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GLOBAL WILDLIFE CONSERVATION

Biodiversity Assessment Survey of the Kaieteur Plateau and Upper Potaro, Guyana

Leeanne E. Alonso, Juliana Persaud, and Aiesha Williams (Editors)

BAT Survey Report No. 2

Unexpected encounter!
Herpetologist Andrew Snyder encountered a rotting tree stump with numerous holes while out on a night hike in primary rainforest along the upper Potaro River. Shining his flashlight into a large hole revealed this possibly undescribed tarantula (Subfamily: Ischnocolinae). Other tarantulas of the same species occupied various other small holes, implying that this may be a communal species, which is an uncommon behaviour in tarantulas. Tarantulas in the subfamily Ischnocolinae lack urticating, or irritating, hairs, which are often the first line of defence for New World tarantulas.

This BAT Survey and Report were made possible through a collaboration of:

WWF-Guianas
WWF is one of the world's largest and most experienced independent conservation organizations, with over five million supporters and a global network active in more than 100 countries. WWF has been active in the Guianas since the 1960s, starting with conservation work on marine turtles. The Guianas office opened in 1998. The mission of WWF-Guianas is to conserve distinct natural communities, ecological phenomena, and maintain viable populations of the species of the Guianas in order to sustain important ecological processes and services that maintain biodiversity, while supporting the region's socio-economic development.

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Global Wildlife Conservation's mission is to protect endangered species and habitats through science-based field action. GWC is dedicated to ensuring that the species on the verge of extinction are not lost, but prosper well into the future. GWC brings together scientists, conservationists, policy-makers, industry leaders and individuals to ensure a truly collaborative approach to species conservation and to meeting its goals of saving species, protecting wildlands and building capacity.

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Cover Photo: Kaieteur golden rocket frog - *Anomaloglossus beebei* © Pete Oxford

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BIODIVERSITY ASSESSMENT TEAM SURVEY

Biodiversity Assessment Survey of the Kaieteur Plateau and Upper Potaro Guyana

Field surveys were carried out from 2 to 31 March 2014

Leeanne E. Alonso, Juliana Persaud, and Aiesha Williams (Editors)

BAT Survey Report No. 2

A publication of
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2017

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Preface

Guyana's landscape is distinct in many ways, but most remarkable is that more than 85 per cent of it is still covered by rainforests, (the second highest proportion in the world, in terms of percentage of forest coverage relative to a country's total land mass), at a time when other countries are experiencing large-scale biodiversity loss and environmental degradation. At the same time, Guyana's biodiversity remains largely undocumented and poorly studied, leaving its national and regional governments and indigenous communities with a paucity of data on which to base land-use planning decisions.

This WWF (2017) publication represents a broad-based documentation of floral and faunal diversity in the Kaieteur Plateau and Upper Potaro region of Guyana, an area characterised by high levels of species endemism and unique highland habitats. The Biodiversity Assessment Team (BAT) surveys which were carried out in 2014 collected new data on terrestrial and freshwater taxonomic groups and also evaluated water quality to provide a comprehensive picture of biodiversity and habitats in the area. The BAT survey methods utilized internationally recognized sampling protocols and undertook limited specimen collection for future identification and/or archival purposes, both local and foreign. This BAT survey was initiated by the Guyana office of WWF-Guianas, with the close collaboration of Global Wildlife Conservation, the Guyana Protected Areas Commission and the Village of Chenapau.

THIS WWF (2017) PUBLICATION REPRESENTS A BROAD-BASED DOCUMENTATION OF FLORAL AND FAUNAL DIVERSITY IN THE KAIETEUR PLATEAU AND UPPER POTARO REGION OF GUYANA, AN AREA CHARACTERISED BY HIGH LEVELS OF SPECIES ENDEMISM AND UNIQUE HIGHLAND HABITATS

The team of experienced field biologists, taxonomists and student and local community research counterparts worked through challenging field conditions to survey flora and fauna, and worked just as diligently to interpret and present the findings in a meaningful way to government agencies involved in conservation and land-use planning, academics, NGOs and wider civil society. We have by no means captured in full the rich diversity and truly unique species of this ancient highland landscape. However, these results allowed us to put forward several recommendations for conservation and management, not only of the Kaieteur National Park, but also of the wider region. These are elaborated in the BAT Recommendations section as well as in each chapter, and we hope that in Guyana and more broadly, these stimulate important discussions on the protection of tropical forests and freshwater ecosystems, foster collaboration and mobilize strong, meaningful conservation actions.

WWF-Guianas and Global Wildlife Conservation are committed to ensuring that conservation and development objectives are achieved in a way which allows ecosystems and species to persist, and people to enjoy the benefits afforded by functioning ecosystems well into the future.

WWF-Guianas, Guyana Office
Global Wildlife Conservation

Acknowledgements

WWF-Guianas and the entire Biodiversity Assessment Team (BAT) are sincerely grateful to all the organizations, communities, and individuals who played a role in preparing for and carrying out this BAT Survey.

Our deepest gratitude goes to the Guyana Defence Force (GDF), without whose assistance the BAT Survey could not have covered such a wide area or reached such remote sites. The GDF staff worked beyond any reasonable expectation to support every aspect of the BAT expedition, from initial site assessments to the final evacuation of staff and equipment from the field. We are especially grateful for the decisive leadership and unceasing support of Brigadier General Mark Phillips, MSM, Chief of Staff, and Lieutenant Colonel Nazrul Hussain, MEM, Staff Officer One, Special Duties. We also recognize the tireless and thoughtful support of the Air Corps, led by Major Courtney Byrne, Commanding Officer, Air Corps and Helicopter Pilot; and Major Anson Weekes, Helicopter Pilot, who provided the fixed-wing and helicopter air transportation for our personnel, equipment and supplies in and out of the remote sites within the Pakaraima Mountains. The staff supporting these efforts included:

- Captain Kevin Moore - Flight Operations Officer
- Lieutenant Col. (ret.) Aziz Nezamudeen - Skyvan Pilot
- Major (ret.) Patrick Nichols - Skyvan Pilot
- Major Mohinder Ramjag - Skyvan Co-Pilot
- Major Miguel Benjamin - Skyvan Co-Pilot
- Captain Clarence Cornette - Helicopter Engineer
- Civilian Terrence Holder - Helicopter Engineer
- Sergeant Joel Paul - Helicopter Technician/Third Crew
- Sergeant Kirk Maxwell - Helicopter Technician/Third Crew
- Corporal Travis Edwards - Flight Dispatcher
- Corporal Joel Yaw - Trainee Helicopter Technician/Third Crew

We are also grateful to Major Sheldon Howell, Officer Commanding, 31 Special Forces Squadron, and Lieutenant Avinash Deonarine, Troop Commander, 31 Special Forces Squadron, for their willingness to assist in accessing the most remote areas. Sergeant Benjamin Hooper, Medic, 31 Special Forces Squadron and Corporal Decius Robin, Medic, Medical Corps, proved to be good-natured escorts for the BAT Survey teams in the field and provided emergency medical support as needed.

We could not have overcome the logistical challenges of the expedition without the rich experience and sage advice of Mr Ovid Williams, who knows the land and people of this region as well as anyone, and his able counterpart, Mr Danny Gordon.

Our deepest gratitude is extended to Toshao David Garcia, to the Village Council and the people of Chenapau for allowing us to visit their spectacular region and study their diverse landscapes and rich resources.

We are grateful to the Ministry of Natural Resources and the Environment (now the Department of the Environment) and the relevant agencies, especially the Protected Areas Commission and the Kaieteur National Park staff for their assistance with planning, accommodation, and vital logistical support, and specifically to the then Commissioner of the PAC, Damian Fernandes, Joel Breems, Sarah Augustus and wardens Maxwell Basil, Nadine Johnson, Phillip Lewis, Leroy Vanhercel and Thomas Williams. We also appreciate the support of Guyana's Environmental Protection Agency, particularly Dr Indarjit Ramdass and Ms Diana Fernandes for their able assistance throughout the process of acquiring permits.

We also wish to express appreciation to the University of Guyana's Biology and Agriculture Departments and School of Earth and Environmental Sciences for releasing students to participate in this BAT Survey. The six students were enthusiastic participants and have vastly increased their field research skills. We particularly appreciate the support of the Department of Biology and the Centre for the Study of Biological Diversity, especially the Dean, Dr Ansari, Kaslyn Holder and Elford Liverpool for their assistance in efficiently processing the specimens for export to the relevant institutions for further study.

The BAT is extremely grateful to the administrative and finance staff of WWF-Guianas, especially Karranchand Indarjit, Tonia Newton and Marlyn Payne who worked tirelessly to keep funds flowing throughout the survey's logistically challenging preparations, and to Ana Denman, Samantha Reza and Chris Jameson from Global Wildlife Conservation (GWC). Thanks also to Dale DeMendonca, for assistance during preparations and for safely transporting the team and all their gear around Georgetown. Our boatmen were patient with our unusual pursuits and schedules, and got us there and back safely. We had well-prepared campsites, excellent and plentiful food (thanks to Lolita Fleming, Karen Gonsalves, Rose Edmonds, Julita Williams and Pinky Skybar), and periods of dry weather, and it all contributed to an outstanding expedition.

Lastly, WWF-Guianas would like to acknowledge the dedication and hard work of the BAT: the lead researchers, research assistants, and field guides. Their enthusiasm, expertise and teamwork during the entire expedition led to its safe and successful outcome.

The WWF-Guianas programme is co-funded by the Embassy of the Kingdom of the Netherlands in Suriname, WWF-Netherlands, WWF- Belgium, WWF-France, WWF-US and WWF International.

Participants and Authors

The team comprised Guyanese and international scientists with expertise in the detection and identification of plants, birds, reptiles and amphibians, large mammals, fishes, aquatic beetles, decapod crustaceans, ants, odonates, as well as expertise in measuring water quality. Undergraduate students from the University of Guyana as well as local community residents participated in the survey.

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The BAT Expedition

Objectives

The Kaieteur Plateau and Upper Potaro Biodiversity Assessment Team (BAT) Survey was conducted during March 2014. The team of Guyanese and international scientists collected data on 10 taxonomic groups including birds, plants, dragonflies and damselflies, aquatic insects, amphibians, reptiles, birds, large mammals, ants, decapod crustaceans and water quality. The aim was to establish a baseline of data for the two areas that can be used by all stakeholders, including the Government of Guyana, the University of Guyana, local communities, NGOs and the private sector, to make informed decisions about the sustainable management and land-use planning of this sub-region.

The expedition was also intended to increase the small pool of data existing for the Kaieteur National Park (KNP). This research contributes valuable data to the country's baseline knowledge of the biological diversity of montane forests and freshwater aquatic systems. The results of the research will also help the managers of protected areas, particularly of the Kaieteur National Park, as well as community members and other resource-use decision-makers, to better understand the biodiversity of this area and better be able to plan for the sustainable use and management of its natural resources.

In summary therefore, the principle aim of the BAT Survey was to gather new biological data to help guide the country's land-use planning, biodiversity conservation and management priorities.

Survey sites: location and description

This BAT Survey was conducted in under-researched sections and relatively pristine areas of the Upper Potaro watershed and within the Kaieteur National Park and the neighbouring indigenous village of Chenapau (see maps: Figures A, B). The survey focused on both freshwater and forest ecosystems within medium to high elevations.

1. Kaieteur National Park (KNP):

- **Tukeit Trail**, along the trail from Kaieteur Top down to Tukeit
- **Kaieteur Top**, around the top of Kaieteur Falls including the tourist area and airstrip (5°10' 47.0" N, 59° 29' 07.9" W)
- **Menzies Landing**, at small streams and trails within the settlement
- **Potaro River**, along the Potaro River between and inclusive of Elinku Creek and southern boundary; Wamamuri River; Amakwa River
- **Murimuri**, at Murimuri Camp, along the Murimuri River (5°16' 30.2" N, 59° 30' 57.9" W)

2. Upper Potaro River (adjacent to the rapids above Chenapau Village and beyond), including:

- **New Ayanganna Camp**, at the foot of Mt Ayanganna close to the new airstrip (5°18.261' N, 59° 50.257' W)
- **Old Ayanganna Camp**, Ayanganna area close to the old airstrip
- **Bay Camp**, above Chenapau Village just below 'Makaduik' rapids [name/ spelling uncertain- as supplied locally] (5°00' 39.5" N, 59°3 8' 21.2" W)
- **Upper Potaro Camp**, about 5 km upriver from Bay Camp on the Potaro River (5° 04' 02.1" N, 59° 39' 26.1" W)
- **Echerak River**, at the confluence of the Potaro River
- **Chenapau Village**, located upstream of KNP (4° 59' 00.7" N, 59° 34' 37.4" W)

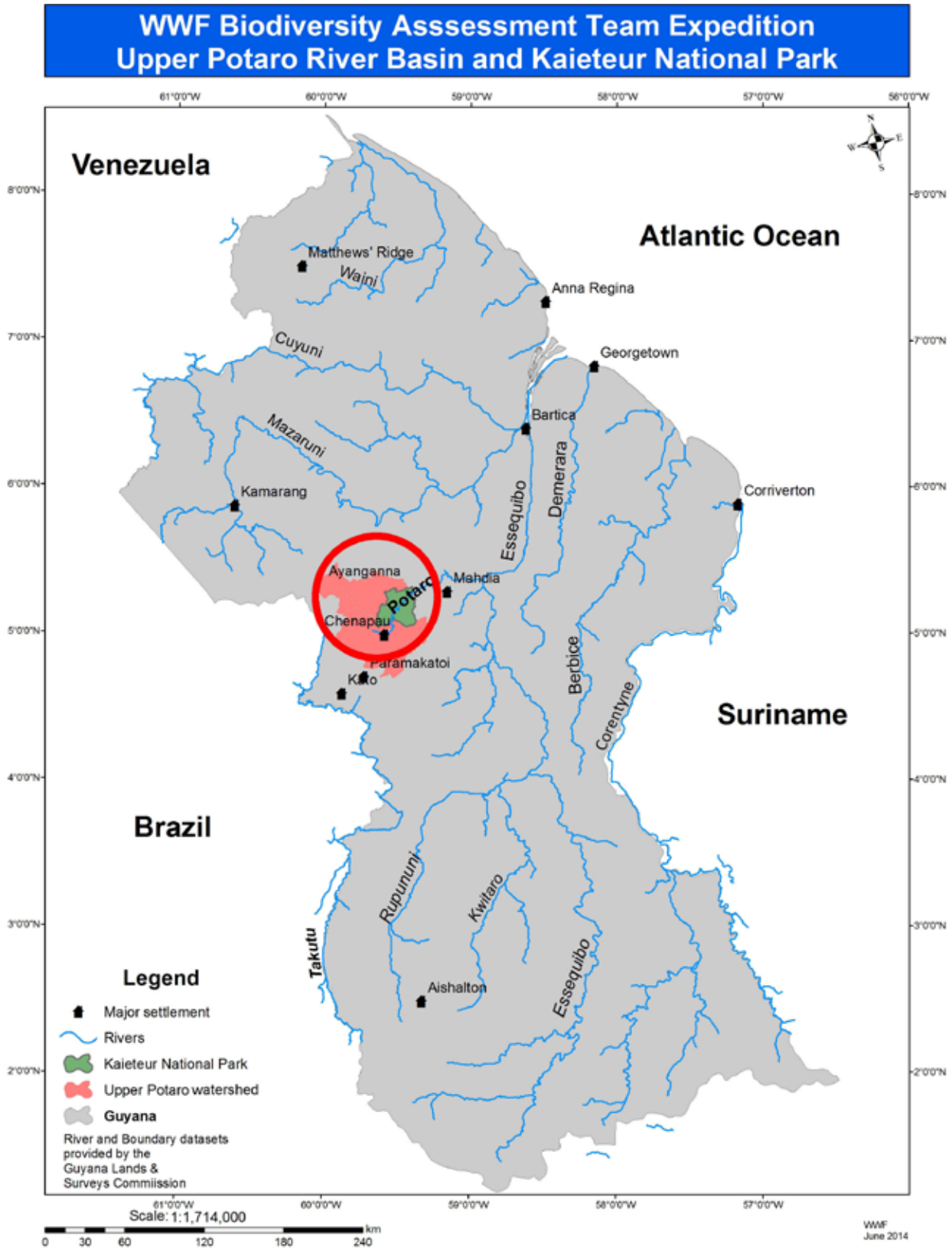

Figure A **General location of the survey areas.**

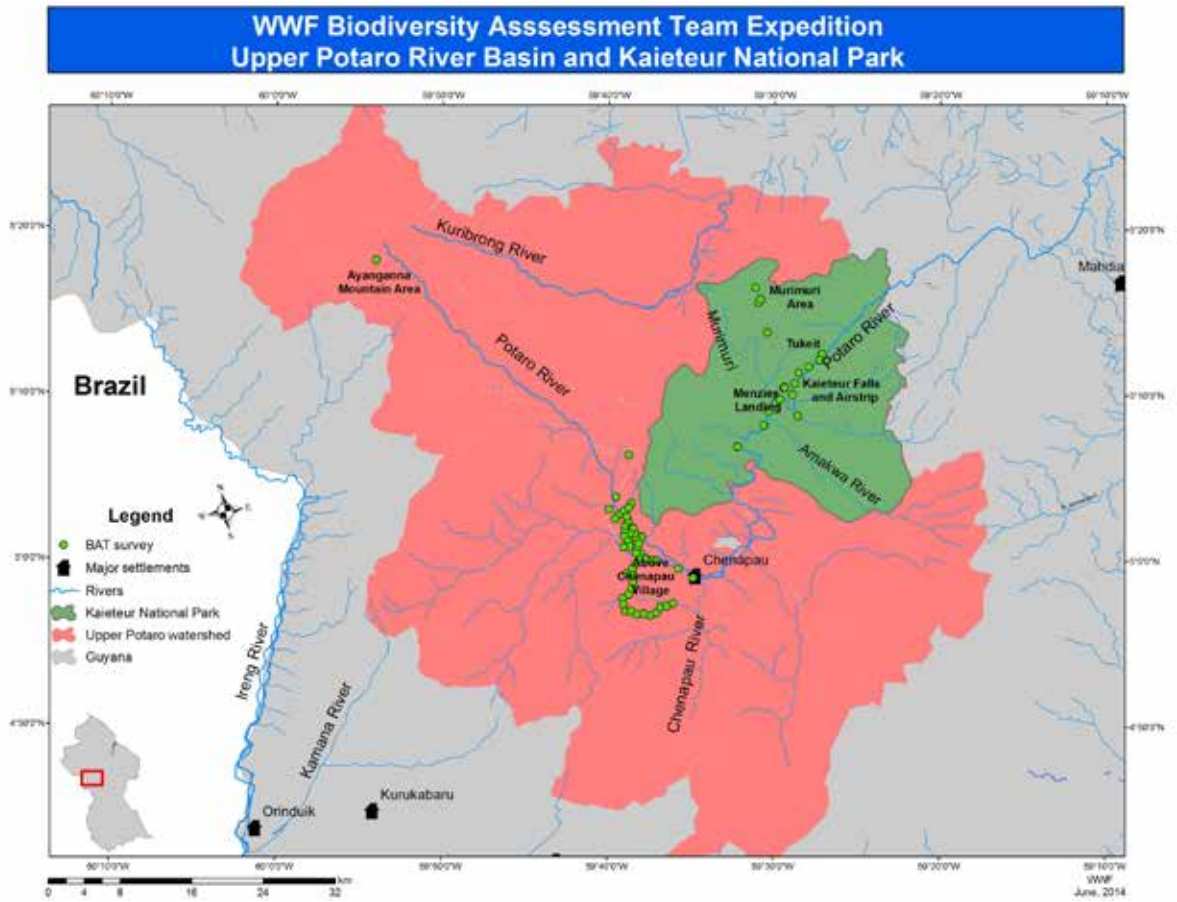

Figure B **Location of the survey sites in Kaieteur National Park and the Upper Potaro Region, including Mt Ayanaganna and Chenapau Village.**

Kaieteur National Park covers a total area of 626.8 km² and is the oldest protected area in Guyana, established in 1929. It sits on the Potaro Plateau of the Pakaraima Mountains, which are made up of ancient rock formations about 1.7 billion years old. Elevation in the Park ranges from 100-900 m and its vegetation is dominated by sub-montane tropical forest (approx. 86%), lowland tropical forest and, upland and lowland shrub/grass savannah (Bicknell et. al. 2013). The forests are relatively intact and support many endemic species, some of which are only known to occur in the Park. The KNP is positioned on the transition point between highland and lowland habitat, which contributes to rich species diversity (Bicknell et. al. 2013). Freshwater habitats are influenced by the Potaro River, the primary river with divides the park. It flows over the Potaro Plateau, eventually falling in a single drop of 741 ft into the gorge, as the Kaieteur Falls. A continuous, unending mist which is created supports unique species communities around the falls. Many other rivers and streams, including those with smaller waterfalls are found throughout the park, including the Murimuri, Elinku, Wamamuri and Amakwa Rivers (Bicknell et al. 2013). Indigenous Patamona people have historically used the area's resources, and these existing traditional rights have been maintained up to today. Due to the history of this area, there is a small existing coastlander settlement within the park at Menzies Landing. The Upper-Potaro region encompasses the KNP and has the Potaro River as one of

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Kaieteur National Park with a view of the Kaieteur Falls. This 741 ft drop of the Potaro River is the main geological feature of the park.

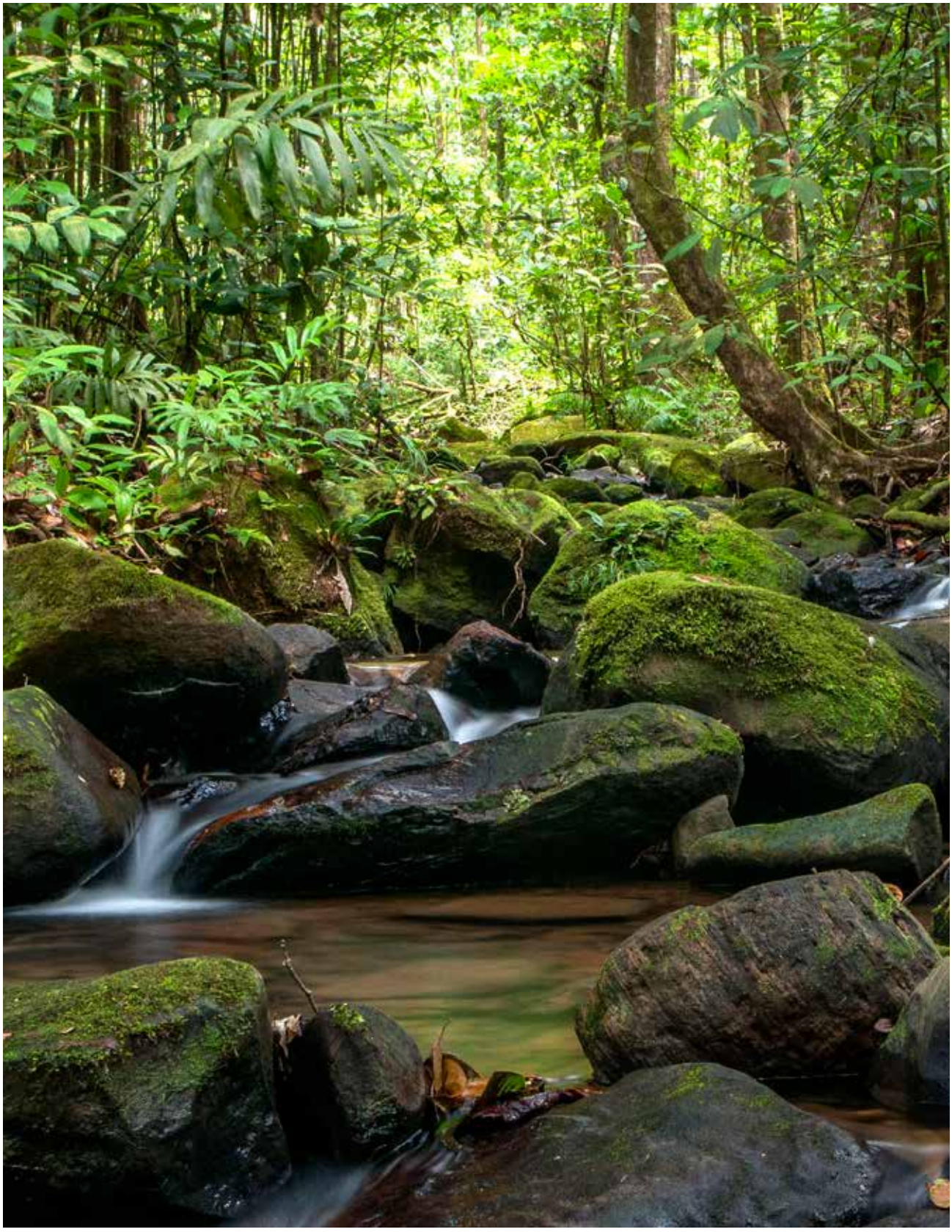
its major rivers. This river originates in the Pakaraima Mountains range, which is the eastern extension of the Venezuelan Roraima sandstone formation that gives rise to table-top mountain types known as tepuis, such as Mt Ayanaganna (Kelloff 2008; Daniel 1984). Numerous rapids in the river and the isolating effect of the Kaieteur Falls have influenced the species communities of the upper Potaro. Deposits of minerals including gold and diamonds are characteristic, and there is active mining within the area, such as at Echerak. The Patamona community of Chenapau is located 25 km south of the falls, just off the southern boundary of the park. Like the KNP, this upper Potaro region supports high levels of biodiversity, including many endemic and globally threatened species.

© Andrew Snyder

A wide expanse of the upper Potaro River.

© Andrew Snyder

A series of small waterfalls on the upper Potaro River.



A creek through the rainforest near Bay Camp.

Context: Ecological Importance of the Kaieteur Plateau and Upper Potaro Region

Overview

The Kaieteur Plateau – Upper Potaro area lies to the mid-west of Guyana, within the extensive Pakaraima Mountains range. These mountains are part of the eastern portion of the Guiana Highlands, the upland area of the Guiana Shield characterised by the eroded sandstone of the Roraima Formation (Kelloff and Funk 2004). The sandstones of the formation were laid down in the Cretaceous period over the igneous-metamorphic basement of the Shield, which is estimated to be 1.7 billion years old (Kelloff and Funk 2004, Bicknell et al 2013). **This makes the Pakaraima Mountains -and thus our overall survey area- part of the oldest rock formations on earth.**

The Upper Potaro region is characterized by high elevation peaks: Mt Ayanganna 2042 m, Kopinang 1594 m, Wokomung 1470 m, and Kowa 1300 m (Shapley et al. 2005). Landforms are also striking since the spectacular table-top type mountains known as tepuis created by years of erosion cycles typify the area (e.g. Mts Ayanganna and Wokomung), along with many rivers, waterfalls and rapids (Kelloff and Funk 2004, Daniel 1984). Kaieteur Falls, a 226 m single drop of the Potaro River, and the focal feature of the Kaieteur National Park, is the most prominent waterfall in the region (Bicknell et al. 2013). The Potaro River, with its headwaters in Mt Ayanganna, is one of the most important drainages in the region. With its many rapids it flows through the forested landscape, dividing the Kaieteur National Park, before finally emptying into the Essequibo River.

THE PAKARAIMA MOUNTAINS -AND THUS OUR OVERALL SURVEY AREA- ARE AMONG THE OLDEST ROCK FORMATIONS ON EARTH

Biodiversity and conservation importance

Biodiversity in this region is among the richest within Guyana, the Guianas and the wider Guiana Shield. The Kaieteur National Park (KNP), established in 1929, is the oldest protected area in the Amazon, and the only protected area that encompasses the eastern portion of the Guiana Highlands, a region that holds great importance for the long-term persistence of many unique species (Bicknell et. al. 2013). Overall, KNP harbours a remarkable diversity of species: 30% of mammals, 43% of amphibians and close to 50% of birds known from Guyana live in and depend on the park for their survival (Bicknell et al. 2013, WWF 2012). At the same time, levels of species endemism are significant, making it important at local, national, regional and global levels. Previous studies show that 44% of amphibians, 16% of mammals, 13% of reptiles, 12% of birds and 8% of plants in KNP are endemic to the wider region of the Guiana Shield and Guiana Highlands (Bicknell et. al. 2013). Some species of herpetofauna and plants are possibly found nowhere else on earth, and may be endemic only to the KNP, including the Kaieteur golden rocket frog (*Anomaloglossus beebei*) which spends its entire life cycle in the giant tank bromeliad (*Brocchinia micrantha*).

Stefania evansi, a frog which exhibits maternal care, commonly occurs in the KNP and is not thought to be found in any other protected area in the world. The range of the Kaieteur tepui tree frog (*Tepuihyla talbergae*) and one species of gymnophthalmid lizard (*Kaieteurosaurus hindsi*) is thought to also be limited, as these are so far only known to occur in the area surrounding Kaieteur Falls. Several species of flora and fauna have been identified as being of special concern, listed by the Convention on International Trade in Endangered Species (CITES) under Appendix I and II, and by the IUCN Red List (EN-Endangered; VU-Vulnerable; NT-Near Threatened). These include charismatic and large fauna such as the white-lipped peccary (*Tayassu pecari*; VU), giant river otter (*Pteronura brasiliensis*; EN, Appendix 1); jaguar (*Panthera onca*; NT, Appendix 1), giant anteater (*Myrmecophaga tridactyla*; VU, Appendix II), Brazilian tapir or lowland tapir (*Tapirus terrestris*; VU, Appendix II), harpy eagle (*Harpia harpyja*; NT) (Bicknell et al. 2013). The orchid community which is particularly diverse provides another good example, with each of the 35 known species so far recorded listed in Appendix I or II of the CITES Convention (Bicknell et. al. 2013). Because of their sheer size, faunal communities contribute to KNP's great importance to conservation. At a regional level, the park is an important area for several species of swifts. The White-collared Swift (*Streptoprocne zonaris*), Grey-rumped Swift (*Chaetura cinereiventris*), Band-rumped Swift (*Chaetura spinicaudus*) and the Tepui Swift (*Streptoprocne phelpsi*) which roost behind the falls, in the gorge, and cliffs along the plateau, occur in large colonies. Based on rough estimates, over one million swifts are thought to roost behind the falls, making it the world's largest swift roost. Taxa such as fungi and invertebrates have not received similar scientific coverage and thus remain largely poorly known in terms of their distribution and conservation status. Although Kaieteur National Park is known for its extraordinary biodiversity and natural beauty, it has not received as much scientific coverage as other areas such as Iwokrama Forest.

BIODIVERSITY IN THIS REGION IS AMONG THE RICHEST WITHIN GUYANA, THE GUIANAS AND THE WIDER GUIANA SHIELD

The areas beyond Kaieteur National Park, extending into the upper Potaro region have not been extensively studied in general. Mt Ayanganna, however, which lies north of KNP, has been the focus of some collecting efforts in the past, for example Braun et al. 2003 (birds), Barnette et al. 2002 (birds), MacCulloch et al. 2002 (amphibians), Lapolla et al. 2007 (ants). These surveys have revealed several species new to science as well as distinctive faunal communities, leading to the conclusion that it is likely a centre for endemism. Some examples described in Hollowell et al. (2005) include: (i) *Hyla roraima*, endemic to the north slope of Mt Roraima and Mt Ayanganna, Guyana (Duellman and Hoogmoed, 1992); (ii) *Hyla warreni,* endemic to the north slope of Mt Roraima and Mt Ayanganna, Guyana (Duellman and Hoogmoed 1992); (iii) *Stefania ackawaio*, *Stefania ayangannae* and *Stefania coxi,* endemic to Mt Ayanganna, Guyana (MacCulloch and Lathrop 2002); (iv) *Stefania roraimae,* endemic to Mt Roraima and Mt Ayanganna, Guyana (Duellman and Hoogmoed, 1984); and (v) *Adenomera lutzi,* endemic to the upper Potaro River and Mt Ayanganna, Guyana (Heyer 1975 GU). Like the KNP, forest cover in the upper Potaro remains largely intact, maintaining the flow of ecosystem services.

Overall the picture which emerges of the Kaieteur Plateau – Upper Potaro area is that it is an area truly rich in biological diversity, including species not known to occur in any other location on earth. The uniqueness of the area's diversity is due to a combination of factors including (i) habitat diversity (forest, riparian corridors, savannah/shrub/grassland, bush islands, rivers, streams and microhabitats created from the permanent presence of mist created by the falls), and (ii) high elevations and sharp changes in elevations; the KNP is positioned at the edge of the Pakaraima escarpment and here montane forest quickly gives way to lowland forest which creates a variety of habitats compressed into a small area (Bicknell et al. 2013).

Communities and natural resource use

Two indigenous Patamona villages, Chenapau and Karisparu, which lie to the west beyond the KNP's border, have existed since the late 1800s, and residents of Chenapau, in particular, continue to use the park for subsistence activities, including fishing, hunting, farming and gathering of forest products. The right to traditional utilization of resources within the park are upheld in the Amerindian Act, 2006 and Protected Areas Act, 2011; however commercial exploitation is prohibited. There have been many initiatives over the years aiming to promote nature-based tourism and the sale of craft and forest products to strengthen livelihoods, but the basis of the village's economy is gold and diamond mining, which expands and contracts based on commodity prices. Karisparu, once a satellite community of Chenapau, is now considered an independent village. The dependence of its residents on the park's resources is less significant, given that it is in a more isolated location than Chenapau. Mining constitutes the basis of Karisparu's economy.

Within the park, a remnant mining settlement, Menzies Landing, continues to exist and provide logistical support to mining in the Amu River and Echerak River areas outside the park. Menzies Landing was subsumed by the park following its expansion in 1999 from 19.4 km^2 to 626.8 km^2 (Kelloff 2003).

Threats

Mining, particularly gold (and diamond) mining, is the primary threat to the integrity of the region's ecosystems. This has been growing over the last decade, possibly as a result of increased access to the region by land and air, and illegal mining activities are encroaching into the park's buffer zone and even into the park itself more and more.

In the past, the Potaro River and some of its smaller tributaries have been subject to gold mining, particularly after the park's size was reduced in the early 1960s from its original size of 114 km² to 19.4 km², to facilitate mining of the area's rich mineral (gold and diamond) resources (Kelloff 2003). **Today, mining continues in the Upper Potaro region, and even within the Park and its buffer zone.** In April 2016, for example, a Brazilian mining operation was discovered operating illegally in the buffer area of the Kaieteur National Park by the authorities (Ministry of Natural Resources, 2016). The residents of Chenapau Village have also repeatedly expressed a desire to undertake mechanized mining in the park. There have been recent (2014-2015) incidences of mining within the park's boundary. The extent of mining has not been fully quantified as yet, but the Guyana office of WWF-Guianas has been working along with the Protected Areas Commission and other relevant authorities to monitor the threats and devise sustainable long-term solutions. Currently there are many active mine sites beyond the park, such as at Amu River and Echerak River. The use of mercury in gold extraction processes is a major issue associated with mining in the region. The magnitude of mercury contamination has not been extensively evaluated, but its ability to bioaccumulate in food chains, travel over long distances by air, and contaminate soil and freshwater resources, means that people, wildlife, and other natural resources can be severely impacted, including in areas far beyond mining sites, if mining and mercury-use are not stringently monitored and regulated. Dumping of tailings into rivers/streams and alluvial mining may indeed already be affecting freshwater supplies, as there have been complaints from Chenapau's residents.

A diamond/gold mining dredge in the upper Potaro River, sighted as the survey team was heading to Bay Camp, above Chenapau Village.

TODAY, MINING CONTINUES IN THE UPPER POTARO REGION, AND EVEN WITHIN THE PARK AND ITS BUFFER ZONE

Although mining largely occurs outside the KNP, the effects of mining, such as elevated turbidity levels and mercury contamination of rivers and wildlife, can spread into the park from the many activities upstream. The network of waterways from mining zones flow into the Potaro River which divides the park, and mercury accumulation in the food chains affects species as well as people. This indicates that the regulation of mining must extend far beyond the boundaries of the park. Turbidity and siltation which result from alluvial mining and improper practices such as the dumping of tailings into rivers and creeks, the dangerous use of mercury, and the presence of illegal mining are among the issues which have to be addressed by regulators. Maintaining water quality, safeguarding the health of indigenous and other communities, reducing and eventually eliminating the use of mercury, and preserving biodiversity and ecosystem services generated by the region, should be key goals which guide this process.

The KNP is one of Guyana's major tourism areas - from 2011 to 2015 visitor arrivals totalled 30,502 persons (PAC 2015) - and it is a significant contributor to tourism revenues in Guyana. Since visitor experiences at KNP are nature-based, impacts from mining can very negatively affect the park's image, visitor perceptions, and, eventually, tourist arrivals. Therefore, robust strategies for monitoring and for enforcement of mining rules and regulations, both outside and within the park, are vital if the ecological, economic and social services which it provides are to be sustained.

Commercial logging is not currently a threat to the KNP; however forests are cleared to facilitate illegal mining within the park.

Emerging hydropower, for which Amaila Falls on the Kuribrong River has been earmarked, is seen as another major contributor to the national economy. While hydropower could help Guyana realize its green development objectives, it requires careful, evidence-based planning, taking into account the need to preserve the integrity of the landscape and the flow of ecosystem services.

Conclusions

The Kaieteur Plateau – Upper Potaro area is remarkable for its high level of endemism, and its intact forest and freshwater ecosystems are home to several species which are globally threatened. The resources of the area support the subsistence activities of indigenous people, as well as a growing nature-based tourism within the Kaieteur National Park. Visitation to the park has increased, with approximately 6,700 tourists arriving annually between 2012 and 2015. However, the integrity of the area is threatened by gold mining activities. Illegal small-scale mining occurs within the park and its buffer zone, impacting habitats and species. Beyond the park, the effects of mining on freshwater and terrestrial habitats are already visible. Deforestation and water pollution, which result from mining activities occurring upstream, threaten both the safe freshwater resources of the local communities, as well as habitats and biodiversity- both outside and within the park. Declining tourism and economic impacts can be expected if mining continues to encroach on the park, and water quality becomes even further compromised as the result of mining activities.

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BAT Expedition – Findings In Brief

BAT survey dates: 2 March to 31 March 2014

BAT survey sites: Kaieteur National Park and the upper Potaro River, Guyana

Summary of results

The Potaro plateau is part of a large intact forest landscape which is of enormous value globally for conservation. It is the epicentre of endemism in the Guianas, where lowland and highland habitats meet, and as such, maintaining forest and watershed connectivity in this region is tremendously important. The BAT survey areas contain a rich diversity of species, but the most striking feature is the high level of endemism, with many species unique to the plateau. Several species new to science were also uncovered during the survey, adding even more to the area's enormous conservation value. The distinctiveness of the area's flora and fauna stems from several factors, including the integrity of the undisturbed forests, river and stream habitats; its topography and geology (it is part of the Guiana Highlands, an upland portion of the ancient Guiana Shield region); and the isolating effect on species which the Kaieteur Falls and the presence of numerous rapids in the Potaro River exert. With its mixture of highland and lowland habitats and high forest coverage, the Kaieteur National Park harbours many species thought to be found only within the park, again making the KNP an area of very significant value conservation-wise. Beyond the park, within the upper Potaro freshwater and terrestrial habitats, fast-flowing rivers, rapids, riparian and other forest types play an important role in sheltering healthy populations of many species, including endemics.

Mining is however impacting the flora and fauna of the Potaro plateau. Mechanized, non-traditional mining methods are particularly detrimental to the habitats of the species documented during this BAT survey. For example, human-impacted sites at the New Ayanganna Camp were almost completely devoid of aquatic beetles and odonates, which are indicators of good water quality. Similarly, these groups were totally absent in a portion of the Murimuri Creek where mining had taken place. The BAT survey also found that much of the mining activity, in its current form, destroys creek banks and creates silt dams downstream, thus destroying habitat critical for fishes and other aquatic species, and results in significant downgrading of water quality. Such a decrease in water quality not only has an impact on the environment and biodiversity, but also on the local human communities who depend on a continuous supply of freshwater, free from sediments and pollutants, for their health and well-being.

Maintaining large-scale connectivity of the terrestrial and freshwater ecosystems of the Potaro plateau is absolutely critical for maintaining the integrity of the KNP; ensuring the continued survival of the region's unique biodiversity; and sustaining the flow of ecosystem services that communities depend on.

Number of species documented during the BAT survey

Taxonomic Group	TOTAL			
	#species (# genera)	#species new or potentially new to science (# genera)	# new records for Kaieteur Plateau -Upper Potaro Region	# new records for Guyana
Plants	> 179 (figure cited for vascular plants only)	3 (2)	42	5
Large mammals	21 (16)	-	-	-
Amphibians[1]	36 (19)	-	2	2
Reptiles[1]	30 (25)	-	1	1
Birds	209	-		
Dragonflies and damselflies[2]	80 (43)	5 (2)	58 (figure cited for KNP only)	22
Aquatic beetles	91 (52)	~ 15 (5)	~15	~15
Crustaceans [3]	~ 31	2 (crustaceans only)	~ 7 (crustaceans only)	~ 2
Fish	27 (24)	6 (5)	6	6
Ants[4]	(60)			

[1] The new records for the region and country are *Osteocephalus* cf. *exopthalmus (*a rare record for this species within the Kaieteur National Park) as well as an unidentified Hysiboas sp. and the swamp snake (*Erythrolamprus* sp.), which remain unidentified and may represent new country records, range extensions, or potentially new species to science.

[2] This is the first record of Odonates for the Kaieteur National Park. Species belonging to the genera *Argia* and *Progomphus* were new to science at the time the study took place.

[3] Further analysis is needed for a complete list of species. For Crustaceans, this is the first record for the Kaieteur National Park and thus all records should be considered notable.

[4] Species identifications were still in the process of being taxonomically finalized at the time this report was prepared, but all observations reported here are new range records for genera.

Number of species of conservation concern recorded during the BAT survey

Taxon	Species	IUCN Red List or CITES Category	English Common Names
Medium and large mammals	***Priodontes maximus***	Vulnerable /Appendix I	Giant armadillo
	Ateles paniscus	Vulnerable /Appendix II	Black spider monkey
	Tapirus terrestris	Vulnerable / Appendix II	Tapir
	Tayassu pecari	Vulnerable / Appendix II	White-lipped peccary
	Panthera onca	Near Threatened / Appendix I	Jaguar
Reptiles	***Tupinambis teguixin***	Appendix II	Gold tegu
	Corallus caninus	Appendix II	Emerald tree boa
	Corallus hortulanus	Appendix II	Amazon tree boa
	Chelonoidis denticulata	Vulnerable/ Appendix II	Yellow-footed tortoise
	Paleosuchus palpebrosus	Appendix II	Cuvier's dwarf caiman
Amphibians	***Anomaloglossus beebei***	Vulnerable	Golden rocket frog
Birds	***Spizaetus ornatus***	Near Threatened	Ornate Hawk-Eagle
	Periporphyrus erythromelas	Near Threatened	Red-and-black Grosbeak
	Patagioenas subvinacea	Vulnerable	Ruddy Pigeon
	Crax alector	Vulnerable	Black Curassow
	Odontophorus gujanensis	Near Threatened	Marbled Wood-Quail
	Celeus torquatus	Near Threatened	Ringed Woodpecker
	Amazona dufresniana	Near Threatened	Blue-cheeked Parrot
	Pyrilia caica	Near Threatened	Caica Parrot
	Ramphastos tucanus	Vulnerable	White-throated Toucan
	Ramphastos vitellinus	Vulnerable	Channel-billed Toucan
	Epinecrophylla gutturalis	Near Threatened	Brown-bellied Antwren
	Hypocnemis cantator	Near Threatened	Guianan Warbling-Antbird
	Tinamus major	Near Threatened	Great Tinamou

Results by taxon

Plants

Two main sites (Bay Camp and Upper Potaro Camp) were surveyed from 13 to 30 March 2014 on the Potaro River above the village of Chenapau, and three areas within the Kaieteur National Park. In total 321 collections of vascular plants were made. To date 224 collections have been determined to species level and this includes three new species (one Myrsinaceae and two Melastomataceae); five other species have not been previously collected in Guyana, and several were not known from the park or the Potaro plateau. Noteworthy among these new records for the Potaro plateau are two species of Bromeliaceae previously only known from the type collections (*Aechmea pallida* and *Brocchinia cataractarum*) and possibly only now photographed for the first time. The high level of plant endemism, new records and range extensions confirm that the Upper Potaro and the Kaieteur National Park represent a unique environment critical for the preservation of the biodiversity of the Guiana Shield.

Medium and large mammals

Medium- and large-sized mammals are important both for forest health and for the role they play in the livelihoods of local indigenous people. Nevertheless, they have received limited or no attention in terms of research within the Pakaraima Mountains. We established camera traps in the dry season near Chenapau Village, bordering Kaieteur National Park, and 18 terrestrial mammal species were detected. The mammals with the highest relative abundance were white-lipped peccaries (*Tayassu pecari*), followed by agoutis (*Dasyprocta leporina*), red and brown brocket deer (*Mazama americana, M. nemorivaga*), labba (*Cuniculus paca*) and jaguar (*Panthera onca*). The presence of disturbance-sensitive species such as the white-lipped peccary, tapir and giant armadillo supports the notion that the habitat remains highly valuable for its wildlife.

Amphibians and reptiles

Herpetofaunal inventory surveys were conducted at five sites throughout Guyana's Kaieteur Plateau from 3-15 March and 18-28 March 2014. 36 species of amphibians and 30 species of reptiles were observed at all of our sites. Of the focal areas surveyed, Bay Camp, the site nearest to Chenapau Village, had the highest species richness with 26 species of amphibians and 23 species of reptiles. Among the 66 species of reptiles and amphibians recorded in total, five are currently included on CITES – the dwarf caiman (*Paleosuchus palpebrosus*), emerald tree boa (*Corallus caninus*), Amazon tree boa (*Corallus hortulanus*), gold tegu (*Tupinambis teguixin*), and yellow-footed tortoise (*Chelonoidis denticulata*); and one is listed as Vulnerable by IUCN (yellow-footed tortoise, *Chelonoidis denticulata*). One species of frog (*Hypsiboas ornatissimus*) found at Bay Camp, is only known from Guyana from a few individuals. Healthy populations of the Guiana Shield endemic frogs, *Stefania evansi* and *Stefania woodleyi*, unique Hemiphractid frogs that exhibit maternal care, were documented. The single *Osteocephalus* cf. *exophthalmus* recorded at Murimuri camp represents a

rare record for this species within the park, and potentially an undescribed variant or new species. Maintaining the integrity of the undisturbed forests and stream habitats are critical to the continued survival of the region's unique biodiversity.

Birds

The upper Potaro plateau is a broad transition zone between highland and lowland areas of endemism on the Guiana Shield, but the elevational limits of many bird species are incompletely known, and published accounts of the region's avifauna are few. During this expedition we expanded the list of species known to occur on the plateau based on surveys conducted at three localities during 13 days in March 2014. The avifauna of the Potaro plateau features high diversity and endemism but relatively low overall abundance of birds, and subtle shifts in the relative abundance of lowland and highland species at different elevations. The preliminary list totals 209 species, 28 of which are endemic to the Guiana Shield, three of them restricted to higher elevations. Our list also includes 14 species listed on the IUCN Red List; of these, ten are Near-Threatened and four are Vulnerable. Of particular significance is the use of these mid-elevation forests by endemic birds of the Guiana Highlands – this phenomenon is largely undocumented for the majority of species, though it seems likely that many birds use these forests either on a seasonal basis (for frugivorous species) or as a matrix to move between islands of suitable highland habitat. A new lower elevation limit for the highland endemic Fiery-shouldered Parakeet (*Pyrrhura egregia*) was recorded. As Guyana's infrastructure expands into this region, conservation priorities should include the preservation of large areas of intact forest spanning a range of elevations.

Crustaceans and other aquatic invertebrates

This survey provided the first inventory of crustaceans in the park. A total of 1,133 specimens of decapod caridean shrimps (865 Euryrhynchidae and 268 Palaemonidae) and 105 of crabs (81 Pseudothelphusidae and 24 Trichodactylidae) were collected. These specimens comprised five species of shrimp and two species of crabs. The species of shrimp *Euryrhynchus* sp. 2 and the crab *Microthelphusa* sp. are potentially new species. Also among the macrocrustaceans, nine semi-terrestrial isopods were recorded, while the aquatic insects collected were mostly larvae from nine orders, representing 20 families. Our preliminary observations suggest that the habitat is healthy, in a good condition of conservation. More extensive sampling is required, including during the wet season, in order to reflect more accurately, the abundance and the species richness at these sites.

Odonates

Eighty species of dragonflies and damselflies, representing 43 odonate genera belonging to 11 families were registered at forest rivers, creeks, swamps, pools, and trails within the Kaieteur plateau and upper Potaro area. This represents over 40% of the species currently known from Guyana. In particular, 58 species were found within the Kaieteur National Park, constituting the first listing of odonates known from the park, and 53 within the upper Potaro area. Five species belonging to the genera *Argia* and *Progomphus* were new to science at the time the study took place. Another 22 described species represent new records for Guyana, and this increased the total number of species known from the country to 217. The results indicate a healthy watershed and well-preserved forest for all of the sites visited, with the exception of two where gold mining had taken place. Sustaining the diversity of odonate assemblages requires that forest cover and morphology of freshwater habitat diversity are maintained in the area; present odonate assemblages are then likely to persist.

Aquatic beetles

Aquatic beetles were surveyed at four sites, with most of the collecting focused on two camps along the Potaro River in the Kaieteur National Park and upriver of Chenapau Village. Most of the habitats consisted of primary tropical forest. More than 1,800 specimens were collected from 49 collecting events. Ninety-one species of aquatic beetles belonging to 52 genera were identified. The primary expedition camps (Upper Potaro and Kaieteur National Park) had relatively similar numbers of species (46 and 41, respectively). Thirty-three species were found at Ayanganna. Five genera and at least 15 species are new to science though this number is likely to increase. The species richness was lower than other surveyed regions in the Guiana Shield, which may be due to habitat homogeneity. However, at the upper Potaro area, the seepage habitats at the top of the Potaro rapids contained a rich community of poorly known beetles, including several new species of water scavenger beetle (*Acidocerinae* gen. nov.). Rotting tree fruits also yielded several rare and interesting species of water scavenger beetles as well (e.g. *Quadriops*). The rock savannahs and associated seepages surrounding the airstrip at Kaieteur National Park proved extremely interesting. Many rare and new species were found in a variety of groups, including the families Hydrophilidae, Dytiscidae, and Torridincolidae.

Fishes

Twenty-seven species belonging to 13 families in five orders were recorded in the upper Potaro River drainage in the Pakaraima Mountains range of northwestern Guyana, above Kaieteur Falls. Although fish diversity was relatively low, as is expected for headwater streams, endemism was high. Several species are likely new to science: *Laimosemion* cf. *breviceps*, *Lebiasina* sp., *Gymnotus carapo* group, *Brachyglanis* sp., *Trichomycterus* sp. “long,” and *Trichomycterus* sp. “small spots.” Most collection sites were in nearly pristine condition and water

quality was excellent. The isolating effect of Kaieteur Falls and the numerous rapids present in the Potaro River meant that many groups common and abundant in the lowlands were conspicuously absent, such as freshwater stingrays (Potamotrygonidae), the pirai and pacus (Serrasalmidae), freshwater anchovies (Engraulidae – Clupeiformes), freshwater drum and croaker (Sciaenidae – Perciformes), freshwater needlefishes and halfbeaks (Belonidae – Beloniformes), arowanas (Osteoglossidae – Osteoglossiformes), and ghost knifefishes (Gymnotiformes - Apteronotidae) among others. Gold and diamond mining pose immediate threats of negative impacts to aquatic ecosystems and fishes and to humans that eat fish potentially contaminated with mercury.

Ants

This ant survey is the first for the upper Potaro River, including the Kaieteur National Park, and represents one of the very few conducted on this taxon in Guyana. Although the total number of species still needs to be tallied, since our 542 separate ant collections are still in the process of being taxonomically identified to species level, all observations reported here constitute new range records for genera. The interim results, thus far, show that in total, 60 different ant genera from 10 subfamilies were collected, with *Pheidole, Crematogaster, Solenopsis,* and *Camponotus* being the most commonly collected genera. All sites had a high abundance and diversity of ants and all were very similar in habitat. Kaieteur Falls is the main exception, as it harboured distinctive savannah ant fauna that will likely prove to be different from the forest fauna in terms of species composition. The presence of a diversity of predatory and arboreal species indicates that the habitats are relatively intact. However, one of the largest potential threats to where we sampled is the mining of gold and diamonds.

Water Quality

A report on our water quality findings will be published separately.

BAT Recommendations for Conservation and Management of the Kaieteur Plateau – Upper Potaro Region, Guyana

Mining

1. Monitor mining and strictly enforce the prohibition of mining in Kaieteur National Park and within the buffer area of the park, in accordance with the laws and regulations governing the park. Suggested actions include:

a.The Protected Areas Commission (PAC) should employ additional rangers at KNP to patrol and detect illegal mining. Rangers can be placed strategically, including at locations that are likely key entry points for miners and mining equipment. They should be provided with resources (communication, fuel, outboard engines etc.) to carry out weekly patrols in areas where mining is known or suspected to be occurring. A permanent, manned KNP guard post should be set up on the Potaro River at the border of KNP to prohibit miners from entering the park on the river, *both upstream and downstream of Kaieteur Falls*. Where possible, ground patrols can be supported using drones to help rangers access and gather information for areas which are otherwise difficult to reach. Incentives should be provided to rangers posted at KNP since it is a remote location.

Another mode of access to the park is using the local flights to KNP. Many miners now enter the park simply by flying directly to KNP and boarding boats at Menzies Landing, which is within the park. In effect, the park is inadvertently facilitating miners' access to the park. Restricting illegal miners' access via flights to KNP should be considered in the wider strategy of prohibiting mining in the park.

b. Additional signage should be posted on the Potaro River to ensure that people remain informed about the border of the park. These should be checked by park authorities as signs may be removed by individuals.

c. The Guyana Geology and Mines Commission (GGMC) should send its inspectors more frequently, as required by the PAC, to help the park rangers follow up on sightings of illegal mining within KNP.

d. When illegal miners are found operating within the park, their equipment should be confiscated so that they cannot move or resume mining easily, and other penalties for breaching mining regulations should be applied.

e. The use of rangers and technology as recommended in section a. above should be set within the framework of a larger monitoring strategy/programme for the park, including buffer area. The monitoring programme should allow for an ongoing, effective process of data collection and analysis by the PAC. This should ensure that changes in forest cover, water quality, and other indicators can be detected as early as possible, minimising impacts to the environment, species and local communities. The monitoring programme should include, at a minimum:

Satellite imagery to monitor the changes in forest cover at six-month intervals; data from the national MRV process are already available and can be used to inform actions on the ground.

Water quality monitoring, to ensure the mining is not altering the water sources (see recommendations for water quality monitoring in part 4 below).

2. Pursue the recovery of abandoned mining areas within KNP as mining operations are closed by the GGMC and the PAC. This can be done by:

a. Researching good international practice for restoring abandoned mining lands
b. Planting native tree seedlings within the abandoned mining areas, including reforesting deforested river banks with native species.
c. Restoring the flow and contours of streams affected by mining.
d. Enhancing soil nutrients and recovering seed banks.

Depending on the goals of such interventions, recovery/reclamation of an area is often costly. The KNP can be used to study and understand the process of natural regeneration to help inform the recovery of other mined-out areas.

3. Enforce mining regulations outside of the park on the Potaro Plateau, particularly within ecologically sensitive and important regions. While the GGMC should be primarily responsible for these enforcement activities, other groups including NGOs and local communities can assist them by reporting illegal mining practices to park authorities or the GGMC. Some of the regulations which should be enforced for non-compliant small-scale mining operations include:

a. Tailings and other sediments from mining operations should be contained in sediment catchment ponds rather than discharged into the river to avoid the excessive sedimentation downstream that destroys benthic aquatic communities and compromises water quality.

b. Fuel, oil and other lubricants for machinery should not be allowed to enter the river. Proper storage facilities, located away from water sources, and handling systems should be set up by mine operators.
c. Strictly, no mining of river banks and buffer areas around rivers and streams should be allowed. The GGMC should consider the application of variable width buffers for areas that are important, such as habitat for important species.
d. Mercury-free options for extracting gold should be adopted by miners and promoted by the Ministry of Natural Resources and GGMC. Guyana is pursuing a phased elimination of mercury use in line with its commitments under the Minimata Convention.

Water Quality

4. Monitor water quality within and outside of KNP on the Potaro Plateau.

The PAC should collaborate with the people of Chenapau through training and partnership with NGOs, researchers, GGMC or other agencies, to develop a water quality monitoring system for surface water that will provide information to establish baselines and to detect changes in quality of freshwater. Monitoring responsibilities can be shared, with the PAC monitoring water quality within the park and the communities monitoring outside the park. Data can be shared using a common database platform. This can be part of a broader system of environmental monitoring for the park and should include:

a. Water quality including turbidity, pH, conductivity, dissolved oxygen, and temperature, using nationally recognised protocols, to ensure that mining is not altering the quality of water resources.
b. Monitoring of aquatic insects, which are known to be effective indicators of water quality in freshwater systems, largely due to their varying response to ecological perturbations such as increasing sediment load, nutrient inputs and loss of canopy cover.
c. Mercury levels in water, soil and sediments.
d. Data collection in both the dry and wet seasons to observe the seasonal variations in parameters.
e. A common data platform (database system) for storing and analysing water quality data from the Potaro River and tributaries, both within KNP and outside of the park, including downstream of the current park boundary.

Alternative Livelihoods

5. Develop alternative livelihoods for the local indigenous people in lieu of employment in the mining sector. Involvement of NGOs, researchers, and international development organizations may be needed. Recognising that it is difficult to compete with the perceived economic benefits of mining, we recommend that a full assessment would first need to be undertaken to determine

what people are most interested in and what is feasible; market access, availability and requirements; and sustainability of potential enterprises. Some options could include:

a. Craft produced from non-timber forest products. These can be produced for sale in the craft shop of the Visitor Arrival Centre at KNP or marketed elsewhere. Branding and advertising products online can increase visibility. An airstrip at Chenapau makes it possible to directly connect with other available markets. Quality control and pricing must be some key considerations.
b. Bee-keeping: if determined to be viable, the production of a high value, branded commodity such as honey can provide a source of income. Training in bee-keeping, hive construction and management and honey production can be done with women and other interested persons. Again, market availability and access, pricing and quality control must be considered.
c. Service provision to the KNP: Training of community representatives as rangers, since local people often have extensive knowledge of the resources. This can be done through the Bina Hill Institute in the North Rupununi, as was previously done.

Tourism

6. Promote tourism at the Kaieteur National Park to increase visitation and visitor experiences by:

a. Enhancing the facilities for overnight and multi-day stays by visitors to KNP.
b. Creating interpretive exhibits at the Visitor Arrival Centre that will improve visitor experience.
c. Developing educational tours at KNP beyond the falls.
d. National tourism authorities and the private sector should work to reduce travel costs for tourists visiting the park, and this should be tied to holistic improvements in the country's tourism industry. In general, tourism in Guyana should be made more accessible for local people as they potentially represent a significant customer base.

7. Tourism to Chenapau village: A feasibility study is needed to better understand how the village can play a role in enriching visitor experience. However, longer tours to KNP could include a boat ride and visit to Chenapau village, led by local guides. Fishing, birding and learning about Guyana's biodiversity with local indigenous guides could be part of a package offered by the village.

Education and Training

8. Provide educational programmes for local indigenous communities on the importance of KNP, clean water, and local biodiversity to their health and welfare. This could be done by NGOs, GGMC, or international development organizations and could include:

a. Training for school teachers in biodiversity and ecology.
b. Education and awareness on the impacts of mining and mercury-use on the health of people and the environment.
c. Collaboration with KNP to establish student visits to the park's visitor station, guided educational tours, and overnight educational stays.
d. Organizing youth exchange programmes with other communities, such as those in the southern Rupununi.
e. Sharing KNP educational materials (booklets, posters) with schools and communities.

9. Prioritise the region for demonstrations of mercury-free and responsible mining; and provide training for local indigenous communities on less environmentally harmful mining practices. This could be done by NGOs, the GGMC, or international development organizations.

Additional Research

10. Study the impacts of mining on the local populations of indigenous people in Chenapau and Karisparu. Studies could be done by NGOs, the University of Guyana, or other agencies. Studies should include:

a. Researching the level of mercury in people and the environment, including assessing the mercury levels in common food fishes. Combining this with social assessments can be included, since this would be a useful source of information to encourage behavioural change.
b. Water quality issues related to mining (see 4 above).
c. Number of accidents monthly related to mining.

11. Research should be continued on the flora and fauna of KNP and the Potaro Plateau, especially for the following taxonomic groups:

a. Birds
b. Aquatic Beetles
c. Mammals
d. Fishes.

CHAPTER 1

PLANTS OF THE POTARO PLATEAU, GUYANA

Fabián A. Michelangeli, Zola Narine, Isaac Johnson, Phillip Lewis, Nick Carter, Paul Benjamin

Abstract

General plant collections were made in the upper Potaro and within Kaieteur National Park 13-30 March 2014. In total, our work yielded 321 plant collections of vascular plants. Even though to date only 224 collections have been determined to species, we have at least three new species (one Myrsinaceae and two Melastomataceae) and five new reports for Guyana. Several species are reported for the first time for the Potaro plateau or Kaieteur National Park. Concentrated efforts on the family Melastomataceae corroborate that collections by specialists find a significantly higher number of species in a given area than those found by general collections. The high level of plant endemism, new records and range extensions confirm that the upper Potaro and the Kaieteur National Park represent a unique environment critical for the preservation of the biodiversity of the Guiana Shield.

Introduction

The Potaro plateau is located within the Guiana Shield at the north-eastern limit of the Roraima formation. Within the Roraima formation the Potaro plateau constitutes the eastern edge of the Pakaraima Mountains, which extends west to the border with Venezuela. The vegetation in the area is a mosaic of different types determined by soil type, proximity to rivers, and drainage and flood regime. While the majority of the area is covered by riparian forests, there are also areas of white sand savannahs, exposed granite, exposed sandstone and low scrub (Kellof 2003, 2008). This combination of location and geology gives the Potaro plateau a mix of plants from lowland Amazonia to the east and south, the Guiana Highlands to the west and the lowland alluvial planes of the Essequibo to the north (Kellog and Funk 2004).

The area around the Kaieteur Falls and gorge have been the subject of several botanical expeditions since C. Barrington Brown's trip in 1870, and the first collections by Im Thurn in 1879 and Jenman in 1881 (see Kellof and Funk 1998). Several other botanists have visited the area since. A preliminary checklist of the Kaieteur National Park by Kellof and Funk (1998) recorded 1,227 vascular plant species from 121 families. Inspection of the collections at the US National Herbarium at the Smithsonian Institution (US) and the herbarium of The New York Botanical Garden (NY) show that these expeditions rarely collected away from the Potaro River and that the great majority of collections upstream from the falls are mostly concentrated at the base of Mount Ayanganna, with very few collections in the middle section of the Potaro Plateau. There are very few collections from the upper Murimuri basin and the middle Potaro between Chenapau and Mount Ayanganna.

Methods and study sites

Due to time limitations at each site and the lack of a tree climber we decided to forego the sampling using 1 ha plots, a method that has been employed in other surveys in the Guianas. Even though this methodology has been widely used in other preliminary vegetation assessments conducted by WWF, it only accounts for trees and larger lianas, while epiphytes, shrubs and herbs are not sampled. Instead we concentrated on walking along established or newly opened trails trying to visit as many habitats and soil types as possible, and collecting all plants found in flower or fruit. In the Kaieteur to Tukeit trail only Melastomataceae were collected.

In total during this survey we made 321 plant collections. In general, we made three or four duplicates per collection, but in a few cases only two duplicates were made. Thirteen collections are represented by unicates. Samples were field-pressed in newspaper and preserved in ethanol 60%. Additionally, for 24 samples we made liquid-preserved collections, in 2 fl. oz bottles, of flowers and/or leaves for future anatomical studies. Tissue collections were made for 222 of the 314 collections; these consisted of leaf tissue placed in coffee filters and dehydrated in silica-gel. All the samples were shipped to The New York Botanical Garden (NYBG) and dried. Duplicates of these were then distributed to specialists within the NYBG and other institutions for expert identification (see complete list in the acknowledgements for individual researchers and herbaria). Once all the plants are processed a duplicate of each collection will be repatriated to the Guyana National Herbarium of the Centre for the Study of Biological Diversity of the University of Guyana, including all unicates.

Localities visited

Upper Potaro River: 17-23 March

Two main sites were surveyed on the upper Potaro River above the village of Chenapau, at the Bay Camp at the base of the Makaduik rapids and the Upper Potaro Camp (ca. 5 km above Makaduik rapids). Plant surveys were carried out in three main ways: walking along trails in the forest surrounding the two camp sites, from the boat along the river (for riparian and aquatic vegetation), and along the river edge and in areas with rapids for aquatic vegetation. We made 165 collections in this area.

Kaieteur National Park: 24-30 March.

Plant collections from the Kaieteur National Park were concentrated in three areas: the savannah and scrub vegetation near the landing strip and Menzies Landing, the upper Murimuri basin, and on the trail from Kaieteur top to Tukeit. In this area we did not carry out collections from a boat. We reached the headwaters of Murimuri creek by helicopter, and then returned to Menzies Landing walking halfway, and then by boat on the Murimuri creek. Collections were made both at the headwaters of the Murimuri and the savannahs on the way back to Kaieteur top. Collections inside the National Park amounted to 149 specimens.

Limitations

The main limitation was the absence of a tree climber that would have allowed us to collect more tree and epiphytic species. Also, due to the high amount of rain the rivers were above the level expected for this time of the year and we were not able to collect most representatives of the aquatic macrophytes that inhabit many of the rapids visited.

For the processing of the samples, one major limitation has been the determination of species in several families for which there is either no specialist or we have yet to receive a report on the specimens sent to them. In the first group are Lentibulariaceae, Malpighiaceae, Marantaceae, Marcgraviaceae, and Poaceae, among others.

Results

A total of 321 plant collections were made during this survey. To date, 224 have been determined to species, 56 to genus, 48 to family, and the remaining five remain undetermined to even family. These represent 65 different flowering plant families and five ferns and allies. The collections determined to species correspond to 179 different species of vascular plants. A summary of the different species collected, their localities and notes is presented in Table 1.1. Appendix 1 has a comprehensive list of collection numbers and precise localities.

Discussion

Aquatic vegetation along rapids

The high level of the river made it extremely difficult and unsafe to collect the aquatic vegetation on the river rapids. Additionally, the high level of the water also meant that only a small proportion of aquatic plants were flowering at the time of our visit (most aquatic plants bloom during the dry season when the plants are exposed). However, we were still able to collect an important number of aquatic species.

The rapids on the Potaro River have a diverse plant community with Podostemaceae, Cyperaceae and Eriocaulaceae in the faster moving areas. Along the river edges and in areas that are more protected there were fewer or no Podostemaceae, but in addition to Cyperaceae and Eriocaulaceae, we also found representatives of Xyridaceae, Apocynaceae, and Mayacaceae.

The predominant plant in the rapids inhabited by the endemic fish *Characidium amaila* along the Kuribrong River has been preliminarily identified as *Rondonanthus capillaceus* (Eriocaulaceae). This plant is an aquatic usually restricted to fast-moving shallow black water rivers. It should be noted that this plant was not found at any of the four different sets of rapids visited along the Potaro River upstream from the village of Chenapau, but has been reported between Menzies Landing and Kaieteur falls.

***Cynanchum mirifolium* (Apocynaceae), a rarely collected member of the milkweed family restricted to the edges of fast moving rivers and streams in the Roraima formation.**

Table 1.1 **List of specimens collected during the BAT Survey to the Potaro Plateau and Kaieteur National Park and currently determined to species with general plant family, determination, general locality, notes and collection number. In the notes 'K&F' denotes that this species was already reported for Kaieteur National Park by Kelloff and Funk, 1998.**

Family	Scientific Name	General Locality	Notes	Collection number
Apocynaceae	*Cynanchum mirifolium*	Upper Potaro	First record for the Potaro basin	2410
Apocynaceae	*Mandevilla benthamii* (A.DC.) K.Schum.	Murimuri Basin	K&F	2496
Apocynaceae	*Matelea stenopetala*	Upper Potaro	K&F	2369
Apocynaceae	*Tabernaemontana undulata* Vahl	Murimuri Basin	New to park; common in the Neotropics	2473
Asteraceae	*Clibadium surinamense*	Upper Potaro	K&F	2377
Bignoniaceae	*Schlegelia spruceana* Bureau & K.Schum.	Upper Potaro	K&F	2299
Bignoniaceae	*Schlegelia spruceana* Bureau & K.Schum.	Murimuri Basin	K&F	2563
Bignoniaceae	*Schlegelia violacea* (Aubl.) Griseb	Upper Potaro	K&F	2409
Boraginaceae	*Cordia trachyphylla* Mart.	Murimuri Basin	Does not match either species already reported for the park	2511
Bromeliaceae	*Aechmea brassicoides* Baker	Murimuri Basin	K&F	2535
Bromeliaceae	*Aechmea pallida* L.B.Sm.	Murimuri Basin	First report for the park; only second collection ever of this plant, previously known only from the Merume mountains	2534
Bromeliaceae	*Brocchinia cataractarum* (Sandwith) B.Holst	Murimuri Basin	First report for the park; only second collection ever of this plant, previously known only from Amatuk falls in the lower Potaro	2547
Bromeliaceae	*Brocchinia reducta* Baker	Kaieteur Top	K&F	2605
Bromeliaceae	*Catopsis berteroniana* (Schult.f.) Mez	Murimuri Basin	K&F	2533

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Family	Scientific Name	General Locality	Notes	Collection number
Bromeliaceae	*Guzmania lingulata* (L.) Mez	Upper Potaro	K&F	2349
Bromeliaceae	*Guzmania pleiosticha* (Griseb.) Mez	Murimuri Basin	K&F	2560
Bromeliaceae	*Navia gleasonii* L.B.Sm.	Murimuri Basin	First report for the park	2561
Bromeliaceae	*Racinaea spiculosa* (Griseb.) M.A.Spencer & L.B.Sm.	Murimuri Basin	K&F	2548
Clusiaceae	*Clusia grandiflora* Splitg.	Murimuri Basin	K&F	2536
Cucurbitaceae	*Psiguria triphylla* (Miq.) C.Jeffrey	Upper Potaro	K&F	2297
Cyperaceae	*Becquerelia cymosa* Brongn.	Upper Potaro	K&F	2437
Cyperaceae	*Calyptrocarya glomerulata* (Brongn.) Urb.	Murimuri Basin	K&F	2472
Cyperaceae	*Calyptrocarya poeppigiana* Kunth	Upper Potaro	K&F	2350
Cyperaceae	*Calyptrocarya poeppigiana* Kunth	Upper Potaro	K&F	2397
Cyperaceae	*Hypolytrum paraense* M.Alves & W.W.Thomas	Upper Potaro	First record for Guyana	2390
Cyperaceae	*Mapania imeriensis* (T.Koyama) R.Gross	Upper Potaro	K&F	2427
Cyperaceae	*Mapania imeriensis* (R.Gross) T.Koyama	Murimuri Basin	K&F	2474
Cyperaceae	*Mapania tepuiana* (Steyerm.) T.Koyama	Upper Potaro	First record for the Potaro plateau	2327
Cyperaceae	*Rhynchospora cephalotes* (L.) Vahl	Upper Potaro	K&F	2382
Cyperaceae	*Scleria latifolia* Sw.	Upper Potaro	First record for the Potaro plateau	2392
Cyrillaceae	*Cyrilla racemiflora* L.	Murimuri Basin	K&F	2567
Ericaceae	*Notopora schomburgkii* Hook.f.	Kaieteur Top	K&F	2607

Family	Scientific Name	General Locality	Notes	Collection number
Eriocaulaceae	*Rondonanthus capillaceus* (Klotzsch) Hensold & Giul.	Kuribrong River	K&F	2608
Euphorbiaceae	*Chaetocarpus* cf. *schomburgkianus*	Upper Potaro	K&F	2424
Euphorbiaceae	*Phyllanthus myrsinites* Kunth	Murimuri Basin	New to the park; collected only once before in Guyana	2517
Euphorbiaceae	*Phyllanthus vacciniifolius* Müll.Arg.	Murimuri Basin	K&F	2514
Fabaceae	*Senna quinquangulata* (Rich.) H.S.Irwin & Barneby	Murimuri Basin	K&F	2506
Gentianaceae	*Chelonanthus purpurascens* (Aubl.) L. Struwe, S. Nilsson & V. A. Albert	Murimuri Basin	Reported as *Irlbachia purpurascens*	2469
Gentianaceae	*Voyria* cf. *aphylla*	Murimuri Basin	K&F	2552
Gentianaceae	*Voyria* cf. *aphylla*	Murimuri Basin	K&F	2553
Gesneriaceae	*Codonanthopsis calcarata* (Miq.) Chautems & Mat.Perret	Upper Potaro	K&F	2359
Gesneriaceae	*Lesia savannarum* (C.V.Morton) J.L.Clark & J.F.Sm.	Murimuri Basin	K&F	2470
Gesneriaceae	*Nautilocalyx coccineus* Feuillet & L.E.Skog	Upper Potaro	Known from Mt Ayanganna, but not the Potaro plateau	2333
Gesneriaceae	*Nautilocalyx cordatus* (Gleason) L.E.Skog	Murimuri Basin	K&F	2554
Gesneriaceae	*Nautilocalyx pictus* (Hook.) Sprague	Upper Potaro	K&F	2335
Gesneriaceae	*Paradrymonia ciliosa* (Mart.) Wiehler	Upper Potaro	New for the Potaro basin and the park	2324
Gesneriaceae	*Paradrymonia ciliosa* (Mart.) Wiehler	Murimuri Basin	New for the Potaro basin and the park	2551
Humiriaceae	*Humiria balsamifera* Aubl.	Murimuri Basin	K&F	2507

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Family	Scientific Name	General Locality	Notes	Collection number
Lentibulariaceae	*Utricularia humboldtii* R.H.Schomb.	Murimuri Basin	K&F	2491
Malvaceae	*Pachira minor* (Sims) Hemsl.	Upper Potaro	K&F	2325
Malvaceae	*Pachira minor* (Sims) Hemsl.	Upper Potaro	K&F	2376
Mayacaceae	*Mayaca longipes* Martius ex Seubert	Upper Potaro	K&F	2344
Melastomataceae	*Aciotis indecora* (Bonpl.) Triana	Upper Potaro	K&F	2309
Melastomataceae	*Aciotis indecora* (Bonpl.) Triana	Upper Potaro	K&F	2330
Melastomataceae	*Aciotis indecora* (Bonpl.) Triana	Chenapau Village	K&F	2456
Melastomataceae	*Aciotis indecora* (Bonpl.) Triana	Murimuri Basin	K&F	2467
Melastomataceae	*Aciotis indecora* (Bonpl.) Triana	Murimuri Basin	K&F	2475
Melastomataceae	*Aciotis purpurascens* (Aubl.) Triana	Chenapau Village	Not reported for the park, but already collected in the Upper Potaro	2454
Melastomataceae	*Aciotis rubricaulis* (Mart. ex DC.) Triana	Chenapau Village	First report for Guyana; common in the Neotropics	2452
Melastomataceae	*Adelobotrys* cf. *adscendens*	Upper Potaro	Not reported by K & F but already collected in the park and Potaro plateau	2391
Melastomataceae	*Adelobotrys* cf. *monticola* Gleason	Upper Potaro	First record for Guyana	2389
Melastomataceae	*Adelobotrys permixta* Wurdack	Upper Potaro	K&F	2311
Melastomataceae	*Appendicularia thymifolia* (Bonpl.) DC.	Murimuri Basin	K&F	2495
Melastomataceae	*Appendicularia thymifolia* (Bonpl.) DC.	Kaieteur Top	K&F	2589
Melastomataceae	*Bellucia pentamera* Naudin	Kaieteur Top	New for the Potaro basin	2465
Melastomataceae	***Boyania* sp. nov.**	**Murimuri Basin**	**NEW SPECIES**	2486

Family	Scientific Name	General Locality	Notes	Collection number
Melastomataceae	*Clidemia capitata* Benth.	Murimuri Basin	K&F	2501
Melastomataceae	*Clidemia capitellata* (Bonpl.) D.Don	Kaieteur Top	New for the park; common throughout the Neotropics	2581
Melastomataceae	*Clidemia charadrophylla* Tutin	Upper Potaro	K&F	2351
Melastomataceae	*Clidemia conglomerata* DC.	Upper Potaro	New for the park; common in the Guiana Shield and Amazonia	2296
Melastomataceae	*Clidemia conglomerata* DC.	Upper Potaro	New for the park; common in the Guiana Shield and Amazonia	2396
Melastomataceae	*Clidemia epibaterium* DC.	Upper Potaro	Not reported in K&F, but second collection	2444
Melastomataceae	*Clidemia heptamera* Wurdack	Murimuri Basin	K&F	2490
Melastomataceae	*Clidemia hirta* (L.) D.Don	Upper Potaro	K&F	2386
Melastomataceae	*Clidemia involucrata* DC.	Upper Potaro	K&F	2414
Melastomataceae	*Clidemia minutiflora* (Triana) Cogn.	Upper Potaro	K&F	2298
Melastomataceae	*Clidemia minutiflora* (Triana) Cogn.	Tukeit-Kaieteur Trail	K&F	2596
Melastomataceae	*Clidemia novemnervia* (DC.) Triana	Kaieteur Top	New for the park; common throughout the Neotropics	2579
Melastomataceae	*Clidemia ostentata* Wurdack	Upper Potaro	K&F	2428
Melastomataceae	*Clidemia ostentata* Wurdack	Murimuri Basin	K&F	2480
Melastomataceae	*Clidemia pustulata* DC.	Upper Potaro	New for the park; Amazonian basin	2416
Melastomataceae	*Clidemia pycnaster* Tutin	Murimuri Basin	K&F	2500
Melastomataceae	*Clidemia urceolata* DC.	Upper Potaro	New for the park; Neotropics	2315
Melastomataceae	*Clidemia urceolata* DC.	Upper Potaro	New for the park; Neotropics	2318

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Family	Scientific Name	General Locality	Notes	Collection number
Melastomataceae	*Comolia angustifolia* Gleason	Murimuri Basin	New for the park	2525
Melastomataceae	*Comolia angustifolia* Gleason	Kaieteur Top	New for the park	2586
Melastomataceae	*Comolia lythrarioides* Naudin	Murimuri Basin	K&F	2526
Melastomataceae	*Comolia lythrarioides* Naudin	Kaieteur Top	K&F	2588
Melastomataceae	*Comolia microphylla* Benth.	Kaieteur Top	K&F	2463
Melastomataceae	*Comolia microphylla* Benth.	Murimuri Basin	K&F	2499
Melastomataceae	*Comolia vernicosa* (Benth.) Triana	Kaieteur Top	K&F	2460
Melastomataceae	*Comolia villosa* (Aubl.) Triana	Kaieteur Top	K&F	2462
Melastomataceae	*Comolia villosa* (Aubl.) Triana	Kaieteur Top	K&F	2587
Melastomataceae	*Graffenrieda irwinii* Wurdack	Kaieteur Top	K&F	2584
Melastomataceae	*Henriettea maroniensis* Sagot	Upper Potaro	New for the Potaro plateau	2375
Melastomataceae	*Henriettea multiflora* Naudin	Upper Potaro	K&F	2320
Melastomataceae	*Henriettea multiflora* Naudin	Upper Potaro	K&F	2418
Melastomataceae	*Henriettea multiflora* Naudin	Tukeit-Kaieteur Trail	K&F	2598
Melastomataceae	*Henriettea ramiflora* (Sw.) DC.	Upper Potaro	K&F	2388
Melastomataceae	*Henriettea ramiflora* (Sw.) DC.	Kaieteur Top	K&F	2590
Melastomataceae	*Henriettea stellaris* O.Berg ex Triana	Chenapau Village	New for the Potaro plateau	2457
Melastomataceae	*Leandra* cf. *aristigera*	Kaieteur Top	First record for Guyana	2464
Melastomataceae	*Leandra* cf. *aristigera*	Kaieteur Top	First record for Guyana	2578

Family	Scientific Name	General Locality	Notes	Collection number
Melastomataceae	*Leandra divaricata* (Naudin) Cogn.	Murimuri Basin	K&F	2487
Melastomataceae	*Leandra divaricata* (Naudin) Cogn.	Murimuri Basin	K&F	2519
Melastomataceae	*Leandra purpurea* Gleason	Upper Potaro	K&F	2294
Melastomataceae	*Leandra purpurea* Gleason	Tukeit-Kaieteur Trail	K&F	2595
Melastomataceae	*Leandra sanguinea* Gleason	Upper Potaro	K&F	2302
Melastomataceae	*Leandra sanguinea* Gleason	Murimuri Basin	K&F	2483
Melastomataceae	*Leandra sanguinea* Gleason	Murimuri Basin	K&F	2522
Melastomataceae	*Leandra solenifera* Cogn.	Chenapau Village	First collection for the Potaro plateau	2453
Melastomataceae	*Macairea pachyphylla* Benth.	Kaieteur Top	K&F	2580
Melastomataceae	*Macairea thyrsiflora* DC.	Kaieteur Top	K&F	2459
Melastomataceae	*Macrocentrum cristatum* var. *microphyllum* Cogn.	Tukeit-Kaieteur Trail	K&F	2593
Melastomataceae	*Macrocentrum droseroides* Triana	Upper Potaro	K&F	2445
Melastomataceae	*Macrocentrum droseroides* Triana	Murimuri Basin	K&F	2489
Melastomataceae	*Macrocentrum minus* Gleason	Upper Potaro	Not reported by K & F but already collected in the park and Potaro plateau	2447
Melastomataceae	*Macrocentrum vestitum* Sandwith	Upper Potaro	K&F	2346
Melastomataceae	*Macrocentrum vestitum* Sandwith	Upper Potaro	K&F	2417
Melastomataceae	*Macrocentrum vestitum* Sandwith	Murimuri Basin	K&F	2488
Melastomataceae	*Macrocentrum vestitum* Sandwith	Murimuri Basin	K&F	2576

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Family	Scientific Name	General Locality	Notes	Collection number
Melastomataceae	*Macrocentrum vestitum* Sandwith	Tukeit-Kaieteur Trail	K&F	2597
Melastomataceae	*Maieta guianensis* Aubl.	Upper Potaro	First collection for the Potaro plateau	2331
Melastomataceae	*Maieta poeppigii* Mart. ex Cogn.	Upper Potaro	K&F	2303
Melastomataceae	*Maieta poeppigii* Mart. ex Cogn.	Tukeit-Kaieteur Trail	K&F	2594
Melastomataceae	*Meriania urceolata* Triana	Upper Potaro	K&F	2378
Melastomataceae	*Miconia bracteata* (DC.) Triana	Upper Potaro	K&F	2305
Melastomataceae	*Miconia bracteata* (DC.) Triana	Upper Potaro	K&F	2440
Melastomataceae	*Miconia bracteata* (DC.) Triana	Murimuri Basin	K&F	2476
Melastomataceae	*Miconia centrodesma* Naudin	Upper Potaro	Common in lowland South America; first report for Potaro plateau	2301
Melastomataceae	*Miconia ciliata* (Rich.) DC.	Murimuri Basin	K&F	2531
Melastomataceae	*Miconia dodecandra* Cogn.	Upper Potaro	K&F	2406
Melastomataceae	*Miconia hypoleuca* (Benth.) Triana	Upper Potaro	Known from Mt Ayanganna, but not the Potaro plateau	2405
Melastomataceae	*Miconia maguirei* Gleason	Murimuri Basin	K&F	2468
Melastomataceae	*Miconia maguirei* Gleason	Tukeit-Kaieteur Trail	K&F	2591
Melastomataceae	*Miconia marginata* Triana	Upper Potaro	K&F	2432
Melastomataceae	*Miconia marginata* Triana	Murimuri Basin	K&F	2482
Melastomataceae	*Miconia plukenetii* Naudin	Upper Potaro	K&F	2373
Melastomataceae	*Miconia polita* Gleason	Upper Potaro	K&F	2342

Family	Scientific Name	General Locality	Notes	Collection number
Melastomataceae	*Miconia prasina* (Sw.) DC.	Upper Potaro	K&F	2317
Melastomataceae	*Miconia prasina* (Sw.) DC.	Upper Potaro	K&F	2371
Melastomataceae	*Miconia racemosa* (Aubl.) DC.	Upper Potaro	K&F	2387
Melastomataceae	*Miconia serrulata* (DC.) Naudin	Chenapau Village	Common in lowland South America; first report for Potaro plateau	2455
Melastomataceae	*Miconia virgulata* Gleason	Upper Potaro	Reported as *Miconia ciliata*, but distinct	2339
Melastomataceae	*Miconia virgulata* Gleason	Upper Potaro	Reported as *Miconia ciliata*, but distinct	2436
Melastomataceae	*Phainantha laxiflora* (Triana) Gleason	Upper Potaro	K&F	2347
Melastomataceae	*Phainantha laxiflora* (Triana) Gleason	Upper Potaro	K&F	2439
Melastomataceae	*Pterolepis glomerata* (Rottb.) Miq.	Chenapau Village	K&F	2458
Melastomataceae	*Pterolepis glomerata* (Rottb.) Miq.	Kaieteur Top	K&F	2601
Melastomataceae	***Salpinga* sp. nov.**	**Murimuri Basin**	**NEW SPECIES**	**2555**
Melastomataceae	*Siphanthera cordifolia* (Benth.) Gleason	Kaieteur Top	K&F	2461
Melastomataceae	*Tococa aristata* Benth.	Murimuri Basin	K&F	2564
Melastomataceae	*Tococa aristata* Benth.	Tukeit-Kaieteur Trail	K&F	2592
Melastomataceae	*Tococa desiliens* Gleason	Murimuri Basin	K&F	2556
Melastomataceae	*Tococa desiliens* Gleason	Kaieteur Top	K&F	2582
Melastomataceae	*Tococa nitens* (Benth.) Triana	Kaieteur Top	K&F	2583
Meliaceae	*Carapa guianensis* Aublet	Upper Potaro	First record for the Potaro plateau; common in the Neotropics	2348
Myrsinaceae	*Cybianthus guyanensis* (A.DC.) Miq. subsp. *multipunctatus* (A.DC.) Pipoly	Upper Potaro	K&F	2316

Table 1.1 **List of specimens collected during the BAT Survey to the Potaro Plateau and Kaieteur National Park and currently determined to species with general plant family, determination, general locality, notes and collection number. In the notes 'K&F' denotes that this species was already reported for Kaieteur National Park by Kelloff and Funk, 1998. (*cont'd*)**

Family	Scientific Name	General Locality	Notes	Collection number
Myrsinaceae	**Myrsinaceae**	**Murimuri Basin**	**NEW SPECIES**	**2544**
Ochnaceae	*Sauvagesia longipes* Steyerm.	Murimuri Basin	First report for the park; only second collection for Guyana	2546
Ochnaceae	*Sauvagesia sprengelii* A.St.-Hil.	Murimuri Basin	K&F	2493
Orchidaceae	*Cheiradenia cuspidata* Lindl.	Murimuri Basin	First report for the park	2545
Orchidaceae	*Epidendrum tridens* Poepp. & Endl	Upper Potaro	K&F	2357
Orchidaceae	*Koellensteinia* cf. *graminea* (Lindl.) Rchb.f.	Upper Potaro	First report for the Potaro plateau. Rarely collected in Guyana	2328
Passifloraceae	*Passiflora glandulosa* Cav.	Upper Potaro	K&F	2399
Polygalaceae	*Bredemeyera densiflora* var. *glabra* A.W.Benn.	Murimuri Basin	K&F	2513
Polygalaceae	*Caamembeca spectabilis* (DC.) J.F.B.Pastore var. *spectabilis*	Murimuri Basin	First report for the park; only second collection for Guyana	2537
Polygalaceae	*Securidaca retusa* Benth.	Upper Potaro	K&F	2355
Pteridophyte	*Cochlidium furcatum* (Hook. & Grev.) C.Chr.	Upper Potaro	K&F	2364
Pteridophyte	*Cyathea pungens* (Willd.) Domin	Upper Potaro	Reported previously as *C. procera*	2394
Pteridophyte	*Dracoglossum plantagineum* (Jacq.) Christenh.	Upper Potaro	Reported previously as *Tectaria plantaginea*	2336
Pteridophyte	*Elaphoglossum glabellum* J.Sm.	Upper Potaro	K&F	2404
Pteridophyte	*Lindsaea lancea* (L.) Bedd.	Murimuri Basin	K&F	2532
Pteridophyte	*Lindsaea reniformis* Dryand.	Upper Potaro	New report for the park	2446

Family	Scientific Name	General Locality	Notes	Collection number
Pteridophyte	*Lindsaea sagittata* Dryand.	Upper Potaro	K&F	2338
Pteridophyte	*Metaxya rostrata* (Kunth) C.Presl	Upper Potaro	K&F	2337
Pteridophyte	*Serpocaulon triseriale* (Sw.) A.R.Sm.	Upper Potaro	Reported as *Polypodium triseriale*	2423
Rapateaceae	*Potarophytum riparium* Sandwith	Murimuri Basin	K&F	2574
Rapateaceae	*Rapatea fanshawei* var. *fanshawei*	Murimuri Basin	First report for the park	2542
Rapateaceae	*Rapatea paludosa* Aubl.	Upper Potaro	K&F	2313
Rapateaceae	*Rapatea xiphoides* Sandwith	Murimuri Basin	K&F	2550
Rapateaceae	*Saxofridericia regalis* R.H.Schomb.	Kaieteur Top	K&F	2599
Rapateaceae	*Stegolepis angustata* Gleason	Kaieteur Top	K&F	2600
Rapateaceae	*Stegolepis ferruginea* Baker	Murimuri Basin	K&F	2530
Rubiaceae	*Didymochlamys connellii*	Upper Potaro	K&F	2329
Rubiaceae	*Notopleura tapajozensis*	Upper Potaro	K&F	2435
Rubiaceae	*Notopleura uliginosa*	Upper Potaro	K&F	2334
Rubiaceae	*Palicourea triphylla*	Upper Potaro	K&F	2312
Rubiaceae	*Perama hirsuta* Aubl.	Murimuri Basin	K&F	2516
Rubiaceae	*Psychotria apoda*	Upper Potaro	Not reported in K&F, but several collections from Ayanganna and other localities in Guyana	2306
Rubiaceae	*Psychotria bostrychothyrsus*	Upper Potaro	K&F	2304
Rubiaceae	*Psychotria maguireorum* Steyerm.	Upper Potaro	K&F	2345
Rubiaceae	*Psychotria platypoda*	Upper Potaro	K&F	2321
Rubiaceae	*Psychotria spadicea*	Murimuri Basin	First report for Guyana	2512

Table 1.1 **List of specimens collected during the BAT Survey to the Potaro Plateau and Kaieteur National Park and currently determined to species with general plant family, determination, general locality, notes and collection number. In the notes 'K&F' denotes that this species was already reported for Kaieteur National Park by Kelloff and Funk, 1998. (*cont'd*)**

Family	Scientific Name	General Locality	Notes	Collection number
Rutaceae	*Raveniopsis ruellioides* (Oliv.) R.S.Cowan	Upper Potaro	First report for the Potaro plateau. Rarely collected in Guyana	2429
Salicaceae	*Casearia singularis* Eichler	Upper Potaro	First collection for the Potaro plateau	2395
Sapindaceae	*Paullinia isoptera* Radlk	Upper Potaro	Not reported in K&F, but already collected in the Potaro plateau	2363
Sapindaceae	*Paullinia rufescens* Rich. ex Juss.	Upper Potaro	Not reported in K & F, but already collected in the Potaro plateau	2365
Simaroubaceae	*Simaba monophylla* (Oliv.) Cronquist	Murimuri Basin	K&F	2572
Theaceae	*Bonnetia sessilis* Benth.	Murimuri Basin	K&F	2575
Theaceae	*Ternstroemia laevigata* Wawra	Murimuri Basin	Not perfect match; this species only reported from Venezuela	2509
Verbenaceae	*Amasonia campestris* (Aubl.) Moldenke	Upper Potaro	K&F	2398
Viscaceae	*Phoradendron bilineatum* Urb.	Upper Potaro	First record for the Potaro plateau	2367
Xyridaceae	*Abolboda grandis* Griseb. var. *grandis*	Kaieteur Top	K&F	2606
Xyridaceae	*Xyris fallax* Malme	Kaieteur Top	K&F	2603
Xyridaceae	*Xyris involucrata* Nees	Kaieteur Top	K&F	2602
Xyridaceae	*Xyris setigera* Oliv.	Murimuri Basin	K&F	2520
Xyridaceae	*Xyris setigera* Oliv.	Kaieteur Top	K&F	2604

THE UPPER MURIMURI BASIN AND THE RIDGES SEPARATING IT FROM THE KURIBRONG RIVER BASIN MAY HAVE SERVED AS A REFUGE FOR TAXA OTHERWISE RESTRICTED TO HIGHER ELEVATIONS IN THE PAKARAIMA MOUNTAINS

Noteworthy collections

AT LEAST THREE NEW SPECIES OF FLOWERING PLANTS WERE FOUND DURING THIS QUICK SURVEY

Even though the Potaro plateau has been much better collected than most areas of Guyana, and in spite of the time and logistical limitations explained above, **during this quick survey we were able to find at least three new species of flowering plants** (one Myrsinaceae, being described by J. Rickets at MO; and two Melastomataceae). Additionally, **five other species had not been previously collected in Guyana and several were not known from the Park or the Potaro plateau.** Noteworthy among these new records for the Potaro plateau are two species of Bromeliaceae previously only known from the type collections (*Aechmea pallida* and *Brochinnia cataractarum*) and probably photographed only for the first time. All of the new reports for the park or the Potaro plateau were from plants collected in the upper Potaro or the upper Murimuri basin, corroborating the fact that these areas should be the target for future collecting efforts. Interestingly as well is the fact that most of the new reports for the park that come from the upper Murimuri basin correspond to plants otherwise known from Mt Wokumung or Mt Ayanganna, or from higher elevation localities further west in the Pakaraima range. This suggests that **the upper Murimuri basin and the ridges separating it from the Kuribrong River basin may have served as a refuge for taxa otherwise restricted to higher elevations in the Pakaraima Mountains.**

***Aechmea pallida* (Bromeliaceae), collected in the Murimuri basin, previously only known from the type collection in the Merume Mountains.**

***Brocchinia cataractarum* (Bromeliaceae), only the second collection ever of this plant, previously known only from the Amatuk Falls in the lower Potaro.**

Melastomataceae

It has been shown that field collections by plant specialists recover a higher proportion of the diversity in this family at a given site than general collectors (Medeiros et al. 2014), as they can discriminate different taxa in the field and generally have a better search pattern for their group of interest. Additionally, recent exploration of other localities in the Guiana Shield continue to yield new country records, range extensions and new species (see Barbosa-Silva et al. 2016). As most of my research concentrates on systematics, taxonomy and evolution of the plant family Melastomataceae, we took the opportunity to sample all of the species that were either in flower or fruit in this group. Melastomataceae are an important component of the understory of most moist environments in the Neotropics and it is especially diverse in the Guianas (Almeda et al. 2007; Wurdack et al. 1993). Kelloff and Funk (1998) reported 61 species of Melastomataceae for the Kaieteur National Park. During this survey we made 105 collections of Melastomataceae (33% of the total plants collected during the trip) representing 66 species from 19 genera from four different tribes of Melastomataceae. Even though the numbers of species reported by Kelloff and Funk (1998) are similar to those found by us, **11 species which we found had not been collected or reported for the park or the Potaro plateau.** This represents an increase of 16.67% on the number of species in this family reported for the area. Similarly, seven species reported by Kelloff and Funk (1998) were not found during this survey; this is probably mostly due to the fact that they were not flowering during the time of our visit. This clearly shows that specialists can indeed recover a higher proportion of the biodiversity at a given site, and that **even localities that have been relatively well collected in the Guiana Shield continue to yield taxonomic novelties and new reports.**

11 SPECIES OF MELASTOMATACEAE WHICH WE FOUND HAD NOT BEEN COLLECTED OR REPORTED FOR THE PARK OR THE POTARO PLATEAU

Clidemia heptamera **(Melastomataceae), an ant-plant restricted to mid-elevations in eastern Venezuela and Guyana.**

Notably, **among the collections of Melastomataceae are collections of *Phainantha*, a rarely collected group endemic to the Guiana shield; four species of *Macrocentrum*, a genus mostly restricted to the Roraima formation, one new species of *Salpinga*, and one new species of *Boyania*. We were also able to collect three species believed to be endemic to the Potaro basin: *Tococa desiliens*, *Graffenrieda irwinii* and *Clidemia charadrophylla*.** Other notable species of Melastomataceae restricted to the Pakaraima Mountains include *Clidemia heptamera*, *Miconia maguirei*, and *Tococa aristata*. Four different species of myrmecophytic Melastomataceae were collected (*Clidemia heptamera*, *Maieta guianensis*, *Maieta poeppigii* and *Tococa aristata*), and a fifth one observed (*Tococa guianensis*) (see Michelangeli 2010).

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***Miconia maguirei* (Melastomataceae), a locally common shrub that is endemic to the Potaro Basin.**

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***Henriettea ramiflora* (Melastomataceae), a common tree that usually grows along streams and rivers in northern South America and Central America.**

***Caamembeca spectabilis* (Polygalaceae), found in the upper Murimuri basin in the Kaieteur National Park, is a rarely collected neotropical vine and represents only the second record for Guyana.**

***Raveniopsis ruellioides* (Rutaceae), a rarely collected plant in Guyana, usually restricted to the edges of fast moving rivers and streams.**

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***Sauvagesia longipes* (Ochnaceae), an epiphytic herb, rarely collected in the Guiana Shield and only the second known collection for Guyana.**

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***Schlegelia violacea* (Bignoniaceae), a vine restricted to the Guianas and northern Brazil.**

Conservation recommendations

The Kaieteur National Park and the upper Potaro River basin represent a unique mid-elevation area (500-700 m above sea level) with several different environments, most of them relatively well preserved. Moreover, most of the areas in this elevation range are usually the slopes of the different mountains in the Guiana Shield, thus they are usually steep. However, because the upper Potaro River basin is a large plateau, it represents a fairly uncommon large area of forests on flatter terrain. This is evident by the number of species endemic to the relatively small area sampled, and the number of new records for Guyana or the Potaro River basin reported here.

It should be noted that some of the collections of the upper Murimuri basin were made in areas that have been degraded due to illegal diamond and gold mining, some of them still active, while others had already been abandoned for a few years. The opportunity should be taken to monitor the recovery of these areas over time as mining operations are closed.

The areas east of Kaieteur top (right margin of the Potaro River) also lack collections and, because they include several unique environments with rock faces and fast-moving creeks that have not yet been surveyed, should also be explored in the near future.

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CHAPTER 2

MEDIUM AND LARGE MAMMALS OF THE PAKARAIMA MOUNTAINS

Evi A.D. Paemelaere, Nick Carter, Frank Carter and Rupert Williams

Abstract

Medium and large mammals are important for forest health and to support local livelihoods of indigenous people. Nevertheless, they have received limited or no attention in terms of research in the Pakaraima Mountains. We conducted a study with camera traps in the dry season near Chenapau village bordering Kaieteur National Park, and detected 18 terrestrial mammal species, plus a further three by other methods. Relative abundance values were low compared to other forested sites in Guyana. We estimated preliminary jaguar densities based on capture-recapture analysis, resulting in a low density of 1.6 (SE=1.2) individuals per 100 km^2. While hunting may have localized impact on wildlife populations, the connectivity with surrounding forests, including the bordering protected area, likely buffers this effect. The low abundance values are expected to result from the tough and highly variable terrain combined with a small sample effort for this level of micro-habitat variation. This is supported by the higher abundance of deer, which are commonly hunted, but may be well adapted to the terrain. Furthermore, the presence of disturbance-sensitive species such as the white-lipped peccary, tapir and giant armadillo supports the notion that the habitat remains highly valuable for wildlife. Our results warrant further research with special attention to micro-habitat variation to better understand the biological value and determine suitable management of mammals in the Pakaraima Mountains, which will be even more important when considering the establishment of a protected area.

Introduction

Mammals have been an important source of protein for Amerindians for tens of thousands of years (Redford 1992), and this continues to be true today, especially in remote forests where options for rearing livestock are limited. Nevertheless, hunting often drives depletion or even local extinction of mammalian populations (Peres 1990; Redford 1992; Cullen Jr, Bodmer and Valladares-Pádua 2000; Hill, McMillan and Fariña 2003). Especially larger species are sensitive to this disturbance due to their naturally low densities and slow reproductive rates (Purvis et al. 2000; Brashares 2003; Cardillo et al. 2004). Therefore, monitoring of mammal populations is important in ensuring long-term sustainability of local livelihoods, especially with growing pressures on previously undisturbed habitat and an increase in population size that leads to a higher demand for food resources.

The Pakaraima Mountains stretch along Guyana's border with Venezuela and Brazil. The mountains offer a unique habitat with tepui formations, an intricate network of waterways and forested ridges.

In part due to its ruggedness, human population density is very low (<1/km^2). Only a few territories of Amerindians of Patamona descent are occupied in this large area. Due to their remoteness, these villages have largely depended on hunting and fishing. The growing mining industry offers an alternative means of livelihood, but wild meat remains an important source of nutrition, even for miners.

While the Pakaraima Mountains have received considerable attention in terms of biological diversity (e.g. Eggleton et al. 1999; Braun et al. 2003; Kelloff and Funk 2004; Kok 2006; Kelloff 2008; Kok and Kalamandeen 2008), medium and large mammal populations have not been studied in the area (Lim, Townsend Peterson and Engstrom 2002), and knowledge of the diversity of these species stems mostly from hunters. Nevertheless, some species are very elusive and difficult to detect, and no information is available on the spatial variability of mammals in this terrain. The objective of this survey was to study the diversity and relative abundance of medium and large mammals in the Pakaraima Mountains along the Potaro River, and to present a baseline for potential future monitoring.

Methods and description of study sites

Study site

The study site (base camp: 5° 02.810' N, 59° 38.929' W) was located along the Potaro River upstream from Chenapau village (4° 58.994' N, 59° 34.664' W) in the Pakaraima Mountains. This forested area ranged between 400 and 900 m in altitude, with steep ridges starting from the river's edge. While the canopy was dense, the forest was generally relatively open, with limited cover of the forest floor and a secondary tree layer with very thin stems. Scattered swamps were mostly dry at the time of the study. Active and abandoned subsistence farms were located between the base camp and the village.

Field surveys

We used camera traps (Cuddeback Capture) for detection of mammals weighing more than 1kg. For these larger land vertebrates, camera trapping is considered the best method for surveying (Rowcliffe et al. 2008; Diaz-Pulido and Payán 2011). The camera traps provide information on the species, and the time and location of activity. Cameras were set between 5 to 15 March 2014 and collected between 8 to 12 April 2014. We set one camera per station along existing walking trails on both sides of the Potaro River with 600-800 m straight line distance between stations. Most trails were hunting lines or gave access to (abandoned) small scale mining locations. Most trails were used infrequently and therefore often not very clear. Sites with wildlife trails or creek beds along these lines were given preference. During camera trapping we recorded animal tracks and live sightings of terrestrial mammals and monkeys.

Data analysis

Photographs were identified to species and independent photographs were considered as single occurrences for estimating relative abundance of species *sensu* O'Brien (2003). We used rarefaction curves to assess completeness of the survey and evaluate species richness and diversity using EstimateS (Colwell 2006). For jaguars, preliminary population densities were calculated (Karanth, Kumar and Nichols 2002; Wallace et al. 2003), using closed populations models in CAPTURE (Otis et al. 1978; White et al. 1982; Rextad and Burnham 1991), and Spatially Explicit Capture Recapture (SECR) in the software package Density (Efford 2012).

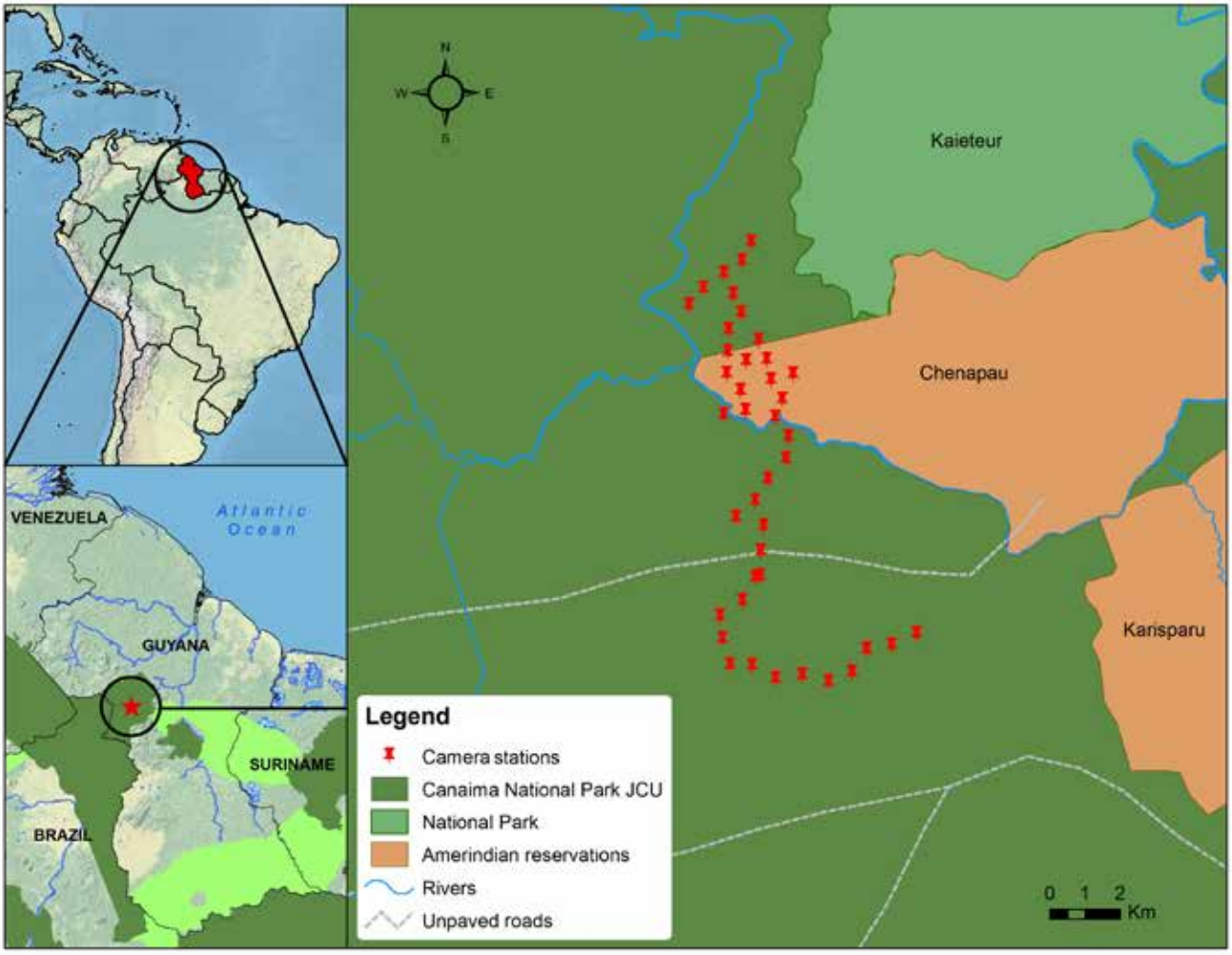

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Figure 2.1 **Study area with camera trap locations. The map on the bottom left shows the location within the jaguar corridor framework, in which Kaieteur connects to Canaima National Park in Venezuela. Chenapau is located within the Jaguar Conservation Unit (JCU).**

Results

In 1,204 trap-nights, we collected 134 independent photographs of mammals and 88 of birds. Mammal photos represented 18 species (see Table 2.1). For birds, we photographed the Black Curassow (*Crax alector*), Grey-winged Trumpeter (*Psophia crepitans*) and a few Undulated Tinamous (*Crypturellus undulatus*). The mammals with the highest relative abundance were white-lipped peccaries (*Tayassu pecari*), followed by agoutis (*Dasyprocta leporina*), red and brown brocket deer (*Mazama americana, M. nemorivaga*), labba (*Cuniculus paca*) and jaguar (*Panthera onca*). Overall, relative abundance values were low. Survey effort was insufficient; the species accumulation curve did not reach the asymptote. Therefore, values of species richness and diversity are preliminary at best. The Simpson Diversity index was 5.3. Based on Jackknife estimators, the total number of medium to large mammals at the study site was 18.93 (SE=1.53).

Live sightings by the team included a tayra (*Eira barbara*) of the black-bodied white-headed class form near the base camp, a group of at least three black spider monkeys (*Ateles paniscus*) by the camp, and a brown brocket deer (*Mazama nemorivaga*) 4 km south-west of Chenapau, in a farm area. The supporting staff from Chenapau encountered brown brocket deer, red brocket deer and labba in the forests surrounding the camp during the nights between 5-11 March 2014 when our team was in the field. While live sightings were very limited during the daytime, tracks were abundant, particularly on the north side of the camp where large sections of the trail were muddy from recent rains. The trails on the south side consisted mostly of roots covered in thick leaf litter, rendering detection of tracks more difficult. The most common footprints were of deer and tapir. Burrows and scratch marks from armadillos and rodents were also common, but the species could not always be identified.

Preliminary jaguar density

We identified at least three jaguars based on the unique coat pattern. Due to the difference between the left and right side of the individual pattern, we could not determine which photographs from the left sides of individuals corresponded to right sides of individuals. We used the nine right-side photographs from three individuals for a preliminary density analysis. Applying closed-population models, the best model was found to be Mh, which accounts for variation between individuals in detection probability. Applying a buffer equal the Mean Maximum Distance Moved (MMDM), this analysis resulted in 1.6 (SE=0.61) individuals per 100 km^2 based on an effective sampling area of 245 km^2. SECR analysis resulted in a similar density: 1.6 (SE=1.2) individuals per 100 km^2.

Table 2.1 **List of mammal species detected at the Chenapau study site. For photo-captured species, the relative abundance index (RAI) represents the number of individuals photographed per 100 trap-nights. Species listed as threatened or near-threatened by IUCN are highlighted.**

Species	Common name	RAI	Footprint	Live	Other	Comment
RODENTIA						
Dasyprocta leporina	Red-rumped agouti	2.243	x		x	Scratch marks
Cuniculus paca	Labba	1.246	x	x	x	Gnaw marks on fruit
XENARTHRA						
***Dasypus* sp.**	Armadillo				x	Burrows, scratch marks
Dasypus novemcinctus	9-banded armadillo	0.415				
Dasypus kappleri	Long-nosed armadillo	0.083				
Priodontes maximus	Giant armadillo	0.083			x	Burrows (inactive)
UNGULATES						
Tapirus terrestris	Tapir	0.166	x			
Mazama americana	Red brocket deer	1.163	x	x		
Mazama nemorivaga	Brown brocket deer	1.495	x	x		
Pecari tajacu	Collared peccary	0.249				
Tayassu pecari	White-lipped peccary	6.312			X*	Wallow
CARNIVORA						
Panthera onca	Jaguar	1.329			x	Scrape mark, tracks
Puma concolor	Puma	0.581				
Puma yagouaroundi	Jaguarundi	0.083				
***Leopardus* sp.**	Margay/Oncilla?	0.166	x			Claw marks on tree
Leopardus pardalis	Ocelot	0.249			x	Skeleton
Eira barbara	Tayra	0.083		x		
Nasua nasua	South American coati	0.249				
DIDELPHIMORPHIA						
Didelphis marsupialis	Common opossum	0.332				
PRIMATES						
***Alouatta* sp.**	Red howler monkey				x	Vocalization
Ateles paniscus	Black spider monkey			x	x	Vocalization

* Believed to be *Tayassu pecari*, but wallow was old

Discussion

We evaluated relative abundance, species richness for medium-large mammals in the Pakaraimas through camera traps, tracks and live sightings, and estimated population density of jaguars, the top predator in this ecosystem. Camera traps detected 18 medium-large mammals, resulting in diversity comparable to other forested sites in Guyana. Relative abundance values, on the other hand, were very low in comparison with other study sites in the country, except for white-lipped peccaries and deer, which fell within the range of values for forested sites (Paemelaere and Payán Garrido 2012; Paemelaere and Payán Garrido 2013; Paemelaere et al. 2014). These results were consistent with our records of tracks and the limited number of live sightings.

Jaguar density was low in comparison to the average of three jaguars per 100 km² recorded for other areas in the Amazon (Tobler et al., 2013). Both SECR and closed population models resulted in the same density (1.6 jaguars per 100 km²). This value, however, was preliminary, based on only three individuals. Capture probability was 0.07, slightly lower than the 0.1 recommended for a reliable estimate (White et al. 1982). The coefficient of variance (SE*100/average) for the Mh model was 37.8% for Mh and even larger for SECR, thus exceeding the 20% maximum recommended (Linkie et al. 2008). This variance indicates that the precision of the estimate is relatively low and more data are needed. At the same time, the comparatively low density of jaguars corresponds with the low abundance data of potential prey species.

Low abundance could result from habitat characteristics or hunting pressure or both. Considering deer abundance was comparatively high, hunting pressure likely only explains a part of our findings. Deer is one of the preferred species of many forest communities (Peres and Nascimento 2006; Read et al. 2010; Paemelaere and Payán Garrido 2012), and this also seemed to be true for our study site. Furthermore, prey species were sufficiently abundant to support both jaguar and puma, albeit at a seemingly relatively low population density. Hunting pressure may be highly localized, with sink (hunting sites) and source (non-hunting sites) populations. Additionally, the habitat with its steep yet low elevation ridges may not be as suitable as lowland forest for many mammals. Species may also be selecting highly specific micro-habitats, such as valleys with creeks, resulting in high local abundance at selected sites and the opposite pattern for the remainder of the area. Indeed, for brown brocket deer, for example, 61% of observations stemmed from a single camera.

CONNECTIVITY IS IMPORTANT FOR THE LONG-TERM EFFECTIVENESS OF PROTECTED AREAS, ESPECIALLY FOR LARGER SPECIES, WHICH REQUIRE LARGE AREAS TO SUPPORT SUFFICIENTLY LARGE POPULATIONS IN ORDER TO MAINTAIN GENETIC VARIABILITY

Camera trapping is considered the best method for evaluation of abundance of medium-large mammals (Rowcliffe et al. 2008; Diaz-Pulido and Payán 2011). The cameras detected all species we had identified through tracks, as well as some for which no tracks were seen. This is expected, considering tracks are typically biased towards hoofed animals. Furthermore, our sampling effort of 1,204 trap-nights was sufficient to detect the more common species (Tobler et al. 2008). Due to low detection rates (17 photographs of mammals/100 trap-nights), sampling was insufficient for reliable species diversity and richness estimates. Nevertheless, richness and diversity were comparable to other forested sites in Guyana (Paemelaere and Payán Garrido 2013; Paemelaere et al. 2014), and further sampling is not expected to result in large differences from our findings here.

Based on tracks, tapir, red brocket deer and brown brocket deer were detected most commonly, which could be expected, based on their weight and the hooves, which result in deeper and clearer imprints than tracks of non-hoofed animals. Forest floor cover varied from thick leaf litter, to bare soil and rocky surfaces, leading to further variability in detectability of tracks. For these reasons, and because no systematic survey could be conducted while setting up the cameras, tracks were not used for quantitative assessments. The high abundance of deer tracks corresponded to camera trap data, while for tapir tracks this was not the case.

Conservation recommendations

While mammal abundance was overall low, the presence of several threatened species could indicate limited disturbance. For example, white-lipped peccaries have recently been up-listed and are now considered 'vulnerable' throughout their range (Altrichter et al. 2012). The decrease in their population may be related to disease, but is also affected by hunting pressure. These peccaries live in large groups that need extensive territories (Fragoso 1998; Carrillo, Saenz and Fuller 2002; Keuroghlian, Eaton and Longland 2004; Reyna-Hurtado, Rojas-Flores and Tanner 2009). Therefore, detection probability is low in designs with limited area coverage, as was the case in this study. The high relative abundance of this species, stemming from different camera traps and from both sides of the river, suggests this vulnerable species is common in the area. White-lipped peccaries serve as forest engineers through the wallows they create (Altrichter et al. 2012), and they form an important part of the jaguar diet (Garla, Setz and Gobbi 2001). Other, more intensive studies with camera traps in Guyana failed to detect the species. Other threatened species, such as tapir and giant armadillo, had low relative abundance. All three species are sensitive to hunting (Bodmer 1995; Peres 2000), but their presence supports the notion that the habitat remains highly valuable for wildlife. The study area borders Kaieteur National Park and lies within the zone that connects this protected area with Canaima National Park in Venezuela. Such **connectivity is important for the long-term effectiveness of protected areas, especially for larger species, which require large areas to support sufficiently large populations in order to maintain genetic variability** (Brashares, Arcese and Sam 2001; Crooks 2002; Cardillo et al. 2005). Our data indicate that the habitat may not support populations as large as in the lowland forests, and further research is needed to better understand the use of this habitat by large mammals.

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Figure 2.2 Top: **Team discussing potential sites for camera traps**
Centre left: **Nick Carter and Rupert Williams crossing a creek.** Centre right: **Frank Carter setting up camera trap.**
Bottom from left: **White-lipped peccaries. Jaguar. Black Curassow.**

Figure 2.3 Top left: **N. Carter and F. Carter adjusting a camera trap;** Top right: **R Williams testing the camera trap setup;** Middle left: **small cat scratch mark;** Middle right: **labba track;** Bottom left: **jaguar scrape mark;** Bottom right: **E. Paemelaere examining ocelot skeleton.**

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Area near the study site with extensive forest in an undulating landscape with rivers and creeks.

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CHAPTER 3

AMPHIBIANS AND REPTILES OF THE KAIETEUR PLATEAU AND THE UPPER POTARO RIVER, GUYANA

Andrew Snyder, Timothy J. Colston, Lewis Skybar, Maxwell Basil, Rufford Ngala and Danny Gordon

Summary

We conducted herpetofaunal inventory surveys at five sites throughout Guyana's Kaieteur plateau from 3-15 March and 18-28 March 2014. During this time, we recorded 36 species of amphibians and 30 species of reptiles. Amphibians were represented by two orders: Anura (ten families) and Gymnophiona (one family). Nearly one half of Anurans were tree frogs (Hylidae), with 15 species. The single caecilian (Gymnophiona) documented was in the family Rhinatremidae. We recorded one species each of crocodilian and tortoise, 11 species of lizards from six families and 17 species of snakes from five families. **Additionally, two tree frogs (*Hypsiboas* sp. and *Osteocephalus* cf. *exophthalmus*) and a swamp snake (*Erythrolamprus* sp.) remain unidentified and may represent new country records, range extensions, or potentially new species to science.** Before formal species assignation can be made, additional morphological and genetic investigation is required. The herpetofaunal composition differed among the five focal areas surveyed during this expedition, with many species being unique to a particular site. The environs around Bay Camp (upper Potaro) appeared to be in pristine condition, though unequal survey efforts and differences in rainfall may explain the variation in community composition and number of species encountered among sites. While the number of species we recorded is low when compared to other, better sampled sites in the Guiana Shield (e.g. Iwokrama, Guyana; Nouragues, French Guiana), our results are comparable with recent studies of similar duration and scope in Suriname and the uplands of Guyana. Ultimately the continual, daily accumulation of new species during our survey, with a lack of a plateau, is evidence of a healthy and diverse forest ecosystem. **Maintaining the integrity of undisturbed forest and freshwater habitats within and outside the Kaieteur National Park and preventing the expansion of mining activities are critical to the future survival of species.**

Introduction

Amphibians and reptiles (herpetofauna) are important components of forests and much of their inherent biology (e.g. large population sizes, small to intermediate body size, position in food webs, and microhabitat requirements) contributes to their value as target taxa for biotic surveys. Amphibians are sensitive to changes in microhabitat and water quality, and as such are good indicators of environmental disturbance (Stuart et al. 2004). Additionally, amphibians lend themselves well to rapid assessment surveys as they are often conspicuous, and even hard to collect species (e.g. canopy dwellers) can be recorded passively via their species specific vocalizations (Marty and Gaucher 2000). Lizard community diversity is known to be higher in primary forest rather than secondary or altered (e.g. agriculture/plantation) forest (Gardner et al. 2007) and therefore lizards are presumed to be good indicators of disturbance as well. Lastly, while snake community structure has been shown to be resilient to some level of anthropogenic disturbance (França and Araújo 2007), the presence of specialist predators and rare taxa (e.g. *Bothriopsis bilineata*) is evidence of a healthy ecosystem. It is also important to note that crocodilians, testudines, and both large lizards and large snakes are hunted and consumed by Amerindians, and thus the records of any of these species can provide an indication of hunting pressure in the area (Peres 2000).

The Guiana Shield's distinctive herpetofauna is a product of its topographical complexity and geologic antiquity (Salerno et al. 2012). For community composition of amphibians and reptiles, species diversity is related to habitat diversity (Tews et al. 2004). While the knowledge of Guiana Shield herpetofauna is increasing rapidly, due in no small part to previous BAT surveys and other similar rapid assessment programmes, the upland regions of the Pakaraima Mountains have not received as much attention relative to the lowland rainforests and the highland tepuis (MacCulloch and Reynolds 2012; Cole et al. 2013). Better knowledge of these upland taxa is critical, as much of this upland area is under threat due to large-scale timber and mining operations. Additionally, as more surveys are being conducted throughout Guyana, a rich herpetofauna and high levels of endemism associated with the uplands and highlands has been revealed. (e. g. MacCulloch and Lathrop 2002, 2005; Means and Savage 2007). **Guyana itself hosts 324 described species (148 amphibians and 176 reptiles) of which 15% are endemic** (Cole et al. 2013).

GUYANA HOSTS **324** DESCRIBED HEPETOFAUNA SPECIES, **148** AMPHIBIANS AND **176** REPTILES, OF WHICH 15% ARE ENDEMIC

In March 2014, as part of the Global Wildlife Conservation and WWF-Guianas Biodiversity Assessment Team Survey, we investigated the herpetofauna in five sites throughout Guyana's Kaieteur plateau. Not all sites received the same search effort. A few such as Chenapau Village and Kaieteur top were only opportunistically surveyed while survey teams were passing through. However, at the main sites of Bay Camp, Upper Potaro Camp, and Murimuri Camp, we sampled as many available microhabitats as possible within the upland rainforest. The results of these surveys are reported herein and provide basic descriptive statistics of the herpetofaunal community, and conservation implications for the region are discussed.

Methods and survey sites

Two separate teams surveyed amphibians and reptiles from the period of 3-15 March 2014 and from 18-28 March 2014. At each location a preliminary survey of the site was conducted in order to identify and prioritize the areas that would receive the greatest search effort, because of our limited sampling time (Scott 1994). Additionally, we took advantage of the brief time that was spent at our stop-over points, such as Chenapau Village, to include species encountered there in our list. Herpetological collections, including whole voucher specimens and tissue samples, were made at all sites during all surveys.

At Chenapau Village, both teams briefly surveyed the open areas as well as disturbed forest along the periphery of the village. Bay Camp was set up just below Makaduik rapids on the upper Potaro River. Elevation varied from 450 m to 650 m and the habitat was primarily upland tropical rainforest. Upper Potaro Camp was established approximately 5 km upriver from Bay Camp, in markedly homogenous upland tropical rainforest habitat. Murimuri Camp was located approximately 10 km northwest of Kaieteur Falls, and contained diverse habitats including upland tropical rainforests, creeks, and savannahs. The final focal area, Kaieteur Top Camp, was located at the visitor's centre for Kaieteur Falls. Surveys covered the area around the top of the falls and included creeks and shrub-herb savannah habitats.

In order to maximize the number of species we would encounter, opportunistic surveys were conducted at various times throughout the day and night; however, they were primarily focused on the peak activity periods of dawn and dusk (Donnelly et al. 2005a, 2005b). Opportunistic surveys involve actively searching for reptiles and amphibians over large areas in suitable habitat and are effective for sampling species richness. We surveyed the primary habitats and microhabitats, particularly those associated with water systems. Our sampling methods also included raking through leaf litter, flipping rocks and logs, and breaking apart rotting logs in order to uncover secretive, inconspicuous species. The availability of boats for transportation between camps meant that we were also able to sample the habitat on either side of the rivers, as well as to conduct night-time river surveys which involved eye shining amphibians and crocodilians as well as searching for arboreal lizards and snakes sleeping in the canopy.

Reptiles and amphibians were captured manually, once observed. Each specimen was assigned a field number, and the corresponding locality data, preliminary identification, and general descriptions of habitat were noted. When possible, specimens were photographed (by Andrew Snyder and Timothy J. Colston) prior to or immediately after euthanasia to document in-life patterning and coloration. Specimens were anaesthetized and fixed using 10% formol, and stored in 70% ethanol as museum voucher specimens. The majority of the collected specimens have been deposited in the collections of the National Museum of Natural History (Washington DC, USA) and the Sam Noble Museum (University of Oklahoma, USA), where they will undergo a final morphological verification. A smaller reference collection of each species was deposited at the Centre for the Study of Biological Diversity at the University of Guyana in Georgetown, Guyana. Before the specimens were fixed in formalin, we took tissue samples of liver/muscle for DNA analysis from each voucher specimen, which was subsequently preserved in 95% ethanol. These tissues have been deposited in the University of Mississippi's frozen tissue collection. Other members of the BAT expedition made photo voucher records of herpetofauna while conducting their own surveys, and these species were included on our lists only if we could accurately identify them. In this report, the amphibian and reptile taxonomy follows that of Vitt and Caldwell (2013) and all species assignments were checked with AmphibiaWeb (www.amphibiaweb.org) and the Reptile Database (www.reptile-database.org) last accessed 4 January 2015.

Results

Overall, 30 species of reptiles and 36 species of amphibians were observed from all of our sites (see Appendix 3, Table 3.2, Figures 3.1-3.2). While most of the species encountered were easily assigned to known species, five (four frogs, one snake) could not be definitively assigned to a known species and have either been labeled "sp." or designated by a "cf." before the specific epithet, which is an informal classification until more rigorous molecular and morphological analyses can be performed. All amphibians found belonged to the order Anura, except for one species representing the order Gymnophiona. For the anurans, almost one half of the species were tree frogs (Hylidae) with 15 species; followed by the Leptodactylidae with six species; toads (Bufonidae) with four species; Aromobatidae, Hemiphractidae, and Craugastoridae each with two species; and finally, single representatives each of Allophrynidae, Microhylidae, Eleutherodactylidae and Pipidae. All caecilians (Gymnophiona) encountered were in the family Rhinatremidae. Within the reptile taxa, serpentes was the most diverse clade, with eight species of Dipsadidae, three species of Colubridae, three species of vipers (Viperidae), two species of boas (Boidae), and one species of pipe snake (Aniliidae). Lizards were the second most speciose clade, with anoles (Dactyloidae and Polychrotidae) and whiptails and tegus (Teiidae) representing three species each; there were also two species of microteiids (Gymnophthalmidae), and single representatives of Phyllodactylidae, Scincidae, and Sphaerodactylidae. We also recorded single representatives of caimans (Alligatoridae) and tortoises (Testudinidae).

Three of our sites, Bay Camp, Upper Potaro Camp and Murimuri Camp supported healthy populations of the Guiana Shield endemic frogs *Stefania evansi* and *Stefania woodleyi*, unique Hemiphractid frogs that exhibit maternal care. Interestingly, at all three sites where they were recorded, these two species were found in sympatry.

***Stefania evansi*, known as the Groete Creek carrying frog, is endemic to Guyana. Like other members of its family, this species rears its offspring on its back, until they are ready to fend for themselves.**

Based on our data from all sites, employing Chao's (1984) estimator, the total number of herpetofaunal species predicted to be present in the habitats associated with the Kaieteur plateau was 88.5. No species were common to all four sites (see Appendix 3, Figures 3.1-3.2). Because the sampling time was not long enough for a complete herpetofaunal inventory, Simpson's (1960) equation was employed, correcting for incomplete sampling, to compare the amphibians and reptiles between each site (Table 3.3).

Of the 66 species of reptiles and amphibians recorded from all survey sites, two are classified as Vulnerable under the IUCN Red List of Threatened Species: the yellow-footed tortoise (*Chelonoidis denticulata*) and golden rocket frog (*Anomaloglossus beebei*) (IUCN 2016; see Appendix 3, Table 3.1). All the other species are listed as either "Least Concern" due to broad distributions or as "Not Evaluated". The assignment of "Not Evaluated" largely applies to reptiles, which are still broadly in need of evaluation; however, there are a few amphibian species that still require evaluation as well.

Additionally, five species are currently listed by the Convention on the International Trade of Endangered Species (CITES; Appendix 3, Table 3.1), meaning special attention is given to these species to ensure the international trade does not impact their long-term survival. **The Cuvier's dwarf caiman (*Paleosuchus palpebrosus*), emerald tree boa (*Corallus caninus*), Amazon tree boa (*Corallus hortulanus*), gold tegu (*Tupinambis teguixin*), yellow-footed tortoise (*Chelonoidis denticulata*), are included in Appendix II of CITES.** CITES assignments are divided into three categories depending on the degree of protection required: Appendix I- species threatened with extinction; Appendix II- species not necessarily facing extinction but requiring controlled trade to avoid impacting survival; and Appendix III- species protected in at least one country.

Table 3.1 **Species of conservation concern (CITES or IUCN) documented during the survey**

Species	Common Name	Group	IUCN Red List	CITES
Tupinambis teguixin	Gold tegu	Reptile	Least Concern	Appendix II
Corallus caninus	Emerald tree boa	Reptile	Least Concern	Appendix II
Corallus hortulanus	Amazon tree boa	Reptile	Not Evaluated	Appendix II
Chelonoidis denticulata	Yellow-footed tortoise	Reptile	Vulnerable	Appendix II
Paleosuchus palpebrosus	Cuvier's dwarf caiman	Reptile	Least Concern	Appendix II
Anomaloglossus beebei	Golden rocket frog	Amphibian	Vulnerable	NA

Table 3.2 **Richness of amphibian and reptile species encountered at each locality, the site-specific percentage of the total species recorded, and uniqueness of each site for both taxonomic groups**

Collection Site	Chenapau Village	Bay Camp	Upper Potaro Camp	Murimuri Camp	Kaieteur Top
Total number of reptile and amphibian species encountered (% of total)	14 (21%)	49 (74%)	18 (27%)	20 (30%)	4 (6%)
Total number of amphibian species encountered (% of total amphibians [36 sp.])	10 (28%)	26 (72%)	12 (33%)	10 (28%)	4 (11%)
Total number of amphibian species encountered that were exclusive to locality (% unique)	4 (11%)	12 (33%)	0 (0%)	1 (3%)	2 (6%)
Total number of reptile species encountered (% of total reptile species encountered [30 sp.])	4 (13%)	23 (77%)	6 (20%)	10 (33%)	0 (0%)
Total number of reptile species encountered that were exclusive to locality (% unique)	2 (7%)	14 (47%)	0 (0%)	5 (17%)	0 (0%)

Table 3.3 **Comparisons among number of species of amphibians and reptiles found at the five target localities for the upper Potaro Biodiversity Assessment Team expedition**

Key

Numbers in diagonal row (in bold italics) are numbers of species found at each site.

Numbers to the upper right of the diagonal are number of species common to sites where rows and columns meet.

Numbers to the lower left of diagonal are faunal resemblance indices with correction for small samples (% of species in the smallest sample found in common between the two samples).

The sites are as follows:

(a) This BAT survey: **CV**- Chenapau Village; **BC**- Bay Camp; **UPC**- Upper Potaro Camp; **MMC**- Murimuri Camp; **KT**- Kaieteur Top

(b) Other survey sites: **P**- Paramakatoi; **K**- Kato; **KoF**- Konawaruk forestA full summary of all species

Survey Sites	CV	BC	UPC	MMC	KT	P	K	KoF
CV	***14***	6	5	3	1	3	2	1
BC	43	***49***	18	12	0	13	6	0
UPC	36	100	***18***	7	0	5	3	0
MMC	21	60	39	***20***	1	5	1	1
KT	25	0	0	25	***4***	1	1	4
P	21	34	28	25	25	***38***	11	11
K	14	33	17	6	25	61	***18***	6
KoF	36	51	72	65	0	29	33	***59***

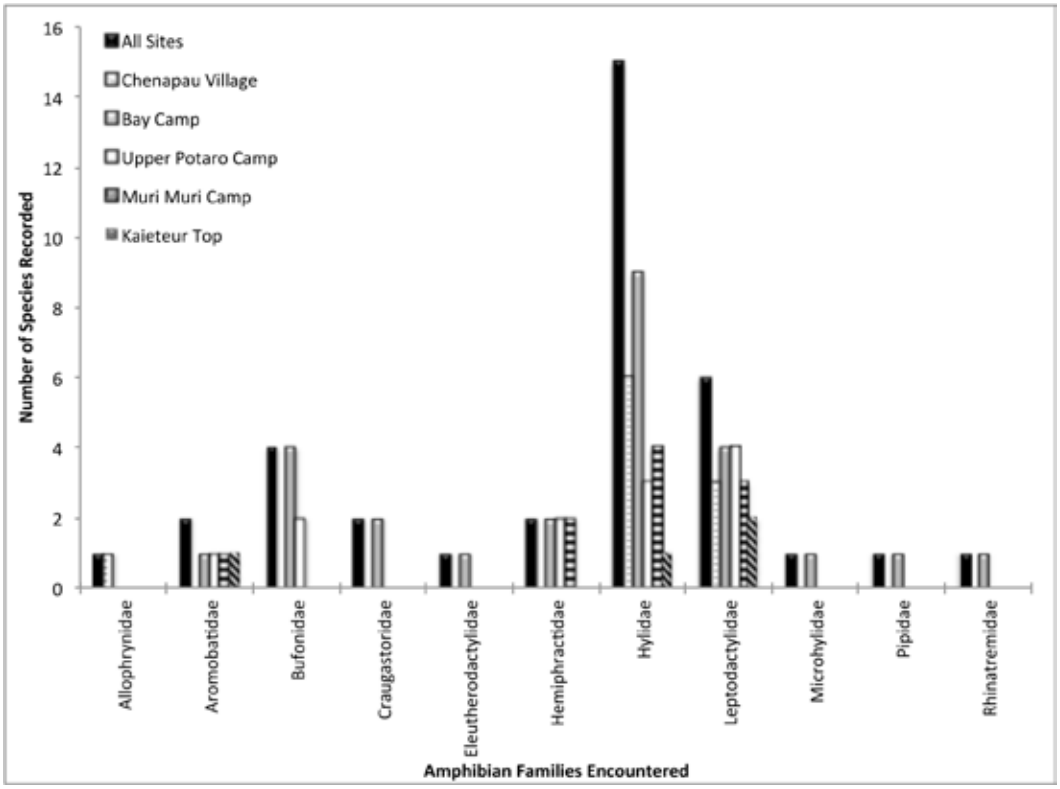

Figure 3.1 **Number of amphibian species, by family, recorded at each focal area during the 2014 BAT Survey of the Kaieteur plateau, Guyana.**

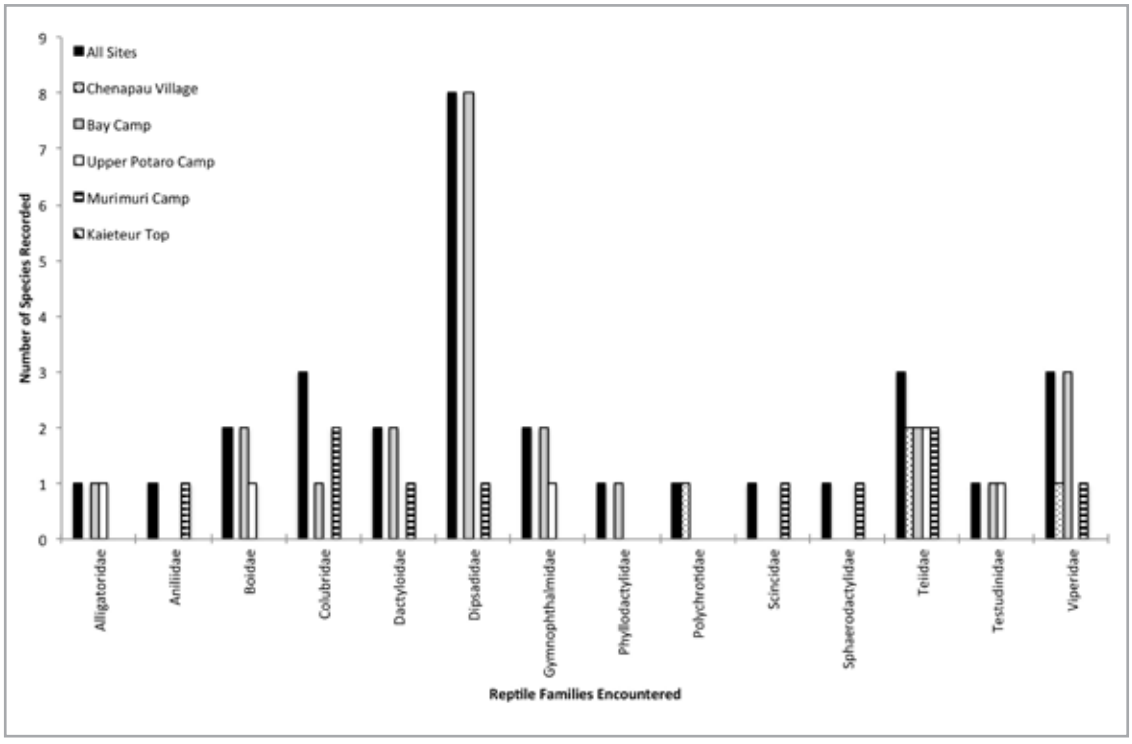

Figure 3.2 **Number of reptile species, by family, recorded at each focal area during the 2014 BAT Survey of the Kaieteur plateau, Guyana.**

A full summary of all species encountered and sites is listed in Appendix 3. The focal areas explored during this survey show marked differences in herpetofaunal composition recorded. The focal areas and their corresponding species compositions are discussed below.

Focal area 1: Chenapau Village (4° 59' 00.7" N, 59° 34' 37.4" W)

Chenapau Village, along the upper Potaro River, was the first stop-over point before traveling to Bay Camp. Both teams overnighted in the village and conducted brief opportunistic surveys in the afternoon and evening while there. Habitats consisted of open areas within the village and disturbed forest along the periphery.

Twenty-eight percent of all amphibians recorded during this BAT survey were found in and around Chenapau Village, and four (11%) were exclusive to this site. Tree frogs and their allies (Hylidae) were the richest group observed with six species representing four genera (*Dendropsophus*, *Osteocephalus*, *Scinax*, *Trachycephalus*) followed by the "southern frogs" with three species (all *Leptodactylus*). Additionally, multiple individuals of the Tukeit Hill frog (*Allophryne ruthveni*) were encountered in the building where we overnighted.

The teams also recorded four species of reptiles during their stay at Chenapau Village, representing 13% of the total species of reptiles, 7% of which were unique to the site. Two of the four species are whiptail lizards (*Ameiva, Tupinambis*) which are known to frequent anthropogenically-influenced areas. Additionally, single individuals of the common monkey lizard (*Polychrus marmoratus*) and the fer-de-lance (*Bothrops atrox*) were observed.

More reptile and amphibian species undoubtedly occur within the boundaries of Chenapau Village. More time and a thorough search effort would likely have greatly increased these numbers.

An example of the Tukeit Hill frog, *Allophryne ruthveni*. We encountered several of these in the building where we were overnighting.

OF THE SITES SURVEYED, THE BAY CAMP FOCAL AREA HAD THE HIGHEST SPECIES RICHNESS WITH 26 SPECIES OF AMPHIBIANS AND 23 SPECIES OF REPTILES

Focal area 2: Bay Camp (5° 00' 39.5" N, 59° 38' 21.2" W)

Bay Camp, the site nearest to Chenapau Village, varied from 450 m to 650 m in elevation and was located along the upper Potaro River, just below Makaduik rapids. Surveys were conducted during both day and night around the base camp, and extended away from camp for a few kilometres, covering all habitats, including upland tropical rainforest, creeks and rivers.

Of the focal areas we surveyed during this BAT expedition, this area had the highest species richness with 26 species of amphibians and 23 species of reptiles. Seventy-two percent of all amphibians recorded during the BAT survey were found at the Bay Camp site; twelve species (33%) were found exclusively at this location. As with Chenapau Village, tree frogs and their allies (Hylidae) were the richest group, with nine species representing three genera (*Hypsiboas, Osteocephalus, Phyllomedusa*), followed by four species each of toads (Bufonidae) and "southern" frogs (Leptodactylidae). Additionally, there were two representatives each of direct developing frogs, Hemiphractidae and Craugastoridae, and single representatives of Aromobatidae, Eleutherodactylidae, Microhylidae, Pipidae, and Rhinatremidae. **One species of frog (*Hypsiboas ornatissimus*) is only known from Guyana from a few individuals.**

A secretive Guiana Shield frog (*Adelophryne gutturosa*), of the family Eleutherodactylidae, which lives amongst leaf litter.

The ornate tree frog (*Hypsiboas ornatissimus*) is an arboreal, nocturnal species typically common in lowland rainforests, especially around streams. Typically widespread, this species is patchily distributed throughout Guyana.

At the Bay Camp site, our teams recorded 23 species of reptiles, representing 77% of the total reptile species encountered, of which 47% were unique to this site. Eight of the 23 species of reptiles were snakes belonging to the family Dipsadidae, followed by three species of vipers (Viperidae). Two of the three viper species are especially notable (*Lachesis* and *Bothriopsis*) because they are infrequently encountered taxa on account of their secretive nature, and they are typically killed on sight when observed. Two representative species each of Teiidae, Gymnophthlamidae, Dactyloidae, and Boidae were present at the site, and one each of Alligatoridae, Colubridae, Phyllodactylidae, and Testudinidae.

A rare, secretive bi-striped viper (*Bothriopsis bilineata*) perched above a stream.

Catesby's snail-eater (*Dipsas catesbyi*) is endemic to the Amazo-Guianan sub-region.

Focal area 3: Upper Potaro Camp (5° 04' 02.1" N, 59° 39' 26.1" W)

The Upper Potaro Camp, located approximately 5 km upriver from Bay Camp, varied in elevation, from 460 m to 700 m, with markedly homogenous habitat when compared to Bay Camp. Surveys were conducted during both day and night around the base camp, and extended away from camp for a few kilometres along the river, covering all habitats, including upland tropical rainforest, creeks, and rivers.

In the Upper Potaro Camp site, we observed a total of 12 species of amphibians representing five families (Aromobatidae, Bufonidae, Hemiphractidae, Hylidae, and Leptodactylidae) and five species of reptiles from five families (Alligatoridae, Boidae, Gymnophthalmidae, Teiidae, Testudinidae).

An adult Boulenger's rough toad-frog (*Leptodactylus rhodomystax*) sits amongst the leaf litter

Smooth-sided toad (*Rhaebo guttatus*), the second largest species of toad in Guyana.

THE SINGLE *OSTEOCEPHALUS* CF. *EXOPTHALMUS* RECORDED AT MURIMURI CAMP REPRESENTS A RARE RECORD FOR THIS SPECIES WITHIN THE KAIETEUR NATIONAL PARK, AND POTENTIALLY AN UNDESCRIBED VARIANT OR NEW SPECIES

Focal area 4: Murimuri Camp (5° 16' 30.2" N, 59° 30' 57.9" W)

Murimuri Camp was located approximately 10 km northwest of Kaieteur Falls, along a series of creeks which had been previously mined for diamonds. Surveys were conducted during both day and night around the base camp and extended away from camp for a few kilometres, covering all habitats, including upland tropical rainforest, creeks, and savannahs.

In the Murimuri Camp site, a total of 10 species of amphibians were observed from four families (Aromobatidae, Hemiphractidae, Hylidae, and Leptodactylidae), and ten species of reptiles were observed from six families (Aniliidae, Colubridae, Dactyloidae, Scincidae, Teiidae, and Viperidae). **The single *Osteocephalus* cf. *exopthalmus* recorded at Murimuri camp represents a rare record for this species within the Kaieteur National Park, and potentially an undescribed variant or new species.**

The tropical flat snake or red vine snake (*Siphlophis compressus*) is another endemic to the Amazo-Guianan Sub-region.

Focal area 5: Kaieteur Top Camp (5° 10' 47.0" N, 59° 29' 07.9" W**)**

Kaieteur Top Camp was located at the tourist/visitors' centre for Kaieteur Falls. Team 2 spent one survey day/night in the area, although both teams used the site as a stop-over point while moving between sites. Surveys were conducted around the top of the falls and extended approximately 1 km around the visitors' centre and included creeks and shrub-herb savannah habitats.

During the brief survey at the Kaieteur top site, we observed a total of four species of amphibians from three families (Aromobatidae, Hylidae, and Leptodactylidae). **The golden rocket frog (*Anomaloglossus beebei*), a species which is so far only known to occur on the Kaieteur Plateau, was the most interesting find.** No reptiles were observed.

Discussion

For reptile and amphibian community composition, species diversity is related to habitat diversity. An increase in habitat heterogeneity usually presents opportunity for an increase in species diversity and this was observed among the surveyed sites. Upper Potaro Camp contained the most homogenous habitat, and although its proximity to Bay Camp would lead us to expect similar species diversity, this was not what was recorded. Additionally, weather patterns affect reptile and amphibian activity patterns, and thus also their detectability. Although an impressive number of species was recorded for the dry season (time of lowest activity in a tropical rainforest), unseasonal torrential downpours limited sampling at Upper Potaro Camp. While this is counter-intuitive, as one might expect rains to increase activity and thus detectability, these rains actually caused activity to decrease, as it did not correspond with breeding cycles and movements which are typically brought about by seasonal rain.

Bay Camp harboured the greatest richness of reptiles and amphibians, including unique species, which could be a product of greater survey efforts by both teams. However, due to the fact that additional species were being encountered daily, species richness is more likely a result of the area's heterogeneous habitat and current pristine condition. Moreover, while the number of species we recorded is low when compared to other better sampled sites in the Guiana Shield (e.g. Iwokrama, Guyana; Nouragues, French Guiana), our results are comparable with recent studies of similar duration and scope in Suriname and the uplands of Guyana (Table 3.4).

THE GOLDEN ROCKET FROG (*ANOMALOGLOSSUS BEEBEI*), A SPECIES WHICH IS SO FAR ONLY KNOWN TO OCCUR ON THE KAIETEUR PLATEAU, WAS THE MOST INTERESTING FIND

Table 3.4 **Herpetofaunal richness at 15 lowland and upland sites in the Guiana Shield. In each column, data are presented as raw species number/percentage of total herpetofauna**

Site	Amphibians	Reptiles	Total
Iwokrama	47/0.40	71/0.60	118
Nouragues	51/0.47	58/0.53	109
Paramakatoi	18/0.47	20/0.53	38
Kato	10/0.56	8/0.44	18
Baramita	25/0.47	28/0.53	53
Kaieteur National Park	45	-	-
Upper Palumeu	30/0.54	26/0.46	56
Grensgebergte	6/0.46	7/0.54	13
Kasikasima	24/0.53	21/0.47	45
Palumeu	13/0.72	5/0.28	18
Mean=	25 (Kaieteur not included)	27 (Kaieteur not included)	52
Chenapau Village	10/0.71	4/0.29	14
Bay Camp	26/0.53	23/0.47	49
Upper Potaro Camp	12/0.67	6/0.33	18
Murimuri Camp	10/0.50	10/0.50	20
Kaieteur Top	4/1.0	0/0.0	4
Mean=	12	9	21
Total Species recorded on this BAT Survey	**36/0.55**	**30/0.45**	**66**

The result of this short dry season survey of the main focal areas of the Kaieteur plateau undoubtedly represent a fraction of the true herpetofaunal diversity at each site. In order to reflect true species richness, repeated sampling, especially during the rainy season, would provide a more thorough species list.

Conservation recommendations

Before anything else, the first recommendation is to maintain the integrity of the undisturbed forests and stream habitats within and around Bay and Murimuri camps. The results of this short dry season survey represent only a fraction of the herpetofauna of these areas. Extensive sampling is required, including during the wet season, in order to reflect more accurately the species richness at these sites. During the brief periods spent surveying at each site, new species were recorded each day and species numbers did not plateau, leading us to believe that many more would have been recorded had survey time allowed. **Additionally, we witnessed active diamond mining within the park boundaries at Murimuri and this activity must be stopped.** While not as destructive as gold mining, diamond mining still destroys creek banks and creates silt dams downstream, thus destroying habitat critical to amphibian reproduction.

Further, **actions should be taken to ensure that gold mining does not extend into the surveyed regions.** Current methods are detrimental to many of the habitats and breeding locations of many species of reptiles and amphibians, and would undoubtedly negatively impact their future survival.

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CHAPTER 4

ADDITIONS TO THE AVIFAUNA OF THE UPPER POTARO PLATEAU AND KAIETEUR NATIONAL PARK, GUYANA

Brian J. O'Shea and Jonathan Wrights

Abstract

The upper Potaro plateau is a broad transition zone between highland and lowland areas of endemism on the Guiana Shield, but the elevational limits of many bird species are incompletely known, and published accounts of the region's avifauna are few. Here we expand the list of species known to occur on the plateau based on surveys conducted at three localities during 13 days in March 2014. Many of the new records were documented by sound recording. We report a new lower elevation limit for the highland endemic Fiery-shouldered Parakeet (*Pyrrhura egregia*). The avifauna of the Potaro plateau features high diversity and endemism but relatively low overall abundance of birds, and subtle shifts in the relative abundance of lowland and highland species at different elevations. As Guyana's infrastructure expands into this region, conservation priorities should include the preservation of large areas of intact forest spanning a range of elevations.

Introduction

The Guiana Shield has long been known as a region of high biodiversity, with many species found nowhere else. The shield encompasses some 2.7 million km^2 and features one of the world's largest remaining expanses of intact tropical forest. A variety of habitat types occurs across this vast region, but many of them remain poorly studied, particularly in the mountainous regions of western Guyana, southern Venezuela and adjacent northern Brazil. This area, known broadly as the Pantepui (Mayr and Phelps 1967), features a dramatic landscape formed by erosion of the Roraima Formation (Hammond 2005), a region of ancient sandstone deposits that have weathered to form numerous flat-topped mountains, or tepuis, several of them exceeding 2000 m in elevation.

Broadly speaking, the Pantepui is the epicentre of Guiana Shield endemism, with roughly 40% of its plant species restricted to the region (Kelloff and Funk 2004). So far as is known, faunal endemism is somewhat lower, but still considerably higher than elsewhere on the Guiana Shield. Indeed, for many vertebrate groups, the majority of species on the upper slopes and summits of the tepuis are endemic (Hollowell and Reynolds 2005). Many highland bird species reach the eastern limits of their distributions in Guyana. Because so much of their habitat is inaccessible, they remain mysterious, and little is known of their ecology and natural history.

The Potaro plateau covers a large portion of western Guyana and forms the eastern edge of the Roraima Formation, known in Guyana as the Pakaraima Mountains. From its escarpment at approximately 400 m, the plateau slopes upward towards the Venezuelan and Brazilian borders. Several tepuis punctuate the landscape, including Mts Kowa (or Kowatipu) (1,300 m), Wokomung (1,470 m), Kopinang (1,594 m), and Ayanganna (2020 m; Barnett et al. 2002). The Potaro River originates on Mt Ayanganna and winds across the plateau in a southeasterly direction before turning northeast and plunging off the escarpment in the form of the 226-metre Kaieteur Falls, the site of Amazonia's oldest protected area and one of the highest waterfalls in the world. The plateau is sparsely populated and heavily forested. Indigenous Patamona people inhabit scattered settlements and practice a subsistence livelihood augmented by small-scale exploitation of resources including timber, gold and diamonds. There are no road connections to the coastal region, and only limited overland access in the southern portions of the plateau. This isolation has served to limit exploitation of the region's forests. In recent years, however, **high gold prices and a push to develop Guyana's resources have resulted in an intensification of small-scale gold mining, along with the first indications that the region's isolation may be coming to an end. It is therefore an urgent priority to establish baseline inventories of flora and fauna occurring in the region to better inform conservation and development.**

Due to its spectacular scenery and importance to Guyana's tourism industry, Kaieteur National Park (KNP) has been the focus of previous biological inventories, primarily under the auspices of the Smithsonian Institution's Biological Diversity of the Guianas programme (Kelloff and Funk 1998, 2004) and a recent rapid inventory carried out by WWF (Bicknell et al. 2013). Surveys of KNP and adjacent areas of the Potaro plateau have generated provisional species lists for several taxonomic groups, including plants (Kelloff and Funk 1998), insects (Eggleton et al. 1999; Kelloff 2003), herpetofauna (Kok and Kalamandeen 2008; MacCulloch and Reynolds 2012), birds (Barnett et al. 2002), and small mammals (Lim 2012). As expected, results of these faunal surveys have revealed high species diversity and endemism on the Potaro plateau and the Guiana Highlands in general.

Birds are ideal subjects for rapid biodiversity inventories because most species are diurnal and easy to identify relative to other groups of organisms. A variety of resources exists to facilitate their identification by both sight and sound; nevertheless, the ecology and distribution of many tropical species are still poorly known. Data from baseline inventories can therefore contribute valuable information to inform conservation planning. Bird surveys also present outstanding opportunities to introduce students to ornithological field research, thereby developing in-country capacity to implement monitoring programmes. This report presents findings from ornithology surveys conducted under the auspices of the Potaro-Kaieteur Biodiversity Assessment Team (BAT), a group of scientists, students and community representatives that surveyed several localities in the upper Potaro watershed from 2-30 March 2014.

Methods and study sites

Study sites

We surveyed the avifauna of the upper Potaro watershed from 10-23 March 2014. Our surveys were based from three camps: along the Potaro River, roughly seven kilometers west of Chenapau (N 05.0111, W 059.6394; 10-15 March); around the guest house and airstrip at Kaieteur National Park (N 05.1776, W 059.4871; 16-17 and 20-23 March); and around an airstrip near Mt Ayanganna (N 05.3027, W 059.8377; 17-20 March). The elevations of these field sites were generally between 500-700 metres, though a short excursion was made on foot to Tukeit, along the Potaro River below Kaieteur Falls (elev. 60 m), on 22 March. All sites were situated amid the continuous forest of the Potaro plateau, within which virtually all non-forest habitats were anthropogenic in origin (e.g., airstrips, old farms, villages). We attempted to cover all habitats thoroughly during the surveys, using whatever trails existed at each site to the fullest extent possible.

During our expedition, a simultaneous survey was conducted at higher elevations on Mt Ayanganna by ornithologists from the Smithsonian Institution and the University of Kansas. Results from that survey are detailed in Milensky et al. (2016).

Pre-montane forest along the trail to Mt Ayanganna, 700 m.

Field methods

We surveyed birds by walking trails and noting all species heard and seen. The "10-species list" technique (Herzog et al. 2002, 2016; Cavarzere et al. 2012) was used to estimate species richness at each site, and to gather data in a standardized way to allow for comparison to other sites across the Guiana Shield. Under this technique, an observer lists all individual birds heard or seen after a given starting time; the lists are then parsed into ten-species units for analysis (see Herzog et al. (2002) for further methodological details). We generally initiated lists shortly after leaving camp each morning, recording times at regular intervals throughout the day. All lists were kept by the senior author (BJO). Lists were generated regardless of habitat or weather conditions, although they were typically not initiated during rain. We generated 98 lists – 43 at the Chenapau camp, two at the Chenapau airstrip, 30 around the Ayanganna airstrip, and 23 at Kaieteur. EstimateS (Colwell 2013) was used to derive an incidence-based richness estimator (Chao 2) for each site and the survey area as a whole. All lists will be entered into eBird, an online checklist program (Sullivan et al. 2009).

To document the avifauna of each site, we set mist nets to capture and photograph birds. Netting effort varied among sites; nets were opened whenever practicable and when weather conditions allowed. All species, and most individuals, were photographed prior to being released. Birds were also documented by sound recording, using a Marantz PMD-661 digital recorder and a Sennheiser ME-62 microphone. A stereo microphone pair (Sennheiser MKH-20 and MKH-30) were used to make general soundscape recordings, mainly at dawn, at the Chenapau and Ayanganna camps, but not at Kaieteur, due to the thunderous sound of the nearby falls. Soundscape recordings typically lasted for 1-2 hours. Five soundscape recordings were made in total (three from Chenapau and two from Ayanganna). All recordings are deposited at the Macaulay Library at the Cornell Lab of Ornithology, Ithaca, NY, USA. These recordings serve to document a substantial proportion of the bird species encountered during the survey.

Jonathan Wrights removes a Wedge-billed Woodcreeper (*Glyphorhynchus spirurus)* from a mist net near the Chenapau camp.

Results and discussion

Our preliminary list totals 209 species; we did not keep separate lists for each site due to their geographic proximity and our uneven sampling effort among the sites (a consequence of generally poor weather and logistics of moving teams among sites). Although most species were observed in forest, a substantial number occurred only in non-forest habitats, particularly around the airstrips at Ayanganna, Kaieteur, and the village of Chenapau.

We registered 163 species, or 78% of the total species observed, on 98 ten-species lists. The incidence-based estimator Chao 2 predicted 234 species for the overall survey area (Table 4.1), with diversity highest at the Chenapau site, which also contributed the greatest number of lists. Predicted diversity was lowest at Ayanganna, despite the fact that more lists were generated there than at Kaieteur.

An analysis of shared species among sites revealed that the Chenapau and Ayanganna sites were more similar to each other than either was to Kaieteur, a reflection of the unique habitats around Kaieteur and the broad similarity of the forest avifauna among sites on the Potaro Plateau (Table 4.2). However, despite the general similarity in species composition between the Chenapau and Ayanganna sites, the relative abundances of birds differed markedly among all three sites when ranked incidences were used as a proxy for abundance (Table 4.3). This was clearly a result of habitat differences among the sites, as well as a general shift in community composition with elevation. This shift was particularly noticeable among the different species of manakins listed in Table 3. These subtle differences over a relatively narrow elevational range underscore the ecological heterogeneity of these mid-elevation forests, despite a superficial appearance to the contrary.

The Helmeted Pygmy-Tyrant (*Lophotriccus galeatus*) was common along the forest edge near the Ayanganna airstrip.

The Rufous-crowned Elaenia (*Elaenia ruficeps*) is a specialist on white-sand scrub; it was common around the Kaieteur airstrip, but we found it nowhere else during the expedition.

Table 4.1 **Predicted diversity of each site, and the overall survey area, based on ten-species lists. The predicted number of species is given as the upper 95% confidence limit for Chao 2, an incidence-based estimator**

Survey Site	Number of lists	Species registered	Upper 95% Chao 2	Fisher's α	Simpson
Chenapau	43	96	178	38.36	48.07
Kaieteur	23	78	147	41.54	42.25
Ayanganna	30	76	111	32.8	37.84
Total	**98**	**163**	**234**	**55.8**	**69.33**

Table 4.2 **Species similarity among sites (Chao Sørenson index/Morisita-Horn/Bray Curtis), calculated from ten-species lists. The indices consistently indicated closer community similarity between Chenapau and Ayanganna than between either of those sites and Kaieteur**

Site	Chenapau	Kaieteur
Chenapau	--	--
Kaieteur	.653/.394/.318	--
Ayanganna	.720/.533/.403	.519/.264/.261

Table 4.3 **The ten most frequently recorded species on ten-species lists and their ranked incidences for each site. Even these common species showed substantial variation in detectability (and hence relative abundance) among sites. A '—' indicates that a species was not recorded on lists at that site. For a fairly low-elevation survey area in the Guiana Shield, the absence on this list of several common and vocal species, including Screaming Piha (*Lipaugus vociferans*) and any species of parrot (Psittacidae), is notable.**

Scientific name	English name	Rank	Chenapau	Kaieteur	Ayanganna
Psarocolius viridis	Green Oropendola	1	1	--	1
Ramphocelus carbo	Silver-beaked Tanager	2	11	6	2
Ramphastos tucanus	White-throated Toucan	3	2	11	12
Tyranneutes virescens	Tiny Tyrant-Manakin	4	3	5	--
Tachyphonus surinamus	Fulvous-crested Tanager	5	6	7	11
Corapipo gutturalis	White-throated Manakin	6	2	9	--
Tyrannus melancholicus	Tropical Kingbird	7	12	4	12
Chaetura spinicaudus	Band-rumped Swift	8	11	--	5
Leptotila rufaxilla	Grey-fronted Dove	9	9	7	13
Lepidothrix suavissima	Orange-bellied Manakin	10	14	10	5

Weather conditions were often poor for surveying birds, especially at Kaieteur and Ayanganna, where rain was frequent. These conditions suppressed bird activity and made canopy species difficult to see well, and as a result, our species list was lower than might be expected for a survey of this length in Guianan lowland forest. We encountered very few canopy mixed-species flocks that were not dominated by small tanagers (genera *Cyanerpes*, *Coereba*, *Chlorophanes*, *Dacnis*, and *Tangara*); these flocks tend to be relatively common at middle elevations in the Guiana Shield, but they are smaller and lack the species diversity of flocks composed mainly of insectivores such as antbirds, flycatchers, vireos, and larger tanagers. Although we are confident that the forests of the Potaro plateau harbour high bird diversity, and despite the effects of weather during the current survey, we were nonetheless struck by the apparent general scarcity of birds relative to other areas BJO has surveyed in Guyana and Suriname. The avifauna comprised many of the typical species of lowland Guianan terra firme forest, but our failure to detect several widespread and conspicuous lowland species is more likely an indication of their relative rarity in the region than our own limitations. These species include *Momotus momota* (Amazonian Motmot); *Galbula dea* (Paradise Jacamar); any species of Grallariidae (Antpittas) or Formicariidae (Antthrushes); *Myiopagis gaimardii* (Forest Elaenia), *Rhytipterna simplex* (Greyish Mourner); and *Lipaugus vociferans* (Screaming Piha, heard only from the Chenapau airstrip). The reasons underlying these species' apparent scarcity are unclear to us.

Our predicted total of 234 species should not be considered a realistic upper limit for avian diversity on the Potaro plateau. Barnett et al. (2002) compiled a regional list of 334 species based on their own observations and those of other observers, including older published sources, and Bicknell et al. (2013) list 393 species for Kaieteur National Park (KNP). During our survey, we observed 57 species not reported by Barnett et al., many of them common birds of Guianan forests (see Appendix 4). Even taking into account the likelihood of several erroneous records on their list, the avifauna of the Potaro plateau is certainly more diverse than has been reported by any single survey to date. We encountered 27 species not reported by Bicknell et al., some of which were observed within the boundaries of KNP. Adding these species to the KNP list would increase the park's list to 420 species, comparable to other highly diverse sites in Guyana such as Iwokrama Forest (Ridgely et al. 2005) and the Konashen Community-Owned Conservation Area (Robbins et al. 2007; O'Shea 2008).

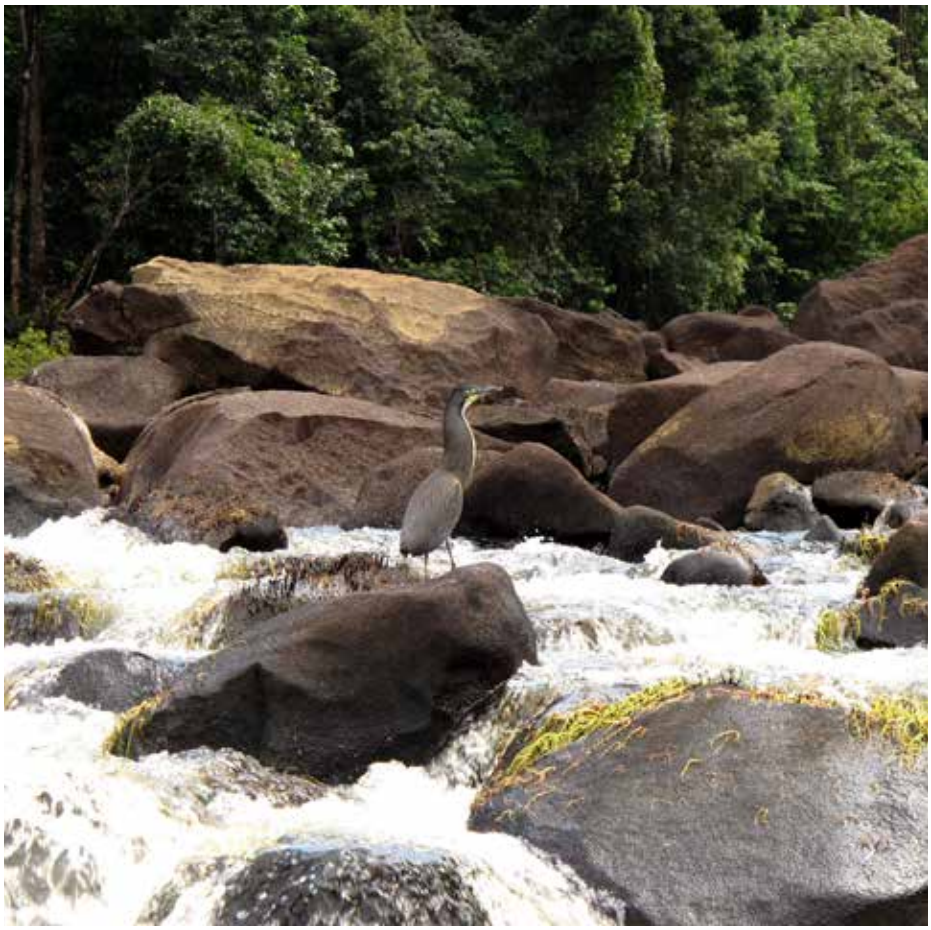
Avian endemism in the eastern Guiana Shield has two broad components: species that inhabit higher-elevation forests on the slopes and summits of the tepuis, and lowland forest species that are broadly distributed east of the Rio Branco and north of the Amazon (Naka 2011). These species come into contact around the bases of the tepuis (Braun et al. 2005), although their elevational ranges seem to vary depending on the orientation of tepui slopes and the humidity and structure of transitional forests (O'Shea et al. 2007; Milensky et al. 2016). **The Potaro plateau is therefore of interest to ornithologists as it represents a broad zone of transition between highland and lowland faunas.**

Thirty-two species endemic to the Pantepui are known or presumed to occur in Guyana – thirty are listed by Braun et al. (2007), another has been elevated to species rank since that time (Bonaccorso et al. 2011; Remsen et al. 2015), and still another was found in Guyana in 2014 (Milensky et al. 2016). Previous ornithological surveys in the Pakaraima Mountains region have focused mainly on clarifying the distributional limits of these highland endemic species, many of which have small global ranges only recently confirmed to include Guyana (Barnett et al. 2002; Braun et al. 2003, 2005; O'Shea et al. 2007; Milensky et al. 2016). Lower elevations of the Potaro plateau (400-900 m), which we focused on, have received relatively little attention, in part because many endemic species are most abundant at elevations greater than 1000 m, prompting researchers to preferentially survey the highest elevations accessible to them (but see Braun et al. 2005). As a consequence, the resident avifauna of mid-elevation forests is rather poorly known, as is the use of these forests by highland endemic species. **Considering the patchy distributions of many tepui endemics, it is important to assess the potential role of mid-elevation forests as a matrix for dispersal among the tepuis, which would promote gene flow among populations and increase landscape-level persistence over the long term.** More generally, the resident avifauna of these forests merits further study, particularly in the context of comparison with lowland forests elsewhere in the eastern Guiana Shield.

THE FASCIATED TIGER-HERON IS RESTRICTED TO LARGE RAPIDS, MAKING IT ONE OF THE MOST SPECIALIZED BIRDS IN THE GUIANA SHIELD, AND THEREFORE ONE THAT IS ESPECIALLY VULNERABLE TO CONTAMINATION OF RIVERS BY GOLD AND DIAMOND MINING

Most endemic bird species of the Guiana Highlands are only known to occur well above the elevations we surveyed. Overall we found 28 taxa endemic to the Guiana Shield, three of them restricted to higher elevations. Our list also includes 14 species listed on the IUCN Red List; of these, ten are Near-Threatened and four are Vulnerable (see species list – Appendix 4). The following accounts provide details on noteworthy species encountered during this survey, and also highlight differences in the avifauna of the Potaro plateau relative to lowland forests of central and eastern Guyana.

***Tigrisoma fasciatum* (Fasciated Tiger-Heron):** We saw this species daily in rapids on the Potaro River upstream from our Chenapau camp. *Tigrisoma fasciatum* is widely distributed in South America, but it is restricted to large rapids, making it one of the most specialized birds in the Guiana Shield and one that is especially vulnerable to contamination of rivers by gold and diamond mining.



A Fasciated Tiger-Heron (*Tigrisoma fasciatum*) in prime habitat along the Potaro River near our Chenapau camp. This species is rare in the Guianas, where it is restricted to large rapids.

***Apodidae* spp. (Swifts):** *Cypseloides cryptus* (White-chinned Swift) and *Aeronautes montivagus* (White-tipped Swift) are relatively rare and localized species. Both can be reliably seen around Kaieteur Falls, where they likely nest; the park is a stronghold for them because it provides critical nesting and roosting habitat on cliff faces behind waterfalls.

***Megascops guatemalae roraimae* (Vermiculated Screech-Owl):** We heard this species only around the Ayanganna airstrip, the highest elevation we surveyed, and where we also had the advantage of a full moon (which tends to favor detection of nocturnal birds). We suspect that this species occurs throughout the Potaro plateau, as it has been documented at other localities in Guyana above 500 m (Braun et al. 2003; O'Shea et al. 2007; Robbins et al. 2007) and also occurs at similar elevations in Suriname (Ottema et al. 2009). Although we follow the American Ornithologists' Union (AOU) South American Checklist Committee (Remsen et al. 2015) in continuing to recognize northern South American and Central American populations of *M. guatemalae* as conspecific, recent genetic work suggests that *M. g. roraimae*, endemic to the Guiana Highlands, merits elevation to species rank (Dantas et al. 2015).

***Pyrrhura egregia* (Fiery-shouldered Parakeet):** We found this species to be rather common around our Chenapau camp, where we observed it as low as 500 m. This is the lowest elevation reported for this species to date; it is not listed on the Kaieteur National Park list (Bicknell et al. 2013), suggesting that it occurs infrequently, if at all, only a few kilometres downriver from our camp. This species is endemic to the Pantepui and is poorly known, and hence of conservation concern.

***Amazona dufresniana* (Blue-cheeked Parrot):** This was the common *Amazona* at and above our Chenapau camp, and we recorded it downriver at Chenapau Village as well. At all elevations, it overlapped with the more widespread *A. amazonica* (Orange-winged Parrot) but was generally more common. This IUCN Near-Threatened species is endemic to the Guiana Shield, within which it has a patchy distribution, occurring principally at elevations above 500 m, though it may occasionally wander to lower elevations. **The conservation of extensive areas of forest at higher elevations in Guyana is particularly critical for this species, which is trapped for the wildlife trade in Guyana and Suriname.**

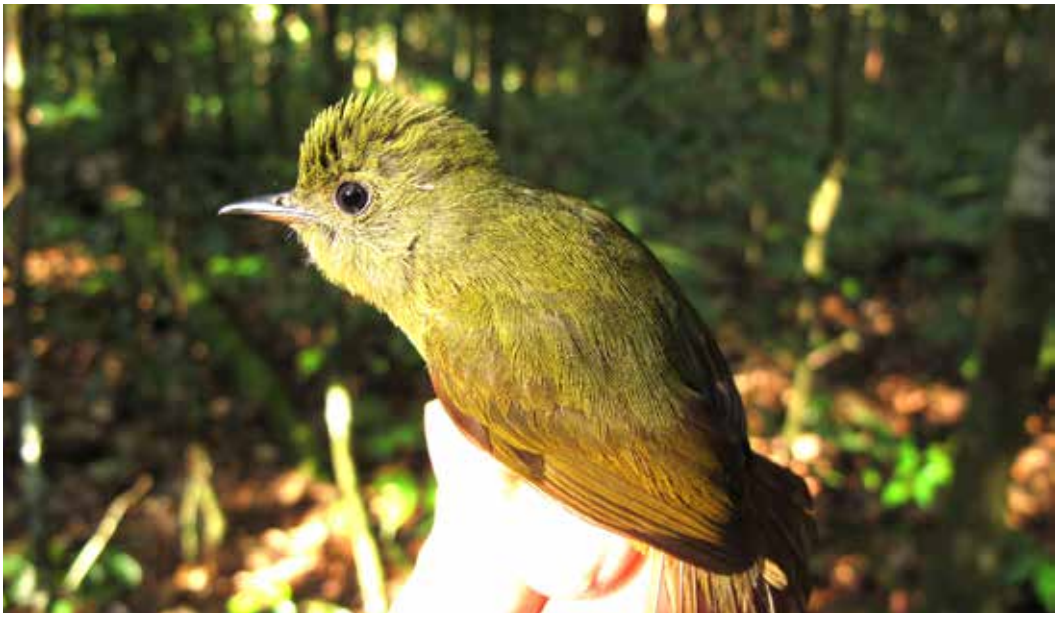
***Herpsilochmus roraimae* (Roraiman Antwren):** We found this species at 700 m around the Ayanganna airstrip, but it was replaced at lower elevations by the widespread *H. stictocephalus* (Todd's Antwren), which was observed up to 850 m along the trail to Mt Ayanganna by the concurrent Smithsonian/ University of Kansas expedition (Milensky et al. 2016). Both species are endemic to the Guiana Shield and replace each other with limited sympatry in the Pantepui, generally between 600-800 m. There are no records of *H. roraimae* from higher elevations in Suriname.

THE CONSERVATION OF EXTENSIVE AREAS OF FOREST AT HIGHER ELEVATIONS IN GUYANA IS PARTICULARLY CRITICAL FOR THE BLUE-CHEEKED PARROT, WHICH IS TRAPPED FOR THE WILDLIFE TRADE IN GUYANA AND SURINAME

***Schistocichla leucostigma* (Spot-winged Antbird)** and ***S. saturata* (Roraiman Antbird):** The split of the cryptic Pantepui highland endemic *S. saturata* from lowland *S. leucostigma* (Braun et al. 2005) added another species to the growing list of Guiana Shield endemics. We only found *S. leucostigma* on this survey, which we attribute to the scarcity in our survey areas of the steep rocky slopes that *S. saturata* seems to prefer. Although these species generally replace each other elevationally, the zone of overlap is apparently broad and influenced more by physical features of the environment than by elevation per se (Braun et al. 2005). *Schistocichla saturata* is observed regularly near Kaieteur Falls (R. Allicock pers. comm.), and we presume that it occurs in suitable habitat throughout the Potaro plateau, where it should be considered vulnerable due to its specialized habitat.

***Zimmerius gracilipes* (Slender-footed Tyrannulet)** and ***Z. acer* (Guianan Tyrannulet):** These species replace one another elevationally in the Pantepui, though they are not each other's closest relatives (Rheindt et al. 2008; Remsen et al. 2015). We only found the highland taxon, *Z. gracilipes*, during this survey; it was fairly common around our Chenapau and Ayanganna camps. We did not find either species around Kaieteur, although *Z. gracilipes* is on the list of species known from the park (Bicknell et al. 2013).

***Mionectes macconnelli* (McConnell's Flycatcher):** We observed and recorded display vocalizations confirming that the taxon on the Potaro Plateau is *M. m. roraimae,* the "Sierra de Lema Flycatcher" (Hilty and Ascanio 2014), which we expect will soon be elevated to full species status pending a decision by the AOU South American Checklist Committee (Remsen et al. 2015). This will be a further addition to the growing list of bird species endemic to the Guiana Highlands. We observed this species down to 500 m at the Chenapau camp.



This McConnell's Flycatcher (*Mionectes macconnelli roraimae*) represents a population recently proposed to be elevated to full species status. It would be another species-level taxon restricted to the Guiana Highlands.

***Lepidothrix suavissima* (Orange-bellied Manakin):** This Pantepui endemic species replaces its lowland congener, *L. serena* (White-fronted Manakin), above roughly 500 m, and is therefore the expected species on the Potaro plateau. We found this species at all of our camps, though it was substantially more common at the Ayanganna camp (700 m) than at lower elevations (see Table 4.3).

***Rupicola rupicola* (Guianan Cock-of-the-rock):** We observed this species at all of our camps. The Potaro plateau clearly supports a robust population of this spectacular bird. Like many large cotingas, *R. rupicola* probably wanders seasonally to track food sources at different elevations. Conservation strategies in the Potaro plateau region should emphasize connectivity between high and low elevation forests to facilitate seasonal movement of animals such as the Cock-of-the-rock.

The Orange-bellied Manakin (*Lepidothrix suavissima*), endemic to the Guiana Highlands, showed a pronounced increase in abundance between 500 and 700 metres.

Conservation recommendations

The Potaro plateau is part of a large intact forest landscape with enormous global conservation value, where lowland and highland endemic species meet and replace each other. As such, maintaining forest and watershed connectivity in this region is tremendously important. The results of our survey augment previous bird survey work in the region (Barnett et al. 2002) and are concordant overall with the view that the Potaro plateau has a highly diverse avifauna, albeit one in which many lowland species appear to be less common than elsewhere in their ranges. **Of particular significance is the use of these mid-elevation forests by endemic birds of the Guiana Highlands – this phenomenon is largely undocumented for the majority of species, though it seems likely that many birds use these forests either on a seasonal basis (for frugivorous species) or as a matrix to move between islands of suitable highland habitat.** Our finding of *Pyrrhura egregia* at 500 m sets a new lower elevation limit for the species; the fact that it was common at this elevation underscores how little is known of the avifauna of this region. There are doubtless other highland species occurring sporadically or seasonally in these forests, as further survey work would likely reveal.

As elsewhere in the Guiana Shield, the Potaro plateau is plagued by small-scale gold and diamond mining, and this poses a serious threat to birds through direct persecution for food (especially for *Tinamus major* and *Crax alector*, both on the IUCN Red List), removal or alteration of forest habitat, and increased environmental toxicity from chemicals used in mining. Conservation efforts in this region should focus on discouraging small-scale mining, encouraging alternatives to bush meat, and limiting infrastructure development to preserve landscape connectivity.

Evidence of artisanal gold mining near the Ayanganna airstrip. Mining poses a serious threat to birds as it results in habitat loss and increased environmental toxicity.

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CHAPTER 5

CRUSTACEANS AND OTHER AQUATIC INVERTEBRATES OF THE POTARO PLATEAU, GUYANA

Cleverson Rannieri Meira dos Santos, Chetwynd Osborne and Paul Benjamin

Abstract

Crustaceans and other aquatic invertebrates were surveyed from 23 to 28 March 2014 within the Kaieteur National Park (KNP), at several points along the upper Potaro River above Kaieteur Falls, and along tributaries and sites within the park. **This represents the first inventory of crustaceans in the park.** A total of 1,133 specimens of decapod caridean shrimps (865 Euryrhynchidae and 268 Palaemonidae) and 105 of crabs (81 Pseudothelphusidae and 24 Trichodactylidae) were collected. These specimens comprised five species of shrimp and two species of crabs. The species of shrimp *Euryrhynchus* sp. 2 and the crab *Microthelphusa* sp. are potentially new species. Also among the macrocrustaceans, nine semi-terrestrial isopods were recorded, while the aquatic insects collected were mostly larvae from nine orders, representing 20 families. Our preliminary observations suggest that the habitat is healthy, in a good condition of conservation.

THIS SURVEY REPRESENTS THE FIRST INVENTORY OF CRUSTACEANS IN THE KAIETEUR NATIONAL PARK

Introduction

KNOWLEDGE OF FRESHWATER SHRIMPS AND CRABS FROM GUYANA IS VERY POOR, MORE SO WHEN CONSIDERING THE SYSTEMATICS OR ECOLOGICAL STUDIES; THERE IS NO COMPLETE LIST OF SPECIES.

The Amazonian region is a very diverse and abundant environment, sustaining a substantial number of freshwater groups of vertebrates and invertebrates. Fishes, amphibians, insects, mollusks and crustaceans are the most representative fauna. Aquatic invertebrate communities are sensitive to pollution and sudden changes in their environment, and many species are often used as indicators of aquatic ecosystem health.

Aquatic insects have a high richness in freshwater environments and exhibit complex patterns of biodiversity (Heino 2009). **Insects used as bio-indicators can be monitored to determine whether the community is changing over time due to natural or human-caused impacts.** Species of Ephemeroptera, Plecoptera and Trichoptera orders are used to monitor water quality and prioritize resource management actions (Lenat 1988).

Freshwater crustaceans are considered to be not only predators but also prey, since they are important elements in the food chain of large rivers. Many species take part in the matter-energy exchange between trophic levels and aquatic and terrestrial systems (Collins et al. 2007). Crustaceans are frequently used as bio-indicators and bio-monitors in various aquatic systems. The reason is that they are a very successful group of animals, are distributed in a number of different habitats, and exhibit varying responses to ecological perturbations (Rinderhagen et al. 2000).

The knowledge of freshwater shrimps and crabs from Guyana is very poor, more so when considering the systematics or ecological studies. There are just some records of crabs from a few locations (Magalhães and Rodríguez 2002) and shrimps (Kensley and Walker, 1982), but no complete list of species. **This is the first inventory of crustaceans from Kaieteur National Park** noting some aspects of their habitats and including other aquatic macroinvertebrates.

Methods and study sites

The period of study was very short, just five days in the field from 23 to 28 March 2014. To optimize the time and space we chose to collect closer to our base camps and spent less time far away. The localities were accessed by trails or boat with two hours sampling effort at each sample point. The survey was conducted only within Kaieteur National Park at several points along the upper Potaro River above Kaieteur Falls, and along tributaries and sites within the park, including Murimuri, Tukeit, Menzies Landing, Elinku and Amakwa. To compare different places, some sites were grouped into regional localities, by similar habitats and proximal distance: nine sites from the Kaieteur base camp region, four sites from the Murimuri region and two sites from the Tukeit region.

In order to provide a thorough inventory, sampling was conducted using a net and/or sieve in shallow waters, capturing as many aquatic invertebrates as possible. Collection was done at both sides of each creek, and within the different microhabitats types such as leaves, rock, sand and mud.

Abiotic variables were measured using a multi-parameter probe: pH (potential of hydrogen), DO (dissolved oxygen), conductivity, air and water temperatures. Other environmental aspects were recorded like colour of water, vegetation and bottom types and wind intensity.

Shrimps and crabs have a large variation size; some individuals are less than 10 mm and others may reach up to 100 mm. Even the large specimens however require accurate examination of small systematic characteristics under a microscope for species identification. Other aquatic invertebrates like insects have a huge diversity and there is no available literature to identify most species in larval stage. Thus, the samples were collected and preserved in ethanol to study in the laboratory for identification.

Sampling a stream for species, and sorting for shrimp, crabs and aquatic insects.

Results and discussion

The average air temperature was 26.4°C (range of 25 to 28.8°C) and water temperature average was 23.6°C (22.1 to 25.3°C). This variation was less than 3.8°C and this difference has no significance. Temperatures higher than 20°C are enough to sustain a good freshwater biodiversity. The pH average was 4.48 (4.09 – 5.54), showing the streams with acid waters, but most aquatic organisms can live under these conditions. Dissolved oxygen showed an excellent range to support aquatic life (average: 7.08 mg/L, range of 3.95 to 9.14 mg/L). Most creeks had values higher than 6.0 mg/L. The values of conductivity were normal for freshwater, averaging 44.33 µS/cm (15.47 – 59.0 µS/cm). All these abiotic values were compared with parameters discussed by Mcdonald et al. (1991).

Summary of habitats

Upper Murimuri region
Four creeks were sampled in this particular region; one of these showed the lowest DO value of the survey, with lower diversity of invertebrates. However, other sites had different and good abiotic parameters with stream water, and high DO values. The substrates were sandy or rocky bottom, with accumulated leaves or roots in some places supporting a microhabitat. The region is interesting because these streams were in densely forested riparian zones closer to a wide open savannah; this formation can provide additional habitats with different species compared to other areas of the Kaieteur National Park.
Kaieteur base camp region
Most of the points sampled in this area were located above Kaieteur Falls (average of 437 metres above sea level). This region had several large rivers (i.e. Potaro, Elinku and Amakwa) and numerous small creeks and streams with different types of natural environments. The small creeks are primarily located in densely forested zones, and most of the substrates were a composite of sand and rocks with leaves, occasionally with mud.
Tukeit region
Access to Tukeit is gained by following trails from Kaieteur Falls. Kaieteur Falls appears to work like a barrier to some species. For example, we found one crab species only at Tukeit. At the Tukeit waterfall flowing down the mountain to the Potaro River, higher values of dissolved oxygen were recorded, and the substrates are rocky with leaves and roots.

Summary of taxa

A total of 1,133 specimens of decapod caridean shrimps (865 Euryrhynchidae and 268 Palaemonidae) and 105 of crabs (81 Pseudothelphusidae and 24 Trichodactylidae) were collected. These specimens comprised five species of shrimp and two species of crabs, which is normal if we consider the range of area sampled. In comparison, in the Amazonian Brazilian forest there are 23 species of shrimps and 22 freshwater crabs (Magalhães, 2003). Also among the

macrocrustaceans, nine semi-terrestrial isopods (woodlice) were recorded. The aquatic insects collected were mostly larvae from nine orders (20 families), including Blattaria (33), Coleoptera (2), Diptera (12), Ephemeroptera (11), Heteroptera (29), Megaloptera (7), Odonata (103), Plecoptera (51) and Trichoptera (42) individuals. Thirteen individuals of Annelida were captured, all of them are Oligochaeta (see Appendix 5). The results suggest dissimilarity among regions, with some crustaceans present only in one region (a crab at Tukeit and a shrimp at Murimuri). Other insect groups were specific to some sites, with higher diversity around the Kaieteur Falls region where more samples were collected.

Interesting species

Determination to species level for some larval insects is almost impossible, but most of the genus records found can be related to some adults in a future survey. Some genera of Odonata (dragonflies and damselflies) and Ephemeroptera (mayflies) may represent new records for Guyana. For crustaceans, all observations should be considered notable, since this is the first inventory list for Kaieteur National Park. (See Appendix 5.) **The species of shrimp *Euryrhynchus* sp. 2 and the crab *Microthelphusa* sp. are potentially new species** and require more laboratory work.

Conservation recommendations

Preliminary observations suggest that the habitat is healthy and in a good condition of conservation. The presence of bioindicators like Odonata, which are somewhat pollution-tolerant organisms, with high diversity and abundance values indicates excellent quality of water. Additionally, the orders Plecoptera (stoneflies) and Trichoptera (caddisflies) are very pollution-sensitive taxa and were present in 10 sites of the three regions sampled. In the same way, the high abundance of crustaceans suggests a complex ecological network with interactions among micro and macroinvertebrates and vertebrate species. Several ovigerous females (with eggs) of shrimps and juveniles of crabs were sampled from 13 sites, indicating that the region is very important to the reproductive cycle and development of these species.

THE SPECIES OF SHRIMP *EURYRHYNCHUS* SP. 2 AND THE CRAB *MICROTHELPHUSA* SP. ARE POTENTIALLY NEW SPECIES

The results of this short dry season survey may not represent all the aquatic macroinvertebrate fauna of these areas. More extensive sampling is required, including during the wet season, in order to reflect more accurately the abundance and the species richness at these sites. Also, sampling at different periods can determine several ecological aspects, including whether some organisms have seasonal or year-round reproduction. Such data can help in preparing a sustainable management plan for aquatic resources within the Kaieteur National Park.

Acknowledgements

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CHAPTER 6

ODONATA (DRAGONFLIES AND DAMSELFLIES) OF THE KAIETEUR PLATEAU AND UPPER POTARO AREA, GUYANA

Natalia von Ellenrieder

Summary

Dragonflies and damselflies were studied during a Biodiversity Assessment Team (BAT) expedition to the Kaieteur Plateau and Upper Potaro area in western-central Guyana. Eighty species, representing over 40% of the species currently known from Guyana, were registered at forest rivers, creeks, swamps, pools, and trails. In particular, **58 species were found within Kaieteur National Park, constituting the first listing of odonates known from the Park**, and 53 within the Upper Potaro area. At the time the study took place, **twenty-two species represented new records for Guyana, increasing the total number of species known from the country to 214, and another five, belonging to the genera *Argia* and *Progomphus*, were new to science at the time the study took place.**

The results indicate a healthy watershed and well preserved forest for all of the sites visited, with the exception of two where gold mining had taken place. If forest cover and morphology of freshwater habitat diversity are maintained in the area, the present odonate assemblages are likely to persist.

KNOWLEDGE OF THE ODONATES FROM GUYANA IS VERY SKETCHY, SINCE ONLY TWO PAPERS ADDRESSED ITS FAUNA SPECIFICALLY. THE AREAS VISITED IN THIS STUDY HAVE NEVER BEEN SURVEYED FOR ODONATES.

Introduction

Dragonflies and damselflies (Order Odonata) are widespread and abundant in all continents with the exception of Antarctica, with centres of species richness occurring in tropical forests. With about 6,000 described species worldwide (Dijkstra et al. 2013), they constitute a relatively small order compared to other insects, representing an ideal target group for a biodiversity assessment survey, because it is feasible to fully document their species diversity for a particular area in a relatively short period of time. They live in aquatic habitats as larvae and use a wide range of terrestrial habitats as adults. Larvae are sensitive to water quality and habitat morphology such as bottom substrate and aquatic vegetation structure. Adult habitat selection is strongly dependent on aerial vegetation structure, including degrees of forest cover. As a consequence, **dragonflies show strong responses to habitat change such as thinning of forest and increased erosion**. Common species prevail in disturbed or temporary waters, while pristine forest rivers, streams and swamps house an array of more vulnerable, often localized species. Thus odonates are useful for monitoring the overall biodiversity of aquatic habitats and have been identified as good indicators of environmental health (Corbet 1999; Kalkman et al. 2008).

Knowledge of the odonates from Guyana is very sketchy, since only two papers addressed its fauna specifically (Erichson in Schomburgk 1848; Calvert 1948), The recently published checklist for the country gives a total of 238 odonate species (von Ellenrieder et al. 2017); this number is low due to limited sampling of the country, compared to the almost 300 species from neighbouring Suriname (Belle 2002; von Ellenrieder 2011) and more than 500 from Venezuela (De Marmels 1990c, 2015), countries which have or had active resident odonate researchers and which have been much more extensively explored. No published data regarding regional distributional data or particular ecological requirements of the odonates from Guyana exists, and **the areas visited in this study have never been surveyed for odonates.**

TWENTY-TWO DESCRIBED ODONATA SPECIES REPRESENT NEW RECORDS FOR GUYANA, INCREASING THE TOTAL NUMBER OF SPECIES KNOWN FROM THE COUNTRY TO 214. ANOTHER FIVE, BELONGING TO THE GENERA ARGIA AND PROGOMPHUS, WERE NEW TO SCIENCE.

Methods and study sites

Odonate species from the upper Potaro area and the Kaieteur National Park in the Potaro-Siparuni Region of western-central Guyana were studied by applying search-collecting methods. In order to provide a thorough inventory, sampling was conducted in as many habitats and elevations as possible given the survey time, using aerial nets for adults, and a sieve for aquatic larvae. Searching, photographing and collecting were carried out around each camp, in terra firme forest, forest swamps, pools, streams, creeks, varzea forest, and rivers. Odonates were surveyed from 17 to 23 March 2014 in the upper Potaro area at Chenapau Village, and at Bay and Upper Potaro Camps on the Potaro River and surroundings (sites 1-9), and from 24 to 29 March 2014 near Murimuri Camp and the Kaieteur Plateau within Kaieteur National Park (sites 10-24) as follows:

Site 1: Chenapau Village: ponds & forest trails (4° 59′ 7.6′′ N, 59° 34′ 45.2′′ W, 445 m) 17 and 23 March 2014

Site 2: Bay Camp to Chenapau: creek (5° 0′ 35.8′′ N, 59° 38′ 11.3′′ W, 470 m) 18 March 2014

Site 3: Bay Camp to Chenapau: creek (5° 0′ 13.8′′ N, 59° 37′ 33.4′′ W, 460 m) 18 March 2014

Site 4: Bay Camp to Chenapau: creek (5° 0′ 10′′ N, 59° 37′ 13.5′′ W, 470 m) 18 March 2014

Site 5: Bay Camp to Chenapau: creek and river (5° 0′ 9′′ N, 59° 36′ 56.6′′ W, 461 m) 18 March 2014

Site 6: Bay Camp to Chenapau: creek (5° 0′ 13.5′′ N, 59° 37′ 37.4′′ W, 459 m) 18 March 2014

Site 7: Upper Potaro Camp: Potaro River (5° 3′ 58.7′′ N, 59° 39′ 24.1′′ W, 560 m) 19 and 21 March 2014

Site 8: Upper Potaro Camp to Bay Camp: Potaro River (5° 3′ 14.8′′ N, 59° 39′ 48.7′′ W, 573 m) 20 March 2014

Site 9: Upriver Upper Potaro Camp: creek (5° 6′ 30.9′′ N, 59° 38′ 38′′ W, 661 m) 22 March 2014

Site 10: Kaieteur Top near reception centre: trickles (5° 10′ 39′′ N, 59° 29′ 17′′ W, 467 m) 24 March 2014

Site 11: Murimuri Camp: creek (5° 16′ 38.7′′ N, 59° 31′ 2.3′′ W, 523 m) 25 and 26 March 2014

Site 12: Murimuri Camp, helipad: sandy creek (5° 15′ 57′′ N, 59° 30′ 44.7′′ W, 482 m) 27 March 2014

Site 13: Murimuri trail to Kaieteur: forest trail (5° 13′ 57′′ N, 59° 30′ 20′′ W, 465 m) 27 March 2014

Site 14: Kaieteur Top: trickles (5° 10′ 37′′ N, 59° 29′ 19′′ W, 470 m) 27 March 2014

Site 15: Elinkwa: creek (5° 8′ 55.38′′ N, 59° 28′ 28.26′′ W, 438 m) 28 March 2014

Site 16: Wamamuri River: mining pits with water (5° 7′ 2.4′′ N, 59° 32′ 6.3′′ W, 447 m) 28 March 2014

Site 17: Amawaka: creek (5° 8′ 19.9′′ N, 59° 30′ 31.4′′ W, 442 m) 28 March 2014

Site 18: Amacua: itabú (blind side channel of river with abundant floating vegetation) (5° 9′ 10.1′′ N, 59° 30′ 12.1′′ W, 440 m) 28 March 2014

Site 19: Kaieteur: Potaro River (5° 9′ 43.7′′ N, 59° 29′ 46.1′′ W, 436 m) 28 March 2014

Site 20: Menzies Landing: creek (5° 9′ 54.9′′ N, 59° 29′ 33.7′′ W, 427 m) 28 March 2014

Site 21: Kaieteur Top: pond with aquatic vegetation (5° 10′ 38.2′′ N, 59° 29′ 17′′ W, 470 m) 28 March 2014

Site 22: Tukeit Trail: trickles on rocky wall (5° 11′ 31.4′′ N, 59° 28′ 25.7′′ W, 430 m) 29 March 2014

Site 23: Tukeit Trail: bedrock creek and associated marshy areas (5° 11′ 53.2′′ N, 59° 27′ 48.6′′ W, 160 m) 29 March 2014

Site 24: Tukeit Landing: Potaro River and nearby trail (5° 12′ 16.5′′ N, 59° 27′ 10.2′′ W, 90 m) 29 March 2014.

Incidence (presence/absence) information on species was recorded in a spatial-relational database, and relative abundance for each species was noted accordingly as rare (1-3 specimens seen), frequent (4-20 specimens seen), or common (21-50 specimens seen) (Appendix 6a). Specific richness, evenness [= H / ln (richness)], diversity (calculated according to Shannon and Simpson indices) per site are presented in Appendix 6a. Collected specimens are deposited at the Centre for the Study of Biological Diversity, University of Guyana (CSBD) and the California State Collection of Arthropods (CSCA).

Species accumulation curves (using Jaccard's distance measure) and total species richness expected for the area according to the Chao 2 estimator were calculated using PC-ORD (McCune and Grace 2002). Composition of odonate communities from the two areas was compared using percentage complementarity (a measurement of distinctness or dissimilarity; Colwell and Coddington 1994). Information on the distribution of the species found, maps for those showing a significant range extension, biological and taxonomic notes, and conservation recommendations are provided.

Results

Overall, 43 odonate genera belonging to 11 families were recorded, with a total of 80 species. These represent over 33% of the total number of odonate species reported for Guyana (von Ellenrieder et al. 2017). In particular, 10 families, 36 genera, and 53 species were collected at the Upper Potaro area, and 9 families, 34 genera, and 58 species at the Kaieteur National Park (Appendix 6a). Estimated species richness for the total area surveyed was 121.53, for the upper Potaro area 93.5, and for the Kaieteur National Park 88.8. The species accumulation curve (Fig. 6.1) did not approach the asymptote.

OVERALL, **43** ODONATE GENERA BELONGING TO 11 FAMILIES WERE RECORDED, WITH A TOTAL OF 80 SPECIES

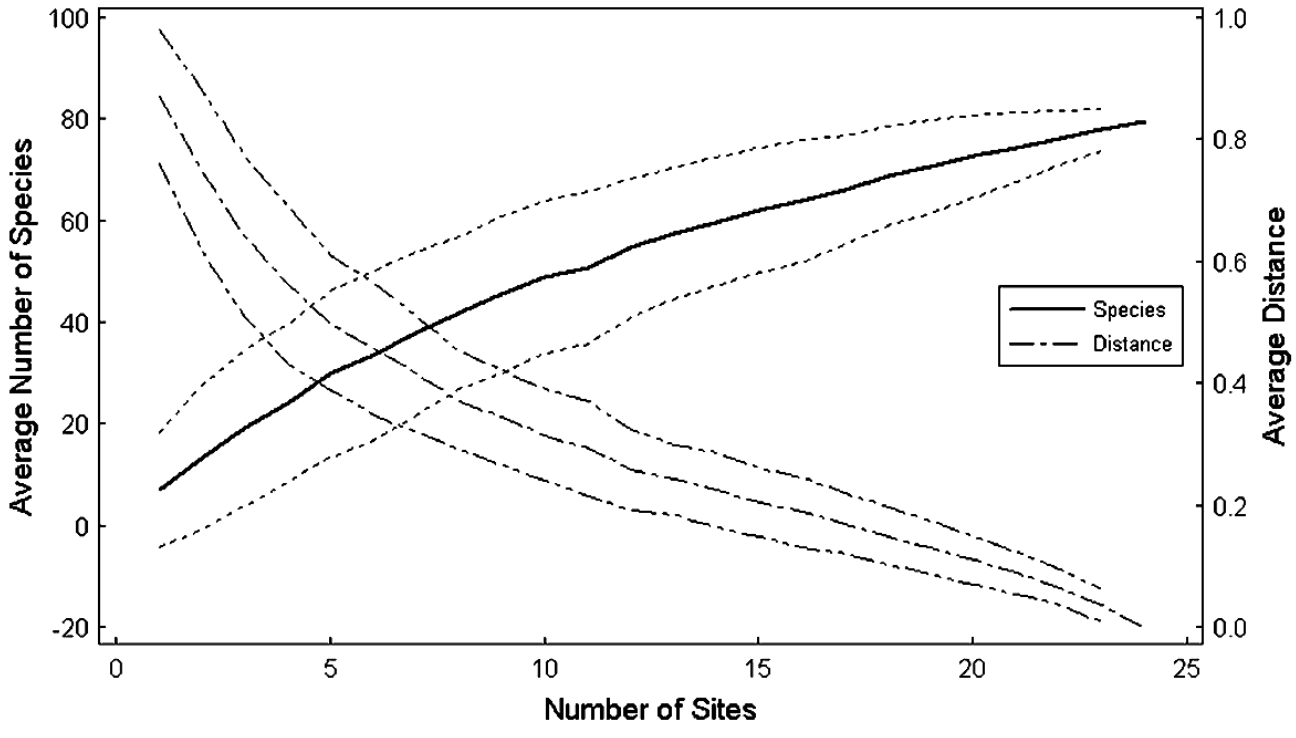


Figure 6.1 **Species accumulation curve of odonate species found in the upper Potaro region.**

Species richness varied from 1 to 19 per site, with a mean and standard deviation of 7.33 ± 5.68 respectively; Shannon diversity ranged from 0 to 2.94 (1.65 ± 0.9) and Simpson diversity from 0 to 0.94 (0.71 ± 0.3). The localities with highest richness and diversity values were Chenapau and surroundings (Site 1) and the Potaro River (Site 8) in the upper Potaro area, and Murimuri Creek (Site 11) and Elinkwa Creek (Site 15) in the Kaieteur National Park (see Appendix 6a).

Kaieteur National Park was slightly richer in odonate species than the upper Potaro area, but the species composition of the two areas differed considerably, with only 31 shared species and a resulting complementarity of 61.25%. Kaieteur National Park hosted 27 species not found at the upper Potaro area, whereas 21 species were found only at the upper Potaro area (see Appendix 6a).

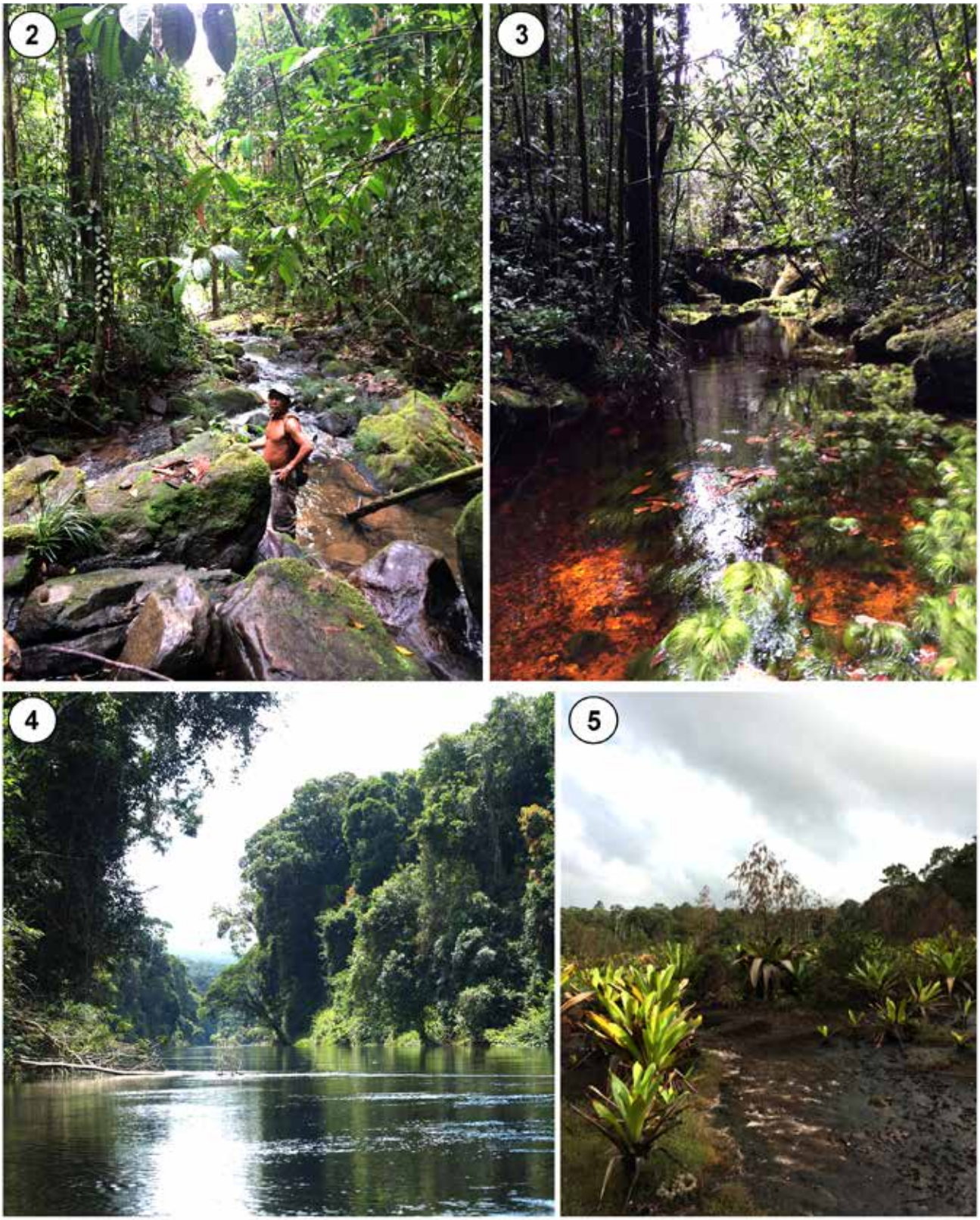
Five of the species found were undescribed at the time the expedition took place, and belong to the genera *Argia* Rambur, 1842 and *Progomphus* Selys, 1854. *Argia* is the most speciose odonate genus in the New World, with 124 described species (Garrison et al. 2010; Garrison and von Ellenrieder 2015). This genus shows its importance in all three sites, being the richest in species (seven total), with four of these species still new to science at the time the expedition took place. These four species were recently described in a separate paper (Garrison and von Ellenrieder 2015), based also on collections from other countries in the Guiana Shield (see Appendix 6b). The three specimens of *Progomphus* collected were all very young freshly emerged adults, which unfortunately did not fully expand or acquire their characteristic colour pattern at the time of preservation. They offer enough evidence to determine them as new (combining absence of sub-basal costal crossveins, presence of a second antehumeral stripe, male cerci recurved with two small apical teeth, female vulvar lamina approximately 0.40 of S9), but a formal and complete description of this species is not warranted until mature specimens are found.

Another twenty-two species were new records from Guyana (Appendix 6a), including ten damselflies: *Epipleoneura pereirai*, *Neoneura fulvicollis*, *Protoneura tenuis*, *Telebasis simulata* (Coenagrionidae); *Heteragrion pemon* (Megapodagrionidae); *Lestes falcifer* (Lestidae); *Perilestes attenuatus*, *Perilestes gracillimus* (Perilestidae); *Palaemnema brevignoni* (Platystictidae), *Chalcothore montgomeryi* (Polythoridae), and 12 dragonflies: *Anax amazili* (Aeshnidae); *Elasmothemis cannacrioides*; *Elasmothemis rufa*, *Gynothemis uniseta*, *Macrothemis belliata*, *Macrothemis cynthia*, *Macrothemis hemichlora*, *Micrathyria catenata*, *Oligoclada rhea*, *Tramea abdominalis*, *Tramea binotata*, *Ypirangathemis calverti* (Libellulidae).

None of the 80 species found is endemic either to the study area or to Guyana, with the possible exception of the undescribed *Progomphus* species. Biogeographically, the odonates recorded here can be broadly categorized as a mixture of: Guianan, limited in distribution to forests overlaying the Guiana Shield and spanning from eastern Colombia, southeastern Venezuela, Guyana, Suriname, French Guiana, to northern Brazil (Gibbs and Baron 1993); Guianan and Amazonian, distributed on the Guiana Shield and across the Amazonian forested lowland areas of South America east to the Andes; and widespread Neotropical taxa, present in the Guianan and Amazonian areas but also further widespread throughout the Neotropical region, each level inclusive of the previous. Some of the genera found, such as *Rimanella*, *Iridictyon*, *Dimeragrion* and *Chalcothore*, are exclusively Guianan; for a complete listing of the Guianan species found (about 36% of the total species) see under GUI in Appendix 6b. Guianan and Amazonian taxa include for example the genera *Bromeliagrion*, *Perilestes* and *Microstigma*, and about 24% of the species recorded show this distribution pattern (see under AMZ in Appendix 6b). Most of the genera and about 40% of species recorded are present in the Guianan and Amazonian areas, but are also further widespread throughout the Neotropical region (see under NEO in Appendix 6b).

No odonates are listed on the CITES appendices. The conservation status of about a fourth of the Neotropical species was assessed by the IUCN Odonate Specialist Group (Claustnitzer et al. 2009), including approximately a third of the species found in the present study (Appendix 6b). From these, most were assessed as Least Concern, and two, *Epipleoneura pereirai* and *Perilestes gracillimus*, as Data Deficient. The recent records of these two species from Suriname and Guyana would allow re-evaluating them as LC, based on the extension of their geographic range according to the IUCN Red List criteria.

AN UNDESCRIBED *PROGOMPHUS* SPECIES MAY POSSIBLY BE ENDEMIC TO GUYANA



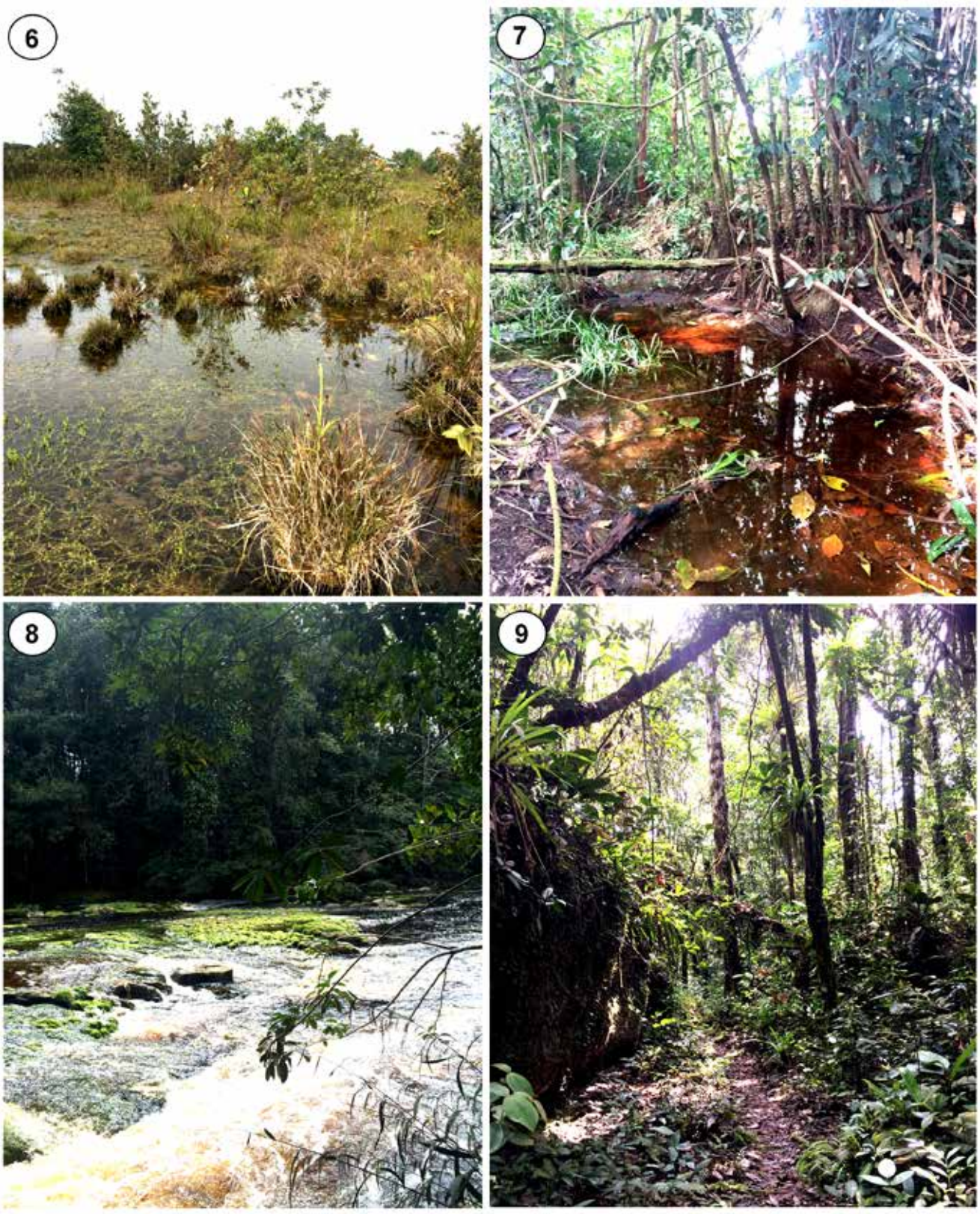
Figures 6.2-6.5

6.2 **Forest stream between Chenapau and Bay Camp (Site 5) with guide Regius Edwards.**

6.3 **Murimuri Creek, a blackwater stream (Site 11).**

6.4 **Potaro River between Bay Camp and Upper Potaro Camp (Site 8).**

6.5 **Water trickles at Kaieteur Top (Site 14).**



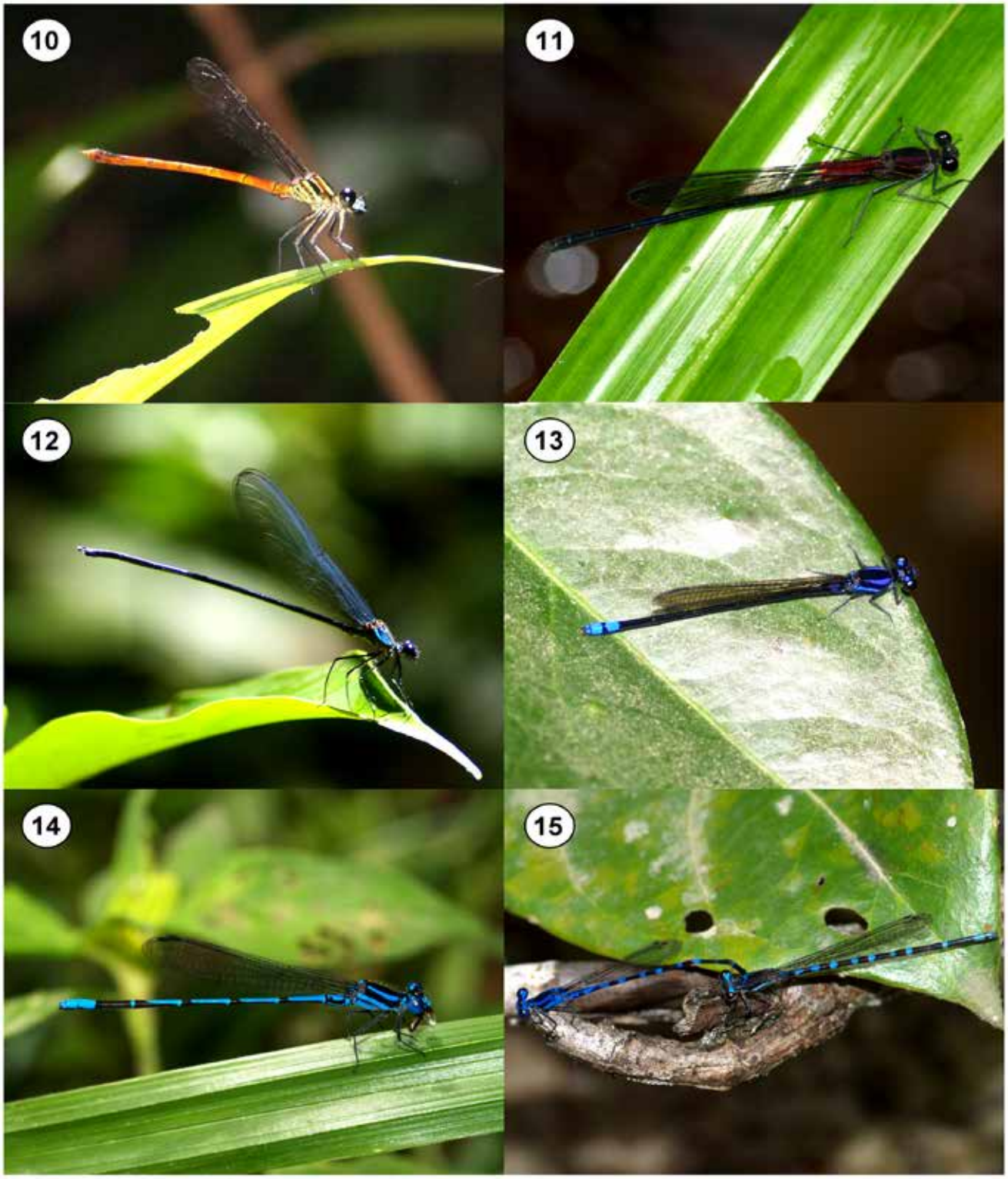
Figures 6.6-6.9

6.6 **Vegetated pond at Kaieteur Top (Site 21).**

6.7 **Creek at Menzies Landing, Kaieteur (Site 20).**

6.8 **Rapids at Elinkwa Creek; the rocks covered in Podostemaceae are the preferred habitat of *Rimanella arcana* (Site 15).**

6.9 **Trickles on rocky wall on trail from Kaieteur to Tukeit (Site 22).**



Figures 6.10-6.15

6.10 ***Rimanella arcana*: male perching with wings closed – adults of this species usually perch with wings open – at Tukeit Creek (Site 23).**

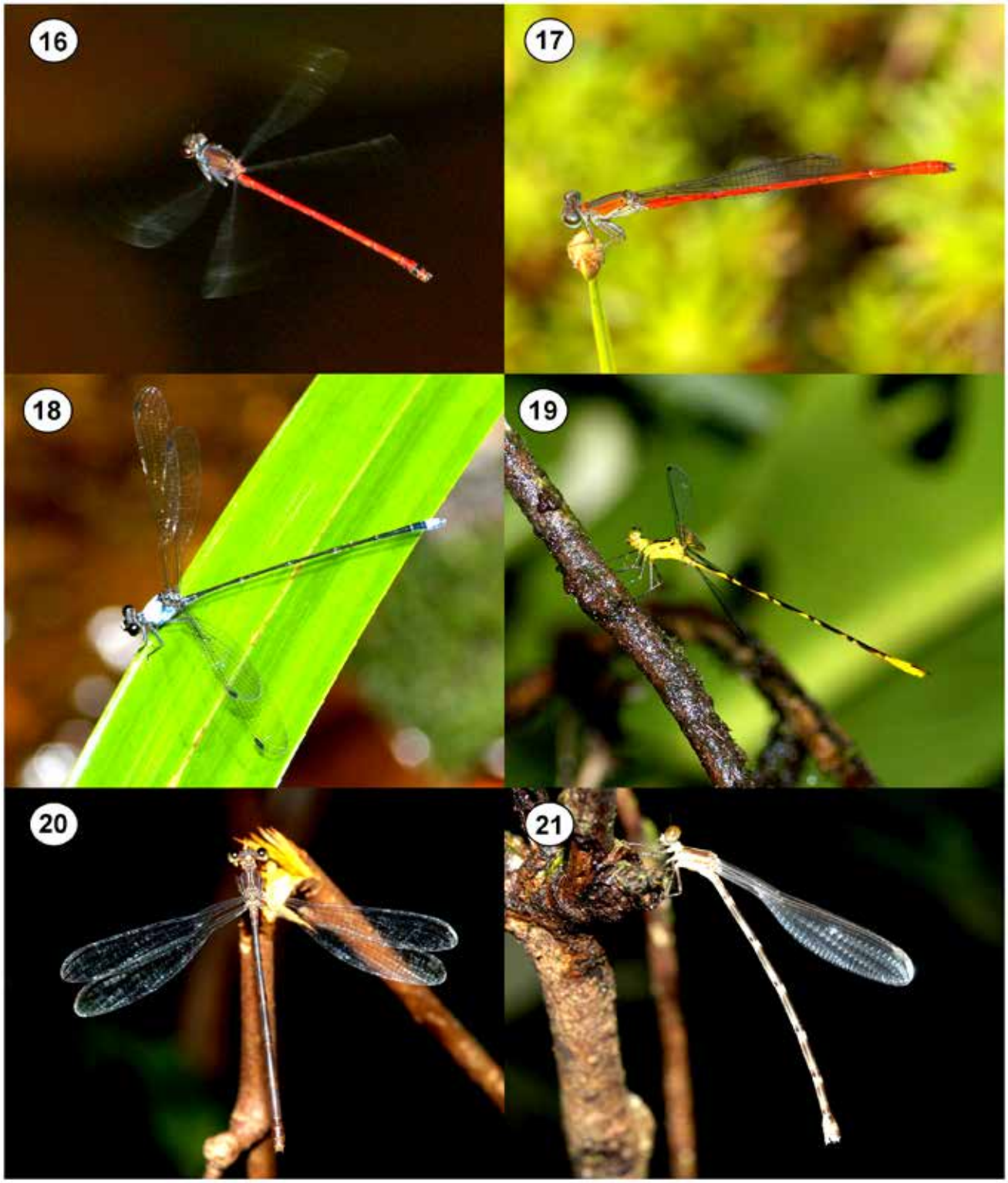
6.11 ***Hetaerina moribunda*: male at Murimuri Creek (Site 11).**

6.12 ***Iridictyon trebbaui*: iridescent male in the sunlight at Tukeit Creek (Site 23).**

6.13 ***Argia fumigata*: male at Potaro River bank in Upper Potaro Camp (Site 7).**

6.14 ***Argia azurea*: male with its prey at Chenapau (Site 1).**

6.15 ***Argia joallynae*: male and female in tandem at Murimuri Camp (Site 11).**



Figures 6.16-6.21

6.16 ***Neoneura myrthea*: male hovering near bank of Potaro River at Upper Potaro Camp (Site 7).**
6.17 ***Telebasis simulata*: male at vegetated pond in Kaieteur Top (Site 21).**
6.18 ***Dimeragrion percubitale*: male at Murimuri Creek (Site 11).**
6.19 ***Heteragrion pemon*: male at Murimuri Creek (Site 11).**
6.20 ***Oxystigma petiolatum*: female perched along forest trail near Chenapau (Site 1).**
6.21 ***Palaemnema brevignoni*: teneral female at a creek between Chenapau and Bay Camp (Site 2).**

Figures 6.22-6.27

6.22 ***Erythrodiplax castanea*: male at creek near Murimuri Camp (Site 11).**
6.23 ***Erythrodiplax famula*: male at creek near Murimuri Camp (Site 11).**
6.24 ***Erythrodiplax paraguayensis*: male at Kaieteur Top (Site 14).**
6.25 ***Micrathyria catenata*: male at vegetated pond in Kaieteur Top (Site 21).**
6.26 ***Orthemis aequilibris*: pruinose male at Murimuri Camp (Site 11).**
6.27 ***Orthemis biolleyi*: female at Murimuri Camp (Site 11).**

Figures 6.28-6.33

6.28 ***Perithemis lais*: male at creek near Menzies Landing (Site 20).**
6.29 ***Uracis fastigiata*: male along forest trail from Chenapau to Bay Camp (Site 3).**
6.30 ***Uracis imbuta*: female in forest trail near Murimuri Camp (Site 11).**
6.31 ***Uracis imbuta*: male and female in tandem at Murimuri Camp (Site 11).**
6.32 ***Ypirangathemis calverti*: male at trickles on Kaieteur Top (Site 14).**
6.33 ***Zenithoptera fasciata*: male perching at pool near Chenapau (Site 1).**

Discussion

The differences in odonate species composition observed between the upper Potaro and the Kaieteur National Park can be explained in part by different qualities of the aquatic habitats sampled at each site. For example, *Erythrodiplax paraguayensis* and *Ypirangathemis calverti*, which were found only on the grassy exposed trickles formed on the rocky outcrops at the Kaieteur top, breed in shallow marshy open areas, a habitat type not sampled during the upper Potaro portion of the survey. Similarly, *Rimanella arcana*, found only at Elinkwa and Tukeit creeks in Kaieteur National Park, oviposits on exposed Podostemaceae covered rocks in fast-flowing portions of creeks and rivers where the males perch, and the only site visited in the upper Potaro area possibly presenting those characteristics (rapids at the Potaro River near Upper Potaro Camp) was at the time of the survey submerged, due to high water volume resulting from recent rains. *Argia guyanica* was found perching near the ground in marshy areas associated with creeks in dappled sunlight, and this type of habitat was only sampled in Kaieteur National Park (Site 23). *Lestes falcifer* and *Zenithoptera fasciata*, found only at temporary pools within the forest near Chenapau Village, prefer small ponds with marginal vegetation and partial shade, habitat not encountered at the Kaieteur National Park, where the exposed ponds at Kaieteur top hosted instead *Telebasis simulata* and *Micrathyria catenata*, which prefer lentic water bodies with abundant floating vegetation in exposed open areas. However, most of the species not shared between the two areas were rare in terms of abundance (Appendix 6b), and 39 of them (79.6% of 49 not shared species) were found at only one site during the survey, which indicates that a longer survey would have probably recovered them at similar habitats in both areas.

The higher richness and diversity values observed at Chenapau and surroundings (Site 1), the Potaro River (Site 8), Murimuri Creek (Site 11), and the Elinkwa Creek (Site 15) in comparision to the other sites in these two areas can be explained by the higher diversity of microhabitats they included, and because three of them were sampled for a more extensive period of time. Chenapau included pools, forest clearings, and forest in proximity to the river, combining species characteristic of both lentic and lotic habitats, and was visited on two separate dates when the weather was sunny and odonates were therefore active and easier to detect. The Potaro River site corresponded to a day-long boat trip, during which numerous stops along the banks allowed access to species normally difficult to approach from the coast in both shaded and exposed areas. Murimuri Camp was surveyed during two full days, and included shaded and exposed portions of the creek, with differing depths and both fast-flowing and slow-moving waters, as well as forest clearings. Elinkwa Creek also included shaded and exposed portions of the creek with differing depths and both rapids and slow-moving waters, although it was visited only once. The lower values from most of the other sites can be explained by comparably shorter survey times, combined in some cases with overcast weather, which considerably decreases odonate

THE PORTION OF THE MURIMURI CREEK VISITED WHERE MINING HAD TAKEN PLACE HAD BEEN STRIPPED OF MARGINAL VEGETATION AND TREES, AND NO ODONATES WERE FOUND THERE

activity and therefore negatively affects sampling, and by lower microhabitat diversity. However, anthropogenic factors can explain some of the low values observed**; the portion of the Murimuri Creek visited where mining had taken place had been stripped of marginal vegetation and trees, and no odonates were found there, and only three ubiquitous dragonflies (*Erythrodiplax famula*, *Orthemis discolor* and *Uracis imbuta*) that are tolerant of a wide range of environmental conditions were recorded flying at the mining pits at Wamamuri River** (Site 16).

Additional odonate species were recorded each day at the different sites visited, and the curve of number of species found did not plateau, indicating that many more species would have been recorded from this area had the survey time been longer. A more thorough and extended study during both the dry and wet seasons around the Kaieteur plateau and the upper Potaro will render additional taxa, as indicated by the results of this short dry season survey.

Conservation recommendations

The diversity of odonate genera and species found in this study is typical of well-preserved rainforest sites; most of the species found in the forest understory, creeks, and rivers in the two areas surveyed would not be present if the forest and its freshwater habitats were disturbed. Many odonate species require closed canopy forest to maintain the appropriate vegetation structure they need as adults. **The main threat to these forest specialist species is habitat destruction; human activities such as deforestation, logging, and mining would affect their occurrence in the area and produce a marked decrease in their diversity.** Forest thinning affects the vegetation structure needed by the adults, and the subsequent alteration of water bodies by increased erosion and siltation is also detrimental for their larvae. Mining leads to increased turbidity, and probably siltation of streams, changing the substrate and reducing the habitat quality needed by the larvae. Therefore, **the main conservation recommendation is to enforce protection of the areas included within the Kaieteur National Park, so that no mining or activities leading to habitat degradation take place within its boundaries**, and the structure and quality of the variety of forest freshwater habitats required by the various odonate species of this area is preserved.

ONLY THREE UBIQUITOUS DRAGONFLIES (*ERYTHRODIPLAX FAMULA*, *ORTHEMIS DISCOLOR*, AND *URACIS IMBUTA*) THAT ARE TOLERANT OF A WIDE RANGE OF ENVIRONMENTAL CONDITIONS WERE RECORDED FLYING AT THE MINING PITS AT WAMAMURI RIVER

THE MAIN CONSERVATION RECOMMENDATION IS TO ENFORCE PROTECTION OF THE AREAS INCLUDED WITHIN THE KAIETEUR NATIONAL PARK, SO THAT NO MINING OR ACTIVITIES LEADING TO HABITAT DEGRADATION TAKE PLACE WITHIN ITS BOUNDARIES

Even though about a fourth of the species in this survey were only found outside of Kaieteur National Park, it is expected that they also occur within the park boundaries, but further surveys to confirm their presence and provide a more complete listing of the odonate species present in the park are needed. **The new species of *Progomphus* found here could possibly represent an endemic species, as some members of this genus have restricted distributions**. Examination of mature adult specimens is necessary before this species can be described, and expeditions to find adults, identify their breeding habitat, and study their biology are needed. The teneral specimens found had just emerged at the end of the dry season, indicating that it might be a rainy season species, so mature adults could possibly be found during the rainy season.

Further surveys are also recommended to improve our knowledge of the habitat preferences and biology of several odonate species that occur in these pristine forests (larval stage of 54% of species still unknown, Appendix 6b), and of the seasonality (dry–rainy season species assemblages) of the odonate community of central Guyana, which are still poorly known.

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CHAPTER 7

AQUATIC BEETLES OF THE UPPER POTARO REGION, GUYANA

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Summary

Aquatic beetles were surveyed in the upper Potaro region of Guyana, during March 2014. We sampled at four sites, with most collecting focused on two camps along the Potaro River in the Kaieteur National Park and upriver of Chenapau Village. Most habitat consisted of primary tropical forest. More than 1,800 specimens were collected from 49 collecting events. We identified 91 species of aquatic beetles in 52 genera. More than half of these (55) were found at only one of the four sampling sites. No single site had more than 46 species. Five genera and at least 15 species are new to science, though this number is likely to increase as the material is studied in more detail. The species richness was lower than other surveyed regions in the Guiana Shield, which may be due to habitat homogeneity. As with prior regional studies, **seepage habitats (particularly around Kaieteur Falls) held a high number of unusual and rare species.**

SEEPAGE HABITATS (PARTICULARLY AROUND KAIETEUR FALLS) HELD A HIGH NUMBER OF UNUSUAL AND RARE SPECIES

Introduction

Aquatic beetles are a diverse guild of aquatic insects that occur in a broad range of habitats including streams, lakes, and waterfalls. There are an estimated 13,000 species of aquatic beetles worldwide (Jäch and Balke 2008). These species are distributed across approximately 20 beetle families in four primary lineages: Myxophaga, Hydradephaga, aquatic Staphyliniformia (Hydrophiloidea and Hydraenidae) and the Dryopidae (or aquatic Byrrhoids). Members of Myxophaga are small beetles that feed largely on algae as larvae and adults. The Hydradephaga (including the diving and whirligig beetles) are largely predators as adults and larvae; the aquatic Staphyliniformia are largely predators as larvae but scavengers as adults; the dryopoids are largely scavengers or eat algae as both larvae and adults (Short 2013).

Aquatic insects (including some groups of aquatic beetles) are often used as effective indicators of water quality in freshwater systems. This is largely due to their varying response to ecological perturbations such as increasing sediment load, nutrient inputs, and loss of canopy cover. Aquatic beetle communities are also effectively used to discriminate among different types of aquatic habitat (e.g. between lotic and lentic; rock outcrops, substrate, etc.).

Aquatic beetles in Guyana are poorly known. There has been some limited prior collecting, notably by Smithsonian researchers in 1983 (Takutu Mountains), 1994, and 1995 (both in the northern Rupununi area). A WWF/Global Wildlife Conservation assessment of the South Rupununi conducted in 2013 provided the first insight into the aquatic beetle fauna of that particular region and was the first significant collecting of water beetles in Guyana in two decades. By comparison, neighbouring Venezuela and Suriname have received significantly more attention in recent years, and been the subject of numerous survey efforts (e.g. Short and Kadosoe 2011, Short 2013). Still, the entire regional fauna is very understudied and many new species are being discovered and remain to be described.

Methods and study sites

Field methods

A mix of passive and active collecting methods were used to try to maximize the amount of species diversity observed at each site. In total, we made 49 separate collections of aquatic beetles at three primary sites, and several small collections at Chenapau Village.

Traps and other passive methods

We used a UV light suspended in front of a white sheet as a light trap at the upper Potaro base camp and erected a flight intercept trap at Kaieteur Falls. Dung traps were also set out at the upper Potaro base camp and at Kaieteur Falls.

Active methods

The vast majority of collecting was conducted in forested streams, forest pools, river margins and rapids, and in several open marshes. Aquatic dip nets were the most commonly used collecting tool. The nets are swept through marginal detritus, vegetation, and open water and the contents subsequently placed on screens over white tubs to extract the beetles. Insects that float to the surface of the water were collected with a kitchen strainer. Partially or fully submerged stream debris was also placed into pans of water to extract insects living in this microhabitat. We used a scrub brush to wash rocks at a large rapid above the upper Potaro base camp. Seepages at Kaieteur Falls were examined in detail during the day and at night when many taxa are more active.

Preservation and identification

As most aquatic beetles are extremely small (few exceed 6 mm in length), specimens were collected and preserved directly into 100% ethanol to sort and identify to species in the laboratory. Representative material from each collecting event was mounted and taxonomically sorted. While all specimens were identified to genus, only a few species names could be accurately assigned due to the dearth of identification resources on this poorly studied fauna. Therefore, most species counts are based on morphospecies. Specimens are deposited in Snow Entomological Museum at the University of Kansas, and the Centre for the Study of Biological Diversity at the University of Guyana.

THE SEEPAGE HABITATS AT THE TOP OF THE POTARO RAPIDS CONTAINED A RICH COMMUNITY OF POORLY KNOWN BEETLES, INCLUDING SEVERAL NEW SPECIES OF WATER SCAVENGER BEETLE (ACIDOCERINAE GEN. NOV.)

Site 1: Upper Potaro (base camp: 5° 0.673' N, 59° 38.358' W): 10-14 March 2014

The upper Potaro site was explored for collecting habitats within an approximately 2 km radius from base camp. The aquatic habitats in the vicinity of the base camp were relatively homogenous. The entire area was forested except for the central channel of the Potaro River itself; no open marshes or swamps were observed. There were numerous small streams and creeks. Most had a sandy or detrital substrate, with medium to large cobbles and boulders in some. We did not find any isolated forest pools or depressions during the course of the survey, which seemed unusual but may have been due to dry weather prior to the survey. We identified several seepage and hygropetric habitats above a large rapid on the Potaro, upriver of base camp. We did not observe any artificially created aquatic habitats. A UV light trap was erected at the edge of the base camp.

Habitats of note

The seepage habitats at the top of the Potaro rapids contained a rich community of poorly known beetles, including several new species of water scavenger beetle (Acidocerinae gen. nov.). Rotting tree fruits also yielded several rare and interesting species of water scavenger beetles as well (e.g. *Quadriops*).

Collecting aquatic beetles along the margin of the rapids along the Potaro River, upstream of the base camp

Site 2: Kaieteur National Park (base camp: 5° 10.514' N, 59° 28.970' W): 15-16 and 20-22 March 2014

We explored an area within an approximately 3 km radius of the airstrip. The collecting area consisted primarily of a mosaic of forest and open rock savannah. This provided a range of aquatic habitats, including forested detrital streams, large expansive hygropetric seepages, and the Potaro River itself. One medium-sized (c. 3 m wide) creek with sand and gravel substrate was also sampled. There were a number of human-mediated habitats, including pools in the forest created by the excavation of sand and dirt, and modified stream channels and pools in trails that collect and drain rainwater. Following rain events, small micropools on fallen leaves also formed and contained several aquatic beetle species. While it was relatively dry during the first few days of collection, heavy rain caused significant alteration in some aquatic habitats, and created many new forest pools and increased flow in seepages and creeks. We erected one FIT and set several dung traps near the visitor cabin.

Habitats of note

The rock savannahs and associated seepages surrounding the airstrip proved extremely interesting. Many rare and new species were found in a variety of groups, including the families Hydrophilidae, Dytiscidae, and Torridincolidae.

Collecting aquatic beetles on a large seepage area in Kaieteur National Park. These areas form where large expanses of bare rock are exposed on the surface. Rainwater drains in large sheets across these surfaces, often long after a storm has passed. These seeps provide a unique home for many rare species of aquatic beetles.

THE AYANGANNA NEW AIRSTRIP SITE WAS HEAVILY IMPACTED BY PREVIOUS MINING ACTIVITY. A VEGETATED OPEN MARSH (MAN-MADE) ALONG THE POTARO WAS NOTABLE FOR ITS COMPLETE LACK BEETLES OF ANY KIND, DESPITE SIGNIFICANT COLLECTING EFFORT.

Site 3: Ayanganna (New) Airstrip (base camp: 5° 18.261' N, 59° 50.257' W): 17-19 March 2014

Natural aquatic habitats included several small to medium forested streams. **The site was heavily impacted by previous mining activity**, which created a range of artificial habitats, including a large open marsh that was contiguous with Black Water Creek (a larger tributary of the Potaro), and small to very large diamond mining pits (ranging from 1 to c. 15 metres in diameter). At least one stream had been excavated for mining and significant habitat alteration and sedimentation was evident. No current or immediately recent mining activity was observed. Due to logistical and time constraints, no FIT, dung, or UV light traps were employed at this site.

Habitats of note

No particularly unusual or rare aquatic habitats were observed at this site. **The vegetated open marsh (man-made) along the Potaro was notable for its complete lack beetles of any kind, despite significant collecting effort.** Rotten tree fruits yielded a new species of the rare water scavenger beetle genus *Quadriops*.

Site 4: Chenapau Village (GPS: 4.98650° N, 59.57890° W): 10 and 14 March 2014

In the space between the Potaro River and the Chenapau Village airstrip, there were a series of pools from small puddles (c. 1 m wide) to large pools (c. 7-10 m wide) along the village paths. The larger pools had dense detrital substrate, while the shallow ones had some light vegetation and mud/clay substrate. All were partly shaded by trees and partly open. We collected in these pools for a few hours on two separate days.

Results and discussion

During the expedition, **91 species of aquatic beetles representing 52 genera were observed** (Table 7.1). The primary expedition camps (Upper Potaro and Kaieteur National Park) had relatively similar numbers of species (46 and 41, respectively). Only 33 species were found at Ayanganna, though the lower observed diversity is likely because only two days were spent collecting at this site, and no traps or baits were employed. Though only a few hours of collecting were conducted at Chenapau village, it yielded 19 species including 12 that were not found at any of the other camps.

Five genera and at least 15 species are new to science. It is expected that many more of the species we found will represent new species, but this will require further study.

91 SPECIES OF AQUATIC BEETLES REPRESENTING 52 GENERA WERE OBSERVED DURING THE EXPEDITION. FIVE GENERA AND AT LEAST 15 SPECIES ARE NEW TO SCIENCE.

Table 7.1 **Aquatic beetle species richness among sites**

	# Genera	# Species	Unique species
Upper Potaro	31	46	22
Kaieteur	27	41	16
Ayanganna	21	33	5
Chenapau	10	19	12
TOTAL:	**52**	**91**	

Taxa of Note

Dryopidae: A new genus and several new species were found in streams at the upper Potaro site.

Dytiscidae: *Platynectes*: This is the first record of this genus in Guyana. We found two species: *P. submaculatus*, which we collected at a seepage along the Potaro River near Camp 1, and a new species which has now been described as *P. garciai* at Kaieteur National Park (Gustafson et al. 2016).

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Platynectes garciai: This is one of the new species of aquatic beetle that was collected in Kaieteur National Park.

A NEW SPECIES OF THE HYDROPHILID GENUS *QUADRIOPS* WAS COLLECTED IN ABUNDANCE IN ROTTEN FRUITS OF THE GENUS *CLUISA*

Dytiscidae: *Spanglerodessus shorti*: This genus and species was only described in 2011 from one locality each in Guyana (near Lethem) and Venezuela. This is only the third published record of the genus. It occurs in seepage habitats.

Hydrophilidae: *Quadriops*: **A new species of the hydrophilid genus *Quadriops* was collected in abundance in rotten fruits of the genus *Cluisa***. Although it is derived from an aquatic lineage, the genus has apparently shifted into terrestrial habitats, which were hitherto unclear.

Hydrophilidae: *Hydrophilus simulator*: **This large water scavenger beetle is extremely rare in collections**, and this was the first time we have collected it ourselves. A series of specimens was found in a mud puddle along a path in Chenapau village.

Torridincolidae: Several undescribed species in at least two genera of the family Torridincolidae were found at both the upper Potaro and Kaieteur sites. This family was first reported from Guyana during the South Rupununi BAT expedition, in 2013.

Conservation recommendations

With only 91 species recorded, the overall species richness for the study region was low compared to other recent expeditions in the region that employed similar methods (e.g. Short and Kadosoe 2011; Short 2013; unpub. data). **Of four recent expeditions in Suriname and Guyana, none recorded less than 130 species. The prior BAT expedition to the Kusad and Parabara regions in the southern Rupununi, Guyana, yielded more than 200 species**. There may have been a seasonal effect; however other regional expeditions during March months have yielded much higher diversity (Short and Kadosoe 2011). Lower overall habitat diversity may have also played a role: for example, the South Rupununi BAT expedition covered both forested and open savannah habitats, and thus would be expected to have a higher raw species diversity than a group of forested sites alone, as was the case in this expedition.

Despite the lower overall species diversity, many of the species that were found are rare or rarely collected, and the number of new genera and species was robust. This is likely due to the unusual microhabitats at several sites, especially Kaieteur Falls. The size of the large tracts of rock savannah and seepage habitats are extremely unusual for the region, and consequently it was not surprising to encounter a rich community of otherwise rare hygropetric/seepage taxa.

One additional observation relates to the human-impacted sites at the Ayanganna Airstrip camp. There were several human-created or impacted habitats, including an open, vegetated marsh and semi-open streams that had been mined. These habitats were almost completely devoid of aquatic beetles. We did not find a single specimen in the open marsh habitats, despite extensive dip-netting. Based on the aquatic vegetation, it was clear these were not recently created habitats. Other artificial habitats at Chenapau Village were relatively rich with beetles, so the fact the marshes were not natural is not in itself a satisfactory explanation for the lack of beetles.

DESPITE THE LOWER OVERALL SPECIES DIVERSITY, MANY OF THE SPECIES THAT WERE FOUND ARE RARE OR RARELY COLLECTED, AND THE NUMBER OF NEW GENERA AND SPECIES WAS ROBUST

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CHAPTER 8
FISHES OF THE UPPER POTARO RIVER, GUYANA

Donald C. Taphorn, Jonathan Armbruster, Diana Fernandes, Matthew Kolmann, Elford Liverpool, Hernán López Fernández and David Werneke

Abstract

An international, multi-institutional team of biologists sampled 24 sites, mainly rapids, in the upper Potaro River drainage in the Pakaraima Mountain range of northwestern Guyana, above Kaieteur Falls. Fish diversity was relatively low (27 species), as expected for headwater streams, but endemism was high. We captured many of the endemic species first described by Eigenmann (1909, 1912), and by making fresh specimens and DNA tissue samples available for study we discovered several species that probably represent species new to science: *Laimosemion* cf. *breviceps*, *Lebiasina* sp., *Gymnotus carapo* group, *Brachyglanis* sp., *Trichomycterus* sp. "long", and *Trichomycterus* sp. "small spots". **Most collection sites were in nearly pristine condition and water quality was excellent. Gold and diamond mining pose immediate threats of negative impacts to aquatic ecosystems and to fishes and humans that eat fish potentially contaminated with mercury. Currently existing laws governing these non-renewable extractive activities should be rigorously enforced to protect streams and rivers and the people that depend upon them.**

Introduction

From 16 to 28 March 2014, two teams of researchers and their support personnel (see Table 8.1), organized and coordinated by WWF-Guianas (Guyana) and Global Wildlife Conservation (GWC), surveyed the fishes at 24 sites located in the upper Potaro River near the Amerindian village of Chenapau and Ayanganna (old Ayanganna village). Collections were made under the EPA collection permit # 022714 BR003 and were exported to the Royal Ontario Museum and to the Auburn University Museum Fish Collection, under EPA export permit 040414 SP: 003, where identifications were verified. Although habitats surveyed were concentrated in the rapids of the upper Potaro River itself, near the village of Chenapau and the old Ayanganna village, (the Potaro River is a tributary of the Essequibo River), nearby forest pools and streams were also sampled.

GOLD AND DIAMOND MINING POSE IMMEDIATE THREATS OF NEGATIVE IMPACTS TO AQUATIC ECOSYSTEMS AND TO FISHES AND HUMANS THAT EAT FISH POTENTIALLY CONTAMINATED WITH MERCURY

Table 8.1. **List of participants for fish sampling**

Royal Ontario Museum (ROM) - Research Associate	Dr Donald C. Taphorn	Project Coordinator
ROM - Curator of Fishes	Dr Hernán López Fernández	Fish sampling and identification Leader of Fish Team 2
Auburn University Museum of Natural History (AUM)- Curator of Fishes	Dr Jonathan W. Armbruster	Fish sampling and identification Fish Team 1
AUM Fish Collection Manager	Mr David Werneke, M.Sc.	Fish sampling and identification Fish Team 1
University of Toronto (UT) Ichthyology Doctoral Student	Mr Matthew Kolmann, M.Sc.	Fish sampling and identification Fish Team 2
University of Guyana (UG) Lecturer	Mr Elford A. Liverpool, M.Sc.	Fish sampling & water quality Fish Team 1
University of Guyana (UG) Lecturer	Ms Denise Simmons	Water quality Fish Team 2
Environmental Protection Agency of Guyana	Ms Diana P. Fernandes	Fish sampling, water quality Fish Team 1
	Mr Ovid Williams	Camp coordinator, translator, logistics Fish Team 1
	Mr Maurice Benjamin	Boat Captain Fish Team 1
	Mr Kendall Salvadore	Boat Captain Fish Team 1
	Mrs Agatha Salvador	Fish sampling (hook and line)
	Mr Leon Benjamin	Labourer Fish Team 1
	Mr Mark Benjamin	Labourer Fish Team 1
	Mr Gavin Pablo	Boat bowman, Labourer Fish Team 1
	Mr Bronnel Salvadore	Labourer Fish Team 1
	Mr Ovid Erigot	Labourer, fish sampling Ayanganna old village
	Mr John Bassett Samuel	Labourer, fish sampling Ayanganna old village
	Mr Patterson Joseph	Labourer, fish sampling Ayanganna old village
	Mr Desmond Joseph	Labourer, fish sampling Ayanganna old village
	Ms Juliana Joseph	Fish sampling Ayanganna old village
	Ms Lucita Erigot	Fish sampling Ayanganna old village
	Ms Terasina Samuel	Fish sampling Ayanganna old village
	Ms Betsy Erigot	Fish sampling Ayanganna old village
	Mrs Lolita Fleming	Cook
	Mrs Rosie Edmonds	Assistant Cook
Guyana Defence Force, Medic - 31 Special Forces Squadron	Sergeant Benjamin Hooper	Medical Personnel
Guyana Defence Force, Medic - Medical Corps	Corporal Decius Robin	Medical Personnel
	Mr Danny Gordon	Camp coordinator Fish Team 2
UG, student	Mr Mark Burnett	Field Assistant Fish Team 2

Methods and description of study sites

Different sampling methods were used depending on the habitat and hydrological conditions, at the discretion of the research team. The primary method of fishing was fine-meshed (1/8-1/4 inch) seine netting, whereby a mesh net is pulled by two workers through shallow water (waist to chest deep), while fish are corralled to the middle of the net, or set in the fast flowing waters of rapids, while members of the team vigorously kick the vegetation and rocks immediately upstream of the net to dislodge fishes. Small-meshed (1/2-3/4 inch) gillnets were deployed in deeper water, targeting larger fishes. Gillnets are monofilament of varying mesh sizes, and primarily entangle fish. Hooks and lines were also used to target larger species of fish, as well as baited minnow traps and hoop net traps, which are usually set close to shore, or in the rapids. Rotenone, a fish toxicant was used in areas of relatively quiet water, where obstacles impeded use of seines. An electric fish finder was sometimes used to localize the electronic signals produced by knifefishes (Gymnotiformes). The collection sites are listed below in Table 8.2 – Base Camp 1 was located near Chenapau and Base Camp 2 was at Ayanganna old village.

Fishes were then manually separated from the sampling gear and placed in buckets until all gear was retrieved from the habitat. Fishes were anaesthetized prior to euthanasia with an overdose of clove oil solution, following pre-approved animal care protocols. Specimens were hand-sorted and tentatively identified to species when possible. Fishes were tissued and tagged with a unique catalogue label. Tissuing involves removing either a fin clip or a section of muscle tissue from the right side of the fish and preserving the sample in 95% ethanol or RNAlater preservative. These samples are necessary for DNA extraction methods in later analyses for bar-code identification, population genetics, phylogenetic, or other molecular studies. It is of critical importance that these tissue samples are matched with the preserved, catalogued, and identified specimen from which they were collected in order to positively match the genetic material to the physical animal. We generally attempted to tissue at least five specimens of a given species from each locality. In this way we capture both the taxonomic and genetic diversity within a given habitat or locality. All fish specimens were preserved in a 4% formaldehyde or 10% formalin solution for later cataloguing and taxonomic confirmation.

Table 8.2. **List of 24 collection sites sampled for fishes**

Field #	Date	Drainage	Locality	Latitude	Longitude	Sampling method
GUY14-33	16-Mar-14	upper Potaro	Potaro River at Ayanganna old village	5.30181	-59.89838	6' x 15' seine with 1/8 " mesh
GUY14-34	16-17-18-Mar-14	upper Potaro	Potaro River at Ayanganna old village, nets and traps set upstream from camp-site, also in 'Aluyawongpalu' (Porcupine Creek)	5.30181	-59.89838	Hook and line, 3/4 "gill net, Amerindians basket traps
GUY14-35	17-18-19-Mar-14	upper Potaro	Streams around Ayanganna old village	5.30181	-59.89838	Hand nets, minnow traps, gill nets
GUY14-36	19-Mar-14	upper Potaro	Potaro River at Ayanganna old village, western side	5.30181	-59.89838	6' x 15' seine with 1/8 " mesh
GUY14-37	19-Mar-14	upper Potaro	Potaro River downstream from Ayan-ganna old village	5.30436	-59.8845	6' x 15' seine with 1/8 " mesh
GUY14-38	20-Mar-14	upper Potaro	Moyow Creek, upstream from Ayangan-na old village	5.304	-59.89819	Rotenone
GUY14-53	28-Mar-14	Potaro	Murimuri near Kaieteur Falls	5.275	-59.516	Hook and line
HLF14-01	15-Mar-14	Potaro	Two little creeks at Base Camp 1	5-00-39.2	-59-38-22.0	Night sampling with gillnets and Electric Organ Discharge (EOD) detectors
HLF14-02	16-Mar-14	Potaro	Riffles 5 minutes by boat downstream from Base Camp 1	5-00.349	-59-57.817	Seine
HLF14-03	16-Mar-14	Potaro	Low current channel section just up-stream of HLF14-02	5-00.464	-59-38.135	2 Gillnets
HLF14-04	16-Mar-14	Potaro	Bank opposite HLF 14-02	5-00.464	-59-38.135	1 Gillnet
HLF14-05	16-Mar-14	Potaro	Gillnet by rocks on farthest rapids down-stream from camp	5-00.305	-59 37,730W	1 Gillnet
HLF14-06	16-Mar-14	Potaro	Small creek flowing into the Potaro; sampled the lowermost 100 m	5-00-25.3	-59-37-54.6	Rotenone
HLF14-07	16-Mar-14	Potaro	Area between the first falls and their opposite bank, right by the camp	5-00-40.0	-59-38-21.9	1 Gillnet
HLF14-08	17-Mar-14	Potaro	Potaro River on top of the rapids/falls that end at Base Camp 1	5-00.456	-59-33.664	Seine
HLF14-09	18-Mar-14	Potaro	Isolated pool by the river, about 10 mins walk downstream from Base Camp 1	5-00.593	-59-38,214	Rotenone
HLF14-10	18-Mar-14	Potaro	Small creek tributary to the upper Pota-ro, just downstream of Base Camp 1 on the right bank	5-00-28.1	-59-38-11.5	Rotenone

Table 8.2. **List of 24 collection sites sampled for fishes (*cont'd*)**

Field #	Date	Drainage	Locality	Latitude	Longitude	Sampling method
HLF14-11	18-Mar-14	Potaro	Creek on the right bank of the upper Potaro, just downstream from Base Camp 1	5-00.483	-59-38.191	Rotenone
HLF14-12	20-Mar-14	Potaro	Surroundings of Base Camp 2, up-stream on Potaro channel and in front of camp	5-04-12.4	-59-39-13.3	Hook and line
HLF14-13	20 -21 Mar-14	Potaro	Creek upstream from camp on left bank of the Potaro (~15 min walking)	5-04-12.4	-59-39-13.3	Dipnets/ Rotenone
HLF14-14	21-Mar-14	Potaro	Potaro River at the lower end of the rapids of Base Camp 2 (boat landing, about 10 minutes' walk from camp)	5.06263	59.66042	Seine
HLF14-15	21-Mar-14	Potaro	Creek upstream from Base Camp 2	5-04-16.1	-59-39-13.4	Night seining
HLF14-16	21-Mar-14	Potaro	Creek upstream from Base Camp 2	5-06-28.4	-59-38-08.7	Night seining
HLF14-17	22-Mar-14	Potaro	Creek upstream from Base Camp 2	5-06 30.9	-59-38-8.3	Rotenone

Potaro River rapids at Ayanganna old village.

Results

Collections were obtained from 24 localities in the upper Potaro River drainage (Table 8.2). The expedition produced a total of 1,714 specimens. 653 of these specimens were deposited at the Royal Ontario Museum, Toronto, Ontario, Canada and 1,061 at the Auburn University Museum, Auburn, Alabama, USA. Overall diversity was relatively low, with only 27 species (Table 8.3) belonging to 13 families in five orders. This low fish diversity reflects the isolation of the upper Potaro River drainage, separated from the rich fish diversity of the lowlands by Kaieteur Falls.

For this expedition, we concentrated our efforts on swift flowing rapids, and in doing so limited the range of fish habitats and resultant diversity. We found that the following orders had the largest numbers of individuals in our collections: Characiformes (67% of total number of individuals captured), Perciformes (16%), Siluriformes (10%), Gymnotiformes (6%), and Cyprinodontiformes (1%). At the family level we obtained these results: Characidae 1,016 (59.3%), Cichlidae 283 (16.5%), Loricariidae 77 (4.5%), Hypopomidae 76 (4.4%), Lebiasinidae 66, (3.9%), Erythrinidae 53 (3.1%), Trichomycteridae 42 (2.5%), Gymnotidae 27 (1.6%), Callichthyidae 25 (1.5%), Rivulidae 20 (1.2%), Heptapteridae 22 (1.3%), Crenuchidae 6 (0.4%), and Cetopsidae 1 (0.1%).

Endemic fishes from the upper Potaro River above Kaieteur Falls were first reported and studied by Eigenmann (1909, 1912). We captured many of the endemic species he described but identifications of some species are still tentative. **We suspect that we collected specimens of several species that probably represent species new to science: *Laimosemion* cf. *breviceps*, *Lebiasina* sp., *Gymnotus carapo* group, *Brachyglanis* sp., *Trichomycterus* sp. "long", and *Trichomycterus* sp. "small spots".**

Because of the isolating effect of Kaieteur Falls and the numerous rapids present in the Potaro River, many groups common and abundant in the lowlands were conspicuously absent, such as freshwater stingrays (Potamotrygonidae), the pirai and pacus (Serrasalmidae), freshwater anchovies (Engraulidae – Clupeiformes), freshwater drum and croaker (Sciaenidae – Perciformes), freshwater needlefishes and halfbeaks (Belonidae – Beloniformes), arowanas (Osteoglossidae – Osteoglossiformes), and ghost knifefishes (Gymnotiformes - Apteronotidae) among others.

WE SUSPECT THAT WE COLLECTED SPECIMENS OF SEVERAL SPECIES THAT PROBABLY REPRESENT SPECIES NEW TO SCIENCE: *LAIMOSEMION* CF. *BREVICEPS*, *LEBIASINA* SP., *GYMNOTUS CARAPO* GROUP, *BRACHYGLANIS* SP., *TRICHOMYCTERUS* SP. "LONG", AND *TRICHOMYCTERUS* SP. "SMALL SPOTS"

Table 8.3 **List of species collected during the expedition. Those in bold type are possibly new to science and those marked with an asterisk (*) are endemic to the Potaro River drainage**

Order	Family	Genus	Species
Characiformes	Characidae	*Astyanax*	*bimaculatus*
Characiformes	Characidae	*Bryconops*	*affinis*
Characiformes	Characidae	*Moenkhausia*	*browni*
Characiformes	Characidae	*Moenkhausia*	*oligolepis*
Characiformes	Crenuchidae	*Poecilocharax*	*bovalii****
Characiformes	Erythrinidae	*Erythrinus*	*erythrinus*
Characiformes	Erythrinidae	*Hoplerythrinus*	*unitaeniatus*
Characiformes	Lebiasinidae	***Lebiasina***	**sp.**
Characiformes	Lebiasinidae	*Pyrrhulina*	*stoli*
Cyprinodontiformes	Rivulidae	*Anablepsoides*	*waimacui*
Cyprinodontiformes	Rivulidae	***Laimosemion***	**cf. *breviceps***
Gymnotiformes	Gymnotidae	***Gymnotus***	***carapo* group**
Gymnotiformes	Hypopomidae	*Hypopomus*	*artedi*
Perciformes	Cichlidae	*Crenicichla*	*alta*
Perciformes	Cichlidae	*Krobia*	*potaroensis*
Perciformes	Cichlidae	*Nannacara*	*bimaculata**
Siluriformes	Callichthyidae	*Callichthys*	*callichthys*
Siluriformes	Cetopsidae	*Helogenes*	*marmoratus*
Siluriformes	Heptapteridae	***Brachyglanis***	**sp.**
Siluriformes	Heptapteridae	*Chasmocranus*	*longior*
Siluriformes	Heptapteridae	*Rhamdia*	sp.
Siluriformes	Loricariidae	*Corymbophanes*	*kaiei**
Siluriformes	Loricariidae	*Hypostomus*	*hemiurus*
Siluriformes	Loricariidae	*Lithogenes*	*villosus**
Siluriformes	Trichomycteridae	*Trichomycterus*	*guianense*
Siluriformes	Trichomycteridae	***Trichomycterus***	**sp. "long"**
Siluriformes	Trichomycteridae	***Trichomycterus***	**sp. "small spots"**

250 tissue samples were also obtained from most of the species captured (Table 8.3). These specimens and tissue samples have been transported to the ichthyological collections at the Royal Ontario Museum in Toronto Canada and the Auburn University Museum Fish Collection, in Auburn, Alabama. There, analysis by experts specializing in the systematics and evolutionary history of particular groups of interest has already begun. Several specimens have been tentatively identified as possibly new species and local endemics. Holotypes and paratypes of these specimens will be stored in the Centre for the Study of Biological Diversity (CSBD) at the University of Guyana once these new specimens are examined and described. Representatives of all species will be returned to the CSBD upon request.

Discussion

This expedition produced a total of 27 species from 24 sites. Fish diversity was low, and the number of specimens collected was also relatively low, a reflection of our concentration of fishing efforts in rapids habitats; of the low diversity inherent in upland streams isolated by waterfalls and rapids; and sampling difficulty caused by high water levels. **However, most of the sites sampled are new locality records, never before sampled by ichthyologists, and as such serve as important documentation of the fish diversity of Guyana.**

Besides the possibly new species collected, **tissue samples of *Lithogenes villosus* are of crucial importance to the understanding of the phylogeny of the family Loricariidae.** Specimens obtained are already being studied by Dr Nathan Lujan (Royal Ontario Museum, University of Mississippi), who has recently produced a new phylogenetic tree for the family Loricariidae based on DNA sequence characters (Lujan et. al. 2015). **The enigmatic *Lithogenes villosus* can be considered as a sort of "missing link" between Loricariidae and Astroblepidae and as absent from most of the molecular genetics studies of this family.**

MOST OF THE SITES SAMPLED ARE NEW LOCALITY RECORDS, NEVER BEFORE SAMPLED BY ICHTHYOLOGISTS, AND AS SUCH SERVE AS IMPORTANT DOCUMENTATION OF THE FISH DIVERSITY OF GUYANA

Figure 8.1 ***Lithogenes villosus*, a loricariid catfish found in rapids.**

Another interesting find are the specimens of an almost completely black killifish, which we have identified here as *Laimosemion* (formerly *Rivulus*) cf. *breviceps*. Although *L. breviceps* was described from near Kaieteur Falls, the population discovered in forest streams near Ayanganna old village differ in pigmentation. Only careful morphometric and molecular genetic analysis can determine if they represent a population of that species, or a completely new species.

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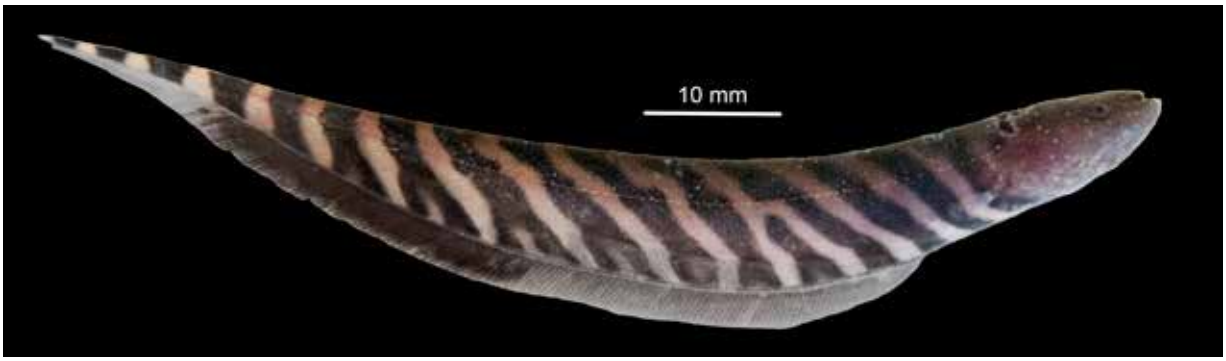
***Laimosemion* cf. *breviceps*, a killifish found in blackwater, slow-moving forest streams, and pools.**

According to Dr Nathan Lovejoy, (Research Associate, Ichthyology Dept., ROM), specimens of the striped knifefish, *Gymnotus carapo* collected in the Potaro River are closely related to similar fishes in the Mazaruni River drainage, and considerably distinct from lowland populations of *G. carapo*.



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***Gymnotus carapo* group, a gymnotid knifefish.**

One of the more unusual finds of this survey was *Trichomycterus* sp. "long". Unlike most *Trichomycterus* that are found in high velocity rapids over rocky substrates, this species was collected in a slow-moving, blackwater forest stream. It is almost surely new to science.

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***Trichomycterus* sp. "long" from Porcupine Creek near Ayanganna old village, almost surely new to science.**

The whole specimens preserved in alcohol as well as the tissue samples of all the species collected will permit taxonomic comparison to determine their status, and are a further contribution to our efforts to document the freshwater fish diversity of Guyana.

***Trichomycterus* sp. "small spots"**

Nannacara bimaculata

Poecilocharax bovalii

From the top: *Trichomycterus* sp. "small spots" is likely new to science; *Nannacara bimaculata and *Poecilocharax bovalii* are two of the species endemic to the Potaro River drainage.**

Conservation recommendations

Our impression of the fish faunas of the creeks and river habitats visited in the upper Potaro River is that they are very well conserved, and nearly in pristine condition. There are currently very few human activities in the regions visited (but gold and diamond mining is present), fishing pressure is low, and contamination levels are presumably also low. Our preliminary recommendations are listed below:

1. Gold and diamond mining activities are not compatible with clean water and healthy fish communities in freshwater habitats. Mining must be better monitored, and prohibition strictly enforced in the Kaieteur National Park.

2. As the incidence of gold mining activities increases in the Potaro, local inhabitants and their principal food fishes should be monitored for the accumulation of mercury in their bodies.

3. In rivers impacted by mining the following mitigation measures should be required and enforced for companies causing the alterations:

(i) While mining is still occurring:
   (a) tailings and other sediments from mining operations should be contained in sediment catchment ponds rather than discharged into the river to avoid the excessive sedimentation downstream that destroys benthic aquatic communities
   (b) fuel, oil and other lubricants for machinery should not be allowed to enter the river.

(ii) After mining is completed:
   (a) restoration of original river channel configuration
   (b) returning lands within 300 m along either side of the river channel to their original contours to facilitate regeneration of riparian forests
   (c) reforestation of natural riverbank vegetation with native species.

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CHAPTER 9
ANTS

Michael G. Branstetter and Leeanne E. Alonso

Abstract

This ant survey represents one of the very few conducted on this taxon in Guyana, and is as well the first for the upper Potaro River, including Kaieteur National Park. Although the total for the species found still needs to be tallied, all observations reported here constitute new range records for genera, as the closest previous survey to our study area was done above 1000 m on Mt Ayanganna. The interim results thus far show that in total, 60 different ant genera from 10 subfamilies were collected, with *Pheidole, Crematogaster, Solenopsis,* and *Camponotus* being the most commonly collected genera. All sites had a high abundance and diversity of ants and all were very similar in habitat. Kaieteur Falls is the main exception, as it harboured distinctive savannah ant fauna that will likely prove to be different from the forest fauna in terms of species composition. The presence of a diversity of predatory and arboreal species indicates that the habitats are relatively intact. However, **one of the largest potential threats to where we sampled is the mining of gold and diamonds.**

THIS ANT SURVEY REPRESENTS ONE OF THE VERY FEW CONDUCTED ON THIS TAXON IN GUYANA, AND IS AS WELL THE FIRST FOR THE UPPER POTARO RIVER, INCLUDING KAIETEUR NATIONAL PARK

Introduction

The ants (Insecta: Hymenoptera: Formicidae) comprise the largest and most successful group of social organisms on Earth. They include over 13,000 described species (Bolton 2014) and are found in nearly all terrestrial ecosystems. Where they occur, ants frequently have a disproportionately high biomass and they are often dominant as predators, scavengers, and indirect herbivores (Hölldobler and Wilson 1990). Ants have also been shown to be ecologically important in seed dispersal, decomposition, and soil turnover. Because of their diversity, abundance, ease of sampling, and sensitivity to habitat disturbance (ants make an ideal arthropod group for biomonitoring programmes (Agosti 2000). **Including ants in conservation studies provides a much needed balance to what is most often a vertebrate-centric endeavour.**

As with most insects, the ant fauna of Guyana, and the Guyana Shield in general, is extremely diverse yet poorly studied. Previous surveys have found approximately 450 ant species in Guyana and suggest that hundreds more remain to be discovered (Kempf 1972; Fernández and Sendoya 2004; LaPolla et al. 2007). Over the last several years, there have been several survey efforts in which quantitative leaf litter sampling of ants was the primary collection method. This approach is powerful in that it is repeatable and can be used to compare ant diversity from multiple sites. One such study by LaPolla et al. (2007) focused on leaf litter ants in wet forest, sampling a total of 150 litter samples from eight sites. They reported a total of 230 litter ant species from 44 genera, providing a baseline dataset from which to compare leaf litter ant diversity at other sites in Guyana. More recently, a similar survey to the one reported here, was carried out in the savannah of the southern Rupununi (Helms and Alonso 2016 in Biodiversity Assessment Survey of the South Rupununi Savannah, Guyana. *BAT Survey Report No. 1*). The current study will extend this work by providing leaf litter ant data from Kaieteur Falls and two nearby sites.

Methods and study sites

Methods

Over the approximately three-week field expedition, we sampled ants using the following collection methods: leaf litter sampling (miniWinkler transects, and maxiWinkler samples), baiting, Malaise trap, light trap, and hand collecting. A brief description of each sampling method is described below.

MiniWinkler Transect: This is a quantitative method used to measure ant diversity in the leaf litter microenvironment. It is repeatable and can be used to compare ant diversity among sites. We employed a slightly modified version of the Ants of the Leaf Litter (ALL) protocol (Agosti et al. 2000). For each transect, we used a compass and tape measure to mark a straight-line transect of up to 195 m (40 samples). Samples were taken at 5 m intervals along the transect, each 1 m to the right of the line. For each sample we lightly chopped and sifted 1 m^2 of leaf litter. After collection, each litter sample was brought back to camp and hung in a miniWinkler extraction bag for two to three days. Falling arthropods were collected into bags containing 95% ethanol.

MaxiWinkler Samples: This is a subjective, non-quantitative way to sample leaf litter ants. In general, a site was chosen and leaf litter was sifted for one to two hours from anywhere within a 10-20 m radius of the GPS point. We tried to maximize species capture by collecting leaf litter from as many different microhabitats as possible, e.g. at the base of trees, in open areas, in treefall gaps, at the base of logs, etc. After collection, samples were brought back to camp and hung in maxiWinkler extraction bags for one to three days.

Baiting: We set up baiting transects by laying out 20, white 3x5 cards, each spaced at 5 m intervals along the edge of trails. We then scattered crumbs of Pecan Sandies cookie bait on top of each card and in nearby soil. The cards were monitored for a period of two hours with all ant species from each card collected into separate vials.

Malaise Trap: These traps are designed to catch flying insects by creating a barrier to their flight path. This method is useful for collecting winged, reproductive ants, as well as arboreal ants that fall out of trees and then climb up into the trap. Several traps were erected along trail and forest margins and on ridge tops.

Light Trap: At most sites either an incandescent light or a black light was turned on at camp at night. These lights were haphazardly monitored and any interesting looking ants that were attracted to the light were hand collected into vials.

Hand Collecting: This method simply involves searching for ants in the environment. We searched a variety of habitats including rotting logs, under leaves, in specialized ant plants, in living wood, under bark, in the ground, in mud banks, and in rotting and live sticks. Stray ants, complete ant colonies, and partial ant colonies were collected into vials of 95% ethanol.

Study Sites

We visited three geographically separated sites, all on the upper Potaro River between Kaieteur Falls and Mt Ayanganna.

Site 1, nicknamed "Bay Camp", was located on the Potaro River about 8 km WNW from the Patamona village of Chenapau (5.01200° N, 59.64398° W). Camp was set at the river margin at the base of the Makaduik rapids. Collections were made at roughly 450-650 m elevation in pristine premontane rainforest over a 10-day period. At this site we made 328 separate collection events of which 80 were miniWinkler samples, 15 were maxiWinkler samples, 185 were hand collections, 40 were bait samples, 2 were Malaise trap collections, and 6 were light trap samples.

Site 2 was located further up the Potaro River at the "new" Ayanganna airstrip (5.30131° N, 59.83319° W), which is also the site of an abandoned diamond mining camp called Black Water Creek. This site is often used as the base for expeditions up to Mt Ayanganna. Collections were made mainly in pristine premontane rainforest from 650-750 m elevation over a four-day period. At this site we made 81 separate collection events of which 8 were maxiWinkler samples, 32 were hand collections, 40 were bait samples, and 1 was a Malaise trap collection.

Site 3 was located on the Potaro River at the top of Kaieteur Falls (5.17522° N, 59.48272° W). Habitats around the falls varied from riparian wet forest to shrubby, white-sand savannah. Collections were made at 400-460 m elevation. At this site we made 133 separate collection events of which 40 were miniWinkler samples, 3 were maxiWinkler samples, 58 were hand collections, 40 were bait samples, and 1 was a Malaise trap collection.

Results and Discussion

Ant Diversity

At the time of the writing of this report, species identifications were still in the process of being taxonomically finalized. Consequently, we describe our results at the generic level. In total we made 542 separate ant collections of which 120 were miniWinkler samples, 26 were maxiWinkler samples, 275 were hand collections, 120 were baiting samples, 4 were Malaise trap samples, and 6 were light trap collections. In total, we collected 60 different ant genera from 10 subfamilies (Table 9.1), with *Pheidole, Crematogaster, Solenopsis,* and *Camponotus* being the most commonly collected genera (Figure 9.1). Among sites, we collected the highest generic diversity from Site 1 (58 genera), followed by Site 2 (44 genera) and Site 3 (36 genera). It is notable that a greater diversity of ants was collected from Site 2 as compared to Site 3, given that more time was spent collecting at Site 3. The disparity is likely due to the fact that Site 2 was located at a higher elevation, in between what might be considered lowland and montane ant faunas. Comparing leaf-litter sampling to other collecting methods (mainly baiting and general hand collecting), we collected 46 genera from leaf-litter samples and 48 genera from other methods. Twelve genera were unique to leaf-litter samples (*Acanthognathus, Acropyga, Carebara, Cerapachys, Discothyrea, Linepithema, Ochetomyrmex, Octostruma, Pseudoponera, Rasopone, Stigmatomma,* and *Tranopelta*), and 14 genera were unique to other methods (*Allomerus, Atta, Cephalotes, Cryptopone, Daceton, Dorymyrmex, Gigantiops, Nomamyrmex, Paraponera, Paratrechina, Platythyrea, Procryptocerus, Pseudomyrmex,* and *Rogeria*). While the total number of ant species still needs to be tallied, **all sites had a high abundance and diversity of ants and all were very similar in habitat. The main exception is Kaieteur Falls, which had a distinctive savannah ant fauna that will likely prove to be different from the forest faunas at the other two sites in terms of species composition.**

ALL SITES HAD A HIGH ABUNDANCE AND DIVERSITY OF ANTS AND ALL WERE VERY SIMILAR IN HABITAT. THE MAIN EXCEPTION IS KAIETEUR FALLS, WHICH HAD A DISTINCTIVE SAVANNAH ANT FAUNA THAT WILL LIKELY PROVE TO BE DIFFERENT FROM THE FOREST FAUNAS AT THE OTHER TWO SITES IN TERMS OF SPECIES COMPOSITION.

Table 9.1 **Complete list of ant genera and the sites where each genus was collected**

Subfamily	Genus	Upper Potaro	Ayanganna Airstrip	Kaieteur Falls
Amblyoponinae	*Cerapachys*		X	
	Prionopelta	X	X	
	Stigmatomma	X		X
Dolichoderinae	*Azteca*	X	X	X
	Dolichoderus	X	X	X
	Dorymyrmex		X	
	Linepithema		X	
Dorylinae	*Nomamyrmex*	X		
	Eciton	X	X	X
	Labidus	X	X	
	Neivamyrmex	X		X
Ectatomminae	*Ectatomma*	X	X	X
Formicinae	*Acropyga*	X		X
	Brachymyrmex	X	X	X
	Camponotus	X	X	X
	Gigantiops	X	X	X
	Myrmelachista	X	X	
	Nylanderia	X	X	X
	Paratrechina			
Myrmicinae	*Acanthognathus*	X		
	Acromyrmex	X	X	X
	Allomerus	X		
	Apterostigma	X	X	X
	Atta	X		
	Basiceros	X	X	X
	Carebara	X	X	X
	Cephalotes	X		X
	Crematogaster	X	X	X
	Cyphomyrmex	X	X	X
	Daceton	X		X

Table 9.1 **Complete list of ant genera and the sites where each genus was collected (*cont'd*)**

Subfamily	Genus	Upper Potaro	Ayanganna Airstrip	Kaieteur Falls
Myrmicinae cont'd	*Hylomyrma*	X	X	X
	Megalomyrmex	X	X	X
	Monomorium		X	X
	Myrmicocrypta	X	X	
	Ochetomyrmex	X		
	Octostruma	X	X	X
	Pheidole	X	X	X
	Procryptocerus	X		
	Rogeria	X		
	Sericomyrmex	X	X	
	Solenopsis	X	X	X
	Strumigenys	X	X	X
	Trachymyrmex	X	X	X
	Tranopelta	X		
	Wasmannia	X	X	X
Paraponerinae	*Paraponera*	X	X	
Ponerinae	*Anochetus*	X	X	X
	Cryptopone	X		
	Gnamptogenys	X	X	X
	Hypoponera	X	X	X
	Leptogenys	X	X	
	Mayaponera	X	X	X
	Neoponera	X	X	X
	Odontomachus	X	X	X
	Pachycondyla	X	X	X
	Platythyrea	X		
	Pseudoponera		X	
	Rasopone	X	X	
Proceratiinae	*Discothyrea*	X	X	
Pseudomyrmecinae	*Pseudomyrmex*	X	X	X

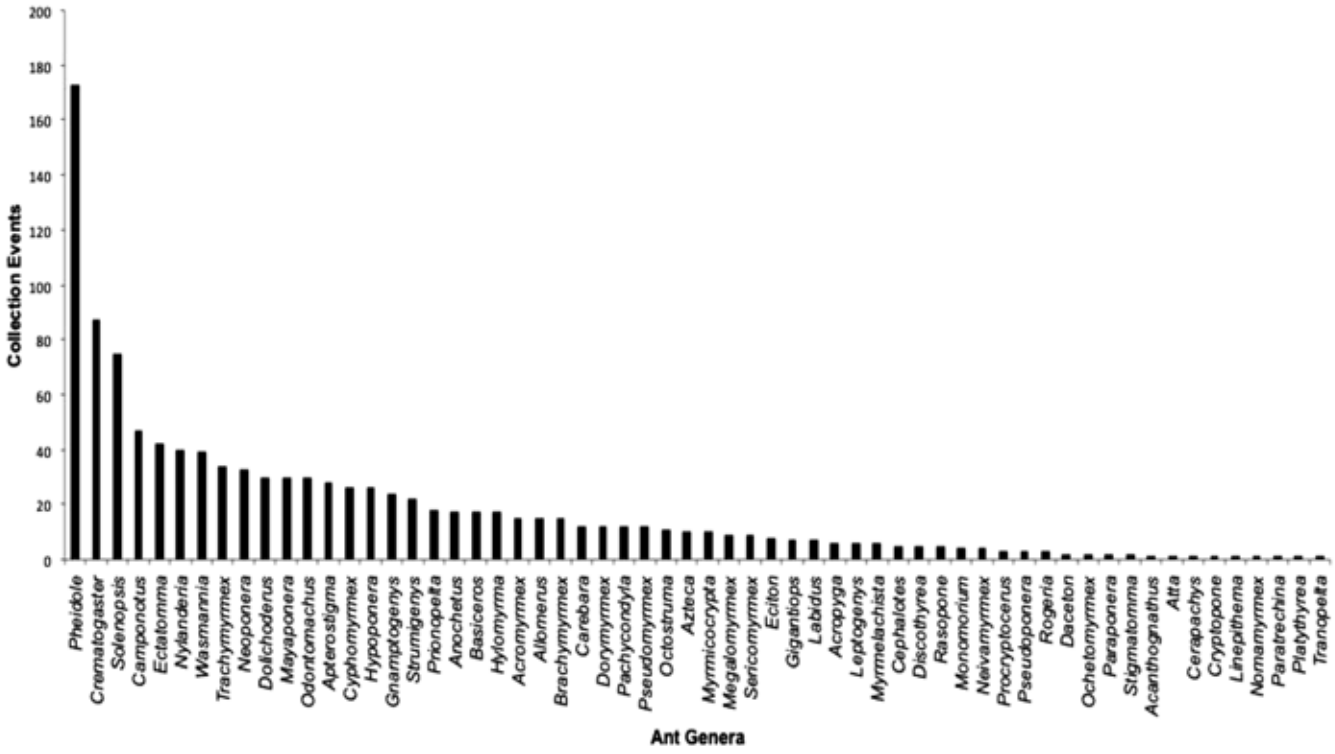

Figure 9.1 **Relative abundance of ant genera as measured by the number of events from which a particular genus was collected. Collection events include leaf-litter sampling, baiting, Malaise trapping, and general hand collecting. A total of 60 different ant genera were collected during the expedition.**

Interesting species

This is one of very few ant surveys conducted in Guyana, and the first for the upper Potaro River, including Kaieteur National Park. The closest previous survey to our study area was done above 1000 m on Mt Ayanganna. Thus, **all observations reported here are new range records for genera.** In addition, **this work will provide an important data point for comparing differences in ant diversity along elevational gradients in Guyana.**

We found an abundance of predatory army ants (Dorylinae) at each site, represented by the genera *Eciton, Labidus, Neivamyrmex,* and *Nomamyrmex*. Army ants play an important role as top predators in these ecosystems, and their nomadic hunting lifestyle and massive colonies require large territories. The presence of several species indicates large blocks of intact habitat, as well as the presence of adequate prey species.

The presence of many arboreal (e.g. *Camponotus* spp., *Cephalotes* spp., *Daceton armigerum*, *Pseudomyrmex* spp.), leaf litter (e.g. *Apterostigma* spp., *Cyphomyrmex* spp., *Strumigenys* spp., *Trachymyrmex* spp.), and specialized predatory (*Hypoponera* spp., *Leptogenys* spp., *Odontomachus* spp., *Pachycondyla* spp.) species is typical of healthy diverse forests. Likewise, the bullet ant (*Paraponera clavata*), which we collected at the Bay Camp and Ayanganna sites, generally nests at the base of large trees and requires fairly large blocks of intact rainforest.

We collected many ants living in specialized ant plants. Among the ant plants we found (*Cordia nodosa*, *Cecropia* sp., *Tachigali* sp., *Maieta guianensis*, and *Tococa guianensis*), we collected ants such as *Allomerus* sp., *Azteca* spp., *Crematogaster* spp., *Pheidole* sp. and *Pseudomyrmex* spp., indicating intact ant-plant symbioses.

ALL OBSERVATIONS REPORTED HERE ARE NEW RANGE RECORDS FOR GENERA

Conservation recommendations

Further sampling of the Potaro plateau will reveal many more species than we found in our three-week survey. Likewise, our sampling focused primarily on litter and ground-dwelling ant species. **Future work should utilize methods that capture a larger proportion of canopy-dwelling and subterranean ant species.**

Tropical rainforests are extremely diverse in ant species, with forests similar to the ones sampled here containing over 500 species. To exhaustively sample this diversity would take years of dedicated work; however, by focusing on the leaf litter, we will be able to quickly characterize one of the most diverse microhabitats for ants. In addition, by sampling in a quantitative way, we provide a baseline dataset that can be used to compare either different sites in Guyana or the same sites, but at different time points. This is especially important as the environment changes in response to climate change or human disturbance. **One of the largest potential threats to where we sampled is the mining of gold and diamonds. If mining affects these sites in the future, our methods could be repeated as a way of assessing the impact of mining on leaf litter ants.**

Acknowledgments

We thank everyone from the Patamona village of Chenapau and the Kaieteur National Park, for assistance and permission to work on their land. We are also grateful to Regis Edwards, Lloyd Peters, Rupert Williams, Shari Salisbury, Nelanie La Cruz, Thomas Williams, and Maxwell Basil for assisting us with collecting ants in the field.

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Appendix 1

Complete list of specimens collected during the WWF-Guianas BAT 2 survey in 2014 of the Potaro plateau with determination and locality data

New species are indicated in bold.

Collection Number	Family	Scientific Name	Locality	Elevation (m)	Latitude	Longitude
2412			Potaro River, left margin, boat landing on third set of rapids above Chenapau	550	5.06303	-59.6602
2448			Potaro River, left bank, landing below third set of rapids above Chenapau	550	5.06303	-59.6602
2450			Potaro River, left bank, landing below third set of rapids above Chenapau	550	5.06303	-59.6602
2451			Potaro River, left bank, landing below third set of rapids above Chenapau	550	5.06303	-59.6602
2562			Kaieteur National Park, upper Murimuri basin, near divide with Kuribrong basin	525	5.28172	-59.5236
2360	Acanthaceae	*Justicia*	Potaro River, along river margin between second and third sets of rapids above Chenapau, around mouth of Kopinang Creek	530	5.02428	-59.6581
2410	Apocynaceae	*Cynanchum mirifolium*	Potaro River, left margin, boat landing on third set of rapids above Chenapau	550	5.06303	-59.6602
2496	Apocynaceae	*Mandevilla benthamii* (A.DC.) K.Schum.	Kaieteur National Park, upper Murimuri basin	500	5.26767	-59.5139
2369	Apocynaceae	*Matelea stenopetala*	Potaro River, along river margin between second and third sets of rapids above Chenapau, around mouth of Kopinang Creek	530	5.02428	-59.6581
2473	Apocynaceae	*Tabernaemontana undulata* Vahl	Kaieteur National Park, upper Murimuri basin, moist forest	490	5.27519	-59.516
2385	Aquifoliaceae	*Ilex*	Potaro River, landing above second set of rapids above Chenapau	530	5.02428	-59.6581
2352	Araceae		Potaro River, left bank, on third set of rapids above Chenapau	570	5.06725	-59.6553
2393	Araceae		Potaro River, trail along left bank, above third set of rapids above Chenapau	625	5.07197	-59.651
2523	Araceae		Kaieteur National Park, upper Murimuri basin	500	5.26767	-59.5139
2539	Araceae		Kaieteur National Park, upper Murimuri basin, near divide with Kuribrong basin	525	5.27406	-59.5246
2540	Araceae	*Anthurium giganteu*m Matuda	Kaieteur National Park, upper Murimuri basin, near divide with Kuribrong basin	525	5.27406	-59.5246
2538	Arecaceae	*Bactris hirta* var. *jemanii* A. J. Hend.	Kaieteur National Park, upper Murimuri basin, near divide with Kuribrong basin	525	5.27406	-59.5246
2314	Asteraceae		Potaro River, left margin above second set of rapids above Chenapau	490	5.01397	-59.6509
2340	Asteraceae		Potaro River, left margin, right below second set of rapids above Chenapau	430	5.00681	-59.6347

Complete list of specimens collected during the WWF-Guianas BAT 2 survey in 2014 of the Potaro plateau with determination and locality data (*cont'd*)

New species are indicated in bold.

Collection Number	Family	Scientific Name	Locality	Elevation (m)	Latitude	Longitude
2377	Asteraceae	*Clibadium surinamense*	Potaro River, landing above second set of rapids above Chenapau	520	5.01397	-59.6509
2299	Bignoniaceae	*Schlegelia spruceana* Bureau & K.Schum.	Potaro River, left margin on portage trail on second set of rapids above Chenapau	490	5.01275	-59.6501
2563	Bignoniaceae	*Schlegelia spruceana* Bureau & K.Schum.	Kaieteur National Park, upper Murimuri basin, near divide with Kuribrong basin	525	5.28172	-59.5236
2409	Bignoniaceae	*Schlegelia violacea* (Aubl.) Griseb.	Potaro River, left margin, boat landing on third set of rapids above Chenapau	550	5.06303	-59.6602
2356	Bignoniaceae	*Tabebuia*	Potaro River, along river margin between second and third sets of rapids above Chenapau, around mouth of Kopinang Creek	530	5.02428	-59.6581
2568	Bignoniaceae	*Tabebuia*	Kaieteur National Park, upper Murimuri basin, savannah on trail to Menzies Landing	465	5.24656	-59.5173
2511	Boraginaceae	*Cordia trachyphylla* Mart.	Kaieteur National Park, upper Murimuri basin	500	5.26767	-59.5139
2535	Bromeliaceae	*Aechmea brassicoides* Baker	Kaieteur National Park, upper Murimuri basin	500	5.26767	-59.5139
2534	Bromeliaceae	*Aechmea pallida* L.B.Sm.	Kaieteur National Park, upper Murimuri basin	500	5.26767	-59.5139
2547	Bromeliaceae	*Brocchinia cataractarum* (Sandwith) B.Holst	Kaieteur National Park, upper Murimuri basin, near divide with Kuribrong basin	490	5.27519	-59.516
2605	Bromeliaceae	*Brocchinia reducta* Baker	Kaieteur National Park, rock outcrops and savannah near northern end of airstrip	440	5.17725	-59.4869
2533	Bromeliaceae	*Catopsis berteroniana* (Schult.f.) Mez	Kaieteur National Park, upper Murimuri basin	500	5.26767	-59.5139
2349	Bromeliaceae	*Guzmania lingulata* (L.) Mez	Potaro River, left bank, on third set of rapids above Chenapau	570	5.06725	-59.6553
2560	Bromeliaceae	*Guzmania pleiosticha* (Griseb.) Mez	Kaieteur National Park, upper Murimuri basin, near divide with Kuribrong basin	500	5.26767	-59.5139
2561	Bromeliaceae	*Navia gleasonii* L.B.Sm.	Kaieteur National Park, upper Murimuri basin, near divide with Kuribrong basin	525	5.28172	-59.5236
2548	Bromeliaceae	*Racinaea spiculosa* (Griseb.) M.A.Spencer & L.B.Sm.	Kaieteur National Park, upper Murimuri basin, near divide with Kuribrong basin	515	5.27572	-59.526
2485	Burmanniaceae		Kaieteur National Park, upper Murimuri basin, moist forest	480	5.27211	-59.5148
2413	Campanulaceae	*Centropogon*	Potaro River, left margin, boat landing on third set of rapids above Chenapau	550	5.06303	-59.6602
2332	Chrysobalanaceae	*Hirtella*	Potaro River, on small creek on the right margin immediately below second set of rapids above Chenapau	430	5.00681	-59.6347
2573	Chrysobalanaceae	*Licania*	Kaieteur National Park, upper Murimuri basin, savannah on trail to Menzies Landing	465	5.24656	-59.5173

Collection Number	Family	Scientific Name	Locality	Elevation (m)	Latitude	Longitude
2341	Clusiaceae		Potaro River, left margin, right below second set of rapids above Chenapau	430	5.00681	-59.6347
2558	Clusiaceae	*Clusia*	Kaieteur National Park, upper Murimuri basin, near divide with Kuribrong basin	515	5.27572	-59.526
2536	Clusiaceae	*Clusia grandiflora* Splitg.	Kaieteur National Park, upper Murimuri basin	500	5.26767	-59.5139
2421	Clusiaceae	*Clusia panapanari* (Aubl.) Choisy	Potaro River, right bank 200-500 m downstream from fourth set of rapids above Chenapau	570	5.10831	-59.6372
2505	Clusiaceae	*Clusia scrobiculata* Benoist	Kaieteur National Park, upper Murimuri basin	500	5.26767	-59.5139
2481	Clusiaceae	*Vismia laxiflor*a Reichardt	Kaieteur National Park, upper Murimuri basin, moist forest	480	5.27264	-59.5136
2297	Cucurbitaceae	*Psiguria triphylla* (Miq.) C.Jeffrey	Potaro River, left margin on portage trail on second set of rapids above Chenapau	430	5.01114	-59.6395
2437	Cyperaceae	*Becquerelia cymosa* Brongn.	Potaro River, right bank 200-500 m downstream from fourth set of rapids above Chenapau	570	5.10831	-59.6372
2472	Cyperaceae	*Calyptrocarya glomerulata* (Brongn.) Urb.	Kaieteur National Park, upper Murimuri basin, moist forest	490	5.27519	-59.516
2350	Cyperaceae	*Calyptrocarya poeppigiana* Kunth	Potaro River, left bank, on third set of rapids above Chenapau	570	5.06725	-59.6553
2397	Cyperaceae	*Calyptrocarya poeppigiana* Kunth	Potaro River, trail along left bank, above third set of rapids above Chenapau	625	5.07197	-59.651
2343	Cyperaceae	*Eleocharis*	Potaro River, left margin, right below second set of rapids above Chenapau	430	5.00681	-59.6347
2390	Cyperaceae	*Hypolytrum paraense* M.Alves & W.W.Thomas	Potaro River, trail along left bank, above third set of rapids above Chenapau	625	5.07197	-59.651
2427	Cyperaceae	*Mapania imeriensis* (R.Gross)T.Koyama	Potaro River, right bank 200-500 m downstream from fourth set of rapids above Chenapau	570	5.10831	-59.6372
2474	Cyperaceae	*Mapania imeriensis* (R.Gross) T.Koyama	Kaieteur National Park, upper Murimuri basin, moist forest	490	5.27519	-59.516
2327	Cyperaceae	*Mapania tepuiana* (Steyerm.) T.Koyama	Potaro River, on small creek on the right margin immediately below second set of rapids above Chenapau	430	5.00681	-59.6347
2403	Cyperaceae	*Rhynchospora*	Potaro River, trail along left bank, above third set of rapids above Chenapau	650	5.07406	-59.6488
2382	Cyperaceae	*Rhynchospora cephalotes* (L.) Vahl	Potaro River, landing above second set of rapids above Chenapau	530	5.02428	-59.6581
2392	Cyperaceae	*Scleria latifolia* Sw.	Potaro River, trail along left bank, above third set of rapids above Chenapau	625	5.07197	-59.651

Complete list of specimens collected during the WWF-Guianas BAT 2 survey in 2014 of the Potaro plateau with determination and locality data (*cont'd*)

New species are indicated in bold.

Collection Number	Family	Scientific Name	Locality	Elevation (m)	Latitude	Longitude
2567	Cyrillaceae	*Cyrilla racemiflora* L.	Kaieteur National Park, upper Murimuri basin, savannah on trail to Menzies Landing	480	5.25756	-59.5112
2508	Dilleniaceae		Kaieteur National Park, upper Murimuri basin	500	5.26767	-59.5139
2503	Dilleniaceae	*Davilla*	Kaieteur National Park, upper Murimuri basin	500	5.26767	-59.5139
2492	Droseraceae	*Drosera*	Kaieteur National Park, upper Murimuri basin	500	5.26767	-59.5139
2358	Ericaceae		Potaro River, along river margin between second and third sets of rapids above Chenapau, around mouth of Kopinang Creek	530	5.02428	-59.6581
2374	Ericaceae		Potaro River, along river margin between second and third sets of rapids above Chenapau, around mouth of Kopinang Creek	530	5.02428	-59.6581
2422	Ericaceae		Potaro River, right bank 200-500 m downstream from fourth set of rapids above Chenapau	570	5.10831	-59.6372
2430	Ericaceae	Ericaceae	Potaro River, right bank 200-500 m downstream from fourth set of rapids above Chenapau	570	5.10831	-59.6372
2607	Ericaceae	*Notopora schomburgkii* Hook.f.	Kaieteur National Park, rocks near top of falls	435	5.17483	-55.4819
2585	Ericaceae	*Thibaudia*	Kaieteur National Park, rocks near top of falls	435	5.17483	-55.4819
2408	Eriocaulaceae		Potaro River, left margin, boat landing on third set of rapids above Chenapau	550	5.06303	-59.6602
2411	Eriocaulaceae		Potaro River, left margin, boat landing on third set of rapids above Chenapau	550	5.06303	-59.6602
2471	Eriocaulaceae		Kaieteur National Park, upper Murimuri basin, moist forest	490	5.27519	-59.516
2608	Eriocaulaceae	*Rondonanthus capillaceus* (Klotzsch) Hensold & Giul.	Kuribrong River			
2379	Erythroxylaceae	*Erythroxylum*	Potaro River, landing above second set of rapids above Chenapau	530	5.02428	-59.6581
2484	Erythroxylaceae	*Erythroxylum*	Kaieteur National Park, upper Murimuri basin, moist forest	480	5.27211	-59.5148
2424	Euphorbiaceae	*Chaetocarpus* cf. *schomburgkianus*	Potaro River, right bank 200-500 m downstream from fourth set of rapids above Chenapau	570	5.10831	-59.6372
2478	Euphorbiaceae	*Mabea*	Kaieteur National Park, upper Murimuri basin, moist forest	480	5.27264	-59.5136
2577	Euphorbiaceae	*Mabea*	Kaieteur National Park, Murimuri Creek on first set of small falls above mouth into the Potaro River	455	5.18719	-59.5124

Collection Number	Family	Scientific Name	Locality	Elevation (m)	Latitude	Longitude
2517	Euphorbiaceae	*Phyllanthus myrsinites* Kunth	Kaieteur National Park, upper Murimuri basin	500	5.26767	-59.5139
2514	Euphorbiaceae	*Phyllanthus vacciniifolius* Müll.Arg.	Kaieteur National Park, upper Murimuri basin	500	5.26767	-59.5139
2529	Fabaceae		Kaieteur National Park, upper Murimuri basin	500	5.26767	-59.5139
2366	Fabaceae	*Abarema jupunba* var. *trapezifolia* (Vahl) Barneby and J.W. Grimes	Potaro River, along river margin between second and third sets of rapids above Chenapau, around mouth of Kopinang Creek	530	5.02428	-59.6581
2510	Fabaceae	*Dimorphandra cuprea* Sprague and Sand-with	Kaieteur National Park, upper Murimuri basin	500	5.26767	-59.5139
2372	Fabaceae	*Inga thibaudiana* DC.	Potaro River, along river margin between second and third sets of rapids above Chenapau, around mouth of Kopinang Creek	530	5.02428	-59.6581
2438	Fabaceae	*Macrolobium bifolium* (Aubl.) Pers.	Potaro River, right bank 200-500 m downstream from fourth set of rapids above Chenapau	570	5.10831	-59.6372
2354	Fabaceae	*Pithecellobium*	Potaro River, along river margin between second and third sets of rapids above Chenapau, around mouth of Kopinang Creek	530	5.02428	-59.6581
2506	Fabaceae	*Senna quinquangulata* (Rich.) H.S.Irwin & Barneby	Kaieteur National Park, upper Murimuri basin	500	5.26767	-59.5139
2469	Gentianaceae	*Chelonanthus purpurascens* (Aublet) L. Struwe, S. Nilsson & V. A. Albert	Kaieteur National Park, upper Murimuri basin, moist forest	490	5.27519	-59.516
2552	Gentianaceae	*Voyria* cf. *aphylla*	Kaieteur National Park, upper Murimuri basin, near divide with Kuribrong basin	525	5.28172	-59.5236
2553	Gentianaceae	*Voyria* cf. *aphylla*	Kaieteur National Park, upper Murimuri basin, near divide with Kuribrong basin	525	5.28172	-59.5236
2359	Gesneriaceae	*Codonanthopsis calcarata* (Miq.) Chautems & Mat.Perret	Potaro River, along river margin between second and third sets of rapids above Chenapau, around mouth of Kopinang Creek	530	5.02428	-59.6581
2470	Gesneriaceae	*Lesia savannarum* (C.V.Morton) J.L.Clark & J.F.Sm.	Kaieteur National Park, upper Murimuri basin, moist forest	490	5.27519	-59.516
2333	Gesneriaceae	*Nautilocalyx coccineus* Feuillet & L.E.Skog	Potaro River, on small creek on the right margin immediately below second set of rapids above Chenapau	430	5.00681	-59.6347
2554	Gesneriaceae	*Nautilocalyx cordatus* (Gleason) L.E.Skog	Kaieteur National Park, upper Murimuri basin, near divide with Kuribrong basin	525	5.28172	-59.5236
2335	Gesneriaceae	*Nautilocalyx pictus* (Hook.) Sprague	Potaro River, on small creek on the right margin immediately below second set of rapids above Chenapau	430	5.00681	-59.6347
2324	Gesneriaceae	*Paradrymonia ciliosa* (Mart.) Wiehler	Potaro River, on small creek on the right margin immediately below second set of rapids above Chenapau	490	5.01397	-59.6509

Complete list of specimens collected during the WWF-Guianas BAT 2 survey in 2014 of the Potaro plateau with determination and locality data (*cont'd*)

New species are indicated in bold.

Collection Number	Family	Scientific Name	Locality	Elevation (m)	Latitude	Longitude
2551	Gesneriaceae	*Paradrymonia ciliosa* (Mart.) Wiehler	Kaieteur National Park, upper Murimuri basin, near divide with Kuribrong basin	515	5.27572	-59.526
2479	Heliconiaceae	*Heliconia*	Kaieteur National Park, upper Murimuri basin, moist forest	480	5.27264	-59.5136
2507	Humiriaceae	*Humiria balsamifera* Aubl.	Kaieteur National Park, upper Murimuri basin	500	5.26767	-59.5139
2497	Lamiaceae		Kaieteur National Park, upper Murimuri basin	500	5.26767	-59.5139
2415	Lamiaceae	Lamiaceae	Potaro River, left margin, boat landing on third set of rapids above Chenapau	550	5.06303	-59.6602
2407	Lentibulariaceae	*Utricularia*	Potaro River, left margin, boat landing on third set of rapids above Chenapau	550	5.06303	-59.6602
2515	Lentibulariaceae	*Utricularia*	Kaieteur National Park, upper Murimuri basin	500	5.26767	-59.5139
2571	Lentibulariaceae	*Utricularia*	Kaieteur National Park, upper Murimuri basin, savannah on trail to Menzies Landing	465	5.24656	-59.5173
2491	Lentibulariaceae	*Utricularia humboldtii* R.H.Schomb.	Kaieteur National Park, upper Murimuri basin	500	5.26767	-59.5139
2570	Liliaceae	*Nietneria*	Kaieteur National Park, upper Murimuri basin, savannah on trail to Menzies Landing	465	5.24656	-59.5173
2370	Loganiaceae		Potaro River, along river margin between second and third sets of rapids above Chenapau, around mouth of Kopinang Creek	530	5.02428	-59.6581
2426	Loganiaceae		Potaro River, right bank 200-500 m downstream from fourth set of rapids above Chenapau	570	5.10831	-59.6372
2569	Loranthaceae	*Psittacanthus lasianthus* Sandwith	Kaieteur National Park, upper Murimuri basin, savannah on trail to Menzies Landing	465	5.24656	-59.5173
2361	Malpighiaceae		Potaro River, along river margin between second and third sets of rapids above Chenapau, around mouth of Kopinang Creek	530	5.02428	-59.6581
2362	Malpighiaceae		Potaro River, along river margin between second and third sets of rapids above Chenapau, around mouth of Kopinang Creek	530	5.02428	-59.6581
2504	Malpighiaceae		Kaieteur National Park, upper Murimuri basin	500	5.26767	-59.5139
2543	Malpighiaceae		Kaieteur National Park, upper Murimuri basin, near divide with Kuribrong basin	490	5.27519	-59.516
2325	Malvaceae	*Pachira minor* (Sims) Hemsl.	Potaro River, on small creek on the right margin immediately below second set of rapids above Chenapau	490	5.01397	-59.6509

Collection Number	Family	Scientific Name	Locality	Elevation (m)	Latitude	Longitude
2376	Malvaceae	*Pachira minor* (Sims) Hemsl.	Potaro River, along river margin between second and third sets of rapids above Chenapau, around mouth of Kopinang Creek	530	5.02428	-59.6581
2402	Marantaceae		Potaro River, trail along left bank, above third set of rapids above Chenapau	650	5.07406	-59.6488
2443	Marantaceae		Potaro River, right bank 200-500 m downstream from fourth set of rapids above Chenapau	570	5.10831	-59.6372
2549	Marantaceae		Kaieteur National Park, upper Murimuri basin, near divide with Kuribrong basin	515	5.27572	-59.526
2326	Marcgraviaceae		Potaro River, on small creek on the right margin immediately below second set of rapids above Chenapau	430	5.00681	-59.6347
2419	Marcgraviaceae		Potaro River, right bank 200-500 m downstream from fourth set of rapids above Chenapau	570	5.10831	-59.6372
2449	Mayacaceae		Potaro River, left bank, landing below third set of rapids above Chenapau	550	5.06303	-59.6602
2344	Mayacaceae	*Mayaca longipes* Martius ex Seubert	Potaro River, left margin, right below second set of rapids above Chenapau	430	5.00681	-59.6347
2309	Melastomataceae	*Aciotis indecora* (Bonpl.) Triana	Potaro River, left margin on portage trail on second set of rapids above Chenapau	430	5.01114	-59.6395
2330	Melastomataceae	*Aciotis indecora* (Bonpl.) Triana	Potaro River, on small creek on the right margin immediately below second set of rapids above Chenapau	430	5.00681	-59.6347
2456	Melastomataceae	*Aciotis indecora* (Bonpl.) Triana	Potaro River, left bank, secondary vegetation and trail edges around village of Chenapau	455	4.98242	-59.5784
2467	Melastomataceae	*Aciotis indecora* (Bonpl.) Triana	Kaieteur National Park, upper Murimuri basin, moist forest	490	5.27519	-59.516
2475	Melastomataceae	*Aciotis indecora* (Bonpl.) Triana	Kaieteur National Park, upper Murimuri basin, moist forest	490	5.27519	-59.516
2454	Melastomataceae	*Aciotis purpurascens* (Aubl.) Triana	Potaro River, left bank, secondary vegetation and trail edges around village of Chenapau	455	4.98242	-59.5784
2452	Melastomataceae	*Aciotis rubricaulis* (Mart. ex DC.) Triana	Potaro River, left bank, secondary vegetation and trail edges around village of Chenapau	455	4.98242	-59.5784
2391	Melastomataceae	*Adelobotrys* cf. *adscendens*	Potaro River, trail along left bank, above third set of rapids above Chenapau	625	5.07197	-59.651
2389	Melastomataceae	*Adelobotrys* cf. *monticola* Gleason	Potaro River, trail along left bank, above third set of rapids above Chenapau	625	5.07197	-59.651

Complete list of specimens collected during the WWF-Guianas BAT 2 survey in 2014 of the Potaro plateau with determination and locality data (*cont'd*)

New species are indicated in bold.

Collection Number	Family	Scientific Name	Locality	Elevation (m)	Latitude	Longitude
2311	Melastomataceae	*Adelobotrys permixta* Wurdack	Potaro River, left margin on portage trail on second set of rapids above Chenapau	490	5.01397	-59.6509
2495	Melastomataceae	*Appendicularia thymifolia* (Bonpl.) DC.	Kaieteur National Park, upper Murimuri basin	500	5.26767	-59.5139
2589	Melastomataceae	*Appendicularia thymifolia* (Bonpl.) DC.	Kaieteur National Park, rock outcrops and savannah between northern end of airstrip and falls	440	5.17725	-59.4869
2465	Melastomataceae	*Bellucia pentamera* Naudin	Kaieteur National Park, Menzies Landing, on margin of Potaro River	435	5.16533	-59.4927
2486	**Melastomataceae**	***Boyania* sp. nov.**	**Kaieteur National Park, upper Murimuri basin, moist forest**	**480**	**5.27211**	**-59.5148**
2319	Melastomataceae	*Clidemia*	Potaro River, left margin above second set of rapids above Chenapau	490	5.01397	-59.6509
2501	Melastomataceae	*Clidemia capitata* Benth.	Kaieteur National Park, upper Murimuri basin	500	5.26767	-59.5139
2581	Melastomataceae	*Clidemia capitellata* (Bonpl.) D.Don	Kaieteur National Park, trail from Menzies Landing to airstrip	435	5.16953	-59.4911
2351	Melastomataceae	*Clidemia charadrophylla* Tutin	Potaro River, left bank, on third set of rapids above Chenapau	570	5.06725	-59.6553
2296	Melastomataceae	*Clidemia conglomerata* DC.	Potaro River, left margin on portage trail on second set of rapids above Chenapau	430	5.01114	-59.6395
2396	Melastomataceae	*Clidemia conglomerata* DC.	Potaro River, trail along left bank, above third set of rapids above Chenapau	625	5.07197	-59.651
2444	Melastomataceae	*Clidemia epibaterium* DC.	Potaro River, right bank 200-500 m downstream from fourth set of rapids above Chenapau	570	5.10831	-59.6372
2490	Melastomataceae	*Clidemia heptamera* Wurdack	Kaieteur National Park, upper Murimuri basin, moist forest	480	5.27211	-59.5148
2386	Melastomataceae	*Clidemia hirta* (L.) D.Don	Potaro River, left bank, immediately above third set of rapids above Chenapau on old homestead site	570	5.06622	-59.6571
2414	Melastomataceae	*Clidemia involucrata* DC.	Potaro River, left margin, boat landing on third set of rapids above Chenapau	550	5.06303	-59.6602
2298	Melastomataceae	*Clidemia minutiflora* (Triana) Cogn.	Potaro River, left margin on portage trail on second set of rapids above Chenapau	430	5.01114	-59.6395
2596	Melastomataceae	*Clidemia minutiflora* (Triana) Cogn.	Kaieteur National Park, trail from Kaieteur Top to Tukeit, steep slopes	430	5.19225	-59.4736
2579	Melastomataceae	*Clidemia novemnervia* (DC.) Triana	Kaieteur National Park, Potaro River, Menzies Landing	435	5.16533	-59.4927
2428	Melastomataceae	*Clidemia ostentata* Wurdack	Potaro River, right bank 200-500 m downstream from fourth set of rapids above Chenapau	570	5.10831	-59.6372

Collection Number	Family	Scientific Name	Locality	Elevation (m)	Latitude	Longitude
2480	Melastomataceae	*Clidemia ostentata* Wurdack	Kaieteur National Park, upper Murimuri basin, moist forest	480	5.27264	-59.5136
2416	Melastomataceae	*Clidemia pustulata* DC.	Potaro River, left margin, boat landing on third set of rapids above Chenapau	550	5.06303	-59.6602
2500	Melastomataceae	*Clidemia pycnaster* Tutin	Kaieteur National Park, upper Murimuri basin	500	5.26767	-59.5139
2315	Melastomataceae	*Clidemia urceolata* DC.	Potaro River, left margin above second set of rapids above Chenapau	490	5.01397	-59.6509
2318	Melastomataceae	*Clidemia urceolata* DC.	Potaro River, left margin above second set of rapids above Chenapau	490	5.01397	-59.6509
2525	Melastomataceae	*Comolia angustifolia* Gleason	Kaieteur National Park, upper Murimuri basin	500	5.26767	-59.5139
2586	Melastomataceae	*Comolia angustifolia* Gleason	Kaieteur National Park, rock outcrops and savannah between northern end of airstrip and falls	440	5.17725	-59.4869
2526	Melastomataceae	*Comolia lythrarioides* Naudin	Kaieteur National Park, upper Murimuri basin	500	5.26767	-59.5139
2588	Melastomataceae	*Comolia lythrarioides* Naudin	Kaieteur National Park, rock outcrops and savannah between northern end of airstrip and falls	440	5.17725	-59.4869
2463	Melastomataceae	*Comolia microphylla* Benth.	Kaieteur National Park, trail from Menzies Landing to airstrip	435	5.16953	-59.4911
2499	Melastomataceae	*Comolia microphylla* Benth.	Kaieteur National Park, upper Murimuri basin	500	5.26767	-59.5139
2460	Melastomataceae	*Comolia vernicosa* (Benth.) Triana	Kaieteur National Park, trail from airstrip to falls	440	5.17725	-59.4869
2462	Melastomataceae	*Comolia villosa* (Aubl.) Triana	Kaieteur National Park, trail from Menzies Landing to airstrip	435	5.16953	-59.4911
2587	Melastomataceae	*Comolia villosa* (Aubl.) Triana	Kaieteur National Park, rock outcrops and savannah between northern end of airstrip and falls	440	5.17725	-59.4869
2584	Melastomataceae	*Graffenrieda irwinii* Wurdack	Kaieteur National Park, rocks near top of falls	435	5.17483	-55.4819
2375	Melastomataceae	*Henriettea maroniensis* Sagot	Potaro River, along river margin between second and third sets of rapids above Chenapau, around mouth of Kopinang Creek	530	5.02428	-59.6581
2320	Melastomataceae	*Henriettea multiflora* Naudin	Potaro River, left margin above second set of rapids above Chenapau	490	5.01397	-59.6509
2418	Melastomataceae	*Henriettea multiflora* Naudin	Potaro River, right bank 200-500 m downstream from fourth set of rapids above Chenapau	570	5.10831	-59.6372
2598	Melastomataceae	*Henriettea multiflora* Naudin	Kaieteur National Park, Tukeit, left bank of Potaro River	90	5.20456	-59.4528

Complete list of specimens collected during the WWF-Guianas BAT 2 survey in 2014 of the Potaro plateau with determination and locality data (*cont'd*)

New species are indicated in bold.

Collection Number	Family	Scientific Name	Locality	Elevation (m)	Latitude	Longitude
2388	Melastomataceae	*Henriettea ramiflora* (Sw.) DC.	Potaro River, left bank, immediately above third set of rapids above Chenapau on old homestead site	570	5.06622	-59.6571
2590	Melastomataceae	*Henriettea ramiflora* (Sw.) DC.	Kaieteur National Park, rock outcrops and savannah between northern end of airstrip and falls	440	5.17725	-59.4869
2457	Melastomataceae	*Henriettea stellaris* O.Berg ex Triana	Potaro River, left bank, secondary vegetation and trail edges around village of Chenapau	455	4.98242	-59.5784
2464	Melastomataceae	*Leandra* cf. *aristigera*	Kaieteur National Park, right bank of the Potaro River above Menzies Landing on mining site	440	5.14675	-59.5124
2578	Melastomataceae	*Leandra* cf. *aristigera*	Kaieteur National Park, Potaro River, Menzies Landing	435	5.16533	-59.4927
2487	Melastomataceae	*Leandra divaricata* (Naudin) Cogn.	Kaieteur National Park, upper Murimuri basin, moist forest	480	5.27211	-59.5148
2519	Melastomataceae	*Leandra divaricata* (Naudin) Cogn.	Kaieteur National Park, upper Murimuri basin, moist secondary forest degraded by mining	480	5.27264	-59.5136
2294	Melastomataceae	*Leandra purpurea* Gleason	Potaro River, left margin on portage trail on second set of rapids above Chenapau	430	5.01114	-59.6395
2595	Melastomataceae	*Leandra purpurea* Gleason	Kaieteur National Park, trail from Kaieteur Top to Tukeit, steep slopes	430	5.19225	-59.4736
2302	Melastomataceae	*Leandra sanguinea* Gleason	Potaro River, left margin on portage trail on second set of rapids above Chenapau	430	5.01114	-59.6395
2483	Melastomataceae	*Leandra sanguinea* Gleason	Kaieteur National Park, upper Murimuri basin, moist forest	480	5.27264	-59.5136
2522	Melastomataceae	*Leandra sanguinea* Gleason	Kaieteur National Park, upper Murimuri basin, moist secondary forest degraded by mining	480	5.27264	-59.5136
2453	Melastomataceae	*Leandra solenifera* Cogn.	Potaro River, left bank, secondary vegetation and trail edges around village of Chenapau	455	4.98242	-59.5784
2580	Melastomataceae	*Macairea pachyphylla* Benth.	Kaieteur National Park, trail from Menzies Landing to airstrip	435	5.16953	-59.4911
2459	Melastomataceae	*Macairea thyrsiflora* DC.	Kaieteur National Park, trail from airstrip to falls	440	5.17725	-59.4869
2593	Melastomataceae	*Macrocentrum cristatum* var. *microphyllum* Cogn.	Kaieteur National Park, trail from Kaieteur Top to Tukeit, steep slopes	430	5.19225	-59.4736
2445	Melastomataceae	*Macrocentrum droseroides* Triana	Potaro River, right bank 200-500 m downstream from fourth set of rapids above Chenapau	570	5.10831	-59.6372

Collection Number	Family	Scientific Name	Locality	Elevation (m)	Latitude	Longitude
2489	Melastomataceae	*Macrocentrum droseroides* Triana	Kaieteur National Park, upper Murimuri basin, moist forest	480	5.27211	-59.5148
2447	Melastomataceae	*Macrocentrum minus* Gleason	Potaro River, right bank 200-500 m downstream from fourth set of rapids above Chenapau	570	5.10831	-59.6372
2346	Melastomataceae	*Macrocentrum vestitum* Sandwith	Potaro River, left bank, on third set of rapids above Chenapau	530	5.06303	-59.6602
2417	Melastomataceae	*Macrocentrum vestitum* Sandwith	Potaro River, right bank 200-500 m downstream from fourth set of rapids above Chenapau	570	5.10831	-59.6372
2488	Melastomataceae	*Macrocentrum vestitum* Sandwith	Kaieteur National Park, upper Murimuri basin, moist forest	480	5.27211	-59.5148
2576	Melastomataceae	*Macrocentrum vestitum* Sandwith	Kaieteur National Park, upper Murimuri basin, forest on trail to Menzies Landing	465	5.24189	-59.522
2597	Melastomataceae	*Macrocentrum vestitum* Sandwith	Kaieteur National Park, trail from Kaieteur Top to Tukeit, steep slopes	160	5.19814	-59.4632
2331	Melastomataceae	*Maieta guianensis* Aubl.	Potaro River, on small creek on the right margin immediately below second set of rapids above Chenapau	430	5.00681	-59.6347
2303	Melastomataceae	*Maieta poeppigii* Mart. ex Cogn.	Potaro River, left margin on portage trail on second set of rapids above Chenapau	430	5.01114	-59.6395
2594	Melastomataceae	*Maieta poeppigii* Mart. ex Cogn.	Kaieteur National Park, trail from Kaieteur Top to Tukeit, steep slopes	430	5.19225	-59.4736
2378	Melastomataceae	*Meriania urceolata* Triana	Potaro River, left bank, landing below third set of rapids above Chenapau	550	5.06303	-59.6602
2305	Melastomataceae	*Miconia bracteata* (DC.) Triana	Potaro River, left margin on portage trail on second set of rapids above Chenapau	430	5.01114	-59.6395
2440	Melastomataceae	*Miconia bracteata* (DC.) Triana	Potaro River, right bank 200-500 m downstream from fourth set of rapids above Chenapau	570	5.10831	-59.6372
2476	Melastomataceae	*Miconia bracteata* (DC.) Triana	Kaieteur National Park, upper Murimuri basin, moist forest	490	5.27519	-59.516
2301	Melastomataceae	*Miconia centrodesma* Naudin	Potaro River, left margin on portage trail on second set of rapids above Chenapau	430	5.01114	-59.6395
2531	Melastomataceae	*Miconia ciliata* (Rich.) DC.	Kaieteur National Park, upper Murimuri basin	500	5.26767	-59.5139
2406	Melastomataceae	*Miconia dodecandra* Cogn.	Potaro River, left bank, immediately above third set of rapids above Chenapau on old homestead site	570	5.06622	-59.6571
2405	Melastomataceae	*Miconia hypoleuca* (Benth.) Triana	Potaro River, left bank, immediately above third set of rapids above Chenapau on old homestead site	570	5.06622	-59.6571

Complete list of specimens collected during the WWF-Guianas BAT 2 survey in 2014 of the Potaro plateau with determination and locality data (*cont'd*)

New species are indicated in bold.

Collection Number	Family	Scientific Name	Locality	Elevation (m)	Latitude	Longitude
2468	Melastomataceae	*Miconia maguirei* Gleason	Kaieteur National Park, upper Murimuri basin, moist forest	490	5.27519	-59.516
2591	Melastomataceae	*Miconia maguirei* Gleason	Kaieteur National Park, trail from Kaieteur Top to Tukeit, 500-1000 N of airstrip		5.18381	-59.4825
2432	Melastomataceae	*Miconia marginata* Triana	Potaro River, right bank 200-500 m downstream from fourth set of rapids above Chenapau	570	5.10831	-59.6372
2482	Melastomataceae	*Miconia marginata* Triana	Kaieteur National Park, upper Murimuri basin, moist forest	480	5.27264	-59.5136
2373	Melastomataceae	*Miconia plukenetii* Naudin	Potaro River, along river margin between second and third sets of rapids above Chenapau, around mouth of Kopinang Creek	530	5.02428	-59.6581
2342	Melastomataceae	*Miconia polita* Gleason	Potaro River, left margin, right below second set of rapids above Chenapau	430	5.00681	-59.6347
2317	Melastomataceae	*Miconia prasina* (Sw.) DC.	Potaro River, left margin above second set of rapids above Chenapau	490	5.01397	-59.6509
2371	Melastomataceae	*Miconia prasina* (Sw.) DC.	Potaro River, along river margin between second and third sets of rapids above Chenapau, around mouth of Kopinang Creek	530	5.02428	-59.6581
2387	Melastomataceae	*Miconia racemosa* (Aubl.) DC.	Potaro River, left bank, immediately above third set of rapids above Chenapau on old homestead site	570	5.06622	-59.6571
2455	Melastomataceae	*Miconia serrulata* (DC.) Naudin	Potaro River, left bank, secondary vegetation and trail edges around village of Chenapau	455	4.98242	-59.5784
2339	Melastomataceae	*Miconia virgulata* Gleason	Potaro River, left margin, right below second set of rapids above Chenapau	430	5.00681	-59.6347
2436	Melastomataceae	*Miconia virgulata* Gleason	Potaro River, right bank 200-500 m downstream from fourth set of rapids above Chenapau	570	5.10831	-59.6372
2347	Melastomataceae	*Phainantha laxiflora* (Triana) Gleason	Potaro River, left bank, on third set of rapids above Chenapau	530	5.06303	-59.6602
2439	Melastomataceae	*Phainantha laxiflora* (Triana) Gleason	Potaro River, right bank 200-500 m downstream from fourth set of rapids above Chenapau	570	5.10831	-59.6372
2458	Melastomataceae	*Pterolepis glomerata* (Rottb.) Miq.	Potaro River, left bank, boat landing of the village of Chenapau	455	4.98242	-59.5784
2601	Melastomataceae	*Pterolepis glomerata* (Rottb.) Miq.	Kaieteur National Park, rock outcrops and savannah near northern end of airstrip	440	5.17725	-59.4869
2555	**Melastomataceae**	***Salpinga* sp. nov.**	**Kaieteur National Park, upper Murimuri basin, near divide with Kuribrong basin**	**525**	**5.28172**	**-59.5236**

Collection Number	Family	Scientific Name	Locality	Elevation (m)	Latitude	Longitude
2461	Melastomataceae	*Siphanthera cordifolia* (Benth.) Gleason	Kaieteur National Park, trail from Menzies Landing to airstrip	435	5.16953	-59.4911
2564	Melastomataceae	*Tococa aristata* Benth.	Kaieteur National Park, upper Murimuri basin, forest on trail to Menzies Landing	480	5.26467	-59.5116
2592	Melastomataceae	*Tococa aristata* Benth.	Kaieteur National Park, trail from Kaieteur Top to Tukeit, 500-1000 N of airstrip		5.18381	-59.4825
2556	Melastomataceae	*Tococa desiliens* Gleason	Kaieteur National Park, upper Murimuri basin, near divide with Kuribrong basin	525	5.28172	-59.5236
2582	Melastomataceae	*Tococa desiliens* Gleason	Kaieteur National Park, trail from Menzies Landing to airstrip	435	5.16953	-59.4911
2583	Melastomataceae	*Tococa nitens* (Benth.) Triana	Kaieteur National Park, trail from Menzies Landing to airstrip	435	5.16953	-59.4911
2348	Meliaceae	*Carapa guianensis* Aublet	Potaro River, left bank, on third set of rapids above Chenapau	570	5.06622	-59.6571
2425	Moraceae		Potaro River, right bank 200-500 m downstream from fourth set of rapids above Chenapau	570	5.10831	-59.6372
2502	Moraceae	*Ficus*	Kaieteur National Park, upper Murimuri basin	500	5.26767	-59.5139
2316	Myrsinaceae	*Cybianthus guyanensis* (A.DC.) Miq. subsp. *multipunctatus* (A.DC.) Pipoly	Potaro River, left margin above second set of rapids above Chenapau	490	5.01397	-59.6509
2544	**Myrsinaceae**	**Myrsinaceae**	**Kaieteur National Park, upper Murimuri basin, near divide with Kuribrong basin**	**525**	**5.27406**	**-59.5246**
2353	Myrtaceae		Potaro River, along river margin between second and third sets of rapids above Chenapau, around mouth of Kopinang Creek	530	5.02428	-59.6581
2368	Myrtaceae		Potaro River, along river margin between second and third sets of rapids above Chenapau, around mouth of Kopinang Creek	530	5.02428	-59.6581
2494	Ochnaceae	*Ouratea*	Kaieteur National Park, upper Murimuri basin	500	5.26767	-59.5139
2546	Ochnaceae	*Sauvagesia longipes* Steyerm.	Kaieteur National Park, upper Murimuri basin, near divide with Kuribrong basin	490	5.27519	-59.516
2493	Ochnaceae	*Sauvagesia sprengelii* A.St.-Hil.	Kaieteur National Park, upper Murimuri basin	500	5.26767	-59.5139
2545	Orchidaceae	*Cheiradenia cuspidata* Lindl.	Kaieteur National Park, upper Murimuri basin, near divide with Kuribrong basin	490	5.27519	-59.516
2357	Orchidaceae	*Epidendrum tridens* Poepp. & Endl.	Potaro River, along river margin between second and third sets of rapids above Chenapau, around mouth of Kopinang Creek	530	5.02428	-59.6581

Complete list of specimens collected during the WWF-Guianas BAT 2 survey in 2014 of the Potaro plateau with determination and locality data (*cont'd*)

New species are indicated in bold.

Collection Number	Family	Scientific Name	Locality	Elevation (m)	Latitude	Longitude
2518	Orchidaceae	*Epistephium*	Kaieteur National Park, upper Murimuri basin	500	5.26767	-59.5139
2328	Orchidaceae	*Koellensteinia* cf. *graminea* (Lindl.) Rchb.f.	Potaro River, on small creek on the right margin immediately below second set of rapids above Chenapau	430	5.00681	-59.6347
2401	Orchidaceae	*Maxillaria*	Potaro River, trail along left bank, above third set of rapids above Chenapau	650	5.07406	-59.6488
2399	Passifloraceae	*Passiflora glandulosa* Cav.	Potaro River, trail along left bank, above third set of rapids above Chenapau	625	5.07197	-59.651
2384	Piperaceae	*Peperomia*	Potaro River, landing above second set of rapids above Chenapau	530	5.02428	-59.6581
2310	Piperaceae	*Piper*	Potaro River, left margin on portage trail on second set of rapids above Chenapau	490	5.01397	-59.6509
2524	Piperaceae	*Piper*	Kaieteur National Park, upper Murimuri basin	500	5.26767	-59.5139
2308	Poaceae		Potaro River, left margin on portage trail on second set of rapids above Chenapau	430	5.01114	-59.6395
2466	Poaceae		Kaieteur National Park, upper Murimuri basin, moist forest	490	5.27519	-59.516
2559	Poaceae		Kaieteur National Park, upper Murimuri basin, near divide with Kuribrong basin	515	5.27572	-59.526
2513	Polygalaceae	*Bredemeyera densiflora* var. *glabra* A.W.Benn.	Kaieteur National Park, upper Murimuri basin	500	5.26767	-59.5139
2537	Polygalaceae	*Caamembeca spectabilis* (DC.) J.F.B.Pastore var. *spectabilis*	Kaieteur National Park, upper Murimuri basin, rock outcrop dominated by *Brocchinia micrantha*, Rapateaceae and *Clusia* sp.	500	5.26767	-59.5139
2355	Polygalaceae	*Securidaca retusa* Benth.	Potaro River, along river margin between second and third sets of rapids above Chenapau, around mouth of Kopinang Creek	530	5.02428	-59.6581
2566	Polygonaceae		Kaieteur National Park, upper Murimuri basin, savannah on trail to Menzies Landing	480	5.25756	-59.5112
2364	Pteridophyte	*Cochlidium furcatum* (Hook. & Grev.) C.Chr.	Potaro River, along river margin between second and third sets of rapids above Chenapau, around mouth of Kopinang Creek	530	5.02428	-59.6581
2527	Pteridophyte	*Cyathea*	Kaieteur National Park, upper Murimuri basin, moist forest between savannahs and rock outcrops	470	5.26486	-59.5113

Collection Number	Family	Scientific Name	Locality	Elevation (m)	Latitude	Longitude
2394	Pteridophyte	*Cyathea pungens* (Willd.) Domin	Potaro River, trail along left bank, above third set of rapids above Chenapau	625	5.07197	-59.651
2336	Pteridophyte	*Dracoglossum plantagineum* (Jacq.) Christenh.	Potaro River, left margin, right below second set of rapids above Chenapau	430	5.00681	-59.6347
2404	Pteridophyte	*Elaphoglossum glabellum* J.Sm.	Potaro River, trail along left bank, above third set of rapids above Chenapau	650	5.07406	-59.6488
2431	Pteridophyte	*Huperzia*	Potaro River, right bank 200-500 m downstream from fourth set of rapids above Chenapau	570	5.10831	-59.6372
2441	Pteridophyte	*Lindsaea*	Potaro River, right bank 200-500 m downstream from fourth set of rapids above Chenapau	570	5.10831	-59.6372
2532	Pteridophyte	*Lindsaea lancea* (L.) Bedd.	Kaieteur National Park, upper Murimuri basin, moist forest between savannahs and rock outcrops	470	5.26486	-59.5113
2446	Pteridophyte	*Lindsaea reniformis* Dryand.	Potaro River, right bank 200-500 m downstream from fourth set of rapids above Chenapau	570	5.10831	-59.6372
2338	Pteridophyte	*Lindsaea sagittata* Dryand.	Potaro River, left margin, right below second set of rapids above Chenapau	430	5.00681	-59.6347
2337	Pteridophyte	*Metaxya rostrata* (Kunth) C.Presl	Potaro River, left margin, right below second set of rapids above Chenapau	430	5.00681	-59.6347
2423	Pteridophyte	*Serpocaulon triseriale* (Sw.) A.R.Sm.	Potaro River, right bank 200-500 m downstream from fourth set of rapids above Chenapau	570	5.10831	-59.6372
2442	Pteridophyte	*Trichomanes*	Potaro River, right bank 200-500 m downstream from fourth set of rapids above Chenapau	570	5.10831	-59.6372
2574	Rapateaceae	*Potarophytum riparium* Sandwith	Kaieteur National Park, upper Murimuri basin, forest on trail to Menzies Landing	465	5.24189	-59.522
2542	Rapateaceae	*Rapatea fanshawei* var. *fanshawei*	Kaieteur National Park, upper basin, near divide with Kuribrong basin	525	5.27406	-59.5246
2313	Rapateaceae	*Rapatea paludosa* Aubl.	Potaro River, left margin on portage trail on second set of rapids above Chenapau	490	5.01397	-59.6509
2550	Rapateaceae	*Rapatea xiphoides* Sandwith	Kaieteur National Park, upper Murimuri basin, near divide with Kuribrong basin	515	5.27572	-59.526
2599	Rapateaceae	*Saxofridericia regalis* R.H.Schomb.	Kaieteur National Park, rock outcrops and savannah near northern end of airstrip	440	5.18047	-59.485
2600	Rapateaceae	*Stegolepis angustata* Gleason	Kaieteur National Park, rock outcrops and savannah near northern end of airstrip	440	5.18047	-59.485

Complete list of specimens collected during the WWF-Guianas BAT 2 survey in 2014 of the Potaro plateau with determination and locality data (*cont'd*)

New species are indicated in bold.

Collection Number	Family	Scientific Name	Locality	Elevation (m)	Latitude	Longitude
2530	Rapateaceae	*Stegolepis ferruginea* Baker	Kaieteur National Park, upper Murimuri basin	500	5.26767	-59.5139
2307	Rubiaceae		Potaro River, left margin on portage trail on second set of rapids above Chenapau	430	5.01114	-59.6395
2380	Rubiaceae		Potaro River, landing above second set of rapids above Chenapau	530	5.02428	-59.6581
2400	Rubiaceae		Potaro River, trail along left bank, above third set of rapids above Chenapau	650	5.07406	-59.6488
2433	Rubiaceae		Potaro River, right bank 200-500 m downstream from fourth set of rapids above Chenapau	570	5.10831	-59.6372
2528	Rubiaceae		Kaieteur National Park, upper Murimuri basin	500	5.26767	-59.5139
2565	Rubiaceae		Kaieteur National Park, upper Murimuri basin, savannah on trail to Menzies Landing	480	5.25756	-59.5112
2329	Rubiaceae	*Didymochlamys connellii* Hook. f.	Potaro River, on small creek on the right margin immediately below second set of rapids above Chenapau	430	5.00681	-59.6347
2383	Rubiaceae	*Manettia alba* (Aubl.) Wernham	Potaro River, landing above second set of rapids above Chenapau	530	5.02428	-59.6581
2541	Rubiaceae	*Notopleura*	Kaieteur National Park, upper Murimuri basin, near divide with Kuribrong basin	525	5.27406	-59.5246
2435	Rubiaceae	*Notopleura tapajozensis* (Standl.) Bremek.	Potaro River, right bank 200-500 m downstream from fourth set of rapids above Chenapau	570	5.10831	-59.6372
2334	Rubiaceae	*Notopleura uliginosa* (Sw.) Bremek	Potaro River, on small creek on the right margin immediately below second set of rapids above Chenapau	430	5.00681	-59.6347
2295	Rubiaceae	*Palicourea jenmanii* (Wernham) C.M. Taylor	Potaro River, left margin on portage trail on second set of rapids above Chenapau	430	5.01114	-59.6395
2312	Rubiaceae	*Palicourea triphylla* DC.	Potaro River, left margin on portage trail on second set of rapids above Chenapau	490	5.01397	-59.6509
2516	Rubiaceae	*Perama hirsuta* Aubl.	Kaieteur National Park, upper Murimuri basin	500	5.26767	-59.5139
2306	Rubiaceae	*Psychotria apoda* Steyerm.	Potaro River, left margin on portage trail on second set of rapids above Chenapau	430	5.01114	-59.6395
2304	Rubiaceae	*Psychotria bostrychothyrsus* Sandwith	Potaro River, left margin on portage trail on second set of rapids above Chenapau	430	5.01114	-59.6395

Collection Number	Family	Scientific Name	Locality	Elevation (m)	Latitude	Longitude
2345	Rubiaceae	*Psychotria maguireorum* Steyerm.	Potaro River, left margin, right below second set of rapids above Chenapau	430	5.00681	-59.6347
2321	Rubiaceae	*Psychotria platypoda* DC.	Potaro River, left margin above second set of rapids above Chenapau	490	5.01397	-59.6509
2300	Rubiaceae	*Psychotria potaroensis* (Sandwith) Steyerm.	Potaro River, left margin on portage trail on second set of rapids above Chenapau	430	5.01114	-59.6395
2512	Rubiaceae	*Psychotria spadicea* (Pittier) Standl. & Steyerm.	Kaieteur National Park, upper Murimuri basin	500	5.26767	-59.5139
2293	Rubiaceae	*Rudgea hostmanniana* Benth.	Potaro River, left margin on portage trail on second set of rapids above Chenapau	490	5.01397	-59.6509
2429	Rutaceae	*Raveniopsis ruellioides* (Oliv.) R.S.Cowan	Potaro River, right bank 200-500 m downstream from fourth set of rapids above Chenapau	570	5.10831	-59.6372
2477	Salicaceae		Kaieteur National Park, upper Murimuri basin, moist forest	490	5.27519	-59.516
2395	Salicaceae	*Casearia singularis* Eichler	Potaro River, trail along left bank, above third set of rapids above Chenapau	625	5.07197	-59.651
2363	Sapindaceae	*Paullinia isoptera* Radlk.	Potaro River, along river margin between second and third sets of rapids above Chenapau, around mouth of Kopinang Creek	530	5.02428	-59.6581
2365	Sapindaceae	*Paullinia rufescens* Rich. ex Juss	Potaro River, along river margin between second and third sets of rapids above Chenapau, around mouth of Kopinang Creek	530	5.02428	-59.6581
2498	Sapotaceae		Kaieteur National Park, upper Murimuri basin	500	5.26767	-59.5139
2381	Sapotaceae	*Micropholis*	Potaro River, landing above second set of rapids above Chenapau	530	5.02428	-59.6581
2434	Selaginellaceae	*Selaginella*	Potaro River, right bank 200-500 m downstream from fourth set of rapids above Chenapau	570	5.10831	-59.6372
2572	Simaroubaceae	*Simaba monophylla* (Oliv.) Cronquist	Kaieteur National Park, upper Murimuri basin, savannah on trail to Menzies Landing	465	5.24656	-59.5173
2322	Smilacaceae	*Smilax*	Potaro River, left margin above second set of rapids above Chenapau	490	5.01397	-59.6509
2557	Solanaceae	*Lycianthes pauciflor*a (Vahl) Bitter	Kaieteur National Park, upper Murimuri basin, near divide with Kuribrong basin	525	5.28172	-59.5236

Complete list of specimens collected during the WWF-Guianas BAT 2 survey in 2014 of the Potaro plateau with determination and locality data (*cont'd*)

New species are indicated in bold.

Collection Number	Family	Scientific Name	Locality	Elevation (m)	Latitude	Longitude
2521	Solanaceae	*Solanum coriaceum* Dunal	Kaieteur National Park, upper Murimuri basin, moist secondary forest degraded by mining	480	5.27264	-59.5136
2575	Theaceae	*Bonnetia sessilis* Benth.	Kaieteur National Park, upper Murimuri basin, savannah on trail to Menzies Landing	465	5.24656	-59.5173
2509	Theaceae	*Ternstroemia laevigata* Wawra	Kaieteur National Park, upper Murimuri basin	500	5.26767	-59.5139
2420	Theophrastaceae	*Clavija*	Potaro River, right bank 200-500 m downstream from fourth set of rapids above Chenapau	570	5.10831	-59.6372
2398	Verbenaceae	*Amasonia campestris* (Aubl.) Moldenke	Potaro River, trail along left bank, above third set of rapids above Chenapau	625	5.07197	-59.651
2367	Viscaceae	*Phoradendron bilineatum* Urb.	Potaro River, along river margin between second and third sets of rapids above Chenapau, around mouth of Kopinang Creek	530	5.02428	-59.6581
2606	Xyridaceae	*Abolboda grandis* Griseb. var. *grandis*	Kaieteur National Park, rock outcrops and savannah near northern end of airstrip	440	5.17725	-59.4869
2603	Xyridaceae	*Xyris fallax* Malme	Kaieteur National Park, rock outcrops and savannah near northern end of airstrip	440	5.17725	-59.4869
2602	Xyridaceae	*Xyris involucrata* Nees	Kaieteur National Park, rock outcrops and savannah near northern end of airstrip	440	5.17725	-59.4869
2520	Xyridaceae	*Xyris setigera* Oliv.	Kaieteur National Park, upper Murimuri basin	500	5.26767	-59.5139
2604	Xyridaceae	*Xyris setigera* Oliv.	Kaieteur National Park, rock outcrops and savannah near northern end of airstrip	440	5.17725	-59.4869

Appendix 2

List of medium- and large-sized mammal species found at the Chenapau site

Species	Common name
RODENTIA	
Dasyprocta leporina	Red-rumped agouti
Cuniculus paca	Labba
XENARTHRA	
***Dasypus* sp.**	Armadillo
Dasypus novemcinctus	9-banded armadillo
Dasypus kappleri	Long-nosed armadillo
Priodontes maximus	Giant armadillo
UNGULATES	
Tapirus terrestris	Tapir
Mazama americana	Red brocket deer
Mazama nemorivaga	Brown brocket deer
Pecari tajacu	Collared peccary
Tayassu pecari	White-lipped peccary
CARNIVORA	
Panthera onca	Jaguar
Puma concolor	Puma
Puma yagouaroundi	Jaguarundi
***Leopardus* sp.**	Margay/Oncilla?
Leopardus pardalis	Ocelot
Eira barbara	Tayra
Nasua nasua	South American coati
DIDELPHIMORPHIA	
Didelphis marsupialis	Common opossum
PRIMATES	
***Alouatta* sp.**	Red howler monkey
Ateles paniscus	Black spider monkey

Appendix 3

Amphibians and reptiles recorded during the BAT Survey

Key

CV: Chenapau Village; **BC**: Bay Camp; **UPC**: Upper Potaro Camp; **MMC**: Murimuri Camp; **KT**: Kaieteur Top.

General geographic distribution: **W**: Widespread; **GS**: Guiana Shield; **GS***: Endemic to Guyana; **AGR**: Amazo-Guianan Subregion

IUCN threat status: **LC**: Least Concern**; NE**: Not Evaluated; **DD**: Data Deficient**; CD**: Conservation Dependent

CITES status:

Appendix I: species threatened with extinction which are or may be affected by trade

Appendix II: species not necessarily now threatened with extinction but may become so unless trade in specimens of such species is subject to strict regulation, and other species which must be subject to regulation

Appendix III: all species which any Party identifies as being subject to regulation within its jurisdiction for the purpose of preventing or restricting exploitation.

		Per Locality Qualitative Records					**Distribution**	**IUCN Threat Status**	**CITES Status**
Taxon	**cf.?**	**CV**	**BC**	**UPC**	**MMC**	**KT**			
AMPHIBIA (36 species total)		**10**	**26**	**12**	**10**	**4**			
ANURA (35 sp.)									
Allophrynidae									
Allophryne ruthveni		x					GS	LC	
Aromobatidae									
Anomaloglossus beebei						**x**	GS*	VU	
Anomaloglossus kaiei			**x**	**x**	**x**		GS*	LC	
Bufonidae									
Atelopus hoogmoedi			**x**				GS	?	
Rhaebo guttatus			**x**	**x**			AGR	LC	
Rhinella marina			**x**	**x**			W	LC	
Rhinella martyi			**x**				GS	LC	
Craugastoridae									
Pristimantis inguinalis	**cf.**		**x**				**?**	**?**	
Pristimantis marmoratus	**cf.**		**x**				**?**	**?**	
Eleutherodactylidae									
Adelophryne gutturosa			**x**				AGR	LC	
Hemiphractidae									
Stefania evansi			x	x	x		GS*	LC	
Stefania woodleyi			**x**	**x**	**x**		GS*	LC	
Hylidae									
Dendropsophus marmor-atus		**x**					AGR	LC	
Hypsiboas boans			**x**				AGR	LC	
Hypsiboas geographicus			**x**				AGR	LC	

		Per Locality Qualitative Records					Distribution	IUCN Threat Status	CITES Status
Hypsiboas ornatissimus			x				GS	LC	
Hypsiboas sibleszi			x		x		GS	LC	
Hypsiboas sp.						x	?	?	
Osteocephalus exophthalmus	cf.				x		?	?	
Osteocephalus leprieurii		x	x	x			AGR	LC	
Osteocephalus oophagus		x	x	x			AGR	LC	
Osteocephalus taurinus			x		x		AGR	LC	
Phyllomedusa bicolor			x	x			AGR	LC	
Phyllomedusa vaillantii			x				AGR	LC	
Scinax boesemani		x			x		AGR	LC	
Scinax ruber		x					W	LC	
Trachycephalus resinifictrix		x					AGR	LC	
Leptodactylidae									
Adenomera lutzi			x	x	x		GS*	DD	
Leptodactylus knudseni		x	x	x			AGR	LC	
Leptodactylus longirostris		x				x	AGR	LC	
Leptodactylus mystaceus		x	x	x			AGR	LC	
Leptodactylus rugosus					x	x	AGR	LC	
Leptodactylus rhodomystax			x	x	x		AGR	LC	
Microhylidae									
Synapturanus salseri			x				GS	LC	
Pipidae									
Pipa arrabali			x				AGR	LC	
GYMNOPHIONA (1 sp.)									
Rhinatremidae									
Epicrionops niger			x				GS	LC	
REPTILIA (30 species total)		**4**	**23**	**6**	**10**	**0**			
CROCODYLIA (1 sp.)									
Alligatoridae									
Paleosuchus palpebrosus			x	x			AGR	LC	Appendix II
SQUAMATA-GEKKOTA (2 sp.)									
Sphaerodactylidae									
Gonatodes alexandermendesi					x		GS	LC	
Phyllodactylidae									
Thecadactylus rapicauda			x				W	NE	

Amphibians and reptiles recorded during the BAT Survey (*cont'd*)

		Per Locality Qualitative Records					Distribution	IUCN Threat Status	CITES Status
SQUAMATA-LACERTIFORMES (5 sp.)									
Teiidae									
Ameiva ameiva		x	x	x	x		W	NE	
Kentropyx calcarata			x	x	x		AGR	NE	
Tupinambis teguixin		x					W	LC	Appendix II
Gymnophthalmidae									
Bachia flavescens			x	x			GS	LC	
Leposoma percarinatum			x				AGR	LC	
SQUAMATA-IGUANIA (3 sp.)									
Dactyloidae									
Anolis fuscoauratus			x				W	NE	
Anolis planiceps			x		x		AGR	NE	
Polychrotidae									
Polychrus marmoratus		x					W	NE	
SQUAMATA-SCINCOIDEA (1 sp.)									
Scincidae									
Copeoglossum nigropunctatum					x		W	NE	
SQUAMATA-SERPENTES (17 sp.)									
Aniliidae									
Anilius scytale					x		AGR	NE	
Boidae									
Corallus caninus			x	x			AGR	LC	Appendix II
Corallus hortulanus			x				W	LC	Appendix II
Colubridae									
Chironius fuscus					x		W	NE	
Phrynonax poecilonotus			x				W	NE	
Rhinobothryum lentiginosum					x		AGR	NE	
Dipsadidae									
Dipsas catesbyi			x				AGR	LC	
Erythrolamprus reginae			x				W	NE	
Erythrolamprus sp.			x				?	?	
Erythrolamprus typhlus			x				W	NE	
Oxyrhopus melanogenys			x				AGR	LC	

		Per Locality Qualitative Records					Distribution	IUCN Threat Status	CITES Status
Oxyrhopus petolarius			x				W	NE	
Pseudoboa coronata			x				AGR	NE	
Siphlophis compressus			x		x		AGR	LC	
Viperidae									
Bothriopsis bilineata			x				AGR	NE	
Bothrops atrox		x	x		x		AGR	NE	
Lachesis muta			x				AGR	NE	
TESTUDINES (1 sp.)									
Testudinidae									
Chelonoidis denticulata			x	x			AGR	VU	Appendix II

Appendix 4

Bird List for Potaro-Kaieteur BAT II Survey, 10-23 March 2014

Sequence and nomenclature follow the American Ornithologists' Union South American Checklist Committee (version 13 May 2015).

List compiled by Brian J. O'Shea and Jonathan Wrights.

Key

END/IUCN: END=endemic to Guiana Shield; NT=Near-Threatened; VU=Vulnerable

Family	Scientific name	English name	END/IUCN	Not in Barnett et al. 2002	Not in Bicknell et al. 2013	Notes
Accipitridae	*Buteo brachyurus*	Short-tailed Hawk			X	
	Buteo nitidus	Grey-lined Hawk			X	
	Buteogallus urubitinga	Great Black-Hawk				
	Elanoides forficatus	Swallow-tailed Kite				
	Rupornis magnirostris	Roadside Hawk				
	Spizaetus ornatus	Ornate Hawk-Eagle	NT		X	
Alcedinidae	*Chloroceryle amazona*	Amazon Kingfisher				
	Chloroceryle inda	Green-and-rufous King-fisher				
	Megaceryle torquata	Ringed Kingfisher				
Anhingidae	*Anhinga anhinga*	Anhinga				
Apodidae	*Aeronautes montivagus*	White-tipped Swift				*Around Kaieteur Falls*
	Chaetura chapmani	Chapman's Swift		X	X	
	Chaetura cinereiventris	Grey-rumped Swift				
	Chaetura spinicaudus	Band-rumped Swift				
	Cypseloides cryptus	White-chinned Swift				*Around Kaieteur Falls*
	Streptoprocne zonaris	White-collared Swift				*Around Kaieteur Falls*
Ardeidae	*Tigrisoma fasciatum*	Fasciated Tiger-Heron				*Rare and local; observed in rapids above Chenapau camp*
	Tigrisoma lineatum	Rufescent Tiger-Heron		X		

Family	Scientific name	English name	END/IUCN	Not in Barnett et al. 2002	Not in Bicknell et al. 2013	Notes
Bucconidae	*Bucco capensis*	Collared Puffbird		X	X	
	Chelidoptera tenebrosa	Swallow-winged Puffbird				
	Monasa atra	Black Nunbird				
	Notharchus tectus	Pied Puffbird		X	X	
Capitonidae	*Capito niger*	Black-spotted Barbet				
Caprimulgidae	*Lurocalis semitorquatus*	Short-tailed Nighthawk			X	
	Nyctidromus albicollis	Common Pauraque		X		
	Nyctipolus nigrescens	Blackish Nightjar				
Cardinalidae	*Caryothraustes canadensis*	Yellow-green Grosbeak				
	Cyanocompsa cyanoides	Blue-black Grosbeak			X	
	Granatellus pelzelni	Rose-breasted Chat		X	X	
	Periporphyrus erythromelas	Red-and-black Grosbeak	END; NT	X		
Cathartidae	*Cathartes aura*	Turkey Vulture				
	Cathartes melambrotus	Greater Yellow-headed Vulture				
	Sarcoramphus papa	King Vulture				
Columbidae	*Columbina passerina*	Common Ground-Dove				*Kaieteur only*
	Geotrygon montana	Ruddy Quail-Dove		X	X	
	Leptotila rufaxilla	Grey-fronted Dove				
	Leptotila verreauxi	White-tipped Dove				
	Patagioenas plumbea	Plumbeous Pigeon		X		
	Patagioenas speciosa	Scaled Pigeon		X		
	Patagioenas subvinacea	Ruddy Pigeon	VU	X		
Corvidae	*Cyanocorax cayanus*	Cayenne Jay	END			

Bird List for Potaro-Kaieteur BAT II Survey, 10-23 March 2014 (*cont'd*)

Family	Scientific name	English name	END/IUCN	Not in Barnett et al. 2002	Not in Bicknell et al. 2013	Notes
Cotingidae	*Cotinga cotinga*	Purple-breasted Cotinga		X		
	Lipaugus vociferans	Screaming Piha				*Chenapau village only*
	Perissocephalus tricolor	Capuchinbird	END			
	Procnias albus	White Bellbird	END			
	Rupicola rupicola	Guianan Cock-of-the-rock	END			
	Xipholena punicea	Pompadour Cotinga				
Cracidae	*Crax alector*	Black Curassow	END; VU			
	Ortalis motmot	Variable Chachalaca				
	Penelope jacquacu/ marail sp.	Spix's/Marail Guan				
Cuculidae	*Crotophaga ani*	Smooth-billed Ani				
	Piaya cayana	Squirrel Cuckoo				
Emberizidae	*Arremon taciturnus*	Pectoral Sparrow				
Falconidae	*Ibycter americanus*	Red-throated Caracara				
	Micrastur gilvicollis	Lined Forest-Falcon				
	Micrastur mirandollei	Slaty-backed Forest-Falcon		X	X	
Fringillidae	*Euphonia cayennensis*	Golden-sided Euphonia			X	
	Euphonia minuta	White-vented Euphonia			X	
	Euphonia sp.	unidentified Euphonia				
Furnariidae	*Automolus infuscatus*	Olive-backed Foliage-gleaner		X	X	
	Automolus ochrolaemus	Buff-throated Foliage-gleaner				
	Deconychura longicauda	Long-tailed Woodcreeper	LC	X		
	Dendrocincla fuliginosa	Plain-brown Woodcreeper				
	Dendrocolaptes certhia	Amazonian Barred-Wood-creeper		X		
	Dendrocolaptes picumnus	Black-banded Woodcreeper		X	X	
	Glyphorhynchus spirurus	Wedge-billed Woodcreeper				

Family	Scientific name	English name	END/IUCN	Not in Barnett et al. 2002	Not in Bicknell et al. 2013	Notes
	Sclerurus sp.	Leaftosser sp.				Probably *S. rufigularis*
	Xenops minutus	Plain Xenops				
	Xiphorhynchus guttatus	Buff-throated Woodcreeper				
	Xiphorhynchus pardalotus	Chestnut-rumped Wood-creeper	END			
Galbulidae	*Jacamerops aureus*	Great Jacamar				
Hirundinidae	*Atticora fasciata*	White-banded Swallow				
	Atticora tibialis	White-thighed Swallow		X	X	
	Hirundo rustica	Barn Swallow				
	Progne chalybea	Grey-breasted Martin		X		
	Tachycineta albiventer	White-winged Swallow				
Icteridae	*Cacicus haemorrhous*	Red-rumped Cacique				
	Icterus cayanensis	Epaulet Oriole				*Chenapau village only*
	Molothrus oryzivorus	Giant Cowbird		X		
	Psarocolius viridis	Green Oropendola				
Incertae sedis	*Piprites chloris*	Wing-barred Piprites		X	X	
	Saltator grossus	Slate-coloured Grosbeak		X		
	Saltator maximus	Buff-throated Saltator		X		
Odontophoridae	*Odontophorus gujanensis*	Marbled Wood-Quail	NT			
Parulidae	*Myiothlypis rivularis*	Riverbank Warbler				
	Setophaga pitiayumi	Tropical Parula		X		
Phalacrocoracidae	*Phalacrocorax brasilianus*	Neotropic Cormorant				

Bird List for Potaro-Kaieteur BAT II Survey, 10-23 March 2014 (*cont'd*)

Family	Scientific name	English name	END/IUCN	Not in Barnett et al. 2002	Not in Bicknell et al. 2013	Notes
Picidae	*Campephilus rubricollis*	Red-necked Woodpecker				
	Celeus elegans	Chestnut Woodpecker				
	Celeus torquatus	Ringed Woodpecker	NT	X		
	Celeus undatus	Waved Woodpecker				
	Colaptes rubiginosus	Golden-olive Woodpecker				
	Dryocopus lineatus	Lineated Woodpecker				
	Melanerpes cruentatus	Yellow-tufted Woodpecker			X	
	Piculus flavigula	Yellow-throated Woodpecker		X		
	Picumnus exilis	Golden-spangled Piculet			X	
	Veniliornis cassini	Golden-collared Woodpecker	END	X		
Pipridae	*Ceratopipra erythrocephala*	Golden-headed Manakin				
	Corapipo gutturalis	White-throated Manakin	END			
	Dixiphia pipra	White-crowned Manakin				
	Lepidothrix suavissima	Orange-bellied Manakin	END			
	Tyranneutes virescens	Tiny Tyrant-Manakin	END	X		
Polioptilidae	*Ramphocaenus melanurus*	Long-billed Gnatwren				
Psittacidae	*Amazona amazonica*	Orange-winged Parrot				
	Amazona dufresniana	Blue-cheeked Parrot	END; NT			
	Ara chloropterus	Red-and-green Macaw				
	Pionites melanocephalus	Black-headed Parrot				
	Pionus fuscus	Dusky Parrot	END			
	Pionus menstruus	Blue-headed Parrot				
	Pyrilia caica	Caica Parrot	END; NT			
	Pyrrhura egregia	Fiery-shouldered Parakeet	END		X	*Observed at 500 m, lowest known elevation for species*
	Touit purpuratus	Sapphire-rumped Parrotlet		X		
Rallidae	*Anurolimnas viridis*	Russet-crowned Crake		X	X	

Family	Scientific name	English name	END/IUCN	Not in Barnett et al. 2002	Not in Bicknell et al. 2013	Notes
Ramphastidae	*Ramphastos tucanus*	White-throated Toucan	VU			
	Ramphastos vitellinus	Channel-billed Toucan	VU			
	Selenidera piperivora	Guianan Toucanet	END			
Scolopacidae	*Actitis macularius*	Spotted Sandpiper				
	Tringa solitaria	Solitary Sandpiper		X		
Strigidae	*Megascops guatemalae*	Vermiculated Screech-Owl	END	X		ssp. *roraimae*
	Pulsatrix perspicillata	Spectacled Owl		X		
Thamnophilidae	*Cercomacra cinerascens*	Grey Antbird		X		
	Cercomacroides tyrannina	Dusky Antbird				
	Cymbilaimus lineatus	Fasciated Antshrike		X	X	
	Epinecrophylla gutturalis	Brown-bellied Antwren	END; NT	X		
	Euchrepomis spodioptila	Ash-winged Antwren		X		
	Frederickena viridis	Black-throated Antshrike	END	X		
	Gymnopithys rufigula	Rufous-throated Antbird	END			
	Herpsilochmus roraimae	Roraiman Antwren	END			
	Herpsilochmus stictocephalus	Todd's Antwren	END	X		
	Herpsilochmus sticturus	Spot-tailed Antwren	END	X		
	Hypocnemis cantator	Guianan Warbling-Antbird	END; NT			
	Isleria guttata	Rufous-bellied Antwren	END	X		
	Myrmeciza ferruginea	Ferruginous-backed Antbird		X		
	Myrmotherula axillaris	White-flanked Antwren				
	Myrmotherula brachyura	Pygmy Antwren				
	Myrmotherula longipennis	Long-winged Antwren		X		
	Myrmotherula menetriesii	Grey Antwren				
	Pithys albifrons	White-plumed Antbird				
	Schistocichla leucostigma	Spot-winged Antbird				
	Thamnomanes ardesiacus	Dusky-throated Antshrike		X		

Bird List for Potaro-Kaieteur BAT II Survey, 10-23 March 2014 (*cont'd*)

Family	Scientific name	English name	END/IUCN	Not in Barnett et al. 2002	Not in Bicknell et al. 2013	Notes
	Thamnomanes caesius	Cinereous Antshrike		X		
	Thamnophilus murinus	Mouse-coloured Antshrike				
	Willisornis poecilinotus	Common Scale-backed Antbird				
Thraupidae	*Chlorophanes spiza*	Green Honeycreeper				
	Coereba flaveola	Bananaquit				
	Cyanerpes caeruleus	Purple Honeycreeper				
	Cyanerpes cyaneus	Red-legged Honeycreeper				
	Dacnis cayana	Blue Dacnis				
	Lanio fulvus	Fulvous Shrike-Tanager				
	Paroaria gularis	Red-capped Cardinal			X	
	Ramphocelus carbo	Silver-beaked Tanager				
	Sporophila angolensis	Chestnut-bellied Seed-Finch		X	X	
	Sporophila nigricollis	Yellow-bellied Seedeater			X	
	Tachyphonus phoenicius	Red-shouldered Tanager				
	Tachyphonus surinamus	Fulvous-crested Tanager				
	Tangara cayana	Burnished-buff Tanager				
	Tangara chilensis	Paradise Tanager				
	Tangara gyrola	Bay-headed Tanager				
	Thraupis episcopus	Blue-grey Tanager				
	Thraupis palmarum	Palm Tanager				
	Volatinia jacarina	Blue-black Grassquit				
Threskiornithidae	*Mesembrinibis cayennensis*	Green Ibis				
Tinamidae	*Crypturellus variegatus*	Variegated Tinamou		X		
	Tinamus major	Great Tinamou	NT			
Tityridae	*Pachyramphus marginatus*	Black-capped Becard		X		
	Schiffornis olivacea	Olivaceous Schiffornis	END			
Trochilidae	*Campylopterus largipennis*	Grey-breasted Sabrewing				
	Heliothryx auritus	Black-eared Fairy				

Family	Scientific name	English name	END/IUCN	Not in Barnett et al. 2002	Not in Bicknell et al. 2013	Notes
	Lophornis ornatus	Tufted Coquette				
	Phaethornis bourcieri	Straight-billed Hermit				
	Phaethornis ruber	Reddish Hermit				
	Phaethornis superciliosus	Long-tailed Hermit				
	Polytmus theresiae	Green-tailed Goldenthroat				
	Thalurania furcata	Fork-tailed Woodnymph				
Trogonidae	*Trogon collaris*	Collared Trogon		X	X	
	Trogon melanurus	Black-tailed Trogon		X		
	Trogon rufus	Black-throated Trogon				
	Trogon violaceus	Guianan Trogon	END			
	Trogon viridis	Green-backed Trogon				
Troglodytidae	*Cyphorhinus arada*	Musician Wren				
	Henicorhina leucosticta	White-breasted Wood-Wren				
	Microcerculus bambla	Wing-banded Wren		X		
	Pheugopedius coraya	Coraya Wren				
	Troglodytes aedon	House Wren				
Turdidae	*Turdus albicollis*	White-necked Thrush				
Tyrannidae	*Attila spadiceus*	Bright-rumped Attila		X		
	Conopias parvus	Yellow-throated Flycatcher				
	Corythopis torquatus	Ringed Antpipit		X		
	Elaenia cristata	Plain-crested Elaenia				
	Elaenia flavogaster	Yellow-bellied Elaenia				
	Elaenia ruficeps	Rufous-crowned Elaenia				*Found only in savannah around Kaieteur airstrip*
	Hirundinea ferruginea	Cliff Flycatcher				
	Lophotriccus galeatus	Helmeted Pygmy-Tyrant				
	Mionectes macconnelli	McConnell's Flycatcher	END			ssp. *roraimae*
	Mionectes oleagineus	Ochre-bellied Flycatcher				
	Myiarchus ferox	Short-crested Flycatcher		X		
	Myiarchus tuberculifer	Dusky-capped Flycatcher				

Bird List for Potaro-Kaieteur BAT II Survey, 10-23 March 2014 (*cont'd*)

Family	Scientific name	English name	END/IUCN	Not in Barnett et al. 2002	Not in Bicknell et al. 2013	Notes
	Myiobius barbatus	Sulphur-rumped Flycatcher				
	Myiornis ecaudatus	Short-tailed Pygmy-Tyrant		X		
	Ornithion inerme	White-lored Tyrannulet				
	Platyrinchus coronatus	Golden-crowned Spadebill				
	Terenotriccus erythrurus	Ruddy-tailed Flycatcher				
	Tolmomyias assimilis	Yellow-margined Flycatcher		X		
	Tolmomyias poliocephalus	Grey-crowned Flycatcher				
	Tolmomyias sulphurescens	Yellow-olive Flycatcher		X	X	
	Tyrannus melancholicus	Tropical Kingbird				
	Zimmerius gracilipes	Slender-footed Tyrannulet				
Vireonidae	*Pachysylvia muscicapina*	Buff-cheeked Greenlet				
	Tunchiornis ochraceiceps	Tawny-crowned Greenlet				

Appendix 5

Preliminary list of freshwater macrocrustaceans and other aquatic invertebrates from three regions of Kaieteur National Park

The numbers represent the total of individuals collected by family or genus level.

Group	Kaieteur	Tukeit	Murimuri
Crustaceans			
Decapoda – Euryrhynchidae (shrimps)			
Euryrhynchus sp. 1	791	2	
Euryrhynchus sp. 2			72
Decapoda – Palaemonidae (shrimps)			
Macrobrachium sp. 1	34		40
Macrobrachium sp. 2	118		24
Palaemon sp.	52		
Decapoda – Pseudothelphusidae (crabs)			
Microthelphusa sp.		81	
Decapoda – Trichodactylidae (crabs)	24		
Isopoda		8	1
Insects			
Blattaria – Blattodea	8	25	
Coleoptera – Gyrinidae			
Gyretes sp.	1		
Coleoptera – Noteridae	1		
Diptera – Chironomidae	4		
Diptera – Empididae	2		
Rhamphomyia sp.		6	
Ephemeroptera – Baetidae	1		
Ephemeroptera – Euthyplociidae	2		
Campylocia sp.	5		
Ephemeroptera – Leptophlebiidae	1	1	
Fittkaulus sp.	1		
Heteroptera – Nepidae			
Ranatra sp.	10		1
Heteroptera – Notonectidae			
Ambrysus sp.	10	1	3
Martarega sp.			1
Megaloptera – Corydalidae	4		3
Odonata – Calopterygidae			

Preliminary list of freshwater macrocrustaceans and other aquatic invertebrates from three regions of Kaieteur National Park (*cont'd*)

Group	Kaieteur	Tukeit	Murimuri
Hetaerina sp.	8	12	
Odonata – Coenagrionidae			
Acanthagrion sp.	5		
Argia sp.	5	1	
Oxyagrion sp.	1	10	2
Odonata – Corduliidae			
Aeschnosoma sp.	19		2
Odonata – Gomphidae			
Aphylla sp.	1		
Cyanogomphus sp.	1		
Phyllogomphoides sp.	2		
Progomphus sp.	5	1	
Odonata – Libellulidae			
Elasmothemis sp.	2		
Orthemis sp.	13	1	
Perithemis sp.	2		
Planiplax sp.	3	1	1
Tramea sp.	1		
Odonata – Megapodagrionidae			
Heteragrion sp.			2
Odonata – Perilestidae			
Perilestes sp.			2
Plecoptera – Perlidae			
Anacroneuria sp.	19	14	18
Trichoptera - Hydropsychidae			
Smicridea sp.	15	18	9
Anelids			
Oligochaeta	11	2	

Appendix 6a

Checklist of Odonates recorded during the Kaieteur Plateau–Upper Potaro Biodiversity Assessment Team (BAT) Survey in 2014

Key

Square brackets [ ] after each family: number of genera/number of species recorded.
Species in bold: new records for Guyana at the time the survey took place.
Relative abundance per site: R (rare = 1-3 specimens seen); F (frequent = 4-20 specimens seen); C (common = 21-50 specimens seen).
Incidence: number of sites where each species was recorded.

	Upper Potaro									Kaieteur National Park																
Sites	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**Incidence**
TAXA																									
Amphipterygidae [1/1]																									
Rimanella arcana (Needham, 1933)															F								F		2
Calopterygidae [3/4]																									
Hetaerina caja dominula Hagen in Selys, 1853				R			F	C	R						R		F								6
Hetaerina moribunda Hagen in Selys, 1853											R									R					2
Iridictyon trebbaui Rácenis, 1968		R		R	R																		F	F	5
Mnesarete cupraea (Selys, 1853)					R																				1
Coenagrionidae [9/20]																									
Acanthagrion indefensum Williamson, 1916																		R	R						2
Argia azurea Garrison & von Ellenrieder, 2015	F			F			F	C	R						R										6
Argia deceptor Garrison & von Ellenrieder, 2015						R																		R	2
Argia fumigata Hagen in Selys, 1865	R			F			F	R							F										5
Argia guyanica Garrison & von Ellenrieder, 2015																							C		1
Argia insipida Hagen in Selys, 1865							R	C							R										3
Argia joallynae Garrison & von Ellenrieder, 2015										R	F			R											3
Argia oculata Hagen in Selys, 1865	R				F						R												C		4
Bromeliagrion beebeanum (Calvert, 1948)		R																							1
Epipleoneura demarmelsi von Ellenrieder & Garrison, 2008											F														1
Epipleoneura lamina Williamson, 1915																				R					1
Epipleoneura pereirai Machado, 1964								C							R			R							3
Mecistogaster lucretia (Drury, 1773)					F		R																	R	3
Microstigma maculatum Hagen in Selys, 1860			R								R														2

Checklist of Odonates recorded during the Kaieteur Plateau–Upper Potaro Biodiversity Assessment Team (BAT) Survey in 2014 (*cont'd*)

	Upper Potaro									Kaieteur National Park																
Sites	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**Incidence**
Neoneura fulvicollis Selys, 1886								R																	1
Neoneura mariana Williamson, 1917							R	C	R						R		R	R						R	6
Neoneura myrthea Williamson, 1917							C	C									F	F							4
Protoneura calverti Williamson, 1915							F	R	R						R			R							5
Protoneura tenuis Selys, 1860															R										1
Telebasis simulata Tennessen, 2002																					C				1
Lestidae [1/1]																									
Lestes falcifer Sjöstedt, 1918	F																								1
Megapodagrionidae [3/6]																									
Dimeragrion percubitale Calvert, 1913				R	R			R			F	R											F		6
Heteragrion ictericum Williamson, 1919					F			F																	2
Heteragrion pemon De Marmels, 1987		R			R						F				F										4
Heteragrion silvarum Sjöstedt, 1918							R																		1
Oxystigma cyanofrons Williamson, 1919	R																								1
Oxystigma petiolatum (Selys, 1862)	R																								1
Perilestidae [1/3]																									
Perilestes attenuatus Selys, 1886								R																	1
Perilestes fragilis Hagen in Selys, 1862								R																	1
Perilestes gracillimus Kennedy, 1941											R														1
Platystictidae [1/1]																									
Palaemnema brevignoni Machet, 1990		F		F							R														3
Polythoridae [1/1]																									
Chalcothore montgomeryi (Rácenis, 1968)		R			R										R								R		4
Aeshnidae [2/2]																									
Anax amazili (Burmeister, 1839)	R																								1
Staurophlebia reticulata (Burmeister, 1839)							R																		1

	Upper Potaro									Kaieteur National Park															
Sites	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**Incidence**
Gomphidae [2/2]																									
Phyllocycla modesta (Belle, 1970)								R																F	2
Progomphus sp.					R																	R	R		3
Libellulidae [19/40]																									
Anatya guttata (Erichson in Schomburgk, 1848)																		R							1
Brechmorrhoga praedatrix Calvert, 1909								R																	1
Diastatops pullata (Burmeister, 1839)																			F						1
Elasmothemis cannacrioides (Calvert, 1906)								F							F										2
Elasmothemis rufa De Marmels, 2008								R																	1
Elasmothemis williamsoni (Ris, 1919)								R																	1
Elga leptostyla (Ris, 1909)							F								R										2
Erythrodiplax amazonica Sjöstedt, 1918											R														1
Erythrodiplax castanea (Burmeister, 1839)	F										R														2
Erythrodiplax famula (Erichson in Schomburgk, 1848)	F										R			F		R					F				5
Erythrodiplax fusca (Rambur, 1842)	F									R															2
Erythrodiplax paraguayensis (Förster, 1905)														F							F				2
Gynothemis pumila (Karsch, 1890)											R				R										2
Gynothemis uniseta Geijskes, 1972									R																1
Macrothemis belliata Belle, 1987															R										1
Macrothemis cynthia Ris, 1913																							R		1
Macrothemis hemichlora (Burmeister, 1839)					R																				1
Micrathyria artemis Ris, 1911																			R						1
Micrathyria atra (Martin, 1897)	F																								1
Micrathyria catenata (Calvert, 1909)																					F				1
Misagria bimacula Kimmins, 1943															R					R					2
Nephepeltia phryne (Perty, 1833)	R																								1

Checklist of Odonates recorded during the Kaieteur Plateau–Upper Potaro Biodiversity Assessment Team (BAT) Survey in 2014 (*cont'd*)

	Upper Potaro									Kaieteur National Park																
Sites	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**Incidence**
Oligoclada rhea Ris, 1911																		R							1
Oligoclada risi Geijskes, 1984							F																		1
Oligoclada walkeri Geijskes, 1931																								R	1
Orthemis aequilibris Calvert, 1909	F						F			F	F			F											5
Orthemis attenuata (Erichson in Schomburgk, 1848)																			R					R	2
Orthemis biolleyi Calvert, 1906											F														1
Orthemis discolor (Burmeister, 1839)	F															F									2
Pantala flavescens (Fabricius, 1798)	F													F											2
Perithemis lais (Perty, 1833)	F																	F	F	F					4
Perithemis thais Kirby, 1889											R														1
Tramea abdominalis (Rambur, 1842)	R																								1
Tramea binotata (Rambur, 1842)														R											1
Uracis fastigiata (Burmeister, 1839)		F					F																	F	3
Uracis imbuta (Burmeister, 1839)	C		C							C	C		C		C	C		C							8
Uracis infumata (Rambur, 1842)	F												R												2
Ypirangathemis calverti Santos, 1945										C				C							C				3
Zenithoptera fasciata (Linnaeus, 1758)	C																								1
Species Richness per Site	**20**	**6**	**2**	**6**	**10**	**1**	**14**	**18**	**5**	**5**	**17**	**1**	**2**	**7**	**17**	**3**	**3**	**9**	**5**	**4**	**5**	**1**	**8**	**8**	
Shannon Diversity per Site	**2.94**	**1.79**	**0.69**	**1.79**	**2.3**	**0**	**2.64**	**2.9**	**1.6**	**1.6**	**2.83**	**0**	**0.7**	**1.9**	**2.8**	**1.1**	**1.1**	**2.2**	**1.6**	**1.4**	**1.6**	**0**	**2.1**	**2.1**	
Simpson Diversity per Site	**0.94**	**0.83**	**0.5**	**0.83**	**0.9**	**0**	**0.93**	**0.94**	**0.8**	**0.8**	**0.94**	**0**	**0.5**	**0.85**	**0.94**	**0.66**	**0.66**	**0.88**	**0.80**	**0.75**	**0.8**	**0**	**0.87**	**0.87**	
Species Richness per Area	**53 (Chao2 = 93.55)**									**58 (Chao2 = 88.8)**															
Species Richness of Survey	**80 (Chao2 = 121.53)**																								

Appendix 6b

Odonates found during the Kaieteur Plateau–Upper Potaro Biodiversity Assessment Team Expedition: Habitat where found, data on known larvae, distribution (from Paulson 2015 and material examined), and conservation status according to IUCN Red List

Key

In bold: new records for Guyana at the time the survey took place.

Distribution: AMZ: Guianan and Amazonian; GUI: Guianan; NEO: widespread in the Neotropical region.

Country codes in parenthesis:

AR: Argentina, BE: Belize, BO: Bolivia, BR: Brazil, CA: Canada, CO: Colombia, CR: Costa Rica, EC: Ecuador, FR: French Guiana, GU: Guatemala, GY: Guyana, ME: Mexico, PA: Panama, PE: Peru, PY: Paraguay, SU: Suriname, TR: Trinidad/Tobago, VE: Venezuela

IUCN category: LC: Least Concern; DD: Data Deficient.

Species	Habitat	Larva described	Distribution	IUCN
Acanthagrion indefensum	river	Geijskes 1943	GUI (VE, GY, SU, FR, BR)	-
Anatya guttata	river	-	NEO (ME to BO)	-
Anax amazili	trail	Calvert 1934	NEO (ME to AR, GY)	-
Argia azurea	creek/river /trail	-	GUI (CO, VE, GY)	-
Argia deceptor	swamp/trail	-	GUI (GY, SU, FR)	-
Argia fumigata	creek/river /trail	-	AMZ (VE, GY, SU, FR, BR, EC)	-
Argia guyanica	creek	-	GUI (VE, GY)	-
Argia insipida	creek/river	Geijskes 1943	NEO (CR, CO, VE, TR, GY, SU, FR, BR)	-
Argia joallynae	trickles/trail	-	GUI (VE, GY)	-
Argia oculata	creek/trail	Limongi 1983 (1985)	NEO (ME to BO, GY)	-
Brechmorrhoga praedatrix	river	Fleck 2004	NEO (VE, TR, GY, SU, FR, BR, AR)	LC
Bromeliagrion beebeanum	trail	-	AMZ (VE, GY, EC)	-
Chalcothore montgomeryi	creek	De Marmels 1988	GUI (VE, GY)	LC
Diastatops pullata	river	Fleck 2003	NEO (VE, GY, SU, FR, BR, EC, PE, BO, AR)	LC
Dimeragrion percubitale	creek	De Marmels 1999	GUI (VE, GY)	LC
Elasmothemis cannacrioides	creek/ river	Westfall 1988	NEO (ME to AR, GY)	-
Elasmothemis rufa	river	-	GUI (VE, GY, SU)	-
Elasmothemis williamsoni	river	Westfall 1988	AMZ (GY, SU, FR, PE)	-
Elga leptostyla	creek/river	De Marmels 1990a, Fleck 2003	NEO (PA to PE)	-
Epipleoneura demarmelsi	creek	-	GUI (VE, GY, BR)	-
Epipleoneura lamina	creek	-	AMZ (VE, GY, BR, PE)	LC
Epipleoneura pereirai	creek/ river	-	GUI (GY, SU, FR, BR)	DD
Erythrodiplax amazonica	creek	De Marmels 1992	AMZ (VE, TR, GY, SU, FR, BR, PE)	-
Erythrodiplax castanea	creek/ pools	-	NEO (GU to AR)	-
Erythrodiplax famula	creek/ pond/ pool/ trickles	-	NEO (CR, VE, TR, GY, SU, FR, BR, PE, AR)	-

Odonates found during the Kaieteur Plateau–Upper Potaro Biodiversity Assessment Team Expedition: Habitat where found, data on known larvae, distribution (from Paulson 2015 and material examined), and conservation status according to IUCN Red List (*cont'd*)

Species	Habitat	Larva described	Distribution	IUCN
Erythrodiplax fusca	pool/ trickles	Santos 1967	NEO (ME to AR)	-
Erythrodiplax paraguayensis	pond/ trickles	Muzón & Garré 2005	NEO (CO, VE, GY, SU, BR, EC, BO, PA, AR)	LC
Gynothemis pumila	creek	Fleck 2004	AMZ (CO, VE, TR, GY, SU, FR, BR, PE)	LC
Gynothemis uniseta	creek	Geijskes 1972	GUI (GY, SU, FR)	-
Hetaerina caja dominula	creek/ river	Geijskes 1943	GUI (VE, GY, SU, FR, BR)	-
Hetaerina moribunda	creek	Geijskes 1943 by supposition	GUI (VE, GY, SU, FR, BR)	-
Heteragrion ictericum	creek/river/ trail	-	GUI (VE, GY, SU, FR, BR)	-
Heteragrion pemon	creek/ trail	-	GUI (VE, GY)	-
Heteragrion silvarum	creek/ trail	-	GUI (GY, SU, FR, BR)	-
Iridictyon trebbaui	creek/ trail	De Marmels 1992	GUI (VE, GY)	LC
Lestes falcifer	pools	-	AMZ (VE, GY, FR, BR, PE)	-
Macrothemis belliata	creek	-	GUI (GY, SU)	-
Macrothemis cynthia	creek	-	GUI (VE, GY, BR)	-
Macrothemis hemichlora	creek/ river	-	NEO (ME to AR, GY)	LC
Mecistogaster lucretia	trail	-	NEO (CO, VE, GY, SU, FR, BR, EC, PE, AR)	-
Micrathyria artemis	pool in river	Santos 1972	NEO (VE, GY, SU, FR, BR, EC, PE, AR)	LC
Micrathyria atra	pool	Santos 1978	NEO (ME to AR)	LC
Micrathyria catenata	pond	-	NEO (CR to AR, GY)	LC
Microstigma maculatum	trail	Neiss et al. 2008	AMZ (VE, GY, SU, FR, BR)	-
Misagria bimacula	creek/ swamp	-	GUI (VE, GY)	LC
Mnesarete cupraea	creek	-	AMZ (VE, GY, SU, FR, PE, BO)	-
Neoneura fulvicollis	river	De Marmels 2007	NEO (VE, GY, BR, AR)	LC
Neoneura mariana	creek/ river	-	GUI (VE, GY, SU, FR)	-
Neoneura myrthea	creek/ river	-	AMZ (VE, GY, SU, FR, BO)	-
Nephepeltia phryne	pool	De Marmels 1990a	NEO (BE to AR)	LC
Oligoclada rhea	river	-	AMZ (GY, SU, FR, BR, BO)	-
Oligoclada risi	river	-	GUI (VE, GY, SU, FR, BR)	-
Oligoclada walkeri	river	-	AMZ (VE, TR, GY, SU, FR, BR, EC, PE)	-
Orthemis aequilibris	clearing/pool/ river/trickles	Fleck 2003	NEO (CR to AR)	-

Species	Habitat	Larva described	Distribution	IUCN
Orthemis attenuata	river	-	AMZ (CO, VE, GY, FR, SU, BR, PE)	-
Orthemis biolleyi	clearing	Fleck 2003	NEO (BE to BO)	LC
Orthemis discolor	pool	-	NEO (ME to AR)	-
Oxystigma cyanofrons	river/trail	Geijskes 1943 as *O. petiolatum*	GUI (VE, GY, SU, FR)	-
Oxystigma petiolatum	trail	-	AMZ (VE, GY, SU, FR, BR, EC)	LC
Palaemnema brevignoni	creek	-	GUI (VE, GY, FR)	-
Pantala flavescens	clearing/ pool	Geijskes 1934	NEO (circumtropical, in New World from CA to AR)	LC
Perilestes attenuatus	river	Neiss & Hamada 2010	AMZ (VE, GY, SU, FR, BR, PE, BO)	LC
Perilestes fragilis	river	Santos 1969	AMZ (GY, BR)	-
Perilestes gracillimus	creek	-	AMZ (GY, SU, BR, PE)	DD
Perithemis lais	creek/ pool/ river	Costa & Regis 2005	NEO (CO to AR)	LC
Perithemis thais	creek	Spindola et al. 2001	NEO (CR to AR)	-
Phyllocycla modesta	river	Belle 1970	GUI (VE, GY, FR, SU)	-
Progomphus sp.	creek/ trickles	-	GUI (GY)	-
Protoneura calverti	creek/ river	-	GUI (VE, TR, GY, SU, FR, BR)	LC
Protoneura tenuis	creek	-	AMZ (VE, TR, GY, SU, FR, BR, PE, BO)	LC
Rimanella arcana	creek/ river	Geijskes 1940	GUI (VE, GY, SU, BR)	LC
Staurophlebia reticulata	river	Geijskes 1959	NEO (GU to AR)	-
Telebasis simulata	vegetated pond	Geijskes 1943 as *T. sanguinalis*	GUI (VE, TR, GY, SU, FR, BR)	-
Tramea abdominalis	pools	Klots 1932	NEO (ME to AR, GY)	-
Tramea binotata	trail	Needham et al. 2000	NEO (ME to AR, GY)	-
Uracis fastigiata	trail	-	NEO (ME to BO)	-
Uracis imbuta	trail	-	NEO (ME to AR)	-
Uracis infumata	trail	-	AMZ (VE, GY, SU, FR, BR, PE, BO)	-
Ypirangathemis calverti	pond/ trickles	-	AMZ (VE, GY, BR)	-
Zenithoptera fasciata	pool	-	NEO (CR to BR)	LC

Appendix 7

List of water beetles collected during the 2014 BAT survey of the Kaieteur Plateau-Upper Potaro region of Guyana

Taxa with asterisks are likely species new to science.

Taxon	Upper Potaro	Kaieteur National Park	Ayanganna (new) Airstrip	Chenapau
DRYOPIDAE				
Gen. nov. A sp. 1*	X	-	-	-
Gen. nov. A sp. 4*	X	-	-	-
Elmoparnus sp. 1*	X	-	-	-
DYTISCIDAE				
Bidessodes charaxinus	-	X	-	-
Bidessonotus sp. 1	X	X	-	X
Copelatus sp. 1	X	X	X	X
Copelatus sp. 2	X	X	X	-
Copelatus sp. 3	X	-	X	-
Copelatus sp. 4	-	X	-	-
Copelatus sp. 5	-	X	-	-
Copelatus sp. 6	-	X	-	-
Copelatus sp. 7	-	X	-	X
Copelatus sp. 8	-	-	-	X
Copelatus sp. 9	-	X	X	-
Copelatus sp. 10	-	X	X	-
Copelatus sp. 11	-	-	X	-
Desmopachria sp. 1	-	X	X	X
Desmopachria sp. 2	-	-	-	X
Desmopachria sp. 3	-	X	X	-
Desmopachria sp. 4	-	-	-	X
Fontidessus aquarupe	-	X	-	-
Fontidessus ornatus	X	X	-	-
Hydaticus lateralis	-	-	-	X
Hydaticus subfasciatus	-	-	-	X
Laccodytes sp. 1	-	X	X	-
Laccophilus sp 1	-	X	X	X
Laccophilus sp 2	-	X	-	-
Neobidessus sp. F*	-	X	X	-
Platynectes submaculatus	X	-	-	-
*Platynectes garciai**	-	X	-	-
Rhantus calidus	-	-	-	X
Spanglerodessus shorti	X	-	-	-
Thermonectus circumscriptus	-	-	-	X
Thermonectus variegatus	-	-	-	X
Vatellus sp. 1	X	-	-	-

Taxon	Upper Potaro	Kaieteur National Park	Ayanganna (new) Airstrip	Chenapau
ELMIDAE				
"Nr. *Microcylleopus*" sp. 1	X	-	-	-
Austrolimnius sp. 1	-	-	X	-
Cylloepus sp. 2	X	-	-	-
Gen. nov. A sp. 1*	-	-	X	-
Heterelmis sp. 1	X	X	X	-
Heterelmis sp. 2	-	X	-	-
Heterelmis sp. 3	-	-	X	-
Heterelmis sp. 4	X	-	X	-
Neoelmis sp. X	X	X	X	-
Phanocerus sp. 1	X	X	-	-
Stenhelmoides sp. 4	X	-	-	-
Tyletelmis sp. 1	-	-	X	-
Xenelmis sp. 1	-	X	X	-
GYRINIDAE				
Gyretes sp. B	X	-	-	-
Gyretes sp. G	X	-	-	-
HYDRAENIDAE				
Hydraena sp. 1	X	X	X	-
Hydraena sp. 2	X	-	-	-
HYDROCHIDAE				
Hydrochus sp. 1	X	-	-	-
HYDROPHILIDAE				
Acidocerini gen. nov. A sp. 1*	X	-	-	-
Acidocerini gen. nov. A sp. 2*	-	X	-	-
Acidocerini gen. nov. B sp. 1*	X	X	-	-
Cercyon sp. 7	-	X	-	-
Chasmogenus sp. A	X	-	X	-
Chasmogenus sp. X	X	X	X	-
Crenitulus sp. 1	-	X	-	-
Dactylosternum sp. 1	X	X	X	-
Derallus intermedius	-	X	-	-
Derallus sp. 2	X	X	-	-
Derallus sp. 6	X	-	-	-
Enochrus sp. 1*	-	-	X	-
Enochrus sp. 2	-	-	X	X
Enochrus sp. 3	X	X	X	-

List of water beetles collected during the 2014 BAT survey of the Kaieteur Plateau-Upper Potaro region of Guyana (*cont'd*)

Taxon	Upper Potaro	Kaieteur National Park	Ayanganna (new) Airstrip	Chenapau
Globulosis hemisphericus	-	-	-	X
Guyanobius adocetus	X	-	X	-
Hydrophilus simulator	-	-	-	X
Notionotus sp. A*	X	-	-	-
Notionotus nr. *lohezi*	X	X	X	-
Oocyclus floccus	X	-	-	-
Oocyclus petra	X	X	-	-
Oosternum sp. 1	-	X	-	-
Paracymus sp. 1	-	X	-	-
Pelosoma sp. 1	X	-	-	-
Pelosoma sp. 2	X	-	-	-
Pelosoma sp. 3	X	-	-	-
Pelosoma sp. 4	X	-	X	-
Quadriops sp. 1*	X	-	X	-
Radicidus sp. 1	-	X	-	-
Tropisternus chalybeus	-	-	X	X
Tropisternus laevis	-	-	-	X
Tropisternus setiger	-	-	-	X
NOTERIDAE				
Liocanthydrus sp.	X	-	-	-
Notomicrus cf. *traili*	X	-	X	-
Notomicrus sp. "small eyes"*	X	-	-	-
Notomicrus sp. X	X	-	X	-
TORRIDINCOLIDAE				
Iapir sp. 1*	-	X	-	-
Gen. nov. A sp. 1*	X	X	-	-

Appendix 8

List of fish species collected during the Upper Potaro and Kaieteur National Park Biodiversity Assessment Team 2014 expedition

Key
Bold type indicates species possibly new to science.
An asterisk (*) indicates those endemic to the Potaro River drainage.

Order	Family	Genus	Species
Characiformes	Characidae	*Astyanax*	*bimaculatus*
Characiformes	Characidae	*Bryconops*	*affinis*
Characiformes	Characidae	*Moenkhausia*	*browni*
Characiformes	Characidae	*Moenkhausia*	*oligolepis*
Characiformes	Crenuchidae	*Poecilocharax*	*bovalii**
Characiformes	Erythrinidae	*Erythrinus*	*erythrinus*
Characiformes	Erythrinidae	*Hoplerythrinus*	*unitaeniatus*
Characiformes	Lebiasinidae	***Lebiasina***	**sp.**
Characiformes	Lebiasinidae	*Pyrrhulina*	*stoli*
Cyprinodontiformes	Rivulidae	*Anablepsoides*	*waimacui*
Cyprinodontiformes	Rivulidae	***Laimosemion***	**cf. *breviceps***
Gymnotiformes	Gymnotidae	***Gymnotus***	***carapo* group**
Gymnotiformes	Hypopomidae	*Hypopomus*	*artedi*
Perciformes	Cichlidae	*Crenicichla*	*alta*
Perciformes	Cichlidae	*Krobia*	*potaroensis*
Perciformes	Cichlidae	*Nannacara*	*bimaculata**
Siluriformes	Callichthyidae	*Callichthys*	*callichthys*
Siluriformes	Cetopsidae	*Helogenes*	*marmoratus*
Siluriformes	Heptapteridae	***Brachyglanis***	**sp.**
Siluriformes	Heptapteridae	*Chasmocranus*	*longior*
Siluriformes	Heptapteridae	*Rhamdia*	sp.
Siluriformes	Loricariidae	*Corymbophanes*	*kaiei**
Siluriformes	Loricariidae	*Hypostomus*	*hemiurus*
Siluriformes	Loricariidae	*Lithogenes*	*villosus**
Siluriformes	Trichomycteridae	*Trichomycterus*	*guianense*
Siluriformes	Trichomycteridae	***Trichomycterus***	**sp. "long"**
Siluriformes	Trichomycteridae	***Trichomycterus***	**sp. "small spots"**

Appendix 9

Complete list of ant genera

Subfamily	Genus
Amblyoponinae	*Cerapachys*
	Prionopelta
	Stigmatomma
Dolichoderinae	*Azteca*
	Dolichoderus
	Dorymyrmex
	Linepithema
Dorylinae	*Nomamyrmex*
	Eciton
	Labidus
	Neivamyrmex
Ectatomminae	*Ectatomma*
Formicinae	*Acropyga*
	Brachymyrmex
	Camponotus
	Gigantiops
	Myrmelachista
	Nylanderia
	Paratrechina
Myrmicinae	*Acanthognathus*
	Acromyrmex
	Allomerus
	Apterostigma
	Atta
	Basiceros
	Carebara
	Cephalotes
	Crematogaster
	Cyphomyrmex
	Daceton
	Hylomyrma
	Megalomyrmex
	Monomorium
	Myrmicocrypta
	Ochetomyrmex

Subfamily	Genus
	Octostruma
	Pheidole
	Procryptocerus
	Rogeria
	Sericomyrmex
	Solenopsis
	Strumigenys
	Trachymyrmex
	Tranopelta
	Wasmannia
Paraponerinae	*Paraponera*
Ponerinae	*Anochetus*
	Cryptopone
	Gnamptogenys
	Hypoponera
	Leptogenys
	Mayaponera
	Neoponera
	Odontomachus
	Pachycondyla
	Platythyrea
	Pseudoponera
	Rasopone
Proceratiinae	*Discothyrea*
Pseudomyrmecinae	*Pseudomyrmex*

Plunging 741 ft into an isolated gorge, Kaieteur Falls is one of the most powerful and spectacular waterfalls on the planet.

BIODIVERSITY ASSESSMENT SURVEY OF THE KAIETEUR PLATEAU AND UPPER POTARO, GUYANA

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