	8	Phyllostomidae	206
Noctilionidae	9	*Artibeus lituratus*	8	*Artibeus anderseni*	1
Noctilio albiventris	2	*Artibeus obscurus*	5	*Artibeus lituratus*	4
Noctilio leporinus	7	*Artibeus planirostris*	9	*Artibeus planirostris*	9
Phyllostomidae	152	*Carollia brevicauda*	4	*Artibeus sp*	2
Artibeus lituratus	4	*Carollia castanea*	15	*Carollia castanea*	4
Artibeus planirostris	9	*Carollia perspicillata*	149	*Carollia perspicillata*	63
Artibeus sp	5	*Carollia sp*	1	*Chiroderma trinitatum*	1
Carollia perspicillata	45	*Chiroderma villosum*	1	*Choeroniscus minor*	2
Carollia sp	6	*Desmodus rotundus*	1	*Desmodus rotundus*	6
Desmodus rotundus	1	*Gardnerycteris crenulata*	2	*Diphylla ecaudata*	1
Glossophaga soricina	5	*Glossophaga soricina*	8	*Gardnerycteris crenulata*	6
Lionycteris spurrelli	1	*Glyphonycteris daviesi*	3	*Glossophaga soricina*	2
Lophostoma silvicolum	1	*Hsunycteris thomasi*	1	*Hsunycteris thomasi*	4
Phyllostomus hastatus	30	*Lichonycteris obscura*	1	*Lionycteris spurrelli*	1
Platyrrhinus brachycephalus	1	*Lionycteris spurrelli*	1	*Lophostoma silvicolum*	4
Platyrrhinus incarum	2	*Lonchophylla handleyi*	1	*Micronycteris microtis*	1
Rhinophylla fischerae	12	*Lonchorhina aurita*	5	*Micronycteris minuta*	2
Rhinophylla pumilio	5	*Lophostoma silvicolum*	28	*Phyllostomus elongatus*	16

Nevati Mission cont.		San Juan cont.		San Pablo cont.	
Chiroptera cont.		Chiroptera cont.		Chiroptera cont.	
Phyllostomidae cont.		Phyllostomidae cont.		Phyllostomidae cont.	
Sturnira bogotensis	1	*Macrophyllum macrophyllum*	1	*Phyllostomus hastatus*	18
Sturnira lilium	19	*Mesophylla macconnelli*	1	*Rhinophylla fischerae*	14
Sturnira sp	2	*Micronycteris hirsuta*	3	*Rhinophylla pumilio*	16
Sturnira tildae	2	*Micronycteris megalotis*	47	*Sturnira lilium*	22
Uroderma bilobatum	1	*Phyllostomus elongatus*	14	*Sturnira magna*	2
Vespertilionidae	35	*Phyllostomus hastatus*	53	*Sturnira tildae*	2
Myotis albescens	10	*Platyrrhinus brachycephalus*	7	*Uroderma bilobatum*	2
Myotis nigricans	21	*Platyrrhinus incarum*	4	*Vampyrodes caraccioli*	1
Myotis sp	4	*Platyrrhinus infuscus*	9	Vespertilionidae	5
Didelphimorphia	18	*Rhinophylla fischerae*	13	*Myotis nigricans*	2
Didelphidae	18	*Rhinophylla pumilio*	1	*Myotis riparius*	3
Caluromys lanatus	2	*Sturnira lilium*	24	Didelphimorphia	22
Didelphis marsupialis	8	*Sturnira magna*	2	Didelphidae	22
Metachirus myosuros	2	*Sturnira tildae*	1	*Caluromys lanatus*	3
Philander canus	5	*Trachops cirrhosis*	2	*Didelphis marsupialis*	1
Philander sp	1	*Uroderma bilobatum*	4	*Marmosops caucae*	8
Pilosa	4	*Uroderma magnirostrum*	1	*Marmosops noctivagus*	1
Choloepodidae	3	Vespertilionidae	49	*Metachirus myosuros*	1
Choloepus hoffmanni	3	*Eptesicus brasiliensis*[E]	1	*Philander canus*	6
Myrmecophagidae	1	*Myotis albescens*	43	*Micoeureus regina*	2
Tamandua tetradactyla	1	*Myotis riparius*	2	Primates	18
Primates	28	*Myotis simus*	3	Atelidae	5
Atelidae	1	Didelphimorphia	7	*Alouatta seniculus*	5
Lagothrix lagotricha	1	Didelphidae	7	Cebidae	13
Cebidae	19	*Caluromys lanatus*	2	*Aotus vociferans*	2
Aotus vociferans	4	*Didelphis marsupialis*	1	*Cebus apella*	2
Cebus apella	5	*Didelphis pernigra*	1	*Saimiri boliviensis*	9
Saguinus fuscicollis	2	*Metachirus myosuros*	1	Rodentia	112
Saimiri boliviensis	8	*Philander andersoni*	1	Cricetidae	68
Pitheciidae	8	*Micoeureus regina*	1	*Hylaeamys perenensis*	6
Pithecia inusta	1	Pilosa	2	*Hylaeamys sp*	2
Pithecia monachus	7	Choloepodidae	1	*Hylaeamys yunganus*	1
Rodentia	181	*Choloepus hoffmanni*	1	*Neacomys sp*	1
Cricetidae	105	Cyclopedidae	1	*Neacomys spinosus*[E]	3
Akodon sp	1	*Cyclopes didactylus*	1	*Nectomys apicalis*	4

Nevati Mission cont.		San Juan cont.		San Pablo cont.	
Rodentia cont.		Primates	16	Rodentia cont.	
Cricetidae cont.		Cebidae	16	Cricetidae cont.	
Hylaeamys perenensis	14	*Aotus nigriceps*	9	*Nectomys rattus*	7
Hylaeamys sp	1	*Saimiri boliviensis*	7	*Nectomys sp*	4
Neacomys spinosus[E]	2	Rodentia	9	*Nectomys squamipes*	13
Nectomys apicalis	2	Cricetidae	4	*Oecomys bicolor*	2
Nectomys rattus	1	*Hylaeamys perenensis*	1	*Oecomys concolor*	3
Nectomys sp	5	*Oecomys bicolor*	3	*Oryzomys sp*	15
Nectomys squamipes	27	Dasyproctidae	1	BLANK	7
Oecomys bicolor	1	*Dasyprocta kalinowskii*[E]	1	Cuniculidae	1
Oecomys concolor	6	Echimyidae	3	*Cuniculus paca*	1
Oligoryzomys destructor	1	*Proechimys sp*	3	Dasyproctidae	2
Oryzomys sp	41	Sciuridae	1	*Dasyprocta sp*	2
BLANK	3	*Hadrosciurus spadiceus*	1	Echimyidae	39
Dasyproctidae	3			*Proechimys sp*	39
Dasyprocta fuliginosa	2			Sciuridae	1
Dasyprocta kalinowskii[E]	1			*Sciurus sp*	1
Echimyidae	56			BLANK	1
Isothrix bistriata	1				
Mesomys sp	1				
Proechimys brevicauda	1				
Proechimys sp	53				
Sciuridae	5				
Hadrosciurus spadiceus	1				
Microsciurus sp	1				
Sciurus sp	2				
BLANK	1				
BLANK	12				
TOTAL	455	TOTAL	635	TOTAL	418

[c] Includes six specimens collected by Donald during his 10-day trip during the 1964 expedition and one specimen collected at elev. 274 m on the trek from Tsioventeni to Nevati during the 1965 expedition (Chapter 2).

[d] Includes three specimens collected by Don J. Grosse during the 1965 expedition yet there is no record of them visiting San Pablo during that expedition.

[E] Endemic species.

Ecoregion – Selva Baja cont.			
Santa Isabella – elev. 457 m		Shahuaya Mission – elev. 177 m	
Carnivora	1	Chiroptera	10
Procyonidae	1	Phyllostomidae	10
Nasua nasua	1	*Carollia perspicillata*	6
Chiroptera	35	*Sturnira lilium*	3
Emballonuridae	4	*Sturnira tildae*	1
Saccopteryx bilineata	4	Rodentia	36
Phyllostomidae	31	Cricetidae	19
Anoura geoffroyi	1	*Neacomys spinosus*[E]	1
Artibeus lituratus	2	*Oecomys bicolor*	6
Artibeus obscurus	1	*Oligoryzomys microtis*	9
Artibeus planirostris	4	*Oryzomys sp*	3
Carollia sp	2	Echimyidae	17
Glossophaga soricina	4	*Proechimys brevicauda*	1
Lonchophylla robusta	6	*Proechimys sp*	16
Phyllostomus hastatus	1		
Platyrrhinus brachycephalus	1		
Rhinophylla fischerae	1		
Rhinophylla pumilio	1		
Sturnira tildae	2		
Uroderma bilobatum	5		
Primates	11		
Atelidae	2		
Alouatta seniculus	2		
Cebidae	7		
Cebus apella	3		
Saguinus fuscicollis	1		
Saimiri boliviensis	3		
Pitheciidae	2		
Pithecia inusta	2		
TOTAL	47	TOTAL	46

[E] Endemic species.

REFERENCE LIST

REFERENCE LIST

Bax, V., & Francesconi, W. (2019). Conservation gaps and priorities in the Tropical Andes biodiversity hotspot: Implications for the expansion of protected areas. *Journal of environmental management*, *232*, 387-396.

Brack-Egg, E. (1986). Las ecorregiones del Perú. *Boletín de Lima*. 44: 57-70.

Ceballos, G., & Ehrlich, P. R. (2006). Global mammal distributions, biodiversity hotspots, and conservation. *Proceedings of the National Academy of Sciences*, *103*(51), 19374-19379.

de Abreu-Jr, E. F., Pavan, S. E., Tsuchiya, M. T., Wilson, D. E., Percequillo, A. R., & Maldonado, J. E. (2020). Museomics of tree squirrels: a dense taxon sampling of mitogenomes reveals hidden diversity, phenotypic convergence, and the need of a taxonomic overhaul. *BMC evolutionary biology*, *20*(1), 1-25.

Eisenberg, J. F., & Redford, K. H. (1999). Mammals of the Neotropics, Volume 3: Ecuador, Peru, Bolivia, Brazil. University of Chicago Press

Gardner, A. L. (2008). *Mammals of South America, volume 1: marsupials, xenarthrans, shrews, and bats* (Vol. 2). University of Chicago Press.

Gaston, K. J. (2000). Global patterns in biodiversity. *Nature*, *405*(6783), 220-227.

Hershkovitz, P. (1983). Two new species of night monkeys, genus Aotus (Cebidae, Platyrrhini): a preliminary report on Aotus taxonomy. *American journal of primatology*, *4*(3), 209-243.

Hillebrand, H. (2004). On the generality of the latitudinal diversity gradient. *The American Naturalist*, *163*(2), 192-211.

Hurtado, N., & D'Elía, G. (2018). Taxonomy of the genus Gardnerycteris (Chiroptera: Phyllostomidae). *Acta chiropterologica*, *20*(1), 99-115.

Kays, R. W., & Wilson, D. E. (2009). Mammals of North America. In *Mammals of North America*. Princeton University Press.

Larsen, P. A., Marchan-Rivadeneira, M. R., & Baker, R. J. (2010). Taxonomic status of Andersen's fruit-eating bat (Artibeus jamaicensis aequatorialis) and revised

classification of Artibeus (Chiroptera: Phyllostomidae). *Zootaxa*, *2648*(1), 45–60-45–60.

Mammal Diversity Database. (2022). Mammal Diversity Database (1.9) [Data set]. Zenodo. https://doi.org/10.5281/zenodo.6407053

Marsh, L. K. (2014). A taxonomic revision of the saki monkeys, Pithecia Desmarest, 1804. *Neotropical primates*, *21*(1), 1-165.

McNeely, J. A., Miller, K. R., Reid, W. V., Mittermeier, R. A., & Werner, T. B. (1990). *Conserving the world's biological diversity*. International Union for conservation of nature and natural resources.

Miranda, F. R., Casali, D. M., Perini, F. A., Machado, F. A., & Santos, F. R. (2018). Taxonomic review of the genus Cyclopes Gray, 1821 (Xenarthra: Pilosa), with the revalidation and description of new species. *Zoological Journal of the Linnean Society*, *183*(3), 687-721.

Myers, N., Mittermeier, R. A., Mittermeier, C. G., Da Fonseca, G. A., & Kent, J. (2000). Biodiversity hotspots for conservation priorities. *Nature*, *403*(6772), 853-858.

Pacheco, V., Cadenillas, R., Salas, E., Tello, C., & Zeballos, H. (2009). Diversidad y endemismo de los mamíferos del Perú. *Revista peruana de biología*, *16*(1), 5-32.

Pacheco, V., Diaz, S., Graham-Angeles, L., Flores-Quispe, M., Calizaya-Mamani, G., Ruelas, D., & Sánchez-Vendizú, P. (2021). Lista actualizada de la diversidad de los mamíferos del Perú y una propuesta para su actualización. *Revista peruana de biología*, *28*(4).

Patterson, B. D., & Velazco, P. M. (2006). A distinctive new cloud-forest rodent (Hystricognathi: Echimyidae) from the Manu Biosphere Reserve, Peru. *Mastozoología neotropical*, *13*(2), 175-191.

Patton, J. L., Pardiñas, U. F., & D'Elía, G. (2015). *Mammals of South America, volume 2: rodents*. University of Chicago Press.

Rodríguez, L. O., & Young, K. R. (2000). Biological diversity of Peru: determining priority areas for conservation. *AMBIO: A Journal of the Human Environment*, *29*(6), 329-337.

Rylands, A. B., Heymann, E. W., Lynch Alfaro, J., Buckner, J. C., Roos, C., Matauschek, C., Boubli, J. P., Sampaio, R., & Mittermeier, R. A. (2016). Taxonomic review of the new world tamarins (primates: Callitrichidae). *Zoological Journal of the Linnean Society*, *177*(4), 1003-1028.

Schipper, J., Chanson, J. S., Chiozza, F., Cox, N. A., Hoffmann, M., Katariya, V., Lamoreux, J., Rodrigues, A. S., Stuart, S. N., & Temple, H. J. (2008). The status of the world's land and marine mammals: diversity, threat, and knowledge. *Science*, *322*(5899), 225-230.

Sher, A., & Molles, M. C. (2022). *Ecology: Concepts and Applications*. McGraw Hill LLC.

Swenson, J. J., Young, B. E., Beck, S., Comer, P., Córdova, J. H., Dyson, J., Embert, D., Encarnación, F., Ferreira, W., & Franke, I. (2012). Plant and animal endemism in the eastern Andean slope: challenges to conservation. *BMC ecology*, *12*(1), 1-19.

Tuttle, M. D. (1970). Distribution and zoogeography of Peruvian bats, with comments on natural history. *University of Kansas Science Bulletin*, *49*(2), 45-86. Retrieved from https://biostor.org/reference/50275

Velazco, P. M., Gardner, A. L., & Patterson, B. D. (2010). Systematics of the Platyrrhinus helleri species complex (Chiroptera: Phyllostomidae), with descriptions of two new species. *Zoological Journal of the Linnean Society*, *159*(3), 785-812.

Velazco, P. M., & Patterson, B. D. (2013). Diversification of the yellow-shouldered bats, genus Sturnira (Chiroptera, Phyllostomidae), in the New World tropics. *Molecular phylogenetics and evolution*, *68*(3), 683-698.

Voss, R. S. (2022). An Annotated Checklist of Recent Opossums (Mammalia: Didelphidae). *Bulletin of the American Museum of Natural History*, *455*(1), 1-76.

Voss, R. S., Díaz-Nieto, J. F., & Jansa, S. A. (2018). A revision of Philander (Marsupialia: Didelphidae), part 1: P. quica, P. canus, and a new species from Amazonia. *American Museum Novitates*, *2018*(3891), 1-70.

Voss, R. S., Fleck, D. W., & Jansa, S. A. (2019). Mammalian diversity and Matses ethnomammalogy in Amazonian Peru Part 3: Marsupials (Didelphimorphia). *Bulletin of the American Museum of Natural History*, *2019*(432), 1-90.

Weksler, M., Percequillo, A. R., & Voss, R. S. (2006). Ten new genera of oryzomyine rodents (Cricetidae: Sigmodontinae). *American Museum Novitates*, *2006*(3537), 1-29.

Young, K. R., & León, B. (2000). Biodiversity conservation in Peru's eastern montane forests. *Mountain Research and Development*, *20*(3), 208-211.