Monitoring biodiversity by Operation Wallacea in the Iwokrama and Surama Forests, Guyana

Research Report 2015

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Summary

From June-August in 2015 Operation Wallacea teams sampled seven forest sites in central Guyana. Surveys focused on bats, birds, large mammals, reptiles, amphibians, dung beetles and forest structure. These surveys aimed to build on a base-line dataset for the monitoring of key biodiversity taxa began in 2011, as well as add the forest structure survey to the protocol.

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1. Introduction

1.1 Stakeholders

Operation Wallacea is a network of academics from European and North American universities, who design and implement biodiversity and conservation management research programmes. Research is supported by students who join the programme, to strengthen their CV or resumé, gain course credit, or collect data for a dissertation or thesis. Academics benefit from funding for high quality fieldwork enabling them to publish papers in peer reviewed journals. This model enables the collection of large temporal and spatial datasets used for assessing the effectiveness of conservation management interventions.

The Iwokrama International Centre for Rainforest Conservation and Development (IIC) forms an international partnership between Guyana and the Commonwealth, to demonstrate how tropical forests can be sustainably used in the interest of global-scale climate change, local communities, and biodiversity conservation. The Iwokrama Forest in central Guyana is 3710 km^2 of low-lying Neotropical rainforest that is of global importance to biodiversity conservation and carbon storage. The IIC's mission is: '*To promote the conservation and sustainable and equitable use of tropical rainforest in a manner that leads to lasting ecological, economic and social benefits to the people of Guyana and to the world in general, by undertaking research, training and development and dissemination of technologies.'* The Iwokrama Forest is divided into roughly half Sustainable Utilization Area (SUA), where sustainable use of forest resources is permitted and tested, and half Wilderness Preserve (WP), where there is no commercial extraction of forest resources.

Surama Village in the North Rupununi, Region 9, is a primarily Makushi Amerindian community that is part of the villages encompassed under the administration of Annai Village. Surama's vision is: *'We will develop, own and manage a community-based eco-tourism business by constructively using the natural resources and our traditional culture in a socially appropriate manner. We will provide opportunities for our people through research, training and employment. We will work with our partners for mutual respect and benefits.'*

1.2 Goals of this monitoring

The purpose of this monitoring is to provide long-term datasets on key biodiversity taxa, and to record trends in abundance (and to some extent diversity) of these taxa. These data may be used to understand changes in the Iwokrama and Surama forests in relation to anthropogenic impacts, climate change and climate fluctuations (in particular El Niño Southern Oscillation patterns), and also the effectiveness of management interventions. These surveys will also provide an equal coverage of the SUA and WP parts of the Iwokrama Forest, and therefore provide further understanding of sustainable use versus strictly protected parts of the Iwokrama Forest. Additionally, these surveys will provide coverage of parts of this area that have not been previously surveyed, and may therefore provide additions to the species list for the area. There are now several derivatives of the UNFCC Reducing Emissions from Deforestation and Forest Degradation (REDD+) mechanism where biodiversity criteria are included in payments derived from REDD+ funding (such as the Climate, Community & Biodiversity Alliance standards). This dataset may therefore be used for similar initiatives in Guyana.

1.3 Team members

Scientists

Coordinating scientists:	Danielle Gilroy, Ph.D – Operation Wallacea
	Scott Sveiven – Operation Wallacea
Birds:	Brian O'Shea, Ph.D - Museum of North Carolina, Meshach Pierre
Mammals:	Matt Hallett – University of Florida
Bats:	Burton Lim, Ph.D – Royal Ontario Museum, Stefanie Bonat
Dung beetles:	Dan Fitzpatrick – St. George's University
Forest structure:	Scott Sveiven – Operation Wallacea
Herpetofauna:	Alfredo Beraun

Local guides/rangers

Micah Davis, James Honorio, Marcy, Martin Carter, Alex Honorio (Iwokrama International Centre); Ron Allicock, Ovid Allicock, Kurt Singh, Garry Sway, Arnaldo, Junior, Kenneth Butler and Clifford Sway (Surama Village).

Many volunteers from Operation Wallacea assisted this data collection.

2. Survey sites and spatial design

2.1 Sites

During June – August 2015, seven sites were surveyed; five within the Iwokrama Forest - Turtle Mountain (SUA), Kabocalli (WP), Canopy Walkway (SUA), Sandstone (SUA), and Logging Camp (SUA), and two outside the Iwokrama Forest in the adjacent Surama Forest – Rock Landing, and Surama Village/Carahaa Landing. Additionally, two stretches of the Burro-Burro River were surveyed for river associated wildlife (Fig 1).

This area lies between 4° and 5° north and 58° and 59° west and is characterised by low-lying tropical rainforest, dominated by *Chlorocardium rodiei*, *Eperua falcata*, *Dicorynia guianensis*, *Mora excelsa* and *Swartzia leiocalycina.* Rainfall averages ~2,500 mm year^{-1}, with a rainy season from April to July (400-500 mm). Most other months experience ~200 mm.

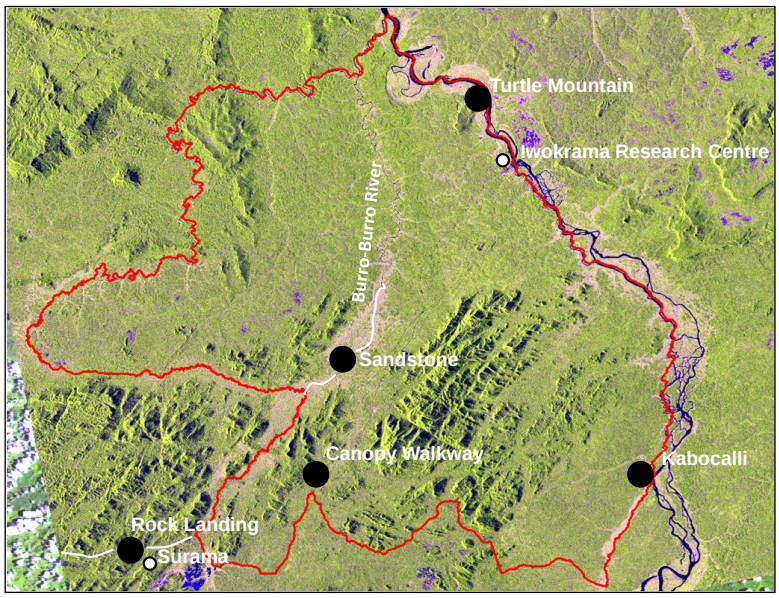


Figure 1. Survey sites (black), and other logistical sites (white). White lines indicate the two river transects along the Burro-Burro River. Red line shows the boundary of the Iwokrama Forest.

Temperatures range from an average minimum of 22°C at night during the July rainy season to an average maximum of 36°C during the October dry season. All sites are characterised by high forest, with the exception of Surama Forest which is located at the frontier of forest and savannah, and may therefore be considered 'intermediate'.

Site coordinates (UTM)

Camp	X	Y
Turtle Mountain	309602	523638
Kabocalli	332576	474100
Sandstone	286965	485188
Canopy Walkway	288651	469828
Rock Landing	268883	462543

2.2 Survey spatial design

At each terrestrial site, two to four 1-4km transects were used to survey large mammals, large-ranging birds, herpetofauna and dung beetles (see specific sections for details). These transects radiated out in different directions greater than 90° from one-another. At each site mist nets were used to sample understorey birds and bats. In most cases the first 200m of one of the transects was also used for the mist net array (Fig 2). Additionally, forest structure plots were surveyed along alternating sides (left and right) of each transect at approximately even intervals. The spacing was determined by the length of the transect, such that each had a minimum of three forest plots. Therefore, a shorter 1km transect might have plots spaced 250m apart, whereas the longer 4 km transects might have plots every 1km.

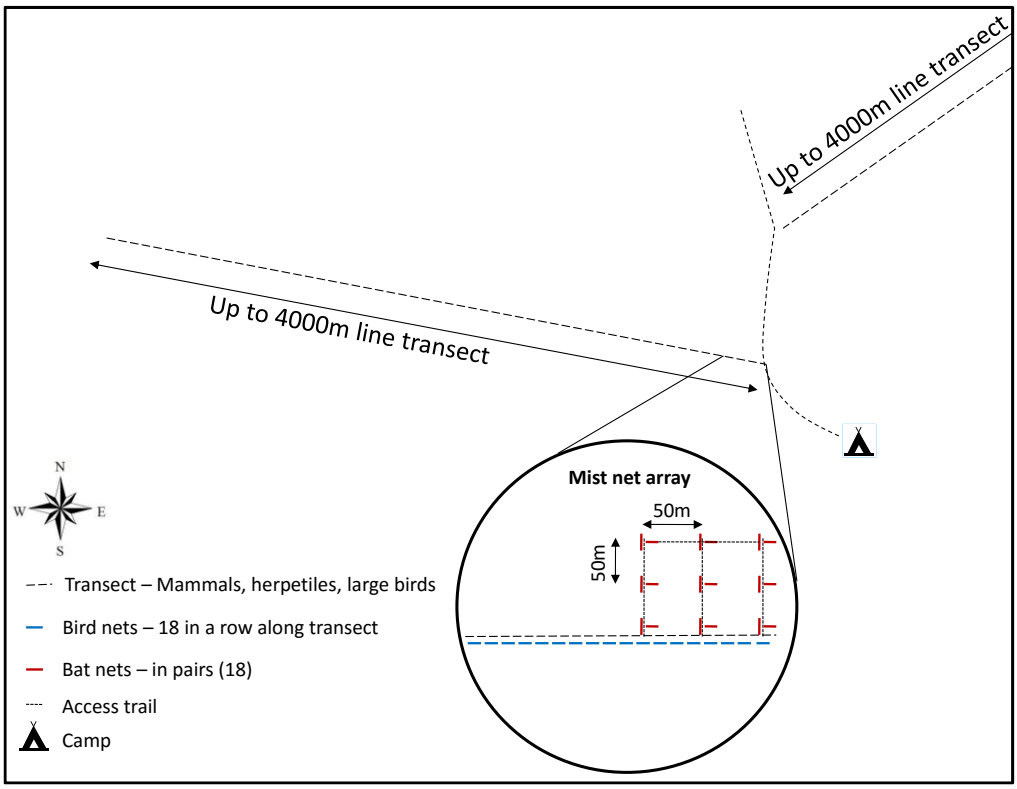


Figure 2. Example of transect set-up and mist-net array which was similar at all sites. Bird nets are shown in blue, and bat nets in red.

3. Methods

3.1 Bird mist net surveys

Survey methods
18 (12 x 2.6 metre) mist nets were placed directly along the transect line, shown in Fig. 2. Nets were opened at 06:00 (dawn) and closed at 18:00 (dusk). Nets were checked approximately every 30 minutes, and birds were extracted and returned to the camp for recording. Birds were identified using two field guides (Hilty 2002; Restall et al. 2006), sexed and aged where possible. In order to record recaptures, birds were marked by making a small triangular clipping on the right-hand outer tail feather. Additionally, SM3 sound recorders were deployed at each site to begin gathering baseline soundscape data on bird species diversity. All species caught in nets were considered target.

3.2 Bat mist net surveys

Methods
18 (12 x 2.6 metre) mist nets were placed in pairs at each of the nine positions shown in the gird format in Fig. 2. Nets were opened at 18:00 (dusk) and closed at 00:00. Nets were checked approximately every 30-60 minutes, and bats were extracted and returned to the camp for recording. Bats were identified using the key developed by Lim & Engstrom (2001), sexed and aged, and reproductive status noted. In order to record recaptures, bats were marked by making a small (3mm) hole punch in the wing membrane (left hand side close to foot) using a biopsy punch. All species caught in nets were considered target.

3.3 Transect sampling for large mammals and large-ranging birds
Following Peres 1999, both line transects were surveyed simultaneously by two separate teams, between the hours of 06:00 – 10:00. Teams were composed of one primary spotter (a local ranger or guide), Matt Hallett, and a few assistants. Observers slowly walked the transects observing for target species. Upon detection of target species (by either vocalisation, direct sighting or tracks/signs), the perpendicular distance was measured (see Fig. 3.) to enable density estimation (Buckland et al. 2001), as well as the group size and any available demographics. Additionally, camera traps were installed by Matt Hallett at five of the seven survey sites (excluding Canopy Walkway and Sandstone).

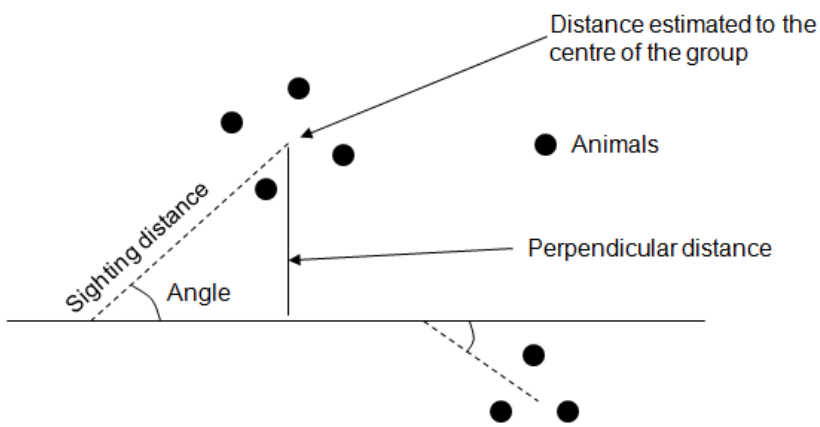


Figure 3. Method for measuring the perpendicular distance from the transect line to the target species for line transect monitoring. Where possible, observers measure perpendicular distance without the need for the angle.

Target species

Target species were selected based on the likelihood of obtaining robust population density estimates using line transect sampling, and to provide a representative profile of species across dietary guilds (Table 1). Closely related congeners of a few of these species, which cannot be reliably differentiated in the field (e.g. the tinamous and the parrots), were pooled together into single functional groups (as in Bicknell & Peres 2010 and Peres & Palacios 2007). Large-ranging birds were considered those that have large (>10 ha^{-1}) home ranges. These include the parrot family, toucans, one species of gregarious forest falcon, and various terrestrial bird groups (see Table 1). Other large mammal species encountered were also recorded, but do not provide robust abundance metrics.

Table 1. Primary target species for morning transect walks. Some represent functional groups where individual species recognition is unreliable in the field.

Taxa **Species**	***Scientific name***
Primates	
Black Spider Monkey	*Ateles paniscus*
Red Howler Monkey	*Alouatta macconnelli*
Wedge-capped capuchin	*Cebus olivaceus*
White-faced Saki	*Pithecia pithecia*
Rodents	
Red-rumped Agouti	*Dasyprocta leporina*
Ungulates	
Red-brocket and Grey-brocket deer	*Mazama americana, gouazoubira*
White-lipped and collared Peccary	*Tayassu pecari, tajucu*
Large-ranging birds	
Macaws	*Ara choropterus, macao, ararauna*
Parrots	*Amazona spp.; Pionites melanocephalus; Pionopsitta caica; Deroptyus accipitrinus; Pionus fuscus, menstruus*
Parakeets	*Pyrrhura picta; Brotogeris chrysoptera*
Toucans	*Ramphastos tucanus, vitellinus*
Tinamous	*Tinamus major; Crypturellus variegatus*
Grey-winged trumpeter	*Phsopia crepitans*
Black Currosow (Powis)	*Crax alector*
Guans	*Penelope marial, jacquacu*
Red-throated Caracara	*Ibycter americanus*

3.4 Herpetofauna surveys

Methods

Daytime visual encounter surveys (DVES) were completed along transects in the morning hours between 09:00 and 11:00. Observers walked slowly along the transect, searching 10m either side of the transect. The team consisted of one experienced herpetologist, and up to four research assistants. The geographical location of all encountered herpetofauna was recorded using a GPS, whenever possible.

Due to the fact that standardised DVES only record a subset of the herpetile species diversity, night-time visual encounter surveys (NVES) were completed to build a species lists for each site. NVES were conducted at varied hours after dark to ensure the most accurate representation of nocturnal species activity. Where possible, all micro-habitats were opportunistically surveyed, including swampy areas, river banks and creeks. All species were considered target species.

3.5 Dung beetle surveys

Methods
Pitfall traps baited with human feces were placed every 150 m along each transect and checked daily to record and assess dung beetle diversity. Dung beetle diversity, population density, and localities were entered into a field journal. Unidentified species were preserved for future identification and subsequent addition to 2015 results. All dung beetle species were considered target species.

3.6 Forest structure surveys

Methods
Forest structure plots (20m x 20m) were surveyed along alternating sides (left and right) of each transect at approximately even intervals. The spacing was determined by the length of the transect such that each had a minimum of three forest plots. Therefore, a shorter 1km transect might have plots spaced 250m apart, whereas the longer 4 km transects might have plots every 1km.

Survey components
Forest structure plots included *dbh* (diameter at breast height) measurements of all trees greater than 15cm diameter. Species were also recorder for each of these trees to the extent local guides could identify them. Any dead or cut trees were also recorded. Saplings, defined as trees less than 3m in height and with a circumference <15cm, were tallied for each 5m x 5m quadrant of the plot. A touch pole was used along two perpendicular lines centered on the plot to assess the density of vegetation at 0.5m intervals up to a height of 3m. Finally, a visual estimate of leaf litter depth to nearest centimeter subclass, as well as an estimate of canopy cover using a densiometer, were recorded at the center of each of the 5x5m subplots and the center of the 20mx20m whole plot.

3.7 Burro-Burro River surveys

Methods
River surveys were conducted by boat. The boat drifted down river (with the engine switched off), and observers recorded all target species (Table 2 & 3) that were visually detected (see Table 2 & 3). Upon detection of target species, their location (GPS for otter and anaconda), group size and any available demographics were recorded. Target species were selected based on species that are either restricted to riparian habitats, or regularly frequent riparian habitats, and on the likelihood of obtaining robust abundance metrics (Table 2 & 3).

Table 2. Burro-Burro River mammal, reptile and fish target species.

Taxa **Species**	***Scientific name***
Mammals	
Giant river otter	*Pteronura brasiliensis*
Neotropical river otter	*Lontra longicaudis*
Reptiles	

Anaconda	*Eunectes marinus*
Giant river turtle	*Podocnemis expansa*
Yellow-spotted river turtle	*Podocnemis unifilis*
Black Caiman	*Melanosuchus niger*
Spectacled caiman	*Caiman crocodilus*
Schneider's dwarf caiman	*Paleosuchus trigonatus*
Cuvier's dwarf caiman	*Paleosuchus palpebrosus*
Fish	
Arapaima	*Arapaima gigas*

Table 3. Burro-Burro River bird target species.

Family **Species**	***Scientific name***
Kingfishers	
Amazon kingfisher	*Chloroceryle amazona*
American pygmy kingfisher	*Chloroceryle aenea*
Ringed kingfisher	*Megaceryle torquata*
Green kingfisher	*Chloroceryle americana*
Green & rufous kingfisher	*Chloroceryle inda*
Tiger-herons	
Rufescent tiger-heron	*Tigrisoma lineatum*
Herons & egrets	
Great egret	*Ardea alba*
Cocoi heron	*Ardea cocoi*
Grey heron	*Ardea cineria*
Little blue heron	*Egretta caerulaea*
Tri-coloured heron	*Egretta tricolor*
Striated heron	*Butorides striata*
Agami heron	*Agamia agami*
Ibis	
Green ibis	*Mesembrinibis cayennensis*
Ducks	
Muscovy duck	*Cairina moschata*
Swallows	
White-winged swallow	*Tachycineta albiventer*
White-banded swallow	*Atticora fasciata*
Terns	
Large-billed tern	*Phaetusa simplex*
Other	
Anhinga	*Anhinga anhinga*
Neotropic cormorant	*Phalacrocorax brasilianus*
Osprey	*Pandion haliaetus*
Black Skimmer	*Rhynchops niger*

Results

4.1 Bird mist net surveys

467 individuals of 61 different bird species were caught across seven different sites (Table 1). The most commonly caught species were from the Pipridae family which is composed of the manakins, white-crowned and golden-headed were the most widely caught across all sites. Other diverse and well-populated families in the forest includes Thamnophilidae's (antshrikes, antwrens and antbirds), Furnariidae (woodcreepers and foliage gleaners) and Tyrannidae (pipits, flycatchers and flatbills). The Kabokalli site produced the most catches, even though the Turtle Bay site had the most number of net-hours invested in catching. Catching seemed very consistent across all sites with the exception of Kabokalli, where over one hundred individuals were caught. Over 4670 hours were invested in mist-net bird surveys from the 20th June 2015 to the 5th August 2015 (Table 2).

Table 1. Birds caught at different sites. Abbreviations: TUR (Turtle Mountain) KAB (Kabokalli) SAN (Sandstone) ROL (Rock Landing) CHA (Caraha Landing) LOG (Iwokrama Mill Site) and CWW (Canopy Walkway).

Family	Species	English name	TUR	KAB	SAN	ROL	CHA	LOG	CWW	TOTAL
Columbidae	*Leptotila rufaxilla*	Gray-fronted Dove				1				1
Columbidae	*Geotrygon montana*	Ruddy Quail-Dove		1						1
Strigidae	*Megascops watsonii*	Tawny-bellied Screech-Owl	3	1					1	5
Bucconidae	*Bucco capensis*	Collared Puffbird			1					1
Alcedinidae	*Chloroceryle inda*	Green-and-rufous Kingfisher	1							1
Picidae	*Celeus elegans*	Chestnut Woodpecker	1							1
Falconidae	*Micrastur gilvicollis*	Lined Forest-falcon			1					1
Thamnophilidae	*Thamnophilus murinus*	Mouse-colored Antshrike		2	1					3
Thamnophilidae	*Thamnophilus punctatus*	Northern Slaty-Antshrike				3				3
Thamnophilidae	*Isleria guttata*	Rufous-bellied Antwren	2	2		7	2	2	1	16
Thamnophilidae	*Epinecrophylla gutturalis*	Brown-bellied Antwren		5	1	1	1	2	3	13
Thamnophilidae	*Myrmotherula axillaris*	White-flanked Antwren	1	1	3		4			9
Thamnophilidae	*Myrmotherula menetriesii*	Gray Antwren	4	6	1			1		12

Thamnophilidae	*Myrmotherula longipennis*	Long-winged Antwren	6	4		2		4	3	19
Thamnophilidae	*Thamnomanes ardesiacus*	Dusky-throated Antshrike	4	4	3	1		3	2	17
Thamnophilidae	*Thamnomanes caesius*	Cinereous Antshrike	6	2	4	1	2	3	1	19
Thamnophilidae	*Hypocnemis cantator*	Guianan Warbling-Antbird	1	2				1		4
Thamnophilidae	*Hypocnemoides melanopogon*	Black-chinned Antbird	1							1
Thamnophilidae	*Cercomacra tyrannina*	Dusky Antbird			1		1	1		3
Thamnophilidae	*Myrmoborus leucophrys*	White-browed Antbird					3			3
Thamnophilidae	*Myrmeciza ferruginea*	Ferruginous-backed Antbird			2	3	2			7
Thamnophilidae	*Gymnopithys rufigula*	Rufous-throated Antbird	1	7	2	3	4	3	1	21
Thamnophilidae	*Pithys albifrons*	White-plumed Antbird	2	3	3	1	1	7	1	18
Thamnophilidae	*Willisornis poecilinotus*	Common Scale-backed Antbird	8	6	4	1		3		22
Thamnophilidae	*Myrmornis torquata*	Wing-banded Antbird	2							2
Formicariidae	*Formicarius colma*	Rufous-capped Antthrush		1		2		2		5
Formicariidae	*Formicarius analis*	Black-faced Antthrush						1		1
Furnariidae	*Deconychura longicauda*	Long-tailed Woodcreeper							1	1
Furnariidae	*Dendrocincla fuliginosa*	Plain-brown Woodcreeper		6	1		1	2	1	11
Furnariidae	*Dendrocincla merula*	White-chinned Woodcreeper	1							1
Furnariidae	*Glyphorhynchus spirurus*	Wedge-billed Woodcreeper	15	6	6	4	5		3	39
Furnariidae	*Xiphorhynchus pardalotus*	Chestnut-rumped Woodcreeper	2	2				1	1	6
Furnariidae	*Xiphorhynchus guttatus*	Buff-throated Woodcreeper		1		2	1		1	5
Furnariidae	*Dendrocolaptes certhia*	Amazonian Barred-Woodcreeper					1	1		2
Furnariidae	*Hylexetastes perrotii*	Red-billed Woodcreeper		3				1		4
Furnariidae	*Xenops minutus*	Plain Xenops	1	2						3
Furnariidae	*Automolus infuscatus*	Olive-backed Foliage-gleaner							1	1
Tyrannidae	*Corythopis torquatus*	Ringed Antpipit						1		1
Tyrannidae	*Myiobius barbatus*	Sulphur-rumped Flycatcher	1	2					1	4

Tyrannidae	*Mionectes oleagineus*	Ochre-bellied Flycatcher		2	2		3	2	2	11
Tyrannidae	*Mionectes macconnelli*	McConnell's Flycatcher	3	4	2			1	1	11
Tyrannidae	*Lophotriccus galeatus*	Helmeted Pygmy-Tyrant	1							1
Tyrannidae	*Terenotriccus erythrurus*	Ruddy-tailed Flycatcher	2	1					2	5
Tyrannidae	*Onycorhynchus coronatus*	Royal Flycatcher			1	1	1		1	4
Tyrannidae	*Rhynchocyclus olivaceus*	Olivaceous Flatbill		3					1	4
Tyrannidae	*Platyrinchus saturatus*	Cinnamon-crested Spadebill		1				2	1	4
Tyrannidae	*Platyrinchus platyrhynchos*	White-crested Spadebill			1				2	3
Tyrannidae	*Ramphotrigon ruficauda*	Rufous-tailed Flatbill						1		1
Tyrannidae	*Attila spadiceus*	Bright-rumped Attila					1			1
Tityridae	*Schiffornis olivacea*	Olivaceous Schiffornis						2	1	3
Pipridae	*Dixiphia pipra*	White-crowned Manakin	11	16	11	2	10	28	3	81
Pipridae	*Pipra erythrocephala*	Golden-headed Manakin		3		7	2	5	1	18
Pipridae	*Manacus manacus*	White-bearded Manakin					1			1
Vireonidae	*Tunchiornis ochraceiceps*	Tawny-crowned Greenlet		3	1	2		2	4	12
Troglodytidae	*Pheugopedius coraya*	Coraya Wren					1			1
Polioptilidae	*Ramphocaenus melanurus*	Long-billed Gnatwren							1	1
Turdidae	*Turdus albicollis*	White-necked Thrush			1		1			2
Cardinalidae	*Cyanocompsa cyanoides*	Blue-black Grosbeak	2		2		2		1	7
Emberizidae	*Arremon taciturnus*	Pectoral Sparrow					1			1
Thraupidae	*Ramphocelus carbo*	Silver-beaked Tanager								0
Thraupidae	*Thraupis palmarum*	Palm Tanager								0

Thraupidae	*Tachyphonus surinamus*	Fulvous-crested Tanager	3	1				2	1	7
Thraupidae	*Tachyphonus cristatus*	Flame-crested Tanager		1						1
		Total per site:	85	104	55	40	55	84	44	467
									Total	**467**

Table 2. Net-hours and effort for each site surveyed during the summer season.

Date	Site	Net-hours	
20-Jun-15	TUR	94.995	
21-Jun-15	TUR	152.505	
22-Jun-15	TUR	152.505	
22-Jun-15	TUR	7.334	
22-Jun-15	TUR	2.167	
23-Jun-15	TUR	180	
24-Jun-15	TUR	180	
25-Jun-15	TUR	117	
Total	**Turtle Mountain**		**886.506**
27-Jun-15	KAB	108	
28-Jun-15	KAB	84	
29-Jun-15	KAB	184.5	
30-Jun-15	KAB	180	
01-Jul-15	KAB	117	
Total	**Kabokalli**		**673.5**
05-Jul-15	SAN	81	
06-Jul-15	SAN	135	
07-Jul-15	SAN	149.94	
08-Jul-15	SAN	189	
09-Jul-15	SAN	117	
Total	**Sandstone**		**671.94**
12-Jul-15	ROL	72	
13-Jul-15	ROL	160	
14-Jul-15	ROL	103.5	
14-Jul-15	ROL	54	
15-Jul-15	ROL	103.5	
16-Jul-15	ROL	63	
Total	**Rock Landing**		**556**
18-Jul-15	CHA	39	
19-Jul-15	CHA	72	

20-Jul-15	CHA	30	
21-Jul-15	CHA	147	
22-Jul-15	CHA	180	
23-Jul-15	CHA	90	
Total	**Caraha Landing**		**558**
25-Jul-15	LOG	63	
26-Jul-15	LOG	72	
27-Jul-15	LOG	126	
27-Jul-15	LOG	3	
28-Jul-15	LOG	168	
29-Jul-15	LOG	189	
30-Jul-15	LOG	117	
Total	**Iwokrama Mill Site**		**738**
01-Aug-15	CWW	84	
02-Aug-15	CWW	105	
03-Aug-15	CWW	138.75	
04-Aug-15	CWW	142.5	
05-Aug-15	CWW	117	
Total	**Canopy Walkway**		**587.25**
	Grand Total		**4671.196**

4.2 Bird sound scape analysis

Guyana is the first site where we have trialled the use of soundscape analysis in order to assess avian communities in tropical rainforests. Four devices were rigorously tested and successfully completed sound recordings from pre-dawn to mid-morning at a series of sites around Iwokrama and surrounding forests. Experienced ornithologists were then able to 'train' software to automatically detect the calls of different species' (of interest). We found this to be an incredibly efficient method for assessing bird communities and also a way of producing verifiable records of the species identified. This analysis managed to cover a highly representative spectrum of species occurring in all strata of the tropical forest ecosystem. From these pilots, we now have established where is best to site the apparatus, the most optimal duration for recordings, its ability to recognize bird calls and have drawn together a list of 30 target species of which we have pre-trained software to detect in preparation for the field season (Table 3). Our next stage is to develop a systematic methodology of which we can detect calls remotely across extensive periods of space and time in an accurate, consistent and repeatable way which will be superior to the previously used manned point-counts methods. Additionally, we aim to create sound samples which are considerably more natural than those from manned observations.

Table 3. List of 30 target avian species established from the 2015 season.

Scientific name	English name	Reasons for choice
Tinamus major	Great Tinamou	hunted
Crypturellus variegatus	Variegated Tinamou	hunted, forest indicator
Micrastur mirandollei	Slaty-backed Forest-falcon	rare
Psophia crepitans	Grey-winged Trumpeter	hunted, forest indicator
Patagioenas subvinacea	Ruddy Pigeon	red list, test for automated ID
Ara macao	Scarlet Macaw	CITES, test for automated ID
Amazona farinosa	Mealy Parrot	forest indicator
Pionus fuscus	Dusky Parrot	Endemic
Neomorphus rufipennis	Rufous-winged Ground-cuckoo	endemic, forest indicator
Galbula dea	Paradise Jacamar	canopy flock sp
Deconychura longicauda	Long-tailed Woodcreeper	Rare
Hylexetastes perrotii	Red-billed Woodcreeper	Rare
Frederickena viridis	Black-throated Antshrike	rare, endemic
Thamnomanes caesius	Cinereous Antshrike	understory flock sp
Myrmeciza ferruginea	Ferruginous-backed Antbird	Endemic
Gymnopithys rufigula	Rufous-throated Antbird	ant follower (forest-indicator); endemic
Myrmornis torquata	Wing-banded Antbird	rare, patchy distribution
Formicarius colma	Rufous-capped Antthrush	forest indicator
Myrmothera campanisona	Thrush-like Antpitta	forest indicator
Hylopezus macularius	Spotted Antpitta	forest indicator
Corythopis torquatus	Ringed Antpipit	forest indicator
Tolmomyias assimilis	Yellow-margined Flycatcher	canopy flock sp
Pachyramphus marginatus	Black-capped Becard	canopy flock sp
Schiffornis olivacea	Olivaceous Schiffornis	endemic
Piprites chloris	Wing-barred Piprites	forest indicator
Cyphorhinus arada	Musician Wren	forest indicator, test for automated ID (variable song)
Vireolanius leucotis	Slaty-capped Shrike-Vireo	canopy flock sp
Pachysylvia muscicapina	Buff-cheeked Greenlet	canopy flock sp
Periporphyrus erythromelas	Red-and-black Grosbeak	rare, endemic
Cyanocompsa cyanoides	Blue-black Grosbeak	forest indicator

4.3 Bat mist net surveys

27 species of bat and 231 individuals were captured using mist nets. Table 4 shows relative abundance of these species including sex and age ratios in addition to mean adult morphometric measurements taken. *Artibeus planirostris* was the most commonly caught species from the overall most common family of bats found in the Guianan Sheild, Stenodernatinae, totalling to nine different species caught from this family alone. Catching juveniles was a relatively rare occurrence, with juveniles only sampled for five out of 29 species caught over the season.

The current known bat species diversity to data is 88 with the most recent additions being two species in 2011 (Furipteridae: *Furipterus horrens;* Phyllostomidae: *Mimon bennetti*) caught in mist-nets in the Iwokrama Forest (Lim & Engstrom 2005) (Fig 4).

Table 4. Summary of bat mist net data for all species.

Species	Family	Female/ Male ratio	Adult/ Juvenile ratio	Mean adult forearm (mm)	Mean adult weight (g)
Artibeus cinereus	Stenodernatinae	2:0	2:0	40.5	12.0
Artibeus gnomus	Stenodernatinae	2:0	2:0	34.0	9.5
Artibeus lituratus	Stenodernatinae	16:5	18:3	72.6	64.5
Artibeus obscurus	Stenodernatinae	5:19	24:0	60.4	35.0
Artibeus planirostris	Stenodernatinae	24:35	53:6	65.7	47.4
Carollia brevicauda	Caroliinae	0:1	1:0	38.0	15.0
Carollia perspicillata	Caroliinae	17:12	29:0	42.1	16.5
Chrotoperus auritus	Phyllostominae	0:1	1:0	86.0	71.0
Desmodus rotundus	Desmodontinae	0:1	1:0	56.0	26.0
Glossophaga soricina	Glossophaginae	1:0	1:0	36.0	10.0
Lionycteris spurrelli	Glossophaginae	0:1	1:0	37.0	6.0
Lonchopylla thomasi	Glossophaginae	3:3	6:0	33.5	8.0
Lophostoma brasiliense	Phyllostominae	0:1	1:0	37.0	13.0
Lophostoma carrikeri	Phyllostominae	0:1	1:0	49.0	35.0
Lophostoma schulzi	Phyllostominae	0:1	1:0	45.0	15.0
Lophostoma silvicolum	Phyllostominae	10:4	12:2	58.3	37.2
Mesophylla macconnelli	Stenodernatinae	1:0	1:0	32.0	8.0
Mimon cernulatum	Phyllostominae	3:5	8:0	49.8	13.4
Phyllostomus elongatus	Phyllostominae	2:4	5:1	68.4	41.2
Phyllostomus hastatus	Phyllostominae	0:1	1:0	88.0	74.0
Pteronotus parnellii	Mormoopidae	12:4	16:0	63.6	23.3
Rhinophylla pumilio	Caroliinae	11:12	22:1	34.1	8.7
Sturnira lilium	Stenodernatinae	1:0	1:0	42.0	17.0
Sturnira tildae	Stenodernatinae	1:0	1:0	42.0	-
Tonatia saurophila	Phyllostominae	0:2	2:0	57.5	18.0
Trachops cirrhosus	Phyllostominae	1:3	1:3	62.0	36.0
Vampyressa bidens	Stenodernatinae	0:2	2:0	36.0	12.0

Figure 4. Left: the 'thumbless bat' *Furipterus horrens* and Right: the 'golden bat' *Mimon bennettii*.

4.4 Transect sampling for large mammals and large-ranging birds

All target large-ranging birds (or functional groups) were detected at each site. Surama village had the highest species diversity at 31 species, notably higher than any other site surveyed. Mill site had the largest abundance of animals surveyed at 190, resulting in the highest ratio of species diversity

and species abundance, making it the most biodiverse site sampled but closely followed by the Kabocalli site (Table 5). Of the birds, the red and green macaws were the most common species observed and of the mammals, the same species were consistently dominating observations across the forest: red brocket deer, red-rumped agouti, lowland tapir and dasypus species (Figs 5 & 6).

Figure 5. More commonly-observed mammal species (from top left clockwise): dasypus species, lowland tapir, red brocket deer and red-rumped agouti.

Table 5. Species diversity and abundance observed at difference sites surveyed for large mammals and large-ranging birds.

Sites	Total number of species	Total count of animals	Species abundance/ species diversity	Top 3 most common species
Canopy walkway	22	84	3.8	red brocket deer; red-rumped agouti; lowland tapir
Kabocalli	18	123	6.8	dasypus sp; red brocket deer; lowland tapir
Mill site	25	190	7.6	red-rumped agouti; red brocket deer; dasypus sp
Rock landing	23	87	3.8	red and green macaws; red-rumped agouti; lowland tapir
Sandstone	15	87	5.8	red brocket deer; lowland tapir; red-rumped agouti
Surama pond	17	35	2.1	red brocket deer; lowland tapir; red-rumped agouti
Surama village	31	80	2.6	red-rumped agouti; red and green macaws; dasypus sp
Turtle mountain	23	125	5.4	dasypus sp; red-rumped agouti; paca

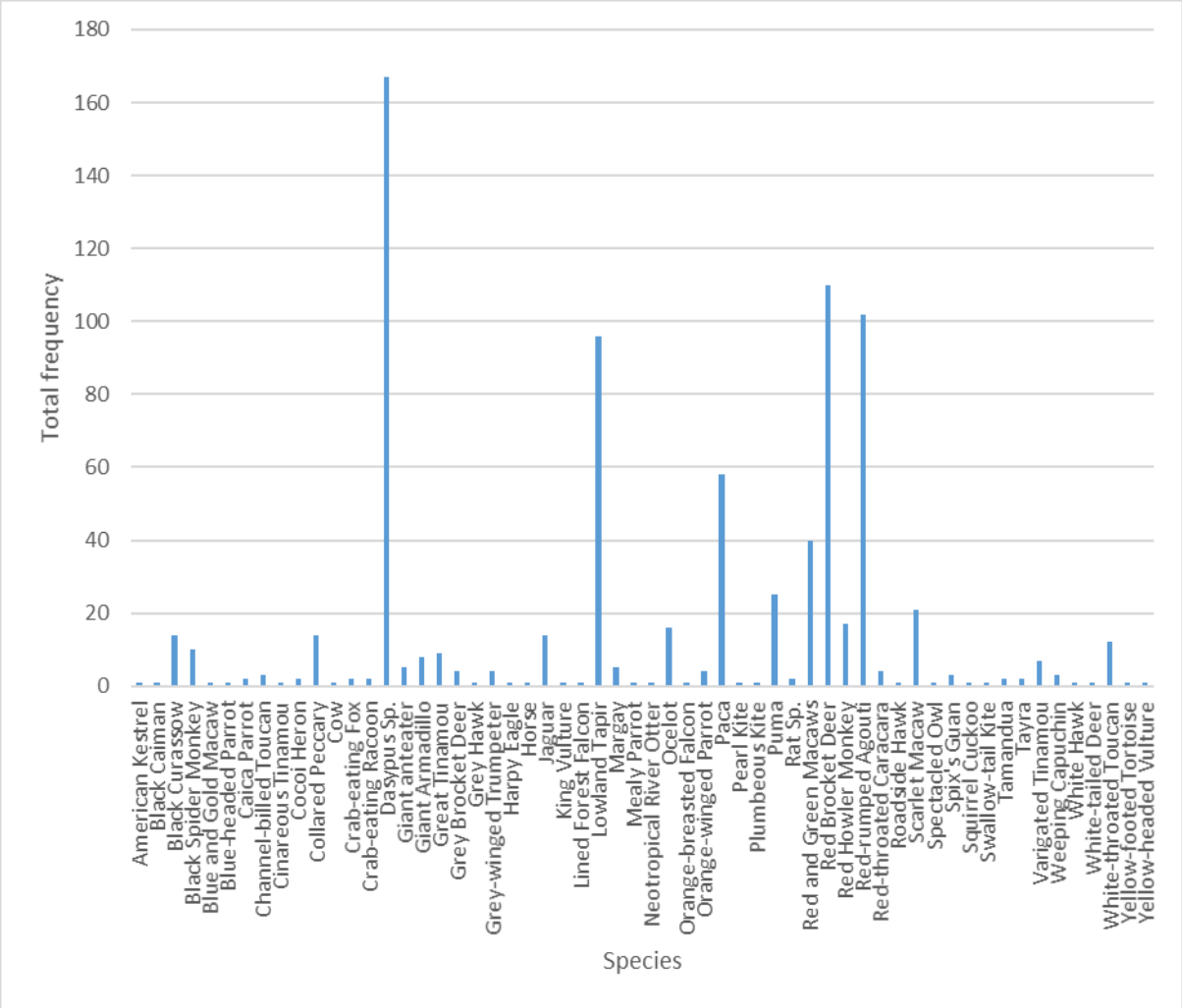


Figure 6. Large mammal and bird encounters measured as total frequency across all sites.

It is clear that a large proportion of this data was from signs found during surveys, which emphasises the importance of having highly skilled field scientists that are able to identify species-specific tracks, marks and prints (Fig 7).

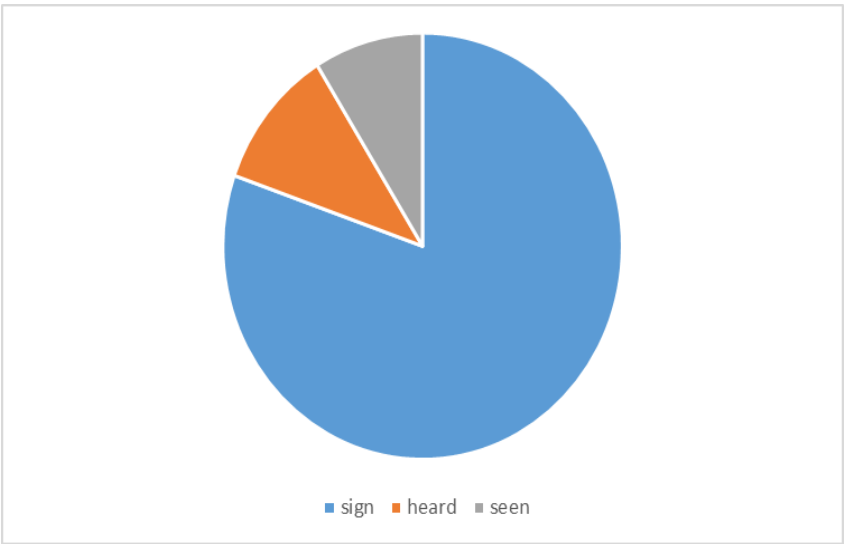


Figure 7. Proportion of recordings from sign identification, hearing or seeing animals in the field

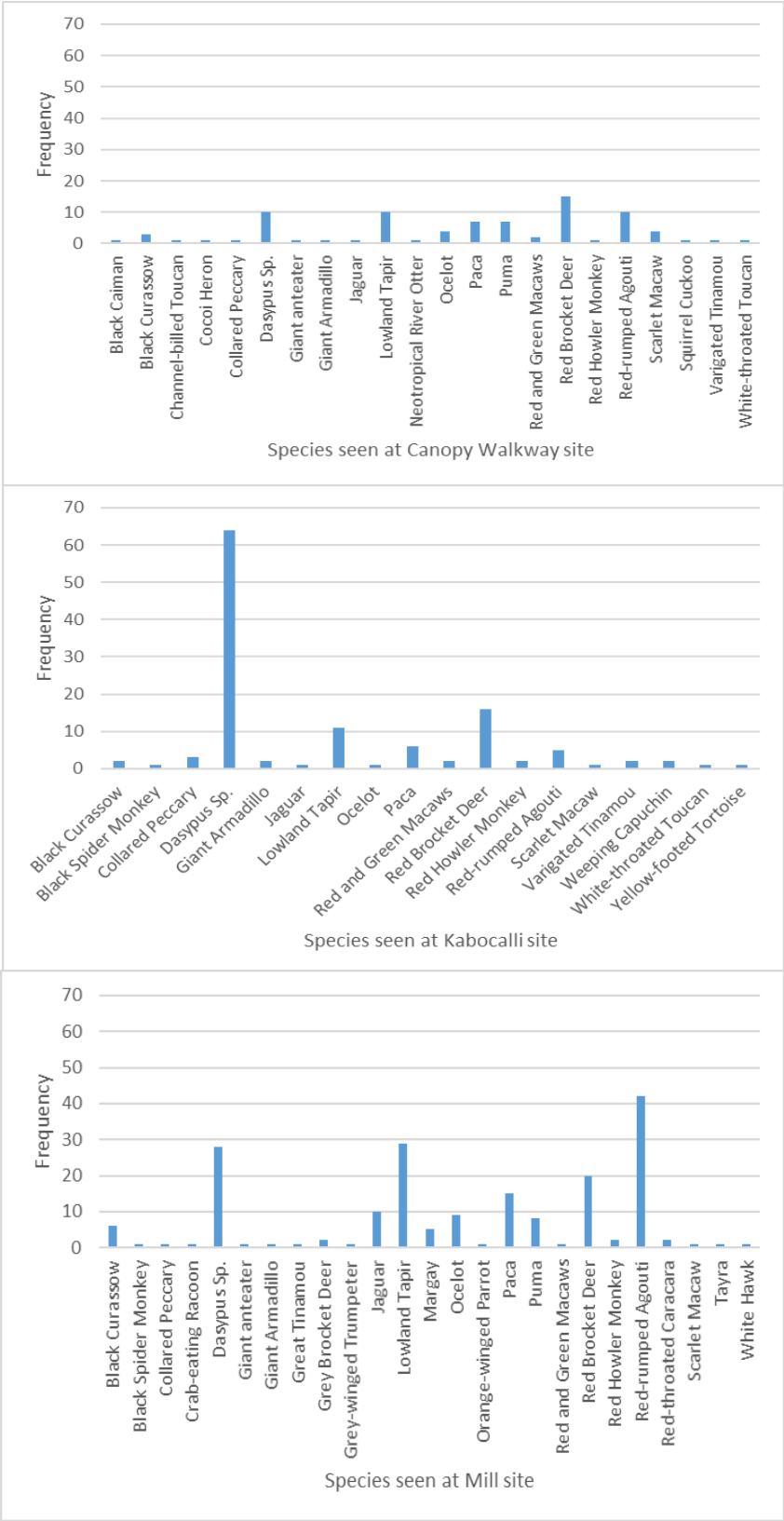
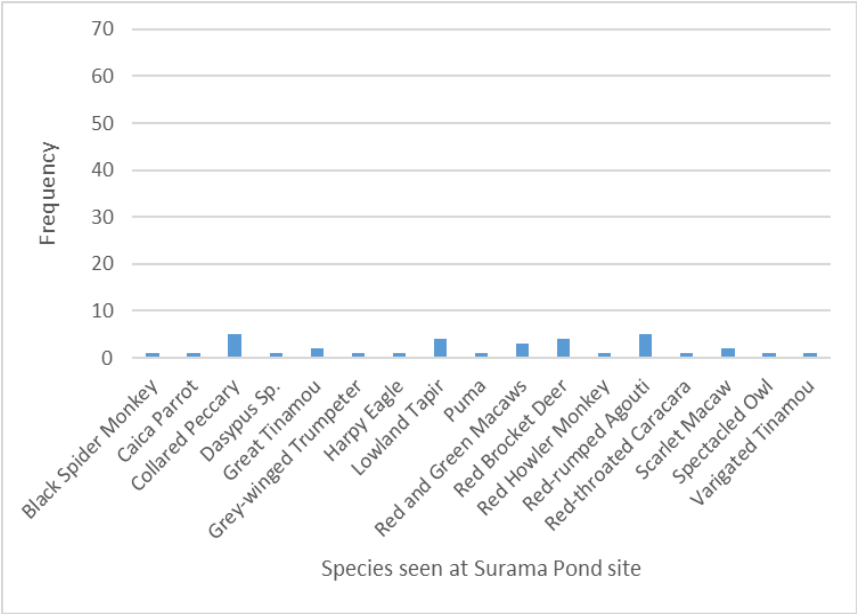
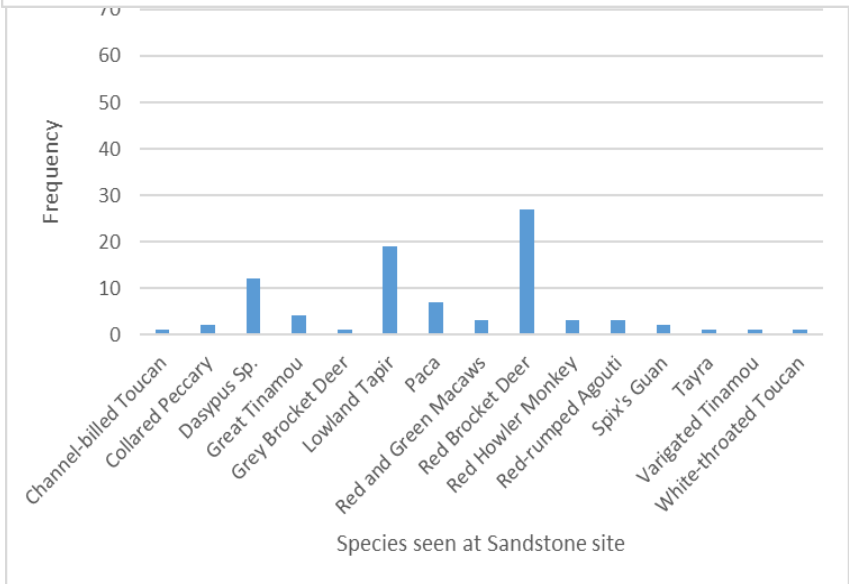


Figure 8. Large mammal and bird encounters measured frequency counts for each site surveyed.





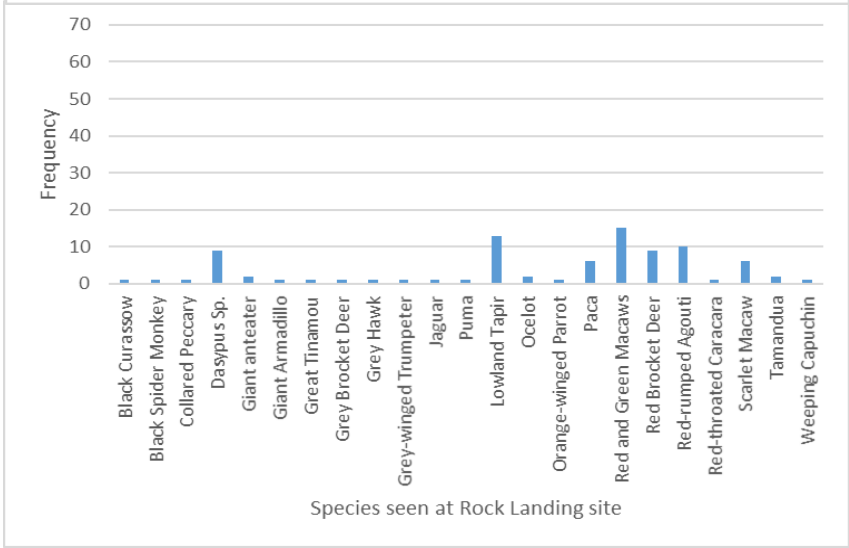


Figure 8. Large mammal and bird encounters measured frequency counts for each site surveyed.

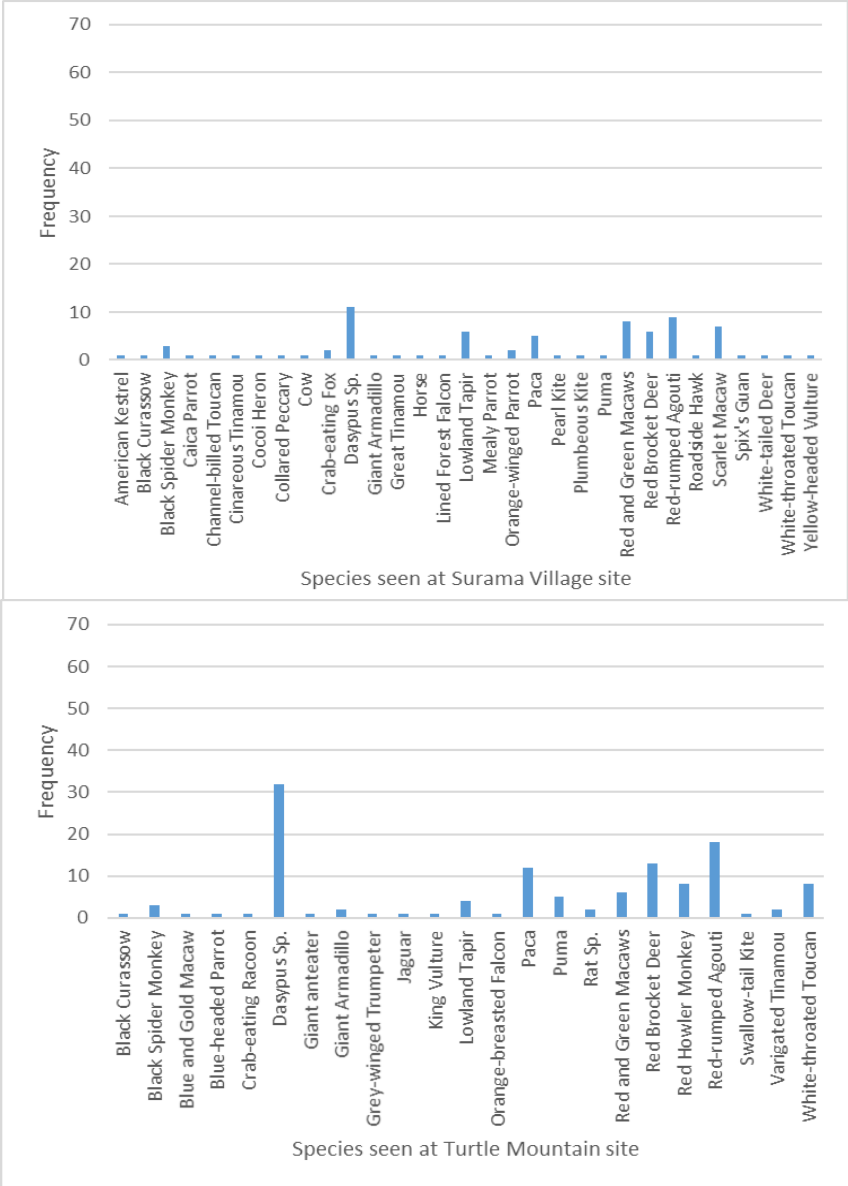


Figure 8. Large mammal and bird encounters measured frequency counts for each site surveyed.

4.5 Herpetofauna surveys

To date, 84 species of reptile (50) and amphibian (34) were recorded using day-time and night-time visual encounter surveys, opportunistic surveys and pit-fall trapping throughout the Iwokrama and Surama forests. Species diversity showed no marked difference between sites. However, species composition varies greatly depending on the site as shown previously for the years 2011-2014 (Table 6) when two species of snake (*Philodryas viridissimus, Oxyrhopus occipitalis*) were not previously recorded in the Iwokrama Forest and were found at the Canopy Walkway site and Turtle Mountain respectively, increasing the known reptile species diversity to 84 species (Donnelly et al. 2005). Unfortunately, data for the 2015 season is inaccessible and will not be available for this report but we can include our most recent data for herpetofauna at our site, collected from 2011-2014 seasons (Table 6).

Table 6. Summary herpetile species richness per site from 2011 – 2014 data.

Site	Species diversity (No. sp. caught)
Turtle Mountain	39
Kabocalli	38
Canopy Walkway	36
Sandstone	41
Rock Landing	41
Pooled (all sites)	84

4.6 Dung beetle surveys

Dung beetle (Coleoptera: Scarabaeidae) sampling in 2015 was interrupted when the entomologist (Dan Fitzpatrick) had to leave the country because of emergency family circumstances. His summary of fieldwork for the season is below and all raw data is secure at the Iwokrama research facility for retrieval in the 2016 season.

> Beetles collected were identified to species if possible, using a dichotomous key provided by a previous entomologist on the OpWall team. This key was easy to use overall, and allowed us to identify over half the beetles with ease. The other beetles were often too small to positively identify without proper microscopy equipment and were saved in ethanol provided by the Iwokrama team for future identification if someone chooses to do so. All data on beetles collected each day was logged in a blue notebook left at the Iwokrama Research Centre. Unfortunately, I was not able to enter the data into a database as I was forced to leave Guyana to attend to a family emergency in the US. Overall, the traps were very successful for catching insects, with traps yielding upwards of 120+ insects each. Based on my recollection, a day's worth of traps typically yielded between eight to fifteen different species of beetles. *Ateuchus* spp. and *Canthon triangularis* were the most commonly collected beetles at each site.
>
> I plan to join the OpWall team in Guyana for the several weeks in the 2016 field season and to the extent feasible, collected specimens from 2015 will be shipped to St. George's University in Grenada for identification. Additionally, because a lack of fecal donations often limited how many traps could be placed each day, new ways to make it less of an imposition for students and staff to donate their "specimens" will be pursued.

4.7 Forest structure

104 tree species were identified in the surveys of the Iwokrama forest in the summer season of 2015 (Figure 9). There was a significant difference in canopy and leaf litter measures across the master plots distributed across the Iwokrama forest ($F = 14.5$, $df = 213$, $P < 0.001$; $F = 5.0$, $df = 214$, $P < 0.001$ respectively) and a significant difference of the numbers of saplings ($F = 3.7$, $df = 163$, $P < 0.001$) (Figure 10).

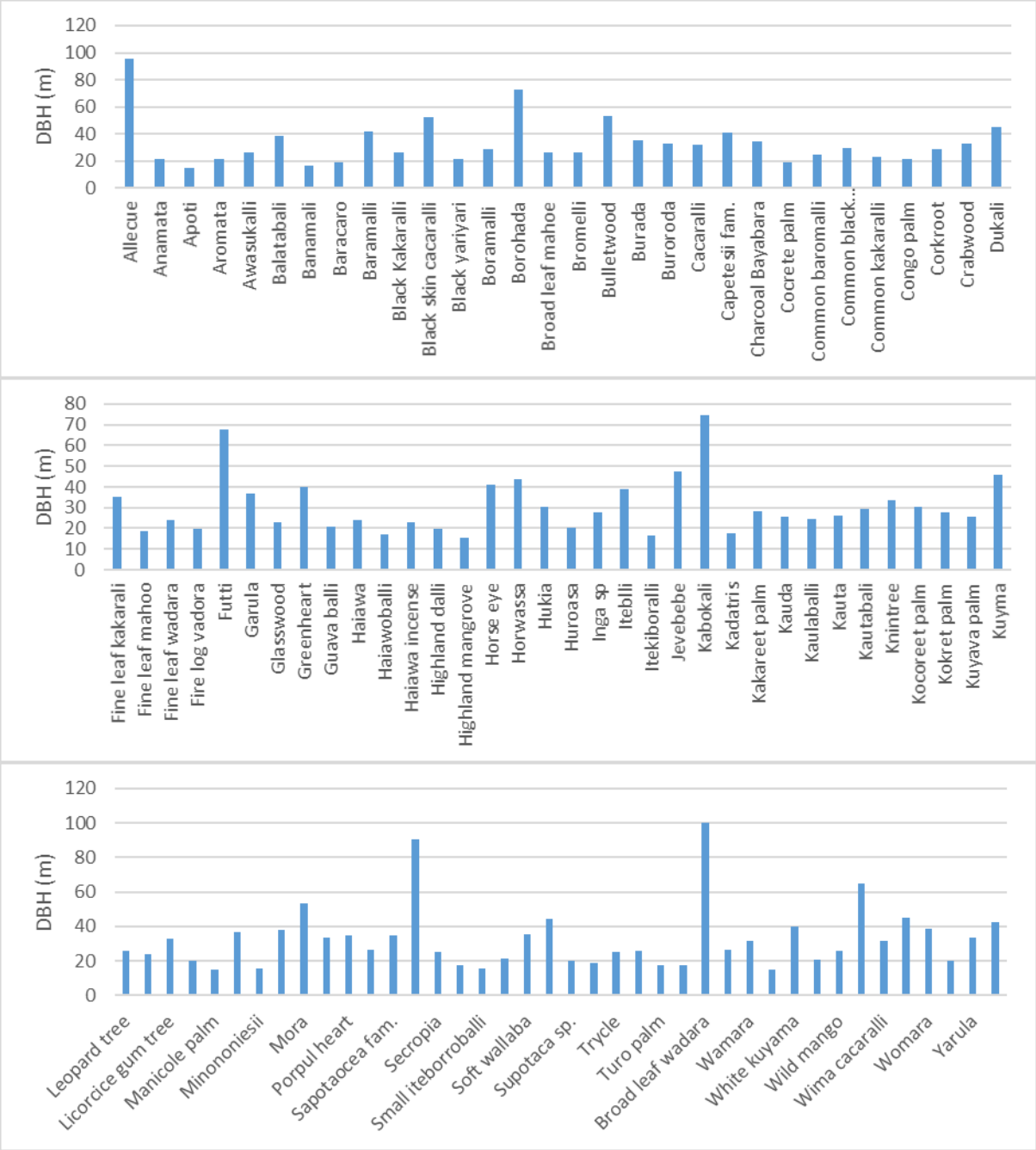
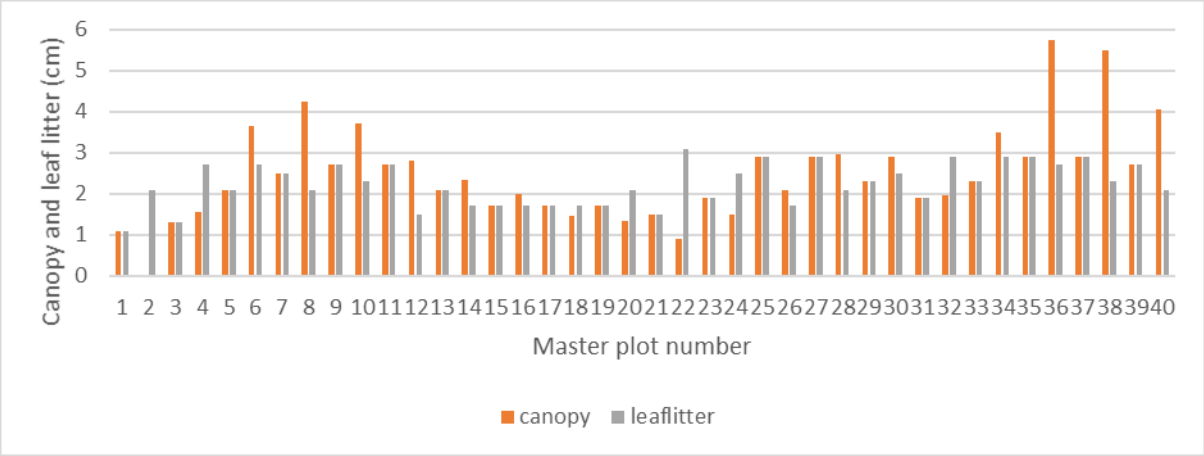


Figure 9. The mean diameter at breast height of different species (common names, listed A-Z) of living trees surveyed in the Iwokrama forest.



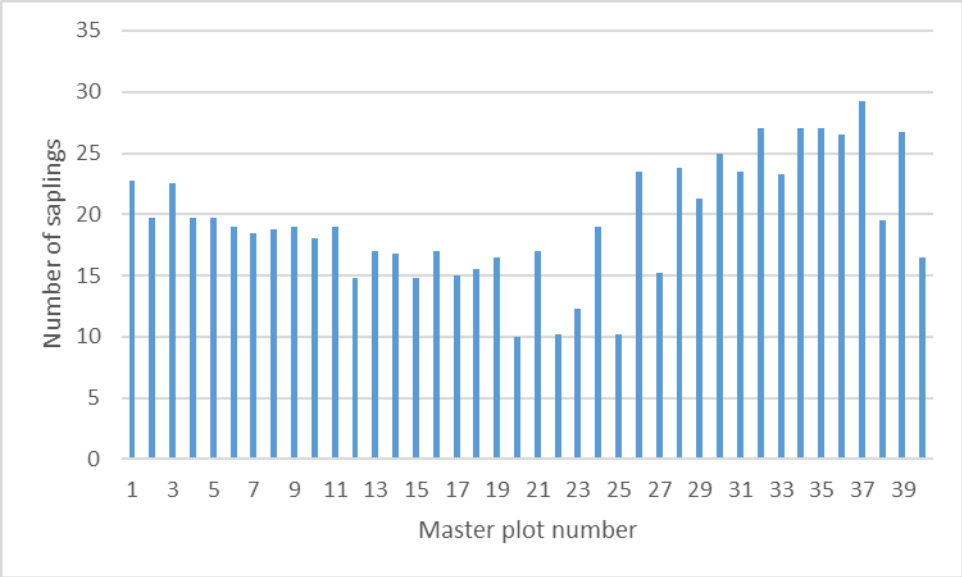


Figure 10. Canopy and leaf litter measures and number of saplings observed at each of the 40 master plots across Iwokrama forest in 2015.

4.8 Burro-Burro River surveys

Mammals

Overall, we observed four mammal species: river bats (n = 102), howler monkeys (n = 1), river otters (n = 2) and wedge-capped capuchins (n = 1) (Fig 1).

The river bats were variable in numbers over the sampling period, ranging from 3 – 19 seen in one day. Only one howler monkey and one wedge-capped capuchin was seen throughout the whole sampling period whereas one river otter was seen at the start and close to the end of the sampling period (Fig 2).

The mean number of river bats seen on any day was 10, whereas the chances of seeing any other mammal species was incredibly low with a mean number of 0.2 for the river otters and 0.1 for both howler monkeys and wedge-capped capuchin.

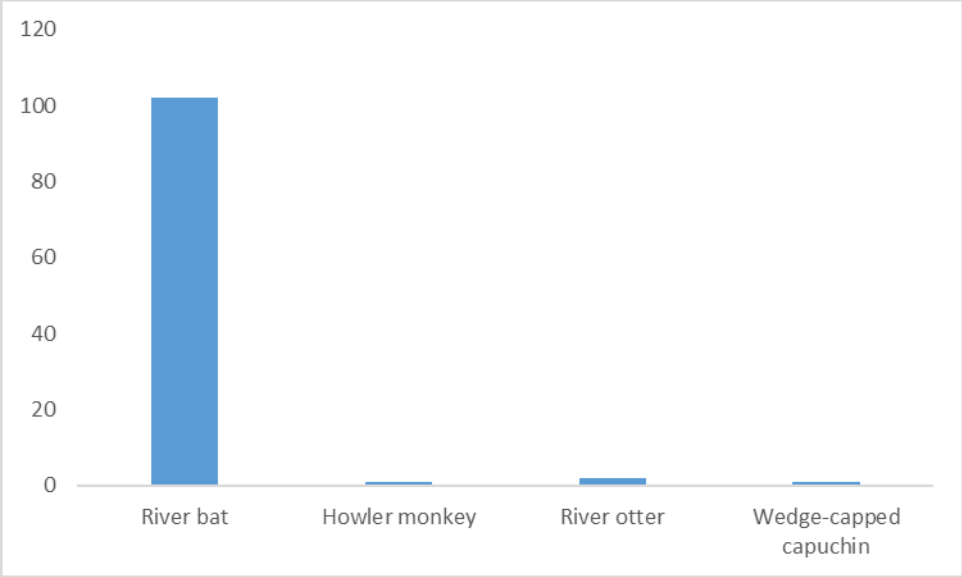


Fig 1. Total frequencies of mammal species observed over the ten days of river transect surveys.

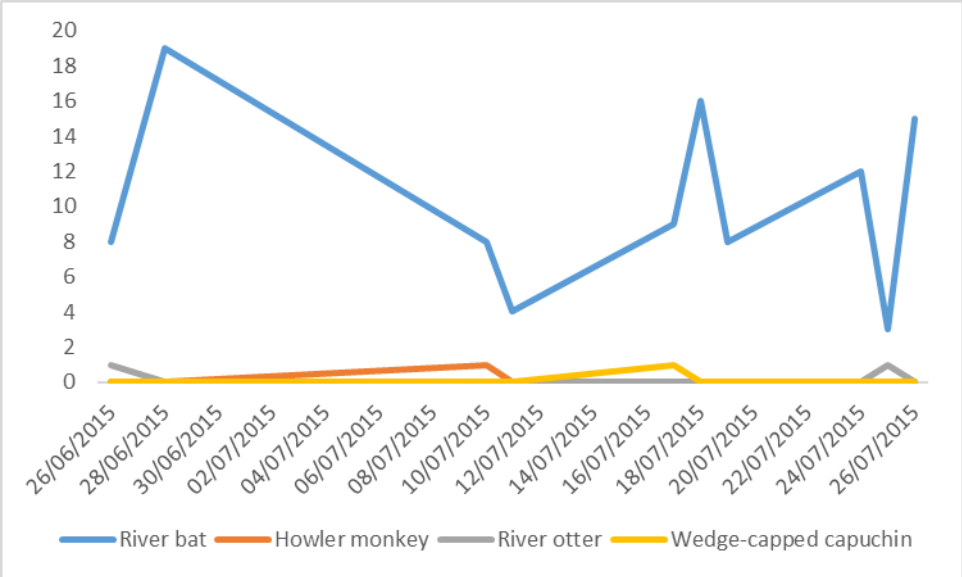


Fig 2. Daily frequencies of mammal species observed during the river transect surveys.

Birds

Overall, we observed 15 bird species: agami heron (n = 1), amazon kingfisher (n = 25), American pygmy kingifhser (n = 2), the anhinga snake bird (n = 2), cocoi heron (n = 49), green and rufous kingfisher (n = 15), green ibis (n = 3), green kingfisher (n = 28), red and green macaw (n = 1), ringed kingfisher (n = 40), rufescent tiger-heron (n = 1), scarlet macaw (n = 3), striated heron (n = 3), white-banded swallow (n = 110) and white-winged swallow (n = 1) (Fig 3).

The ratio of species number to number of individuals sighted was variable throughout, ranging from < 2 up to > 8 individuals per species seen that day but this was largely determined by the stochastic large groups of Hirundines (white-banded swallow) on particular days and large flocks of Cocoi heron moving up and down the river. On average, the same species were consistently being sighted with only the occasional sighting of more cryptic species (Fig 8).

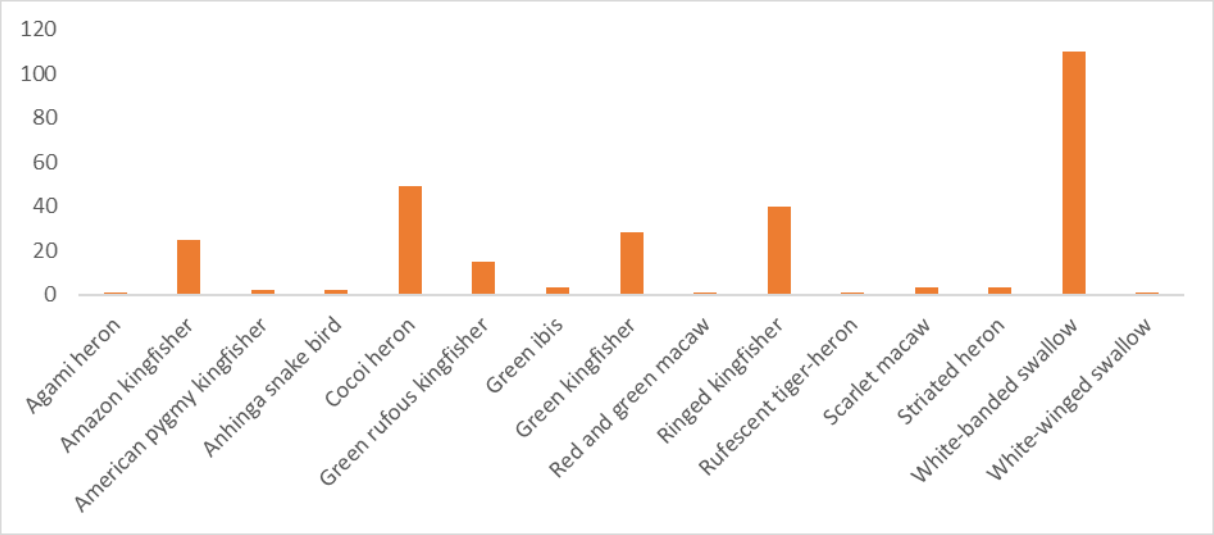


Fig 3. Total frequencies of bird species observed over the ten days of river transect surveys.

The birds were a far more diverse and abundant class of animals inhabiting the river. There were four species of heron, five species of kingfisher, two species of swallow, two species of macaw and then one ibis and one snake bird species.

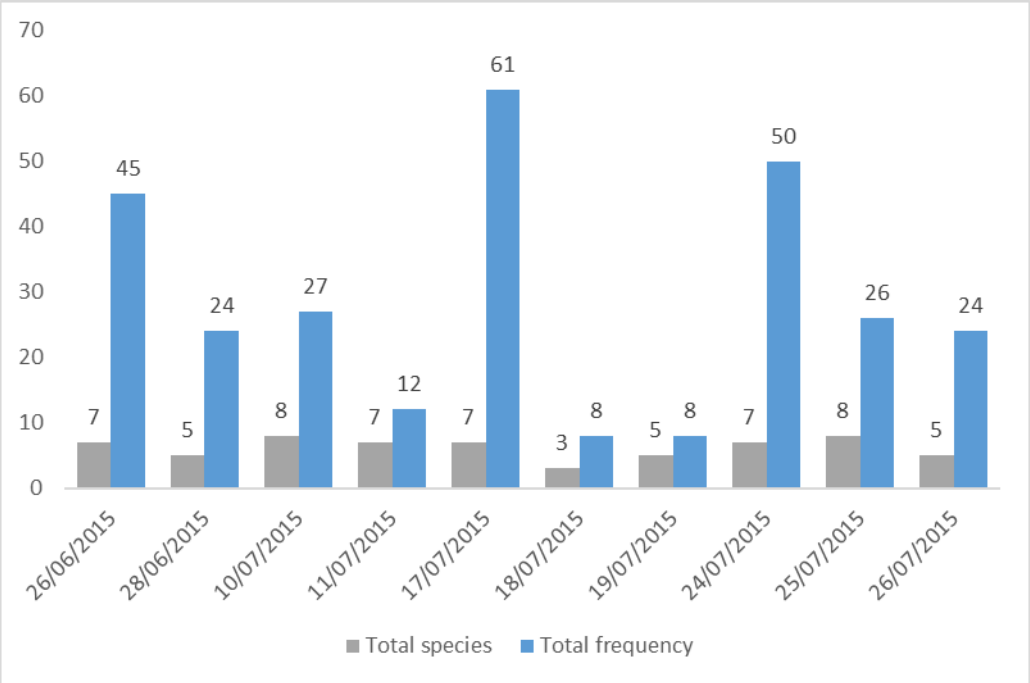


Fig 8. Total number of species and total counts of all species on each of the ten days surveying.

Table 1. Detailed avian species list and counts.

Date	Species	Frequency
26/06/2015	Amazon kingfisher	7
	Anhinga (snake bird)	1
	Cocoi Heron	3
	Green & rufous kingfisher	4
	Green kingfisher	3
	Ringed kingfisher	6
	White-banded swallow	21
28/06/2015	Agami Heren	1
	Cocoi Heron	16
	Green & rufous kingfisher	2
	Ringed kingfisher	3
	White-banded swallow	2
10/07/2015	Amazon kingfisher	2
	American pygmy kingfisher	2
	Cocoi Heron	2
	Green & rufous kingfisher	3
	Green ibis	1
	Green kingfisher	6
	White-banded swallow	10
	White-winged swallow	1
11/07/2015	Amazon kingfisher	1
	Cocoi Heron	4
	Green & rufous kingfisher	1
	Green kingfisher	1
	Red and green Macaw	1
	Scarlet Macaw	3
	White-banded swallow	1
17/07/2015	Amazon kingfisher	4
	Cocoi Heron	8
	Green & rufous kingfisher	1
	Green ibis	1
	Green kingfisher	6
	Ringed kingfisher	11
	White-banded swallow	30

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