EXPEDITION REPORT

Expedition dates: 23 November – 19 December 2008
Report published: March 2009

Icons of the Amazon: jaguars, pumas, parrots and peccaries in Peru.

BEST VOLUNTEERING ORGANISATION	BEST FOR GREEN-MINDED TRAVELLERS	TOP RESPONSIBLE HOLIDAY	BEST WILDLIFE VOLUNTEERING HOLIDAY	BEST IN SUSTAINABLE TRAVEL	ENVIRONMENT AWARD	TOP HOLIDAY FOR NATURE
First Choice Responsible Tourism Awards	The Independent on Sunday	responsibletravel.com	theguardian	Islands	Umwelt-Online-Award	P.M.
UK	UK	UK	UK	USA	Germany	Germany

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Abstract

Macaw behaviour: Red-and-green macaws (*Ara chloropterus*) are one of the most common members of the parrot family observed at large, riverside claylicks in south-eastern Peru. Although considered common and widespread in aviculture, little is known about their social interactions in the wild. Claylicks provide an ideal setting at which to study wild bird behaviour, with the caveat that the claylick itself may impact on social interactions. We observed macaws around two claylicks in the lowland Amazon. Macaw behaviour differed significantly on the surface of the claylick compared to the surrounding vegetation. The position of a bird in the surrounding vegetation may also influence behaviour, with the canopy level associated more with preening and inter-pair bonding interactions like allopreening. Aggression increases closer to, and on the claylick, although a high degree of submissiveness appears to accommodate bird proximity on the claylick itself. Whether aggression is a characteristic of individual macaws, or whether these interactions help establish a dominance hierarchy among the local population of macaws is unclear at this stage. In comparison to a control group of scarlet macaws observed around nesting sites, macaws at the claylick appeared to be bothered less by insects. Playing, preening and aggression were all observed more around the claylick compared to birds around nests. Lower vigilance and a comparable number of aggressive interactions at a site with fewer red-and-green macaws and more scarlet macaws appears to indicate the interactions of these species as a “super flock” at this site. Of conservation concern, it appears that a smaller proportion of birds will feed when there are fewer than ten macaws in the area of the claylick, highlighting the vulnerability of these sites to human and other disturbance. We suggest further studies of macaw claylicks to determine seasonal changes in behaviour; the role of claylicks in the social structure of the macaws; and how these interactions are influenced by disturbances factors such as passing boat traffic.

Seasonal patterns at claylicks: We present results from claylick monitoring studies conducted at three sites in the lowland rainforest of south-eastern Peru in the department of Madre-de-Dios, for the period 2005 to 2008. Red-and-green macaws are commonly observed around riverside claylicks of the region, where they can be observed throughout the day. Seasonal patterns of claylick visitation by the macaws to the three claylicks show broad patterns of similarity, but monthly feeding shows different patterns between the sites. Patterns of daily feeding also show different trends. Roosts and similar congregation sites for birds can be used for monitoring populations and recruitment rates and we discuss the potential of claylicks for performing similar studies. We discuss the results in the context of a region facing large anthropomorphic change to increased human settlement of the region with the paving of a major road through the region.

Mammal survey: Neotropical game species are important ecologically and economically. Subsistence hunters depend on wild game for food, but local extinction of these species has broad effects on forest structure, plant diversity and predator populations. Previous research has addressed some of the effects of hunting on large game, however none have examined the synergistic effects of habitat factors, such as the presence of claylicks, in addition to hunting, that can affect game populations. We continued a multi-year dataset monitoring mammals and large-bodied birds after the cessation of logging and hunting activities at Las Piedras Biodiversity Station, Madre de Dios, Peru. We compared encounter rates of large mammals with distance to a mammal claylick. We also monitored two claylicks with camera traps and one with human observers. The results of this study will facilitate better understanding of the habitat requirements of these species, as well as their recovery after disturbance. This information will help guide future decisions regarding management of Neotropical mammals and selection of protected sites.

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Resumen

Comportamiento de guacamayos: El guacamayo cabezon (*Ara chloropterus*) es uno de la mas común de las especies de loro que se encuentra cerca tierras salados de las orillas de ríos (o colpas) del sureste de Perú. Aun común en cuativario, existe poco información sobre interacciones sociales en su estado silvestre. Colpas son sitios ideales donde se puede monitorear comportamiento de aves silvestres, aun la presencia de la colpa misma puede tener un impacto en el comportamiento. Hicimos monitoreo de guacamayos alrededor de dos colpas en bosque de lluvia de la Amazona. Comportamiento de guacamayos estaba significante diferente entre aves en los árboles y aves en la misma colpa. La posición del ave en la vegetación alrededor de la colpa también puede tener impacto en su comportamiento, con aves más alto observado más acicalándose y acicalando parejas. Agresión es elevado con proximidad de la colpa y en la colpa misma, pero los guacamayos aguantan la presencia de vecinos con signos de sumisión. Si agresión es una característica de individuos o si interacciones sirven como una manera de sustentar su posición de poder dentro de la comunidad no es claro. Insectos molestan más a los guacamayos escarlatas alrededor de sus nidos como los guacamayos alrededor de la colpa. Jugando, acicalándose y agresión se observa más alrededor de la colpa que los nidos. Niveles bajo de vigilancia y un nivel de agresión comparable entre los dos colpas son indicaciones que los guacamayos cabezones están utilizando guacamayos escarlatas como parte de un “gran bandada”. Un punto de preocupación para su conservación, es que no hemos observado guacamayos colpeando con menos de diez aves alrededor de la colpa, que puede indicar un número mínimo para esa actividad. Sugerimos mas estudios de comportamiento para entender el impacto de estaciones y como botes son fuente de perturbación.

Patrones estacionales alrededor de colpas: Presentamos resultados del monitoreo de tres colpas de la selva del Perú sureste, de observaciones hecho entre 2005 y 2008. Guacamayos cabezones (*Ara chloropterus*) se encuentra frecuentemente alrededor de colpas de ríos de la región, donde se paran por muchas horas durante del día. Patrones estacionales entre las tres colpas son aparentemente parecidos, pero cambios entre meses son diferentes. Patrones de visitas a la colpa también son distintos entre las colpas. Dormideros y lugares similares donde se encuentra gran cantidades de aves puede ser herramientas para el monitoreo de poblaciones y consideramos la potencial de colpas para hacer estudios similares. Discutimos los resultados en el contexto de cambios de gran escala que viene a propósito de la carretera interoceánica que va a resultar en altos niveles de migración de humanos a la zona.

Estudio de mamíferos: Especies Neotropicales frecuentemente cazados son importantes ecológicamente y económicamente. Mitayeros depende de esas especies para comida, pero extinción de esas especies tiene gran impactos en la estructura de los bosques, diversidad de plantas, y poblaciones de depredadores. Investigaciones anteriores han discutido algunas de esos impactos, pero ninguno se ha enfocado en el impacto de tipos de bosque, presencia de colpas además que el impacto de mitayeros que puede impactar poblaciones de animales. Continuamos el monitoreo largo plazo de mamíferos y aves grandes después de una época de casaría en los bosques alrededor del Las Piedras Biodiversity Station, Madre de Dios, Perú. Hicimos comparaciones entre tipos de encuentro de mamíferos con distancia de colpas. Hicimos monitoreo de colpas con trampas cameras y observaciones visuales de observadores. Los resultados son útiles para el conocimiento de uso de tipos de bosque por los mamíferos, y muestran recuperación de poblaciones de algunas especies después de ser casados. Esa información sirve como un guía para el manejo de mamíferos Neotropicales de áreas protegidas.

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Contents

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Please note: Each expedition report is written as a stand-alone document that can be read without having to refer back to previous reports. As such, much of this and the following sections, which remains valid and relevant, is a repetition from previous reports, copied here to provide the reader with an uninterrupted flow of argument and rationale.

1. Expedition Review

M. Hammer (editor)
Biosphere Expeditions

1.1. Background

Biosphere Expeditions runs wildlife conservation research expeditions to all corners of the Earth. Projects are not tours, photographic safaris or excursions, but genuine research expeditions placing ordinary people with no research experience alongside scientists who are at the forefront of conservation work. Expeditions are open to all and there are no special skills (biological or otherwise) required to join. Expedition team members are people from all walks of life and of all ages, looking for an adventure with a conscience and a sense of purpose. More information about Biosphere Expeditions and its research expeditions can be found at www.biosphere-expeditions.org.

This expedition report deals with a survey of iconic wildlife species in one of the best conserved remaining regions of the Amazon basin with vast areas of unbroken canopy, which ran from 23 November to 19 December 2008. The aim of the survey was to gain a better understanding of the ecological importance of natural clay licks as this information will assist in the development of an environmentally sensitive and sustainable management strategy. The project built on one of Biosphere Expeditions' longest running studies, with the focus changing to better understand the importance of mineral licks in the lives of macaws and peccaries, as well as the top-end predators puma and jaguar. Once we understand how the clay lick ecology works, strategies for their sustainable use in eco- and nature tourism can be developed that will benefit local people and wildlife and provide strong incentives to protect more natural habitat that is currently threatened by unsustainable and short-term gain logging, gold mining and oil & gas exploration.

1.2. Research Area

Flag and location of Peru and study site.

An overview of Biosphere Expeditions' research sites, assembly points, base camp and office locations is at Google Maps.

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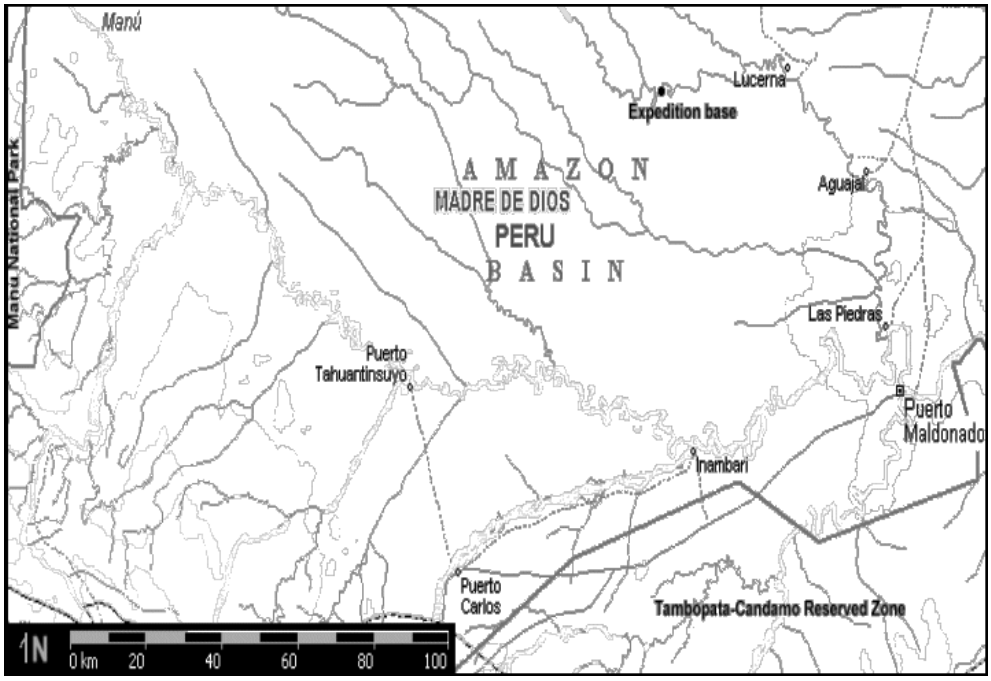
Peru is located on the Pacific coast of South America and is the third largest country on the continent. Two thirds of Peruvian territory is located within the Amazon basin. The expedition base camp is within the department of Madre de Dios, internationally known as “the Biodiversity Capital of the World”. The department already contains two large national parks covering over half of its 78,000 km² area – Manu and the vast Bahuaja-Sonene (Tambopata) area. The Rio Piedras is located between the two.



Map of the area showing Puerto Maldonado (assembly point), Manu (NW corner), Tambopata-Candamo (SE corner) and base camp location (N edge).

In terms of biological diversity, the research area is amongst the richest in the world. The area’s ecosystems hold several world records in flora and fauna species numbers and are recognised as one of the planet’s biodiversity hotspots. Research conducted over the last 20 years in the Bahuaja-Sonene National Park has shown that it harbours more species of birds (587), butterflies (1,230) and many other animal taxa than any other location of comparable size. It has recently also been identified as the largest uninhabited and untouched rainforest wilderness on Earth, covering about 1 million hectares (2.5 million acres) of undisturbed and unhunted habitat (the nearest rival, the island of New Guinea has about 100,000 hectares of uninhabited tropical forest habitat). The area is also home to a number of landmark animals listed in the IUCN's Red Data Book. Amongst them the giant river otter, giant armadillo, giant anteater, ocelot, jaguarundi, jaguar, harpy eagle, crested eagle, spectacled caiman, and black caiman. Over 150 different species of tree can be found within 100 m^2 alone, and the WWF and IUCN have identified the area as a 'Centre of Plant Diversity'.

1.3. Dates

The expeditions ran over a period of four weeks divided into two two-week slots, each composed of a team of international research assistants, scientists and an expedition leader. Slot dates were:

2008: 23 November – 5 December | 7 – 19 December (12 nights).

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1.4. Local Conditions & Support

Expedition base

The expedition was based in a remote region along the Las Piedras river. Base camp was a large, comfortable jungle lodge / research station made from local materials with twin rooms, showers and toilets. By and large team members paired up to share rooms. All meals were prepared for the team and vegetarians and special diets were catered for.

Field communications

Mobile phones did not work in the remote research area. Base camp had a radio for emergency communication with Puerto Maldonado. The expedition leader sent an expedition diary to the Biosphere Expeditions HQ every few days and this diary was then distributed to team members and appeared on the Biosphere Expeditions website at www.biosphere-expeditions.org/diaries for your friends and family to access.

Transport & vehicles

Team members made their own way to the Puerto Maldonado assembly point. From there they travelled six to seven hours by boat to base camp. Once at base, most studies were conducted on foot. Boats were also used for transport where necessary. All transport, boats and vehicles were provided from the expedition team assembly point onwards and back.

Medical support & insurance

The expedition leader was a trained first aider, and the expedition carried a comprehensive medical kit. Further medical support was provided through a medical post in the Colpayo community, about three hours by boat. The nearest hospital was in Puerto Maldonado, about six hours by boat. Safety and emergency procedures were in place. All team members were required to carry adequate travel insurance covering emergency medical evacuation and repatriation. There were no serious medical incidences in 2008. There was one case of a mild fever, which was treated at base.

1.5. Expedition Scientists

Alan Lee is a graduate of Manchester Metropolitan University. His undergraduate studies in biology were conducted in South Africa, where he grew up. After working as a game ranger for one of South Africa's most exclusive lodges, Mala Mala, he moved to England for a change in career direction and for travel opportunities, that to date have taken him to every continent except Antarctica. He first came to Peru in 2002 where he worked as a guide at Explorer's Inn, and then joined the Tambopata Macaw Project. From 2003-2004 he supervised teams of volunteers on a project looking at the impacts of tourism on large mammal wildlife. In 2005 he was scientific adviser for the Biosphere Expedition to Las Piedras. During 2006 as part of his ongoing research into the impact of clay licks on parrot abundance, he was project manager for the Tambopata Macaw Project at Posada Amazonas and Refugio Amazonas.

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Miguel Licona graduated from Dartmouth College with a BA in Environmental and Evolutionary Biology and is currently a graduate student at Texas A&M University pursuing a Master's of Science degree in Wildife & Fisheries Sciences. He has worked for state and federal agencies as well as NGOs in North and South America studying the ecology of trout, songbirds, deer, elk, and wolves. His first experience conducting research in the Amazon was with white-lipped peccaries and other rainforest mammals in Madidi National Park, Bolivia. Miguel has just completed nearly a year of fieldwork for his Master's thesis, *Occupancy Modeling of Large Mammals in Madre de Dios Peru,* which includes some of the data collected during this expedition.

1.6. Expedition Leader

This expedition was by Andrew Stronach. Andrew was born in Scotland, studied Engineering and then flew aircraft for the Royal Air Force before working in wildlife. Surveys of wild plants, birds and marine mammals led him into anti-wildlife crime work that has become his passion and taken him all over Britain and Cyprus. He has taken part in expeditions to Belize, Honduras and Sulawesi, surveying coral reefs and rainforest. Due to a rare allergy to offices, Andrew is almost always found outdoors, whether it is working in the highlands of Scotland, trekking in some remote national park on one of his many foreign travels or dangling from a rope on a rock face.

1.7. Expedition Team

The expedition team was recruited by Biosphere Expeditions and consisted of a mixture of all ages, nationalities and backgrounds. They were (with countries of residence in parentheses):

23 November - 5 December 2008

Gebhard Becks (Germany), Stefanie Beil (Germany), Mary Fitzpatrick (USA), Johannes Georg (Germany), Winfried Hochstetter (Germany), Margret Kessler (Germany), Cassie Mercer (UK), Kevin Telfer (UK), Janice Thompson (UK), Uli Uerlings (Germany).

Also: Dr. Martin Amanshauser (journalist from Austria).

7 - 19 December 2008

Katie Bunting (UK), Lisa Hilbrecht (Canada), Bob Husey (UK), Heidrun Kohler (Germany), Jeannette Sander (Germany), Stefan Tomalak (Germany).

Throughout the expedition: Emma Hume coordinated activities around the research base. Jhin Solis was an able guide for the first expedition, while Gloria Sovero ably assisted in both expeditions. Fantastic food was prepared by Gloria Duran, with assistance from Meli Duran.

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1.8. Expedition Budget

Each team member paid towards expedition costs a contribution of £1090 per person per two week slot. The contribution covered accommodation and meals, supervision and induction, a permit to access and work in the area, all maps and special non-personal equipment, all transport from and to the team assembly point. It did not cover excess luggage charges, travel insurance, personal expenses like telephone bills, souvenirs etc., as well as visa and other travel expenses to and from the assembly point (e.g. international flights). Details on how this contribution was spent are given below.

Income	£
Expedition contributions	17,170
Expenditure	
Base camp and food includes all meals, lodging, base camp equipment, boat transport	7,488
Equipment and hardware includes research materials & gear, etc. purchased in UK & Peru	340
Biosphere Expeditions staff includes salaries, travel and expenses to Peru	3,186
Scientific & local staff includes salaries, travel and expenses, gifts	4,225
Administration includes permits, registration fees, sundries, etc.	397
Team recruitment Peru as estimated % of PR costs for Biosphere Expeditions	3,120
Income – Expenditure	- 1,586
Total percentage spent directly on project	**109%***

*This means that in 2008, the expedition ran at a loss and was supported over and above the income from the expedition contributions by Biosphere Expeditions.

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1.9. Acknowledgements

This study was conducted by Biosphere Expeditions which runs wildlife conservation expeditions all over the globe. Without our expedition team members (who are listed above) who provided an expedition contribution and gave up their spare time to work as research assistants, none of this research would have been possible. The support team and staff (also mentioned above) were central to making it all work on the ground. Thank you to all of you, and the ones we have not managed to mention by name (you know who you are) for making it all come true. Biosphere Expeditions would also like to thank members of the Friends of Biosphere Expeditions and donors, Land Rover, Swarovski Optik, Cotswold Outdoor, Globetrotter Ausrüstung, Snowgum and Buff for their sponsorship.

1.10. Further Information & Enquiries

More background information on Biosphere Expeditions in general and on this expedition in particular including pictures, diary excerpts and a copy of this report can be found on the Biosphere Expeditions website www.biosphere-expeditions.org.

Enquires should be addressed to Biosphere Expeditions at the address given below.

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2. Social behaviour of red-and-green macaws (*Ara chloropterus*) around claylicks in south-eastern Peru

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2.1 Introduction

Red-and-green macaws (*Ara chloropterus*, previously *Ara chloroptera*) are the second largest of the seventeen macaw species after the hyacinth macaw (*Anodorhynchus hyacinthinus*), weighing 1230 g and measuring up to a metre from head to tail (Forshaw 2006). They are found throughout South America in lowland Amazon rainforest and temperate deciduous forest, with a range of over 8 million square kilometres (Figure 2.1a). They are classified as Least Concern by the IUCN (IUCN 2008), although populations have been reduced in parts of their range due to over-harvesting for the pet trade (Juniper and Parr 1998). They are widespread in captivity (the aviculture name is green-winged macaw) as they are socially interactive with both people and other parrots (Abramson et al. 1995).

These macaws have been the focus of few studies in their natural habitat and so little information exists regarding red-and-green macaw ecology. They are regarded as common in lowland Amazon rainforest, with published abundance for the species ranging from 1.8 to 8 individuals per square kilometre (Terborgh et al. 1990, Haugaasen and Peres 2008). Like most of the macaws, red-and-green macaws are known to eat unripe fruits and seeds, which may give them a competitive advantage over other frugivores, such as monkeys (Norconk et al. 1997). They are known seed predators, particularly of trees of the Lecythidaceae (Brazil nut) family (Trivedi et al. 2004, Haugaasen 2008). The species nests in cliffs in Bolivia, but in Peru they predominantly nest in natural cavities in ancient *Dipteryx micrantha* trees, with the breeding season lasting from November to March (Brightsmith 2005). During this period large numbers are seen on geophagy sites (hereon referred to as claylicks) where birds descend in large multi-species flocks to consume clay along exposed river banks (Brightsmith 2004). Despite being one of the most common large species of parrot seen at claylicks across South America (Lee et al. in review), few publications exist regarding the species' social behaviour in the wild.

Claylicks offer an opportunity for several species of parrot to interact. However, patterns of behaviour emerging from small scale studies have not painted a complete picture of the role of claylicks in the social lives of the parrots, or how variables impact upon inter- and intra-species interactions. A study of a claylick in Manu, south-eastern Peru, showed red-and-green macaws to be more aggressive than scarlet macaws (*Ara macao*), which they outnumbered (Burger and Gochfeld 2003). Red-and-green macaws are larger than scarlet macaws, and a correlation between size and aggression between smaller parrot species has been reported (Shaw 2008). However, aggression levels may also depend on group size, since the medium sized blue-headed parrot, the most aggressive parrot feeding in the early morning in Manu, was also the most common (Burger and Gochfeld 2003). Agonistic behaviours between breeding macaws can have fatal consequences for chicks caught up in the battle for nesting sites (Wilson and Brightsmith 2003, Renton 2004).

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It is still speculation whether claylicks act to establish a social hierarchy among macaws that help reduce the need to fight for nesting sites, but the claylicks may be serving a purpose above and beyond the supplementation of dietary sodium and the adsorption of dietary toxins (Brightsmith et al. 2008).

During initial red-and-green macaw behaviour observations carried out during a Biosphere Expeditions study at the Las Piedras River, changes in patterns of behaviour were observed through the course of the day (Lee 2006). Initially, this was thought to be due to the need for birds to preen more in the early morning, and then becoming more sedentary as the day wore on. However, several variables were not taken into account, including the number of macaws in the area of the claylick, how social interactions changed in relation to position around the claylick, or with distance from nearest birds. As such, this report delves deeper into the social interactions of macaws around claylicks, in an attempt better to understand the role of these unique resources to the natural lives of wild macaws.

Figure 2.1a. Range map of red-and-green macaw distribution in South America, modified from Forshaw (2006).

As such the objectives of the study were (1) to determine daily trends in major behaviour categories around a claylick, (2) to determine flock size and nearest-neighbour birds impact on parrot behaviour, (3) to determine how a bird behaviour changes in relation to a bird's location in the vicinity of the claylick, and (4) to compare levels of aggressive interactions and other social behaviour for birds at the claylick to birds around nesting sites

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2.2 Methods

Study area

The Madre-de-Dios department of south-eastern Peru is on paper one of the best protected areas of the Amazon in South America, with five protected areas covering over a third of the department (Figure 2.2a). The study area lies at the boundary between tropical moist and subtropical wet forest. Average elevation is 250 m and average rainfall 3200 mm (Brightsmith 2004). The expedition base used by Biosphere Expeditions, where the methodology was refined and tested, is the Las Piedras Biodiversity Research Station (Piedras) (S 12º05.663' W 69º52.852'). Located on the Las Piedras River, the area has been used by Biosphere Expeditions since 2002 (Hammer and Tatum-Hume 2003). The area is protected by an ecotourism and Brazil nut concession and boasts high biodiversity (Hammer and Tatum-Hume 2003). The claylick is a 20 m wide and 15 m high section of fluvial sediments of the western bank of the Las Piedras River.

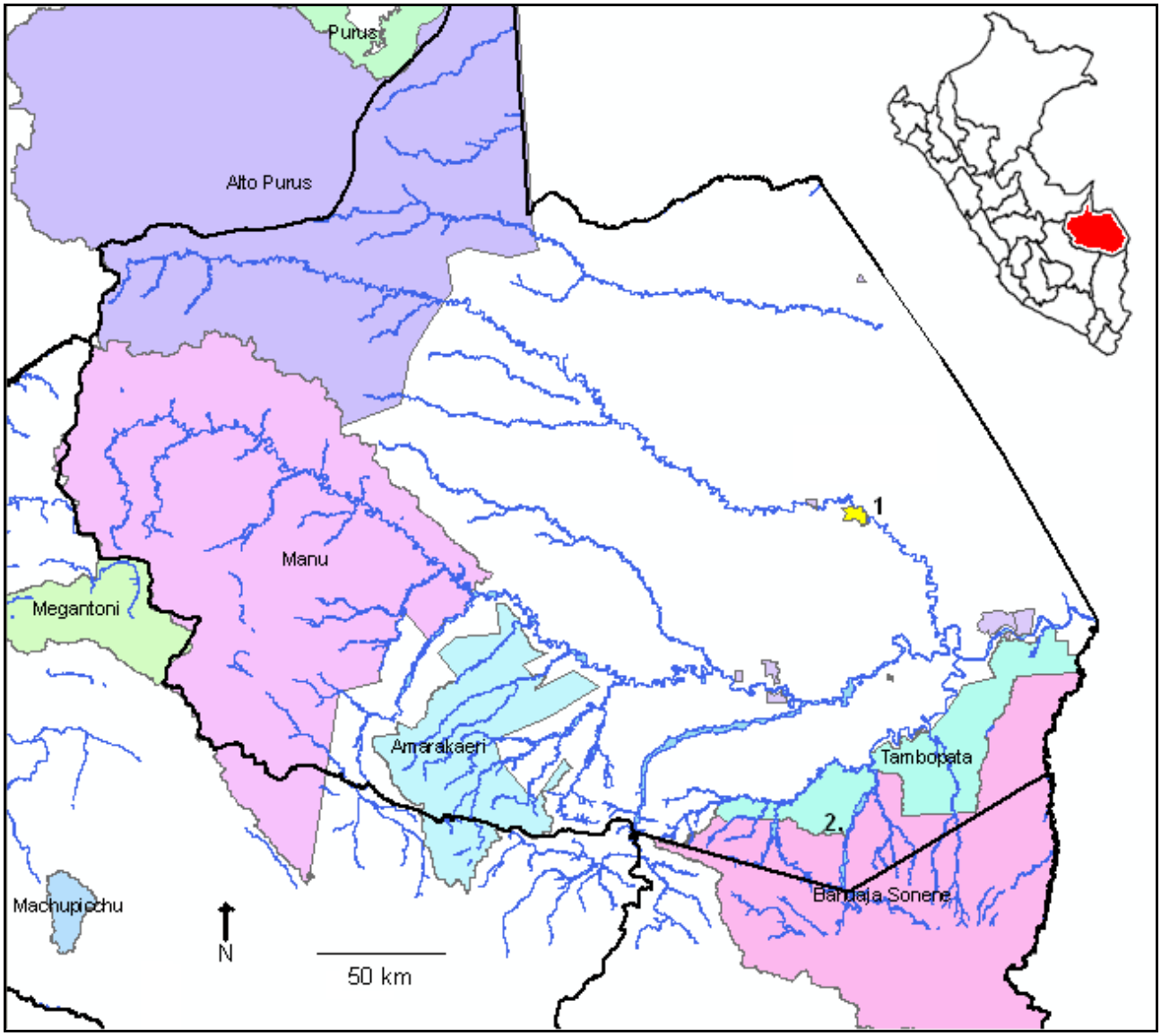

Figure 2.2a. Map of the protected areas of the Madre-de-Dios department, south-eastern Peru, showing the location of the Las Piedras tourism concession (1) and the Tambopata Research Centre (2).

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Studies outside the current Biosphere Expeditions project were also conducted at the Tambopata Research Center (TRC) (S 13º07, W 69º36) on the border of the Tambopata National Reserve (275,000 ha) and the Bahuaja-Sonene National Park (537,000 ha). The TRC claylick is a 500 m long, 30 m high cliff along the western edge of the upper Tambopata River, formed by the river's erosion of uplifted Tertiary age alluvial sediments (Räsänen et al. 1995). A total of 28 bird species have been reported eating soil from this lick, and the lick may be visited by up to 1700 psittacines of 17 species per day (Brightsmith 2004).

Behaviour monitoring

Behaviour activities were recorded for the focal species: red-and-green macaw, being the species seen at most claylicks across the region, and the predominant species at the Piedras claylick. Observations were carried out from behind a blind, using a telescope and two observers. Observations were conducted for 15 days, from 26 November to 17 December 2008, at the main macaw claylick at the Las Piedras Biodiversity Research Station. Observations were carried out from 5:00 until 14:00, when most of the birds had disappeared from the area of the claylick. Observations were carried out for 7 days from 8 January to 14 January 2009 at the Tambopata Research Centre, where observations were conducted from 5:00 until 17:00 as birds remained in the area for a much longer period of time. The first slot of the current Biosphere Expeditions project (25 November to 5 December 2008) was used to refine methodology and over 400 observations were recorded. No position data were taken, but the importance of a macaw's position in the vicinity was realised, together with the role of other birds in the vicinity, and this information included in the methodology for the second slot (7 to 19 December) as outlined below. In addition, to compare behaviour of birds around a claylick to birds away from a claylick, scarlet macaws were observed around nest sites at the TRC. This was done to look for any differences in a similar-sized macaw that occupies a similar niche to the red-and-green macaw, given that no red-and-green macaws nesting sites were available for observations. Clear observations of groups of macaws away from the claylick are difficult as views of birds encountered along the trails are restricted due to their upper canopy habits, and few birds are observed from the only other convenient observation posts that do offer these views, namely towers and overlooks. However, this first comparison of bird behaviour will provide the groundwork for longer-term studies on these iconic species and the roles that claylicks play in their lives.

Using a telescope, a bird was randomly selected and observed carefully for 60 seconds every five minutes. Efforts were made to follow the same individual for the duration of its stay in the area of the claylick. In effect, this proved to be impossible due to the movements of the birds in the vicinity. Therefore the results reflect the behaviour of a group of, rather than individual birds. A note was made if subsequent observations involved the same individual.

One observer described what the bird was doing to another person acting as recorder, who ticked a box for the activity that that bird was involved in. Once a behaviour category was ticked during the minute's observation, it was not ticked again, providing simple binomial data for the bird behaviour.

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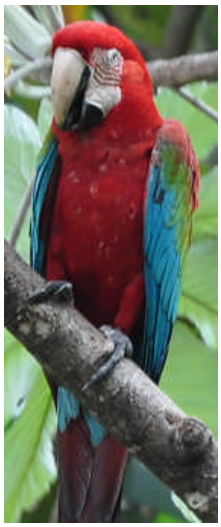
The maximum number of birds of the same species that were present within beak reach of the target bird was recorded. The number of the same species in the area of the claylick was recorded, being all the birds that are in the field of view and not just those perched in the vicinity of the target bird including birds in the trees, claylick and flying.

The position of the bird was recorded as follows: 1. High - high up in the vegetation (15 m or higher above the claylick surface), 2. Low - in vegetation within 15 m of the claylick, or 3. Clay - on the surface of the claylick.

Weather was recorded as rain, fog, cloud, sun (a clear shadow cast in the area of the claylick or clear skies if before sunrise).

The following behaviour categories were recorded, some of which are illustrated below.

Resting. Bird perched, usually looking forward, maybe looking slowly around, but not doing any of the following. Bird is in this position for more than 10 seconds before this behaviour is recorded.



Vigilant. Bird actively looking around; head movement is notable, often with head twisted at 90 degrees from the body.

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Panting. Beak is open and tongue moving up and down, much like a panting dog.

Headshake. This is normally a quick movement of the head often associated with a bird being bothered by insects.

Sleeping. Head tucked beneath wing for long period of time

Moving. Bird moving along a branch or between branches, or on the claylick. Does not include flight or other body movements covered by the following categories.

Calling. Bird obviously vocalizing – beak is open and call can be heard.

General Calling. Recorded when there was doubt as to whether the target bird was vocalising or not, but when vocalization could be heard that may have involved the target bird.

Begging. Juvenile birds emit a slow “erp, erp, erp…” noise, accompanied by fluffed up head feathers; usually done in the presence of an adult bird.

Playing. Bird or birds engaged in robust movements, involving hanging upside down, squawking, gentle lunging. Distinguished from fighting which is very loud, and occurs over a very short period with wings open.

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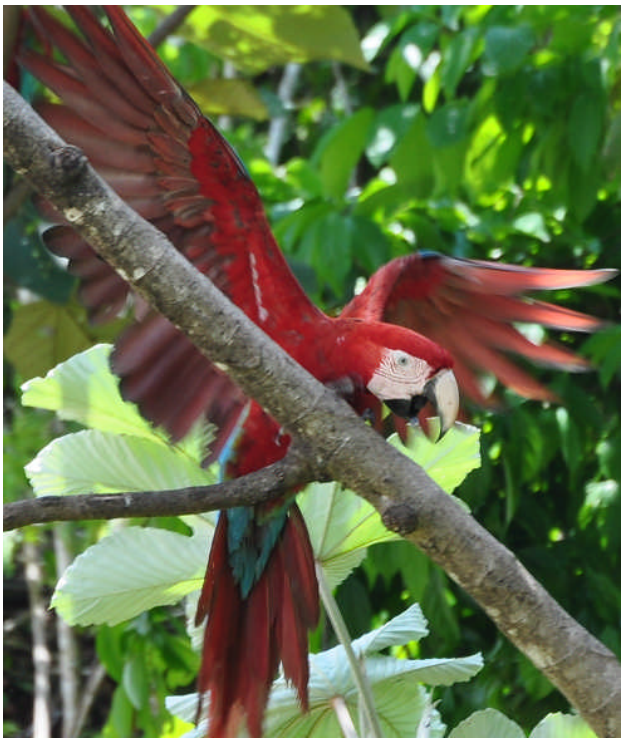
Regurgitation. A bird engages in rapid up and down movements with the head, head tilted back, to move food from crop to beak. This is sometimes followed by allo-feeding.

Hanging. Bird hanging upside down, almost bat-like, from a branch or liana.

Aggression. Bird lunging quickly, with beak open, at another bird. If the aggression was not towards the same species, then a note of the species involved was made.



Submission. Bird retreats from an aggressive bird, either backing away or flying off.

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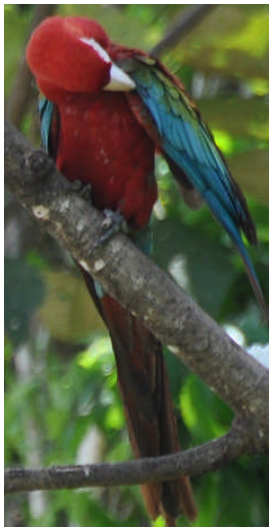
Fighting. Two birds engaged in loud strident calls, lots of wing flapping.

Preening. Bird grooming itself with its beak.



Allopreening. Bird grooming or being groomed by another bird (includes simultaneous allopreening and non-simultaneous allopreening).

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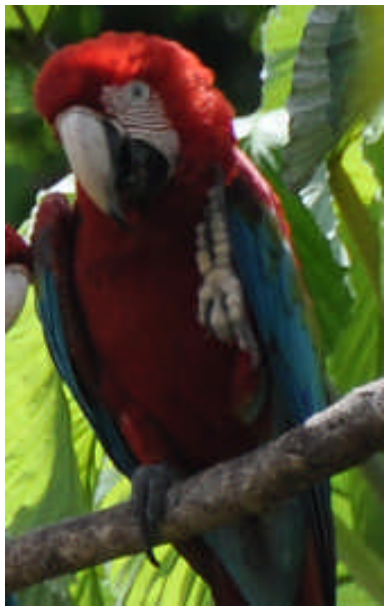
Wingstretch. Bird opens wing/s in a stretch and does not fly away, a behaviour associated with part of the preening process.

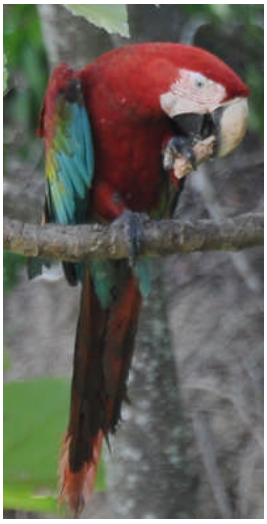
Scratch. Bird using its foot to groom.



Branch biting. Bird using its beak to bite the branch it is on.

Eating seed/fruit. Any feeding behaviour observed in the trees around the claylick, including leaves.

Eating clay (on lick or in trees). Bird is either on the claylick (left photo) or is perched in the vegetation with a lump of clay (right photo).



Defecation. Observed bird defecates.

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Analysis

Results are binomial and presented as proportions of observations where a behaviour was observed. Chi-squared tests were performed to determine differences in proportional observed behaviour between trees, clay and nests using FC-stats. Linear regression was performed to determine the influence of time of day on macaw behaviour for those were trends were displayed. Spearman's correlation was used to test the relation between the mean number of birds in the area of the claylick and the proportion of birds observed eating clay.

2.3 Results

Summary

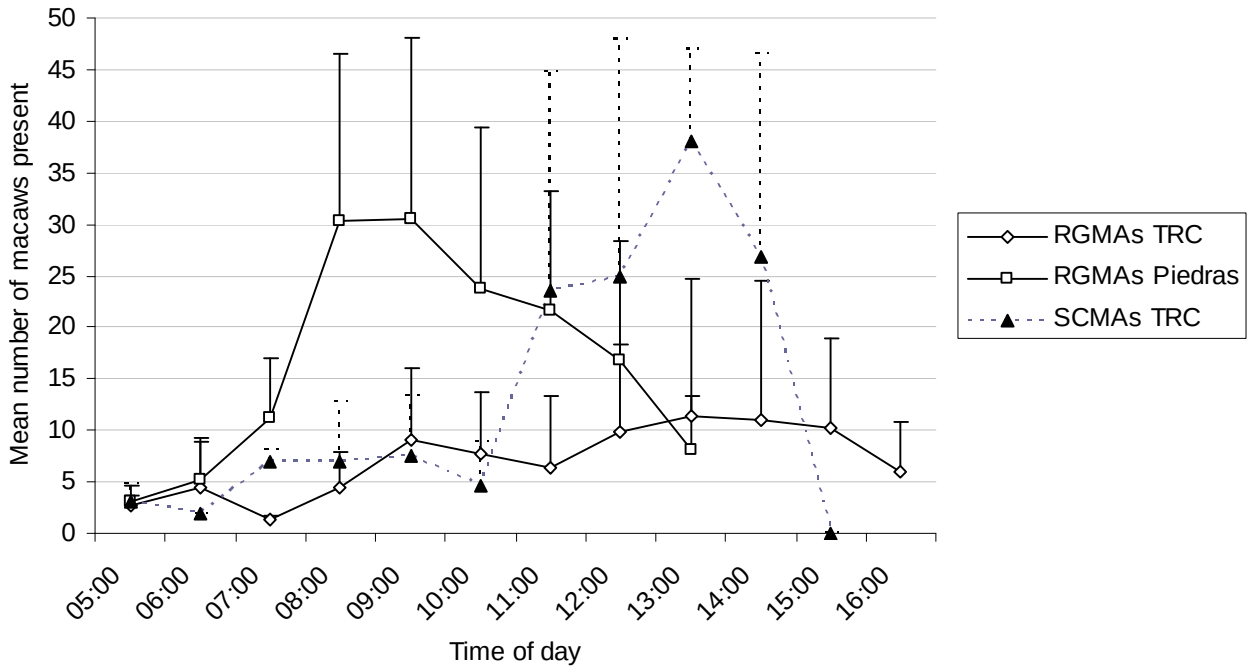

Figure 2.3a. Mean numbers of red-and-green macaws (RGMAs) and scarlet macaws (SCMAs) in the vicinity of the Piedras and TRC claylicks. Differences in patterns of visitation are evident for both mean flock size and peak flock size. Error bars represent ±1 standard deviation.

In total, 1427 minutes (23.8 hours) of observation were conducted on red-and-green macaws in the vicinity of the two claylicks. The mean count of red-and-green macaws in the vicinity of the claylick at Piedras was 19.4±16 and 8.4±9 at TRC, although scarlet macaws were all but absent at Piedras, there were 13.2±16 at TRC. However, these numbers fluctuated through the day (see Figure 2.3a above). In addition, a trapping exercise carried out by a separate study at TRC in the early morning may have influenced bird numbers in the area, resulting in larger numbers of birds in the vicinity of the claylick after 11:00.

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Behaviour patterns between trees and on the claylick

To compare differences in behaviour on claylicks and in the trees, data for the two sites were combined. These results are presented in Table 2.3a below. In addition, 179 minutes of observation of scarlet macaws around their nests are presented. These are results from seven periods of observation on four different nests at TRC (Hugo, Invisible, Odio, Pukakuro). Less panting, resting and scratching was observed on the clay compared to birds in the trees or at the nests, while more aggression and submission was observed. More preening, allopreening and playing behaviours were observed for birds in the trees. Birds in the nest move and fly less compared to birds in the vicinity of the claylick, but display more headshaking behaviour.

Table 2.3a. Proportion of key behaviours recorded during minute interval observations of red-and-green macaws on the clay (Clay) and trees around two claylicks from south-eastern Peru. Results from observations on scarlet macaw behaviour around nest sites are presented for comparison (Nests).

	Clay (n=161)		**Trees (n=879)**		**Nests (n=179)**	
	n		**n**		**n**	
Resting	10	6% *	377	43%	122	68%
Sleeping	0	0%	3	0%	0	0%
Vigilant	71	44%	407	46%	93	52%
Calling	9	6%	50	6%	4	2%
General calling	9	6%	102	12%	3	2%
Panting	2	1% *	162	18%	18	10%
Playing	0	0%	53	6% **	2	1%
Hanging	2	1%	37	4%	0	0%
Headshake	1	1%	27	3%	96	54% **
Moving	21	13%	185	21%	7	4% *
Flight	29	18%	145	16%	3	2% *
Preening	4	2%	345	39% **	12	7%
Allopreening	1	1%	55	6%	4	2%
Scratch	6	4% *	166	19%	33	18%
Wingstretch	2	1%	28	3%	3	2%
Begging	0	0%	1	0%	0	0%
Regurgitation	0	0%	1	0%	2	1%
Branch biting	2	1%	36	4%	1	1%
Eat fruit / leaves	0	0%	6	1%	0	0%
Eat clay on lick	144	89%	n.a.		n.a.	
Defecation	4	2%	18	2%	0	0%
Fighting	1	1%	9	1%	0	0%
Aggression	13	8% **	8	1%	0	0%
Submission	11	7% **	6	1%	0	0%

n.a. Not applicable
* Lower than expected compared to other positions, p<0.01
** Higher than expected compared to other positions, p<0.01

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The role of a bird position in surrounding vegetation on behaviour

Significantly more panting and playing were observed at TRC compared to Piedras (Table 2.3b below). However, playing behaviour was observed on several occasions outside of observation periods at Piedras. More playing behaviour was observed later in the day at TRC – so the period of peak playfulness may simply not have been recorded at Piedras due to the difference in observation intervals.

Table 2.3b. Proportion of key behaviours recorded during minute interval observations of red-and-green macaws in trees around two claylicks from south-eastern Peru. P values are given for results of X^2 tests between lodges for combined High and Low positions results.

	High			Low			Combined		
	TRC	Piedras	Combined	TRC	Piedras	Combined	TRC	Piedras	P
N	276	232	508	197	170	367	473	402	
Resting	43%	47%	45%	54%	24%	39%	48%	37%	0.27
Vigilant	34%	49%	42%	42%	66%	54%	37%	56%	0.06
Moving	22%	13%	18%	24%	27%	26%	23%	19%	0.64
Calling	6%	6%	6%	3%	8%	5%	5%	7%	0.77
Gen calling	4%	16%	10%	13%	16%	15%	8%	16%	0.15
Panting	17%	3%	10%	37%	22%	29%	25%	11%	0.03*
Playing	14%	0%	7%	7%	0%	3%	11%	0%	0.002*
Hanging	10%	0%	5%	3%	2%	3%	7%	1%	0.07
Headshake	3%	3%	3%	5%	2%	3%	4%	2%	0.68
Preening	35%	52%	43%	35%	35%	35%	35%	45%	0.31
Allopreening	8%	7%	7%	5%	4%	5%	7%	6%	1.0
Scratch	13%	32%	23%	12%	17%	15%	13%	26%	0.06
Wingstretch	3%	2%	3%	6%	1%	3%	4%	2%	0.7
Regurgitation	0%	0%	0%	0%	0%	0%	0%	0%	-
Branch-biting	5%	3%	4%	5%	3%	4%	5%	3%	-
Eat fruit / leaves	0%	0%	0%	2%	1%	1%	1%	0%	-
Eat clay in trees	0%	0%	0%	2%	4%	3%	1%	2%	-
Defecation	1%	3%	2%	3%	1%	2%	2%	2%	-
Fighting	0%	0%	0%	2%	2%	2%	1%	1%	-
Aggression	1%	0%	1%	1%	1%	1%	1%	1%	-
Submission	0%	0%	0%	1%	1%	1%	1%	1%	-

- sample size too small to provide meaningful results

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There is some indication that a bird's position in the vegetation surrounding the claylick may have an influence on behaviour. At both claylicks, fighting and submission were only observed low down, as was eating clay and fruits or leaves. Birds higher up to tend to show more resting and preening-related behaviour. However, patterns of behaviour changes in relation to bird position are obscured at TRC where the vegetation structure around the claylicks is different from Piedras (see Figures 2.3b and 2.3c below), allowing birds to perch and undertake activities associated with a high position lower down. Vigilance did not seem to increase on the surface of the claylick, even though this is when birds are most vulnerable to predators.

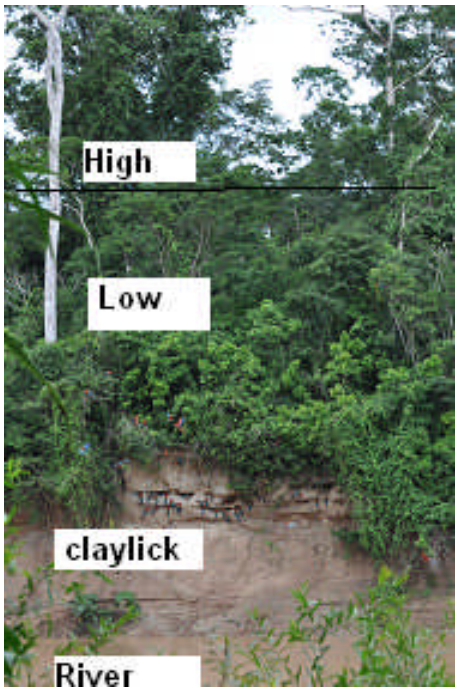

Figure 2.3b. The Piedras claylick; showing the river, the bank of clay, the area of vegetation above the claylick classified as Low and the start of the area classified as High.

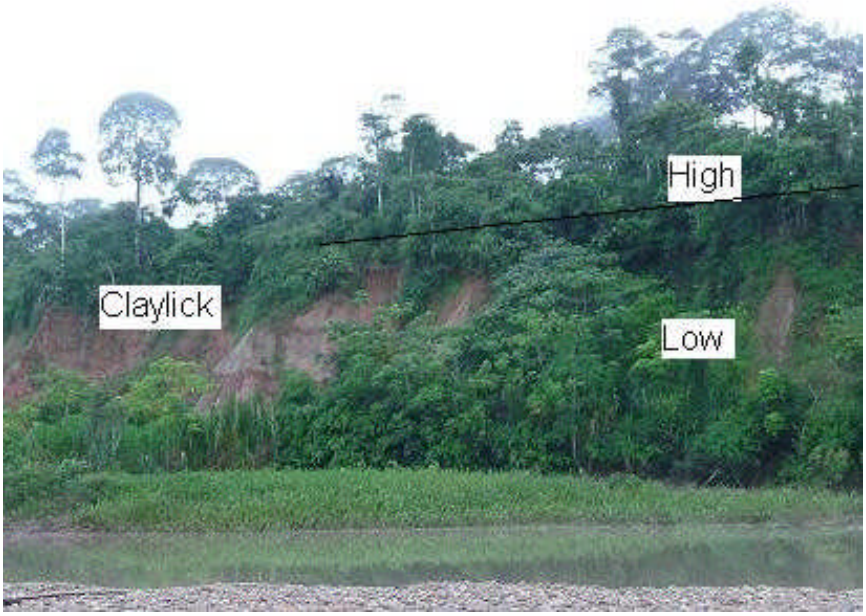

Figure 2.3c. The TRC claylick, showing bird position classifications

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Behavioural changes in relation to nearest neighbour and “flock” size

As the number of birds increases in the area of the claylick, so do the incidents of encounters with other birds overall, measured as the number of birds within beak-reach during the period of observation (Table 2.3c below). This is seen in the decrease in the proportion of the number of observations of birds with no birds in beak-reach, with an increase in the proportion of two or more birds within beak-reach with increasing birds in the area. This trend is not obvious for only one bird within beak-reach, as this is indicative of bird pairs and there is probably an equal chance of observing paired birds regardless of the total number of birds in the area.

All 11 agonistic reactions between birds at Piedras were between the same species. However, at TRC the 12 agonistic reactions observed were recorded as follows: Fighting: 3 between red-and-green macaws, 1 with scarlet macaw; Aggression: 2 towards red-and-green macaws, 3 towards scarlet macaw; Submission: 2 submissive responses to scarlet macaw and one to red-and-green macaws.

Table 2.3c. Nearest neighbour proximity of red-and-green macaws in relation to total number of macaws in the area of the claylick, grouped into four categories.

Number of macaws within beak-reach	Total number of macaws in the area			
	1 to 10 (n=973)	11 to 20 (n=207)	21 to 30 (n=91)	> 30 (n=156)
0	80%	56%	57%	40%
1	19%	37%	29%	33%
2	1%	5%	8%	15%
3 or more	0%	2%	7%	12%

Results (Table 2.3d) show that when the number of macaws feeding on the claylick increases, the chances of interactions with two or more macaws increases. In contrast, other behaviours such as resting and preening decrease with the number of nearest neighbours and macaws in the vicinity of the claylick.

Table 2.3d. Behaviour of red-and-green macaws in relation to number of nearest neighbour macaws, i.e. maximum number of birds within beak-reach.

Birds within beak-reach	0	1	2	>2
N	620	335	53	29
Vigilant	49%	41%	40%	48%
Resting *	43%	32%	19%	14%
Moving	18%	24%	19%	10%
Calling *	7%	5%	4%	0%
General calling	11%	12%	9%	0%
Playing	0%	15%	4%	0%
Preening	35%	37%	15%	0%
Allopreening *	N.a.	15%	6%	0%
Scratching *	19%	15%	4%	3%
Eating clay on lick **	6%	16%	60%	79%
Fighting	n.a.	2%	2%	3%
Aggression	n.a.	3%	13%	3%
Submission **	n.a.	3%	6%	10%

* Decreasing trend in observed behaviour with increasing number of neighbouring macaws
** Increasing trend in observed behaviour with increasing number of neighbouring macaws

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Table 2.3e. Change in red-and-green macaw behaviour in relation to the total number of macaws around the claylick.

Behaviour	N observations	Number of macaws in area of observation			
		1 to 10 (n=573)	11 to 20 (n=207)	21 to 30 (n=89)	> 30 (n=158)
		573	207	89	158
Vigilant	473	44%	50%	46%	50%
Resting *	383	44%	34%	31%	20%
Moving	206	20%	18%	21%	22%
Calling	59	7%	5%	2%	5%
General calling	111	11%	10%	13%	11%
Playing	53	7%	4%	0%	4%
Preening *	347	39%	37%	25%	16%
Allopreening	56	6%	7%	4%	4%
Scratching *	171	18%	17%	16%	10%
Eating clay **	151	3%	21%	27%	43%
Fighting	10	1%	0%	1%	3%
Aggression	21	1%	2%	1%	7%
Submission	17	1%	0%	2%	7%

* Decreasing trend in observed behaviour with increasing number of neighbouring macaws
** Increasing trend in observed behaviour with increasing number of neighbouring macaws

Trends in behavioural change in relation to time of day

The proportion of birds recorded as resting increases from 15% to 60% over the course of the day. However, there was no change in vigilance and no clear linear trends for defecation, calling or moving. There is a significant increase in the amount of Resting behaviour observed during the course of the day (R^2 = 0.60, F=15.24, p=0.03)

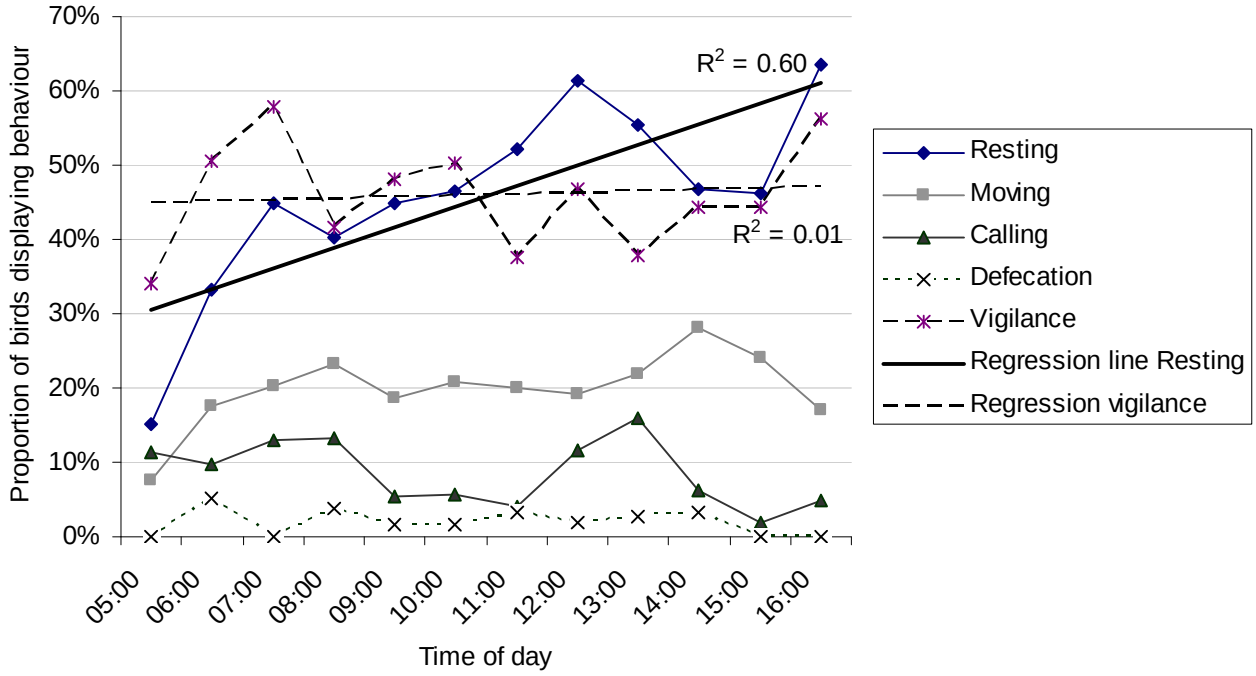

Figure 2.3d. Trends in behavioural change during the course of the day for proportion of red-and-green macaws observed resting, moving, calling, defecating and vigilant in the vicinity of the Piedras and TRC claylicks.

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Panting increases significantly through the course of the day (R^2 = 0.67, F = 20.33 p = 0.001). There is a significant correlation between the number of birds in the vicinity of the claylick and the proportion of birds observed eating clay (r^2 = 0.76, N = 12, p = 0.004). The number of observations of aggressive interactions is too small to be conclusive, but show a trend towards being observed in the morning when larger numbers of birds are on the claylick.

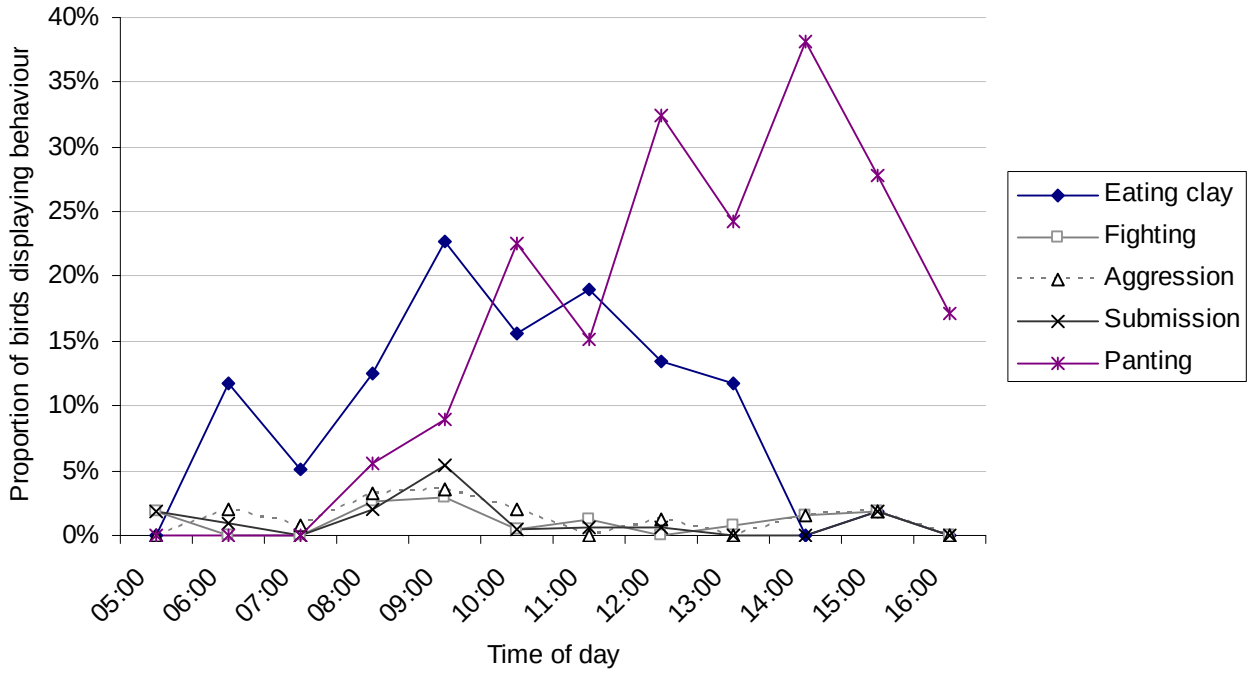

Figure 2.3f. Trends in behavioural change during the course of the day for proportion of red-and-green macaws observed eating clay on the claylick, fighting, being aggressive, being submissive and panting in the vicinity of the Piedras and TRC claylicks.

Preening behaviour is dominant in the early morning (Figure 2.3g below), and decreases significantly over the course of the day (R^2 = 0.54, F = 11.87, p = 0.006). However, even in the late afternoon preening activity was recorded for 20% of all observations. The degree of preening intensity was not recorded, and this may reduce later in the day. Scratching, a bird's way of preening head and neck regions, also decreased over the course of the day (R^2 = 0.65, F = 18.48, p = 0.002). Allopreening did not display as notable a trend, although was higher in the early morning. Similar to playing, this social interaction behaviour commonly observed between paired macaws, also showed an increase in the afternoon, although not to the degree of the proportion of birds observed playing and this relationship was not significant (R^2 = 0.19, F = 2.34, p = 0.16).

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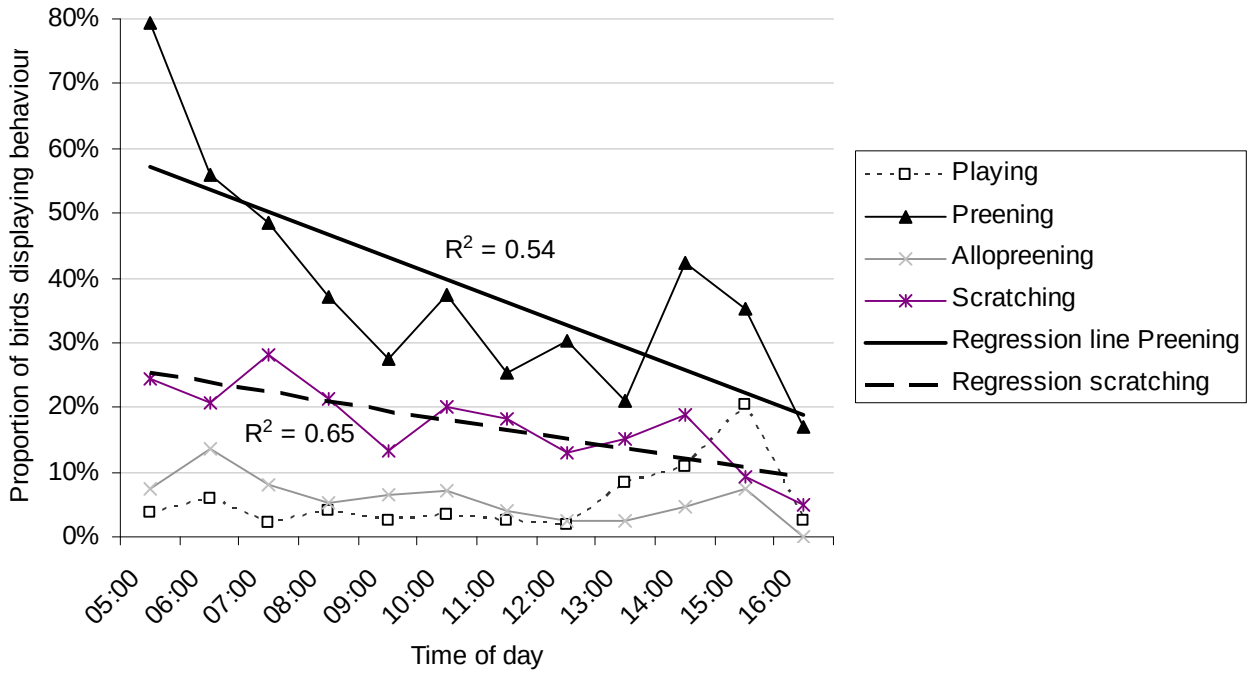

Figure 2.3g. Trends in behavioural change during the course of the day for proportion of red-and-green macaws observed playing, preening, allopreening and scratching in the vicinity of the Piedras and TRC claylicks.

2.4 Discussion

General

Red-and-green macaws start to arrive to the area of the claylick from early morning (07.00) onwards. The first birds to arrive normally do so in pairs, although they do not necessarily perch close to each other during this period. When they do, allopreening behaviour is frequently observed (over 10% of observations), while the rest of the time is spent predominantly calling. Most of the birds arriving in the early morning tend to perch high in the trees, in positions that presumably offer them good vantage points from which to look for predators. In addition, vocalisations also tend to be higher when there are fewer birds in the area and in close proximity, so this period could be a “recruitment” period, letting macaws from further away know that the area is safe.

Once enough birds are recruited to the area of the claylick, they start to drift to the lower vegetation above or around the claylick. Here, preening behaviour is lower at Piedras, but the change at TRC is not as marked, probably due to the different physical structure of the claylick and the suitability of trees at the level of the claylick, which serve as resting trees. As birds move towards the claylick, they come into closer contact and chances of aggressive encounters increase.

On the claylick, it is clear that the primary purpose for landing on the clay is for clay consumption, with nearly 90% of observations actively including the consumption of soil. Vigilance continues to be a prominent behaviour, and preening and resting are at much lower levels. However, aggressive interactions are much higher. Few aggressive approaches give way to fights, instead a corresponding degree of submission is displayed, with birds making way for new birds on the claylick, and a high degree of near neighbour

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tolerance displayed. Whether this is a trade-off of 'safety in numbers' for the chance to assert oneself socially is still not clear at this stage. Although no predator attacks on birds on the clay were observed, several different species of raptors were seen in the area of the claylick. At Piedras, an orange-breasted falcon (*Falco deiroleucus*) was observed attacking a pair of red-and-green macaws in flight over the river; while at TRC a black-hawk eagle (*Spizaetus tyrannus*) was observed attacking a blue-and-yellow macaw (*Ara ararauna*) perched in the trees above the claylick. Neither attack resulted in the capture of a macaw. However, the need for constant vigilance is clear.

Once macaws have finished feeding, at Piedras, most dispersed in flocks in indeterminate directions into the surrounding forest. At TRC, individuals were often still seen in the vicinity of the claylick, where couples were observed playing and allopreening.

Vigilance

There was no decrease in vigilance with increasing numbers of birds in the vicinity of the claylick, although a decrease in vigilance has been recorded for red-rumped parrots, (*Psephotus haematonotus*), and galahs (*Cacatua roseicapilla*) from Australia with increasing flock size (Westcott and Cockburn 1988). Vigilance was lower at TRC compared to Piedras, even though mean red-and-green macaw flock size was lower at TRC. Similarly, no change in vigilance has been observed around a small claylick in relation to number of birds in the vicinity of the claylick for a range of smaller species from south-eastern Peru, including dusky-headed parakeet, mealy parrot, chestnut fronted macaw and white-eyed parakeet (Shaw 2008). At TRC lower red-and-green macaw vigilance may be due to the presence of scarlet macaws functioning as flock members, as combined numbers were higher at TRC compared to Piedras. A more quantitative approach may show if there is a change in scan rate or scan time during vigilant behaviour, information not collected using the methodology employed here.

Preening and amicable social behaviour

Preening was highest in the early morning, when fewer other birds were around and with fewer birds in closer proximity. Birds may be making the most of the quiet period before other birds arrive in the vicinity of the claylick in order to groom. When other birds are in the vicinity, more time is spent interacting. Birds may be more vulnerable to aggression from other macaws when in a preening position. Birds appear to be comfortable preening in the company of a mate, when allopreening also occurs.

Allopreening is appeasement behaviour (Hardy 1963). Conflict resolution in the form of reconciliation has been shown for red-and-green macaws in captivity (Wanker et al. 2006). In red-fronted macaws (*Ara rubrogenys*) an increased amount of time spent allopreening in the early breeding period probably indicated the importance of maintaining the relationship between the pair members during the breeding period, when copulations and courtship feeding were also seen (Pitter and Christiansen 1997). No copulations were observed among the red-and-green macaws, but an incident of scarlet macaw mating was observed outside the observation period at a scarlet macaw nest.

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There are implications for changes in bird behaviour with the number of surrounding birds for captive birds in a cage setting. Birds in a caged environment may be less able to obtain respite from companion birds that may be needed for a bird to feel comfortable with an extended preening session. This may result in poor feather condition and secondary problems, for instance feather plucking or parasite infestation. In contrast, since preening was higher at the onset of the social event at the claylick compared to around the nests, solitary birds may also preen less with similar consequences.

Aggression

Aggression between neighbouring birds was rare, and chasing of individuals was seen on very few occasions. Agonistic behaviour is frequent in budgerigars (*Melopsittacus undulatus*) in captivity, which in the wild show few agonistic encounters and no peck order or dominance hierarchy (Wyndham 1980). No evidence of peck order was observed in flocks of red-fronted macaw, except for a breeding pair that seemed to be socially superior to non-breeding birds (Pitter and Christiansen 1997). Aggression may be reduced by the spreading out of the pairs when resting. Galahs (*Eolophus roseicapillus)* also space themselves out when roosting and feeding (Rowley 1990). Levels of aggression between sites were the same, although at TRC many of these encounters involved scarlet macaws, supporting the “super-flock” theory.

Dealing with heat and insects

Although temperatures in the tropical sun easily pass 35^{o}C, birds are observed at the claylicks even at the hottest times of the day. During this time, the rate of panting increased, so this behaviour must be important for thermal regulation. When no feeding on the claylick was going on, birds also disappeared into the depths of the foliage of the surrounding trees, presumably in order to seek shelter from the sun. Around the nests, panting rate was lower since most nests are below the level of the upper canopy, and therefore better shaded. However, although heat may not be as much of an issue, insects do seem to bother birds at the nests more, as evidenced by a much higher rate of headshaking and scratching. Birds at the claylick seem to avoid bothersome insects by moving more and flying between perches more regularly. Bot flies are well documented parasites of parrot chicks and negatively impact on their growth (Seixas and Mourão 2003). There seems to be little chance of avoiding insects around the nest, and this may be an added attraction for spending extended periods of time at the claylicks.

Claylick activity

Our data show that feeding activity is much lower when there are fewer than ten birds in the area of the claylick. It therefore appears that there is a critical threshold in the number of birds needed in the vicinity before claylick activity will commence. This is the first time that such a threshold has been quantified. In addition, most feeding takes place in close proximity to other macaws, where some birds display dominance, but where the overall social interaction observed is one of submission, i.e. birds appear to accommodate each other’s presence on the claylick.

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Conserving claylicks is essential for the social functioning of red-and-green macaw populations. Once bird numbers in the area drop below a critical threshold, birds will be less likely to feed, less likely to interact, and so less likely to maintain a social hierarchy. Without this social hierarchy, there is less competition for nesting resources, meaning that there are fewer constraints on the species' fitness, which could lead to a weakening of its genetic pool and the introduction of deleterious traits. In addition, anecdotal evidence suggests that macaws can form bonds that may help protect nesting birds against possible intruders, be they other macaws or predators.

We urge the utmost attention to the conservation of macaw claylicks across south-eastern Peru for the ongoing survival of one of the region's most iconic bird species.

Recommendations for further research

Biosphere Expedition's monitoring of macaws in the vicinity of claylicks has been pivotal to the development of the current protocol. The scope of this study needs to be extended in order to investigate trends, as well as to account for behaviour change with seasons, interactions with other bird species. There is also a need to extend this survey to other bird species. The use of multiple observers could substantially increase observations during short expeditions. In order to understand the role of the claylick to macaw social structure, observations should also be undertaken away from the claylick, for instance from towers or other vantage points, as well as at any known nesting sites. Observations using a similar protocol for birds in captivity would better enable us to give recommendations for improving the lives of captive bred birds from lessons learned by birds in their natural environment.

2.5 Acknowledgements

We are grateful for the assistance of the Biosphere Expeditions participants led by Andrew Stronach. In addition, further observations at the Tambopata Research Centre were facilitated by Donald Brightsmith and the Tambopata Macaw Project, especially George Olah. Thanks to Graham Dixon for providing the photo of the TRC claylick.

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3. Patterns of clay consumption by red-and-green macaws (*Ara chloropterus*) at three avian claylicks in south-eastern Peru

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3.1. Introduction

Temporal and spatial variations in estimates of wild animal populations are important indicators of underlying demographic processes and ecological interactions. Estimating bird species abundance in tropical rainforest environments is made difficult by the terrain and issues of detection (Whitney 1996, Buckland et al. 2001). Sites where birds gather in large numbers to roost or use seasonal resources provide opportunities to monitor some bird populations. Seasonal changes in roost counts have been used to estimate the size and recruitment of threatened populations (Matuzak and Brightsmith 2007) and to provide information about population size and structure (Berg and Angel 2006). Monitoring over long periods of time is the only efficient tool to distinguish between natural fluctuations and those caused by human influence (Bibby et al. 1998). Population monitoring is particularly important in the case of the parrot family as parrots are vulnerable to poaching and loss of nesting sites (Wright et al. 2001). A large number of parrot species are endangered or threatened (Collar et al. 1992). Macaws are especially vulnerable, with two out of 17 species extinct and most of the rest declining throughout their range. Where macaws gather in large numbers at mineral claylicks in south-eastern Peru, they become easy targets for hunters who know the locations of these sites (Hammer and Tatum-Hume 2003).

Across the western Amazon basin, several species of frugivorous and granivorous birds, especially parrots, have been observed feeding on clay at exposed river banks (Emmons and Stark 1979, Hammer 2001). Although birds consume for a variety of reasons (Diamond et al. 1999, Symes et al. 2006), parrots in the western Amazon appear to gain benefits from the clay consumed for two principal reasons. Firstly, the clay can adsorb dietary toxins such as quinine (Gilardi et al. 1999, Brightsmith et al. 2008) and, more importantly, the clay is a significant source of sodium (Brightsmith and Munoz-Najar 2004, Powell et al. in press).

Parrot activity around a large claylick on the Tambopata river shows that most parrots feed only for a brief period in the early morning before dispersing into the surrounding forests (Brightsmith 2004). A study of three closely situated claylicks on the Las Piedras river reported similar patterns (Lee 2005). At both these sites, large macaws were observed in the vicinity of the claylick for the remainder of the day. However, numbers of macaws at claylicks along the Tambopata river fluctuate through the year in what appear to be broadly repeatable patterns with a clear high season and low season (Brightsmith 2004, Lee 2008). This pattern has not been demonstrated outside this river system, leaving observers unable to draw conclusions as to whether these patterns were due to local influences or broad-scale migrations or seasonal movements based on food availability or other resource requirements.

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We focus our observations on the red-and-green macaw as this is the most ubiquitous species present at many lowland Amazon claylicks and because macaws as a group are highly threatened and are most vulnerable to anthropomorphic changes to their habitat. The identification of repeatable seasonal trends will allow a degree of population monitoring and may provide information on species recruitment through changes in flock sizes.

Expedition objective

The main objective of the Biosphere Expeditions project conducted from November 2008 to December 2008 was to collect data on the feeding activity of red-and-green macaws at a claylick at the Las Piedras Biodiversity Research Station. This was one of the last significant periods where this claylick had not been monitored. In so doing we can now determine the extent of seasonal changes in feeding activity at this site. We predicted, based on patterns from other claylicks, that feeding would be highest for these months compared to the period May to August.

3.2. Methods

The lowland rainforests of south-eastern Peru are a hotspot for avian geophagy (Lee et al. in review). The area is described in detail in other sections of this report and elsewhere (e.g. Lee 2006, Pitman 2008). Year-round monitoring of bird activity at claylicks has been conducted intensively by the Tambopata Macaw Project, directed by Donald Brightsmith, along the Tambopata river since 2000. Monitoring of the Las Piedras river claylicks using the same protocol was instigated in 2003 by Emma Hume, owner and manager of the Las Piedras Biodiversity Research Station. Most of the intensive monitoring has been conducted by Biosphere Expeditions, with trained volunteer observers under the direction of Emma Hume accounting for periods of observation outside these expeditions on an ad-hoc basis determined mostly by observer availability and logistics. Normally only one of the three claylicks was monitored at a time, being the claylick where macaws were observed to congregate most regularly. During 2005 this was a claylick known as claylick 1, while from 2006 onwards this was claylick 2 (see Lee, 2005, for further descriptions of these claylicks).

Data were also analysed for two macaw claylicks on the Tambopata river, Hermosa and TRC (Figure 3.2a). These were monitored using the same protocol and results are presented for the periods January 2006 to December 2008 (344 days of monitoring) for Hermosa and January 2006 to December 2007 (227 full days monitoring) for TRC. Monitoring was conducted from daybreak (around 5:00) until all the birds had dispersed from the area at around 17:00.

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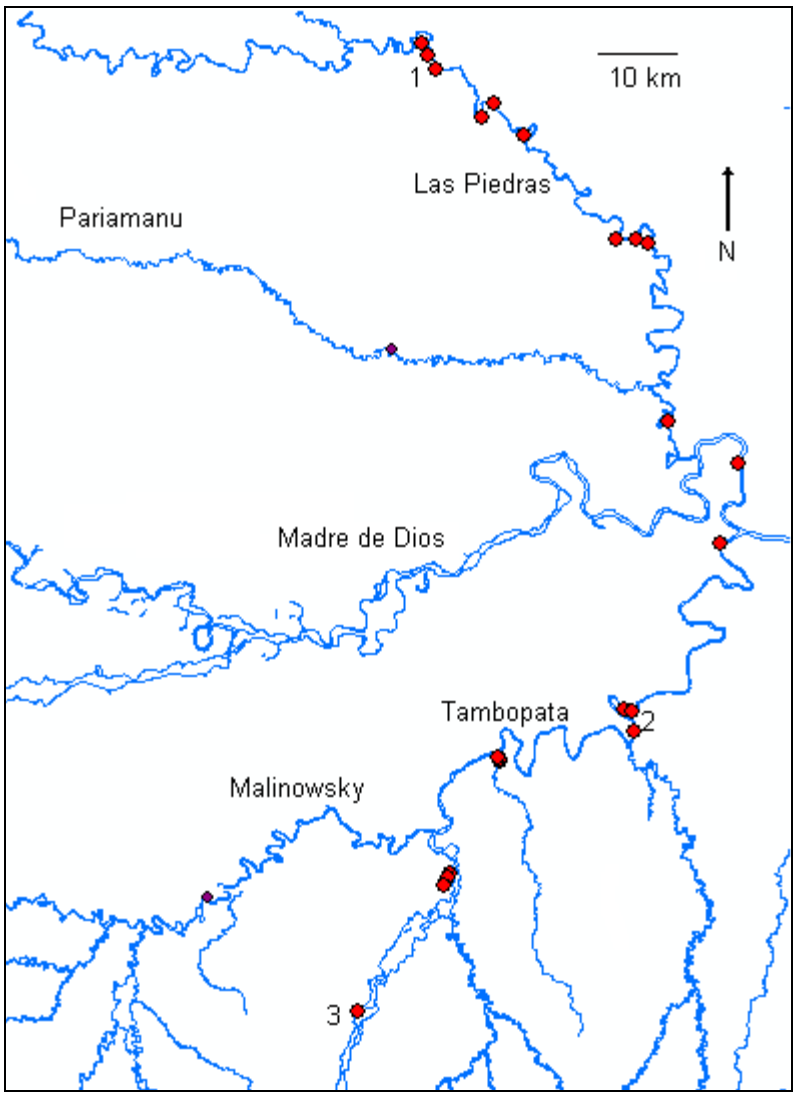

Figure 3.2a. Major river systems of the Madre de Dios department, Peru, with the location of known parrot claylicks and study sites: 1 – Piedras, 2 – Hermosa, 3 - TRC

The monitoring protocol follows that described by Brightsmith (2004), with modifications for flushes, and has generally been used in previous Biosphere Expeditions studies (Lee 2006). A summary of the monitoring protocol is as follows:

1. The first psittacine to be seen or heard in the vicinity of the clay lick was recorded, together with the time. The time that any psittacine was first seen or heard in the vicinity of the clay lick was also recorded, even if it was thought that the species in question would not be feeding on the clay lick.

2. The species and time that birds were observed descending towards the clay lick was recorded as a “fly by”. A “fly by” is defined as the activity of birds as they begin to show an increased interest in the clay lick and begin to fly across the clay lick to check for danger. In many cases birds slowly descend through the vegetation over the clay lick, and if no distinctive “fly by” was observed, the time a species crossed down below half the height of the vegetation above the clay lick was recorded. This was recorded in order to record occasions when species were interested in feeding and was of special importance for days when no feeding was subsequently observed.

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3. The first species to land on the clay lick was recorded, as well as the number of individuals to first land on the clay.

4. The total number of birds for each species on the clay lick was recorded at five minute intervals from when the first bird was recorded on the clay lick.

5. Weather was recorded at five minute intervals from when observers first arrived at the clay lick as “fog” if low lying cloud was observed; as “clear” if there was good visibility and no cloud; as “cloudy” if the weather was overcast or when no sun could be observed falling in the vicinity of the clay lick; “partly cloudy” when cloud cover was between 25-75% and as “rain” if precipitation was recorded in the area of the clay lick.

6. A “max count” was recorded at the end of each day’s feeding bout, representing the maximum number of birds recorded at any one time in the vicinity of the clay lick (in the trees as well as on the clay lick).

7. If birds flew from the trees or the clay lick together in a large group, this was recorded as a flush (also known as an anti-predatory response). Flushes were classified as follows: 0 – no reaction, 1 – increase in alarm calls, 2 – slow dispersal of birds to the vicinity of the clay lick, 3 – minor flush (up to 75% of birds take flight, but remain in the area), 4 – major flush (up to 100% of the birds take flight, but remain in the area), 5 – complete flush (100% of the birds take flight and leave the area completely for a time period of at least ten minutes). Any reason for the flush was noted if known (birds of prey, boats, vultures, mammal or people activity).

8. All boats passing in front of the clay lick were recorded. The following information was recorded for boat traffic: The time the boat passed in front of the clay lick; whether the boat was travelling upstream or downstream; whether the boat was carrying brazil nuts; how many rows of wood were being carried if the boat was pushing a raft of wood; if the boat was driven by a peke-peke motor or an outboard motor; how birds on the clay lick or in the trees above the clay lick reacted to the boat (using the flush categories described above).

Analysis

Due to negative exponential patterns of feeding displayed, non-parametric tests were used throughout. Kruskal-Wallis tests were used to determine differences in daily feeding for each parrot species between claylicks, and Mann-Whitney U-tests were used to compare results further between claylicks. Wilcoxon Signed Ranks Test was used to compare month on month changes in red-and-green macaw feeding between claylicks for each month as a proportion of the maximum observed monthly feeding. Spearman’s correlation was used to compare proportional monthly changes in feeding between claylicks.

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3.3. Results

Expedition summary

The Biosphere Expeditions study conducted 16 days of observation, totalling 130 hours. Feeding was seen on every day. The first species seen were red-and-green macaw (6), mealy parrot (6) and blue-headed parrots (3). Seven species of parrot were recorded on the clay during this period, and one mammal – southern Amazon red squirrel (*Sciurus spadiceus*). By far the most abundant species registered on the clay was red-and-green macaw (1453 mean bird minutes per day), followed by blue-headed parrot (84), dusky-headed parakeet (46) and mealy parrot (39). Largest recorded flock size was also recorded for red-and-green macaw, with an estimated 84 birds in the area of the claylick on one day (Figure 3.3a).

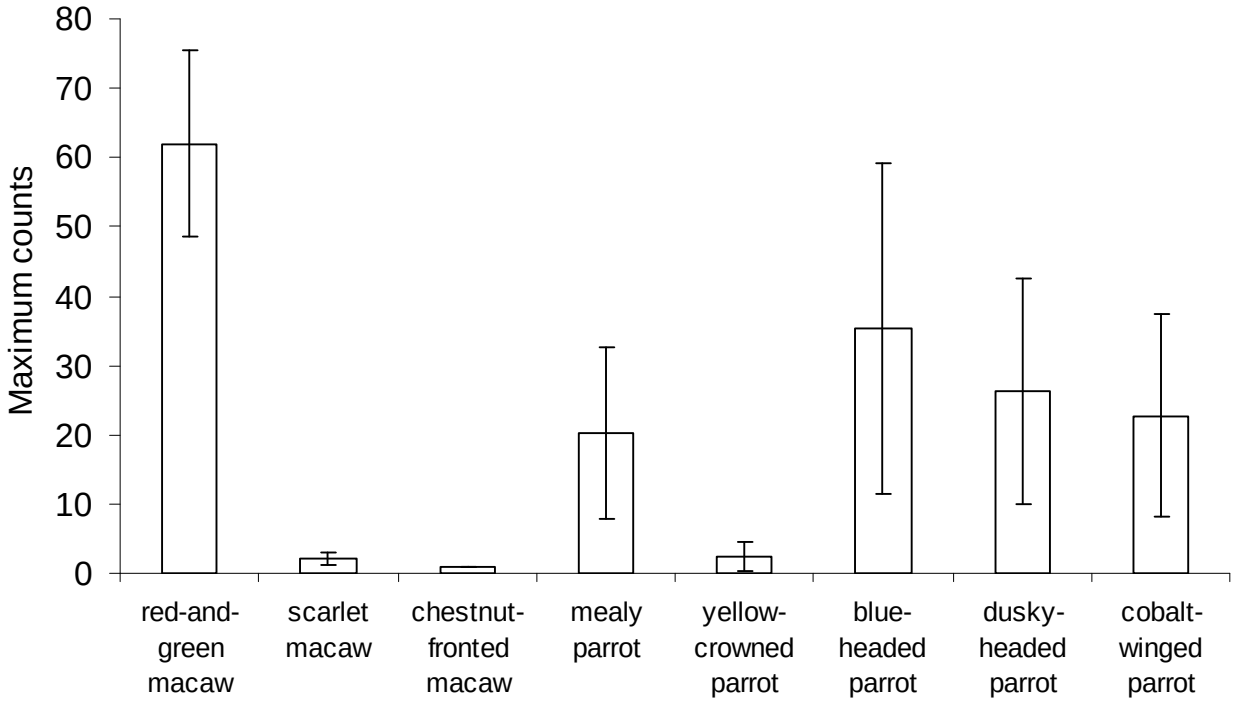

Figure 3.3a. Average maximum counts of the number of key species of parrot in the area of the claylick, for the period 26 November to 19 December 2008.

Disturbance factors for claylick activity

Only 36 boats were observed passing the claylick: 28 (78%) peke-pekes and 8 (22%) outboards, equivalent to 0.27 boats per hour, or one boat every 3 hours. Only 11% passed when no bird were in the area, the remaining boats caused flushes to various degrees: from the trees, outboards flushed birds 50% of the time, while pekes caused flushes 89% of the time. All six pekes that passed the claylick when birds were feeding caused flushes.

There were 200 flushes of varying degrees recorded in the vicinity of the claylick. The reason for the majority (66%) were for unknown reasons. 15% were attributed to raptors, including grey-headed kite, plumbeous kite, roadside hawk, grey hawk, zone-tailed hawk, slate-coloured hawk, crane hawk, double-toothed kite, black caracara, orange-breasted falcon. Vultures (yellow-headed, black and king) were responsible for 8% of flushes.

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Las Piedras claylick activity in comparison to other claylicks of Madre-de-Dios

The amalgamated dataset for Piedras observations consists of 126 days of observation, from May 2005 to December 2008 (Table 3.3a). Due to the low sample size between years and suspected impacts of seasonality, it is not possible to determine changes between years. For the entire period, 10 species were recorded feeding on the claylick. Of these, the red-and-green macaw is most abundant.

Table 3.3a. Number of days of monitoring of the Las Piedras claylicks per month for different years of monitoring.

Month	2005	2006	2007	2008	Total
1		17			**17**
2		16	11		**27**
3			5		**5**
4					**0**
5		2			**2**
6	19	11			**30**
7	7	4			**11**
8		5	6		**11**
9		6			**6**
10		1			**1**
11				4	**4**
12				12	**12**

There is a significant difference in mean monthly feeding between months for the whole period (X2 = 59.16, p<0.001) and for each of the six most commonly observed species at the three claylicks (Table 2.2). There was also a significant difference for most species from claylick to claylick, with the following exceptions: no difference between dusky-headed parakeet between TRC and Hermosa (Z=-048, p=0.63), and between Piedras and Hermosa there was no difference in average daily feeding for scarlet macaws (Z=-2, p=0.1). For all the species a high degree of standard deviation shows there is much variation in daily feeding.

Table 3.3b. Mean daily feeding (bird minutes) for six common parrot species at three claylicks from south-eastern Peru. There is a significant difference between feeding between sites p values from Kruskal-Wallis tests). Figures in *italics & grey* show significantly higher levels of feeding compared to both other sites.

	TRC (n=228 days)		Hermosa (n=344)		Piedras (n=126)			
	Mean	**sd**	**Mean**	**sd**	**Mean**	**sd**	**Chi-Square**	**p**
Blue-headed parrot	*340*	482	107	144	115	287	59.9	<0.001
Dusky-headed parakeet	157	232	214	314	24	64	75.9	<0.001
Mealy parrot	*902*	1383	50	192	38	154	67.4	<0.001
Red-and-green macaw	494	499	241	244	*767*	704	233.0	<0.001
Scarlet macaw	*387*	442	3	10	4	9	472.7	<0.001
Yellow-crowned parrot	*72*	107	59	97	7	27	92.4	<0.001

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For all three claylicks, a low season for red-and-green macaws is observed from March to June (Figure 3.3b below). The relative degree to which the high season is then apparent is different between the three claylicks. Overall, Piedras displays the highest levels of feeding, matched only in January at TRC. There is no difference in feeding between Piedras and either Hermosa or TRC (Z=-0.09, p=0.93 and Z=-1.24, p=0.21) based on proportional month-on-month rankings, but there is between Hermosa and TRC (Z=-2.13, p=0.03). Thus, the season trends are not the same for all sites.

Table 3.3c. Average daily feeding (bird minutes) for red-and-green macaws per month for three claylicks in south-eastern Peru, as a proportion of the month with the highest average feeding. Values are used for pair-wise testing to determine significant seasonal changes.

Month	Hermosa	Piedras	TRC
Jan	1.00	0.85	1.00
Feb	0.62	0.54	0.66
Mar	0.27	0.03	0.33
Apr	0.13		0.15
May	0.11	0.00	0.09
Jun	0.21	0.11	0.04
Jul	0.41	0.59	0.32
Aug	0.51	0.61	0.32
Sep	0.93	0.52	0.41
Oct	0.66	0.84	0.53
Nov	0.76	0.93	0.36
Dec	0.81	1.00	0.41
Max. average feeding per day	**441.4**	**1479.6**	**1193.6**

Red-and-green macaws show different daily patterns of feeding between the claylicks (Figure 3.3b below). Macaws at the Piedras claylick peak at 10:00 and very little feeding in the afternoon. At Hermosa feeding remains constant from 10am onwards, while at TRC the feeding reaches a peak at 14:00.

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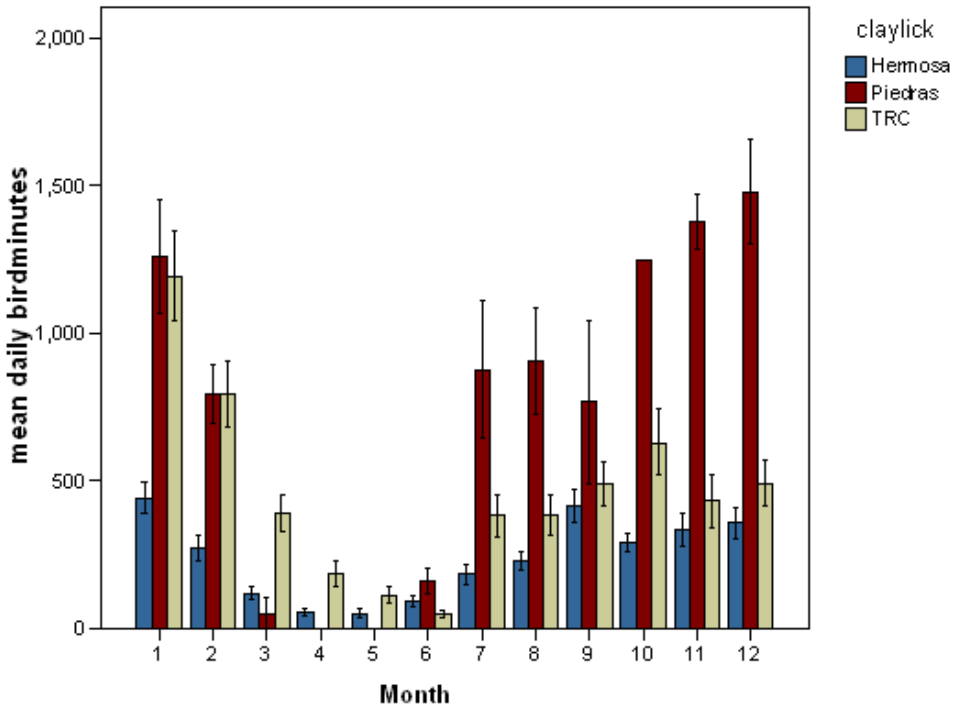

Figure 3.3b. Mean of daily feeding per month for red-and-green macaws from two claylicks on the Tambopata river (Hermosa and TRC) and Piedras, for the period 2006-2008. Error bars represent ±1 standard error (s.e.) There is a significant correlation between average daily red-and-green macaw feeding between Hermosa and Piedras (r=0.727, n=11, p=0.011) and between Hermosa and TRC (r=0.839, n=12, p=0.001) , but not between TRC and Piedras where there is only a trend (r=0.564, n=11, p=0.071), indicating that month-on-month change is not the same.

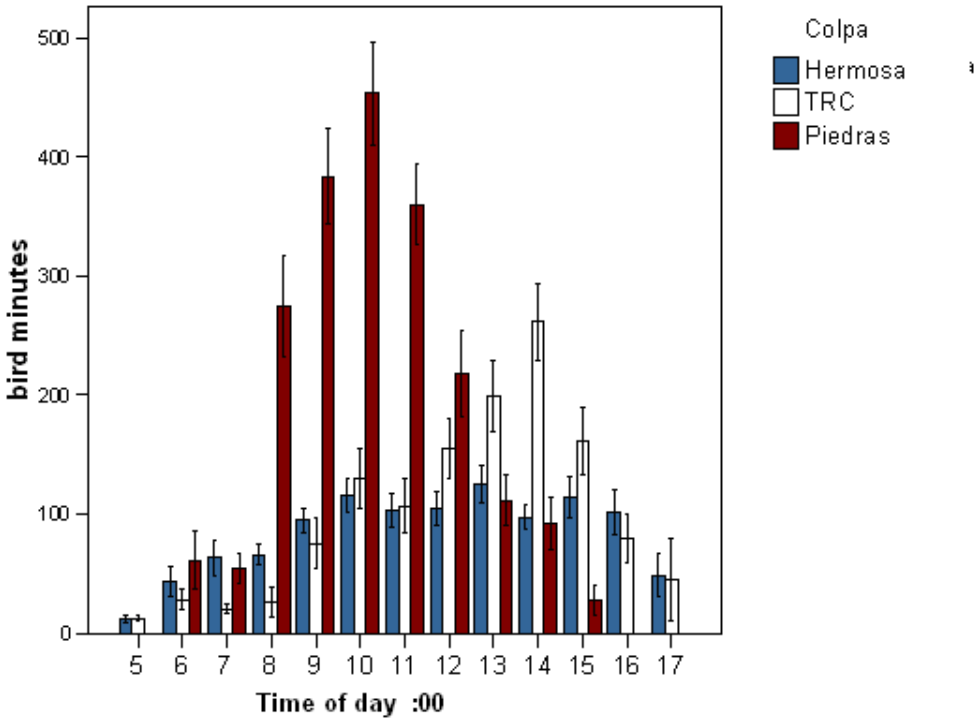

Figure 3.3c. Changes in daily visitation rate (mean bird minutes per hour) from 5:00 to 17:00 for red-and-green macaws at three parrot claylicks – Hermosa, TRC and Piedras, for the period 2006-2008. Bars are the mean of hourly counts. Error bars represent ±1 s.e. There is a significant correlation between mean hourly feeding between Piedras and Hermosa (r=0.762, n=13, p=0.02), but not between TRC and Piedras (r=-0.094, n=13, p=0.760) or TRC and Hermosa (r=0.352, n=13, p=0.239)

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3.4. Discussion

General patterns of claylick use

The Piedras claylicks are important for red-and-green macaws with the most feeding observed compared to the other two claylicks, TRC and Hermosa. TRC, on the other hand, attracts greater numbers of most other parrot species. Hermosa showed the lowest visitation rates, possibly influenced by this claylick's closest proximity to centres of human population. However, even at this claylick the red-and-green macaw was the most predominant species in terms of claylick use. The red-and-green macaw is thus a highly important species for the ecotourism industry as its presence at claylicks enhances the visual experience for tourists. An understanding of its biology and ecology should be fundamental knowledge for the guides of the area.

Daily patterns of claylick use

Patterns of birds arriving and leaving roosts are generally predictable (Cougill and Marsden 2004). However, although small parrots arrive and leave early, the number of red-and-green macaws show different patterns of peak claylick use (which we will consider here to be surrogate for birds in the area). Reasons for this are unclear. Although the impact of high boat traffic volume has been demonstrated to impact patterns of feeding at Hermosa (Lee 2006), both Piedras and TRC are isolated and there is little boat traffic. The impacts of general tourism cannot be ruled out at TRC where guides are known to use a trail system, which meanders through the staging area where macaw like to perch on mid-morning walks, that correspond with what may be a preferred feeding time for macaws (based on patterns of observed feeding at Piedras). Humans are clearly visible to macaws on this trail system due to the broken nature of the vegetation and the presence of humans can cause macaws to utter alarm calls and fly away (AL personal observation). That the peak feeding period occurs during the time interval from when guides and tourists are having lunch (13:00) to when they set out on afternoon walks (15:00) may not be a random coincidence. Whether this is impacting feeding patterns and whether overall feeding is reduced as a consequence will not be clear without an idea of how much each bird needs to feed and better estimates of macaw abundance from each site. With minimal boat traffic and little tourism, it is most likely that the feeding trend for red-and-green macaws at Piedras is typical of an undisturbed landscape.

Seasonal patterns of claylick use

The lack of a stronger correlation in seasonal patterns of feeding was unexpected. A high season and low season for the claylicks is evident, but results presented here point to differences in the details of the seasonal trend. In the case of Piedras, how much this is influenced by the drawing together of datasets from various years of monitoring is unclear. However, there is no difference between trends in seasonal feeding at Piedras and the other two claylicks, with only a difference in the degree of the monthly changes. Hermosa, the claylick with the lowest amount of macaw feeding, differs to TRC (a claylick on the same river system) even though sample effort and sample period are comparable. The degree to which results from Hermosa have been influenced by incomplete capturing of all red-and-green macaw feeding from the surrounding area is complicated by the lack of data from a nearby claylick also known to attract macaws, and which anecdotal evidence leads us to believe feeding has been increasing over the last few years.

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This highlights the difficulties in monitoring a species at a claylick where it is possible that other claylicks in the area may be attracting individuals differentially. To capture seasonal trends, monitoring would either have to be done at both sites, or the site selected based on where the focal species was known to be heading preferentially - something that would be difficult to gauge for small species that feed for a short time only.

We hope we have established a useful baseline of macaw use for these different sites. However, it appears that impacts should be examined on a site-by-site basis as comparisons across sites are difficult. We predict declines in use of claylicks over the coming years as macaws are hunted by human immigrants into the area following the pavement of a major road through the region. In addition, the bird's key nesting trees, *Dipteryx micrantha*, are being heavily harvested from all non-protected areas. This has severe repercussions for the future of the macaws of the Piedras river. The construction of an access road to the river edge from the Interoceanic Highway within 10 km of the claylick complex highlights the urgency of the need to protect not only the birds, but their keystone resources too.

Figure 3.4a. Satellite image (Google) of the Las Piedras river in relation to the Interoceanic Highway. The deforestation already associated with what was a dirt road when the image was taken, can clearly be seen as the white areas marking areas of deforestation in close proximity to the road. This road is paved to within 30 km of the town of Puerto Maldonado at the time of writing.

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Our recommendations for the monitoring of populations at claylicks are

1. Should a claylick be used to monitor trends in changes in local populations, it is critical that all local claylicks are monitored for the target species.

2. Monitoring should be conducted during comparable periods, as seasonality in claylick use is evident

3. Drawing comparisons between macaw populations from differences in feeding patterns is complicated by disturbance factors, such as boats, tourism, birds of prey and other site specific environmental factors.

4. More valuable information about population status and recruitment may come from looking at individual group composition of macaw arriving to the area, specifically the presence or absence of juveniles.

Recommendations for further research

The observations of the Piedras claylick, supported by Biosphere Expeditions, have been fundamental to the broadening of our understanding of claylick patterns, and the confirmation of hypotheses on seasonal visitation rates. However, much has yet to be done. Future monitoring needs to compare macaw numbers over time in relation to the increasing rate of deforestation related to the increased immigration associated with the Interoceanic Highway. Monitoring of increased timber extraction of species such as *Dipteryx micrantha*, which are now easier to extract due to the proximity of access routes, needs to be undertaken by extending the focus of research to beyond the boundaries of the area protected by the concession. Impacts close to the concession will impact on wildlife populations of the concession since there are no physical boundaries to prevent movement out of the protected areas. The research conducted so far provides a baseline from which the clear and present danger of human encroachment and associated impacts can be measured, and this report serves to make this information available to the Peruvian Ministry of the Environment, and other conservation bodies, better positioned to help mitigate these impacts.

3.5 Acknowledgements

In addition to the Biosphere Expeditions participants already listed in this report, we would like to thank the many assistants who contributed to the collection of data through volunteering at the Las Piedras Biodiversity Research Station and the Tambopata Macaw Project. This report would not have been possible without you. Alan Lee would also like to thank Anja Kirchdoerfer for putting up with long periods of his absence while conducting fieldwork.

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4. The effects of past hunting and claylicks on animal encounter rates at Las Piedras Biodiversity Station, Peru

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4.1. Introduction

Game species inhabiting Neotropical forests are important ecologically as well as economically. Wild game is an important food source for subsistence hunters living in rural areas (Robinson and Bodmer 1999). Hunting is one of the greatest threats to protected areas in the Neotropics because it is the most geographically widespread form of resource extraction and can affect large and inaccessible areas (Peres and Terborgh 1995). Redford (1992) reviewed available data for game species and found that non-primate mammalian densities were 80–94% lower in hunted areas than similar, non-hunted areas.

Subsistence hunters exhibit a preference for large game species including deer, peccary and tapir because they are the most efficiently hunted prey items; meaning that they provide the highest caloric return per unit of time spent in pursuit and handling (Alvard 1993). This preference presents a problem because large-bodied animals also tend to have longer lifespans and lower reproductive rates (Robinson and Redford 1986). This makes them more sensitive to hunting pressures, and especially vulnerable to local depletion or extinction (Peres 2000).

In addition to meeting subsistence needs, hunting is also a major source of income for rural communities. In the entire Amazon Basin, the value of wild meat harvested exceeds $175 million annually (Bennett and Robinson 2000). Bodmer and Puertas (2000) reported that 1,278 animals equalling 22 tons of wild meat were harvested annually in a 500 km^2 community reserve in north-eastern Peru. Of that, 14% was consumed and the remaining 86% was sold locally for more than $17,000 per year.

Game animals also play several important ecological roles including seed dispersal, seed predation, and herbivory (Redford 1992). The loss of these species results in gradual yet profound shifts in the character of the plant community and a major loss of biodiversity. Dirzo and Miranda (1990) compared a Mexican tropical forest containing peccary, deer, and tapir with one in which these species had been exterminated by hunting. In the hunted forest, seedling densities were twice as high and understory plant diversity was less than one third of that found in the non-hunted forest. Stoner et al. (2007) reported that in hunted areas, plants whose seeds are dispersed by game animals exhibited decreased abundance compared to non-hunted areas. Seed-eating mammals were excluded from newly-formed islands in an artificial lake in Panama and trees with large seeds, no longer controlled by predation, dominated forest patches in fewer than 75 years (Leigh et al. 1993).

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Red brocket deer, collared peccary, white-lipped peccary, and lowland tapir are important prey items for jaguar and puma (Weckel et al. 2006). Population declines in these predators may result from depletion of prey species. Hunting of large ungulates in Indian tropical forests has caused declines in densities of tigers that prey on them. Additionally, depletion of preferred prey can cause large predators to shift to smaller, less preferred prey items, which causes further detrimental impacts on the greater biological community (Karanth and Nichols 1998).

Hunting can affect species in different ways depending on differences in their natural history and habitat. Peres (2000) found that hunting caused a decline in the population density of large-bodied mammals in the Brazilian Amazon. He attributed this to their lower reproductive rates and longer lifespans, which makes them more susceptible to hunting pressure than smaller game. Bodmer (1995) found that both game choice by hunters and species sensitivity to hunting is highly correlated with their population growth rate. Reyna-Hurtado and Tanner (2007) compared the relative abundance of large ungulates in hunted and non-hunted tropical forests in Mexico. They found that white-lipped peccary abundance declined in hunted areas and they suggest that this may be due to their increased sensitivity to habitat fragmentation due to their use of large home ranges. Collared peccary and brocket deer appeared to be less affected and the authors speculate that they are more resistant to hunting pressure due to their tolerance of fragmented habitat of hunted areas as well as possible source-sink dynamics between hunted and non-hunted areas.

If hunted areas are surrounded by or are adjacent to areas with abundant game populations or similar, undisturbed habitat, game species can potentially disperse into and replenish these areas. The distance between hunted and non-hunted (potential source) areas is a key element in determining the role of dispersal. Size, spatial arrangement, and connectivity of habitat patches will influence game populations (Novaro et al. 2000). Forest fragmentation can decrease or eliminate dispersal from non-hunted source populations (Peres 2001).

Proximity to human communities and accessibility by hunters could also affect game populations. Alvard et al. (1997) noted that the majority of hunting trips by indigenous hunters were single day events on foot along trails that radiated from the village, which limited the range of hunting to distances that could be travelled round-trip in about 12 hours. Based on this, he estimated the hunted area around the village to have a radius of 10 km, and data on the location of kills indicated that 87% of game harvest was from within this radius. In an indigenous reserve in Paraguay, Hill et al. (1997) found that hunting pressure was highest, and game animal encounters were lowest, within six km of hunter access points. Forest fragmentation can increase hunter access to previously remote areas and intensify hunting pressure on game species (Peres 2001). Therefore, distance between protected areas, hunted areas, and human communities could also greatly affect the occupancy of these species.

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Another important factor that can affect wildlife populations in the Amazon is the presence of claylicks. A claylick is an area of soil or stone that has been exposed by erosion where animals come to lick or consume soil. These soils usually have high clay content as well has higher concentrations of several minerals, principally sodium, but also calcium, magnesium, and phosphorus (Montenegro 2004). There are two main hypotheses to explain why animals consume soil. Claylicks probably compensate for mineral deficiencies or imbalances in the animals' diets. They can also reduce the effects of secondary plant compounds, acidosis, and intestinal infections. Therefore, it is possible that the benefits of soil consumption can influence population density and structure and increase the carrying capacity of areas with claylicks (Klaus and Schmid 1998).

Previous research has addressed some of the effects of hunting on large game (Alvard et al. 1997, Hill et al. 1997, Bodmer and Puertas 2000, Peres 2000, Reyna-Hurtado and Tanner 2007). However, none have examined the synergistic effects of habitat and anthropogenic factors, in addition to hunting, that can affect game populations. Several studies have quantified the effects of hunting by comparing species relative abundance or density between hunted and non-hunted areas (Peres 2000, Reyna-Hurtado and Tanner 2007). None of these studies examined differences in habitat or human activities other than hunting that could have affected game species.

With all this in mind, the objectives of this study were to (1) survey mammals and large-bodied birds in Las Piedras Biodiversity Station, Madre de Dios, Peru, (2) compare encounter rates of large mammals with distance to a claylick, (3) compare four methods for detecting large mammals (camera traps, track traps, line transects and direct observation) and (4) monitor visitation rates at two mammal claylicks.

Study area

Thee study area is located within Las Piedras Biodiversity Station (LPBS), which is a 6,000 ha privately-owned Brazil nut and ecotourism concession on the Las Piedras River in Madre de Dios, Peru. The region is considered lowland tropical rainforest and receives between 1600–2400 mm of rain annually (INRENA 2003). LPBS consists of continuous canopy primary forest interspersed with "aguajales" which are important resource patches dominated by Aguaje palm (*Mauritia flexuosa*). The land that is now LPBS was selectively-logged between 1994 and 1999, but has been protected from logging and hunting activities since 2002 when the concession was granted (Tatum-Hume 2006).

LPBS is located between Tambopata National Reserve and Manu National Park in south-eastern Peru. This area is considered a biodiversity "hotspot" due to its record numbers of species including several which are endemic or endangered. The area is inhabited by 103 amphibian, 103 reptile, 130 fish, 632 bird, and 169 mammal species (INRENA 2003). More importantly, LPBS lies within a 30 million ha conservation corridor which stretches across Peru and Bolivia and contains 16 protected areas.

Study sites consisted of three line transects that radiated out from LPBS. Two transects of four km each run through terra firma forest at an altitude of approximately 240 m. The third transect measured two km and runs through floodplain forest at approximately 150 m.

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4.2. Methods

We used four different methods for detecting animals along the transects. We walked a total of 98 km of transects, 84 km in terra firma forest and 14 km in floodplain forest. All transects were walked by an experienced biologist or local guide, followed by one or two other observers walking at a pace of about one km/h. First, we walked each transect and recorded all large mammals that were seen on or near the transect (observation). We also recorded any track that crossed the transect (track). If a track followed the transect itself, we only recorded the first encounter. In the middle of each transect (at the 500 m marker) we made track traps (trap). A track trap is an area of the forest floor that has been cleared of debris and had the soil loosened in order to record animal tracks by leaving clearly visible imprints in the soil. Tracks are more easily visible in this manner than on a trail covered with vegetation and debris. The track traps were made in the middle of the trail and had a radius of approximately one meter. Each time the transect was walked, tracks in the track trap were recorded and the track trap was "erased" and any debris was removed.

The final method we used for detecting large mammals was the use of camera traps. A camera trap is a remotely-triggered camera that is set to monitor a specific area (in this case a section of trail) and take a photograph when an animal passes. We used 11 Cuddeback C3000 digital cameras (www.cuddeback.com) to conduct camera surveys for seven to 15 days. Cameras traps were subjectively placed in an area of the transect with the highest potential for animal encounters such as a mud bath, stream crossing, or the transect itself.

We monitored two mammal claylicks or "colpas" within LPBS, which we named the mammal colpa and the lost colpa. The mammal colpa was monitored continuously with a camera trap for 24 trap nights. In addition, it was monitored by human observers for two separate 24 hr periods. The human observers monitored the colpa from a raised hide, from which they scanned the colpa every five minutes. The lost colpa was monitored continuously with a camera trap for 19 trap nights.

4.3. Results

We calculated the number of individuals and number of groups of monkeys encountered per km of transect walked. In previous years of this study, transects existed only in terra firma forest, therefore we compared encounters of monkeys only in terra firma forest; 84 km in total. No clear patterns exist in the encounters of monkeys. The number of groups or individuals encountered increased or decreased depending on species, however, this change was not significantly different among the five years of monitoring, except for spider monkeys.

We compared encounter rates of the large mammals with distance to the mammal colpa. Each transect was divided into one km sections and all encounters within each section were grouped. Distance from the mid-point of each transect was measured to the mammal colpa and applied to all encounters within each section. Encounters for each species were ranked for each of the four methods used. The number of encounters of each species were placed in one of five categories for each method, one being the least number of encounters, five being the most.

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The rank for each method was summed for an overall encounter rate for each species, which was compared to the distance of each section of the transect. We conducted this analysis for the white-lipped peccary, collared peccary, red brocket deer, grey brocket deer, tapir, jaguar and puma. We also had a category for unknown cat species. These were scrapes or scats of a big cat that were impossible to identify to species level in the field.

We compared encounter rates of ungulates and large cats with distance to a mammal colpa (Figure 4.3b). We found an inverse relationship between encounter rate and distance to the mammal colpa for white-lipped peccaries (r^2=0.42), and a weak relationship for red brocket deer (r^2=0.19), grey brocket deer (r^2=0.04), lowland tapir (r^2=0.12), jaguar (r^2=0.05), and unkown cat species (r^2=0.02) . There was a weak positive relationship between encounter rate and distance to the colpa for collared peccary (r^2=0.22) and puma (r^2=0.01).

We compared the effectiveness of the four methods we used for detecting large mammals (Figure 4.3c). We compared the number of species and the number of observations made per species for observations, transects, track traps, and camera traps. We detected four, six, seven, and six species, respectivley. The number of detections was comparable for each method except for tracks along the transects.

The camera trap detected southern Amazon red squirrel (*Sciurus spadiceus*), red howler monkey (*Alouatta seniculus*), and white-bellied spider monkey (*Ateles belzebuth*) in the mammal colpa. The human observers detected southern Amazon red squirrel, green acouchy (*Myoprocta pratti*), Spix's guan (*Penelope jacquacu*), and unidentified species of rat and bat. The camera trap in the lost colpa detected red brocket deer, white-lipped peccaries, and a giant anteater (*Myrmecophaga tridactyla*). It is likely that the giant anteater was only passing through and not using the claylick.

Finally, we added one more year to the inventory of mammals and large-bodied birds at LPBS (Appendix 1).

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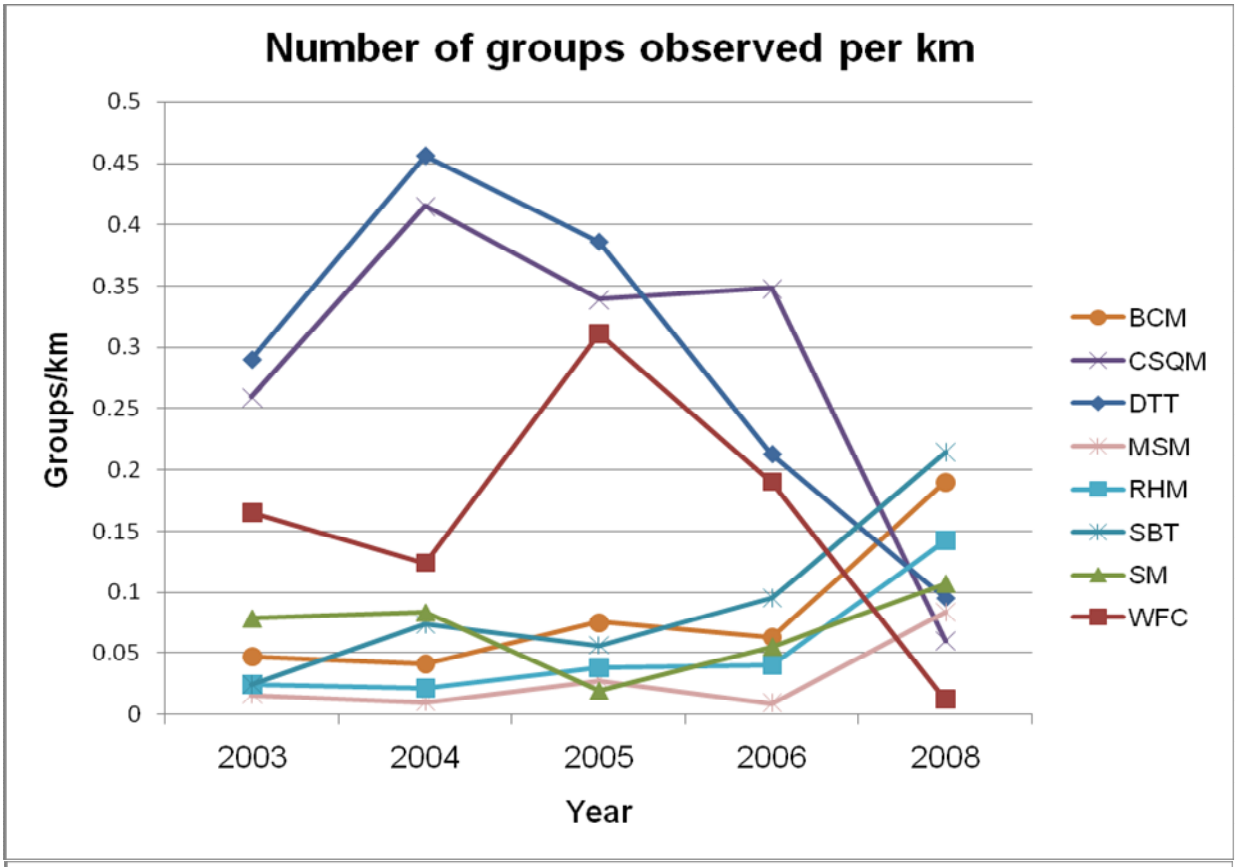

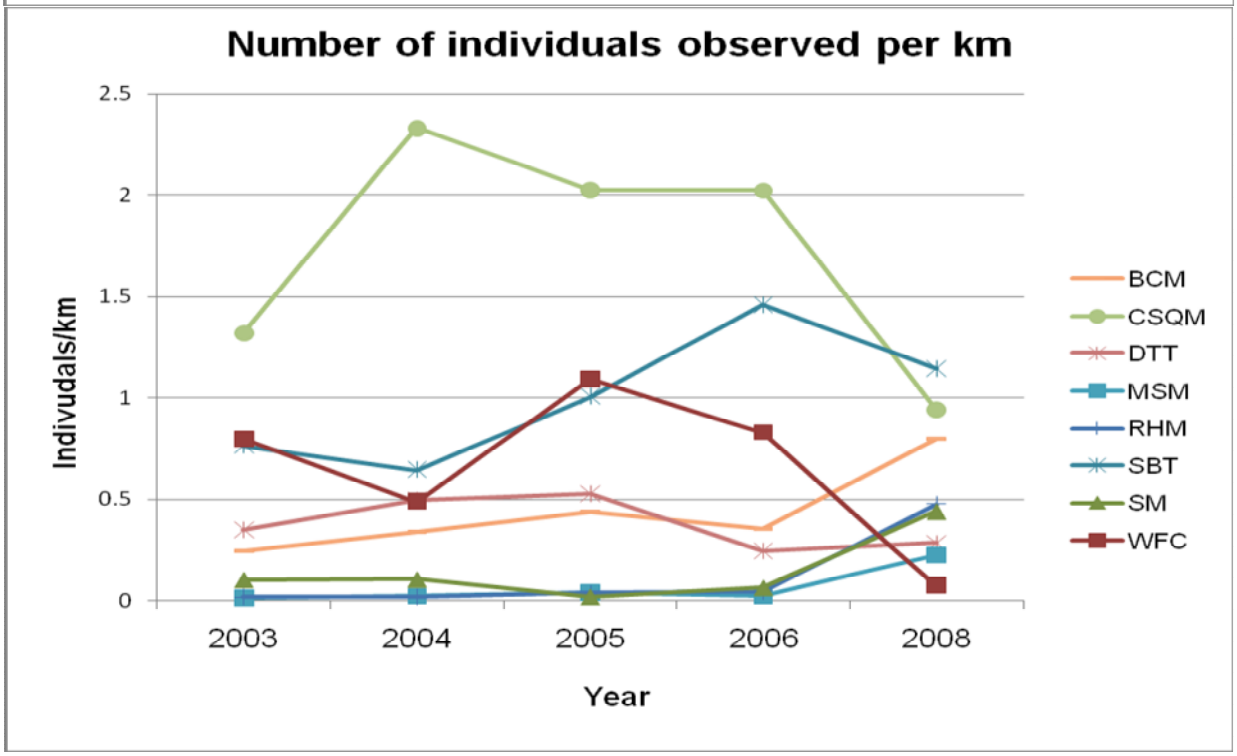

Figure 4.3a. Encounters of individuals and groups of monkeys among five years of surveys.

Key: BCM brown capuchin monkey (*Cebus apella*), CSQM common squirrel monkey (*Saimiri sciureus boliviensis*), DTT dusky ti-ti (*Callicebus moloch brunneus*), MSM monk saki monkey (*Pithecia monachus*), RHM red howler monkey (*Alouatta seniculus*), SBT saddleback tamarin (*Saguinus fuscicollis*), SM spider monkey (*Ateles belzebuth chamek*), WFC white-fronted capuchin (*Cebus albifrons*).

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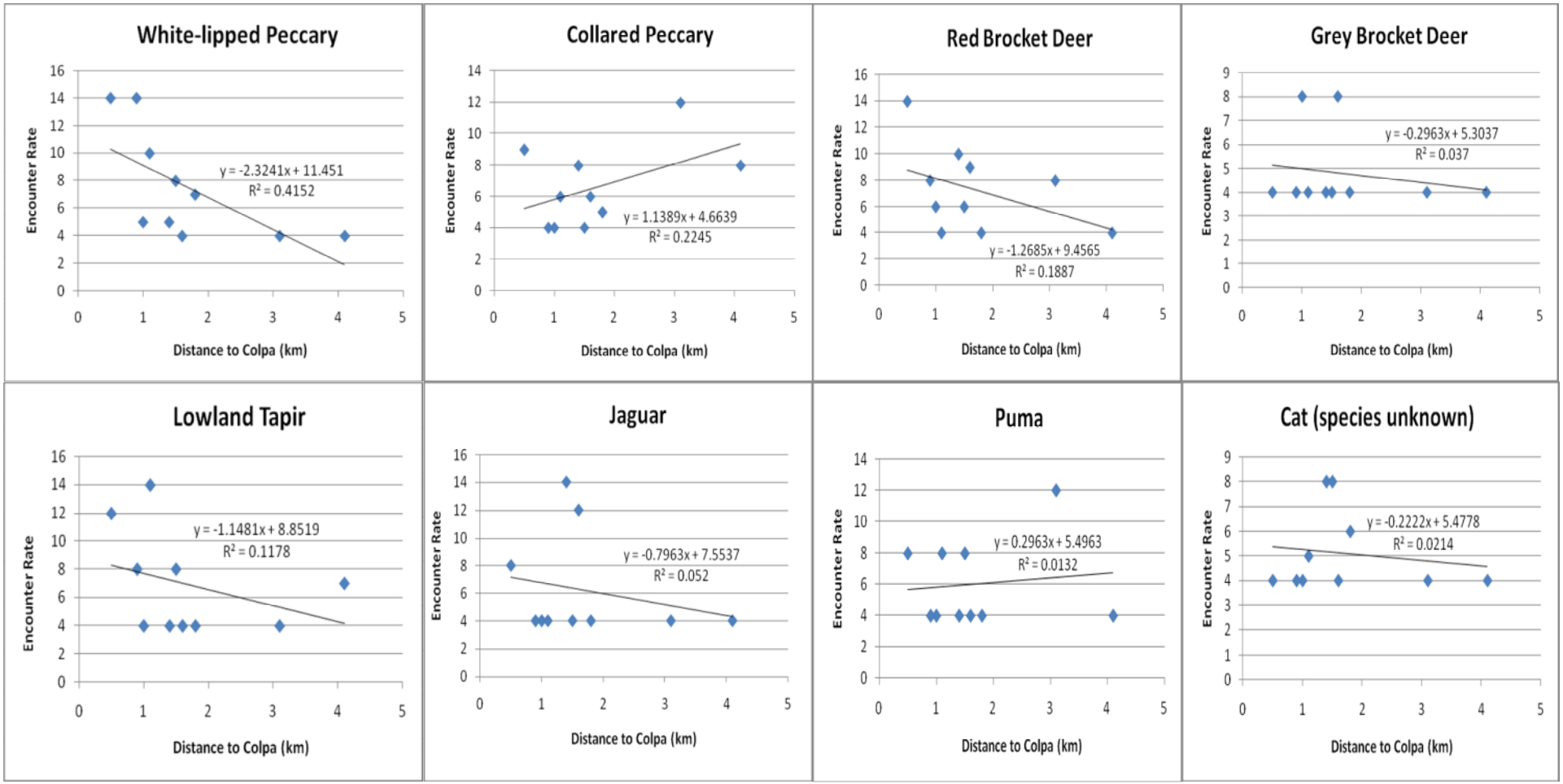

Figure 4.3b. Comparison of ranked encounter rates of large mammals with distance to the mammal colpa using 98 km of transects, 10 track traps and 128 camera trap nights.

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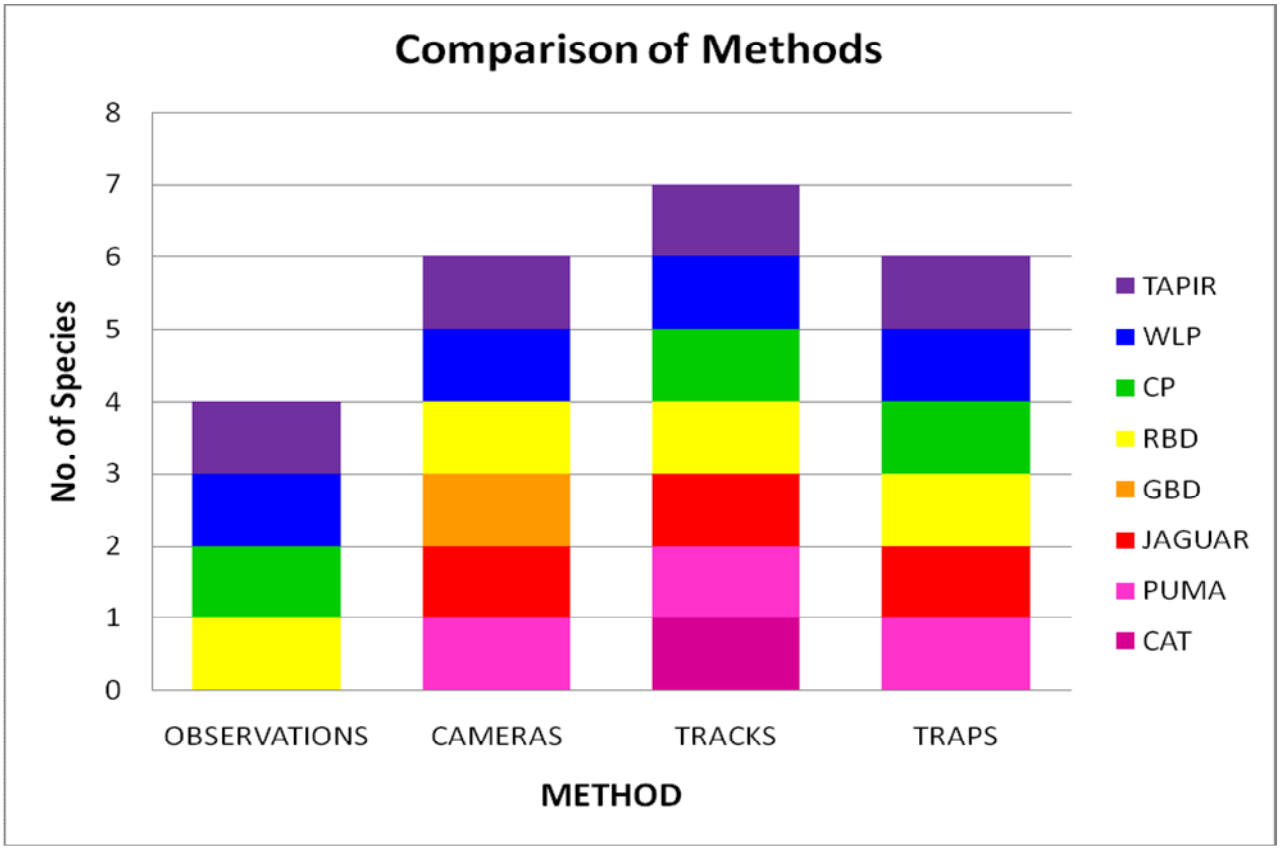

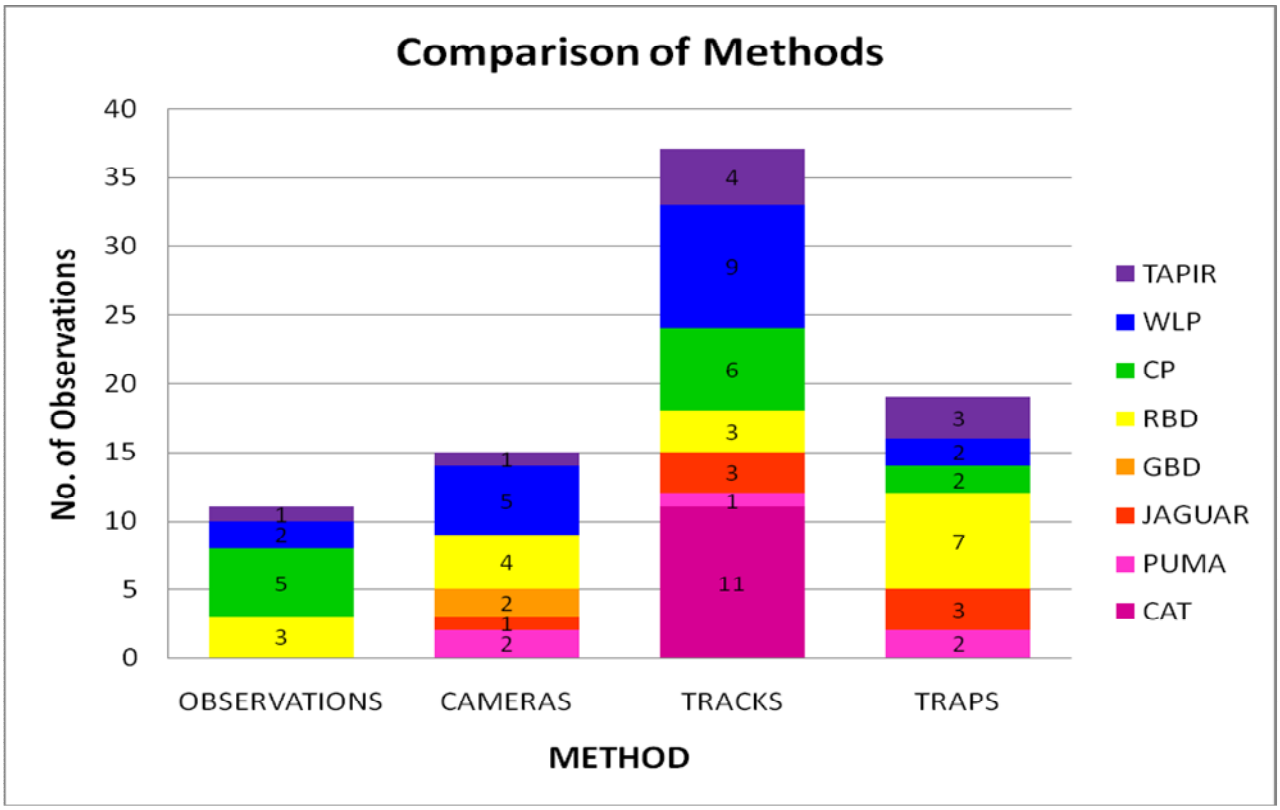

Figure 4.3c. Comparison of large mammal species detection using 98 km of transects, 10 track traps and 128 camera trap nights.

Key: WLP white-lipped peccary, CP collared peccary, RBD red brocket deer, GBD grey brocket deer, CAT unidentified cat species.

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4.4. Discussion

No clear patterns exist in the fluctuations of encounters of groups or individuals of monkeys across five years of surveys. The only exception is spider monkey encounters, which have increased slightly since the beginning of surveying in 2003. Therefore, it is difficult to draw conclusions on the effects of cessation of hunting activities on other species of monkeys. Furthermore, it is not clear if these fluctuations are due to species' recovery from hunting, or other factors, including environmental fluctuations and observer experience. It is possible that spider monkey populations are experiencing a recovery from hunting and logging activity. Future years of study will help to clarify if differences in encounter rates of all monkeys are experiencing small fluctuations or had an initial increase and subsequent plateau.

The inverse relationships we found between encounter rate and distance to the colpa for white-lipped peccary, red brocket deer, grey brocket deer, tapir, and jaguar support the idea that claylicks are an important resource for herbivorous mammals and perhaps their predators as well. It is still unclear if animal densities are higher near the claylick, or if the animals are simply using the area more than areas without claylicks. Either explanation still lends support to the importance of the claylick to animal populations. More data should be gathered to elucidate this relationship further.

However, we found a higher encounter rate for collared peccary and puma further from the claylick. This is probably because these animals were encountered more in floodplain forest in an area away from the claylick. It is also possible that collared peccaries were using this type of habitat more and that the puma was following one of its preferred prey items.

The results highlight the difficulty of detecting large mammals through direct observation. Searching for tracks along trails and in track traps is a low budget method, but takes skill and experience to identify species properly. Camera traps provide a sure way to identify species (see Appendix 1 & 2), and even individuals, but requires a large investment of equipment. Tracking animals appears to provide the highest number of detections. However, this category was dominated by white-lipped peccary and unidentified cat species. White-lipped peccary tracks are often ubiquitous in the rainforest, and can give a skewed impression of animal numbers. The unidentified cat tracks were mostly scrapes that were unusually common and concentrated along the transects.

It is clear that claylicks are important resources for many rainforest species and special conservation considerations should be made to protect them. Colpas are important areas for several species in LPBS and throughout the area of Madre de Dios. Further study using either human observers or camera traps would help identify all of the species that visit these areas and allow us to create an index of visitation. This would help give a more complete picture of the influence of claylicks on animal populations.

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The information gained from this study will facilitate the identification of habitat characteristics, such as claylicks, in addition to hunting, that affect large mammals. The results of this study will enable managers to identify the characteristics of areas that support populations of large game. These data will also facilitate the identification of specific habitat characteristics such as availability of clay licks and vegetation type that may influence these species. Finally, the comparison of four different methods will provide wildlife managers with more information about the tools available to monitor animal populations.

In addition, the data collected in this study will be used as part of a larger research project examining the effects of different management plans, human disturbance, and habitat characteristics on the occupancy of large mammals in Madre de Dios, Peru. The information derived from this expedition will be used to test a model of large mammal occupancy created over a 10-month period in Bahuaja-Sonene National Park, Tambopata National Reserve, the native community of Infierno, and the buffer zone around these areas. This larger study aims to test the ability of different types of protected areas on the occupancy of large mammals, including ungulates and big cats. It will also identify specific anthropogenic and habitat characteristics that affect these species, such as spatial relationships of protected areas and distribution of claylicks.

The area around LPBS is currently threatened by the scheduled connection of the Inteoceanic highway from Brazil to Lima, which will bisect this section of the conservation corridor. This development will increase human population densities, access to remote areas, habitat fragmentation, and hunting in the region. It is critical to understand the effects that such land use practices will have on wildlife, and how careful selection of protected areas can best offset these effects.

Areas in south-eastern Peru that are currently designated with some level of protection status should be monitored to control activities such as illegal hunting and logging. Decisions regarding future federal or privately-owned protected areas should pay special attention to important wildlife resources such as claylicks. Emphasis should also be placed on protecting areas that connect or are adjacent to other conservation areas. Research and conservation efforts should encourage sustainable development and conservation of biodiversity in this unique ecosystem.

In order to draw more credible conclusions about the effects of hunting and claylicks on mammals, a more studies should be conducted at LPBS. With the continued help of Biosphere Expeditions and drawing on other resources and organisations, study effort should be increased and sampling should take place in both the wet and dry season. In addition, the area should be thoroughly surveyed for mammal claylicks, and these areas should be monitored to document visitation frequency.

4.5. Acknowledgements

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Appendix 1: Table of mammals and large-bodied birds detected using direct observations, transects, track traps and camera traps.

Common name	Latin binomial	Direct observ.	Transects tracks	Track traps	Camera traps
Mammals					
Brown agouti	*Dasyprocta variegata*	x	x	x	x
Green acouchy	*Myoprocta agouchy*	x			
Paca	*Agouti paca*	x	x	x	x
Southern Amazon red squirrel*	*Sciurus spadiceus*	x			x
Spiny rat	*Proechimys* spp.	x			
Mouse opossum sp.*	*Marmosa* spp.	x			
Common opossum	*Didelphis marsupialis*	x	x		
Saddle-back tamarin*	*Saguinus fuscicollis*	x			
Dusky titi monkey*	*Callicebus moloch*	x			
Night monkey*	*Aotus nigriceps*	x			
Squirrel monkey*	*Saimiri sciureus*	x			
Brown capuchin monkey*	*Cebus apella*	x			
White capuchin monkey*	*Cebus albifrons*	x			
White-bellied spider monkey*	*Ateles belzebuth*	x			
Red howler monkey*	*Alouatta seniculus*	x			
Saki monkey*	*Pithecia (monachus)*	x			
Kinkajou *	*Potos flavus*	x			
Olingo*	*Bassaricyon gabbii*	x			
Southern tamandua*	*Tamandua tetradactyla*	x			
Giant anteater	*Myrmecophaga tridactyla*				x
Armadillo sp.	*Dasypus*		x		
Nine-banded armadillo	*Dasypus novemcinctus*		x		
Giant armadillo	*Priodontes maximus*		x		
Red brocket deer	*Mazama Americana*	x	x	x	x
Grey brocket deer	*Mazama gouazoubira*				x
Collared peccary	*Pecari tajacu*	x	x	x	
White-lipped peccary	*Tayassu pecari*	x	x		x
Tapir	*Tapirus terrestris*	x	x	x	x
Ocelot	*Leopardus pardalis*	x	x	x	
Jaguar	*Panthera onca*		x	x	x
Puma	*Puma concolor*		x	x	x
Jaguarundi	*Puma yagouaroundi*			x	
Birds					
Spix's guan*	*Penelope jacquacu*	x		x	x
Common piping guan*	*Pipile pipile*	x			
Speckled chachalaca*	*Ortalis guttata*	x			
Razor-billed currasow	*Mitu tuberose*	x		x	
Pale-winged trumpeter	*Psophia leucoptera*	x	x	x	x

*arboreal species

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Appendix 2: Camera trap photographs.

Grey brocket deer

Red brocket deer

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Paca

Brown agouti

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Pale-winged trumpeter

Spix's guan

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Giant anteater

Lowland tapir

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Southern Amazon red squirrel

White-lipped peccary

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Jaguar

Puma

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Appendix 3: Expedition leader diary by Andy Stronach.

11 November

Hi there, this is Andy Stronach, leader of Biosphere Expeditions Peru 'Icons of the Amazon' expedition.

I arrived in Puerto Maldonado today, after having spent a fair bit of time preparing during the last two months. Administrative business had I suppose, taken a bit of the shine off the anticipation of coming here. However, when I got out of the airport, all those necessary evils were blown away behind me as the wonderful reality of this most special of places hit me right between the eyes with its beautiful lush vegetation; right between the ears with the sounds of forest birds and cicadas, on my skin with the strong heat of the tropical sun, whilst the knockout blow was square on my nose with the wonderfully rich earthy aroma of the forest. This could only be a very, very special place. Somewhere, a switch was flicked and having arrived in the Amazon, I felt I had come home, wow!

I staggered into my hotel (WASAI) under an unfeasibly large load of telescopes, binoculars, GPS, tripods and cabbage coloured clothing, already, I'm glad I got a decent pair of jungle boots! Tanagers, scarlet cardinals and parrots flew around the trees of the gardens; Mila, the receptionist, says there are sloths in the trees as well as night monkeys; I'm beginning to wonder why we need to leave this place for Piedras at all ☺

In the afternoon, I met Emma Hume who owns the Piedras Biodiversity Research Station where we will be based and we went out shopping for medical supplies, batteries (Duracell available), stationary and most importantly, mango refrescos. Yes, mangos, the emperor of all fruits are in season and I for one will be exploiting this fortunate fact as much as possible – yum.

Tomorrow, I'll be looking for a boat going up the Tambopata river so I can meet Alan Lee our expedition scientist and his assistant Miguel. I'll stay with them for a week or so, so the next diary entry will probably be then.

I hope all you team members are fired up for the expedition - it's fantastic here and I'm looking forward very much to meeting and working with you all.

Andy

P.S. If you have not yet packed your silica gel or crystals to keep your electronic equipment dry, please pack some and then some more for expedition use.

13-15 November: Posada Amazonas

I took a boat up the Tambopata river a couple of hours to Posada Amazonas Lodge, where our expedition assistant scientist is currently based. Miguele is studying rainforest mammals and how factors such as proximity to humans and whether an area has a protected status or not, affects the likelihood of these animals being present. As well as looking for animal tracks on trails, a bit of a passion of mine, Miguele also uses camera traps to survey the animals present. At a presentation he gave at the lodge, Miguele showed a small (!) selection of the pictures he has already succeeded in capturing. These include expected animals such as collared peccaries, white-lipped peccaries, tapir, red brocket deer, armadillo; rare animals such as grey brocket deer and ocelot and totally unexpected animals such as racoon dog. It will be fantastic to have Miguele with his great experience and knowledge on the expedition and the results of his studies should help in determining the effectiveness or otherwise of declaring protected areas, or whether, simply the proximity, or rather lack of proximity, of humans, is the more important factor in effectively protecting mammals. Las Piedras is supposed to be very rich in mammals and I can't wait to see what there is there :-)

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16-19 November: Tambopata Research Centre

I went another five hours upriver to the Tambopata Research Centre (TRC); whilst there were occasional signs of human habitation before Posada Amazonas, there was far less on the way to TRC. Both lodges are owned by Rainforest Expeditions who, as well as catering for tourists, support conservation research by providing facilities for researchers at reduced or no cost. Posada Amazonas is more a tourist destination, but TRC is more heavily a research centre. Most of the research carried out at TRC is to do with macaws and parrots; and with good reason, there are lots and lots of these fantastically beautiful and charismatic birds everywhere! I had come here to meet our expedition scientist, Alan Lee, and see what he was up to. The main studies being carried out at TRC relate to breeding biology, clay lick use and artificial nest boxes, and I was extremely privileged to be directly involved in all of these during my brief stay here. This has given me a rare insight into macaws and parrots; that will be very useful for our particular studies on the expedition.

Macaws and parrots eat clay, probably to obtain salt and to assist in the removal of toxins from their food. The biggest and most spectacular known clay lick in the world, the Colpa Colorado, is here, near to TRC. Around 16 different species of macaws and parrots visit the colpa early in the morning to eat clay (and potentially to socialise) and the whole thing is a spectacular confusion of all the colours of the rainbow and a raucous, rowdy assault on the ears at what is a rather ungodly hour of the morning; I've never seen anything like it – wow!

What macaws and parrots eat is not at all well known and is obviously a very important factor in their effective conservation, so this is being studied at TRC too. I went on a few 'foraging transects' looking for birds eating; when found, samples of the plant were taken for identification. It was amazing watching the experts sneaking around quietly and finding birds that most people would walk past unaware.

The macaws started laying eggs on the first of November and nest monitoring is now in full swing. Along with researchers, I checked nests, both by remotely viewing them with a camera installed in the nest and also by climbing up into the wonderful forest canopy and visually checking. I was advised to wear a bee proof suit to do this; I have to say I wasn't too keen as it was very hot, but when I got to the nest and was covered with bees, that suit instantly became my very best friend in the whole wide world :)

I'm really looking forward to getting stuck into our bit of macaw/parrot research at Piedras; certainly no climbing into the canopy, checking nests or the like, but hopefully some great encounters at our colpa and some useful scientific information that can help contribute to macaw and parrot conservation.

20 November: Tambopata Research Centre to Puerto Maldonado

I took a boat all the way back to Puerto Maldonado today, watching trees and animals go by. On the way up I'd seen an osprey with a fish, on the way down, it was a great black hawk, carrying what looked like a fresh water stingray. There were flocks of black skimmers, a family of capybara and even a basking turtle with a great big bright orange butterfly perched on its snout – wonderful.

21 November: Slow boat from Puerto Maldonado up the Piedras river.

Took a 20 min ride in a taxi to Puerto Arturo where Gloria, Melissa, Miguel and myself met Chino, our boat driver who was waiting for us in his peke-peke boat which, I was delighted to see, was loaded to the gunnels with all sorts of lovely looking food. After crossing the Madre de Dios river, we entered the Piedras River and for me, we had really started the expedition ;-) Our peke-peke boat was far slower than the outboard powered boats I had been in previously and as such was far superior in terms of being able to spot and watch wildlife on the way. Birds in particular were very abundant and easy to see; my particular favourite of the day, of the many spectacular birds being the sunbittern. This bird is a medium sized heron-like bird, not actually closely related to any other bird, whose wings are fantastically coloured in grey, black, yellow and terracotta with a 'sun' in the centre of each wing. Turtles too were in abundance, again, many of which had, what appears to be, a compulsory orange butterfly, perched on their snoots.

As we were travelling at a stately pace, we stopped at a comfortable looking beach complete with capybara tracks and camped for the night, leaving the remainder of the journey for the next day. Melissa cooked us a lovely dinner, which we ate whilst watching parrots and oropendolas in the trees around us.

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22 November: Slow boat to Piedras Biodiversity Station ;-)

Up with the dawn and off up the river again. Lots more wonderful wildlife.

Arrived at Piedras Biodiversity Station about 14:00 and proceeded to unload all our kit and the mountain of food. The path from the boat to the station is not very short, it is definitely steeply stepped in places and it was very hot; with the breeze whilst travelling on the boat we had managed to avoid sweating too much, but with the heat and exertion, our clothes were soon absolutely soaked in sweat as we carried everything uphill.

The Station itself is beautiful, surrounded by a garden full of fruit trees and red and yellow heliconia flowers being visited by hummingbirds. The station is built on a raised platform of lovely wood, the rooms being open to the air on one side with the walls only being about 1 m high, giving lovely views into the rainforest and its wildlife just outside. However, the best bit of the lodge was, without a doubt, the cold showers; unquestionably the best in the whole world :-)

23 November: Piedras Biodiversity Station

Spent the day with Gloria and Miguel walking the trails, familiarising ourselves with the area – wow, what a place. During the day, we saw many monkeys; saddleback tamarins, black spider monkey, brown capuchin, squirrel monkeys, white faced capuchins and dusky titi monkeys, along with the red howler monkeys we heard, that made seven species in one day – amazing.

24 November: Piedras Biodiversity Station Training

With team 1 safely at the Station, we were up early in the morning, split into two groups and then went into the forest for an orientation walk; Jhin, our local and exceptionally good guide showed us some of the plants to avoid touching, many rare and beautiful birds and some of the other animals and insects present here; well, everyone was blown away by the diversity, abundance, beauty and strangeness of what they saw, heard and smelt.
After delicious lunch :) we did training in machete use, telescope use, rangefinder use, GPS use, and how to use Miguel's automatic camera traps.

Late afternoon was a trip to the tower with Jhin where we saw a stunning iridescent bluish fronted jacamar amongst other birds.

The evening was spent with a talk by Miguel who explained all about his studies, how we will be collecting data, what it will be used for and how it all fits into larger conservation plans; fascinating.

25 November: Piedras Biodiversity Station Training

In the early morning, half of the team went to the macaw clay lick for training, whilst the other half went training on a mammal transect. Having been to the biggest known macaw clay lick in the world last week, I was not expecting the large numbers of macaws and parrots that we found there; around 40 red and green macaws, 40 blue headed parrots, 25 mealy parrots and a few dusky headed parakeets. The view we had of the clay lick too, was fantastic, across the Piedras river. We could see the whole clay lick clearly as well as all the birds in the surrounding trees – wonderful. Mammal transect training went well too, my favourite bit being when I got to be a monkey in the forest for the team members to find and practice recording.

In the afternoon we split into two groups, I went to the platform with Emma, Mary, Gebard and Johannes, whilst Alan went to the mammal colpa with everyone else. At the colpa, Miguel set up one of his camera traps, which will record the animals that visit there. hen that was done, he switched to peccary mode and charged around the forest, so that the team members could practice recording mammal observations…… all kinds of fun. Back at the platform, it was much calmer, until that was, Chico went off for a pee; a shout was heard and when he returned, he told us he had seen a jaguar; there was then a bit of a loss of interest in the platform and more of a desire to go for a wee walk……. until Chico said he had scared the jaguar away :(

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The platform is located about 25 metres up in a strangler fig tree, access being either by jummaring up a rope or by getting winched up. I went up first, followed by Johannes, Mary and lastly, Gebhard. Mary gets vertigo and Gebhard has a great fear of heights, but both were determined not to miss out on a once in a lifetime opportunity to get up into a big emergent tree above the canopy and enjoy the wonderful views of a sea of green disappearing away to the horizon in all directions; such was our view of the Amazon rainforest.

In the evening, Alan gave a talk about macaw breeding biology, conservation, clay licks and how the data we collect will be used, all really interesting stuff, unfortunately, cut a little short by the very impressive storm that blew up with fantastic thunder and lightning ;-)

26 November: Piedras Biodiversity Station. Starting survey work.

After completing our training yesterday, today is our first day where we did some proper scientific survey work. Mary, Martin and Alan went to the macaw clay lick, setting off at 0430. Martin got carried away with the drama of recording macaw behaviour – "ok watching the red and green macaw; OK, he flies away, no, no, NO, NO, FIGHTING, FIGHTING, ONE FLIES AWAY, ONE STILL THERE, if that's mine, he won, wow."

27 November: Piedras Development Corporation in action.

Yesterday, those at the macaw clay lick said that it was very hot, so I decided to build a proper bird hide to provide shelter from the sun as well as hide us from the birds. Mary, Steph, Miguel, Jhin and I set off, armed with machetes. We made a frame of wood lashed together with vines. We then covered the roof and front with split palm fronds and we were done – finest bird hide in the known universe ;-)

28 November: Search for the lost mammal colpa.

There was a grand total of two breakfasts at civilised 'o' clock, everyone else was up around 4 or 5 and off out on the trail. One of Emma's employees had found a mammal colpa, around 10 km from the station and in her Brazil nut concession, but we were far from sure where it was. So it was that Mary, Emma, Gebhard, Jeffa (our boat driver) and myself all headed off to look for it, loaded up with gallons of water, machetes and loads of enthusiasm. The weather was ideal, being overcast and cool, relatively speaking! We got to the boundary of the Brazil nut concession quickly, only having stopped a few times to see red howler monkeys, brown capuchin monkeys and some beautiful birds. The boundary, which we planned to follow to get to the colpa was marked with flagging tape occasionally and though we had feared it would be totally overgrown, it was not too bad and with "Hacker Hume" and her favoured machete, progress was fine, though the chances of sneaking up on any animals was around zero.

Having reached and turned the corner of the concession, we were nearing where we thought the colpa was. We crossed a stream and then, the trail ended. Jeffa had a look down along a mammal trail that we saw, and there it was, all of 50 m away, the colpa we were looking for! We could see mud going high up the tree trunks from the colpa – a sign that monkeys and the like had been here. There were peccary tracks and most exciting of all, fresh jaguar tracks. We selected a tree trunk that faced and had a good view of the colpa and then fixed one of Miguel's automatic cameras to it, tested it and then left it to photograph whatever visited the colpa.

Meantime, back at the ranch Margret, Janice and Kevin were cleaning up the hide at our mammal colpa, in preparation for the first of our two planned 24 hour watches there, can't wait to see what wanders past.

29 November: Macaws, macaws, macaws.

Johannes and I went to the macaw clay lick early in the morning; early on, there were a few dusky headed parakeets, lots of blue headed and mealy parrots. However, it was a bit later, around 09:00, that the most spectacular part of the morning happened. Around 55 stunningly beautiful red and green macaws descended on the clay lick and surrounding trees, turning the drab brown clay into a raucous Technicolor explosion of red, blue and green – amazing.

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Out on transect A, Kevin and Janice along with Emma had an equally wonderful day, recording no fewer than eleven species of monkey, two agouti species, Spix's guan, a herd of white lipped peccary and a partridge in a pear tree.

30 November: Day off!

Had a late breakfast and then those with the inclination headed off to play football on the beach; scorching temperatures, sand, insects and football – my idea of living hell, takes all types I guess. After their exertions, the footballers took the boat to swing over the river and everyone had a go, even those afraid of heights. Next was a swim to the waterfall; no-one got eaten by piranhas or caiman, stung by sting-rays or zapped by electric eels, so that was good.

After lunch, the Piedras Card-playing Society convened and we stretched our brains/sharpened our reflexes with canasta, sevens, switch, trumps, spoons, etc, etc…… it was a long afternoon. Later, the Piedras Dance Society met and under the expert tutelage of Gloria we sampled the sensuous delights of salsa, cumbia, tacirari and those more rhythmically challenged or with co-ordination issues conjured up some interesting variations all their own. Next on the action packed agenda was a presentation, by myself about Biosphere's expedition to Altai on which I have been for the last three years; everyone loved the photos of the stunning scenery there.

1 December: Back to work.

Almost everyone was up at 4 or 5 in the morning for transect surveys and macaw colpa observations whilst Miguel and myself headed for "The lost colpa" to retrieve the memory card from the automatic camera we installed a few days ago. The sky was overcast, so it was reasonably cool and we got there quickly, only stopping to look at jaguar and giant anteater tracks :-) golden collared toucanet and white throated toucan :-) saddleback tamarins, squirrel monkeys, white fronted capuchin and brown capuchin monkeys :-) etc. etc. :-)

At the colpa, all was quiet and there were no fresh tracks, so we collected the memory card and headed back. On the way, we cleared a tree that had fallen across the trail, getting stuck in with the machetes. We thought we had had our measure of good luck for the day, but no, we found no fewer than five puma scrapes :-) and a flock of cobalt winged parakeets feeding in a big fig tree :-)

At the station, Miguel got out his laptop and plugged in the memory card from the automatic camera at "The lost colpa" and everyone gathered round to see this, the first set of photos. There were 7 photos, not many :-/ Photo 1, me looking into the camera… Photo 2, me looking into the camera…. Photo 3, nothing. Photo 4 Emma. Photo 5 Nothing, but it was from the day after we installed it. Photo 6, A giant anteater right in the middle of the frame, resplendent with his big bushy tail, a huge roar goes up from around the laptop – what a result! [Photo 7, me looking into the camera :-)]

Later, Emma, Steph and Mary did a night transect survey which gave the sighting of the expedition so far, a fabulous ocelot that they saw on the trail no more than 5 m away – amazing!

2 December: Macaw colpa #2

Dropped off Janice, Kevin and Jhin at the macaw colpa and then continued upriver for another kilometre or so to a second macaw colpa that we were not sure if the birds were using or not. Got dropped off and Gloria, Miguel and myself were left with a wooden canoe to get back again. Emma had done some weeding in the canoe yesterday, so we were no longer sure just how watertight it was. Anyway, got to the colpa and built a hide from canya brava, a huge grass that grows along river banks and then waited to see if any birds would appear. We did not have long to wait, with chestnut fronted macaws appearing almost immediately, perching in the trees above the colpa. So far, we have only seen one of these macaws at our main colpa, but here, we had 10. There were also dusky headed parakeet, cobalt winged parakeet, mealy parrots, red and green macaws and scarlet macaws. However, these birds did not hang around the colpa for nearly as long as at colpa 1. At this colpa, they eat and go, rather than catching up on the gossip before having a leisurely feed.

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3 December: Automatic camera results, treetop platform climb

Miguel started collecting his automatic cameras today, when he got back, everyone gathered around to see the results on his laptop. They were impressive. Red brocket deer, pale winged trumpeter, Spix's guan, paca, brown agouti, southern amazon red squirrel, white lipped peccary and confirming the sign we had found over the last two days, a fabulous image of a puma.

After lunch, we headed for the treetop platform; Johannes, Jhin, Alan and Jeffa provided the power to winch Cassie, Janice, Margret, Emma, Kevin, Uli and myself up to the treetops where we enjoyed fabulous views of the forest, with macaws and parrots flying by, it was wonderful. Someone quoted Biosphere's philosophy of safety, science and satisfaction; Cassie said "Well, I certainly got my satisfaction today"……. ;-)

4 December: Last work day.

Emma, Margret and Gebhard did transect A for the last time and it was a good one. Difficult to see Saki monkeys and red howler monkeys that descended a little in the trees to get a better view were a couple of the great sights. Janice, Kevin and Jhin were on the early macaw colpa shift; the river had risen around a metre so that there were seven boats heading downstream with rafts of timber…… During the previous week we had only recorded a total of five boats. Every time a boat passes, it causes a flush of the macaws and parrots from the colpa, disturbing or even preventing their feeding; recording and subsequent analysis of these data being an important part of our work here.

With all expedition work finished by 14:00, the afternoon was free for some R&R and team members relaxed in the hammocks, played backgammon, sat by the river watching logs drift by, photographed bugs and birds or said goodbye to the forest in their own ways.

Before dinner, Alan and Miguel gave presentations on the science, summarising what we had achieved, how the data will be used. This was rounded off with Miguel's photos from his automatic cameras which were fantastic; red brocket deer, grey brocket deer, pale winged trumpeter, spix guam, paca, brown agouti, white lipped peccary, giant anteater, southern Amazon red squirrel, puma and the piece de la resistance, walking straight towards the camera and looking awesome, the most wonderful looking jaguar. ;-)

Gloria provided us with yet another lovely meal. Emma produced some pisco sour drinks ;-) which was the perfect start to an evening of dancing and chatting; it's amazing to see how everyone has gelled together so well, through the time spent working together in the forest and how relaxed and at ease we all are together…. Or maybe that was the pisco sour at work!

5 December: Piedras to Puerto Maldonado

Had breakfast and set off around 0630. With the river being high, water was flowing fast and we hoped for a speedy trip to Puerto Maldonado. However, logs, branches and occasionally whole trees in the river slowed our progress a little. Nevertheless, after, much wildlife spotting and innumerable games of backgammon, we arrived in Puerto Maldonado early afternoon.

I would like to thank all of the team for a fantastic first slot; you were a joy to work with, much was achieved and I had a wonderful time.

6 December - Puerto Maldonado

Did some very exciting shopping for batteries, printed some datasheets, did the internet thing, etc. etc……. Oh how I've missed civilisation……

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7 December - Puerto Maldonado to Piedras

All team members up bright and early as planned and after some delays, which allowed us to watch a sloth at Wasai lodge ;-), we eventually made it to the boat at Puerto Arturo and departed at 07:45. With Jeffa at the tiller, we made good progress seeing capybara, turtles, black spider monkeys, red howler monkeys, giant anteater – yippee! My first ever sighting, as well as many, many kinds of birds. Arrived at Piedras at 17:30, installed ourselves in or very fine, fantastically ventilated rooms before moving on to the most important matter of the evening; sampling some of Gloria's finest cuisine.

8 December - Start of training.

Alan and Miguel gave talks on the background to the expedition, why the research was being done and what it would be used for; all very interesting. We went for a familiarisation walk in the forest, seeing cayman tracks by the river and Jeanette's razor sharp eyes found a couple of very well camouflaged frogs. Alan and Miguel explained the survey methodology for both the macaw colpa monitoring and the mammal transects. I had to 'be a macaw' so that everyone could practice recording macaw behaviour; I suppose that's something not many people could add to their CVs. After lunch we did training in the use of equipment; GPS, rangefinders, machetes, Miguel's automatic cameras and telescopes. No deaths or serious injury during the machete training, so that's good.

Went for a short, but very successful night walk. Geckos, frogs, birds, a very speedy and beautiful pink-toed tarantula, two cayman in the river and a red brocket deer that Alan got us all excited with by first thinking it was an ocelot. Not bad for about 40 min!

9 December - The return of Charlie!

Up with the lark, or whatever the equivalent is here – up with the brown rumped foliage gleaner? Doesn't have quite the same ring to it eh. Katie, Jeanette, Stefan, Alan and myself headed for the macaw colpa and installed ourselves in the hide under a blanket of cloud that came down to the tree tops. The weather conditions were not good for seeing lots of macaws and parrots, but it was not long before we had blue-headed parrots, dusky headed parakeets, mealy parrots and red and green macaws were on the trees around the clay lick. Soon, the blue-headed parrots landed on the clay and started feeding. Katie, Jeanette and Stefan were kept busy, observing and recording bird sightings, arrival times, and weather conditions, flushes where the birds flew away from the clay lick area, boat traffic and its effect on the birds as well the feeding activity. Whilst observing macaw behaviour, I noticed that one of the birds had a very asymmetrical bill, being 'corkscrewed' very seriously to the left. On mentioning this to Alan, he got very excited and started ranting about a long lost pal called Charlie. After about 10 minutes of hysteria, we eventually managed to calm Alan down enough to work out that Charlie was the macaw we were looking at and had last been seen November 2007 at Posada Amazonas on the Tambopata river, about 70km away. On the leaving the hide, Alan spotted a swamp snake that was in the process of swallowing a frog; we all watched in silence. We were there for a while, long enough for a group of collared peccaries to approach us, unaware of our presence, what a great morning and it wasn't even breakfast time.

Later in the morning, after breakfast, we went out with Miguel to put into practice what he had been telling us about mammal transect survey methodology. All went well and I ended up doing more animal impersonations, this time a tapir and then a jaguar; where's that CV of mine?

Lunch went well too, but after lunch, disaster. My backgammon crown was unceremoniously taken from me by Lisa in very short order :-((I let her win really).

10 December - First day of work.

After all our training, today, we got stuck into the work, both at the macaw colpa and on the mammal transects. All the hard work done during the training paying off with lots of good data. Second shift on the macaw colpa was cut a little short when we had a little (!!!!!!!!!!) rain; that'll be why they call it a rainforest then, quack!

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Having succeeded in creating some data, we then had to transfer it all to the computer, so Bob got stuck in and with Stefan's help, it was soon done :-)

We are really right in the middle of the rainforest here at Piedras Biodiversity Station and see all sorts of things from the dining room table. Alan was particularly pleased to see some dusky-headed parakeets feeding on a palm; a particularly useful and usually hard won piece of data.

11 December

As usual, everyone was woken up early by Heidi's very persistent alarm clock, everyone apart from Heidi that is. More than one person has now very kindly offered to turn off Heidi's alarm clock…..permanently!

Chito, one of our local guides, first led transect went well with Bob and Alan. In the space of around 100 m, everyone got great views of the four guan species that occur here; chacalaca, spix, common piping and razorbill curassow! Alan also said something about getting great views of red squirrels having sex; need to book him an appointment with a psychiatrist I think….. Jeanette and Heidi took late shift in the macaw colpa, being made of stern stuff, they braved a downpour and continued to monitor two hardy macaws who remained on the colpa during the rain.

Undaunted by the rain, Katie, Lisa and Bob headed out on the mammal colpa trail after lunch, armed to the teeth with tape measures, marker pens and flagging tape to mark the trail. Mask, snorkel and fins might have been more appropriate ;-)

Heidi practiced her Spanish, adding pillow and candle to her vocabulary, great to have these for comfort and ambiance. Jeannette was programmed to do a mammal transect survey on Friday with Chito. Alan suggested that it would be a good opportunity for her to practice her Spanish; Jeannette agreed, saying she could book a room! Maybe she could set out some candles and get the pillows ready too…. Doesn't waste any time our Jeannette!

12 December

Bob, Stefan and Alan took the early shift at the macaw colpa and were extremely lucky to see an orange-breasted falcon half-heartedly though very spectacularly, attacking a much larger red and green macaw. Katie and I had a good morning at the macaw colpa too, with a maximum of 63 red-and-green macaws. We managed to maintain continuous behavioural observations on one macaw for 30 minutes. During this time, it preened itself and (presumably) its mate on a branch high above the colpa, also looking around continually, checking for dangers. Both birds made their way down towards the colpa and then onto the clay itself. Many macaws are crowded onto the small colpa and the pair stayed together, occasionally asserting their right to be there with a bit of shouting at other macaws. There are two deep holes in the colpa that have been made by macaws eating the most favoured clay. Our pair ate clay from the entrance to one of these holes, as well as from inside. It was amazing to watch these very dextrous birds break off a bit of clay and grind it down with their beaks and eat it. The quantity of clay that they ate too was remarkable; lots and lots of it. Red-and-green macaws are beautiful, raucous and rowdy when spread out in the trees, fantastic and fascinating to observe when all on and around the colpa together and utterly spectacular when they all fly off together in synchrony during a flush; an ephemeral kaleidoscope of blues and reds. This rare treat reserved only for those who come here.

Highlight of the afternoon was the banana hunt. Supplies were running low in the kitchen, so Stefan, Heidi and Jeannette set off for the chacra armed to the teeth with a blunt machete. No sooner had they gone and they were back, asking what kind of bananas they should get, green or yellow, and how many they should get, I thought 14 would be about right. Two hours later, they returned triumphant….. with a papaya and two oranges.

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13 December

Stefan and Alan set off at 03:30 (!) to survey mammal transect A. Turned out to be well worth the ungodly hour though. At around 2500 m on the Brazil nut trail, they saw orange/yellow eye shine and heard bone crunching. Despite their best efforts, they could not get clear sight of what was there because of the very thick vegetation. Their vegetation crunching must have sounded pretty scary because whatever was crunching the bones then slipped off into the night. Alan and Stefan continued to the far end of transect A and then started working their way back towards base. On the way, near where the bone crunching had been heard, Alan found very, very fresh jaguar scat on the trail…..

Jeannette and I headed off downstream at the positively lazy hour of 05:00 to parrot colpa number 3. This colpa had been studied intensively in previous years, but we had not checked it this year. And we had not been missing much! No birds visited the colpa, However, we were entertained by watching a big red tractor going down the river. I need to get more sleep.

14 December

Miguel and Stefan surveyed transect B for mammals, seeing collared peccary, southern Amazon red squirrel and white-throated toucan amongst other things. Lisa and I were at the macaw colpa early, but it was unusually quiet, there being only one blue-headed parrot feeding on the clay other than the red-and-green macaws. Jeannette and Heidi had a quiet second macaw colpa shift too with the red-and-green macaws being rather skittish today. Katie, Bob and Chito fared much better seeing saddleback tamarind, dusky titi monkey and white cappuccino as Katie seems to call them; must be suffering from coffee withdrawal. Spix guan, common piping guan, many toucan, toucanets, woodcreeper, cobalt winged parakeet and oropendulas were some of the long list of birds they saw.

After lunch, we all went to the platform (27 m) with ropes, harnesses, helmets and enough karabiners to sink a long boat. This was our afternoon for a climb up a big emergent tree to get up above the canopy to see some of the different flora and fauna that live in this habitat that is so different to the dark ground level that we have become used to. There were many fascinating and unusual insects as well as epyphitic plants such as orchids and bromeliads adapted for the extreme bright sun and very dry conditions. The views were not bad either ;-)

First up to the top was Bob, complete with white knuckles. Next was Katie who managed a sort of a smile for the camera on the way up. Stefan managed to get tangled up in the safety line on the way up, which everyone thought was amusing, even Stefan! Lisa squared up to her fear of heights because she didn't want to regret missing out on this once in a lifetime experience. I got a look that would have killed from her on the way down, but she swears she enjoyed it :) Heidi was so keen to get up into the canopy, so didn't have lunch, racing round to the platform after her late macaw shift so she didn't miss her chance; the smile on her face afterwards lasted well into the night.

15 December - Day off

Alan, our lead scientist left today, having to return to Tambopata where he is running another macaw research project. Alan has been great to work with, but now Miguel will be in charge of planning the science work that needs to be done. Miguel got off to a very popular start by planning a day off, no sooner than Alan's boat had slipped its lines. The day's activities were the following; 07:30 breakfast, 08:30 mid morning nap, 10:00 hammock workshop, 13:00 lunch, 14:00 canasta/uno/backgammon/yahtzee, 15:00 rope swing/swim in river, power shower (waterfall), football/volleyball on the beach, 19:00 dinner, 20:00 dance. And who said science was dull!

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Katie, Lisa, Miguel, Stefan, Jeffa and Chito did the rope swing into the river. I would have had a go as well, but had a technical difficulty with the stitching around the groin area of my trousers that meant I was rather better ventilated in that area than planned. In order to preclude any possibility of shock or heart attack to innocent team members that were hoping for a display of daring and sporting prowess, rather than any other sort of display as I flew through the air, I decided to stay on terra firma. [Gloria very kindly donated a pair of shorts, which I wore apron like to protect the sensibilities of those with a delicate disposition]. Heidi, Bob, Stefan and I walked back from the waterfall whilst everyone else went back on the boat. We walked very slowly and quietly so we managed to see a red brocket deer and a group of 5 red howler monkeys; a lovely walk.

After the dancing, I went for a walk to look for frogs as there had been rain and so, at last, there was some standing water, I did ask if anyone wanted to join me, but everyone opted to go to bed. Only about 500 m from base, I found a small swampy area, the noise coming from it was amazing. What is normally very, very quiet forest, was now almost becoming deafening with the sound that the frogs were making. I waded in up to my knees and there were frogs everywhere, hundreds of them. Many of the males were calling, I saw one frog being eaten by a tarantula and a snake swam past also hunting frogs; this was a dangerous place for a frog to be, but also an important place as they were mating. With a wet bum I had from crouching down to photograph the frogs and a grin like a Cheshire cat, I headed for home; what an amazing experience.

16 December - Mammal colpa survey

Heidi and Miguel did early shift at the macaw colpa and Bob and Stefan did the late one. The river continues to rise with all the rain we have had the last couple of days, most of the beach on the far side of the river is now gone and I wonder how long it will be till the macaw hide gets swept away too? Katie and I did the first of four six hour shifts at the mammal colpa, seeing a green agouchi for about 0.001 seconds and a Southern Amazon red squirrel who kept coming back, for about an hour all together. A twist-necked turtle swam around in a muddy pool for a bit, headed off purposely, returned later and swam around a bit more. A black poison dart frog with beautiful green stripes hopped around the colpa for a while, entertaining us. Miguel and Jeannette did the second shift seeing ruddy quail dove and tinamou. Third shift, into the night, was taken by Heidi and Bob who only saw a rat. Last shift from midnight till 06:00 was completed by Stefan with the assistance of our two lovely cooks, Gloria and Melissa; they saw a butterfly….. So, not the most exciting of watches at the mammal colpa, but that's sometimes the way it goes.

Back at base in the evening, Jeannette, Katie, Gloria, Melissa, Miguel and I went to look for frogs. We passed the small swamp where I had been last night, it was alive with the calls of frogs and headed straight for the frog trail. A couple of hundred metres down the trail we came to another small swamp, this too was almost deafening with the sound of frogs calling, however the calls were different and it was different species of frogs we found. Monkey frogs, sheep frogs (actually a kind of toad), leaf frogs and many species of tree frogs were all around in their tens or hundreds, amazing. After a while we decided to go to the bridge on frog trail, our original planned destination, but when we got there, there were no frogs! In the distance, we could hear a commotion of frogs, so we headed off to investigate. We arrived at another small swamp. Small, but big enough to ensure everyone was thoroughly soaked in no time flat. Here again, the calls were different as were the species of frogs, but this time the frogs were in their hundreds and perhaps even thousands of a small golden species of tree frog. In big palms were big monkey frogs and on the ends of the palm fronds, frog spawn hung like jewels. The golden tree frogs sat on short lime green plants, whilst small toads and brown frogs were to be found on dead leaves by the edge of the water. Frog heaven! Well, frog spotters heaven anyway. As with last night we saw a tarantula killing a frog and a snake swimming in the water, hunting for frogs. We headed back to base, soaked to the skin, but buzzing with excitement from the fantastic spectacle we had been in the middle of.

17 December

Miguel and Jeannette surveyed mammal transect A in the morning and collected the cameras. There were many animals captured, including a puma that had wandered past yesterday mid-day. In the afternoon, Miguel, Katie, Bob, Stefan and Chito went to the lost colpa to collect Miguel's automatic camera. There were photos of white lipped peccary and red brocket deer. Meanwhile, Jeannette, Heidi and Jeffa were having an adventure of their own. They were walking on transect B, collecting Miguel's cameras, actually, swimming might be a better description…….

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After dinner, Heidi and Jeannette did a night mammal transect survey with Chito.

18 December - Last day at Piedras Biodiversity Station :-(

We surveyed mammal transects A and C in the morning and collected the last of Miguel's automatic cameras later. Miguel finally got the picture of a tapir that had eluded him for so long. However, the best images were from the mammal colpa near base. Fortunately, Miguel had set the camera to record movies as well as still images. A troop of white bellied spider monkeys had visited the colpa and we could see that one or two would descend from the trees to feed on the clay whilst others probably maintained a lookout from above. Miguel is unaware of these monkeys having been recorded eating clay before, so that is a fantastic result for the expedition.

After lunch, Jeannette wanted to climb to the platform in the canopy, so off we set. Stefan, Chito and Elias winched Jeannette, Gloria, Melissa and myself up to the platform whilst Chito climbed the tree, protected by the rope from above, an impressive climb.

After dinner, Miguel gave a great end of expedition talk. We recorded an impressive 30 mammal species from observations, automatic cameras and track identification. We collected much data on feeding and behaviour from the macaw colpa and had a dazzling maximum of 83 red and green macaws on one day. Our data will add to long running datasets that are used by many different scientists/conservationists for important nature conservation work. Miguel's work will create a model that can be used to identify areas that are important for wildlife, taking into account factors such as protection status of the land, proximity to human habitation and habitat characteristics. Very important stuff.

With all the work done, after dinner we had a party with pisco, dancing and telling of tall tales late into the starry night.

19 December - Piedras to Puerto Maldonado

Breakfast at 05:30 and off at 06:15 :(Stefan decided that his boots needed to be cleaned, so he washed them in the river as we went along; one of them got a better wash than planned, it should be really clean by now….

Well, that's the end of the 2008 Biosphere Expedition to Piedras in South East Peru. Thanks to Alan and Miguel for their instruction and direction in matters scientific. Along with them, Chito, Jhin and Emma were our excellent guides who are tuned into the forest and its animals, showing us all sorts of wonders and without whom most of them would have slipped quietly past us. Jeffa was our boat driver, ferrying us across the Piedras every day to the macaw colpa, always ready and waiting for us. Gloria and Melissa were our wonderful cooks who continually amazed us with the delicious meals they prepared in a basic kitchen. Emma and JJ who own Piedras Biodiversity Station did a fantastic job of setting up the station in the first place and continue to ensure a not too small piece of wild paradise is protected. Emma's enthusiasm and love for the wild was plain to see, infectious and an inspiration for us all. Finally, thanks to all you team members without whom the research simply would not have happened. You were very easy to work with, enthusiastic and very helpful. Thanks ;-)

Andy

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