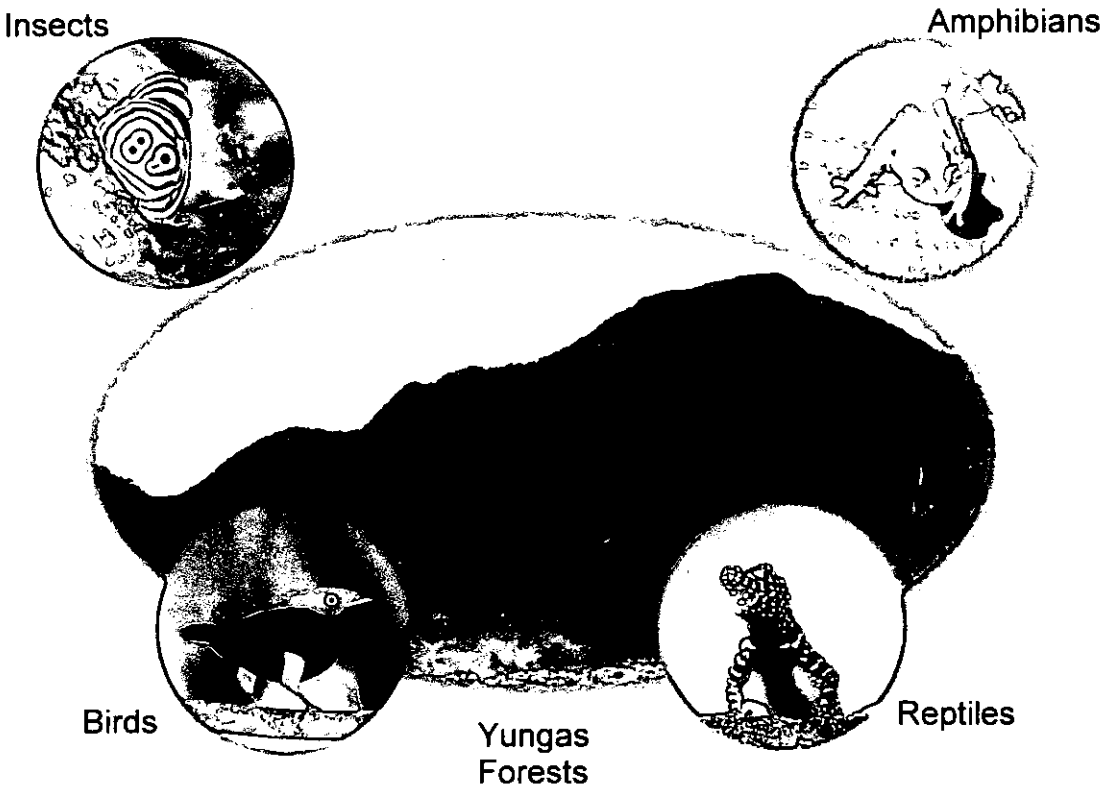
Yungas 2001 Project Report

July - October 2001

Biological inventory and conservation assessment of the yungas forests of Cordilleras Cocapata and Mosetenes, Bolivia.

Edited by Aidan Maccormick & Ross MacLeod, 2003.



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Summary

The forested eastern slopes of the Bolivian Andes are a global biodiversity hotspot containing three of the world's Endemic Bird Areas (EBAs). Two of these EBAs are comprised of yungas habitats, the mountain forest that rises from the lowland Amazonian rainforests and continues upwards covering the steeply sloping cordilleras for a vertical height of over three kilometres. The upper limits of these forests started to disappear at the beginning of the pre-Columbian colonisation of the South American highlands and today it is estimated that less than 1% of the natural tree line remains in the eastern Andes with both the remaining upper and lower yungas forests experiencing daily habitat loss and destruction due to logging and land clearance. Yungas 2001 to completed a biological inventory within the largest remaining unsurveyed area of yungas forest, concentrating on birds, amphibians & reptiles and insects. The aim of the project was to work with Bolivian scientists, government and non governmental organisations to provide a greater knowledge of the biodiversity wealth contained within the yungas. We aimed to provide a greater understanding of individual species, especially threatened species and to show the international scientific and conservation community that the yungas forests contain a wealth of undescribed vertebrate and invertebrate taxa. Above all, the project's objective was to gather and disseminate information on the distribution and ecological requirements of as many yungas species as possible, and to stimulate and catalyse further biological research within the yungas.

Yungas 2001 carried out biological inventories at two, previously unsurveyed, sites in the yungas forests of Cordilleras Cocapata-Mosetenes. The project work concentrated on ornithological, herpetological and entomological studies at both these sites, working with an international team of biologists from Bolivia and two UK universities. The project collected site-specific ecological data for 339 bird species, including two globally threatened species and recorded a new species for Bolivia, the Cloud-forest Screech-Owl. The project discovered at least five new amphibians and one new reptile species and collected data on an additional 37 species. The entomological aspect is represented by the first study of the diversity patterns in dung beetles in the Andes and the first systematic insect collection from the Bolivian yungas. The project's results highlight the national and international importance of the yungas forests for biodiversity conservation with the project recommending that the yungas forests of Cordilleras Mosetenes and Cocapata receive the highest level of protection because of its endemic bird and herpetological fauna.

If the yungas and its biodiversity are to exist in the future then realistic and pragmatic decisions using the finite and limited resources that Bolivia has for nature conservation have to be made with informed decisions using good quality scientific data such as we present in this report. It is important to note that the number of novel vertebrate and invertebrate species recorded by this project, during one field season, graphically demonstrates our profound lack of knowledge regarding the yungas forests of South America and highlights the fact that more resources are urgently needed to fully document the habitat's biodiversity.

Acknowledgements

Yungas 2001 is indebted to a large number of individuals, organisations, companies and institutions, without whom this project would not have been a success. In Britain we would have not developed the project without the help and advice of Roger Downey at the University of Glasgow and George McGavin and Darren Mann at the University of Oxford and to the previous members of Glasgow University conservation projects in Bolivia whose hard work and success set a high standard for this project to follow. Thanks also go to many individual staff and students of both universities who supported our fundraising. Staff at the Royal Geographical Society (RGS) and BirdLife provided valuable advice and Ignacio De la Riva of the National Science Museum, Spain and Michael Kessler of University of Göttingen, Germany, provided valuable support. In Bolivia we are extremely indebted to many, many people who helped the project succeed. We give thanks to all those named below and to the many that remain unmentioned whose contributions, big or small, all helped the project a success: Collecion Boliviana de Fauna for organising the permits. All the staff at Armonia, in particular Bennett Hennessey who provided assistance when the project was still just an idea, through the planning stages, project completion and the production of this final report. Steffan Loetters and Jose Munoz. Col. Germán Valenzuela Lemaitre in La Paz for help with helicopter hire. Freddie Céspades of Akhamani Tours, La Paz, and Constancio for assistance during the recognisance of the study area. To Don Leon and his family at Carmine Pampa and all at Pampa Grande. The owners of Hostal Elisa, Cochabamba for putting up with our often strange requests. For loan of recording equipment we would like to thank Will Cresswell of Oxford University and the Media Services department of Glasgow University for lond of video camera equipment.

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Copies of this report will be available online at *http://www.yungas.org.uk/finalreport* and are available in paper or CD versions on request from *Aidan Maccormick or Ross MacLeod, Bolivian Important Biodiversity Sites Project, Glasgow University, Graham Kerr Building, Glasgow. G12 8QQ.*

1 Introduction

This is the final report of Yungas 2001, a scientific and conservation project from Glasgow and Oxford Universities to the yungas forests of Cordilleras Cocapata-Mosetenes, Cochabamba, Bolivia. Following this short introduction the report begins with Chapter 2, a review of the project's aims and the success achieved in meeting them. Following this Chapter 3 provides a general project background and discusses the conservation importance of the Bolivian yungas and sites chosen for biological surveys by the project. The results of the work of this project are split into separate chapters for the herpetological, entomological and ornithological groups. For those wishing to read a general overview of the project the Summary (page 1), Meeting Aims and Objectives (page 6) and individual group summaries (on pages 13, 35 and 45) and discussions (on pages 20, 41 and 52) should provide a clear indication of the project's purpose, success and conservation recommendations.

The ornithological work is presented in the form of a general inventory (Chapter 5) and separate chapters on two important conservation species (Chapter 6 & 7), the herpetological work is described in the form of a general inventory in Chapter 8 and entomological work is represented by a chapter on dung beetles (Chapter 9). Towards the end of the report a series of appendices provide comprehensive data collected by the project and finally the individual project personnel are detailed in Appendix 3.

One of the aims of this project was to distribute the knowledge and data gained during this project to the scientific community through publications. For this reason many of the chapters were written in a style intended for publication in specific scientific journals. However it must be noted that when published these individual chapters may differ slightly in content and style. It should also be noted that certain aspects of the work, particularly species description for herpetological and insect taxa are ongoing due to the need to work with international experts and collections while writing formal species descriptions. Further results will therefore be published in the scientific literature at a later data, these are planned to include papers developing and testing new biodiversity survey methodologies and the formal description of the new entomological and herpetological species.

2 Meeting Aims and Objectives

The aim of Yungas 2001 was to conduct a series of biological inventories within a previously unsurveyed yungas forest of the Cocapata-Mosetenes Cordilleras, to increase the biological knowledge of the habitat and region and to highlight the potential international importance of Cocapata-Mosetenes for conserving threatened species. To meets these aims the project set the following objectives described below in bold, followed by a short piece detailing the success achieved for each individual objective.

- **To carry out comprehensive ornithological inventories within the Cocapata-Mosetenes Cordilleras**

Chosen in conjunction with Armonia (BirdLife International's Bolivian partner) and the management of Isiboro-Securé National Park, the first ornithological inventories of the río Pampa Grande valley and Cordillera Mosetenes were completed. During the project 339 species of birds were recorded within the two sites, with a full altitudinal distribution and habitat association for each species. This included the globally threatened Scimitar-winged Piha *Lipaugus uropygialis*, Yungas Antwren *Myrmotherula grisea* and one new species for Bolivia, the Cloud Forest Screech-Owl *Otus marshalli*.

- **To perform detailed herpetological inventories within the Cocapata-Mosetenes cordilleras and to provide a complete altitudinal distribution for each species**

During the herpetology survey 43 species were recorded, 27 anuran and 16 reptiles, with a detailed altitudinal distribution for all species. Seven species are Bolivian endemics, while at least six taxa, five anurans and one reptile, represent undescribed species. It is thought likely that further work involving international experts and collections will identify further undesribed species in the collection.

- **To describe the levels of endemism and species richness of key taxa of yungas flora, across an altitudinal gradient**

Due to personal medical circumstances of the Bolivian botanist, the botanical component was cancelled a few days before fieldwork was due to start.

- **To establish the importance of the Cocapata-Mosetenes Cordilleras for the globally threatened Horned Curassow *Pauxi unicornis***

No records of Horned Curassow where obtained during the project. It is probable that this was due to the short time spent in suitable habitat by the expedition due to difficulties in accessing certain areas. Future surveys will be needed to document the presence or absence of populations of this species within the area.

- **To compare arthropod diversity indices within four groups (spiders, cockroaches, dung beetles and tree hoppers) across altitudinal gradients and to create the first systematic collection of yungas insects**

A successful study of dung beetle diversity patterns was completesd, given the high large number of specimens collected and udescribed types found the full results from the entomological study are expected to take several years. Preliminary study of a sample within the Coleoptera suggests c.50% of taxa are novel.

Although not all of the objectives we had set were successfully completed the successes of the project were many and perhaps far greater than had been hoped for or expected. The herpetological team managed to provide a thorough species inventory and a detailed altitudinal distribution for all species recorded. The team also managed to collect at least six new species, a truly staggering figure for any location in the world. The ornithological team managed to complete a successful inventory with detailed ecological data for 339 species. The team also managed to document the first record of Cloud Forest Screech-Owl *Otus marshalli* for Bolivia, a restricted range species previously known from only two locations in Peru. The largest known population of the globally threatened Scimitar-winged Piha *Lipaugus uropygialus* was also recorded within the study site while a single record of the Yungas Antwren *Myrmotherula grisea* increases the known range of this globally threatened species. The team also recorded further sightings of an undescribed species of Flowerpiercer but was unable to collect a specimen. Due to the lengthy process of entomological specimen processing the entomology team are only able to report the results of a single insect group. Within dung beetles the project can report the first study of their diversity patterns within the Andes, and the study also represents only the third dung beetle survey within Bolivia. Perhaps the most surprising result that the entomology team can report is that within a sample of Coleoptera around 50% are thought to be new taxa.

3 Project Background: Conservation Importance of the Bolivian Yungas and Threats to Habitat and Areas

3.1 Bolivia

Bolivia is one of the world's mega diversity countries that holds a large percentage of the planets biodiversity, including 14% of the world's bird species (Stattersfield *et al* 1998). This figure is likely to rise as new records for the country or new taxa are described almost annually from Bolivia (See Contingas 12-17). Bolivia is similarly rich in other taxa of critical importance to the conservation of the earth's biological richness. Bolivia covers c.1.1 million km^2 with a relatively small population of 8 million concentrated in the rural Altiplano and the conurbations of La Paz, Santa Cruz and Cochabamba (Murphy 1997).

The country has a varied topography dominated by the Andes in the central and western regions and Amazonian lowlands to the north and east. Forest covers some 49% of the land area (Murphy 1997) and it is within these forests, particularly the Amazonian lowland and the montane forests where species diversity, richness and endemism are greatest. Remsen and Parker (1995) state that the humid foothills and mountain slopes of the eastern slope of the Andes are home to some of the greatest diversity of terrestrial life in the world. Bolivia contains five Endemic Bird Areas (EBA's) which are defined by BirdLife International as holding "*at least two restricted-range species, and thus represent areas where global extinctions are likely to occur unless the integrity of habitat can be guaranteed*" (Stattersfield *et al* 1998). Three of Bolivia's EBA's cover the montane forests known as the Yungas

3.2 Yungas

Yungas refers to the humid montane and sub-montane forests found on the eastern slope of the Bolivian and Peruvian Andes. The forests stretch from the Amazonian foothills of 500m to the tree-line forests at 3,700m (Stattersfield *et al* 1998). The topography is typically steep with frequent landslides creating open areas in various states of regeneration. The ridges are narrow and dominated by vegetation prolific in epiphytes more typical of the upper montane zone. Most of the forest is humid evergreen while dryer regions have deciduous elements such as alder *Alnus*. The yungas mainly forms two EBA's, the Bolivian and Peruvian Upper Yungas and the Bolivian and Peruvian Lower Yungas. These two areas cover some 88,000 km^2 and have been designated as 'Urgent' priorities for biodiversity conservation.

Several national parks within Bolivia and Peru contain large areas of yungas habitat with the largest, Madidi National Park covering 19,000km^2 and expected to hold the greatest avian diversity of any protected site in the world (Remsen and Parker 1995). However despite the fact that perhaps a total of c.40% of the two Yungas EBA's are within reserves or other protected areas, it is often the case that these areas are protected in theory but not in practice. These reserved areas are typically under-funded with few biological surveys having been completed. Hence, the biological knowledge of the yungas remains very poor. This is coupled with an almost complete absence of active scientific research and conservation plans for areas or specific species. A case in point being Isiboro-Securé National Park containing c.15% of the total yungas coverage in which only a single biological survey has been conducted.

3.3 Cordilleras Cocapata-Mosetenes

Cordilleras Cocapata-Mosetenes are located where the departments of La Paz, Cochabamba and Beni converge in north-central Bolivia, with our study sites located within the río Pampa Grande valley, Cordillera Cocapata, and at the confluence of the río Pampa Grande and río Altamachi at the western base of Cordillera Mosetenes, see figure 3.1. These two adjacent cordilleras contain sections of both Yungas EBA's. At present the only protected area is that on the eastern side of Cordillera Mosetenes contained within Isiboro-Securé National Park, although plans do exist to extend the park boundary to cover most of the Cordillera Mosetenes (per. Municipal Alcaldía, Cochabamba). Only one previous survey has been conducted within the yungas of Cordillera Cocapata. This survey described one new Tyrant Flycatcher species, one new sub-species of Spinetail *Synallaxis* sp. and recorded an as yet undescribed species of Flower-piercer *Diglossa* sp. (Herzog *et al* 1999). During fieldwork conducted by Yungas 2001 the first record of Cloud-forest Screech-Owl *Otus marshalli* for Bolivia was obtained along with additional sightings of the undescribed Flower-piercer. This demonstrates that the yungas of Cocapata-Mosetenes supports a high degree of endemism and is therefore of crucial importance both nationally and international in terms of biodiversity conservation. It also demonstrates that yungas biodiversity is poorly known with many further studies required before a complete description of its vertebrate diversity and distribution are known.

Figure 3.1. Map of Bolivia showing location of project study sites.

3.4 Globally Threatened Species

With so little baseline data available on amphibians, reptiles, plants and arthropods in the yungas an accurate determination of which species in these groups are globally threatened has not yet been possible (IUCN 2000). For example, despite the worldwide decline in amphibian populations (Houlahan *et al.* 2000) the Bolivian Red Data Book for vertebrates only had sufficient data to include two species of amphibians (Ergueta & Morales 1996). Birds reflect better knowledge of the taxa with one Endangered and three Vulnerable species found within the two EBA's. However this should not hide the fact that other taxa are also likely to hold many threatened species (e.g. De La Riva 2000). Species are generally defined as threatened by their

distribution, ecological requirements and the perceived and actual threats to the species in particular and to the habitat in general (Stattersfield *et al* 1998). This report provides valuable information on the above criteria allowing important decisions to be made with greater accuracy when assessing species threatened status in the future.

3.5 Threats to the Yungas

In Bolivia, as elsewhere in the neotropics, habitat destruction or degradation is the major causal factor resulting in the threatened status of many bird species. Trapping for the wild-bird trade and over hunting are additional threats (Remsen & Quintela in Collar et al. 1992). Yungas habitat destruction and degradation within both protected and non-protected areas is mainly by burning for grazing, logging (both legal and illegal) and land clearance for colonisation (pers. obs). Unlike deforestation of the Amazonian lowlands occurring in the rest of the continent, the greatest threat to yungas forests comes from deforestation at the upper end of its altitudinal range. Here the relatively densely populated Altiplano puts greater pressure on the remaining yungas as more forest is removed down slope for grazing stock. Historically grazing animals were the native camelids such as alpaca and llama which evolved in the high Puna grasslands. Today however non-native horses and cattle which prefer lower altitudes are increasingly kept as live stock (pers.obs). The extent of this pressure on the high Andean tree line is demonstrated by the fact that only 5% of the original humid woodland above 3,500m is now left in Bolivia (Fjeldså & Kessler 1996).

Despite perhaps c.40% of the Bolivian yungas contained within protected areas, these protected areas are not providing adequate protection for the habitat or its species. Carrasco National Park (P.N.C.) contains one of the greatest areas of protected yungas in Bolivia, but has only 14 full-time park guards. The park suffers from daily immigration by settlers which requires, at times, almost all the park's resources to police certain areas dealing with this single problem (pers. Jose Vega). Dynamite fishing and hunting also occurs within the park's boundaries. In September 2001 the remains of a hunted Horned Curassow *Pauxi unicornis* were found well within the official park boundary. This is the most threatened species within the whole of the yungas and the flagship species of Amboró National Park which is contiguous with P.N.C. The problems and threats detailed for P.N.C. are not unique to this site but occur throughout the yungas forests and are increasing.

3.6 Threats to Cocapata-Mosetenes

Threats to the yungas forests of the Cordilleras de Cocapata-Mosetenes are similar to those experienced by forested habitats throughout the Americas, primarily that of habitat destruction and disturbance (Stattersfield et al. 1998). Within Bolivia this is occurring through increased land clearance of the upper yungas for grazing by existing Andean communities and by colonisation of the lower yungas to grow cash crops such as coca. Within the study area of the río Pampa Grande valley forest clearance at its upper limits, at the now artificial tree line, was clearly visible with forest being burnt to provide grazing for horses, sheep, cattle and llama. The valley is also under pressure from potential colonisation by people from the Altiplano after the collapse of the mining industry in Bolivia in the 1990's. Furthermore at the lowest altitude, the forests at the confluence of the río Pampa Grande and río Altamachi are being selectively logged for tropical hardwoods, mainly mahogany. The direct removal of individual trees or stands of mahogany is not as destructive as the side-effects of this illegal logging process. It is the guns and slingshots brought in by the loggers that perhaps do far worse damage. Arboreal and terrestrial mammals are taken

to supplement a mundane and protein lacking diet with large birds, especially cracids, being highly vulnerable to this type of pressure. However despite the large numbers of illegal loggers observed at the Pampa Grande-Altamachi confluence, the behaviour of adult Spider monkeys *Ateles paniscus* suggested that, at that time, Spider monkeys were not suffering form hunting pressures. During the project one of the three families living in the Pampa Grande valley also reported the practice of dynamite fishing, a destructive and unselective fishing practice. Within those few families present within the valley, subsistence and opportunistic hunting is common practice with cracids, monkeys, agoutis and peccary being taken, albeit on a very limited scale.

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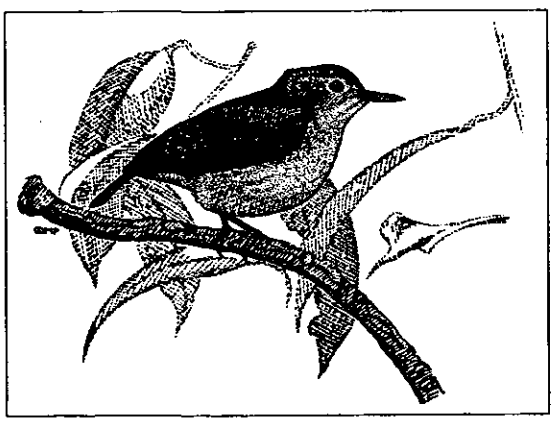
4 Ornithological Introduction

The ornithological work carried out during the project was co-ordinated through discussions with Armonia, BirdLife International's Bolivian partner, Collecion Boliviana de Fauna and SERNAP, the Bolivian National Park Service. The ornithological survey team consisted of 6 ornithologists, all with neotropical experience, 4 of whom had previously worked in the Bolivian yungas. The team collected data using visual and audio identification relying heavily on the CR-Rom 'Bird Sounds of Bolivia' for audio identification and the field guides, Birds of South America and Birds of the High Andes. Sound recording and sound-recording-playback was essential for identification of many passerines and especially the owls. Mist netting was used on very few occasions with no species recorded by this technique that was not recorded using either visual or audio methods.

The aim of the ornithological survey was to accurately survey the avifauna of the río Pampa Grande valley, between 1800m and 3600m and an area of forest at the río Pampa Grande-Altimachi confluence at 1100m. We aimed to provide a detailed data set for each individual species covering its altitudinal range and habitat requirements, as well as documenting and publishing undescribed behavioural observations, breeding data and vocalisations. This is represented by the inventory and conservation assessment of the Cordilleras Cocapata-Mosetenes, the review article of the Scimitar-winged Piha *Lipaugus uropygialus* and article on the Cloud-forest Screech Owl *Otus marshalli*.

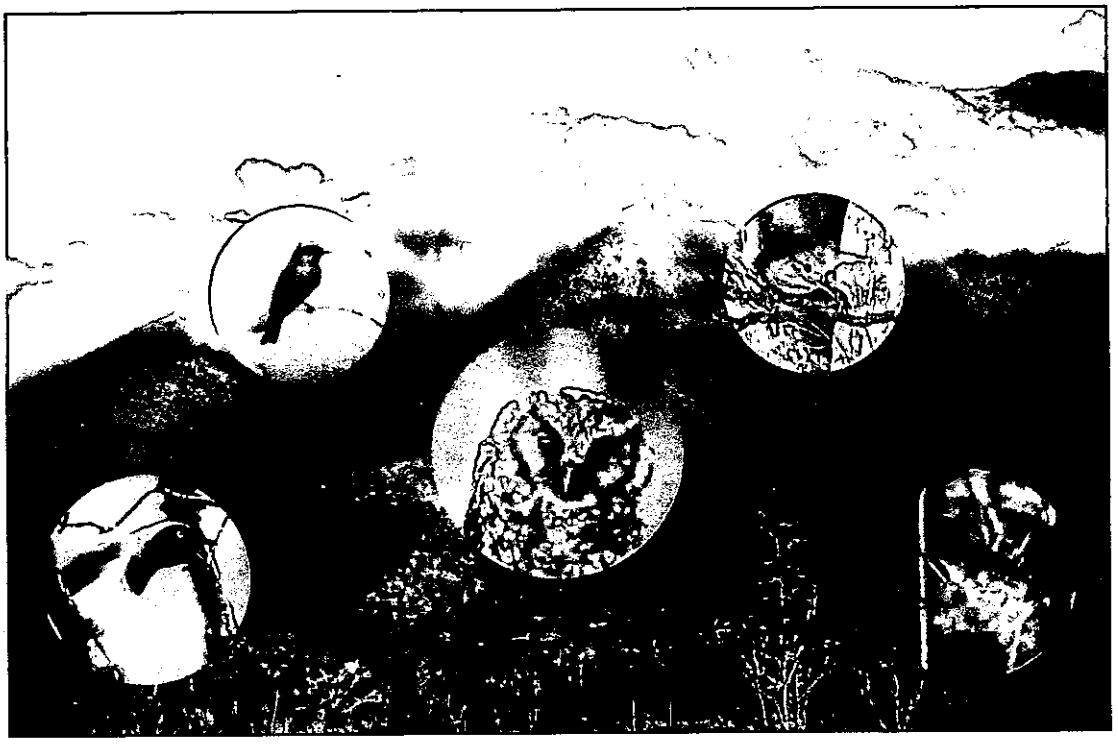
The ornithological inventory, Chapter 5, provides data detailing the presence of 339 birds from what was perhaps the largest area of unexplored forest remaining in Bolivia. We recorded 23 restricted range species, 4 near-threatened and 2 globally threatened species. For all species we also provide a comprehensive data set detailing each specie's altitudinal distribution and habitat requirements. This includes new altitudinal range information for 70 species. We also report in Chapter 6 on the first documented report of Cloud Forest Screech Owl *Otus marshalli* for Bolivia as well as describing and confirming its vocalisations. In Chapter 7 we report on the discovery of an important population of the globally threatened Scimitar-winged Piha *Lipaugus uropygialis* and provide the first documented description of its voice. We also provide data that increases the known geographical range of the globally threatened Yungas Antwren *Myrmotherula grisea*. Conservation assessments and recommendations for the study sites, Cloud-forest Screech and Scimitar-winged Piha are given at the end of their respective chapters.



Yungas Antwren, *Myrmotherula grisea*. A globally threatened yungas endemic.

5 First Ornithological Inventory and Conservation Assessment of the Yungas Forests of the Cordilleras Cocapata and Mosetenes, Cochabamba, Bolivia.

Ross MacLeod, Steven Ewing, Sebastian K. Herzog, Rosalynd Bryce, Karl Evans & Aidan Maccormick



5.1 Summary

Bolivia holds one of the world's richest avifaunas, however large areas remain biologically unexplored or surveyed. This study carried out the first ornithological inventories of one of the largest of these unexplored areas, the yungas forests of Cordilleras Cocapatta & Mosetenes. A total of 339 bird species were recorded including 23 restricted range bird species, 4 near-threatened species, 2 globally threatened species, 1 new species for the country and one species possibly new to science. Illustrating how poorly known much of Bolivia's avifauna is the study extended the known altitudinal ranges of 70 species, 26 by at least 500m, representing a substantial increase in our knowledge of species distributions in the yungas. Species characteristic of or unique to 3 Endemic Bird Areas were found. The Cocapata & Mosetenes Cordilleras are a stronghold for yungas endemics and hold large areas of pristine Bolivian & Peruvian Upper & Lower Yungas habitat (EBAs 54 &55). Human encroachment is starting to threaten the area and priority conservation action including designation as a protected area and one of Bolivia's first Important Bird Areas (IBA), is recommended.

5.2 Introduction

Conducting biological inventories and publishing their results "represents a very good conservation investment" because it enables efficient and effective use of conservation resources in conserving biological diversity (Balmford & Gaston 1999). Biological inventories provide essential baseline data. Firstly, they facilitate the

setting of conservation priorities and the establishment of well designed protected area networks. Secondly, they act as a snapshot of environmental conditions against which to measure future change. This study details the first ornithological inventory work carried out in an unexplored area of montane rainforest in the Bolivian Andes and uses the data to make recommendations on its future conservation.

Bolivia holds the richest avifauna of any landlocked country. With a total of 1358 species (Armonia 1995), it contains 14% of all bird species, making Bolivia one of the most species rich countries in the world (Wege & Long 1995). The specialist nature of many of these species means that they are restricted to very small areas in global terms and their populations are, therefore, extremely vulnerable to disturbance and habitat destruction (Ridgely & Tudor 1989). Within the country there are large areas still biologically unexplored due to the logistical difficulties of accessing remote and steep terrain, the largest and most important of these gaps in knowledge (verbally B. Hennessey, Bolivian Important Bird Area Co-ordinator) was the 80,000 km2 of yungas forest that lie between the potential IBA sites of Alto Tuichi (Madidi National Park), Serranía Pilon to the north west and the Carrasco-Amboró National Parks site to the south east of this section of the Andes (Hennessey 1999).

The yungas habitat, much of it covered by the two EBAs, is one of the characteristic vegetation zones of the eastern slope of the Andes, extending from south-west Peru through the La Paz, Cochabamba and into the Santa Cruz Department of Bolivia. This area of extremely steep slopes and high rainfall consists of montane and sub-montane forest, at altitudes ranging from 400m to 3,700m (Stattersfield et al. 1998). Much of the Yungas situated within Bolivia comprises the transitional zone between the humid tropical forest found on the lower Andean slopes and valleys, and elfin forest located at higher altitudes. (Stattersfield et al. 1998, Ridgley & Tudor 1989).

Where it remains yungas forest and high Andean treeline habitat is threatened due to human activities (Stattersfield et. al. 1998). Many species endemic to the yungas and other forested habitats on the eastern slopes of the Andes are particularly vulnerable to encroachment as they are restricted to very narrow altitudinal bands (Remsen & Quintela in Collar et al. 1992). The major pressure being placed on these habitats is forest clearance for agriculture, especially cash crops such as cocoa, bananas and coffee on the lower edge, and grazing at higher altitudes. Logging, subsistence agriculture and hunting are other major factors causing habitat degradation. (Remsen & Quintela in Collar et al. 1992). Pressures on yungas habitats and birds are exacerbated by the increasing human migration into the area from the Altiplano (pers. obs.). The amount of destruction that has occurred is illustrated by the fact that less than 5% of the original humid woodland above 3,500m is now left in Bolivia (Fjeldså & Kessler 1996).

Before survey work commenced, the area from the east side of Cordillera Cocapata to the Cordillera de Mosetenes was predicted to hold extensive pristine habitat (Herzog et al. 1999) representative of three of Bolivia's five EBAs (EBA 54, the "Bolivian and Peruvian Lower Yungas", EBA 55 "Bolivian and Peruvian Upper Yungas" and EBA 56 "High Andes of Bolivia and Argentina", Stattersfield et al. 1998). Based on the information presented by Stattersfield et al. (1998) it was predicted that 30 out of the country's 68 restricted range bird species might be found in the area.

The ornithological inventory reported here represents the first biological fieldwork on the north-eastern slope of Cordillera Cocapata and on Cordillera Mosetenes. Our primary objective was to conduct a comprehensive ornithological survey that would establish the species richness of the area and allow assessment of its importance in conserving Bolivia's threatened and restricted range bird species for possible nomination as an IBA. A subsidiary objective was to collect detailed altitudinal distribution data for each species to improve our understanding of species distributions and ecological requirements which will give greater accuracy to conservation plans targeting yungas bird endemics. In combination with this ornithological study detailed herpetological and entomological inventories were performed, the results of which will be published elsewhere.

5.3 Study Area

The study was carried out on the east side of the Cordillera de Cocapata and at the western base of the Cordillera Mosetenes, Cochabamba, (see Figure 5.1) Bolivia between 2 August and 19 September 2001 as part of the Yungas 2001 expedition. These mountain ranges, which form part of the eastern Andean slope, are located in the Cuzco-Cochabamba sub-region of the Central Andes zoographic region of Stotz et al. (1996) and are covered by the humid forest known as the yungas (Stattersfield et al. 1998). Within this region inventory work focused on the río Pampa Grande and río Altamachi valleys.

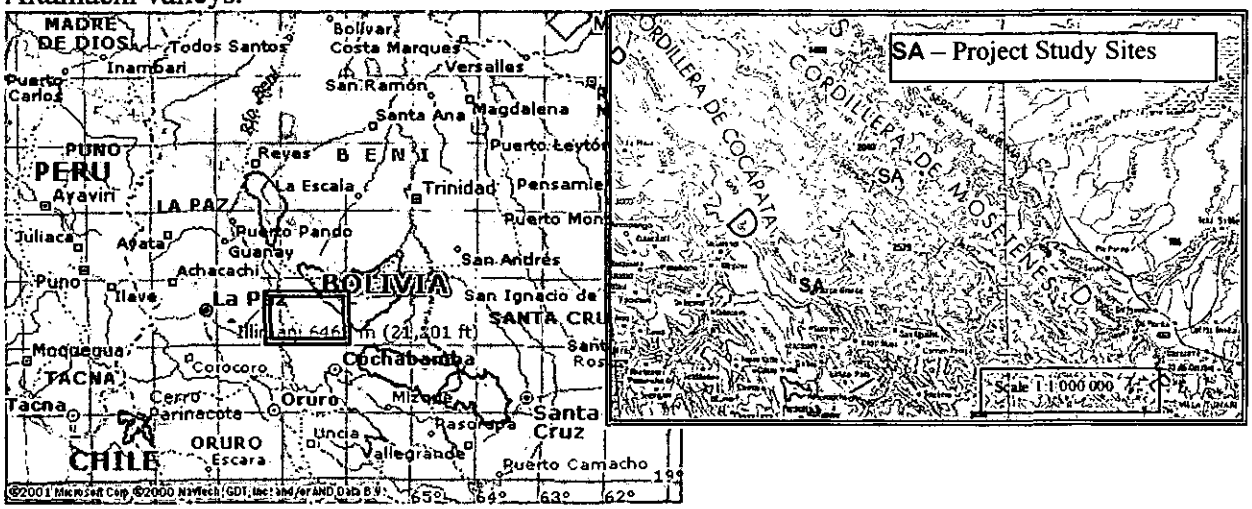


Figure 5.1. Map of northern Bolivia showing location of study area and project study sites (enlarged section).

The fieldwork covered an altitudinal range from 1100m to 4100m, mainly within undisturbed and disturbed primary Montane Evergreen Forest (Stotz et al. 1996), although areas of greater disturbance including secondary forest and a few areas cleared for grazing were also present within the study area. Inventory work focused on a comprehensive survey of the forest habitats in the río Pampa Grande valley (16° 39.9' S 66° 29.1' W) between altitudes of 1800m and 2600m, with a main camp at 2110 m and shorter camps at 1850 m and 2550 m. This was supplemented by rapid assessment surveys from 2600m to the treeline (16° 42.3' S 66° 28.9' W) at 3200-3300m and near the confluence of the río Pampa Grande and río Altamachi rivers at the base of Cordillera Mosetenes (16° 24.3' S 66° 19.7' W) between 1100m and 1250m. Limited survey work was also carried out in puna habitat up to 3600m in the río Pampa Grande valley and up to 4100m on the Tunari Highland during entrance and exit of the study area. The terrain of the area was a mixture of flat wide-bottomed valleys and steep to extremely steep valley sides.

5.4 Methods

Systematic inventories of the birds present were conducted primarily using visual and audio identification supplemented in the río Pampa Grande valley with occasional mist netting. In the field, visual identification was based on standard field guides including, Ridgely & Tudor (1989, 1994) and Fjeldså & Krabbe (1990). Visual identifications were made using binoculars and supported by field notes, sketches and photographic evidence. Audio identification was based on extensive use of sound recording and play back techniques (Parker 1991). In addition, the CD-ROM "Bird Sounds of Bolivia" CD-Rom (Mayer, 2000) and the CD "Birds of the Bolivian Yungas" (Maccormick & MacLeod 2000) were used for reference in the field.

5.5 Altitudinal Range

We divided the río Pampa Grande study area into altitudinal bands of 200m, yielding eight bands between 1800m and 3400m. For each species found during the study the minimum and maximum altitudes and presence/absence within each band were recorded by reference to hand held altimeters. The altitude of each camp was established by calibrating from a point of known height and confirmed by reference to topographic 1:50,000 scale maps (Defence Mapping Agency). Altimeters were then calibrated daily and used to establish points of known height along survey routes so that altitudes of individual observations could be recorded accurately and problems of daily fluctuations in barometric pressure overcome.

5.6 Inventory Effort

Quantification of effort is important in allowing comparison of species inventories from different studies (Remsen 1994); the inventory effort for this study was as follows. A team of six ornithologists, four with previous experience working in the Bolivian yungas and two with other South American experience, performed the ornithological inventory work. Three professional quality sound recording systems were used, a Sony Professional Walkman and two Sony TCM5000 tape machines, each with a Sennheiser ME66 shotgun style directional microphone. Three Sharp MiniDisc recorders with shotgun microphones were also used.

Inventory work began before first light with sound recording of the dawn chorus at different altitudes and normally continued throughout the morning until between 12h00 and 14h00 depending on bird activity. Inventory work then restarted at about 16h00 and continued until dusk. Additional night survey work was carried out on 15 occasions (34% of survey duration). A mixture of newly cut trails, an existing path and dry riverbeds were used as transects covering the complete range of microhabitats in the survey area. Inventory effort for the different altitudes is quantified in Table 5.1.

Table 5.1 - Level of survey effort at different altitudes and locations in Cordilleras Cocapata & Mosetenes, Cochabamba, Bolivia.

Site	Dates	Days for Inventory	Observers	Length of Forest Transects
Rio Pampa Grande 1800-2600 m	2 Aug - 19 Sept.	30	6	10 km
Rio Pampa Grande 2600-3000 m	6 - 12 Sept.	5	2	1 km
Rio Pampa Grande 3000-3300 m	14 - 19 Sept.	4	3	1 km
Rio Altamachi 1100 - 1250 m	6-10 Sept.	5	3	2.5 km

5.7 Results

In total, 339 bird species were recorded in the río Pampa Grande and río Altamachi valleys, across an altitudinal range of 1100-4100m (see Appendix 1 for a list of all

species, along with altitudinal ranges and habitat associations). At the principal site of survey, the río Pampa Grande (1800-2600m), 211 species were recorded. At the río Altamachi (1100-1250m), 129 species were observed, 81 of which were not recorded at the río Pampa Grande. Above 2600m 117 species were recorded, including 41 species that were not found below 2600m. Of these, 108 were associated with high altitude Upper Yungas or treeline habitats (e.g. Black-throated Thistletail *Schioeaca harterti*) and 15 with puna grasslands (e.g. Mountain Caracara *Phalcoboenus megalopterus*).

Species richness showed an overall decline at the río Pampa Grande site with increasing altitude. The number of species recorded within successive 200m altitudinal bands, (i.e. 1800-1999m, 2000-2199, 2200-2399 and 2400-2599) was relatively consistent at 132, 155, 126, and 101 species, respectively. The maximum in the 2000-2199m band certainly is due to the location of the main camp in this band. In comparison, above 2600m the species counts were only one half of that observed at lower altitudes (see Appendix 1). However, this as much highlights differences in survey effort over various altitudinal bands, as any biological trend for reduced species diversity at higher altitudes.

5.8 Species of Special Conservation Concern

In total, the expedition identified 26 species in the study area that are of special conservation concern. Of these, two are globally threatened (Scimitar-winged Piha *Lipaugus uropygialis* and Yungas Antwren *Myrmotherula grisea*) and four are near threatened (Andean Condor *Vultur gryphus*, Cloud-forest Screech Owl *Otus marshalli*, Hooded Mountain-Toucan *Andigena cucullata* and Line-fronted Canestero *Asthenes urubambensis*) (BirdLife International 2000).

We found 24 restricted range species, 10 of which are representative of the Bolivian and Peruvian Lower Yungas EBA 054, and 11 are characteristic of the Bolivian and Peruvian Upper Yungas EBA 055. Additionally two represent the High Andes of Bolivia and Argentina EBA 056 and one, the Cloud-forest Screech Owl, had only previously been recorded in the Peruvian East Andean Foothills EBA 053.

In addition, the expedition recorded 59 species that are 'indicator' species of good quality habitat (Stotz et al. 1996) i.e. those on whose presence or absence, inferences can be made on the integrity of the surrounding environment. Of these 59 species, 49 are indicative of good quality montane evergreen forest (20 for the upper tropical zone, 15 for mid-montane zone and 14 for the upper montane to treeline zone), seven of bamboo-dominated forest and three of humid broadleaf forest (see Appendix 1).

5.9 Distributional and Altitudinal Range Extensions

The expedition documented the first record for Bolivia of Cloud-forest Screech-Owl *Otus marshalli*, previously only known from a small region in south-east Peru (see species accounts).

In addition, following observations made on the expedition, the altitudinal ranges of 70 species have been extended beyond the most recently published known distributions (e.g. Armonia, 1995 and subsequent literature accounts on the Bolivian avifauna such as Herzog et al., 1999). These distributional records have been included in the new check list of Bolivian birds currently being published (Hennessey et al., 2003). 69 Species were documented above published ranges while one was

found below. Appendix 1 lists habitat and altitudinal distributions for each species observed and those whose ranges have been extended are highlighted.

5.10 Species Accounts

Andean Condor *Vultur grypus*
Observed frequently flying over the puna grassland above the tree line, groups of up to 3 individuals of this near-threatened species were seen.

Stripe-faced Wood-quail *Odontophorus ballivani*
Occasionally seen and frequently heard throughout the expedition over an altitudinal range of 2000-3300m, this was 300m higher than this restricted range species had previously been found in Bolivia (Armonia 1995). The observations were documented by sound recordings made at 3300m.

Cloud-forest Screech-owl *Otus marshalli*
This is a little-known species recently described from specimens obtained on the Cordillera Vilcabamba in south-east Peru (Weske and Terborgh 1981). We document the first recorded observations of the species in Bolivia and in EBA 54, it was found to be relatively common over an altitudinal range of 2150-2600m. The first individual was located and sighted on the 24 August 2001, when several identified recordings of the owl's song were made. A male was then captured on the 31 August in mist nets and taken as a specimen. A full description of the specimen and the owl's vocalisations will be published elsewhere (Herzog et al. in prep.).

Hooded Mountain-toucan *Andigena cucullata*
Frequent sightings and several sound recordings were made of this near-threatened species between 2400m and the tree line at 3300m. At the relevant altitudes it would appear relatively common in the río Pampa Grande valley.

Line-fronted Canestero *Asthenes urubambensis*
This near threatened species was seen rarely in puna grassland above the tree line at between 3200m and 3400m.

Yungas Antwren *Myrmotherula grisea*
This threatened species was heard on one occasion by SKH during our 5 day rapid assessment of the río Altamachi valley at an altitude of 1250 m.

Rufous-faced Antpitta *Grallaria crythrotis*
This Bolivian endemic was heard and sound recorded between 2000m and 3300m, this represents an increase in the known upper altitudinal distribution of 300m (Armonia 1995).

Scimitar-winged Piha *Lipaugus uropygialis*
This threatened species (BirdLife 2000) was found to be uncommon in the río Pampa Grande valley. Groups of 2-4 individuals were observed on 5 occasions, all within the same altitude band of 2400-2600m. A group of 4 individuals was observed on the 22 August 2001 and tape recordings were made of the group's vocalisations. This represents, to our knowledge, the first verified sound recordings made of the Scimitar-winged Piha. A full description of vocalisations and behavioural observations will be published elsewhere (Bryce et al. in prep.)

Hazel-fronted Pygmy-tyrant *Pseudotriccus ruficeps*

This restricted range species characteristic of EBA 54 was frequently heard and occasionally seen between 1800m and 2500m, representing an increase in known altitudinal range in Bolivia of 500m (Armonia 1995). The range extension was documented by sound recordings.

White-bellied Pygmy-tyrant *Myiornis albiventris*
This species was observed both during the rapid assessment at the río Altamachi at 1100m and also at 1900m. This represents an altitudinal range extension of 700m, as previous published altitude ranges document the species occurring to 1200m only (Armonia 1995). At río Altamachi, the White-bellied Pygmy-tyrant was relatively common and at 1900m it was uncommon.

Yungas Tody-tyrant *Hemitriccus spodiops*
Occasionally observed, frequently heard and sound recorded from 1800m to 2200m representing an increase of 600m of the known upper altitudinal distribution of this Bolivian endemic (Armonia 1995). The species was found in scrub, secondary forest and on the edge of disturbed primary forest habitats but not in undisturbed primary forest.

Unadorned Flycatcher *Myiophobus inornatus*
This restricted range species characteristic of EBA 54 was uncommonly seen and commonly heard from 1800m to 2550m. The known altitudinal range was raised by 550m and documented by sound recordings.

Rufous-bellied Bush-tyrant *Myiotheretes fuscorufus*
Relatively common below the treeline at 3200m, several individuals were observed and recordings were made of vocalisations, this is a 300m extension to the previously recorded altitudinal range of this restricted-range species (Armonia 1995).

Slaty Tanager *Creurgops dentata*
Observed on a couple of occasions in primary forest between 2400m and 2550m, representing an increase of known altitudinal range by 350m (Armonia 1995).

Diglossa sp.
An all-black flowerpiercer was observed on two separate occasions, by different observers, foraging in mixed flocks in the upper canopy. Both observations occurred between 2300 & 2400m in secondary forest on a somewhat drier ridge and on the edge of disturbed primary forest associated with mixed flocks. Similar sightings of an all-black flowerpiercer have been documented from the south-western Cordillera Cocapata, and it is postulated that these sightings are of an undescribed taxon endemic to this part of the yungas (Herzog et al. 1999). During one of the observations, a Masked Flowerpiercer *Diglossopis cyanea* was watched foraging close to the all-black flowerpiercer, thus allowing direct comparison of the two species. The all-black flowerpiercer appeared smaller than the Masked Flowerpiercer – perhaps more similar in dimension to Moustached Flowerpiercer *Diglossa mystacalis* (Herzog et al. 1999). We were unable to collect specimens or obtain recordings of the flowerpiercer's vocalisations.

5.11 Discussion

The 320 bird species recorded in forest habitats during this study indicates that the Cordilleras of Cocapata and Mosetenes hold a species rich avifauna. The large number of indicator species present show that the area consists of high quality

montane evergreen forest and represents a continuous altitudinal cross section of yungas forest from foothills to treeline.

5.12 Assessment of Conservation Importance

The Bolivian and Peruvian Upper Yungas (EBA 55) holds 20 restricted range species, 16 of these are known from Bolivia. From a total of 13 predicted to occur within the study area based on geographic distribution, we observed 11, representing 85% of these upper yungas endemics. To discover such a wealth of diversity in a single valley is an impressive testament to the conservation importance of the Cocapata and Mosetenes area. The discovery of a healthy population of the Cloud-forest Screech-Owl *Otus marshalli*, a restricted range species not previously recorded in Bolivia or this EBA, adds significantly to the conservation importance of the area. Of even greater interest is the observation of the flowerpiercer species that is probably new to science (Herzog et al. 1999). Should this species, once formally described, be confirmed as an endangered Bolivian Yungas endemic – possibly even an endemic of the Cocapata Cordillera – it will make the establishment of a formal reserve to protect the area an even more fundamental conservation priority. Both the upper yungas species expected but not recorded during this survey (Scaled Metaltail *Metallura aeneocuda* and Golden-collared Tanager *Iridosornis jelskii*) are characteristic of elfin forest, which along the study transect was highly disturbed. Less degraded elfin forest could be observed further along the treeline, and although time constraints prevented its survey, it is likely that both species will be found in the area by future surveys.

The Bolivian and Peruvian Lower Yungas (EBA 54) holds 15 restricted range species, 13 of which are known from Bolivia and were therefore possible for the study area. That ten (77%) of these lower yungas endemics were found in the survey area again highlights that Cocapata and Mosetenes are a major stronghold of yungas avifauna and, as such, deserves protection. All three of the lower yungas species (Horned Curassow *Pauxi unicornis*, Yellow-rumped Antwren *Terenura sharpei*, Bolivian Recurvebill *Simoxenops striatus*) not recorded during this survey inhabit altitudinal ranges below the survey areas along the río Pampa Grande. As the rapid assessment survey near the confluence with the río Altamachi lasted only 5 days and these species are extremely hard to detect if not vocalising, it is likely that all three species will be found in the area with further survey work. There is already reported evidence of hunters returning from Mosetenes with the distinctive casques of *Pauxi unicornis* (Herzog et al. 1999).

The High Andes of Bolivia and Argentina (EBA 56) holds 21 restricted species in four habitat types (semi-humid forest, Polylepis forest, dry scrub and grassland). Only the four species of semi-humid mountain forest/scrub were thought likely in the surveyed area, with a further five species thought possible if there was extensive Polylepis woodland at higher altitudes. The limited survey work above 3000 m found two of these high Andean species, one of which the Grey-bellied Flowerpiercer *Diglossa carbonaria*, also inhabits the upper yungas. The treeline in the survey area occurred between 3200 and 3300 m, the habitat at this altitude was severely degraded and the treeline had been depressed by burning to create grassland for grazing. Survey work was limited by weather and time constraints to areas in the vicinity of an established trail and close to the treeline. The results are therefore not representative of the High Andean habitat of Cocapata. Rather they represent a few interesting records and indicate the need for proper inventory in the future. Less disturbed treeline habitat appeared to be present towards the north-eastern end of the Cocapata Cordillera. In addition to any further high altitude forest species that might be found

in this habitat, it is likely a survey of the montane grassland habitat would reveal a considerable number of the High Andean EBA species. At the moment there is insufficient data to draw conclusions about the importance of Cocapata in conservation of the high Andean specialists. Inclusion of this habitat in any proposed protected area would however, be important to protect the treeline from further depression and to ensure that a continuous cross-section of Andean habitats was available to those species that use more than one habitat.

During the expedition a number of significant threats to the area were observed. These included selective commercial logging along the río Altamachi, burning of the treeline to clear forest for grazing and an influx of peasant farmers searching the upper reaches of the río Pampa Grande for land that could be cleared for farming. Other human impacts observed were a limited amount of hunting, dynamite fishing and subsistence farming along the upper part of the río Pampa Grande. Currently the four families living in the valley have no significant impact on the area as a whole. As their presence discourages other settlers they could be a positive influence in future plans to conserve the area.

5.13 Altitudinal Extensions

If we compare the range of altitudes in which species were observed during the course of the project to the most recently published accounts (Armonia 1995), we provide altitudinal extensions for 70 species (21% of our total number of observed species). For 26 of these species known altitudinal ranges were extended by more than 500m. This represents a substantial increase in our knowledge and understanding of species distribution within the Upper Yungas, and provides a clearer idea of how bird community composition alters with altitude.

From these observations two suggestions can be put forward. Firstly, there is much still to be learnt about the ecology of many of the Yungas bird species, and thus, many of the range extensions identified by the project simply represent a previous deficiency of data. Secondly, it is likely that the environmental conditions prevailing within the río Pampa Grande valley are warmer and more stable than elsewhere in the yungas, allowing species to live at higher altitudes than normal. The valley is surrounded on all sides by steep mountain ridges; therefore it is sheltered from the seasonal south polar winds that impact the outer eastern slopes of the Andes (Fjeldsa et al. 1999, Herzog et al. 1999). Herzog et al. (1999) carried out an ornithological survey of the south-westerly facing slopes of Cordillera Cocapata, and also noted that many species were observed at exceptional high altitude. Following that survey, 26 species were recorded at higher altitudes than previously documented. In addition, the increased ranges of six of those species are backed up by similar observations made by this expedition.

5.14 Conclusions & Conservation Recommendations

This study of the birds of the río Pampa Grande and río Altamachi valleys confirms the predictions that the Cocapata and Mosetenes Cordilleras are a stronghold for yungas endemics. The diversity and species richness of the avifauna combined with the large number of endemic species found make this area of major conservation importance. The whole Cocapata-Mosetenes area is of special significance because it represents a critical link in the Vilcabamba-Amboro Biodiversity Corridor that is designed to help conserve one of the world's most important biodiversity hotspots. These cordilleras hold extensive habitat from three out of Bolivia's five Endemic Bird

Areas, making it one of the most important areas for bird conservation in Bolivia and of major significance in terms of global bird conservation.

On the basis of these facts and the data collected by the Yungas 2001 Expedition the following recommendations are made. (1) The forests of the Cordilleras of Cocapata and Mosetenes should be designated fully protected areas receiving the highest level of protection possible. (2) Commercial timber extraction should be prevented and the illegal selective logging currently underway out of Covendo along the río Altamachi should be investigated and stopped. (3) The area should be designated as one of Bolivia's first Important Bird Areas. (4) The few families currently living on the fringes of the río Pampa Grande valley should be allowed to continue making a living in the area as they are potentially important allies in ensuring that further human encroachment is limited. (5) The importance of Cordilleras Cocapata and Mosetenes as being a vital part of plans to conserve and protect Bolivia's biodiversity should be recognised. Specifically, the conservation of this area should be considered at least as important as the great national parks of Madidi and Carrasco in protecting the globally important yungas forests of the Andes.

5.15 Acknowledgements

We gratefully acknowledge the help of Collecion Boliviana de Fauna for organising the permits and many thanks to all those who helped and supported the Yungas 2001 expedition and its members. Special thanks to Bennett Hennessey for his advice and encouragement and to Armonia, the Bolivian BirdLife International partner, for their support. We are grateful for the assistance of Michael Kessler, Ignacio De la Riva, Steffan Loetters, Jose Munoz, George McGavin, and Darren Mann in advising the expedition. The expedition was financially supported by the Thriplow Charitable Trust, BP Conservation Programme, Royal Geographic Society (Rio Tinto Award), Oxford University (A.A. Paton Fund & Exploration Council), British Ecological Society, Gilchrist Educational Trust, Glasgow University Council, The Russell Trust, Royal Society of St George Award, Chester Zoo, Scottish Royal Geographic Society, Albert Reckitt Charitable Trust and BOU. A final thanks to Professor Sir Richard Southwood for acting as expedition patron.

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6 New data on one of the world's most elusive owls, Cloud Forest Screech-Owl Otus marshalli

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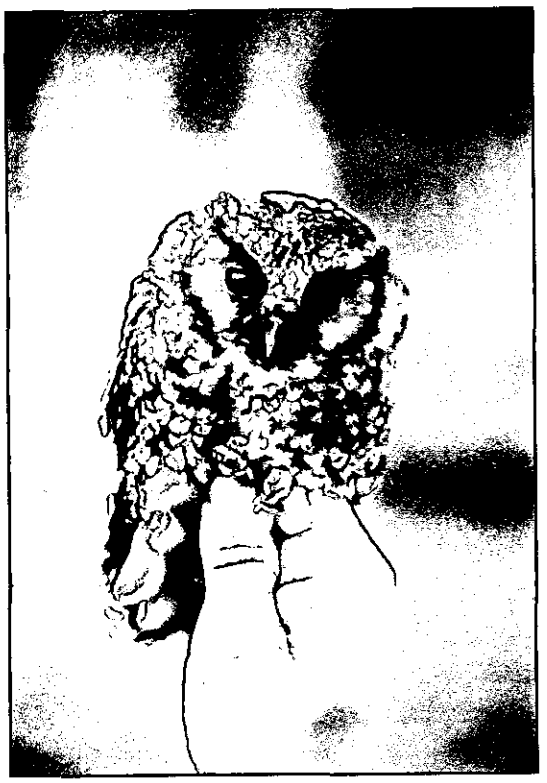

Figure 6.1. Cloud-forest Screech-Owl, *Otus marshalli*. río Pampa Grande, Cochabamba, Bolivia. © Ross MacLeod.

6.1 Introduction

The Cloud-forest Screech-Owl *Otus marshalli* is one of the most poorly known owls in South America and worldwide. As its name implies, the species occurs in mossy cloud forest and is apparently confined to a narrow altitudinal range from about 1900 m to 2250 m. It was described quite recently by Weske and Terborgh (1981) based on several specimens from Cordillera Vilcabamba in central Peru, and an additional specimen was collected in 1982 by Schulenberg et al. (1984) in Cordillera Yanachaga, Peru, located c. 500 km north-west of the species' type locality. However, *O. marshalli* is so elusive that neither Weske and Terborgh, nor Schulenberg et al. obtained a visually confirmed tape recording of the species' voice that hence remained a mystery.

On the 16th July 1996 Herzog tape-recorded an unidentified *Otus* owl at 1600 m in the Serranía de Callejas in the north-west corner of Bolivia's Parque Nacional Carrasco in depto. Cochabamba. About two years later, the same species was tape-recorded at the same site by Maccormick. Both recordings were included by Mayer (2000) on the CD-ROM "Birds of Bolivia", but the owl's identity remained unknown.

Between the 3rd and the 24th August 2001 the same *Otus* sp. was heard and tape-recorded between 2120m and 2580m in the rió Pampa Grande valley in the Cordillera Cocapata, depto. Cochabamba. Following this, a pair of birds were recorded, and one captured and identified as *O. marshalli* on the 31st August 2001 (SKH & SRE). The captured bird, a male, was taken as a specimen which was deposited at the national natural history museum in La Paz, CBF-03760 (skin and partial skeleton). The individual was prepared by S.K.H. This increases the known distribution of Cloud-forest Screech Owl to four sites, two in Bolivia and two in Peru, see figure 6.2.

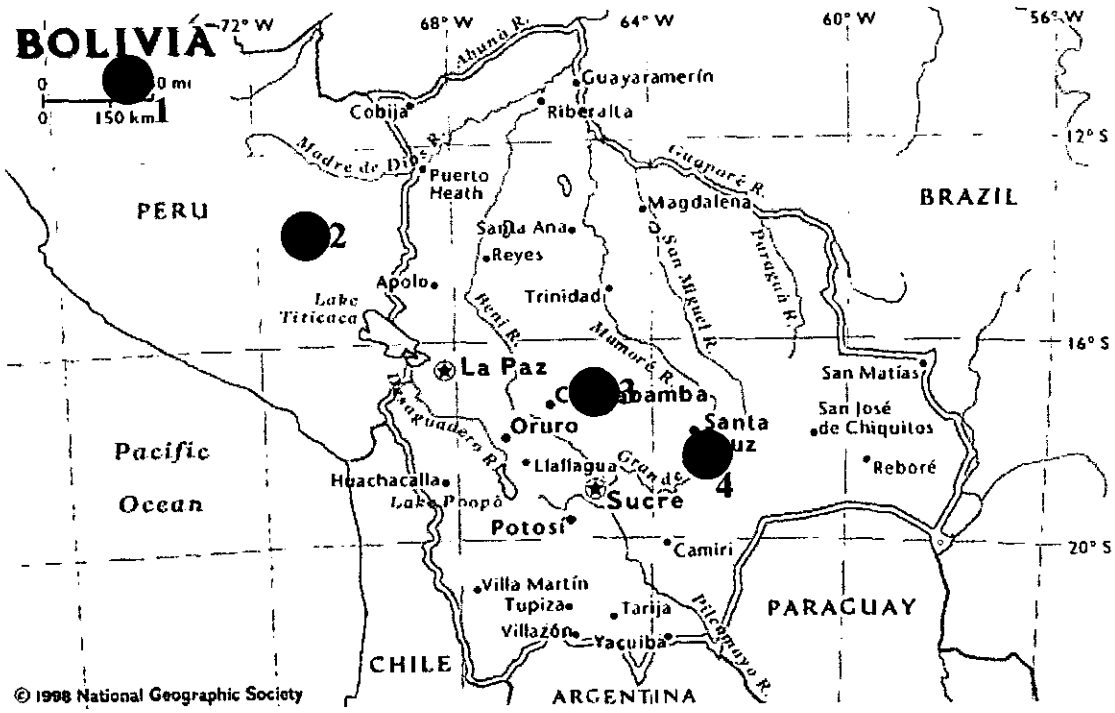

Figure 6.2. Map showing distribution of known records of Cloud-forest Screech-owl *Otus marshalli*. 1 = Cordillera Yanachanga, 2 = Cordillera Vilcabamba, 3 = Cordillera Cocapata and 4 = Serranía de Callejas.

6.2 Voice

The song of *O. marshalli* is similar to those of other *Otus* species, comprising a continuous series of monotonic hoots. *O. marshalli* most resembles the Rufescent Screech-owl *Otus ingens* in the characteristics of its songs. However, it can be differentiated firstly, by the slower song, and secondly, by the lower pitch and shorter note. The song of *O. marshalli* begins quietly and grows in intensity, then ends, often with a reduction in intensity. In comparison to the most frequently heard vocalization of *O. ingens* (long song), the song of *O. marshalli* is noticeably shorter.

6.3 Behaviour

Owls are notoriously difficult to observe as a consequence of their nocturnal habits. We can say very little about the behaviour of *O. marshalli* other than that which was witnessed during sound recording and specimen capture. During sound-recording, the owls were exposed to playback recording in order to mimic a territorial infraction and encourage them to vocalize. The territorial individuals responded quite readily to playback and reciprocal territorial vocalisations were recorded within 30 minutes. However, the territorial owl(s) did not, at least initially, directly confront the 'intruder'. It took about 2 hours to coax them to within 25m. When individual *O. marshalli* were encouraged to close proximity, they were very difficult to spotlight,

instead skulking in and around the heavy growths of epiphytes covering the tree branches. Frequently, it appeared that individuals moved around large trees, not by flying from branch to branch, but by clambering along the branches.

6.4 Habitat Associations and Altitude Distribution

O. marshalli occurred in primary and slightly disturbed montane evergreen forest between the altitudes of 2120-2580m. These forests were characterized by their structural complexity; with most trees supporting a high degree of epiphytic growth, mainly, mosses, orchids and bromeliads, while the understorey was similarly very dense. .*O marshalli* was not recorded from degraded and highly disturbed areas of forest at similar altitudes and would appear to require such a pristine, complex habitat in which to live, although the records from Parque Nacional Carrasco were from within a few metres of a rarely used road.

We identified three species of congeneric Screech-owls in the río Pampa Grande valley that were distributed in an altitudinally replacing series. Similar distributional patterns have been observed previously in the *Otus* genus in Peruvian cloud forest (Weske and Terborgh, 1981). *O. ingens* occurred up to 2200m, *O. marshalli* from 2120-2580, and the White-throated Screech-owl *Otus albogularis* above 2540m. It would appear that successive species were narrowly syntopic, their distributions overlapping by no more than 50-100m. This would suggest that species distribution is primarily maintained by exclusion via interspecific competition. Where *O. ingens* and *O. marshalli* were seen to be syntopic between 2100-2200m, observations of *O. ingens* were only ever made in areas of secondary forest with less epyphitic growth while at this altitude no *O. ingens* were found in primary forest with heavy epyphitic growth although they were found in primary forest at lower altitudes.

6.5 Discussion

The Cloud-forest Screech-owl *O. marshalli* would appear to require verdent high-altitude cloud forest cloaked in an abundance of epiphytic growth. Individuals were not recorded in heavily degraded or disturbed forest habitats. Its habitat associations and the manner in which it was seen to clamber around large trees may lend some insight into the feeding habits of this poorly known species. It is possible that *O. Marshall*i specialises in searching for insects among the abundant epiphytic growth, but further behavioural observations are required to confirm this. Considering the isolated and widely separated records of this species and the near contiguous distribution of potentially suitable habitat from south-central Bolivia to central Peru the authors believe that ornithological surveys within this area should tape record all vocalising *Otus* owls in order to shed light on the full distribution of *O. Marshalli* and altitudinal distribution patterns within the *Otus* group found in the Andes.

6.6 Acknowledgements

The field work was financially supported by the Thriplow Charitable Trust, BP Conservation Programme, Royal Geographic Society (Rio Tinto Award), Oxford University (A.A. Paton Fund & Exploration Council), British Ecological Society, Gilchrist Educational Trust, Glasgow University Council, The Russell Trust, Royal Society of St George Award, Chester Zoo, Scottish Royal Geographic Society, Albert Reckitt Charitable Trust and BOU.

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7 First sound recordings, new behavioural and distributional records and a review of the status of the globally threatened Scimitar-winged Piha Lipagus uropygialis

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7.1 Introduction

The Scimitar-winged Piha *Lipaugus uropygialis* is a poorly known globally threatened and restricted range species found only in the Bolivian and Peruvian Upper Yungas Endemic Bird Area, EBA 055 (Ridgley and Tudor 1994, BirdLife International 2000). Other than a morphological description of the species, and limited information on its distribution, few data have been published (Remsen *et al.* 1982, Snow 1982). We present the first documented description of the voice of *L. uropygialis* as well as new data on its distributional range, habitat preferences and behaviour for the species. These novel data are placed in context by presenting a review of all existing information on the species, including previously undocumented specimens and observations. We conclude by assessing the conservation status of *L. uropygialis* and formulate conservation recommendations.

Table 7.1. Known specimens and previous observations of Scimitar-winged Piha *Lipaugus uropygialis.* ANSP= Academy of Natural Sciences of Philadelphia, AMNH= American Museum of Natural History, BM= Berlin Museum, LSUMZ= Louisiana State University Museum of Zoology, MCZ=, Museum of Comparative Zoology and MSECK= Forschungsinstitut Senckenberg

Location	Month	Year	Altitude	No. of observations/ specimens	Observer/ Collector
Abra de Maruncunca, SE Peru	Nov-Dec	1980	2000 m	3-4 ind. obs.	L. Binford, L. Campos, T. Schulenberg
Abra de Maruncunca, SE Peru	AUG	1986	2200 m	1 ind. obs.	M. Kessler and B. Walker
Apa Apa, La Paz, Bolivia	MAR	1996	2300 m	1 ind. obs.	B. Woods
Apa Apa, La Paz, Bolivia	DEC	1996	2300 m	1 ind. obs.	B. Woods
Apa Apa, La Paz, Bolivia	DEC	1996	2200 m	1 ind. obs.	T. Gullick
Apa Apa, La Paz, Bolivia	AUG	1999	2400 m	1 ind. obs.	A.B. Hennessey and A. Jaramillo
Apa Apa, La Paz, Bolivia	OCT	1999	?	1 ind. obs.	D. Mason
Apa Apa, La Paz, Bolivia	JUL	2001	?	1 ind. obs.	L. Rubey and B. Woods
Chapare, Cochabamba, Bolivia		1970	?	up to 10 ind. obs.	R. Ridgely
Chapare, Cochabamba, Bolivia	APR	1977	1800 m	1 ind. obs.	R. Ridgley
Chapare (Old road), Cochabamba, Bolivia	JUL	1996	?	1 ind. obs.	S. Herzog
Chapare (Old raod), Cochabamba, Bolivia	OCT	1997	?	1 ind. obs.	M. Kessler
Coroico (Tilotilo), La Paz, Bolivia		1876	2400 m	4 sp (2 m and 2 f) BM	C. Buckley
Coroico (Chaco), La Paz, Bolivia	JUL	1894	?	3 sp. (2 m and 1 f) AMH & MCZ	G. Garlepp
Coroico (San Antonio), La Paz, Bolivia	MAY	1895	?	1 sp (f) MSECK	G. Garlepp
Coroico (San Antonio), La Paz, Bolivia			?	1 sp	(Hellmayr 1929)
Coroico (Sandillani), La Paz, Bolivia	JUL	1896	2500 m	3 sp (2 m and 1f) MSECK	G. Garlepp
Coroico (Sandillani), La Paz, Bolivia	NOV	1934	2010 m	1 sp. ANSP	M.A. Carriker
Coroico (Sacromento Alto), La Paz, Bolivia	AUG	1979	2575 m	1 sp. LSUMZ	V. Remsen
Coroico (Sacramento Alto), La	OCT	1979	?	1 ind. obs.	R.A. Rowlett with R. Ridgley

Paz, Bolivia					
Coroico (Corani), La Paz, Bolivia	JUL	1989	2750 m	1 ind. obs.	M.Kessler
Corioco, La Paz, Bolivia	MAR	1994	2090 m	1 ind. obs.	A. Moon
Coroico, La Paz, Bolivia	MAR	1996	?	1 ind. obs.	J. Rossouw
Cotapata, La Paz, Bolivia	SEP	1999	?	1 ind. obs.	J. Balderama
Irupana, Peru	?	?	?	1 sp.	(Niethammer, G. 1956)
Locatal	MAR	1891	?	1 sp (m) MSECK	G. Garlepp

7.2 Methods

The authors' observations and sound recordings were made in 2001 during two biological inventory expeditions to previously unsurveyed areas of Bolivia; the first was to the río Pampa Grande (16°39.9' S 66°29.1' W), Cordillera Cocapata, Dept. of Cochabamba (MacLeod et al. In prep.) and the second was to Tokoaque (14°37' S 68°57' W), Madidi National Park, La Paz (Hennessey & Gomez In press). Observations were made at distances ranging from 2m to 20m, with binoculars, by six different observers. Sound recordings where made, using a Sony TCM5000 tape recorder and a Sennhieser ME66 directional microphone, at río Pampa Grande. The behaviour of *L. uropygialis* is described based on the authors' observations and previous, mainly unpublished, observations supplied by the observers listed in Table 1.

7.3 Voice

The only known vocal description is provided by Ridgely & Tudor (1994) and is based on a recording made during an observation of *L. uropygialis* on 27th October 1979. However, the bird was not seen vocalising and the recording was later identified, by the sound recordist, as a Blue-winged mountain-tanager *Anisognathus flavinucha* (Rowlett pers. com.). No identifiable recordings have been made and thus the vocalisations of *L. uropygialis* have been unknown, until now, although Walker (pers com.) had heard a seemingly agitated bird give "a short series of notes".

The voice of *L. uropygialis* is a noisy and variable shriek, like a parakeet of the genus *Aratinga*. The most frequent call consists of two notes, with the first note rising sharply and the second descending sharply. Single notes and more complex combinations of shrieks are also given. The sonogram in Figure 7.1 represents a typical burst of song and demonstrates considerable vocal dexterity within the species. More than one individual is vocalising, with upto four individuals being represented in the first section of the sonogram. The second part demonstrates three distinct sound patterns. This could represent two vocalising individuals with perhaps a single individual producing two of the sound patterns. Opposing sounds such as this are commonly heard from the genus *Psarocolius* (Jaramillo & Burke 1999). Of the few examples we recorded we found no distinctive patterns in note type or rhythm. The pattern of silence with a burst of song of different singing individuals is frequently found in lekking species in the genus *Pipra*, and within the Cotingidea with the Cock-of-the-rock *Rupicola peruviana* and the Screaming Piha *L. vociferans*. We cannot rule out the possibility that some sounds might be made by the males' wings, as described for the related Dusky Piha *L. fuscocinereus* (López-Lanús 2000).

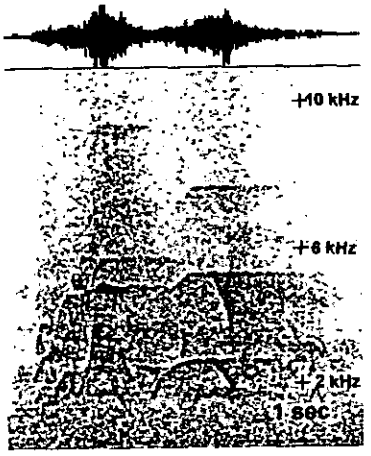

Figure 7.1 – Sonogram of Scimitar-winged Piha *Lipaugus uropygialis*, calls from a group of upto four individuals, río Pampa Grande Valley, 2560m Dept. Cochabamba, Bolivia. Recording by Ross MacLeod.

We heard vocalisations during four, of our five, observations. Individuals were seen vocalising at distances down to 5m on all occasions and recordings were made twice. Playback of recordings, both immediately after recording and one week subsequently, resulted in birds increasing the volume and tempo of their calls and approaching the broadcast. One observation resulted from the birds responding to playback of recordings made the previous week at the same location.

7.4 Behavioural Observations

Based on the reports of the observers in Table 7.1, birds are most often observed quietly perching within the sub-canopy or, less often, at the forest edge. They tend to perch approximately 10-15 metres off the ground and have been observed to remain motionless for several minutes at a time (Rubey pers. com.). During the 1970's Ridgley regularly observed *L. uropygialis* as singletons accompanying mixed flocks and less often in pairs (pers. com.). Kessler once observed four or five birds chasing each other through the canopy (pers. com.).

The authors' observations ranged from a single bird to groups of four. Groups were active and noisy, with the birds often chasing one another through the understorey and sub-canopy between 5 and 15m above the forest floor. Normally one individual would fly into sight and land on a tree branch close to the trunk, where it would pause and actively look around. A second individual would then follow and land close by. The first individual would then take off, to the accompaniment of the shriek-calls described above. The process would then be repeated with the birds chasing each other for 5 to 10 m, each time, from perch to perch. The first two birds would be followed by another two, which chased either each other or the first two. Occasionally the birds would stop and perch motionless, as recorded by other observers and described above. No wing noise was heard whilst the birds were in flight.

Records of stomach contents (Remsen et al. 1982) and observations of birds feeding (pers. obs Hennessey) demonstrate that *L. uropygialis* feeds partly on berries and tree fruits. During one observation a single bird performed a series of what appeared to be 'fly-catching' sallies (Moon and Rubey pers. com.). The bird flew to 2-3m and then returned to the same, or a nearby, perch. This suggests that insects are also included in the diet and on one occasion the authors observed a bird consume a caterpillar.

7.5 Review of Specimens and Observations

L. uropygialis appears to be confined to the upper yungas forests of central and west Bolivia (the eastern Andean slope) and south-east Peru. It has been recorded from five Bolivian localities (Coroico, Cotapata, Irupana, Apa Apa, Locotal, Chapare) and one Peruvian locality (Abra de Maruncunca), see Figure 2. All these localities are between 1800m and 2750m.

The sixteen known specimens of *L. uropygialis* were collected between 1876 and 1979. During the 19th century fourteen birds were collected during seven trips, giving an average of two birds per trip; twelve of these birds came from Coroico, La Paz, Bolivia. Subsequently, two birds were collected from Coroico in 1934 and 1979. No other birds have been collected, despite many collecting trips being made to Coroico and other sites close to localities where birds were collected. The decline in the frequency and size of collections could result from a reduced interest in collecting *L. uropygialis*. However, we consider this unlikely as very few specimens exist and collectors typically take hundreds of specimens of the same taxa (pers. obs Hennessey). We therefore believe that the paucity of specimens in the 20th century is evidence for population declines, a conclusion that is supported by field observations.

Prior to the authors' observations, *L. uropygialis* had been observed on sixteen occasions between 1970 and 2001. In the 1970s a maximum of 10 individuals, in singles and pairs, were recorded at Coroico and Chapare. In 1986 and 1989 groups of three to five individuals were observed at Abra de Maruncunca. Since then there have been twelve recorded sightings of single birds at a small number of localities. The sites at Coroico and Chapare now appear degraded with less than pristine habitat and although they have been frequently visited there are extremely few records of *L. uropygialis*. At the sites that have been frequently visited both number of observations and group size has declined in recent decades; the decline correlates with deterioration in habitat quality.

The authors new observations, at the two Bolivian sites described above were made between the 22nd August and 8th September 2001. At río Pampa Grande five observations were obtained, in two different locations, during 50 days of fieldwork in montane evergreen forest by five experienced ornithologists. The two locations were at altitudes of 2560m and 2450m on opposite sides of a valley, approximately 2km apart. The habitat in each location was primary forest on a steep ridge. A further observation was made by one of the authors (Gomez) on the 8th November 2001 at 2500m in primary montane evergreen forest at Tokoaque during the first ornithological surveys of the Upper Yungas section of Madidi National Park.

7.6 Discussion and Conservation Assessment

L. uropygilalis was first designated as a globally threatened species in 2000, when it was classified as Vulnerable (BirdLife 2000). This classification was based on the unpublished information presented in Table 7.1. The new data collected by the authors in 2001, combined with previous records, show that *L. uropygialis* is a genuinely rare species, even in pristine forest.

During 50 days of fieldwork in the río Pampa Grande valley at Cocapata, observations were made on just five occasions in only two locations, both along ridges. Previous observations and collections further suggest that the species is extremely localised as these records come from only six localities. Four out of the five observations at río Pampa Grande were made at a location visited almost daily, so this low number of

sightings suggests that the birds might be utilising large tracts of forest within the area. All bar one of the recent observations have been made in pristine habitat, thus although it has once been observed foraging on fruit from early successional plants (Cotapata observation), it appears that *L. uropygialis* requires primary forest habitat. Interestingly the observation by Kessler in 1997 was made at exactly the same spot on the old road at Chapare as the individual recorded by Herzog in 1996. This pattern of the species only appearing at one spot within a location is repeated elsewhere, such as in the Apa Apa site, where four observations have been recorded near the same ridge top. This apparent restriction to specific spots within primary forest, often associated with ridge tops, suggests that the species has currently unknown habitat requirements and that it may be inaccurate to estimate population size by assuming that the species will be found in all apparently suitable primary forest habitat.

Much of the forest habitat where *L. uropygialis* has been recorded has now undergone degradation due to anthropogenic impacts. Selective logging, road construction, agriculture, clearance for plantations, grazing and hunting may all change habitat suitability and have contributed to the transformation of pristine habitat into disturbed forest and we believe this probably explains the recent paucity of records from areas of former occurrence. Within Bolivia and south-east Peru there still remain extensive areas of undisturbed forest, where little or no survey work has been carried out. The true status of *L. uropygialis* will remain unknown until these areas have been surveyed. However, the limited range and localised distribution of this species, even in primary forest, combined with continued habitat degradation in the Yungas (pers obs.) suggest that the species is indeed globally threatened and should continue to be classed as Vulnerable. Unknown reasons for the highly localised distribution of *L. uropygialis* and its apparent total dependence on pristine forest suggest it is probably under greater threat than some other Upper Yungas endemic birds. Future conservation action for *L. uropygialis* should concentrate on survey work in unexplored regions of yungas forest in Bolivia and south-east Peru between 1500m and 3000m, designed to estimate geographical range and abundance; investigations of habitat selection may facilitate this goal. Historic sites should be revisited to confirm presence or absence.

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8 First herpetological survey of Cordillera Mosetenes, Cochabamba, Bolivia.

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8.1 Summary

We present a checklist and ecological data of amphibians and reptiles recorded during fieldwork covering a two-month period of the dry season within the río Pampa Grande Valley, Cochabamba, Bolivia. The fieldwork covered both forest (yungas) and montane grassland (puna) habitats. 43 species of herpetos were recorded: 27 anurans and 16 reptiles. 7 Species of the amphibians are endemic to Bolivia, while a further 6 taxa, 5 amphibians and 1 reptile, represent undescribed species.

8.2 Resumen

En el presente trabajo presentamos una lista de los anfibios y reptiles que fueron encontrados en el trabajo de campo, llevado a cabo en la época seca, en dos meses del 2001 en el Valle de Pampa Grande (Cochabamba, Bolivia). Se encontraron 43 especies de herpetos, 27 especies de anfibios y 16 de reptiles, siete especies de anfibios son endémicos de Bolivia y probablemente cinco son nuevas para la ciencia, respecto a los reptiles probablemente una especie sea nueva para la ciencia.

8.3 Introduction

Bolivia is one of the world's megadiversity countries holding a large percentage of global biodiversity, encompassing a great number of ecoregions and a highly variable topography (Stattersfield *et al.* 1998). At topographic extremes within Bolivia are the Altiplano highlands at 5200m with a mean annual temperature of 10°C and 500-700mm annual precipitation; and the Amazonian lowlands at 100-600m with a mean annual temperature of 27-29°C and annual precipitation of 1800-2200mm (De la Riva

*et al.*2000; Navarro, G. & M. Maldonado, 2002). This variable topography encompasses a number of species-rich habitats reflected in the country's immense biodiversity. Within Bolivia, as elsewhere in South America, herpetological and vertebrate diversity is greatest within the lowland Amazonian forests, with endemism highest in the humid montane forests known as yungas (Köhler, 2000). However while Bolivia contains one of the world's richest avifaunas, covering 14% of the globe's bird species (Wedge and Long, 1995), the number of reptiles and anuran fauna reported for Bolivia is relatively small, with many authors stressing a lack of distributional and ecological data (De la Riva *et al.* 2000; Köhler, 2000 Harvey, 1997, Aguayo, 2000, Muñoz, 2002). This is reflected in Bolivia's Red Data Book containing only two amphibians despite 18% of Bolivia's species being endemic and a world-wide decline in amphibian populations (De la Riva *et al* 2000, Ergueta and Morales 1996).

The obvious gap in Bolivia's herpetological knowledge highlights the necessity for further studies which will allow accurate conservation assessments and lead to realistic conservation strategies; essential for a country rich in biodiversity but poor in financial resources for biological conservation.

8.4 Methods

The fieldwork was conducted during the dry season between the 2nd of August and the 19th September 2001, covering an altitudinal range of 1700m between 1800m and 3500m at Pampa Grande, Depto. Cochabamba (16° 37' S and 66° 28' W). Additional sampling was carried out during a five day period (6th - 11th September) near the confluence of the río Pampa Grande and río Altamachi at an altitude of 1100m (16°24' S and 66° 19' W). Survey methodology used throughout the fieldwork follows techniques described and developed by Heyer et al (1994) and Bennet (1999) for tropical herpetological inventories.

8.5 Visual Encounter Surveys (VES)

This active survey method is an efficient and systematic time-constrained technique for locating herpetos. This technique can be applied both during the night, for amphibians and during the day, for reptiles. During this project all VES were of 30 minutes duration and covered the entire altitudinal range from 1800-3500m and at the lower río Altamachi site.

8.6 Drift Fence and Pitfall Traps

These passive methods detect shy, cryptic, swift and fossorial (adapted for digging) species; those notoriously difficult to detect and capture during VES. Drift fence and pitfall traps were located in all habitat types within the 2100-2200m altitudinal band and checked twice daily over a five week period.

As further herpetos were encountered during initial site exploration and out with the above survey methods, general ad hoc collecting helped to provide greater accuracy of species richness, habitat requirements and altitudinal distribution. To provide a thorough species inventory for the río Pampa Grande valley all habitat types, both natural and disturbed were surveyed. We also attempted to cover as many micro-habitats as logistically possible such as leaf litter, rotten logs, sand bar shingle etc. However we were unable to sample arboreal herpetofauna, especially those restricted to epiphytes, at a height greater than 2m. All animals processed were measured, photographed and weighed before being released at original capture site. When positive identification was not possible, animals were taken as voucher specimens following standard methodology (Heyer et al. 1994, Köhler, 2000, Pisani et al. 1974).

For many of the voucher specimens, muscle and/or liver tissue was taken and deposited in the Colección Boliviana de Fauna (CBF) for future genetic and molecular studies. All voucher specimens were deposited at the Collecion Boliviana de Fauna (CBF), the national natural history museum in La Paz, Bolivia. Preliminary identification of species was carried out on return from the field at San Simón University, Cochabamba using all currently available identification literature (Peters J. & Orejas-Miranda, 1970; Peters J. & Donoso-Barros, 1970; De la Riva et al. 2000; Köhler, 2000; Dirksen & De La Riva, 1999; Fugler et al. 1995).

8.7 Results

During the field work we positively identified 27 species of anuran. Seven of the species recorded are endemic to Bolivia: *Bufo quechua, Bufo justinianoi, Eleutherodactylus mercedesae, Eleutherodactylus fraudator, Eleutherodactylus llojsintuta Phrynopus sp., Phyllonastes sp.* A further three species; *Phrynopus sp., Phyllonastes sp.* and *Bufo* sp. almost certainly represent new species, and are also likely to be Bolivian endemics (M. Harvey, *pers. com*). The status of a further two species, *Bufo sp.* and *Hyla sp.* are at present uncertain. The 27 identified morphotypes represent four amphibian Families within the río Pampa Grande Valley: *Bufonidae (8), Centrolenidae (1), Hylidae (6)* and *Leptodactilydae (12),* See table 8.1.

Sixteen species of reptiles were found in the Pampa Grande Valley, representing two snake Families, *Colubridae* and *Viperidae*, and four lizard Families, *Polychrotidae, Tropiduridae, Teiidae* and *Gimnophthlamidae*. Several of these reptiles still require identification to species level, but it appears that one lizard species, within the family *Gymnophthlamidae*, is new to science (See table 8.2). Tables 8.1 and 8.2 provides a species list for the río Pampa Grande valley, containing both those species collected and deposited at CBF and those released at site, along with the recorded altitudinal distribution.

Table 8.1. Amphibian species list of the río Pampa Grande Valley, showing taxonomic status and recorded altitudinal distribution.

	Altitude								
Species	**1100**	**1800**	**2100**	**2300**	**2500**	**3300**	**3500**	**Endemic**	**Probably new sp**
Bufo fissipes		X							
Bufo justinianoi		X						*	
Bufo poeppigii	X								
Bufo quechua			X	X				*	
Bufo spinulosus							X		
Bufo veraguensis		X	X	X					
Bufo sp.		X							x
Bufo sp. nov.		X							x
Centrolenidae 1		X							
Gastrotheca marsupiata						X	X		
Gastrotheca sp.						X			
Hyla andina							X		
Hyla armata				X					
Hyla armata group			X	X					x
Hyla balzani		X	X						
Eleutherodactylus fenestratus	X								
Eleutherodactylus fraudator			?					*	

Eleutherodactylus llojsintuta			X					*		
Eleutherodactylus mercedesae		X						*		
Eleutherodactylus platydactylus		X	X	X	X	X				
Eleutherodactylus rhabdolaemus		X	X							
Eleutherodactylus sp		X	X							
Eleutherodactylus sp.1(small)			X							
Phrynopus sp.						X	X	*	x	
Phyllonastes sp.		X	X	X	X			*	x	
Pleurodema marmoratum							X			
Telmatobius sp.							X			
	27	3	12	10	6	2	4	6	7	5

Table 8. 2. Reptile species list of the río Pampa Grande Valley showing recorded altitudinal distribution and taxonomic status.

			Altitude						
Species	**1100**	**1800**	**2100**	**2300**	**2500**	**3300**	**3500**	**Endemic**	**Probably new specie**
Clelia clelia		X							
Chironius monticola		X	X						
Chironius fuscus		X	X						
Echinanthera occipitalis		X	X						
Liophis sp.		X	X						
Tachymenis peruviana							X		
Thamnodynastes pallidus			X						
Colubridae 1		X							
Colubridae 2			X						
Colubridae 3		X							
Bothrops sp.		X							
Anolis sp.									
Gymnophthalmidae 1		X	X						x
Gymnophthalmidae 2		X							
Ameiva ameiva	X								
Liolaemus sp.							X		
	16	1	10	7	0	0	0	2	0	1

8.8 Altitudinal Distribution

The altitudinal distribution pattern of the amphibian community can be split in to three groups: those restricted to high elevations on or above the artificial treeline (>3300m) those restricted to lower elevations (<2700m) and altitudinal generalists (figure 8.1). Seven species were recorded above 3300m (*Bufo spinulosus, Gastrotheca marsupiata, Gastrotheca. sp. Hyla andina, Pleurodema marmoratum, Telmatobius sp* and *Phrynopus sp nov*), 19 species below 2700m (*Bufo fissipes, Bufo justinianoi, Bufo poeppigii, Bufo quechua, Bufo veraguensis, Bufo* sp, *Bufo* sp. nov, Centrolenidae 1, *Hyla armata, Hyla armata group, Hyla balzani, Eleutherodactylus fenestratus, Eleutherodactylus fraudator, Eleutherodactylus llojsintuta, Eleutherodactylus mercedesae,, Eleutherodactylus rhabdolaemus, Eleutherodactylus sp1, Eleutherodactylus sp2, Phyllonastes sp nov).* Only three species had a recorded

altitudinal range of 500m or more, *Bufo veraguensis* (500m), *Eleutherodactylus platydactylus* (1500m) and *Phyllonastes sp nov.* (700m). Only one species, *Eleutherodactylus platydactylus,* was recorded both above and below 3300m. Many species (24) within the valley were recorded as having a relatively narrow distribution with an altitudinal range of 700m or less, with 11 species recorded from a single locality. We are unsure if the restricted altitudinal distribution shown by some species reflects their true distribution or whether this is an artefact of species rareness. This might be the case with *Eleutherodactylus mercedesae* which was reported by Kohler (2000) as rare and only found at a single locality within the río Pampa Grande valley.

The majority of the reptiles were recorded between 1800 and 2600 which is clearly an artefact of the increased effort within the range. Only two species, *Liolaemus* sp. and *Tachymenis peruviana*, were recorded above the treeline in puna habitat (3500m). Recorded altitudinal distribution was very narrow for the majority of the reptiles. Only two taxa, Gymnophthalmidae 1 and *Echinanthera occipitalis* had a range greater than 200m.

It must be noted that the recorded altitudinal distributions presented here represent the presence in or use of habitat type(s) during a relatively short non-breeding period. Altitudinal distributions could differ from surveys conducted at other times of the year.

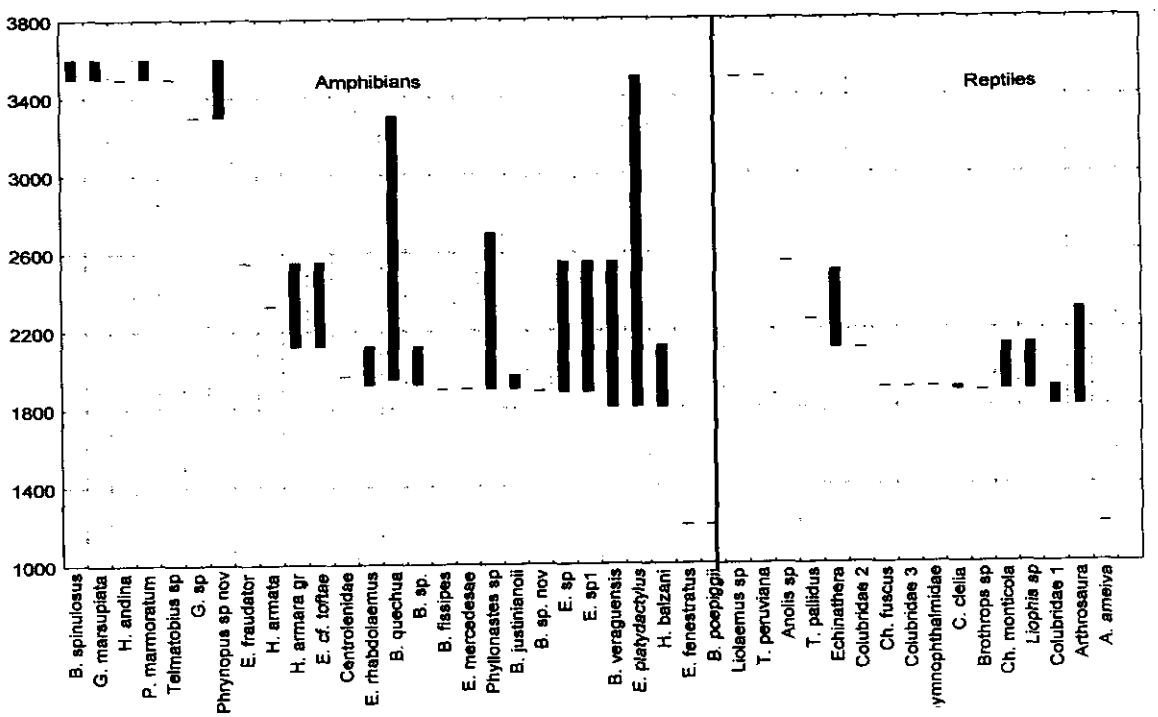

Figure 8.1. Altitudinal distribution of herpetofauna found in the río Pampa Grande Valley, from 1800 to 3600m. Altimachi site shown separate at 1100 m.

8.9 Microhabitat and Temporal Activity

Observations during fieldwork revealed differences in microhabitat preferences and temporal activity of individual species. Within the study area and fieldwork duration only four amphibian species were active during the day, *Phyllonastes* sp. nov., *Phrynopus* sp. nov., *Eleutherodactylus rhabdolaemus* and *Eleutherodactylus platydactylus*. *Eleutherodactylus platydactylus* was also active at night. All other

species are crepuscular or nocturnal with activity generally beginning shortly after 1800hrs. As with most of the genus *Hyla*, the three species within the study area were associated with fast, or very fast flowing water of the main river and smaller streams. While present in or near slower or dry water courses was the single Centrolenid, *Bufo justianoii*, *B. quechua* and *B. veraguensis*. As is typical of the genus *Eleutherodactylus* all 8 species were strongly associated with shrubs of the forest understorey and epiphytes such as bromeliads (Bromeliaceae) and ferns (Pterophyta). Above the treeline 6 species of anuran were recorded. Three of those were only found in association with the permanently soaked marshy valley bottoms known as "bofedales", *Pleurodema marmoratum*, *Bufo spinulosus* and *Gastrotheca marsupiata*.

Almost all of the 16 species of reptiles were recorded from open or exposed microhabitats such as clearings (*Echinanthera occipitalis*, Gymnophthalmidae 1 and *Liophis* sp), edges of water courses (*Chironius monticola*) or recently burnt areas (*Clelia clelia*, *Liophis* sp., *Bothrops* sp.). Only one species, *Chironius fuscus*, was recorded from within secondary forest while none were recorded from primary forest, although a single sloughed skin from an unidentified species was found.

8.10 Cluster Analysis

To compare the herpeto community recorded within the río Pampa Grande valley with similar sites on the eastern Andean slope in Peru and Bolivia we performed a cluster analysis. Results for this are shown in figure 8.2. Results show that the río Pampa Grande valley herpetofauna is most similar to that of La Paz, but also Tarija and Chuquisaca.

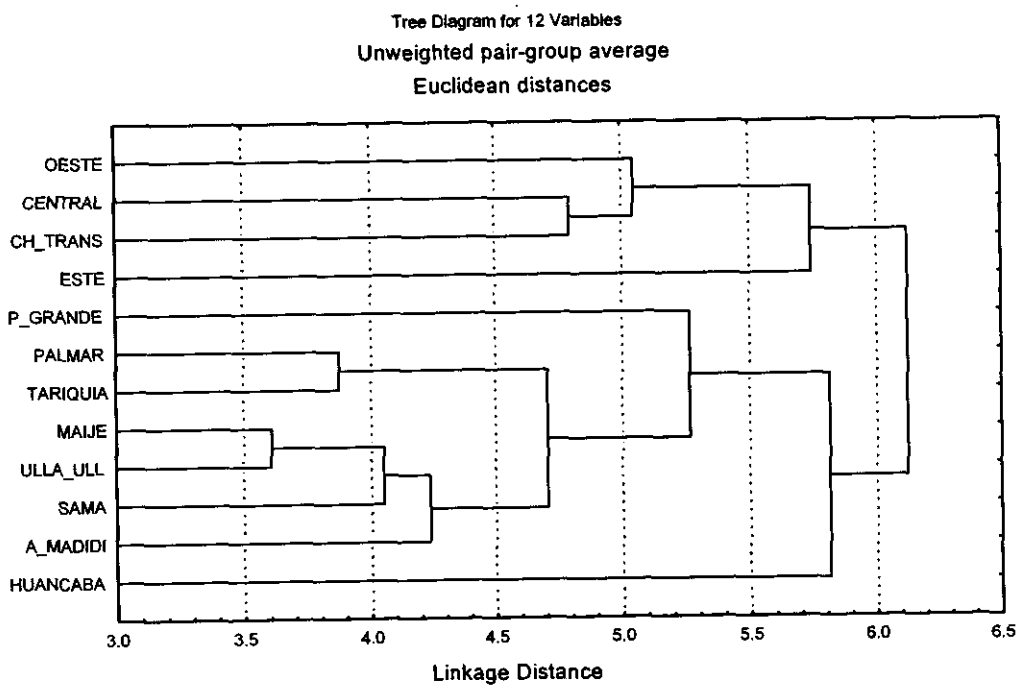

Figure 8.2. Cluster analysis comparison with data from other Bolivian and Peruvian amphibian surveys. **Oeste, central** and **este** from Carrasco National Park (Aguayo, et al. 1999); **Ch trans** (Köhler, 2000) in chapare transect; **Palmar** depot. Chuquisaca (Harvey, 1997); **Tariquia** (Aparicio, 1998) and **Sama** (Muñoz, 2002) Depto. Tarija; **Maije**, Maije river (Padial et al 2000), **Ulla Ull**, Ulla Ulla National park and **Madidi**, Madidi National Park all Depto. La Paz; and **Huancaba**, Huancabamba transect in Peru (Duellman & Wild, 1993); **P_grande**, present work.

8.11 Species Accumulation Curves

To quantitatively estimate the total species richness of the río Pampa Grande valley herpetofauna we used the bootstrap estimator (Colwell 1997). Figure 8.3 shows that an asymptote was not reached indicating the total number of species recorded to be lower than the true figure for the study site. Using the bootstrap estimator we calculate that a further 4 amphibian and 4 reptile species are present. Köhler (2000) also reports that 63 species are present in the yungas ecoregion and a further 23 in the ceja. We believe that further work carried out during the wet season within the study site will provide a full species list and a greater accuracy on individual species altitudinal distribution.

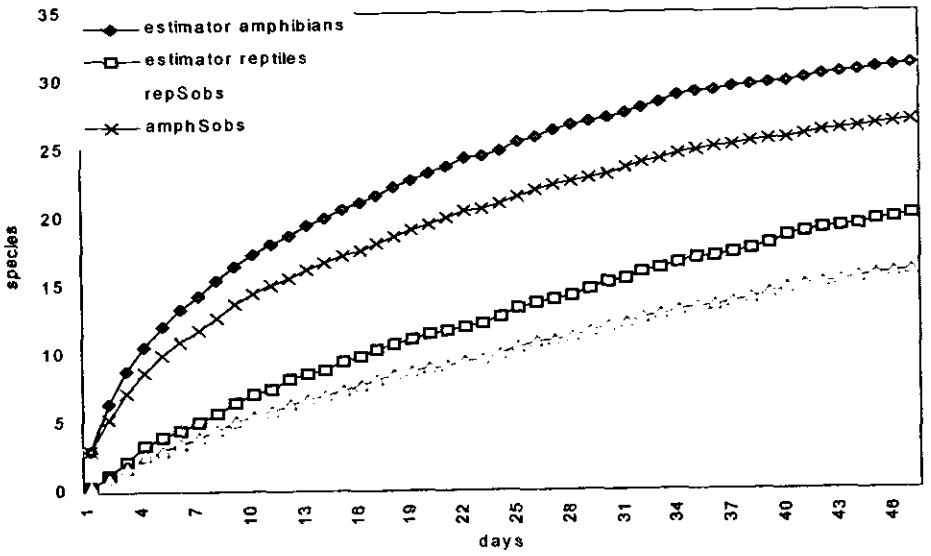

Figure 8.3. Species accumulation curves, showing number of amphibian and reptiles species ecorded during the field work in the Pampa Grande valley, based on 100 randomizations of sample order using the program *EstimateS* (Colwell 2000).

8.12 Discussion & Conservation Assessment

Work carried during the project recorded 43 species of herpeto: 27 anurans and 16 reptiles. 7 amphibians are endemic to Bolivia. While a further 6 amphibians, representing 22% of the amphibian community represent new species. 1 New species of reptile was also recorded. These figures are truly phenomenal for any site on earth and indicate both the herpetological wealth of the yungas as well as the current lack of knowledge. The new amphibian species include examples from the genus Phyrnopus and Phyllonastes, which often have very restricted distributions, some known only from a single locality.

The río Pampa Grande valley represents an important site for herpetos within the Bolivian yungas, including the only known site for 7 species. It is therefore of international importance for biodiversity conservation and on the data available at present we propose that the area should be designated a fully protected area receiving the highest level of protection possible. It would also be a crucial link in the Vilcabamba-Amboró biodiversity Corridor. The area is also a site of international importance for bird conservation and has been proposed as a protected area by MacLeod *et al.* (In Prep.) The study site is also located within a valley that has experienced little human disturbance relative to other yungas sites. Further fieldwork is required during the wet season to fully document the sites herpetofauna, while further surveys are required on the eastern base of Cordillera Cocapata and the

western and eastern slopes of Cordillera Mosetenes (north and east of the study site) to provide a better indication of herpeto distribution and endemism within the Bolivian yungas.

8.13 Acknowledgments

We gratefully acknowledge the help of Collecion Boliviana de Fauna for organising the permits and many thanks to all those who helped and supported the Yungas 2001 expedition and its members. We are grateful for the assistance of Bennett Hennessey, Michael Kessler, Ignacio De la Riva, Steffan Loetters, Jose Munoz, in advising the project. The project was financially supported by the Thriplow Charitable Trust, BP Conservation Programme, Royal Geographic Society (Rio Tinto Award), Oxford University (A.A. Paton Fund & Exploration Council), British Ecological Society, Gilchrist Educational Trust, Glasgow University Council, The Russell Trust, Royal Society of St George Award, Chester Zoo, Scottish Royal Geographic Society, Albert Reckitt Charitable Trust and BOU. A final thanks to Professor Sir Richard Southwood for acting as expedition patron.

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9 Diversity and Composition of Dung Beetle Communities on an Andean Altitudinal Gradient in the Bolivian Yungas

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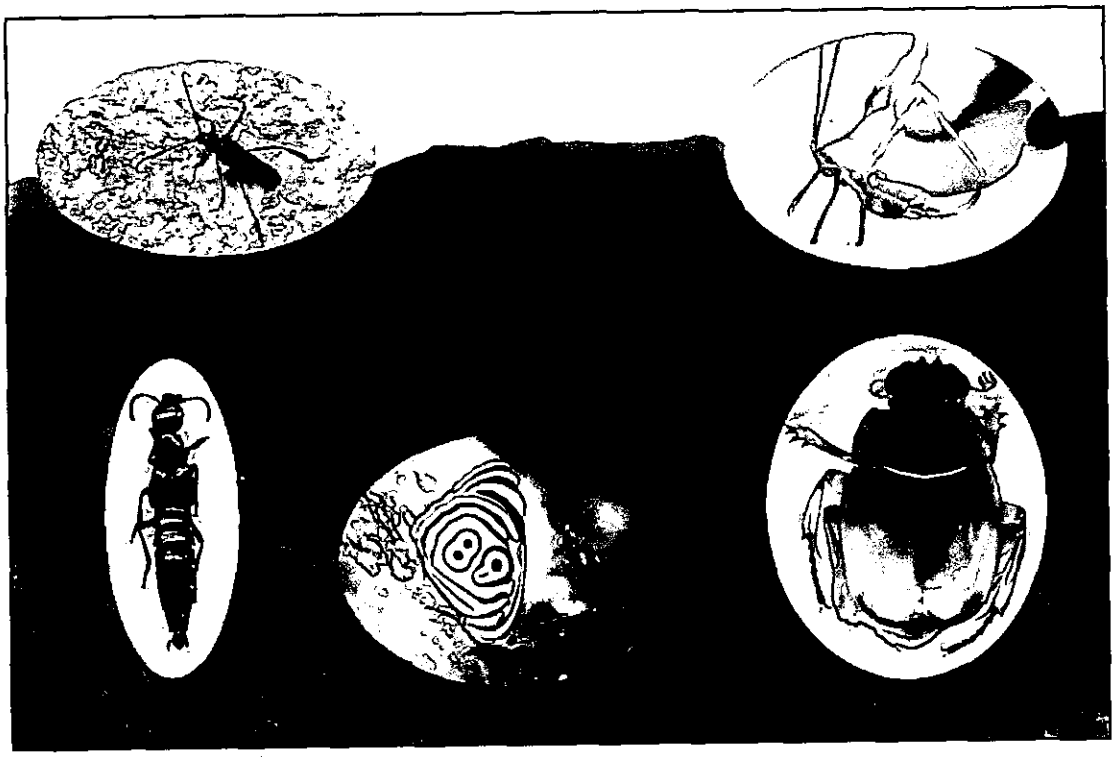


9.1 Summary

Dung beetles play an important ecological role in tropical forests and are considered good biological indicators, but little is known about their taxonomy, distribution, and ecology in South America. For the first time we report on the Scarabaeidae fauna from a tropical Andean locality in the Bolivian Yungas. Six transects of human faeces baited pitfall traps were established at four altitudes between 1820 m and 2530 m in humid montane forest in August/September 2001. We recorded 2526 dung beetle individuals of 19 'species' in a total of 204 trap-days. The three most abundant species (*Ontherus obliquus*, *Dichotomius carbonarius*, *D. diabolicus*) accounted for 68.8 percent of the entire catch. Six species occurred across the entire gradient; six other species were found only at 1820 m. Species richness per transect varied from 7 to 16. Sample-based species accumulation curves indicated that sampling was exhaustive on only two transects. Individual-based rarefaction curves were used to standardize for sampling effort and to estimate total species richness using the Chao 1 and MMMean statistics. MMMean performed poorly. Linear regression indicated a fairly pronounced but non-significant decrease of the standardized Chao 1 richness estimates with elevation. Morisita-Horn indices showed moderate to high similarity in community composition between almost all transects and indicated that, within the relatively narrow altitudinal gradient of this study, habitat factors and/or human disturbance had a greater influence on community composition than altitudinal

distance between transects. Comparisons with other studies are hampered by the poorly known species-level taxonomy of Bolivian Scarabaeidae, emphasizing that extensive field and museum work is needed to examine the potential of dung beetles as biological indicators in the Neotropics.

9.2 Resumen

Los coleopteros coprófagos juegan un rol ecológico importante en los bosques tropicales y son considerados como buenos indicadores biológicos. Sin embargo, se conoce poco acerca de su taxonomía, distribución y ecología en Sudamérica. Por primera vez reportamos la fauna de Scarabaeidae de una localidad en los Andes tropicales en la región de los Yungas bolivianos. Se establecieron seis transectas de trampas pitfall cebadas con heces humanos en cuatro altitudes entre 1820 m y 2530 m dentro de bosque húmedo montano en agosto y septiembre del 2001. Se capturaron 2526 individuos de 19 'especies' en un total de 204 trampas-días. Las tres especies más abundantes (*Ontherus obliquus*, *Dichotomius carbonarius*, *D. diabolicus*) correspondierón al 68.8 porciento de toda la captura. Seis especies se registraron en todo el gradiente; seis otras especies fueron encontradas solo a 1820 m. La riqueza de especies por transecta varió entre 7 y 16. Curvas de acumulación de especies a partir de muestras indicaron que el muestreo fue completo en solo dos transectas. Se utilizaron curvas de rarefacción a partir de individuos para estandardizar el esfuerzo de muestreo, y para estimar la riqueza total de especies con los estimadores Chao 1 y MMMean. MMMean se comportó inadecuadamente. Un análisis de regresión linear mostró una bastante pronunciada (R^2 = 0.50) pero no significativa disminución de la riqueza estimada por Chao 1 con la altitud. El indice de Morisita-Horn mostró una moderada a alta similitud en la composición de la comunidad entre casi todas las transectas. Además indicó, que dentro del gradiente altitudinal estrecho de este estudio, factores de hábitat y/o la disturbación humana tuvieron mayor influencia en la composición de la comunidad que la distancia altitudinal entre las transectas. Comparaciones con otros estudios se ven limitados debido al poco conocimiento taxonómico a nivel específico de Scarabaeidae en Bolivia, lo cual indica la necesidad de estudios extensos para poder examinar el potencial de los coleopteros coprófagos como indicadores biológicos en el neotrópico.

9.3 Introduction

Ecological patterns in Neotropical insect communities have recently been investigated with increasing frequency, including research on altitudinal distributions, responses to forest fragmentation or selective logging, and foraging ecology (Estrada et al. 1993, Olson 1994, Didham et al. 1998, Shahabuddin & Terborgh 1999, Lewis 2001). In Bolivia however, ecological studies of insect communities are virtually non-existent. This is partly due to the fact that Bolivia is one of the least explored countries in the Neotropical region, but it certainly also is a consequence of the staggering tropical diversity and problematic species identification characteristic of this taxonomic group.

The enormous species richness of tropical insects almost inevitably forces ecologists and taxonomists alike to restrict their studies to smaller, more manageable taxonomic groups such as butterflies (Lewis 2001), ants (Fisher 1999), or dung beetles (Estrada *et al.* 1994, Forsyth *et al.* 1998). Dung beetles have received special attention because they are considered good biological indicators (see review in Davis *et al.* 2001), have a relatively well-known taxonomy and natural history (Hanski & Cambefort 1991a), and because they can be sampled quantitatively with a standard protocol (Lobo *et al.*1988, Forsyth *et al.* 1998). As decomposer organisms they also play an important ecological role in tropical forest systems and contribute to seed dispersal (Vulinec

2002), nutrient recycling, and pest control in vertebrates (Hanski & Cambefort 1991a). Nonetheless, many dung beetle groups of tropical American forests remain poorly known taxonomically (Gill 1991), and most studies on their ecology and taxonomy are restricted to the northern Neotropics (*e.g.*, Janzen 1983, Zunino & Halffter 1988, Estrada *et al.* 1994, Delgado 2000) or Amazonia (Vulinec 2002).

Diversity patterns in dung beetles have, to our knowledge, not been documented anywhere in the Andes, despite the classification of the tropical Andes as one of the world's major biodiversity and conservation hotspots (Myers *et al.* 2000). Field surveys of dung beetles in Bolivia are published from only two sites in the southeastern part of the country in Depto. Santa Cruz (Kirk 1992, Forsyth *et al.* 1998). The objectives of the present study therefore were to: (1) conduct a general survey of dung beetles (Scarabaeidae) attracted to human faeces at a middle montane forest locality in the Bolivian *Yungas*; (2) determine the species richness of dung beetle communities and any altitudinal variation therein; (3) examine altitudinal changes in dung beetle community composition.

9.4 Methods

Field work was carried out in humid montane forest on the east side of the Cordillera de Cocapata in the remote valley of the río Pampa Grande (16°40'S, 66°29'W) within an altitudinal range from about 1800 m to 2550 m from 8 August to 16 September 2001. In our study area, the overall direction of the river was roughly north south. East-facing slopes west of the river received early morning sun and were somewhat drier and warmer than west-facing slopes. The east-facing slopes extended continuously up to over 4000 m on the Tunari Highland, whereas the west-facing slopes only extended up onto the top of a ridge at ca. 2600 m. At the time of our study, the Pampa Grande valley was inhabited by four peasant families, but up to 40 families had previously lived in the area. West of the river the forest in the valley and on the lower slopes had partly been cleared for cattle pasture and subsistence farming, and much of the remaining forest on the western valley bottom was either secondary or moderately to severely disturbed (selective logging, cattle). The forest east of the river was largely primary with some slight to moderate local disturbances.

We established six transect lines at four altitudes:

Transect 1 (T1): 1820 m, primary forest, part of transect on flat, seasonally flooded ground;

Transect 2 (T2): 2110 m, dense secondary forest on west side of valley bottom, in part grazed by cattle;

Transect 3 (T3): 2110 m, primary forest on east side of valley bottom, selectively logged and occasionally grazed by cattle;

Transect 4 (T4): 2300 m, primary forest on shallow east-facing slope, selectively logged and occasionally grazed by cattle;

Transect 5 (T5): 2300 m, primary forest on steep west-facing slope with abundant patches of bamboo, very little to no human disturbance;

Transect 6 (T6): 2530 m, secondary and disturbed primary forest on east-facing slope, selectively logged, some bamboo present.

Each transect was 450 m long and contained ten pitfall traps baited with human faeces (*ca.* 25-30 g per trap) at 50-m intervals. Due to steep topography it was sometimes not feasible to place traps in a single transect line, but there always remained 50 m between traps. Beetles were collected from all traps every 24 hours and traps were re-baited with fresh faeces (usually from one person, when not possible the bait was

homogenized) at the same time. Each transect had 3-4 days of beetle collection. All samples were preserved separately in 70 percent alcohol.

Preliminary specimen identification to genus and morphospecies was done by A. C. Hamel and D. J. Mann, with species identifications where possible made by F. Génier. Voucher specimens of all species have been deposited at the Hope Entomological Collections, Oxford University Museum of Natural History, U.K. The remaining material will be deposited at the Colección Boliviana de Fauna, La Paz, Bolivia.

To determine the degree of completeness of the dung beetle survey sample-based species accumulation curves were computed for all trap-days combined and separately for each transect by randomizing sample accumulation order 100 times using *EstimateS* (Colwell 2000). This same program was used to estimate total species richness for the whole study area and for each transect. Because our data sets differed considerably in the mean number of individuals per sample and in the number of samples per transect, it was necessary to standardize the observed and estimated richness values to evaluate species richness across transects at comparable levels of sampling effort. We followed Gotelli and Colwell (2000) and rescaled the *x*-axes of the sample-based rarefaction curves to individuals. The lowest number of individuals captured per transect was 137, and we used this cut-off value to obtain the standardized values of estimated species richness from each transect's rarefaction curve.

A variety of statistical species richness estimators is available, and the performance and biases of different statistics are still being evaluated (Colwell & Coddington 1994, Walther & Morand 1998, Walther & Martin 2001, Herzog *et al.* 2002). The two Chao estimators (Chao 1984, Chao 1987) were recommended by several studies (Chazdon et al. 1998, Walther & Morand 1998, Walther & Martin 2001), whereas Herzog *et al.* (2002) recommended the MMMean statistic, which is based on the Michaelis-Menten model (Raaijmakers 1987, Keating & Quinn 1998, Colwell 2000). However, most if not all studies that have evaluated and compared the performance of different estimators to date used sample-based rather than individual-based rarefaction curves, and it is uncertain whether their conclusions are directly applicable to individual-based rarefaction curves. Therefore, we applied both MMMean and Chao 1 to our data (when applied to individual-based rarefaction curves, the incidence-based Chao 2 computes values identical to those of the abundance-based Chao 1; see Colwell & Coddington 1994).

We used linear regression to determine the relationship between species richness and altitude. Data were transformed where necessary. Community composition was compared between transects using the Morisita-Horn similarity index (see Magurran 1988).

9.5 Results

We collected 2526 dung beetle individuals belonging to 11 genera and 19 species in a total of 204 trap-days (Table 9.1). The number of trap-days per transect varied from 28 (T3) to 40 (T1), which was largely due to the occasional destruction of traps or the removal of bait (presumably by mammals). The number of individuals captured per transect ranged from 137 (T2) to 891 (T4) (Table 9.1). This variability was largely unrelated to the sampling effort per transect as the number of individuals per trap-day showed a similar trend (4.2 on T2 *versus* 29.7 on T4; Table 9.1). Observed species richness was highest at 1810 m (T1), where 16 species (84%) were collected, and it

decreased to eight (T2) and 12 (T3) at 2110 m and 10 (T4) and seven (T5) at 2300 m, from where it increased slightly to 10 species at 2530 m (Table 9.2). The considerable difference in species richness between T2 and T3 is noteworthy as both transects were located at the same elevation.

The randomized species accumulation curve for all 204 samples continued to rise only slightly at maximum sample size (Fig. 9.1), indicating that the majority of dung beetle species attracted to human faeces present in the study area were collected. Sampling at individual transects was most complete on T4, where the species accumulation curve reached an asymptote after about 20 trap-days, and on T5, where an asymptote was approached closely (Fig. 9.2). The species accumulation curves of all other transects continued to rise at maximum sample size with the steepest increase on T1 (Fig. 9.2).

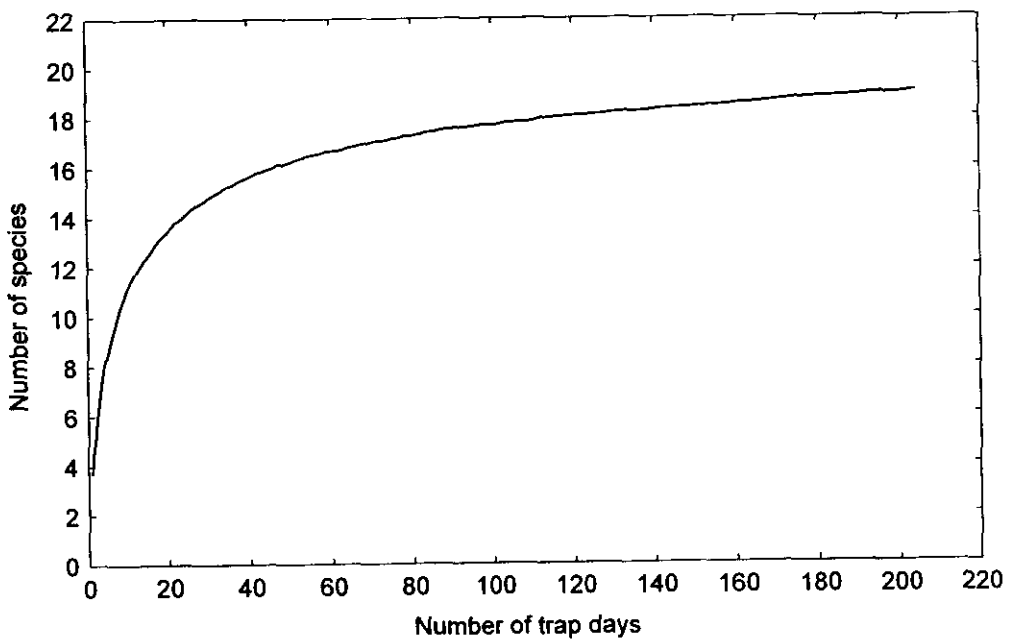


Figure 9.1. Species accumulation curve for the entire study area combining samples from all transects based on 100 randomizations of sample order using the program *EstimateS* (Colwell 2000).

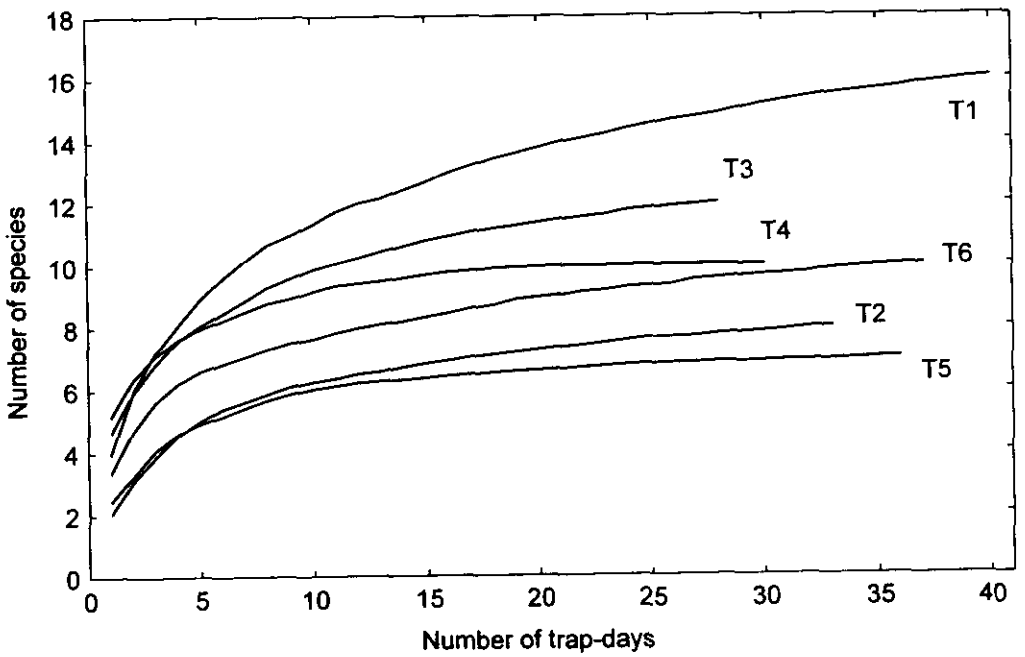


Figure 9.2. Species accumulation curves for transects 1 through 6. Curves are based on 100 randomizations of sample order using the program *EstimateS* (Colwell 2000).

Values computed by the Chao 1 richness estimator using individual-based rarefaction curves indicated the same trend. At maximum individual number, sampling appeared to be complete on T4 (Table 9.2, Fig. 9.3) and virtually so on T5 (Table 9.2). For each of the remaining transects and for all transects combined, the Chao 1 max values suggested that two or three species went unrecorded (Table 9.2), which is shown exemplary for T1 in Figure 9.3. MMMean consistently computed lower estimates than Chao 1 (except for very small numbers of individuals). Except for T2 and T5, the MMMean estimates even fell below the observed species richness after about 100 to 200 individuals (Fig.9.3), rendering the estimator useless.

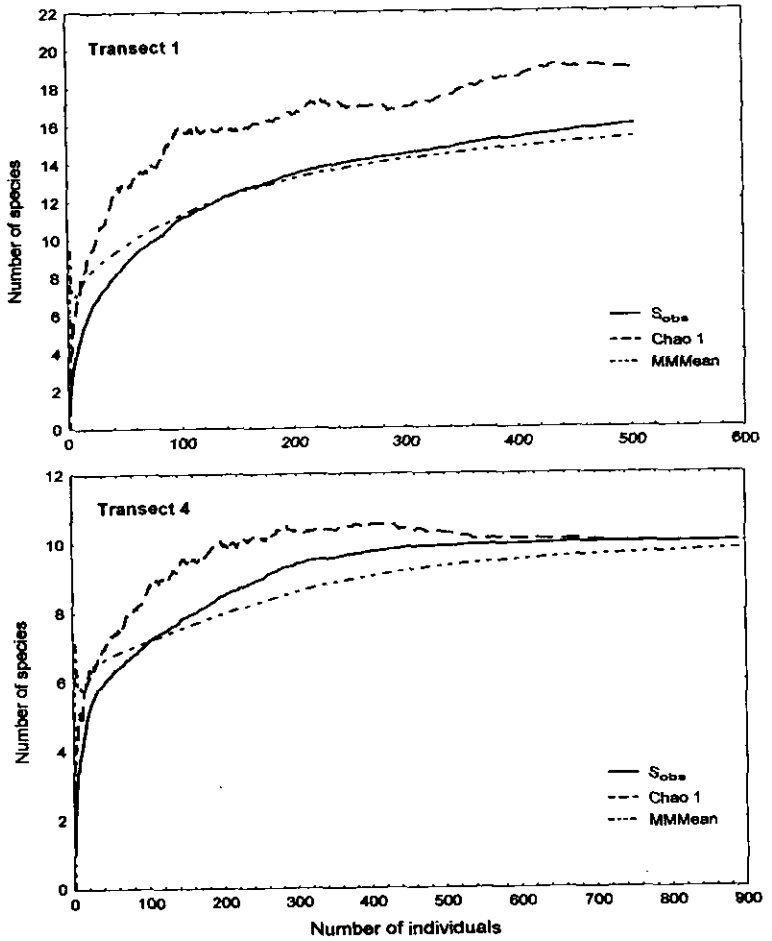


Figure 9.3. Individual-based species accumulation curves and estimated total species richness using the Chao 1 and MMMean statistical richness estimators for Transect 1 (1820 m) and Transect 4 (2300 m). Curves are based on 100 randomizations of individual order using the program *EstimateS* (Colwell 2000).

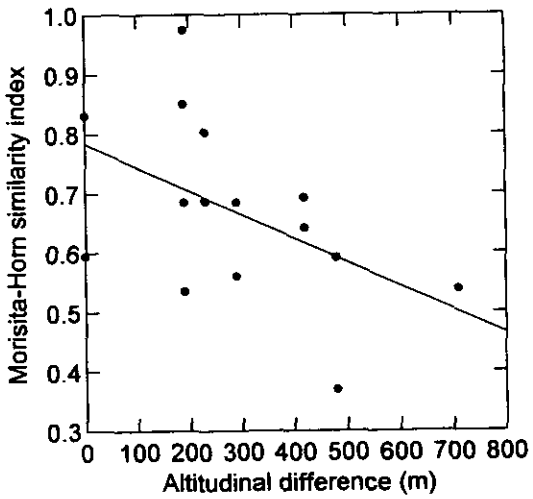
After standardizing Chao 1 and MMMean richness estimates on each transect for sampling effort and capture rate (Table 9.2), linear regression indicated a fairly pronounced but non-significant decrease of species richness with elevation (R = -0.71, P = 0.12 for Chao 1 estimates; R = -0.65, P = 0.16 for MMMean estimates). The same trend was evident when using the raw (R = -0.67, P = 0.15) or the standardized values of observed species richness (R = -0.65, P = 0.16) in Table 9.2.

Of the 19 dung beetle species collected, six spanned the entire altitudinal gradient, three of which (*Dichotomius carbonarius*, *Eurysternus* nr. *marmoreus*, *Ontherus obliquus*) were found on all transects (Table 9.1). By contrast, six species were found only on a single transect (all on T1), and two species were restricted to two transects each. Interestingly, *Canthon pallidus* was collected at the two endpoints of the transect but went unrecorded at intermediate altitudes, although this may in part be attributable to the species' low abundance (Table 9.1). The overall most abundant species was *Ontherus obliquus* (954 individuals, 37.8 percent of all collected beetles), followed by *Dichotomius carbonarius* (463, 18.3%) and *Dichotomius diabolicus* (322,

12.7%). Thus, the three most abundant species alone accounted for over two thirds (68.8%) of all individuals captured. Opposed to this, less than 10 individuals were trapped of seven species each. The least abundant species were *Coprophanaeus ignecinctus* and *Phaneus* sp. with only a single individual collected each (Table 9.1). A Spearman rank correlation indicated that the overall relative abundance of each species correlated closely to the number of transects on which each species was found ($r = 0.89$, $P < 0.0001$).

Figure 9.4. The relationship between community similarity and altitudinal distance between transects ($R = -0.50$, $P = 0.059$).

Community composition was overall fairly similar between transects. All Morisita-



Horn similarity coefficients were > 0.5 except for T1 *versus* T5 ($C = 0.369$; Table 9.3). By contrast, T3 and T4 had nearly identical dung beetle assemblages with a coefficient of 0.974. The beetle communities on T2 *versus* T4 ($C = 0.850$), T2 *versus* T3 ($C = 0.831$) and T5 *versus* T6 ($C = 0.802$) also were remarkably similar (Table 9.3). Similarity tended to decrease with increasing altitudinal difference between transects, but this trend was weak and non-significant ($R = -0.50$, $P = 0.059$) (Fig. 9.4).

9.6 Discussion

At the transect level, species richness of dung beetles at Pampa Grande was comparable to the number of species of Scarabaeinae trapped by Forsyth *et al.* (1998) in each of the 10 habitats (3-16 species per habitat) of Noel Kempff Mercado National Park (NKMNP) on the Precambrian Brazilian Shield in eastern Bolivia. By contrast, overall species richness in NKMNP is about five times higher than in our study area. Similarly, 13 genera reported from NKMNP were not recorded at Pampa Grande (*e.g.*, *Ateuchus* Weber, *Oxysternon* Laporte de Castelnau), and most of the genera collected in both areas where considerably more species-rich in NKMNP (Forsyth *et al.* 1998). This is largely a result of the much greater habitat diversity in NKMNP (at Pampa Grande we essentially surveyed a single habitat, *i.e.*, humid montane forest), the larger survey area of Forsyth *et al.* (1998) (spread out over an entire national park), and the effects of altitude (the maximum altitude of NKMNP is only about 900 m).

In Pampa Grande, species richness showed a tendency to increase with decreasing altitude, and a total of six species were found only at our lowest survey altitude (1820 m). Although no general conclusions can be drawn from a single study that covered only a partial altitudinal gradient, Hanski and Cambefort (1991b) also indicated that dung beetle diversity generally decreased with increasing altitude. On an altitudinal transect from 300 m to 2020 m in Panama, Olson (1994) found altitudinal richness peaks between 800 m and 1100 m for five out of eight groups of leaf litter arthropods (not including dung beetles) and an overall richness peak of all groups combined at 800 m. Thus, α-diversity (*sensu* Whittaker 1972) of dung beetles is expected to be considerably higher in lower Yungas and Andean foothill forests than on any one of our transects or in any of the habitats of NKMNP.

Anthropogenic disturbance and the presence of cattle may also influence local species richness of dung beetles and may have increased the overall species richness in our study area as compared to a former pristine state. Virtually no human disturbance was found on T5, and its species richness was considerably lower than that of the moderately disturbed T4 at the same altitude, where signs of occasional cattle intrusion were found. However, differences in habitat structure due to different slope aspects and steepness may also be involved (*i.e.*, a somewhat warmer, drier microclimate and shallower slope on T4) in causing the higher richness on T4.

We encountered two additional species only during *ad hoc* hand collecting (one individual of *Oruscatus* nr. *davus* Banks, two of *Canthon* sp.), which indicates that probably not all dung beetles present in our study area were attracted to human faeces. Estrada *et al.* (1993) observed differences in richness and composition between dung beetle assemblages of mammalian herbivore and omnivore dung in a Mexican rain forest. Use of different types of bait (*e.g.*, from native mammal species) therefore seems preferable if entire dung beetle communities are to be inventoried in the neotropics, although this may be logistically problematic in many cases.

The overall similarity in community composition between transects (most Morisita-Horn coefficients for dung beetle assemblages in NKMNP were < 0.5; Forsyth *et al.* 1998) certainly reflects the relatively narrow altitudinal gradient, the location of all transects in the same valley, and the sampling of essentially just one habitat (humid montane forest) by the present study. Even the two altitudinal endpoints of our gradient had over 50 percent similarity in their dung beetle assemblages, and we found little indication for a general decrease in similarity with increasing altitudinal difference between transects. In contrast, within the relatively narrow altitudinal gradient of our study, forest structure, slope aspect, and/or human disturbance apparently had a greater impact on community composition than the altitudinal distance between communities.

A direct comparison of community composition between our transects and those of Forsyth *et al.* (1998) in NKMNP in eastern Bolivia is hampered by the poorly known species level taxonomy of Bolivian Scarabaeidae. Collecting expeditions and taxonomic studies are urgently needed to assess which and how many species occur in the country. Published keys to Neotropical dung beetle faunas are restricted to Central American countries, and only a few generic treatments (*e.g.*, Genier 1996) include Bolivian taxa. Much remains to be learned and discovered about dung beetle taxonomy, ecology, and distribution in the Andes. The identification of the material collected from Pampa Grande is continuing and might reveal that some of the taxa may represent first records for Bolivia, and it is quite likely that some of these species

will be new to science. Extensive future field work in the Andes and other parts of Bolivia is needed to document patterns in species richness and community composition of dung beetles and to examine their potential as biological indicators in the neotropics.

9.7 Acknowledgements

This study was part of the Yungas 2001 expedition organized by R. MacLeod and A. Maccormick, and we are indebted to all who helped and supported the expedition. A. C. Hamel and D. J. Mann wish to thank H. Mendel and M. Barclay (The Natural History Museum, London) for access to the collections, and a special thanks to F. Génier (Musée Canadien de la Nature) for his assistance in the identification of the species. A. C. Hamel would like to thank G. McGavin, J. Hogan, and J. Ismay for support during her stay at the Hope Entomological Collections, Oxford University Museum of Natural History, and R. MacLeod and P. Ganter for their hospitality. We gratefully acknowledge the help of Á. Garitano-Zavala, Colección Boliviana de Fauna, La Paz, in obtaining work permits from the Dirección Nacional de Conservación de la Biodiversidad, La Paz. M. Kessler made useful comments on the manuscript. The expedition was financially supported by the Thriplow Charitable Trust, BP Conservation Programme, Royal Geographic Society (Rio Tinto Award), Oxford University (A.A. Paton Fund & Exploration Council), British Ecological Society, Gilchrist Educational Trust, Glasgow University Council, The Russell Trust, Royal Society of St. George Award, Chester Zoo, Scottish Royal Geographic Society, Albert Reckitt Charitable Trust and BOU. A final thanks to Professor Sir R. Southwood for acting as expedition patron.

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10 Records of mammals with notes on behavioural observations from the río Pampa Grande and río Altamachi valleys, Cochabamba, Bolivia.

Aidan Maccormick

10.1 Introduction

A detailed mammal inventory was not one of the aims of Yungas 2001. However, as almost no mammal related studies have been conducted within the Cocapata-Mosetenes area (pers. S. Herzog) we thought it important to record and report observations of those mammals we were able to identify. Neotropical lowland and montane rainforests support a large diversity of mammals (Emmons and Feer 1997), a number of which are threatened by forest destruction and over-hunting, therefore it is important to identify which protected areas are inhabited by threatened and endemic mammal species (Emmons and Feer 1997). The following annotated list below represents observations recorded on an ad hoc basis of relatively visible and identifiable species, and falls well short of a full species inventory for the río Pampa Grande and Altamachi valleys.

10.2 Methods

Records were based on visual and audio identification by observers with previous neotropical mammal experience and aided by the guide Neotropical Rainforest Mammals by Emmons and Feer (1997) and the accompanying sound guide Neotropical Rainforest Mammals (Emmons *et al* 1998).

10.3 Results

Jaguarundi *Herpailurus yaguarondi*

Single adult observed making unsuccessful hunting attempt on Andean Guan *Penelope montagnii* foraging on the forest floor. Recorded in primary forest at 2250m.

Southern amazon red squirrel *Sciurus spadiceus*

Four sightings of single individuals, including one black (dark) morph. Observed in primary, secondary, disturbed forest and cultivated (maize) fields. Two observations were of individuals foraging on the ground. Recorded between 2000m and 2350m.

Ocelot *Leopardus pardalus*

One adult observed drinking from small stream in daylight within primary forest 2000m. Tracks presumably of the species observed along río Pampa Grande throughout August and September.

Puma *Puma concolor*

Presumably this species heard calling on the 15th August within disturbed forest c.2150m.

Brown Capuchin *Cebus apella*

Relatively common within the study area, although behaviour towards observers suggests past or present hunting pressure. Several groups observed in primary and

disturbed forest usually in the mid to upper canopy. Largest group of ten individuals seen on the 28th September contained 2 small infants.

Azara's night monkey *Aotus azarae*
Regularly recorded both visually and audibly. Observed in disturbed and secondary forest between 2100m and 2550m. Most sightings were of groups containing two to three individuals. One group on the 5th September comprised three adults and one small infant.

Montane bamboo rat *Dactylomys peruanus.*
Recorded frequently during the night by its loud and distinctive vocalisations. Found In primary, secondary and heavily disturbed forest on edge of grazed clearings. Recorded between 2050m and 2550m.

Black spider Monkey ***Ateles paniscus***
Several males observed near camp in primary and disturbed forest on edge of río Altamachi, 1,100m. Relaxed behaviour suggests lack of hunting pressure despite presence of small scale selective logging

Brown agouti *Dasyprocta variegata.*
Fairly common in the río Pampa Grande valley. Small numbers hunted on an opportunistic basis by locals. Recorded singly and in groups of up to three, all within secondary or disturbed forest. One individual found dead after attack by local dogs. All sightings between 2050 and 2150m.

Pygmy rice rat species *Oligoryzomys sp.*
One individual found dead in reptile pitfall trap located in a grazed clearing 2100m.

10.4 Discussion

Although little can be drawn from the small number of mammal observations described above, the cordilleras of Mosetenes and Cocapata are likely to hold important numbers of CITES 1 listed species such as Jaguar *Panthera onca* and CITES 2 listed species such as the Black Spider Monkey *Ateles paniscus* and Ocelot *Leopardus pardalus*. Perhaps more importantly, as the ornithological surveys conducted within the region observed a probable new species, and the herpetological work found six new species, it is likely that the area will contain both novel mammalian taxa and new records for Bolivia.

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11 Appendix 1 - Bird species habitat requirements and altitudinal distributions in the río Pampa Grande and río Altimachi valleys.

ENGLISH NAME	LATIN NAME	Prim	Dist	Sec	Scr	Puna	11-13	18-26	26-30	30-34	34+	Status	Range Extension
Grey Tinamou	*Tinamus tao*	0	0	0	0	0	1	0	0	0	0		
Hooded Tinamou	*Nothocercus nigrocapillus*	1	1	0	0	0	0	1	1	1	0	IND-MM	33(30)
Little Tinamou	*Crypturellus soui*	0	0	0	0	0	1	0	0	0	0		
Brown Tinamou	*Crypturellus obsoletus*	1	1	0	1	0	0	1	1	0	0		
Huayco Tinamou	*Rhynchotus maculicollis*	0	0	0	0	1	0	0	0	1	0		
Neotropical Cormorant	*Phalacrocorax brasilianus*	0	0	0	0	0	1	0	0	0	0		
Fasciated Tiger-heron	*Tigrisoma fasciatum*	0	0	0	0	0	1	1	0	0	0		
Black-crowned Night-heron	*Nycticorax nycticorax*	0	0	0	0	1	0	0	0	0	1		
Torrent Duck	*Merganetta armata*	0	0	0	0	0	0	1	0	0	0		
Speckled Teal	*Anas flavirostris*	0	0	0	0	0	0	0	0	0	1		
Turkey Vulture	*Cathartes aura*	0	0	0	0	0	1	1	0	1	1		
Andean Condor	*Vultur gryphus*	0	0	0	0	1	0	0	0	1	1	NT	
King vulture	*Sarcoramphus papa*	0	0	0	0	0	1	0	0	0	0		
Hook-billed Kite	*Chondrohierax uncinatus*	1	1	1	0	0	0	1	1	0	0		26(20)
American Swallow-tailed Kite	*Elanoides forficatus*	1	0	1	0	0	1	1	0	0	0		
Plumbeous Kite	*Ictinia plumbea*	0	0	0	0	0	1	0	0	0	0		
Sharp-shinned Hawk	*Accipter striatus*	1	0	1	0	0	1	1	1	0	0		
Solitary Eagle	*Harpyhaliaetus solitarius*	1	0	0	0	0	1	0	0	0	0		
Roadside Hawk	*Buteo magnirostris*	0	1	1	0	0	1	1	0	0	0		
White-rumped Hawk	*Buteo leucorrhous*	0	0	1	0	0	0	1	0	0	0		
Red-backed Hawk	*Buteo polyosoma*	0	0	0	0	0	0	0	0	0	0		
Puna Hawk	*Buteo poecilochrous*	0	0	0	0	1	0	0	0	0	1		
Black-and-chestnut Eagle	*Oroaetus isidori*	0	0	0	0	0	0	1	0	0	0		
Mountain Caracara	*Phalcoboenus megalopterus*	0	0	0	0	1	0	0	0	1	1		
Barred Forest-falcon	*Micrastur ruficollis*	0	1	0	0	0	1	1	0	0	0		
Bat Falcon	*Falco rufigularis*	0	0	1	0	0	0	1	0	0	0		20(15)
Speckled Chachalaca	*Orialis guttata*	0	0	1	1	0	0	1	0	0	0		
Andean Guan	*Penelope montagnii*	1	1	1	0	0	0	1	1	0	0		
Blue-throated Piping-guan	*Pipile pipile*	0	0	0	0	0	1	0	0	0	0		
Stripe-faced Wood-quail	*Odontophorus balliviani*	1	1	0	0	1	0	1	1	1	0	EBA 55, MM	33 (30)
Sunbittern	*Eurypyga helias*	0	0	0	0	0	0	1	0	0	0		21 (12)
Andean Lapwing	*Vanellus resplendens*	0	0	0	0	1	0	0	0	0	1		
Spotted Sandpiper	*Actitis macularia*	0	0	0	0	0	1	0	0	0	0		
Andean Snipe	*Gallinago jamesoni*	0	0	0	0	1	0	0	0	1	0		
Grey-breasted Seedsnipe	*Thinocorus orbignyianus*	0	0	0	0	1	0	0	0	0	1		
Andean Gull	*Larus serranus*	0	0	0	0	1	0	0	0	0	1		
Band-tailed Pigeon	*Columba fasciata albilinea*	1	1	1	0	0	0	1	1	1	0		32.5(30)
Plumbeous Pigeon	*Columba plumbea*	1	1	1	1	0	1	1	0	0	0		25.5(16)
Picui Ground-dove	*Columbina picui*	0	0	0	0	0	0	1	0	0	0		
Grey-fronted Dove	*Leptotila rufaxilla*	0	0	0	0	0	1	0	0	0	0		
White-throated Quail-dove	*Geotrygon frenata*	0	0	0	0	0	0	1	1	1	0	IND-MM	32(29)
Mitred Parakeet	*Aratinga mitrata*	0	0	0	0	0	1	0	0	0	0		
Green-cheeked Parakeet	*Pyrrhura molinae*	1	1	1	0	0	1	1	1	0	0		
Barred Parakeet	*Bolborynchus lineola*	0	1	0	0	0	0	0	1	1	0		
White-bellied Parrot	*Pionites leucogaster*	0	0	0	0	0	1	0	0	0	0		
Blue-headed Parrot	*Pionus menstruus*	0	0	0	0	0	1	0	0	0	0		

ENGLISH NAME	LATIN NAME	Prim	Dist	Sec	Scr	Puna	11-13	18-26	26-30	30-34	34+	Status	Range Extension
Red-billed Parrot	*Pionus sordidus*	1	1	0	0	0	0	1	0	0	0		26(24)
Plum crowned Parrot	*Pionus tumultuosus*	0	1	1	0	0	1	1	1	0	0		
Scaly-naped Parrot	*Amazona mercenaria*	0	0	0	0	0	1	1	1	1	0		
Squirrel Cuckoo	*Piaya cayana*	1	1	1	1	0	1	1	0	0	0		24 (23)
Smooth-billed Ani	*Crotophaga ani*	0	0	0	0	0	1	0	0	0	0		
Pavonine Cuckoo	*Dromococcyx pavoninus*	0	1	0	0	0	0	1	0	0	0		19 (05)
Cloud-forest Screech-owl	*Otus marshalli*	1	1	0	0	0	0	1	0	0	0	NT, EBA 53	Bol
Rufescent Screech-owl	*Otus ingens*	1	1	1	0	0	0	1	1	0	0		22(14)
White-throated Screech-owl	*Otus albogularis*	1	1	0	0	0	0	1	1	0	0		
Band-bellied Owl	*Pulsatrix melanota*	0	0	0	0	0	1	0	0	0	0	IND-HT	
Rufous-banded Owl	*Ciccaba albitarsus*	1	1	0	0	0	0	1	1	1	0		33(30)
Yungas Pygmy-owl	*Glaucidium bolivianum*	0	0	1	0	0	0	1	0	1	0		
Rufous-bellied Nighthawk	*Lurocalis rufiventris*	0	0	0	0	0	0	1	0	0	0	IND-MM	
Band-winged Nightjar	*Caprimulgus longirostris*	0	E	0	0	0	0	0	0	1	0		
Swallow-tailed Nightjar	*Uropsalis segmentata*	0	0	0	0	0	0	1	0	0	0		21(23)
Chestnut-collared Swift	*Cypseloides rutilus*	0	0	0	0	0	0	1	1	0	0		
White-collared Swift	*Streptoprocne zonaris*	0	0	0	0	0	1	1	1	0	0		
Chaetura sp.	*Chaetura sp.*	0	0	0	0	0	1	1	0	0	0		
Long-tailed Hermit	*Phaethornis superciliosus*	0	0	0	0	0	0	0	0	0	0		
Green Violetear	*Colibri thalassinus*	0	1	1	1	0	0	1	1	0	0		
Sparkling Violetear	*Colibri coruscans*	0	1	0	0	0	0	1	0	0	0		
Blue-tailed Emerald	*Chlorostilbon mellisugus*	0	0	0	0	0	1	0	0	0	0		
Fork-tailed Woodnymph	*Thalurania furcata*	0	0	0	0	0	1	0	0	0	0		
Golden-tailed Sapphire	*Chrysuronia oenone*	0	0	0	0	0	1	0	0	0	0		
Speckled Hummingbird	*Adelomyia melanogenys*	1	1	1	1	0	0	1	0	0	0	IND-MM	
Giant Hummingbird	*Patagona gigas*	0	0	0	0	1	0	0	0	0	1		36
Black-hooded Sunbeam	*Aglaeactis pamela*	0	E	0	1	0	0	0	0	1	0	EBA 55	
Great Sapphirewing	*Pterophanes cyanopterus*	0	0	0	0	0	0	0	0	1	1		38(37)
Bronzy Inca	*Coeligena coeligena*	0	1	0	0	0	0	1	0	0	0	IND-MM	
Collared Inca	*Coeligena torquata*	0	1	0	0	0	0	1	0	0	0		
Violet-throated Starfrontlet	*Coeligena violifer*	0	1	1	0	0	0	0	1	1	0	IND-UM	
Sword-billed Hummingbird	*Ensifera ensifera*	1	1	0	0	0	0	1	0	0	0	IND-UM	
Amethyst-throated Sunangel	*Heliangelus amethysticollis*	0	1	1	1	0	0	1	1	1	0	IND-UM	
Booted Racket-tail	*Ocreatus underwoodii*	0	1	0	0	0	0	1	0	0	0		
Tyrian Metaltail	*Metallura tyrianthina*	0	1	0	1	0	0	1	1	1	0		
Rufous-capped Thornbill	*Chalcostigma ruficeps*	0	0	0	1	0	0	1	0	0	0		
Long-tailed Sylph	*Aglaiocercus kingi*	0	1	1	0	0	0	1	0	0	0		
White-bellied Woodstar	*Acestrura mulsant*	0	1	1	0	0	0	1	0	0	0		
Crested Quetzal	*Pharomachrus antisianus*	1	1	1	0	0	0	1	1	0	0	IND-UT	
Golden-headed Quetzal	*Pharomachrus auriceps*	1	1	1	0	0	0	1	0	0	0	IND-UT	
Masked Trogon	*Trogon personatus*	1	1	1	1	0	0	1	1	0	0	IND-UT	
Blue-crowned Trogon	*Trogon curucui*	0	0	0	0	0	1	0	0	0	0		
Broad-billed Motmot	*Electron platyrhynchum*	0	0	0	0	0	1	0	0	0	0		
Blue-crowned Motmot	*Momotus momota*	0	0	0	0	0	1	0	0	0	0		
Ringed Kingfisher	*Ceryle torquata*	0	0	0	0	0	1	1	0	0	0		
Black-streaked Puffbird	*Malacoptila fulvogularis*	0	0	0	0	0	1	0	0	0	0		
Versicoloured Barbet	*Eubucco versicolor*	1	1	1	0	0	0	1	0	0	0		23(20)
Chestnut-tipped Toucanet	*Aulacorhynchus derbianus*	1	0	0	0	0	1	0	0	0	0		
Blue-banded Toucanet	*Aulacorhynchus coeruleicinctis*	1	1	0	0	0	1	1	1	0	0	IND-MM	29.5(25)
Chestnut-eared Aracari	*Pteroglossus castanotis*	0	0	0	0	0	1	0	0	0	0		
Hooded Mountain-toucan	*Andigena cucullata*	0	1	0	0	0	0	1	1	1	0	NT, EBA 55	
Channel-billed Toucan	*Ramphastos vitellinus*	1	1	0	0	0	1	1	0	0	0		24.5(16)

ENGLISH NAME	LATIN NAME	Prim	Dist	Sec	Scr	Puna	11-13	18-26	26-30	30-34	34+	Status	Range Extension
Red-billed Toucan	*Ramphastos tucanus*	0	0	0	0	0	1	0	0	0	0		
Yellow-tufted Woodpecker	*Melanerpes cruentatus*	0	0	0	0	0	1	0	0	0	0		
Bar-bellied Woodpecker	*Veniliornis nigriceps*	1	1	1	0	0	0	1	1	0	0		
Smoky-brown Woodpecker	*Veniliornis fumigatus*	0	1	1	0	0	0	1	0	0	0		
Crimson-mantled Woodpecker	*Piculus rivolii*	0	1	0	0	0	0	1	1	0	0		
Andean Flicker	*Colaptes rupicola*	0	0	0	0	1	0	0	0	1	1		
Lineated Woodpecker	*Dryocopus lineatus*	0	0	0	0	0	1	0	0	0	0		
Red-necked Woodpecker	*Campephilus rubricollis*	1	1	1	0	0	1	1	0	0	0		
Plain-brown Woodcreeper	*Dendrocincla fuliginosa*	0	0	0	0	0	1	0	0	0	0		
Olivaceous Woodcreeper	*Sittasomus griseicapillus*	1	1	1	0	0	1	1	0	0	0		
Barred Woodcreeper	*Dendrocolaptes certhia*	0	0	0	0	0	1	0	0	0	0		
Strong-billed Woodcreeper	*Xiphocolaptes promeropirhynchus*	1	1	1	0	0	1	1	1	1	0	IND-MM	33(31)
Black-banded Woodcreeper	*Dendrocolaptes picumnus*	1	1	1	0	0	0	1	0	0	0		
Ocellated Woodcreeper	*xiphorhynchus ocellatus*	0	1	0	0	0	1	1	0	0	0	IND-UT	18(15)
Buff-throated Woodcreeper	*xiphorhynchus guttatus*	0	0	0	0	0	1	0	0	0	0		
Olive-backed Woodcreeper	*xiphorhychus triangularis*	1	1	1	1	0	0	1	0	0	0	IND-UT	
Montane Woodcreeper	*Lepidocolaptes lacrymiger*	1	1	1	0	0	0	1	1	1	0		3 8
Bar-winged Cinclodes	*Cinclodes fuscus*	0	0	0	0	1	0	0	0	0	1		
Black-throated Thistletail	*Schizoeaca harterti*	0	0	E	1	0	0	0	1	1	0	EBA 55	
Cabanis' Spinetail	*Synallaxis cabanisi*	0	0	1	0	0	0	1	0	0	0		18(13)
Azara's Spinetail	*Synallaxis azarae*	E	1	1	1	0	0	1	1	0	0		
Ash-browed Spinetail	*Cranioleuca curtata*	E	0	1	1	0	1	1	0	0	0		
Light-crowned Spinetail	*Cranioleuca albiceps*	0	0	0	0	1	0	1	1	1	0	EBA 55, BB	
Puna Canastero	*Asthenes punensis*	0	0	0	0	0	0	0	0	0	1		
Line-fronted Canastero	*Asthenes urubambensis*	0	0	0	0	1	0	0	0	1	0	NT, EBA 56	
Spotted Barbtail	*Premnoplex brunnescens*	1	1	1	0	0	0	1	0	0	0		
Pearled Treerunner	*Margaromis squamiger*	1	1	1	1	0	0	1	1	1	0	IND-UM	
Streaked Tuftedcheek	*Pseudocolaptes boissonneautii*	1	1	1	0	0	0	1	1	1	0		32 (31)
Buff-browed Foliage-gleaner	*Syndactyla rufosuperciliata*	0	1	1	1	0	0	1	0	0	0	IND-UT	
Montane Foliage-gleaner	*Anabacerthia striaticollis*	1	1	1	1	0	0	1	1	0	0	IND-UT	29.5(26)
Buff-fronted Foliage-gleaner	*Philydor rufus*	0	1	0	0	0	1	1	0	0	0		22(18)
Buff-throated Foliage-gleaner	*Automolus ochrolaemus*	0	0	0	0	0	1	0	0	0	0		
Striped Treehunter	*Thripadectes holostictus*	1	1	1	0	0	0	1	0	0	0	IND-MM	
Streaked Xenops	*xenops rutilans*	0	1	1	1	0	1	1	0	0	0		
Sharp-tailed Streamcreeper	*Lochmias nematura*	E	E	E	0	0	0	1	0	0	0		
Chestnut-backed Antshrike	*Thamnophilus palliatus*	0	0	0	1	0	1	1	0	0	0		
Plain-winged Antshrike	*Thamnophilus schistaceus*	0	0	0	0	0	1	0	0	0	0		
Upland Antshrike	*Thamnophilus aroyae*	0	1	1	0	0	1	1	0	0	0	EBA 54	
Variable Antshrike	*Thamnophilus caerulescens*	1	1	1	1	0	0	1	0	0	0		
Plain Antvireo	*Dysithamnus mentalis*	1	1	1	0	0	1	1	0	0	0	IND-UT	22(20)
Stripe-chested Antwren	*Myrmotherula longicauda*	0	0	1	0	0	1	1	0	0	0		18(13)
Yungas Antwren	*Myrmotherula grisea*	0	1	0	0	0	1	0	0	0	0	VU, EBA 54	IND-HT
Rufous -winged Antwren	*Herpsilochmus rufimarginatus*	0	0	0	0	0	1	0	0	0	0	IND-HT	
White-backed Fire-eye	*Pyriglena leuconota*	0	1	0	1	0	0	1	0	0	0		
Black-faced Antbird	*Mymoborus myotherinus*	0	0	0	0	0	1	0	0	0	0		
Chestnut-tailed Antbird	*Mymmeciza hemimelaena*	0	0	0	0	0	1	0	0	0	0		
Black-faced Antthrush	*Formicarius analis*	0	0	0	0	0	1	0	0	0	0		
Short-tailed Antthrush	*Chamaeza campanisona*	1	1	1	1	0	0	1	0	0	0	IND-UT	23(18)
Barred Antthrush	*Chamaeza mollissima*	1	1	1	0	0	0	1	1	0	0	IND-MM	
Undulated Antpitta	*Grallaria squamigera*	0	1	0	0	0	0	0	0	1	0	IND-UM	
Scaled Antpitta	*Grallaria guatimalensis*	1	1	0	0	0	0	1	0	0	0	IND-UT	23 (15)
White-throated Antpitta	*Grallaria albigula*	1	1	1	1	0	0	1	0	0	0	EBA 54, MM	

ENGLISH NAME	LATIN NAME	Prim	Dist	Sec	Scr	Puna	11-13	18-26	26-30	30-34	34+	Status	Range Extension
Rufous Antpitta	*Grallaria rufula*	1	1	0	1	0	0	1	1	1	0	IND-UM	
Rufous-faced Antpitta	*Grallaria erythrotis*	1	1	0	1	0	0	1	1	1	0	EBA 55, UM	33(30)
Ochre-breasted Antpitta	*Grallaricula flavirostris*	1	1	1	0	0	0	1	0	0	0		
Slaty Gnateater	*Conopophaga ardesiaca*	E	1	1	0	0	0	1	0	0	0	IND-UT	
Grey Tapaculo	*Scytalopus parvirostris*	1	1	1	1	0	0	1	1	1	0		
White-crowned Tapaculo	*Scytalopus bolivianus*	1	1	1	0	0	1	1	0	0	0		
Andean Tapaculo	*Scytalopus simonsi*	0	0	0	0	1	0	0	0	1	1		
Diademed Tapaculo	*Scytalopus schulenbergi*	0	1	0	0	0	0	0	0	1	0	EBA 55	
Red-crested Cotinga	*Ampelion rubrocristata*	0	1	0	1	0	0	0	0	1	0		
Chestnut-crested Cotinga	*Ampelion rufaxilla*	1	1	1	0	0	0	1	1	0	0		29(27)
Band-tailed Fruiteater	*Pipreola intermedia*	1	1	1	1	0	0	1	1	1	0		
Barred Fruiteater	*Pipreola arcuata*	1	1	0	0	0	0	1	1	1	0		
Scimitar-winged Piha	*Lipaugus uropygialis*	1	1	0	0	0	0	1	0	0	0	VU EBA 55	
Amazonian Umbrellabird	*Cephalopterus ornatus*	0	0	1	0	0	0	1	0	0	0		
Andean Cock-of-the-rock	*Rupicola peruviana*	1	1	1	0	0	1	1	0	0	0	IND-UT	
Wing-barred Piprites	*Piprites chloris*	1	1	0	0	0	1	0	0	0	0		
Yungas Manakin	*Chiroxiphia boliviana*	1	1	1	1	0	0	1	0	0	0	EBA 54, UT	
Round-tailed Manakin	*Pipra chloromeros*	0	0	0	0	0	1	0	0	0	0		
Streak-necked Flycatcher	*Mionectes striaticollis*	1	1	1	1	0	0	1	0	0	0		
Sepia-capped Flycatcher	*Leptopogon amaurocephalus*	0	0	0	0	0	1	0	0	0	0		
Slaty-capped Flycatcher	*Leptopogon superciliaris*	1	1	1	0	0	1	1	0	0	0	IND-UT	
Hazel-fronted Pygmy-tyrant	*Pseudotriccus simplex*	1	1	1	0	0	0	1	0	0	0	EBA 54, UT	25(20)
White-bellied Pygmy-tyrant	*Myiornis albiventris*	1	0	0	0	0	1	1	0	0	0		19(12)
Short-tailed Pygymy-tyrant	*Myornis ecaudatus*	0	0	0	0	0	1	0	0	0	0		
Yungas Tody-tyrant	*Hemitriccus spodiops*	0	1	1	1	0	0	1	0	0	0	EBA 54, BB	22(16)
Black-throated Tody-tyrant	*Hemitriccus granadensis*	1	1	1	0	0	0	1	1	1	0		30(28)
Ochre-faced Tody-flycatcher	*Todirostrum plumbeiceps*	0	0	0	1	0	0	1	0	0	0		
Golden-browed Tody-flycatcher	*Todirostrum chrysocrotaphum*	1	1	0	0	0	1	0	0	0	0		
Sclater's Tyrannulet	*Phyllomyias sclateri*	0	1	1	0	0	1	1	0	0	0		
Bolivian Tyrannulet	*Zimmerius bolivianus*	1	1	1	1	0	0	1	0	0	0	EBA 54, MM	
Southern Beardless Tyrannulet	*Camptostoma obsoletum*	0	1	0	0	0	1	0	0	0	0		
Forest Elaenia	*Myiopagis gaimardii*	0	0	0	0	0	1	0	0	0	0		
Yellow-bellied Elaenia	*Elaenia flavogaster*	0	0	E?	1	0	0	1	0	0	0		
White-crested Elaenia	*Elaenia albiceps*	0	0	1	1	0	0	1	0	0	0		
White-throated Tyrannulet	*Mecocerculus leucophrys*	1	1	1	1	0	0	1	1	1	0		
Buff-banded Tyrannulet	*Mecocerculus hellmayri*	1	1	0	0	0	1	1	0	0	0		
White-banded Tyrannulet	*Mecocerculus stictopterus*	0	1	0	0	0	0	0	1	1	0	IND-UM	
Torrent Tyrannulet	*Serpophaga cinerea*	0	0	0	1	0	1	1	0	0	0		
White-bellied Tyrannulet	*Serpophaga munda*	0	0	0	0	0	0	0	0	0	0		
Marble-faced Bristle-tyrant	*Phylloscartes ophthalmicus*	1	1	1	1	0	1	1	0	0	0		
Mottle-cheeked Tyrannulet	*Phylloscartes ventralis*	0	1	1	1	0	0	1	0	0	0		
Fulvous-breasted Flatbill	*Rhynchocyclus fulvipectus*	0	1	0	0	0	0	1	0	0	0		21(20)
Yellow-olive Flycatcher	*Tolmomyias assimilis*	0	1	1	0	0	1	1	0	0	0		23(18)
Yellow-margined Flycatcher	*Tolmomyias assimilis*	0	0	0	0	0	1	0	0	0	0		
Unadorned Flycatcher	*Myiophobus inornatus*	1	1	1	0	0	0	1	0	0	0	EBA 54, UT	25.5(20)
Cinnamon Flycatcher	*Pyrrhomyias cinnamomea*	E	E	E	0	0	1	1	1	1	0		
Olive Flycatcher	*Mitrephanes olivaceus*	1	1	1	0	0	0	1	0	0	0	IND-UT	23(20)
Smoke-coloured Pewee	*Contopus fumigatus*	1	1	1	0	0	1	1	0	0	0		
Black Phoebe	*Sayornis nigricans*	0	0	0	0	0	1	1	0	0	0		
Slaty-backed Chat-tyrant	*Ochthoeca cinnamomeiventris*	1	1	1	0	0	0	1	1	1	0	IND-UM	
Crowned Chat-tyrant	*Ochthocca frontalis*	0	1	0	0	0	0	0	0	1	0	IND-UM	
Golden-browed Chat-tyrant	*Silvicultrix pulchella*	1	1	1	1	0	0	1	1	1	0		31.5(29)

ENGLISH NAME	LATIN NAME	Prim	Dist	Sec	Scr	Puna	11-13	18-26	26-30	30-34	34+	Status	Range Extension
Rufous-breasted Chat-tyrant	*Ochthoeca rufipectoralis*	0	1	0	0	0	0	0	0	1	0		
Brown-backed Chat-tyrant	*Ochthoeca fumicolor*	0	1	1	1	0	0	1	1	1	0		
D'orbigny's Chat-tyrant	*Ochthoeca oenanthoides*	0	1	0	1	0	0	0	0	1	0		
White-browed Chat-tyrant	*Ochthoeca leucophrys*	0	0	0	1	0	0	0	0	0	1		
Streak-throated Bush-tyrant	*Myiotheretes striaticollis*	0	0	0	1	0	0	1	0	0	0		
Rufous-bellied Bush-tyrant	*Myiotheretes fuscorufus*	1	1	0	0	0	0	1	1	1	0	EBA 55	32(29)
Little Ground-tyrant	*Muscisaxicola fluviatilis*	0	0	0	1	0	0	1	0	0	0		
Long-tailed Tyrant	*Colonia colonus*	0	0	0	1	0	0	1	0	0	0		20.5(12)
Yellow-browed Tyrant	*Satrapa icterophrys*	0	0	0	1	0	1	1	0	0	0		
Bright-rumped Attila	*Attila spadiceus*	0	0	0	0	0	1	0	0	0	0		
Greyish Mourner	*Rhytipterna simplex*	0	0	0	0	0	1	0	0	0	0		
Thrush-like Sciffornis	*Sciffornis turdinus*	0	0	0	0	0	1	0	0	0	0		
Dusky-capped Flycatcher	*Myiarchus tuberculifer*	1	1	1	1	0	1	1	1	1	0		
Social Flycatcher	*Myiozetetes similis*	0	1	1	1	0	1	0	0	0	0		
Piratic flycatcher	*Legatus leucophiaus*	0	0	1	1	0	1	1	0	0	0		19(10)
Tropical Kingbird	*Tyrannus melancholicus*	0	0	1	1	0	1	1	0	0	0		
Golden-crowned Flycatcher	*Myiodynastes chrysocephalus*	1	1	1	0	0	0	1	0	1	0		30(25)
Streaked Flycatcher	*Myiodynastes maculatus*	0	0	0	0	0	0	1	0	0	0		20.5(15)
Great Kiskadee	*Pitangus sulphuratus*	0	0	0	1	0	0	1	0	0	0		
Chestnut-crowned Becard	*Pachyramphus castaneus*	0	0	1	0	0	0	1	0	0	0		19(12)
Barred Becard	*Pachyramphus versicolor*	0	1	1	0	0	0	1	1	0	0		
Masked Tityra	*Tityra semifasciata*	0	1	1	1	0	1	1	0	0	0		22.5(18)
Brown-bellied Swallow	*Notiochelidon murina*	0	0	0	1	0	0	1	0	1	0		
Blue-and-white Swallow	*Notiochelidon cyanoleuca*	0	0	0	0	1	0	0	0	0	1		37(35)
Pale-footed Swallow	*Notiochelidon flavipes*	E	E	E	0	0	0	1	1	1	0		
Andean Swallow	*Stelgidopteryx andecola*	0	0	0	0	1	0	0	0	0	1		
Southern Rough-winged Swallow	*Steligidopteryx ruficolis*	0	0	0	0	1	0	0	0	1	0		33.5(20)
Paramo Pipit	*Anthus bogotensis*	0	0	0	0	1	0	0	0	1	0		
White-capped Dipper	*Cinclus leucocephalus*	0	0	0	0	0	0	1	0	0	0		
Sepia-brown Wren	*Cinnycerthia peruana*	1	1	0	0	0	0	1	0	0	0	IND-UM,BB	
Sedge Wren (=Grass Wren)	*Cistothorus platensis*	0	0	0	1	1	0	0	0	1	0		
Moustached Wren	*Thryothorus genibarbis*	0	0	E	1	0	0	1	0	0	0		19(15)
House Wren	*Troglodytes aedon*	0	0	1	1	0	1	1	0	0	0		
Mountain Wren	*Troglodytes solstitialis*	1	1	1	0	0	0	1	1	0	0		
Grey-breasted Wood-wren	*Henicorhina leucophrys*	1	1	1	1	0	1	1	0	0	0	IND-UT	
Nightingale Wren	*Microcerculus marginatus*	0	0	0	0	0	1	0	0	0	0		
Andean Solitaire	*Myadestes ralloides*	1	1	1	0	0	0	1	1	0	0		28(27)
White-eared Solitaire	*Entomodestes leucotis*	1	1	1	0	0	0	1	1	1	0		33(28)
Spotted Nightingale-thrush	*Catharus dryas*	1	1	1	0	0	1	1	0	0	0	IND-UT	
Chiguanco Thrush	*Turdus chiguanco*	0	0	0	1	0	0	1	0	0	0		
Great Thrush	*Turdus fuscater*	0	0	0	1	0	0	1	1	0	0		
Glossy-black Thrush	*Turdus serranus*	0	1	1	0	0	0	1	1	1	0		33(28)
Slaty Thrush	*Turdus nigriceps*	0	0	1	0	0	0	1	0	0	0		
Creamy-bellied Thrush	*Turdus amaurochalinus*	0	0	0	0	0	1	0	0	0	0		
White-necked Thrush	*Turdus albicollis*	0	1	0	0	0	0	1	0	0	0		
White-collared Jay	*Cyanolyca viridicyana*	1	1	1	1	0	0	1	1	1	0		
Purplish Jay	*Cyanocorax cyanomelas*	0	0	0	0	0	1	0	0	0	0		
Green Jay	*Cyanocorax yncas*	1	1	1	1	0	0	1	0	0	0		
Red-eyed Vireo	*Vireo olivaceus*	0	1	0	0	0	1	1	0	0	0		
Brown-capped Vireo	*Vireo leucophrys*	1	1	1	0	0	0	1	0	0	0		
Dusky-capped Greenlet	*Hylophilus hypoxanthus*	0	0	0	0	0	1	0	0	0	0		
Olivaceous Siskin	*Carduelis olivacea*	0	E	1	1	0	0	1	0	0	0		

ENGLISH NAME	LATIN NAME	Prim	Dist	Sec	Scr	Puna	11-13	18-26	26-30	30-34	34+	Status	Range Extension
Yellow-bellied Siskin	*Carduelis xanthogastra*	0	0	1	1	0	0	1	0	0	0		
Tropical Parula	*Parula pitiayumi*	1	1	1	0	0	0	1	0	0	0		
Masked Yellowthroat	*Geothlypis aequinoctialis*	0	0	0	1	0	1	1	0	0	0		
Slate-throated Redstart	*Myioborus miniatus*	1	1	1	0	0	1	1	0	0	0		
Brown-capped Redstart	*Myioborus brunniceps*	0	1	0	0	0	0	1	0	0	0		
Spectacled Redstart	*Myioborus melanocephalus*	1	1	1	0	0	0	1	1	1	0		32(28)
Two-banded Warbler	*Basileuterus bivittatus*	0	0	1	0	0	1	1	0	0	0		
Pale-legged Warbler	*Basileuterus signatus*	1	1	1	0	0	0	1	1	0	0		29.5(26)
Citrine Warbler	*Basileuterus luteoviridis*	1	1	1	0	0	0	1	1	1	0	IND-UP	
Russet-crowned Warbler	*Basileuterus coronatus*	1	1	1	0	0	0	1	0	0	0	IND-MM	
Three-striped Warbler	*Basileuterus tristriatus*	1	1	1	0	0	0	1	0	0	0	IND-UT	25.5(22)
River Warbler	*Basileuterus rivularis*	0	0	0	0	0	1	0	0	0	0		
White-browed Conebill	*Conirostrum ferrugineiventre*	0	1	0	0	0	0	0	1	1	0		
Blue-backed Conebill	*Conirostrum sitticolor*	0	1	1	0	0	0	0	1	1	0		
Capped Conebill	*Conirostrum albifrons*	1	1	1	0	0	0	0	1	1	0		
Magpie Tanager	*Cissopis leveriana*	0	0	0	1	0	0	1	0	0	0		18(14)
Grass-green Tanager	*Chlorornis riefferii*	0	1	1	0	0	0	1	1	1	0		32(29)
Common Bush-tanager	*Chlorospingus ophthalmicus*	1	1	1	1	0	0	1	1	0	0	IND-UT	28(26)
Yellow-whiskered Bush-tanager	*Chlorospingus parvirostris*	0	0	0	0	0	0	1	0	0	0	IND-MM	
Orange-browed Hemispingus	*Hemispingus calophrys*	0	1	1	0	0	0	0	1	1	0	EBA 55, UM	IND-BB
Superciliaried Hemispingus	*Hemispingus superciliaris*	0	1	1	0	0	0	0	1	1	0		
Black-eared Hemispingus	*Hemispingus melanotis*	E	E	E	0	0	0	1	0	0	0	IND-MM, BB	
Three-striped Hemispingus	*Hemispingus trifasciatus*	0	1	1	0	0	0	0	0	1	0		
Rust-and-yellow Tanager	*Thlypopsis ruficeps*	1	1	1	1	0	0	1	1	0	0		
Slaty Tanager	*Creurgops dentata*	1	0	0	0	0	0	1	0	0	0	EBA 54	25.5(22)
Yellow-crested Tanager	*Tachyphonus rufiventer*	0	1	1	0	0	1	1	0	0	0		22(12)
Red-crowned Ant-tanager	*Habia rubica*	0	0	0	0	0	1	0	0	0	0		
White-winged Tanager	*Piranga leucoptera*	0	1	0	0	0	0	1	0	0	0		
Silver-beaked Tanager	*Ramphocelus carbo*	0	0	1	1	0	1	1	0	0	0		20.5(10)
Palm Tanager	*Thraupis palmarum*	0	0	0	0	0	1	0	0	0	0		
Blue-capped Tanager	*Thraupis cyanocephala*	0	1	1	1	0	0	1	1	0	0		
Blue and Yellow Tanager	*Thraupis bonariensis*	0	0	0	1	0	0	1	0	0	0		
Hooded Mountain-tanager	*Buthraupis montana*	0	1	1	0	0	0	0	1	1	0		33.5(32)
Scarlet-bellied Mountain-tanager	*Anisognathus igniventris*	0	1	1	0	0	0	1	1	1	0	IND-UM	
Blue-winged Mountain-tanager	*Anisognathus somptuosus*	1	1	1	0	0	0	1	1	0	0		27(25)
Chestnut-bellied Mountain-tanager	*Delothraupis castaneoventris*	1	1	1	0	0	0	1	1	1	0		
Fawn-breasted Tanager	*Pipraeidea melanonota*	1	1	1	0	0	1	1	0	0	0		
Blue-hooded Euphonia	*Euphonia elegantissima*	0	1	1	0	0	0	1	0	0	0		
Bronze-green Euphonia	*Euphonia mesochrysa*	0	0	0	0	0	1	0	0	0	0		
Orange-bellied Euphonia	*Euphonia xanthogaster*	1	1	1	0	0	1	1	0	0	0		23(20)
Rufous-bellied Euphonia	*Euphonia rufiventris*	0	0	0	0	0	1	0	0	0	0		
Blue-naped Chlorophonia	*Chlorophonia cyanea*	0	1	1	0	0	0	1	0	0	0		
Orange-eared Tanager	*Chlorochrysa calliparaea*	0	0	0	0	0	0	1	0	0	0		
Paradise Tanager	*Tangara chilensis*	0	0	0	0	0	1	0	0	0	0		
Green-and-gold Tanager	*Tangara schrankii*	0	0	0	0	0	1	0	0	0	0		
Saffron-crowned Tanager	*Tangara xanthocephala*	1	1	1	0	0	0	1	1	0	0		26(24)
Yellow-bellied Tanager	*Tangara xanthogastra*	0	0	0	0	0	1	0	0	0	0		
Bay-headed Tanager	*Tangara gyrola*	0	0	0	0	0	1	0	0	0	0		
Golden-naped Tanager	*Tangara ruficervix*	1	1	0	0	0	0	1	1	0	0		
Blue-necked Tanager	*Tangara cyanicollis*	0	0	1	0	0	1	1	0	0	0		
Masked Tanager	*Tangara nigrocincta*	0	0	0	0	0	1	0	0	0	0		
Beryl-spangled Tanager	*Tangara nigroviridis*	1	1	1	0	0	0	1	0	0	0		

ENGLISH NAME	LATIN NAME	Prim	Dist	Sec	Scr	Puna	11-13	18-26	26-30	30-34	34+	Status	Range Extension
Blue-and-black Tanager	*Tangara vassorii*	1	1	1	0	0	0	1	1	1	0		
Straw-backed Tanager	*Tangara argyrofenges*	1	1	1	0	0	0	1	0	0	0	EBA 54	
Black-faced Dacnis	*Dacnis lineata*	0	0	0	0	0	1	0	0	0	0		
Blue Dacnis	*Dacnis cyana*	0	1	0	0	0	1	1	0	0	0		22(10)
Purple Honeycreeper	*Cynerpes caeruleus*	0	0	0	0	0	1	0	0	0	0		
Swallow Tanager	*Tersinia viridis*	0	0	0	0	0	1	0	0	0	0		
Bananaquit	*Ceoerba flaveola*	0	0	0	0	0	1	0	0	0	0		
Plushcap	*Catamblyrhynchus diadema*	0	0	0	0	0	0	0	1	0	0	IND-BB	
Yellow-browed Sparrow	*Ammodramus aurifrons*	0	0	0	0	0	1	0	0	0	0		
Rufous-collared Sparrow	*Zonotrichia capensis*	0	0	0	0	0	0	0	0	1	0		
Pectoral Sparrow	*Arremon taciturnus*	0	0	0	0	0	1	0	0	0	0		
Plumbeous Sierra-Finch	*Phrygilus unicolor*	0	0	0	0	1	0	0	0	0	1		
Ash-breasted Sierra Finch	*Phrygilus plebejus*	0	0	0	0	1	0	0	0	0	1		
White-winged Diuca Finch	*Diuca speculifera*	0	0	0	0	1	0	0	0	0	1		
Bright-rumped Yellow-finch	*Sicalis uropygialis*	0	0	0	0	1	0	0	0	0	1		
Rufous-naped Brush-finch	*Atlapetes rufinucha*	E	E	E	1	0	0	1	1	1	0		32.5(30)
Stripe-headed Brush-finch	*Atlapetes torquatus*	0	1	0	1	0	0	1	0	0	0		
Moustached Flower-piercer	*Diglossa mystacalis*	0	0	0	1	0	0	0	0	1	0		
Grey-bellied Flower-piercer	*Diglossa carbonaria*	0	0	0	0	0	0	0	0	1	0	EBA 55, 56	
Deep-blue Flower-piercer	*Diglossopis glauca*	0	1	1	0	0	0	1	0	0	0		
Masked Flower-piercer	*Diglossopis cyanea*	0	1	1	0	0	0	1	1	1	0		
All black flowerpiercer	*Diglossa sp.*	0	0	0	0	0	0	1	0	0	0		New?
Band-tailed Seedeater	*Catamenia analis*	0	0	0	0	0	1	0	0	0	0		
Black-backed Grosbeak	*Pheucticus aureoventris*	0	E	E	E	0	0	1	1	0	0		
Buff-throated Saltator	*Saltator maximus*	0	0	0	0	0	1	0	0	0	0		
Crested Oropendola	*Psarocolius decumanus*	1	1	1	0	0	1	1	0	0	0		21.5(18)
Dusky-green Oropendola	*Psarocolius atrovirens*	1	1	1	0	0	0	1	0	0	0		
Russet-backed Oropendola	*Psarocolius angustifrons*	0	0	0	0	0	1	0	0	0	0		
Amazonian Oropendola	*Psarocolius bifasciatus*	0	0	0	0	0	1	0	0	0	0		
Yellow-rumped Cacique	*Cacicus cela*	0	0	0	0	0	1	0	0	0	0		
Southern Mountain-cacique	*Cacicus chrysonotus*	1	1	0	0	0	0	1	0	0	0		32(30)
Yellow-billed Cacique	*Amblycercus holosericeus*	0	1	1	1	0	0	1	1	1	0	IND-BB	
Giant Cowbird	*Scaphidura oryzivora*	0	0	0	0	0	1	1	0	0	0		
TOTALS	***339***	109	169	141	75	18	129	211	83	75	15		

Key

Habitats: Prim=Undisturbed Primary Forest, Dist=Disturbed Primary Forest, Sec= Secondary Forest, Scr= Scrub, Puna= Montane grassland.
E= Edge eg. Edge of primary forest.

Altitudes:
11-13=1100 to 1300 m, rapid assessment at the confluence with the Altamachi.
18-26=1800 to 2600m, full inventory in the valley of the Rio Pampa Grande.
26-30=2600-3000m, rapid assessment in the valley of the Rio Pampa Grande.
30-34=3000-3400m, rapid assessment in the valley of the Rio Pampa Grande.
34+=incidental records above tree line.

Status: IND=Indicator species of, HT=Upper Tropical, Montane Evergreen Forest, MM=Mid-montane, Montane Evergreen Forest, UP=Upper Montane, Montane Evergreen Forest, HT=Hill Tropical, Humid Broadleaf Forest, BB=Bamboo Forest. Range Extensions: Where inventory data represents an extension of previous known altitudinal range the first figure x100 gives new highest or lowest altitude at which species found, second figure in brackets gives previously published highest or lowest known altitude. Bol=new record for Bolivia, New?=possible new species to science.

12 Appendix 2 - Data tables for Scarabaeidae collected in the río Pampa Grande and río Altimachi valleys.

TABLE 9.1. *Number of individuals collected per species on the six study transects (T1 – T6).* N = *number of trap-days.*

Species	T1 1820 m (*N* = 40)	T2 2110 m (*N* = 33)	T3 2110 m (*N* = 28)	T4 2300 m (*N* = 30)	T5 2300 m (*N* = 36)	T6 2530 m (*N* = 37)	Total (*N* = 204)
Canthidium sp.	1	11	12	3	—	22	49
Canthon pallidus (Schmidt)	4	—	—	—	—	3	7
Coprophanaeus ignecinctus (Felsche)	1	—	—	—	—	—	1
Delthochilum nr. *mexicanum* (Burm)	9	—	—	—	—	—	9
Delthochilum nr. *morbillosum* (Burm)	33	10	49	74	9	—	175
Dichotomius planicollis (Gillet)	171	1	3	—	—	—	175
Dichotomius diabolicus (Harold)	—	5	77	73	111	56	322
Dichotomius carbonarius (Mannerheim)	2	16	147	275	15	8	463
Eurysternus caribaeus	6	—	—	—	—	—	6

(Herbst)							
Eurysternus nr. *marmoreus* (Castelnau)	28	6	1	5	1	1	42
Gonaphodiellus sp. 1	46	—	5	81	14	49	195
Gonaphodiellus sp. 2	6	1	13	9	—	—	29
Ontherus obliquus (Génier)	179	87	192	362	63	71	954
Ontherus bridgesi (Waterhouse)	—	—	6	—	—	20	26
Onthophagus sp. 1	4	—	—	—	—	—	4
Onthophagus sp. 2	4	—	—	—	—	—	4
Phaneus sp.	1	—	—	—	—	—	1
Uroxys sp. 1	9	—	1	4	18	19	51
Uroxys sp. 2	—	—	7	5	—	1	13
Total number of beetles	504	137	513	891	231	250	2526
Beetles per trap-day	12.6	4.2	18.3	29.7	6.4	6.8	12.4

TABLE 9.2. *Observed and estimated species richness computed by the Chao 1 and MMMean statistics on the six study transects (T1 – T6) using individual-based rarefaction curves (100 randomizations) to standardize for sampling effort and capture rate.* N = *total number of individuals sampled; Chao 1 max = estimated richness at maximum number of individuals; MMMean max = estimated richness at maximum number of individuals;* S_{obs} *standard. = mean observed species richness after 137 individuals; Chao 1 standard. = mean estimated richness after 137 individuals; MMMean standard. = mean estimated richness after 137 individuals.*

Species	T1 1820 m (*N* = 504)	T2 2110 m (*N* = 137)	T3 2110 m (*N* = 513)	T4 2300 m (*N* = 891)	T5 2300 m (*N* = 231)	T6 2530 m (*N* = 250)	Total (*N* = 2526)
Observed species richness	16	8	12	10	7	10	19
Chao 1 max	19.0	10.0	14.0	10.0	7.5	12.0	21.0
MMMean max	15.3	8.1	11.5	9.8	7.0	9.6	18.0
S_{obs} standard.	12.2	8.0	9.5	7.6	6.7	8.9	12.1
Chao 1 standard.	15.9	10.0	11.3	9.2	7.0	10.1	15.0
MMMean standard.	12.2	8.1	9.3	7.5	6.9	9.0	12.7

TABLE 9.3. *Bivariate comparisons of community composition between the six transects using the Morisita-Horn similarity index.*

	T1	T2	T3	T4	T5
T2	0.684				
T3	0.560	0.831			
T4	0.591	0.850	0.974		
T5	0.369	0.535	0.685	0.595	
T6	0.538	0.641	0.692	0.686	0.802

13 Appendix 3 - Project Personnel

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14 Appendix 4 - Project Accounts

Income

Thriplow Charitable Trust	£6,500
BP Conservation Award	£6,000
Personal Contributions and Fundraising	£5,500
Royal Geographical Society	£2,250
Oxford University (AA Paton Fund)	£1,855
British Ecological Society	£1,250
Gilchrist Educational Trust	£1,000
Oxford University Exploration Council	£819
Glasgow University Council	£750
BP Award Workshop Travel Expenses	£514.10
Russel Trust	£500
Edinburgh Trust No. 2.	£300
Chester Zoo	£200
BOU Book Grant	£100
Albert Reckit Charitable Trust	£100
Scottish Royal Geographical Society	£100
Interest	£16.27
Total Income	**£27,754.37**

Pre-Project Expenditure

Flights	£5,700
First Aid & Biological Training	£711.10
Project Personnel Training	£173
Administration	£223.10
Insurance	£850
Medical Equipment	£950
Base Camp Equipment	£2,259
Satellite Phone & calls	£1,500
Scientific Equipment	£1537.27
Total Pre-Project Expenditure	**£13,903.47**

Project Costs in Bolivia

Food	£1,125.67
Accommodation	£418.33
Transport	£2,245.38
Helicopter Hire	£8,014.29
Bolivian Counterpart Expenses	£671.43
Departure Taxes	£142.86
Field Equipment	£302.07
Miscellaneous Equipment & Admin.	£200.87
Total Costs in Bolivia	**£13,120.91**

Post Project Costs

Phone tax	£232
Laptop Battery Replacement	£252.48
Project Report Production & Dissemination	£245.52
Total Post Project Costs	**£730**