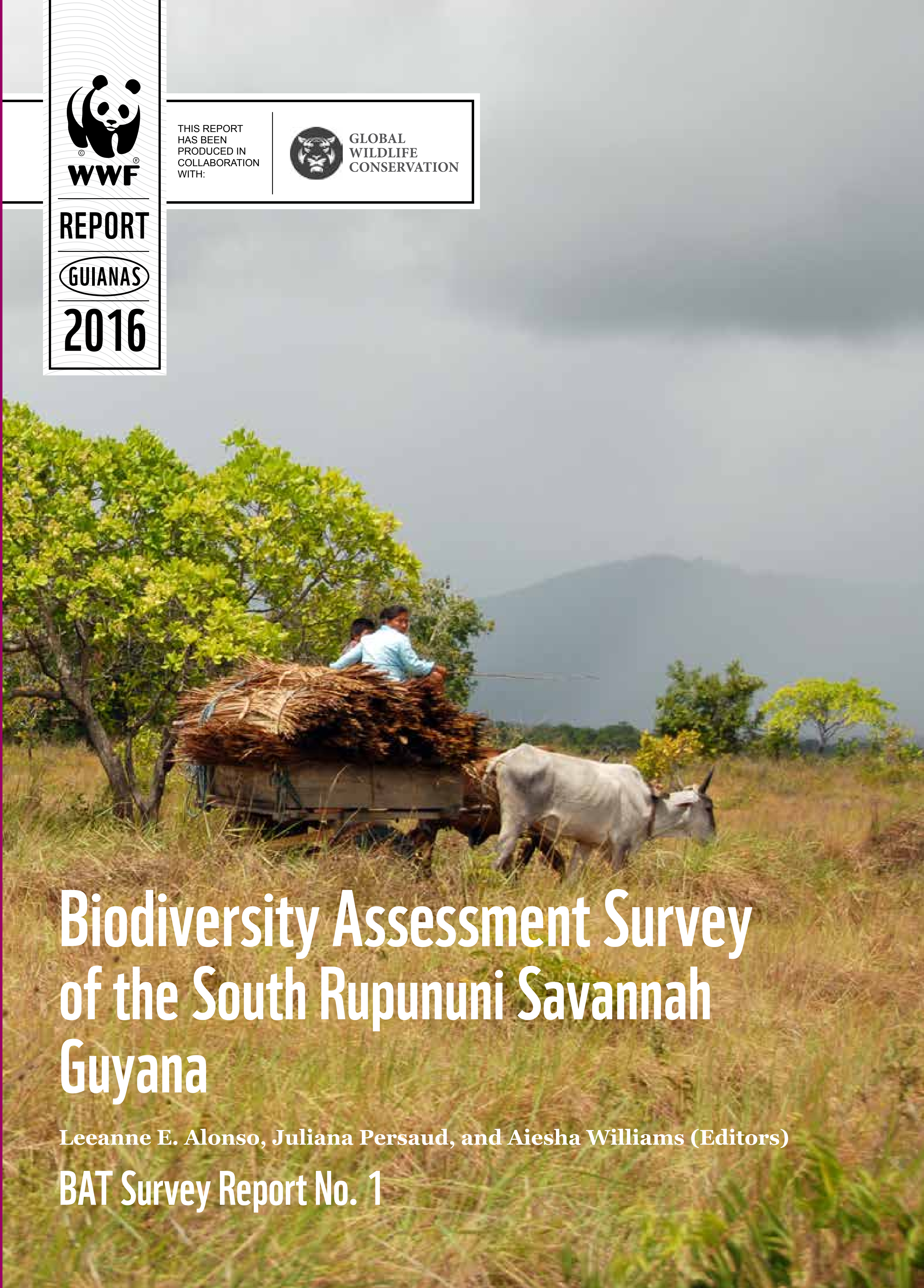

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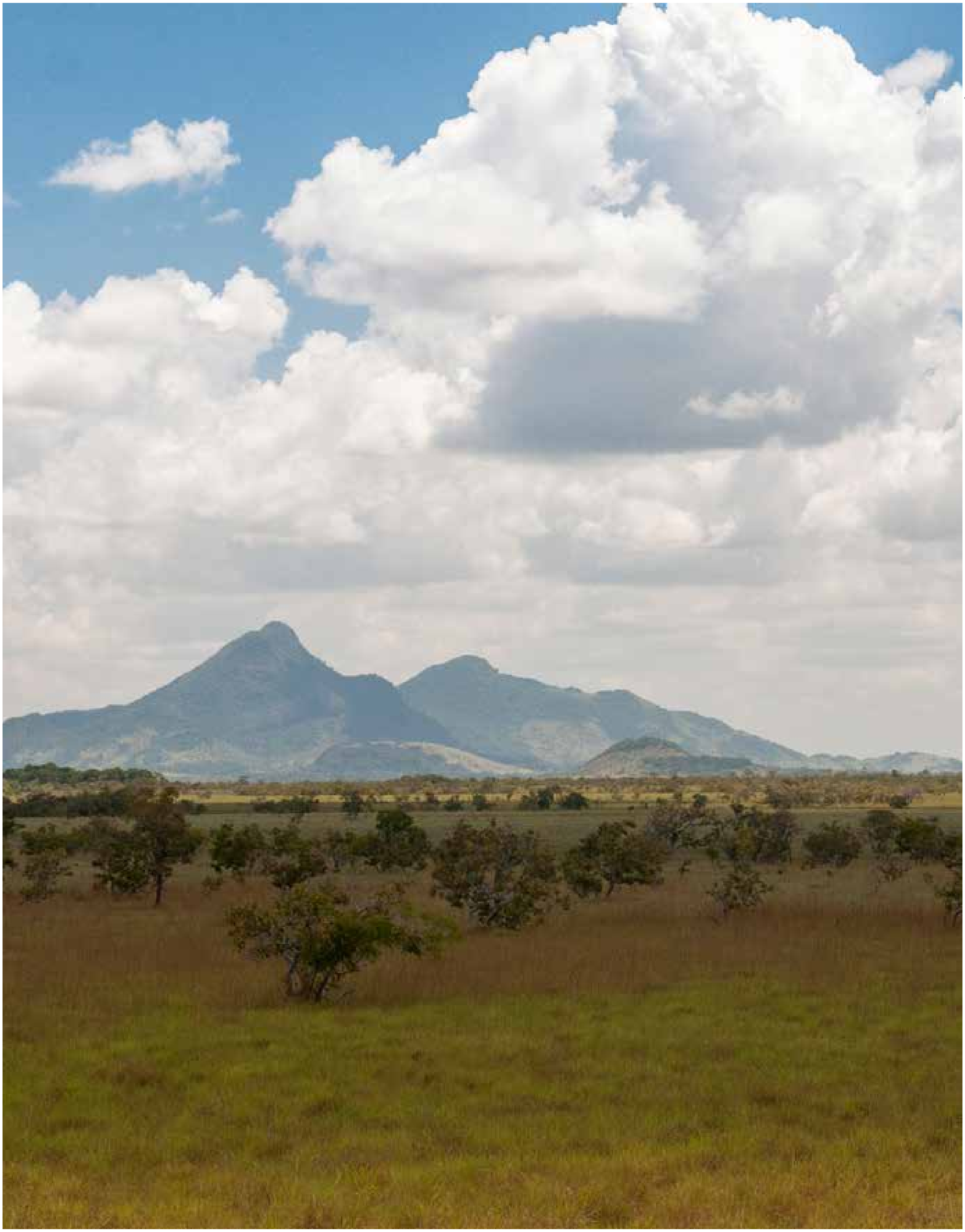
# Biodiversity Assessment Survey of the South Rupununi Savannah Guyana

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

BAT Survey Report No. 1



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**South Rupununi savannah landscape**

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**Cover Photo: Rupununi savannah © Vitus Antone**





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# Biodiversity Assessment Team survey

## Biodiversity Assessment Survey of the South Rupununi Savannah Guyana

***Field surveys were carried out from 22 October to 7 November 2013***

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

## BAT Survey Report No. 1

A publication of
WWF-Guianas and Global Wildlife Conservation
2016

Koninkrijk der Nederlanden

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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 (2016) publication represents the most recent (and in some instances the first) broad-based documentation of floral and faunal diversity in Guyana's southern Rupununi region.** The Biodiversity Assessment Team (BAT) surveys which were carried out in 2013 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 also captured, based on consultations with the local indigenous Wai-Wai and Wapishana communities, the species which are important to the cultural and socio-economic aspects of local livelihoods, and changes in their availability which have become apparent over the years.

The biodiversity assessment team (BAT) of experienced field biologists, taxonomists and student and local community research counterparts worked through challenging field conditions to survey, interpret and represent the ecological and socio-economic realities in a way that is meaningful to readers - whether academics, government officers involved in conservation planning, or those looking to gain general knowledge. We have by no means captured fully the incredible diversity of the southern Rupununi landscape, but the significance of these results has been enough to support several recommendations for conservation and management of the area. These are elaborated in the BAT Recommendations section as well as in each chapter, and we hope that in Guyana's conservation arena, it stimulates important discussions and mobilizes conservation actions.

WWF-Guianas and Global Wildlife Conservation remain 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*

THIS WWF (2016) PUBLICATION REPRESENTS THE MOST RECENT (AND IN SOME INSTANCES THE FIRST) BROAD-BASED DOCUMENTATION OF FLORAL AND FAUNAL DIVERSITY IN GUYANA'S SOUTHERN RUPUNUNI REGION

# Acknowledgements

WWF-Guianas and the entire Biodiversity Assessment Team (BAT) are sincerely grateful to all the organisations, communities and individuals that played a role in preparing for and carrying out the BAT expedition in 2013. Our deepest gratitude is extended to the toshaos, village councils, and people of the deep south and south-central Rupununi, and especially the villages of Potarinau, Sawariwau, Karaudanawa, Parabara and Shulinab for allowing us to visit their spectacular region and study their diverse landscapes and rich resources. We wish to thank the members of South Rupununi District Toshaos Council and the South Central People's Development Association (SCPDA), particularly Nicholas "Sparrow" Fredericks, for their assistance throughout the preparation and during the expedition.

We are grateful to Guyana's Environmental Protection Agency (EPA), particularly Dr Indarjit Ramdass and Ms Diana Fernandes, for assisting us throughout the process of acquiring permits. We also thank the Ministry of Amerindian Affairs (renamed the Ministry of Indigenous People's Affairs in 2015) and Mr Besham Ramsaywack, and Ms Sharon Hicks for their help with permits.

We express gratitude to the University of Guyana's Biology and Agriculture Departments and School of Earth and Environmental Sciences for identifying and allowing students to participate in the BAT expedition. Those seven students, energetic and enthusiastic participants in the expedition, have now returned to their departments with vastly increased field experience and research skills. We also appreciate the support of the Department of Biology and the Centre for the Study of Biological Diversity, especially the Dean, Dr Abdullah Ansari, Hemchandranauth Sambhu, Kaslyn Holder, and Elford Liverpool for loaning survey equipment, and for their assistance in efficiently processing the specimens for further study.

Thanks also to the Iwokrama International Centre for Rainforest Conservation and Development for loaning camera traps, and to Conservation International Guyana, especially Curtis Bernard and René Edwards and the Lethem office, for their technical and logistical assistance.

The BAT is grateful to the administrative and finance staff of WWF-Guianas and Global Wildlife Conservation (GWC), and especially Tonia Newton, who worked tirelessly to keep funds flowing throughout the survey's logistically challenging preparations. We thank Ana Denman and Sam Reza of GWC for their assistance with logistics and payments. Thanks also to Dale DeMendonca, for assistance during preparations and for safely transporting the BAT and all their gear around Georgetown, and Charles "Charlo" Hendricks, for expert bush driving and sage advice that opened up the hidden treasures of the Rupununi. The drivers of all the trucks and boats were patient with our unusual pursuits and schedules, and got us there and back safely. We had well-prepared campsites, excellent and plentiful food (Fayonne and Nicolas overseeing it all!) and good weather (for the most part), and it all contributed to an outstanding expedition.

Patricia “Miss Pat” Fredericks knows and is known in every corner of the Rupununi. Without her rich history, deep understanding, extensive contacts, and sage council-on-everything this expedition would have had a much bumpier road.

Lastly, WWF-Guianas would like to acknowledge the dedication and hard work of the entire team: the lead researchers, research assistants, field guides and logistics support staff. Their enthusiasm, expertise and teamwork during the entire expedition led to its 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 and small mammals, fishes, aquatic beetles, katydids and ants, as well as expertise in measuring water quality. A training component was also included as part of the BAT expedition; seven undergraduate students from the University of Guyana and 13 local community residents participated in the surveys and, at the conclusion of the fieldwork, a series of training workshops were offered to UG students in Georgetown. 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. The BAT survey was initiated by WWF-Guianas, Guyana office, with the close collaboration of Global Wildlife Conservation, the South Central People's Development Association and the University of Guyana. Other partners included Conservation International-Guyana and Panthera.

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# The BAT Expedition

**OBJECTIVES**
A Biodiversity Assessment Team (BAT) from the World Wildlife Fund Guianas (WWF-Guianas) and Global Wildlife Conservation (GWC) carried out a South Rupununi expedition in 2013 to obtain a snapshot of the region's biodiversity and environment, collecting data on seven taxonomic groups (mammals, birds, reptiles, amphibians, fish, insects and plants) as well as on water quality. To understand biodiversity use, its role and relationship to local livelihoods, we also undertook an assessment of the usage of natural resources by indigenous communities located close to the study sites. This information establishes a baseline which we hope will be used by all stakeholders, including the Government of Guyana, the University of Guyana, NGOs, local communities, and businesses to guide further research and to make informed decisions about sustainable management of the Rupununi's resources.

**SURVEY SITES**
The Rupununi survey was carried out by the biodiversity assessment team (BAT) in two under-studied areas of the southern Rupununi savannah – Kusad Mountain and Parabara. The survey focused on freshwater and terrestrial habitats within the savannah, savannah-forest, and riverine ecosystems. The areas visited included a number of distinct savannah types: forests, including rainforest, dry and riparian forest; bush islands and seasonal wetlands; and creeks, rivers, and lakes. Four indigenous communities adjacent to the study sites - Potarinau, Sawariwau, Karaudanawa, and Parabara (Eropoimo) – were also included in the BAT survey as part of a natural resource use component (see Figure E for location of study sites).

1) **Site 1: Kusad Mountain.** Base Camp at N 2.81245 W 59.8666, 125 m elevation. 23-29 October 2013. In general, the extent of the site can be described as follows: in and around the forested Kusad Mountain about 40 miles south-southeast from Lethem, in an area drained by the Skabunk and Sawariwau Rivers, tributaries of the Takutu, and very close to a series of wetlands, which in flooded periods merge the Takutu (Amazon) and Rupununi (Essequibo) watersheds. Kusad is a sprawling rocky mountain surrounded by savannah. Principal habitat types surveyed included savannah, bush islands, gallery forests, creeks, rivers and rocky outcrops. Potarinau (Ambrose) and Sawariwau villages are adjacent to this site and were included in the component which examined the local use of natural resources.

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Figure A **Understory habitat on the rocky Kusad Mountain**

© Nelanie LaCruz

Figure B **Seasonal wetland habitats in the savannahs of the southern Rupununi, like those nearby Kusad Mountain, are an important feature of the landscape, recharging freshwater aquifers, and providing food for communities and habitats for many species of fish and migratory birds. Kusad Mountain lies in the background.**

2) **Site 2: Parabara.** Base Camp at N 2.18201 W 59.33704, 245 m elevation. 30 October – 5 November 2013. The second site was situated approximately 10 km north of the Parabara area, in savannah beside gallery forest bordering the Bototo Wau creek, as far south as could be travelled by road in the Rupununi, and west of the Marudi Mountains. In this area, the savannah begins to give way to rainforest; patches of forest in savannah become patches of savannah in forest. Bush islands and riverine forests still occur along creeks, but are located among blocks of rainforest. The creeks here flow into the Kuyuwini River, a tributary of the Essequibo River. The indigenous communities of Parabara (Eropoimo) and Karaudanawa are located in close proximity to this site, and were surveyed as part of the natural resource use component of this expedition.

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Figure C **Riverine forest along the creek near the Parabara base camp.**
**At Parabara, the extensive savannahs begin to merge with rainforest habitats.**

© Leeanne Alonso

Figure D **Savannah habitats and their bush islands create connectivity with rainforest habitats and this helps many animal species to thrive in the Rupununi.**

## MAP - LOCATION OF SURVEY SITES

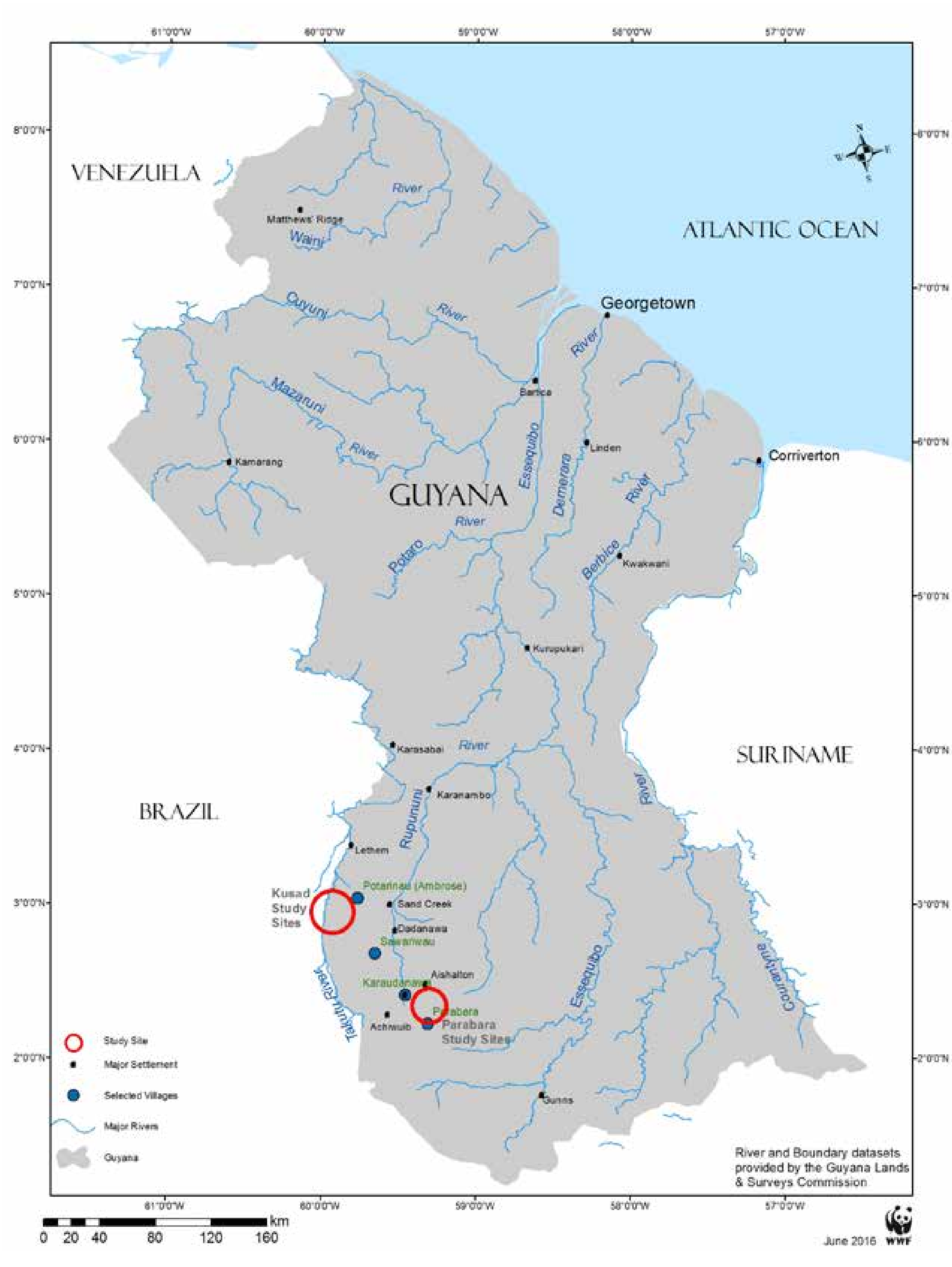


Figure E **Location of Kusad Mountain and Parabara survey sites, including indigenous communities surveyed within the areas.**

# Context: Ecological Importance of the Southern Rupununi Savannah

## An overview and contributory factors to biological diversity

The savannahs of the South Rupununi are part of an extensive, biologically rich region situated in southwestern Guyana – the Rupununi savannah. It is separated from the North Rupununi by the Kanuku Mountains, a heavily-forested range that stretches for about 100 km in an east-to-west direction and is about 50 km wide (PAC 2015). In 2011, the Kanuku Mountains were declared a protected area, and is one of only four sites currently part of Guyana's national system of protected areas. The savannahs of the Rupununi are the largest such ecosystems in the country and in the Guianas (see Figure F). It is bounded by the Pakaraima Mountains (north), the Marudi Mountain (southeast) and the headwaters of the Kuyuwini River (southwest). Ecologically, it is part of a larger, transboundary savannah ecosystem that extends into the Brazilian state of Roraima (Daniel 1984).

The Rupununi savannah sits on ancient Precambrian rocks formed over 1.7 million years ago. Geological processes, including erosion and sedimentation, have resulted in some unique, contrasting landscape features in the north and south savannahs (Daniel 1984, Watkins 2010). The biological diversity that presents itself today is a consequence of this long geological history that has also influenced socio-cultural and economic development.

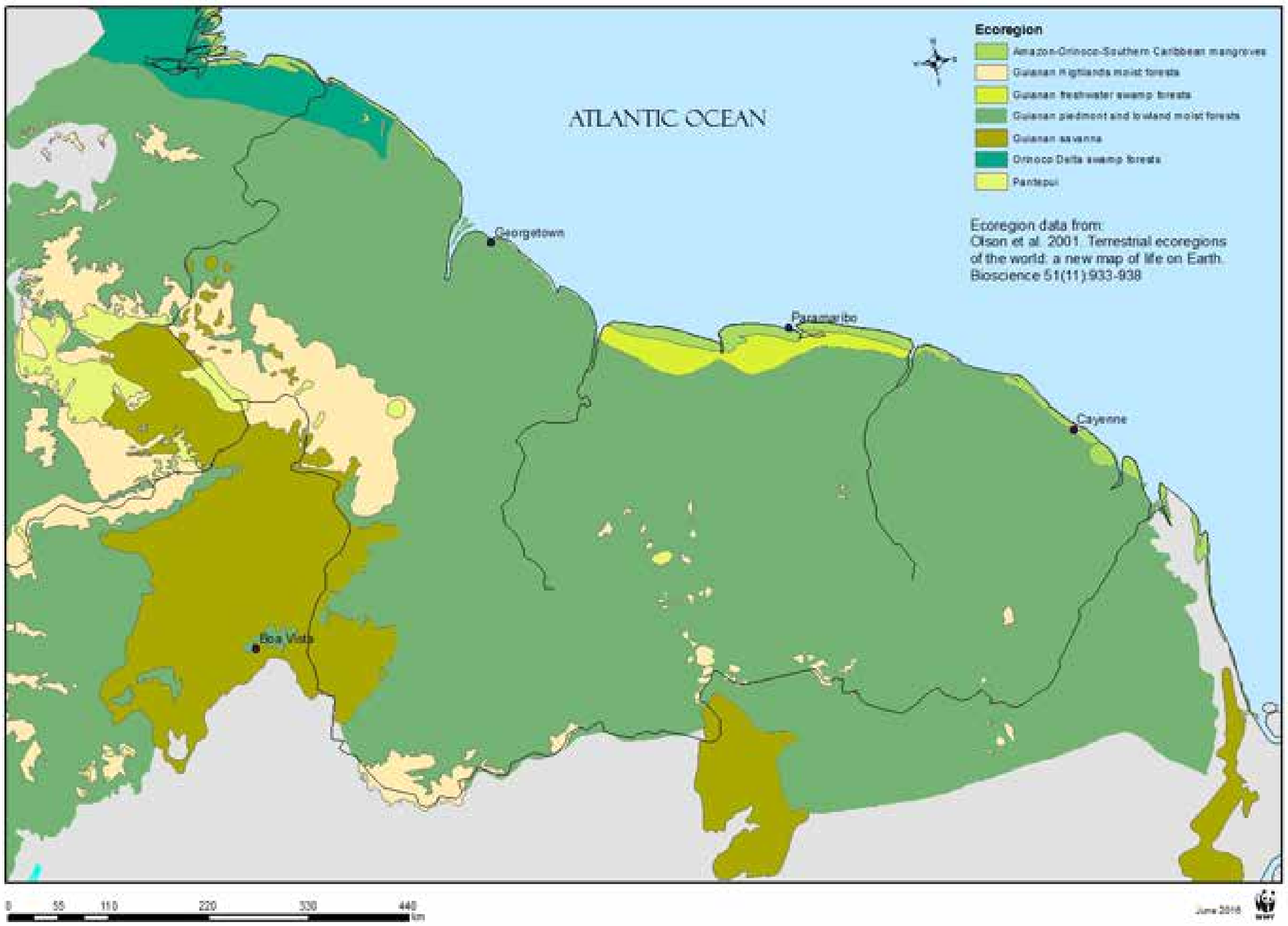


Figure F **The Rupununi savannahs are the largest such ecosystem in the country and the wider Guianas.**

The Rupununi is one of Guyana's most unique and diverse ecosystems, and among the last great wilderness areas on Earth. It is home to more than 5,400 known species, including 70% (1,414) of all vertebrates recorded in Guyana, and to many species which are highly endangered globally (Jansen-Jacobs and ter Steege 2000, Hollowell and Reynolds 2005, DIREN 2006, Conservation International 2003, Funk et al. 2007 in WWF 2012, Helms et al. WWF 2016, Pos et al. WWF 2016, and Watkins et al. 2010). These include many iconic Amazonian species; the jaguar (*Panthera onca*), giant river otter (*Pteronura brasiliensis*), harpy eagle (*Harpia harpyja*), Brazilian tapir (*Tapirus terrestris*), giant anteater (*Myrmecophaga tridactyla*) and giant armadillo (*Priodontes maximus*).

In the southern Rupununi, high levels of biological diversity can be primarily attributed to several factors:

*(a) Extremely diverse and closely packed habitats*

The area is a mix of tropical savannah grasslands, "bush-islands" (isolated, usually small forest patches), gallery forest, seasonally flooded wetlands, creeks, rivers, lowland forests and rocky outcrops. *Curatella americana* (locally referred to as the "sandpaper tree" or "caimbe") groves which occur at the forest to savannah interface in the southern Rupununi serve for example as nesting sites for the Red Siskin – a bird that has been largely extirpated in the wild and is now critically endangered (Robbins et al. 2003). Forested rocky outcrops, such as Kusad, which are not found in the northern Rupununi area, act as stepping stones or refuges for wildlife, bridging the southern savannah and the forested Kanuku Mountain (Daniel 1984, Paemelaere et al. WWF 2016, Pos et al. WWF 2016). Phytogeographically, the Rupununi savannah represents an extension of the Rio Branco savannahs in Brazil, and is therefore distinct from the other parts of Guyana (Berry et al. 1995, in Jansen-Jacobs and ter Steege 2000). In addition, several plant species found within the southern savannah have restricted ranges and this adds to the distinctiveness of the area (Pos et al. WWF 2016).

*(b) Mixing of Amazonian and Guiana Shield fauna, and marked seasonal variability, including flooding*

There is a very distinct 'wet' and 'dry' season in the Rupununi. The dry season lasts from September to April each year, and during this time water levels drop significantly, exposing river and creek beds. The wet season is from May to August and is marked by heavy rainfall which results in extensive flooding and the conversion of dry savannah grasslands into seasonal wetlands. Flooding in the low-lying savannah areas during the rainy season creates a complex hydrological connection between the Amazon and Essequibo river systems, and allows for the exchange of fauna, particularly freshwater fishes, which increases diversity (de Souza et al. 2012) and can promote gene flow (Lovejoy and de Araujo 2000). This modern hydrology system and diversity and distribution of some fish species are suggested to have their roots in a huge, ancient river that may have once drained the Central Guiana Shield – the Proto-Berbice river (Lujan 2008, Lujan and Armbruster 2011, Daniel 1984). This river would have flowed through the northern Rupununi savannahs, to drain 'portions of Roraima state, Brazil, most of Guyana, and parts of southern and eastern Venezuela and western Suriname' into the Atlantic Ocean near the mouth of the Berbice River (Lujan 2008, Lujan and Armbruster 2011). The role of the Rupununi area as a corridor in creating landscape connectivity, promoting ecosystem resilience and functioning, and enhancing biodiversity values also extends to other species within the Rupununi and the wider Guiana and Amazonian region (Montambault and Missa 2002). Several species of migratory North American shorebirds, for example, use the southern savannahs as a stop-over point (Robbins et al. 2004), as do several species of swallows and flycatchers from southern South America, seeking new habitats during the austral winter (O'Shea et al. WWF 2016).

*(c) Recent historical factors*

Recent historical factors such as its relative isolation, low human population densities, traditional lifestyles, minimal road infrastructure and connectivity, and few viable transportation options have limited the scale of economic expansion, thus contributing to the current status of high biodiversity.

## Biodiversity knowledge and data gaps

The southern Rupununi has only recently been subject to formal biodiversity assessments. Logistical challenges, remoteness, and scarcity of financial resources have limited both collecting frequency and intensity. Some important contributions to our understanding of the area's species composition and abundance, prior to this BAT survey, are elaborated below.

(i) There are not many published avifaunal studies available. Mees & Mees-Balchin (1990) and Mees (2000) documented birds in the region during 1989 and 1992 (Robins et al. 2004). More recently, collections were done in the eastern Kanuku Mountains (Finch et al. 2002), and in five sites in South Rupununi by the Smithsonian Institution and the University of Kansas (Robins et al. 2004) which also included Parabara savannah and Kusad Mountain, our own two general study sites (WWF 2016). A total of 456 bird species was recorded, including the critically endangered Red Siskin (*Spinus cucullatus*) and several new species for Guyana (Robins et al. 2004). With additions from this BAT survey, the total number of bird species is 487, of which 32 are new records for the southern savannah. This diversity is representative of more than 50% of Guyana's known bird species (O'Shea et al. WWF 2016). Community-led initiatives, such the Red Siskin monitoring project undertaken by the South Rupununi Conservation Society, have contributed invaluable information on the biology and ecology of species, greater awareness among local people, and positive conservation outcomes. In the case of the Red Siskin, its capture by local caged-bird traders has been stopped and a more sustainable form of income provided through birdwatching.

(ii) Mammalian diversity in the southern savannahs has received some amount of attention. Paemelaere and Payán Garrido (2012), Payán et al. (2013), and Sanderson and Ignacio (2002) have contributed to documenting the area's large mammals. Traditional knowledge of the local indigenous peoples has made an important contribution to what is known about this sub-group in particular (Paemelaere et al. WWF 2016). The results, such as the presence of top predators like the jaguar (*Panthera onca*), are indicative of an ecosystem that has maintained its stability and functionality. Apex predators are sensitive to ecosystem disturbances, including pollution and habitat fragmentation; their density is correlated to indicators of ecosystem productivity which, in turn, predicts biodiversity value; large numbers of primary and secondary prey species are a necessary requirement of their diet (Sergio et al. 2008). Small-mammal species, which include opossums and bats, were surveyed in the eastern Kanuku Mountains (Lim and Norman 2002), and collections from the Kwitaro River, Rewa River and Dadanawa Ranch have been reported by Emmons (1993). Small mammals comprise the majority of species within the mammal taxon (over 50 per cent) and are important in ecosystem regeneration - dispersing seeds, pollinating flowers and regulating the population of insects which damage vegetation (Lim et al. WWF 2016)

(iii) **The state of reptiles, amphibians, and invertebrate groups such ants and aquatic beetles were previously unknown in the southern Rupununi savannah and studies of fishes were confined to the eastern part of the Kanuku Mountains** (Mol 2002). **These taxa are poorly known in Guyana (and the Guianas) and are generally under-represented in biodiversity assessments. The records provided by this BAT are therefore invaluable in addressing this knowledge shortfall as we seek to improve our understanding of the biological (and socio-economic) value of the savannah ecosystem.** The abundance and composition of species within these taxa suggest that aquatic and terrestrial habitat quality is good, in general. The existence of such diverse groups of fauna in the southern Rupununi savannah is not possible without correspondingly high levels of floral diversity. Jansen-Jacobs and ter Steege (2000) and Diaz (2002), for example, suggest that the vegetation is largely intact, not having been historically subject to large-scale land conversion activities such as commercial agriculture. However, the increasing accessibility afforded by growing road networks has been identified as a threat to its biodiversity (Diaz 2002).

(iv) Natural resource use assessments also provide data on the taxonomic groups surveyed during our BAT survey, with the added value of putting into perspective their importance to the livelihoods, culture and development of local peoples. A sustainable land-use plan, *Thinking together for those coming behind us - An outline plan for the care of Wapichan territory in Guyana South Rupununi* (South Central and South Rupununi Districts Toshaos Councils, 2012) and *Wa Wiizi – Wa Kaduzu (Our territory – Our Custom): Customary Use of Biological Resources and Related Traditional Practices within Wapichan Territory in Guyana* (David et al. 2006) are two recent efforts in the South Rupununi which have been led by indigenous peoples. Community resource evaluations were also completed as part of the process to establish the Kanuku Mountains as a protected area (Stone 2002).

## Indigenous peoples and biodiversity

The biological importance of the region is intrinsically related to the socio-cultural systems of indigenous Wai- Wai and Wapishana peoples living in the southern Rupununi savannah (David et al. 2006, South Central and South Rupununi Districts Toshaos Councils 2012). Their customary land-use practices, resource-use rules and cultural practices - such as those relating to the timing of hunting and fishing, and the species to be harvested – play an important role in maintaining generally high levels of diversity (Read et al. 2010, South Central and South Rupununi Districts Toshaos Councils 2012). While indigenous lifestyles remain largely traditional, with people continuing to depend on the savannah, wetlands and forest, much has changed. People live in a cash-based economy, some customs have been lost and family units are less cohesive, for example, and this affects the way that resources are perceived, used and conserved over time. While this translates into increased environmental costs such as pollution from gold mining, it provides added impetus for conservation. For example, recent community-level discourses outlined in a plan designed 'for the care of the Wapichan territory in Guyana' (titled community lands and traditional lands in the South Rupununi) reflect their desire to engage with REDD+ (Reducing Emissions from Deforestation and Forest Degradation), and payment for watershed services as a means of incentivizing community members to use resources wisely (South Central and South Rupununi Districts Toshaos Councils 2012).

## Threats to biodiversity

**Several threats to biodiversity have emerged in recent times which, if unchecked, can have significant impacts on ecosystems and their ability to generate benefits.** The threats are briefly outlined here; however the individual chapters and the section entitled "BAT Recommendations for Conservation and Management" contextualize and elaborate on these in detail.

SEVERAL THREATS TO BIODIVERSITY HAVE EMERGED IN RECENT TIMES WHICH, IF UNCHECKED, CAN HAVE SIGNIFICANT IMPACTS ON ECOSYSTEMS AND THEIR ABILITY TO GENERATE BENEFITS

*Overharvesting of wildlife*

Overharvesting of wildlife is a primary threat to biodiversity in the southern Rupununi brought on by increasing external demands, greater access to once isolated areas and the use of advanced harvesting techniques. Species sold in the pet trade such as the Towa-towa songbird (*Sporophila angolensis*, formerly called *Oryzoborus angolensis*); those used for food, like freshwater fishes (Haimara – *Hoplias aimara*), game reptiles (red and yellow-footed tortoises – *Chelonoidis carbonaria, C. denticulata*) and mammals (savannah deer – *Odocoileus virginianus*); and palm and timber trees are affected (Fredericks et al. WWF 2016). The effects of overharvesting are not widespread as yet, however.

*Habitat Degradation and Fragmentation*

**Gold mining affects aquatic and terrestrial ecosystems through increased turbidity, erosion, mercury pollution and loss of forest cover and wildlife. The problem is further compounded by illegal miners operating in some sections of the southern Rupununi. Regular burning of the savannah is another contributory factor, affecting species inhabiting the grassland and 'bush-islands'. During intense dry periods, these fires can also spread to forested sites as well, destroying vegetation. In addition, there is growing interest regarding agricultural expansion in the savannahs for large-scale crop cultivation (rice and soya beans). Already in parts of the North Rupununi, rice is being cultivated at commercial scales** (Stabroek News 2014; Elias 2014) **and the extensive cultivation of soya bean and other crops has been proposed** (Stabroek News 2015; Disarz, undated; Ministry of Agriculture 2013). **Soils in these areas are nutrient poor and require heavy, frequent inputs of fertilizers in order to achieve yield targets. The insecticides used for pest control along with the fertilizer run-off infiltrate water sources, resulting in contamination.**

*Erosion of traditional knowledge and language*

The drivers of the erosion of traditional knowledge and language are a complex mix of socio-cultural and economic factors, including lack of intergenerational transmission, disinterested youth, migration and globalization of trade and

**GOLD MINING AFFECTS AQUATIC AND TERRESTRIAL ECOSYSTEMS THROUGH INCREASED TURBIDITY, EROSION, MERCURY POLLUTION AND LOSS OF FOREST COVER AND WILDLIFE. THE PROBLEM IS FURTHER COMPOUNDED BY ILLEGAL MINERS OPERATING IN SOME SECTIONS OF THE SOUTHERN RUPUNUNI.**

communications, but the evidence suggests that their loss negatively affects biodiversity conservation (Loh and Harmon 2014, UNESCO 2015a). This loss of knowledge and language has been recognized by communities in the southern Rupununi, but there has been some effort to preserve indigenous languages, for example the Wapishana Language Project (2000). Both the Wai-Wai and Wapishana languages have been listed as vulnerable in the *UNESCO Atlas of the World's Languages in Danger* (UNESCO 2015b).

## Conservation importance

To date, our knowledge of the southern Rupununi savannah points to its high conservation value for both people and nature. **The savannah is a critical contributor to the livelihoods and culture of indigenous people:** *"We cannot live without our savannahs. We depend on these lands for our daily lives. The savannah provides us with fresh green pastures for our livestock and it has ité groves, swamps and ponds that are important to us and the birds, animals and wildlife. Savannahs support game and fishes that we use for food..."* (Achawib[1] Community, 2009 - South Central and South Rupununi Districts Toshaos Councils 2012). Its resources are used to generate important, sustainable income for communities. Nature-based tourism, and research initiatives involving the jaguar (*Panthera onca*), freshwater turtles (*Podocnemis expansa* and *Podocnemis unifilis*) and the highly endangered Red Siskin (*Spinus cucullatus*), spearheaded by the South Rupununi Conservation Society (a major community-based organisation in the area), are good examples. **The high levels of species and habitat diversity and endangered fauna in the savannah, as well as its role in the provision of critical ecosystem services such as freshwater, also make the savannah an important area for conservation, particularly because of its vulnerability to large-scale impacts.** Forested rocky outcrops which are common in the southern savannah create connectivity between the forests further south and the Kanuku Mountains Protected Area, and this plays an important role in maintaining the health and resilience of wildlife.

**Effective protection and sustainable use of both the South Rupununi savannah as well as the wider Rupununi savannahs are a necessary part of maintaining Guyana's natural heritage.** Sustainable options for the livelihood, well-being and development of Wapishana and Wai-Wai peoples living in the area are therefore very important to achieve the protection of the savannahs. Although these savannah ecosystems (as well as those in the North Rupununi) are not part of the current protected area network, indigenous community-driven initiatives have led to the development of a land-use plan to support village councils to protect important resources (South Central and South Rupununi Districts Toshaos Councils 2012). Building on such local initiatives, strengthening partnerships and participatory approaches, and empowering communities are important for positive conservation outcomes.

[1]Also spelt Achiwuib.

## Conclusion

Guyana's Rupununi savannah region is a unique and diverse mosaic of ecological habitats with high species diversity, and is very important in the safeguarding of the culture and livelihoods of indigenous peoples. Considering these biological and socio-cultural roles of the savannah, its protection therefore becomes vital, and even more so in view of local and global threats to its persistence. Much remains to be discovered, recorded and understood about the species and habitats of the southern Rupununi savannah. This BAT survey helps to fill some of the gaps; however, additional research to support the management of wildlife, freshwater and other natural resources, including anthropogenic impacts on these, should be undertaken to aid and enable effective decision-making and action for the conservation of the area.

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# The Bat Expedition – Findings In Brief

**BAT survey dates:** 22 October–7 November 2013

**BAT survey sites:** Kusad Mountain and the Parabara region, southern Rupununi savannah, Guyana

**Summary of results**

The most striking characteristic of the South Rupununi savannah region is its diversity of habitats, reflected in the high species richness and ecological diversity of the flora and fauna. This diversity flows from the unfragmented nature of the landscape, where natural processes such as fire and flood go unhindered to mould the landscape into a variety of forms. Varying local conditions create intermixed patches of different habitats, each harbouring a unique fauna, resulting in high species turnover within relatively small areas. Covered in forests and spanning a range of elevations, isolated mountains such as Kusad harbour many unique species, and the tallgrass savannahs which lie at the base of these differ from more exposed shortgrass savannahs. Similarly, fingers of riparian forest allow rainforest communities to penetrate deep into the Parabara savannah. Even bush islands, a relatively transient habitat with few or no unique species, play an important role by sheltering a subset of forest species within a grassland matrix. **Maintaining the large-scale integrity of the landscape, rather than viewing its component parts in isolation, is therefore essential for its effective conservation.**

**Number of species documented during the BAT survey**

| Taxonomic Group | KUSAD | | PARABARA | | TOTAL | | BETWEEN SITES | | |
|---|---|---|---|---|---|---|---|---|---|
| | #species | #species new to science | #species | #species new to science | #species (# genera) | #species new to science (# genera) | #species in common (%) | #new records for South Rupununi | #new records for Guyana |
| Plants | 102[1] | - | 78[1/2] | - | 180 | - | 17[1/3] | | |
| Ants | 109 | 10-25% | 115 | 10-25% | 175 (48) | 10-25% | 48 (27%) | ~175[4] | 14 |
| Aquatic Beetles | 127 | ~10 | 125 | ~6 | 201 (72) | 15 (4) | 51 (25%) | >90% | >75% |
| Birds | 201 | 0 | 344 | 0 | 487 | 0 | 151 (31%) | 32 | 0 |
| Amphibians | 12 | | 20 | | 27 (9) | | 5 (19%) | 10 | 2 |
| Reptiles | | | | | 30 | | | | |
| Large Mammals | 15 | | 14 | | 17 | | | | |
| Bats | 22 | - | 25 | 1 | 35 | 1 | 12 (34%) | 1 | 1 |
| Rodents | 1 | - | 1 | - | 2 | - | 0 (0%) | 0 | 0 |
| Fish | 114 | 9 | 85 | 6 | 168 | 12 | 44 (26%) | 12 | 10 |

[1] Morphospecies
[2] Sampled in the four main vegetation types
[3] Morphospecies in common between the two 0.5 ha plots (Parabara area)
[4] No previous surveys of ants had been done

**Number of Species of Conservation Concern recorded during the BAT survey**

| Taxon | Species | IUCN Red List or CITES Category | Notes / English Common Names |
|---|---|---|---|
| **Ants** | *Gnamptogenys ammophila* | | Restricted range; previously known only from a single watershed in Venezuela |
| **Birds** | *Tinamus major* | Near Threatened | Great Tinamou |
| | *Crax alector* | Vulnerable | Black Curassow |
| | *Mitu tomentosum* | Near Threatened | Crestless Curassow |
| | *Odontophorus gujanensis* | Near Threatened | Marbled Wood-Quail |
| | *Spizaetus ornatus* | Near Threatened | Ornate Hawk-Eagle |
| | *Psophia crepitans* | Near Threatened | Gray-winged Trumpeter |
| | *Patagioenas subvinacea* | Vulnerable | Ruddy Pigeon |
| | *Ramphastos tucanus* | Vulnerable | White-throated Toucan |
| | *Ramphastos vitellinus* | Vulnerable | Channel-billed Toucan |
| | *Pyrilia caica* | Near Threatened | Caica Parrot |
| | *Epinecrophylla gutturalis* | Near Threatened | Brown-bellied Antwren |
| | *Myrmotherula surinamensis* | Vulnerable | Guianan Streaked-Antwren |
| | *Hypocnemis cantator* | Near Threatened | Guianan Warbling-Antbird |
| | *Myrmornis torquata* | Near Threatened | Wing-banded Antbird |
| | *Polystictus pectoralis* | Near Threatened | Bearded Tachuri |
| | *Spinus cucullatus* | Critically Endangered | Red Siskin |
| **Amphibians** | *Ameerega trivittata* | CITES Appendix II | |
| | *Allobates femoralis* | CITES Appendix II | |
| **Reptiles** | *Chelonoidis carbonaria* | CITES Appendix II | Red-footed tortoise |
| | *Tupinambis teguixin* | CITES Appendix II | Gold tegu |
| | *Corallus caninus* | CITES Appendix II | Emerald tree boa |
| | *Corallus hortulanus* | CITES Appendix II | Amazon tree boa |
| | *Eunectes murinus* | CITES Appendix II | Green anaconda |
| | *Crotalus durissus* | CITES Appendix III | Neotropical rattlesnake |
| **Large Mammals** | *Tapirus terrestris* | Vulnerable | Brazilian tapir |
| | *Panthera onca* | Near Threatened | Jaguar |
| | *Mazama americana* | Data Deficient | Red brocket deer |
| | *Tayassu pecari* | Vulnerable | White-lipped peccary |
| | *Myrmecophaga tridactyla* | Vulnerable | Giant anteater |
| **Bats** | *Lonchorhina orinocensis* | Vunerable | |
| **Fish** | *Arapaima* sp. (not collected, reported by locals) | Not assessed | The species in Guyana should be listed as Endangered, because it is not the same species as the common one in the Amazon (*Arapaima gigas*), which is listed as Data Deficient. |
| | *Potamotrygon* spp. (not collected, reported by locals) | Most species are listed as Data Deficient | Freshwater stingrays were reported as extirpated from the upper Kuyuwini, which may or may not be true. They are usually killed whenever captured because of the wounds they cause. |
| | *Hoplias aimara* | Not assessed | Possibly threatened by overfishing. |

## RESULTS BY SITE

### Kusad Site

The survey in the Kusad area, from 23- 29 October 2013, was centred around the Kusad Mountain, a large 125 m tall forested rocky outcrop, surrounded by savannah. Fauna were sampled in eight habitat types. At Kusad these included dry forest on Kusad Mountain, montane forest at the top of the Kusad Mountain, and tallgrass savannah. At Parabara, habitats included bush islands, rainforest, and shortgrass savannah. Flora was sampled within four main vegetation types: savannah, bush-islands, rocky outcrops and gallery forests. For the Kusad area, a total of 102 plant morphospecies were recorded, many of which are not found in the more northern Rupununi area. A total of 109 ant species were documented from the Kusad area, nine of which were new country records for Guyana, including one restricted-range species (*Gnamptogenys ammophila*) previously known only from a single watershed in Venezuela. The Kusad herpetological surveys yielded 14 species of amphibians and 26 species of reptiles. Of the 23 species of small mammals documented from Kusad, the Orinoco sword-nosed bat (*Lonchorhina orinocensis*), listed as vulnerable on the IUCN Red List, represents a new country record for Guyana, or a distributional range extension of approximately 700 km from its previous known occurrence in the savannahs of Venezuela and Colombia.

Aquatic habitats sampled for fishes included blackwater streams over sandy substrates and shaded by palm forests; sunny marsh habitats in grassland savannahs; large rocky substrate river rapids; muddy-bottomed streams; mixed substrate creeks (sand, rock, leaf litter), and tiny primary streams in dense forest. Due to the nature of the annual flood pulse in the Rupununi, these habitats all rise and fall with the rain pulse, often coalescing as streams and rivers rise above their banks to overflow onto the surrounding savannah. The fish team spent more time, and sampled a much wider variety of habitats at Kusad than at Parabara, and thus obtained significantly more fish species there (114), including several species that are probably new to science. Aquatic beetles were sampled from forested streams and hygropetric seepage habitats on Kusad Mountain itself, several larger creeks and rivers with rocky substrates, and numerous isolated ponds and marshes in the surrounding savannah. The large array of aquatic habitats in the region resulted in an extremely diverse water beetle fauna.

**Parabara**

At Parabara, a total of 78 plant morphospecies were recorded within four main vegetation types, and 75 within two plots which had been set up. In this region, the bush islands increased in number and size closer to the continuous rainforest, creating a transition from savannah to forest. Several woody species are quite commonly collected in the southern Rupununi (e.g. *Senna multijuga, Platymiscium trinitatis* and *Securidaca diversifolia*) but have not been recorded as present in the northern Rupununi. Furthermore, the two additional 0.5 ha plots revealed high regional diversity of tree composition over a small geographic distance. At least 115 ant species were collected at Parabara. Twenty-two species of amphibians and 18 species of reptiles were documented for Parabara. Based on biodiversity measures of species estimators and diversity indices, Parabara was more species rich and diverse for small mammals than Kusad.

Aquatic habitats included a small stream with a strip of riparian forest, and the large Kuyuwini River and forested pools and creeks near the village of Parabara. At least 85 species of fish were documented here, several of which may be new to science, and included many species with potential for sustainable harvest as ornamental aquarium fishes. The forested aquatic habitats yielded many new and interesting species of aquatic beetles, some of which were previously only known from Brazil or are new to science.

## RESULTS BY TAXON

### Plants

Plant diversity was surveyed in four main vegetation types at the two sites: savannah, bush-islands, rocky outcrops and gallery forests. Overall, 180 morphospecies of plants were documented: 105 species of trees or treelets; 26 species of bushes, woody herbs, climbers and vines; 15 species of grasses, sedges and rushes; and 34 herbaceous species. At Parabara, two 0.5-hectare plots were also set up to investigate the tree species composition. Of 75 morphospecies recorded in these plots, 36 were positively identified, with only three out of these latter found in both plots), revealing high regional tree diversity even within relatively short distances. Many plant species documented during this study are not common across the South American savannahs and have a more restricted range. As such, the South Rupununi savannah contributes greatly to the floristic diversity and species richness of northern South America.

### Ants

A total of 175 ant species was documented at the two sites, from 48 genera and 10 subfamilies. This represents the most diverse ant fauna yet documented in Guyana or Suriname, and further sampling would undoubtedly increase the total number of species. Fourteen species (16% of identified species) are new country records for Guyana, and 10 species (12% of identified species) are new records for the Guianas as a whole (Guyana, Suriname and French Guiana). Many species, perhaps over 25%, are likely undescribed. The high species richness compared to other surveys in the Guiana Shield is likely due to the habitat diversity of the southern Rupununi region. Landscape heterogeneity leads to high species turnover, with 73% of ant species found in only one of two sites 100 km apart, and 61% of species collected in only one habitat type. The ant fauna is ecologically diverse and characteristic of a relatively intact landscape with large interconnected blocks of suitable habitat. Several species have cultural or medicinal importance to the local Wapishana people.

### Aquatic Beetles

Aquatic beetles were collected over a 14-day period in October-November 2013 in the southern Rupununi region of Guyana, encompassing both open savannah and tropical forest habitats. We collected more than 7,500 specimens from a variety of aquatic habitats. From these samples, we identified 201 species of aquatic beetles in 72 genera, an exceptionally rich and diverse fauna. Both Kusad and Parabara base camps had similar numbers of species (127 and 125 respectively), but their communities were strongly dissimilar, with only 51 species shared between them. Four genera and at least 15 species are new to science, though many more of the morphospecies we identified are likely to ultimately prove to be undescribed taxa.

The family Torridincolidae is recorded from Guyana for the first time. The exceedingly high richness of aquatic beetles in the region is likely the result of the habitat diversity, which ranges from large rivers to small streams, and from savannah lakes to dense forest pools. Hygropetric habitats (i.e. seepages and thin water films on rock) on Kusad Mountain also contributed to the high diversity.

### Birds

Birds were surveyed opportunistically over 15 field days, and documented by sound recording and specimen collection.  Since both localities had been surveyed by previous researchers, we combined our results with existing species lists for each locality.  Our combined list of 487 species includes 32 species previously unrecorded from the southern Rupununi, and is the highest species list recorded for any region of Guyana to date, a reflection of the exceptional diversity of habitats in the area.  The southern Rupununi is home to numerous rare and endemic bird species which are likely to continue to draw tourism revenue to local communities if their habitats remain intact.

### Reptiles and Amphibians

We recorded a total of 60 species comprising 27 species of amphibians and 33 species of reptiles for the entire study area during this survey. Relative to the north Rupununi, the southern Rupununi has received less survey effort by previous researchers. The Myer's thin-toed frog (*Leptodactylus myersi*) was officially recorded for the first time in Guyana during this survey. The four focal areas (Kusad forest and savannah, Parabara forest and mosaic) which were surveyed during this expedition differed in their herpetofaunal composition, with many species exclusive to a particular site. The habitats in and around Kusad Mountain appear to be in pristine condition, while those adjacent to Parabara Village show signs of possible over-exploitation of medium-to-large bodied reptiles.

### Large mammals

Large mammals contribute to the livelihoods of Rupununi inhabitants not only by serving as a food source, but also as a tourism attraction and through their role as ecosystem engineers. Information on mammal abundance is still rare for Guyana, and the diverse landscape of the Rupununi warrants more detailed studies. We evaluated relative abundance of mammals >1 kg using camera traps at Kusad Mountain – a forested mountain in the savannahs – and in the Parabara area – a savannah island in Guyana's southern forest connecting to the Amazon. In 850 camera trap nights at Kusad and 445 at Parabara, we detected 15 and 14 species, respectively, or a total of 17 large mammals for both sites combined. Considering the low number of trap nights, these represented the more common species. Nevertheless, they included threatened mammals such as the Brazilian tapir, white-lipped peccary, and giant armadillo. Species composition and relative abundance differed between sites, with larger ungulates being more common at Parabara and smaller ones more common at Kusad. Under growing human population density, increased accessibility and anticipated increase of habitat conversion for farming and mining in the area, continued monitoring of wildlife will be essential for the development of sound management practices that will allow for the livelihoods dependent upon the populations of medium and large mammals to be supported.

**Small Mammals**

The total number of species of small mammals recorded was 37 for the Biodiversity Assessment Team (BAT) survey of the South Rupununi region in Guyana. This included 35 species of bats and two species of rodents. At the two primary sampling sites, the foot of Kusad Mountain had 22 species of bats and one species of rodent; and Bototo Wau near Parabara had 25 species of bats and one species of rodent. The highlight of the survey was the new country record of the Orinoco sword-nosed bat (*Lonchorhina orinocensis*) that was previously known from the savannahs of Venezuela and Colombia. Another interesting result was the fourth documentation of an undescribed species of free-tailed bat (*Molossus* sp. nov.) from Guyana. The overall general threat to small mammals is the loss of forested habitat where bats, rodents and opossums primarily live. The conservation recommendation is the protection of the mosaic of gallery forests and bush islands within the larger Rupununi savannahs, which harbour a small but distinct assemblage of small mammals.

**Fishes**

Twenty-four sites near two camps (one near Kusad Mountain, and the other in the Parabara area) in the southern Rupununi Savannah region of Guyana were sampled between 20 October to 6 November 2013 by an international team of researchers and local fishermen. We recorded 168 fish species in 34 families. This very high species diversity is a result of the diversity of tropical freshwater aquatic habitats sampled, such as savannah and forest streams, forest pools, and flooded savannahs as well as larger rivers. We collected 18 species of fishes potentially new to science, 25 species endemic to Guyana, and 19 that are rare (at least in museum collections). The primary threats to the fishes of the southern Rupununi vary with the area under consideration. In the Kusad area, potential damage to fish faunas comes from the periodic poisoning of streams with native poison by indigenous people in order to harvest fish for food. In the Kuyuwini River area the major threat is gold mining, which has already caused visible alteration in water quality, especially turbidity. Gold mining is undoubtedly causing as yet unmeasured mercury contamination of food fishes and of the local populations of indigenous people who frequently consume fish.

## Water Quality

Water quality surveys were conducted at 51 locations on 19 water bodies at the Kusad Mountain and Parabara study areas, in the South Rupununi. Parameters measured were: temperature, pH, dissolved oxygen, conductivity, total dissolved solids, turbidity, chemical oxygen demand, nutrients, and metals. Water quality analyses and observations indicate that except for a few water bodies, namely Cocosabana Lake and Marudi Creek (located close to areas with human activities), Mokorowau and Tarayara Creek, the water bodies are not subjected to intensive anthropogenic disturbance, and therefore, natural processes influenced the water quality of water bodies. The range of pH values (5.03-7.96) was characteristic of rivers and creeks of the Amazon basin. Lower levels of conductivity and total dissolved solid values were found in the ponds/wetlands, and higher values in the creeks as they were flowing down the Kusad Mountain. While iron was not detected in any of the waters sampled, zinc, cadmium, lead and mercury were detected. For drinking purposes, the majority of water bodies did not satisfy the WHO's and Guyana's drinking water pH and the heavy metals (cadmium, lead and mercury) requirements but they did pass for zinc and total dissolved solids.

## Conservation Recommendations

The South Rupununi savannah remains largely intact. However, pressures linked to overharvesting and gold-mining are already evident in some parts and are likely to expand, due to increased accessibility and growing external demands for wildlife and other natural resources. Together with the anticipated expansion of commercial agriculture in the region, these threats represent major challenges to the continued resilience of biodiversity, habitats and local livelihoods in the southern Rupununi. Protecting these savannahs in a way which maintains ecosystem functions, preserves the large-scale integrity of the landscape, ensures the security of indigenous livelihoods and adopts participatory approaches that effectively empower indigenous communities to wisely govern and manage natural resources is important in going forward. Toward this end, we recommend the following strategies: establishing protected/conservation areas; monitoring and effectively regulating gold mining in the area and preventing further expansion of mining activities – both legal and illegal; developing and implementing plans for sustainable use of wildlife and other natural resources; promoting the South Rupununi as a destination for culture and nature-based tourism; conducting additional studies to gather data in order to support the long-term monitoring of ecological indicators of change and strengthening data management; and building capacity and awareness on conservation issues and solutions.

# BAT Recommendations for Conservation and Management of the Southern Rupununi Savannah

**1. Establish protected areas under the NPAS that are co-managed by local communities to preserve the ecological integrity and function of the Rupununi savannah.**

**The savannahs of the southern Rupununi together with those in the northern Rupununi represent the largest swatch of such landscapes in the country and in the Guianas, and, despite their tremendous value to people and biodiversity (both in the wider Rupununi and the Guiana Shield), savannah ecosystems are not currently protected in Guyana.** The levels of species richness and quality of habitats in the South Rupununi savannah are characteristic of tropical ecosystems which are largely in a pristine state. However, overharvesting of wildlife and gold-mining are the major threats to the area's integrity; and, with plans being made for further expansion of commercial agriculture in the savannahs, impacts on the environment and local livelihoods can be significant if steps are not taken to effectively conserve and manage resources of the area.

**There is no doubt that the South Rupununi savannah supports an incredible diversity of species, many of which are globally threatened. The giant armadillo (*Priodontes maximus*) which has predominantly disappeared from large parts of its range (and even thought to be extinct in Uruguay) resides in these savannahs** (Anacleto et al. 2014). **Giant anteaters (*Myrmecophaga tridactyla*), Brazilian tapirs (*Tapirus terrestris*), white-lipped peccaries (*Tayassu pecari*), and the endangered Red Siskin (*Spinus cucullatus*) are among the other threatened fauna at home in the southern Rupununi. The jaguar (*Panthera onca*), a symbol of Guyanese nationhood and the only living representative of its genus in the New World, lives in healthy numbers in the Rupununi although it has disappeared or is declining in other parts of its range** (Caso et al. 2008, Paemelaere et al. WWF 2016). Species new to science, Guiana Shield endemics, and migratory birds from North America and southern South America have also been recorded in these savannahs. The high levels of species diversity result from the relatively unfragmented nature of the landscape, high habitat heterogeneity, and the area's hydrological connectivity to the Essequibo and Amazon river systems which create a link with wider regional-scale ecological processes. **Freshwater habitats – wetlands, streams, rivers, and savannah lakes – are pristine or nearly so with the exception of a few locations around Parabara, such as the Kuyuwini and Marudi rivers** (see Chapter 8: Water Quality). **Terrestrial habitats (open savannah, bush-islands, rocky outcrops and gallery forests) are also largely intact.**

**The area's ecological integrity and continued security of local livelihoods, however, are under growing threats from anthropogenic activities – with the major drivers of habitat and species loss being gold mining and overharvesting** (see discussions in 2 and 3, below, and Chapter 10 – Natural Resource Use). The expansion of commercial agriculture into the southern savannahs is likely in the coming years given the renewed interest expressed by the Government (Guyana Chronicle, 2015). While the savannah would seemingly lend itself to agriculture because it is clear and suitable for mechanized methods, its low soil fertility means that high amounts of fertilisers (and pesticides) are required to sustain desired crop yield. The negative effect is that this would jeopardize wetlands, other habitats, species and local livelihoods, by for instance producing water contaminated from pesticides and fertilizers. Reduced availability of fuel wood and an increased risk of fire are also likely impacts from the expansion of commercial agriculture in the savannah (Watkins et al. 2010).

**THE MAJOR THREATS TO HABITATS AND SPECIES IN THE SOUTH RUPUNUNI ARE GOLD MINING, OVERHARVESTING AND COMMERCIAL AGRICULTURE**

The advantage the South Rupununi has at this moment is that gold mining does not occur at the scales observed in other parts of Guyana, and communities are keen to implement management systems which will protect the integrity of the resources on which they depend. This can translate into significant, consistent, long-term benefits for biodiversity and indigenous peoples inhabiting the area, providing that conservation actions for the southern Rupununi are prioritized. **Urgent conservation actions are also necessary given the vulnerability of these tropical landscapes to human-induced degradation, and the increased rate at which technology can facilitate such modifications.**

We recommend protected area and conservation strategies that:

a. **Create landscape connectivity.**

**In the modern era of rapid human-induced environmental changes, connectivity must be created between important habitats in the Rupununi to maintain ecological and evolutionary processes, rather than simply establishing and protecting stepping-stones or corridors. This makes wildlife populations more resilient to climate change and habitat conversion, affording them the ability to persist in the long term** (Watson et al. 2011). Connectivity would confer protection to the mosaic of terrestrial and aquatic habitats; species moving among habitats, particularly during seasonal flooding cycles; migrating species; species important to local livelihoods; and ecological processes occurring across the wider Guianas and Amazonia. **A landscape level approach should consider connectivity between these savannahs and the southern forests, the Kanuku Mountains protected area and the north Rupununi, since there is a natural flow of species among these areas.**

## SAVANNAH ECOSYSTEMS ARE NOT FORMALLY PROTECTED IN GUYANA

b. **Improve representativeness.**

Representativeness speaks not only to protecting the diversity of species and their communities, but also the structure of habitats and ecological processes such as the provision of freshwater which are important to us (Watson et al. 2011). **Savannah ecosystems are not formally protected in Guyana.** The Kanuku Mountains Protected Area which lies just north of our study sites, for example, is completely forested. Establishing the southern Rupununi savannahs as part of the national protected areas network will improve representativeness given the uniqueness of the savannah ecosystem.

c. **Adopt active participatory approaches, strengthen community governance and decision-making institutions, and incorporate indigenous knowledge.**

**Successful conservation outcomes in the South Rupununi depend on Wai-Wai and Wapishana peoples participating jointly in the governance and management of the area's resources.** Their livelihoods depend on the resources of the savannah, and this makes them primary stakeholders in the development and implementation of conservation strategies. Additionally, **the remoteness of the region presents a challenge for adequate management and monitoring, and as such, local peoples, international partners, and government will be required to partner to achieve meaningful conservation outcomes.**

d. **Maintain indigenous communities' rights to traditional resource-use, to keep local livelihoods secure.**

Customary usage by communities takes place across a range of ecosystems and habitats in the southern Rupununi – wetlands, bush islands, rivers, creeks, forests, mountains. This means that communities often depend on areas beyond their titled lands for hunting, fishing, farming and gathering resources for medicine, housing and income.

## SUCCESSFUL CONSERVATION OUTCOMES IN THE SOUTH RUPUNUNI DEPEND ON WAI-WAI AND WAPISHANA PEOPLES PARTICIPATING JOINTLY IN THE GOVERNANCE AND MANAGEMENT OF THE AREA'S RESOURCES

**2. Monitor and effectively regulate gold mining activities, prevent the expansion of mining into priority areas, and stop occurrences of illegal mining.**

THE IMPACTS OF MINING ARE ALREADY EVIDENT IN THE SOUTH RUPUNUNI

Local indigenous peoples practice artisanal gold mining in areas within the southern Rupununi. Over the decades, however, mining has picked up pace and the industry currently reflects a mix of locals, small Guyanese companies, Brazilian miners and other larger international interests (Pearce 2015). Influenced by an upsurge in world-market prices for gold in the early 2000s, mining expanded and intensified as seen in some sites around the Parabara study area. However, a decline in the price of gold, together with high operational costs and enforcement actions, resulted in the closure of some operations, including some which were illegal. Should incentives to mine be restored by another boom on the international market, it can be expected that the industry will again accelerate in the southern Rupununi.

**The impacts of mining are already evident. Water from the Marudi River, at the Parabara study site, for example, was turbid and had high concentrations of mercury - likely due to the mining activities occurring in the upper reaches of the creek** (see Chapter 8: Water Quality). Erosion and sedimentation which result from mining increase turbidity and suspended solids in waterways, alter flow rates and negatively impact fish and other aquatic species on which local communities depend. **Mercury, a toxic heavy metal utilized in the processing of gold, is also released into the environment and transported over long distances, resulting in damage to distant ecosystems.** The ability of mercury to bio-accumulate in food webs means that top predators are severely affected. Since some species are favoured food species for locals, **human health becomes a major concern.**

**The extensive removal of vegetation which occurs in mining fragments habitats and, at large scales, can result in biotic homogenization, or the 'dissolving' of biotic distinctiveness over time, as species which cannot tolerate human activities lose suitable habitats and are replaced by those which thrive in disturbed areas** (McKinney and Lockwood 1999).

THE ADOPTION OF SAFE MERCURY-FREE GOLD RECOVERY TECHNOLOGIES MUST BE PURSUED URGENTLY

**Mining exacerbates the pressures on wildlife, as game-meat is used to supplement food stocks in the mining camps.** This contributes to the depletion of fish, mammals and reptiles, limiting their availability for local household use. **Road and trail networks also expand, increasing the accessibility to and exploitation of natural resources**. Pearce (2015) reported, for instance, the intention of Brazilian miners to construct a road from Parabara to the Brazilian border in order to establish a direct link with the 'boomtown' of Boa Vista. The result of these impacts acting collectively is a loss in ecosystem functionality, as evidenced at other mining sites in Guyana. For local people, it means a decline in primary food species; health-related issues, from the consumption of mercury-contaminated fish, for example; and lack of access to safe drinking water and greater social instability.

Effective regulation of the gold-mining industry, including **the adoption of safe mercury-free gold recovery technologies, must be pursued urgently** to mitigate environmental and social impacts which can easily be exacerbated in the southern Rupununi, because of the sensitivity of its ecosystems and the extent to which local livelihoods depend on the environment.

**3. Develop and implement plans for the sustainable use of wildlife and management of other natural resources.**

Effectively conserving the biodiversity of the South Rupununi, while ensuring that local livelihood needs are met, requires a holistic approach to management and to sustainable harvesting of wildlife. **Across the taxonomic groups of mammals, birds, fish, reptiles and plants, several species that are commonly harvested for food were reported by the communities to be showing signs of decline due to overharvesting** (see Chapter 10: Natural Resource Use). The biodiversity component of our survey revealed that around the Parabara study site, fewer than expected number of individuals of reptile species used as food such as caimans, turtles and tortoises were found. Certain fishes like the arowana (Family: Osteoglossidae) were notably absent from samples. Overfishing had reportedly severely affected these species in some areas (see Chapter 2: Amphibians and Reptiles and Chapter 9: Fishes). The presence of disturbance-sensitive mammals like jaguars at Kusad and Parabara; the diversity and abundance of aquatic beetles and the relatively high fish diversity, however, are indicative of overall ecosystem stability. Nevertheless, given the observations of decline made by local indigenous groups, it is important that the take of game animals be managed.

Overharvesting has also been linked to the decline in those species utilized in traditional construction, for instance timbers such as redwood (*Centrolobium paraense*) and water/white cedar (*Tabebuia insignis*), and palms such as ité (*Mauritia flexuosa*) and kokerite (*Attalea maripa*) used for income generation. The caged-bird trade which now commonly targets the towa-towa songbird (*Sporophila angolensis*) is being linked to its scarcity in the savannah (see Chapter 10: Natural Resource Use).  Without adequate conservation measures, towa-towa populations may face the same declines as the twa-twa songbird (*Sporophila crassirostris*, formerly *Oryzoborus crassirostris*). Once favoured in the songbird trade by locals, *S. crassirostris* was not reported to be part of the current trade. Red Siskins (*Spinus cucullatus*), a species largely extinct from other parts of its range due to the trade, so far do not seem to be the focus of local trappers.

Planning for effective wildlife management should take into account the need for:

(1) More sustainable harvesting methods

**The poisoning of streams to harvest fish, for example, has long-lasting effects on fish fauna and is possibly linked to the low diversity of fishes in a stream located at Kusad** (see Chapter 9: Fishes). In fact, **residents in all the communities which took part in the BAT survey noted that poisoning ponds, rivers and lakes was harming fish populations and recommended that it should not be practiced.** The use of poisons has declined over the years due to strong community actions, but additional efforts are still needed. Restricting the use of pin seines is another example.

(2) Monitoring of hunting activities and hunting rates; and enforcing regulations

Strong and sustained community-led initiatives are needed if the long-term use and management of wildlife in the South Rupununi are to be effective. Communities told us that many game animals were scarce due to overhunting, and recommended management actions which included: limiting hunting during breeding seasons, establishing quotas and avoiding harvesting females with young or large numbers of individuals at once (see Chapter 10: Natural Resource Use). Local regulations governing the 'sensible (sustainable) use of resources' have been established by many Wapishana villages in the South Rupununi and outlined in their land management plans (see South Central and South Rupununi Districts Toshaos Councils. 2012 - *Thinking together for those coming behind us: An Outline Plan for the Care of Wapichan Territory* and David et. al. 2016 - *Wa Wiizi Wa Kaduzu: Our Territory, Our Custom*). However, **effective enforcement and implementation are major challenges.**

**A strong link can be established with Guyana's tertiary education institutions for the development of appropriate methodologies for monitoring. While this partnership generates valuable data for decision-making, it can also generate investment in research capabilities, strengthen data management, and improve museum and herbarium facilities at these institutions.**

(3) Sustainable livelihood initiatives

Having alternative sources of dietary protein and income available to the local population can reduce harvesting pressures placed on wildlife. Rearing hardy 'creole' chickens for meat and eggs (at a non-commercial scale), expanding nature-based tourism, increasing crabwood oil and cashew-nut production as well as beekeeping are viable options for development and, with proper access to markets, can also act as an incentive for villagers not to invest in gold mining.

RESIDENTS IN ALL THE COMMUNITIES WHICH TOOK PART IN THE BAT SURVEY NOTED THAT POISONING PONDS, RIVERS AND LAKES WAS HARMING FISH POPULATIONS AND RECOMMENDED THAT IT SHOULD NOT BE PRACTICED

Additionally, in an effort to regulate the domestic trade and use of wildlife, the Wildlife Management and Conservation Regulations (2013) were recently enacted by the Guyana Government. This can support local management efforts as penalties for illegal harvesting can now be enforced.

**Extensive burning of savannah grasslands** and the use of fire should also be addressed as a broader issue which adversely affects wildlife and other natural resources. The use of fire by indigenous people in the savannah is tied to local ways of life, such as cattle ranching in the savannahs (where fire is used in management of grazing areas and in maintaining vegetation); hunting (to 'flush out' game from burrows and hiding places); farming (slash and burn agriculture); maintaining trails and dwelling areas (brush cleared from trails, pathways and around homes) and protecting stands of useful plants (ité palm - *Mauritia flexuosa*) and bush islands though the use of fire breaks (David et al. 2006). Frequent and extensive burning however has an impact on both livelihoods and biodiversity in the southern Rupununi, and is a cause for concern among local people:

(i) Forest edges are pushed further back each year (ter Steege and Zondervan 2000)
(ii) Sensitive savannah avifauna (e.g. the Ocellated Crake (*Micropygia schomburgkii*) and the Bearded Tachuri (*Polystictus pectoralis*) become vulnerable to local extinction increases (see Chapter 3: Avifauna). For highly endangered species such as the Red Siskin, fire is a major threat (Robbins et al. 2003)
(iii) Bush islands, which act as 'store-houses' of food for communities, (see Chapter 10: Natural Resource Use) and dry forests are damaged by fires lit to manage pasture areas (David et al. 2006).

**Indigenous peoples of the South Rupununi have specifically identified fire-use in pasture areas as a concern in communities, and in some instances, village rules have been established to stop fire damage** (David et al. 2006). **However, here again, enforcement is a challenge.** Reducing the frequency of fire-use, unnecessary burning, and properly managing fires when used (or if they occur) requires close attention.

INDIGENOUS PEOPLES OF THE SOUTH RUPUNUNI HAVE SPECIFICALLY IDENTIFIED FIRE-USE IN PASTURE AREAS AS A CONCERN IN COMMUNITIES, AND IN SOME INSTANCES, VILLAGE RULES HAVE BEEN ESTABLISHED TO STOP FIRE DAMAGE

**4. Promote the South Rupununi savannahs as a destination for nature and culture-based tourism.**

NATURE AND CULTURE-BASED TOURISM IN THE SOUTHERN RUPUNUNI SAVANNAH HAS THE POTENTIAL TO DEVELOP INTO A VIABLE ECONOMIC ACTIVITY IN THE LONG TERM

**Nature and culture-based tourism in the southern Rupununi savannah has the potential to develop into a viable economic activity in the long term**. The presence of large expanses of intact habitats; large charismatic mammalian species such as the jaguar (*Panthera onca*; IUCN-Near Threatened) and giant anteater (*Myrmecophaga tridactyla*; IUNC-Vulnerable), and endangered birds like the Red Siskin (*Spinus cucullatus*), have helped to build recognition and promote visitation to the area. **Maintaining the ecological integrity of the landscape therefore will be critical for continued development of tourism, given that there are other destinations in the Rupununi which are less expensive**. Birding, fishing, hiking expeditions and mammal spotting have potential for development, and can benefit from the existing infrastructure such as trail networks and guesthouses in the communities. The cultural practices and heritage of the local indigenous Wai-Wai and Wapishana peoples are unique to the southern Rupununi region. Incorporating elements such as their history (through story-telling and the visiting of petroglyphs), their traditional medicinal practices, architecture, and other elements that have helped to shape their way of life in tour packages can make for a richer visitor experience. These opportunities can be linked to ongoing tourism initiatives such as the annual South Rupununi Safari. The safari, which takes visitors through about 14 indigenous communities, can provide a platform for integrating and marketing new tourism goods and services. There are working tourism models in the Rupununi, especially in the communities further north such as Surama. These can be used as a basis for expanding tourism opportunities in the southern Rupununi – building on learnt best practices, but at the same time incorporating differences in visitor expectations, culture and landscape. The presence of the Kanuku Mountains Protected Area can also help to diversify tourism options. Promoting the image of the southern Rupununi savannah to tourists and adventure-seekers through strengthened collaboration between the private sector, community operators, regional authorities and state agencies can boost tourism and improve economic feasibility. These **public-private-community partnership models for tourism have proven effective at achieving both conservation and development goals when implemented correctly, and should be considered.**

**5. Conduct additional studies to gather data, in order to support the long-term monitoring of ecological indicators of change and strengthen data management.**

Our assessment, together with the work done by communities and other researchers in the South Rupununi, has provided useful baseline information on biodiversity and natural resource use. There are gaps in the current knowledge of the area which would benefit from additional research. We recommend sampling in the wet season and prioritizing habitats or taxa not previously sampled such as vegetation in ponds and marshes; fishes in deep water bodies; and all taxa at higher elevations on isolated areas like Kusad Mountains. **Given the number of species which are new to Guyana and likely new to science, the high species turn-over in certain taxonomic groups between habitats and sites, and the high level of landscape heterogeneity, we believe that there is much more biodiversity to be discovered.**

Increasing the scale at which additional collecting is done will also help us to understand more about the species that exist here. In addition to baseline information, having a detailed view of species such as the gradients in species diversity; the turn-over of species over large geographic scales; species dispersal, as well as population sizes, sources and sinks, is important in planning for and implementing long-term conservation and management strategies. Further detailed work is also necessary to understand the harvesting and hunting pressures imposed by forms of non-subsistence natural resource use; quantify the impacts of existing threats, and understand emerging ones, on both aquatic and terrestrial habitats and species. Such data will help to answer key questions, such as: What are the quantities which can be reasonably harvested for trade and food without causing population declines? Which are the areas most sensitive to human disturbance? How can the flow of benefits from the environment be maintained over the long term for local people?

**Long-term monitoring can bring about successful conservation outcomes for both biodiversity and local communities.** Populations of the highly endangered Red Siskins are increasing in the South Rupununi, due to the efforts of community-based organisations such as the South Rupununi Conservation Society. Their capture by local caged-bird traders has been stopped and this iconic species is now included instead as part of birdwatching activities which the SRCS facilitates (SRCS, 2016). The SRCS has expanded its work with partners to include initiatives on jaguar- and freshwater turtle conservation. **As far as possible monitoring activities should be community-led, empowering local people to govern and better use resources.**

**The development and implementation of a protocol to monitor water quality and availability is recommended as part of monitoring ecological changes and climatic impacts in the southern Rupununi. Pollution from gold mining activities and extreme drought events threaten local households' access to safe freshwater and freshwater habitats and biodiversity** (see Chapter 10: Natural Resource Use).

Strengthened data management is urgently needed. **The Centre for the Study of Biological Diversity (CSBD) located at the University of Guyana's Turkeyen campus, which houses herbarium and zoological collections, is the primary source for reference specimens from Guyana. However, poor and limited storage facilities and collection management affects the Centre's ability to adequately cater for new specimens, and results in loss/degradation of specimens already housed there. Technological upgrades which would allow for electronic data storage and processing is also an immediate need.**

The further financial, technological and human-resource requirements which this set of recommendations necessitate will require continued collaborative research efforts and financial cooperation with international organizations and scientists.

**6. Build capacity, raise awareness, and educate local peoples, as well as the wider Guyanese public, on the need for conservation and sustainable use of resources.**

**The role of local people in achieving desired conservation goals needs to be advertised and emphasized, as well as their capacity strengthened to enable an effective engagement in natural resource management and governance**. For example, locals trained as parataxonomists can access and catalogue biodiversity to increase taxonomic efficiency and our understanding of species present in these important landscapes. Additionally, as forest or wildlife monitors, community members can collect long-term data on bush-meat trade and consumption, on water quality, and can report illegal hunting activities.

Traditional ecological knowledge and practices should also be integrated into strategies which address conservation and natural resource use challenges. **Efforts aimed at inter-generational knowledge transfer should be supported, since the loss of traditional knowledge negatively affects biodiversity conservation** (Loh and Harmon 2014, UNESCO 2015). Peer-based learning among youths, facilitated through the establishment of eco-clubs for example, is an important component of capacity and knowledge building.

**At the national level, there needs to be a much greater focus on conservation and the value of savannah biodiversity and ecosystems to human well-being. Promoting greater environmental education and stewardship in Guyana's urban populations, who are seen as increasingly disconnected from nature, and empowering broader civil society involvement, whether as advocates or citizen scientists, can lead to the realisation of conservation goals.**

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# CHAPTER 1

# PLANTS OF SOUTHWEST GUYANA:
# RUPUNUNI SAVANNAH AND PARABARA REGION

*Edwin Pos, Isaac Johnson, Zola Narine, Frank Johnny, Alcidio Isaacs, and Magnus Raymond*

THE RUPUNUNI SAVANNAH ADDS TO THE FLORISTIC DIVERSITY AND SPECIES RICHNESS OF GUYANA. IN TURN, THIS MAKES THE RUPUNUNI SAVANNAH A HABITAT WORTHY OF CONSERVATION.

## Summary

A study of the plant diversity of southwest Guyana was conducted as part of a large multi-taxa survey carried out in cooperation with World Wildlife Fund (WWF) Guyana and Global Wildlife Conservation (GWC) in 2013, from 24 October – 5 November. The  Kusad Mountain area and 2) the Parabara region. Four main vegetation types were sampled: savannah, bush-islands, rocky outcrops and gallery forests. In addition, two 0.5-hectare plots were set up in the Parabara region, to investigate the tree species composition. **Sampling main vegetation types yielded 180 morphospecies: 105 of which were trees or treelets; 26 were bushes, woody herbs, climbers and vines; 15 were grasses, sedges and rushes; and 34 belonged to herbaceous species.** For the Kusad region, a total of 102 morphospecies were recorded. For the Parabara region, 78 morphospecies were recorded within the main vegetation types and 75 morphospecies were recorded in the plots. Results from this expedition were added to an earlier synthesized dataset by Jansen-Jacobs and ter Steege (2000), based on herbarium collections. The results from sampling the four main vegetation types and the forest inventory show much diversity. **In the light of current rapid climate change and overall loss of biodiversity due to, among other factors, logging efforts and increased mining activity, it is important to gain further insight into the community composition and structure of forests in the South Rupununi and the surrounding areas, if adequate protection of plant diversity is to be provided.**

## Introduction

**Plants constitute a significant part of all biomass on our planet and, as primary producers, they play a vital role in any ecosystem (terrestrial and aquatic).** In addition, floral diversity is not only important in maintaining ecosystem functioning on a biological level, but also plays an important role in many cultures and within the local populations. Communities often find many uses for plants in medicinal, ornamental, religious or other practices (e.g. Johnston 1997). Hence, plants also constitute a large part of any culture. Although (vascular) plants are well distributed over the world, the Neotropics have always been a focus of attention regarding plant diversity, with good reason. The Neotropics provide a habitat for more than 90,000 species of seed plants (approximately >35% of the world's species) (Antonelli and Sanmartín 2011). **Recently, using an unprecedented large-scale dataset, ter Steege et al. (2013) estimated that the Amazon region (including the Guiana Shield) should harbour an incredible 16,000 species of trees, an indication of the vast diversity of plant life that can be found within this extensive area. Considering that trees themselves support various species, from insects to mammals and other plant species, the total biodiversity supported by the forests is staggering.** Although the floristic composition of southwest Guyana is relatively well-known (Jansen-Jacobs and ter Steege 2000), there are still large parts that have not been studied yet or require more attention.

From 24 October – 5 November 2013, a survey of the plant diversity of southwest Guyana, part of a large multi-taxa survey, was carried out in cooperation with World Wildlife Fund (WWF) Guyana and Global Wildlife Conservation (GWC).

**FLORAL DIVERSITY IS NOT ONLY IMPORTANT IN MAINTAINING ECOSYSTEM FUNCTIONING ON A BIOLOGICAL LEVEL, BUT ALSO PLAYS AN IMPORTANT ROLE IN MANY CULTURES AND WITHIN THE LOCAL POPULATIONS. COMMUNITIES OFTEN FIND MANY USES FOR PLANTS IN MEDICINAL, ORNAMENTAL, RELIGIOUS OR OTHER PRACTICES.**

The survey took place within the southern Rupununi savannah area. Covering approximately 13,000 $km^2$ , it is the largest savannah area of the country (Daniel and Hons 1984). Base camps were located at two sites: 1) Kusad Mountain and 2) Parabara Savannah (the southern-most part of the greater Rupununi savannah area).

*Climate and soil characteristics*

The Rupununi area has only one wet season and a prolonged dry season; a second short rainy season is absent. Annual rainfall is between 1500-2000 mm $y^{-1}$ and mean annual daily temperature is 27.5 °C (Persaud 1994, Jansen-Jacobs and Steege 2000). Due to the fact that the Rupununi river system is not able to drain all of the savannah area adequately, which is in general quite flat, most of the area will flood in the wet season, resulting in a number of ponds and lakes, which persist for several months (Sinha 1968, Hills 1969, Eden 1973, Daniel and Hons 1984). The southern Rupununi savannah soils, being part of the Guiana Shield, consist mainly of folded schist, gneiss and granite (McConnell, 1968). The southwest of Guyana itself is part of the so-called Precambrian Lowlands, due to the Precambrian crystalline basement rocks also present (Jansen-Jacobs and ter Steege 2000). In the southern Rupununi savannah, the granite is found much closer to the surface than in other parts of Guyana, and steep hills can be seen covered by a moderately thick forest, which is supported by a rather thin sandy soil (Jansen-Jacobs and Steege 2000). The Parabara region lies considerably closer to the edge of the continuous rain forest and has many larger forest patches intersecting the savannah.

*Earlier studies*

Plant species composition of southwest Guyana, including the Rupununi savannah, was already relatively well-known from previous expeditions, which have been carried out since the 19th century (Ek 1990, Jansen-Jacobs and ter Steege 2000). Some striking examples, among many others, are expeditions led by Robert and Richard Schomburgk in the mid 19th century (Schomburgk et al. 1848). Many of those collections still remain in herbaria (Jansen-Jacobs and ter Steege 2000). Continuing in the 1970s, the Utrecht Herbarium conducted several botanical expeditions in south Guyana as part of the “Flora of the Guianas Project”. These resulted in a substantial database of 6,333 specimens of vascular plants of the entire southwestern area of Guyana (including the northern Rupununi; Jansen-Jacobs and ter Steege 2000). The authors who synthesized the database have graciously allowed us also to use it in our study, to combine with the results of the present expedition. Figure 1.1 shows a map, after Jansen-Jacobs and ter Steege (2000), of the locations of these collections (red squares indicate locations of present expedition).

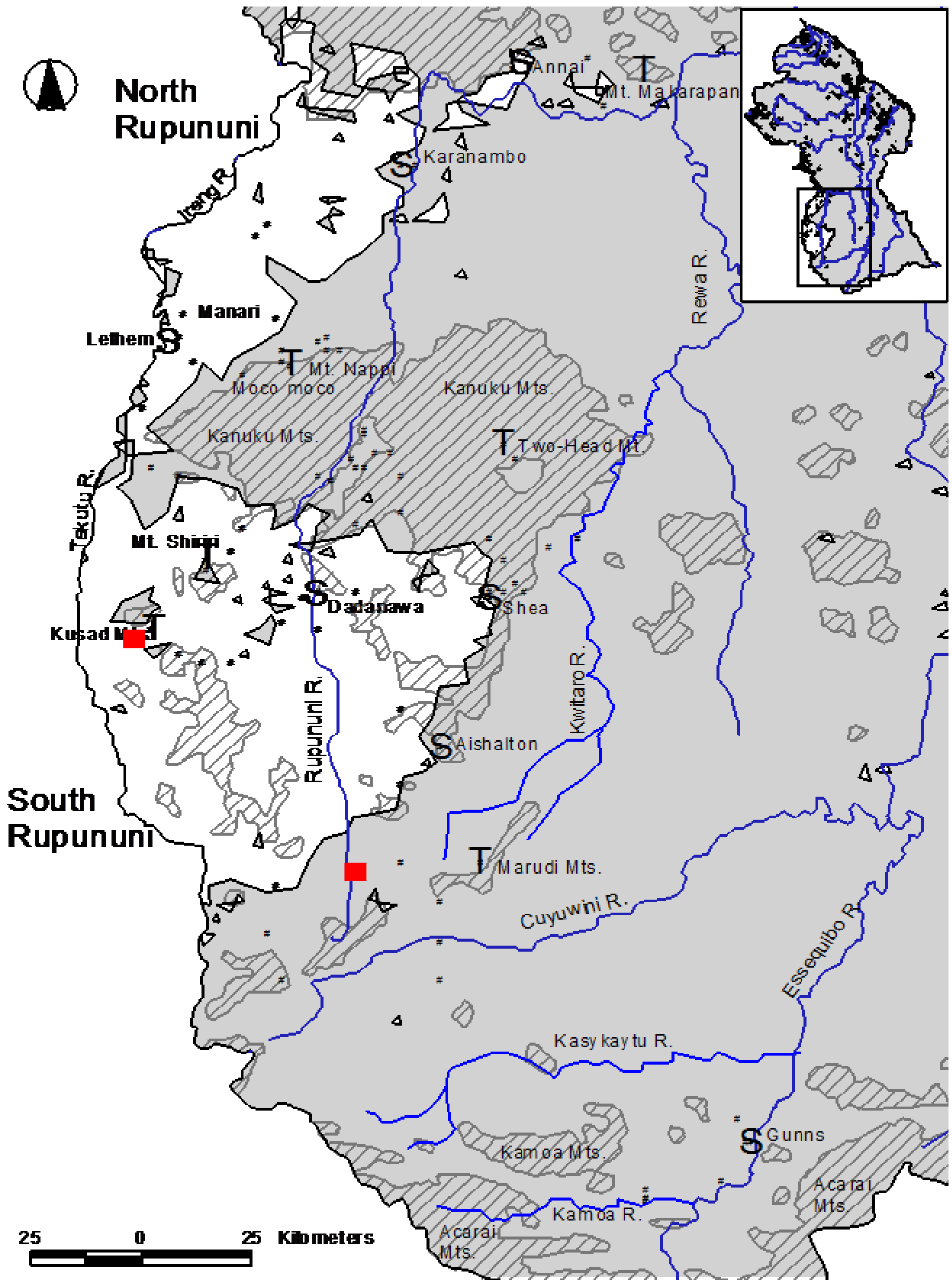



Figure 1.1 **Map overview of the Rupununi Savannah reprinted with permission of Jansen-Jacobs & ter Steege (2000). Black dots indicate collections of the National Herbarium of the Netherlands (formerly of Utrecht University, now located in Leiden at the Natural Museum of History). Red squares indicate locations of campsites and new collections of the Oct-Nov 2013 expedition.**

**THE AMAZON REGION (INCLUDING THE GUIANA SHIELD) SHOULD HARBOUR AN INCREDIBLE 16,000 SPECIES OF TREES, AN INDICATION OF THE VAST DIVERSITY OF PLANT LIFE THAT CAN BE FOUND WITHIN THIS EXTENSIVE AREA**

The database included 3,618 species belonging to 150 families. The most abundant families in terms of species were: Fabaceae (255 species), Rubiaceae (131), Poaceae (124), Cyperaceae (107), Orchidaceae (90), Melastomataceae (89), Euphorbiaceae (70) and Asteraceae (51). In total, 111 species belonged to the paraphyletic group of the Pteridophyta. The most species-rich genera were: *Miconia* (28), *Psychotria* (26), *Rhynchospora* (26), *Piper* (24), *Utricularia* (24) and *Polygala* (21). The largest number of species (1,165) was found in the South Rupununi savannah (2,281 collections), against 713 species from the North Rupununi savannah (1,149 collections). When compared, the South Rupununi seems to be richer in terms of species and their collections in comparison to the North Rupununi. As Jansen-Jacobs and ter Steege (2000) conclude, this difference can be partly assigned to more intensive collecting activity in the southern savannah, but a major contributor also seems to be the small (rocky) hills in the South Rupununi containing many site-specific species (Jansen-Jacobs and ter Steege 2000).

**Orchidaceae family.**
**© Andrew Snyder**

**Melastomataceae family.**
**© Andrew Snyder**

***Amazonia campestris***
**© Andrew Snyder**

## Methodology and Study Sites

The Rupununi savannah can be subdivided into four main vegetation types (Jansen-Jacobs and ter Steege 2000): savannah, bush-islands, gallery forests and rocky outcrops. Although vegetation in ponds and marshes can be distinguished as a fifth type, it will not be discussed further as these habitats were not sampled during this particular study. To provide a detailed and thorough inventory of the area and to be able to combine data from earlier collections, sampling was conducted in each main vegetation type. Two main methods of sampling were used: 1) general sampling of the specific vegetation types (conducted at both study sites in the southern Rupununi savannah – Kusad Mountain and Parabara); and 2) sampling of tree species by plot in the Parabara region; (plants were surveyed in plots established in contiguous rainforest around Parabara.)

*Main vegetation types*

Savannahs are characterized by large open areas that often reach relatively high temperatures. As mentioned earlier, the rivers are not able to drain the Rupununi savannah adequately. As a result, most of the area floods in the wet season, resulting in a number of ponds and lakes, which persist for several months. Bush-islands are the small to large patches of forest that can be found scattered over the savannah. Gallery forests are forests growing on riverbanks and often can be seen from afar as they form a distinct line of trees across the horizon. Rocky outcrops in the southwest Rupununi savannah area are classified within this study as being the mountainous areas such as Kusad Mountain, Shiriri Mountain and Saddle-Top Mountain. Consisting mostly of rock, these outcrops are relatively bare, but those with substrate can sustain plant life.

*Sampling of vegetation types*

General sampling within each vegetation type at both sites was conducted by each member of the research team walking in a straight line through the vegetation and collecting all unique species. As plants tend to show clustering patterns, a result of dispersal limitation, sampling in a straight line is expected to allow for the collection of more species than sampling randomly through an area. Sampling in this way also offers the possibility of collecting more unique species in one area, with the advantage being that it is not necessary to set up plots or specific areas to be sampled. However, this technique does not give any information on community composition, since information regarding the number of individuals for each species is not recorded. At the first site (the Kusad Mountain area) all main vegetation types except the bush-islands were sampled. Due to a lack of time and means of transportation, no bush-island could be reached. At the Parabara site the same vegetation types were sampled, with the exception of rocky outcrops, to collect the necessary data required for comparisons between the Kusad Mountain and Parabara study sites. Due to a lack of rocky outcrops within reasonable vicinity, this vegetation type could not be sampled at the Parabara site.

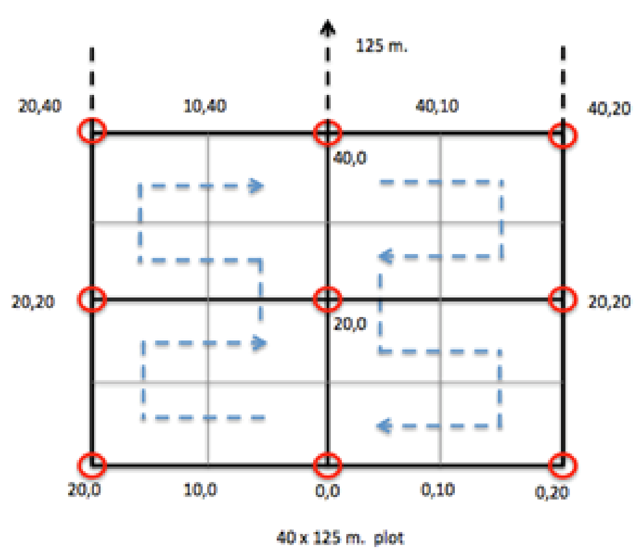
*Sampling of tree species by plot*

In addition to sampling the four main vegetation types, two plots were set up in the Parabara region. Because a reasonable amount of sampling had already been conducted in the Rupununi area (Jansen-Jacobs and ter Steege 2000) and due to time limitations, no plots were constructed in the area near Kusad Mountain (Site 1). The setting up of plots has the obvious disadvantage of being extremely laborious- a 1.0 hectare plot can take one team of approximately four to six people roughly one day to complete. Sampling the plot then might take the same team another full day. However, there are some distinct advantages to this sampling method, mainly that in contrast with the previously mentioned method, this one provides information regarding community composition. To save time, we established two 0.5-hectare plots instead of 1.0-hectare plots. Within the plot area, each individual tree measuring≥10 cm DBH (diameter at breast height; standardized at 1.30 metres from the forest floor) was photographed, sampled and if possible identified.

*Plot Structure*

All plots were established with a main transect line of 125 metres with 20 x 20 m blocks on both sides of the line. Such rectangular plots are better suited for small teams and are quicker to establish. As plant species tend to cluster, setting up plots in a rectangular shape instead of a square circumvents this problem. The main line of the plot (see Figure 1.2) was established using poles with flagging tape set up every 20 metres. Along the main line from each 20 metre pole a second pole was placed 20 metres perpendicular to the main line at a fixed distance, thus creating the subplots of 20 x 20 m each. Within each subplot, all trees of ≥ 10 cm DBH were flagged and inventoried. Part of the team flagged trees, moving up through the subplots starting from the lower left corner (see Figure 1.2). Other team members then moved through the same subplots, identifying, photographing and sampling all flagged trees.

Figure 1.2 **Plot structure (after Banki 2006). Red circles indicate the position of white tipped pickets; blue lines indicate movement through the plot.**



*Plot Location*

Plots were established in undisturbed high forest standing on mixed soils. The first plot near Parabara, over the Kuyuwini River (see the plot coordinates, Table 1.1), was located in continuous rainforest to the south of the village. Directly adjacent to the village are a number of old and recent plantations. To avoid edge effects created by these plantations, a minimal walk of 30 minutes past these plantations was taken into account. The second plot was set up in the rainforest near the base camp at the Parabara savannah, intersected by a small creek. In total, two 0.5-hectare plots were established and inventoried (see Table 1.1 for plot data).

Table 1.1 **Data for the two plots at the Parabara site (Site 2)**

| Plot Code | Country | Region | Size (hect.) | Forest Type | Latitude | Longitude |
|---|---|---|---|---|---|---|
| GR_PB01 | Guyana | Parabara Bush | 0.5 | Continuous | 2.084917 | -59.236233 |
| GR_PB02 | Guyana | Parabara Savannah | 0.5 | Continuous/ Bush island | 2.175495 | -59.337144 |

*Identification and processing of collections*

All individual trees with a DBH of 10 cm and above were pre-identified in the field as much as possible, with the help of the entire team (especially tree-spotter Mr Isaac Johnson). Duplicate samples were taken of unique species for each plot, i.e. species that were not earlier collected within the specific plot. All collections from both methods (i.e. sampling the main vegetation types and plot inventories) were photographed both in the field and shortly before pressing and pickling. Descriptions of all collections were made in situ and a collection was made per species. Specimens were pressed in the field and later pickled in diluted ethanol at the base camp to ensure preservation for a prolonged period of time. Collections were later identified as accurately as possible with the help of several experts at the National Herbarium of the Netherlands.

## Results and description of vegetation types

In total, 180 morphospecies were recorded at both sites during sampling of the vegetation types (excluding plots). These belonged to 62 families, 98 genera and 35 species (see Appendix 1). Those with positive identification up to species level were added to the earlier mentioned database by Jansen-Jacobs and ter Steege (2000). This provided the opportunity for a more thorough analysis. By doing so we were able to make a comparison between the northern and southern part of the Rupununi savannah. Each vegetation type is discussed below in terms of habitat, composition and the most abundant species.

*Savannah*

The savannahs of southwest Guyana are large open areas (see also Figure 1.3) subjected to fires, ranging from small local fires to larger fires capable of lasting for prolonged periods of time. As such, the vegetation of these savannahs can be described as a fire-climax habitat.

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Figure 1.3 **Typical view of the southern Rupununi savannah with its low, relatively open vegetation, large open areas and small hills (as at the right).**

Characteristic species such as *Curatella americana* (locally known as the sandpaper tree) and *Byrsonima verbascifolia* (also known as savannah toilet paper, Figure 1.4) can be found over the entire savannah area.

## CONSIDERING THAT TREES THEMSELVES SUPPORT VARIOUS SPECIES, FROM INSECTS TO MAMMALS AND OTHER PLANT SPECIES, THE TOTAL BIODIVERSITY SUPPORTED BY THE FORESTS IS STAGGERING

A

B



C

D

Figure 1.4 **Examples of a number of plant specimens**

**A:** ***Byrsonima verbascifolia*, one of the most common species of the savannah.**

**B: The Devil's ear or elephant-ear (*Enterolobium cyclocarpum*), found in this survey in one of the Bush Islands near Site 2, Parabara.**

**C: A tree species often planted for landscaping purposes (Riariadan, *Senna multijuga*).**

**D: A species of the *genus Polygala* sampled on the Parabara savannah.**

The most dominant genera of grasses to be found on the savannah are *Trachypogon*, *Paspalum*, *Axonopus* and *Andropogon*; main sedges belong to the genera *Rhynchospora* and *Bulbostylis* (Myers 1936, Fanshawe 1952, Jansen-Jacobs, and ter Steege 2000). A very characteristic species of the savannah is the sedge *Bulbostylis paradoxa*, clearly recognizable by the short black stumps on which the new shoots grow. The short black stumps are part of an ingenious method of coping with savannah fires, constituting an enlarged caudex of leaf sheaths, which only flower after a fire. Other species appear and flower only after substantial amounts of rain, such as members of the genus *Polygala* (Figure 1.4) and *Schultesia*. Table 1.2 lists some of the more abundant herbs found on the savannah based on all collections.



***Bulbostylis* sp. This intriguing sedge species has an ingenious method of coping with savannah fires.**

Table 1.2 **Overview of the more abundant non-grass or sedge species found on the savannah, based on collections after Jacobs and ter Steege (2000), reprinted with permission. Names indicated with * represent changes in nomenclature based on the latest updates of the W3 Tropicos database using the TNRS (Boyle et al. 2013).**

| FAMILY | GENUS | SPECIES | N. RUP. | S. RUP. |
|---|---|---|---|---|
| Hypoxidaceae* | *Curculigo* | *scorzonerifolia* | 1 | 4 |
| Fabaceae* | *Chamaecrista* | *hispidula* | 4 | 4 |
| Convolvulaceae | *Merremia* | *aturensis* | 4 | 5 |
| Fabaceae | *Clitoria* | *guianensis* | 2 | 2 |
| Fabaceae | *Indigofera* | *lespedezioides* | 2 | 7 |
| Fabaceae | *Macroptilium* | *gracile** | 3 | 1 |
| Gentianaceae | *Schultesia* | *benthamiana* | 2 | 9 |
| Haemodoraceae | *Schiekia* | *orinocensis* | 3 | 2 |
| Iridaceae | *Herbertia** | *lahue** | 2 | 1 |
| Iridaceae | *Cipura* | *paludosa* | 4 | 1 |
| Lythraceae | *Cuphea* | *antisyphilitica* | 2 | 6 |
| Orchidaceae | *Galeandra* | *styllomisantha** | 1 | 4 |
| Polygalaceae | *Polygala* | *longicaulis* | 4 | 4 |
| Polygalaceae | *Polygala* | *trichosperma* | 6 | 4 |
| Rubiaceae | *Diodia* | *apiculata* | 3 | 5 |
| Rubiaceae | *Perama* | *hirsuta* | 3 | 6 |
| Rubiaceae | *Sipanea* | *hispida* | 6 | 1 |
| Orobanchaceae* | *Buchnera* | *rosea* | 5 | 3 |
| Malvaceae* | *Waltheria* | *indica* | 2 | 0 |
| Passifloraceae* | *Turnera* | *guianensis* | 4 | 3 |
| Verbenaceae | *Lippia* | *origanoides* | 5 | 4 |
| Xyridaceae | *Abolboda* | *pulchella* | 2 | 3 |

### *Bush-Islands*

Being small to large patches of forest, these can be found scattered over the savannah and hence are fairly isolated; bush-islands potentially harbour many distinct species. **The climate within bush-islands is quite different from the surrounding savannah, and as such these islands may act as a refuge for many species.** Bush-islands tend to increase in number and size the closer they are located to the continuous rain forest, as was the case in the Parabara region, ultimately slowly creating the transition from savannah to continuous forest. Table 1.3 lists a number of collections of woody species from these bush-islands. **Interestingly, there are a number of species which are quite commonly collected in the southern Rupununi (e.g. *Senna multijuga*, *Platymiscium trinitatis* and *Securidaca diversifolia*), whereas no collections of these species were recorded in the northern Rupununi** (Jansen-Jacobs and ter Steege 2000).

Table 1.3 **Overview of the more abundant species found on bush islands, based on collections after Jacobs and ter Steege (2000), reprinted with permission. Names indicated with * represent changes in nomenclature based on the latest updates of the W3 Tropicos database using the TNRS (Boyle et al. 2013).**

| FAMILY | GENUS | SPECIES | N. RUP. | S. RUP. |
|---|---|---|---|---|
| Annonaceae | *Annona* | sp. nov. | 4 | 0 |
| Annonaceae | *Guatteria* | *schomburgkiana* | 2 | 2 |
| Annonaceae | *Xylopia* | *aromatica* | 1 | 2 |
| Apocynaceae | *Himatanthus* | *articulatus* | 2 | 4 |
| Boraginaceae | *Varronia** | *curassavica* | 0 | 3 |
| Fabaceae* | *Cassia* | *moschata* | 1 | 4 |
| Caesalpiniaceae* | *Peltogyne* | *paniculata* | 0 | 5 |
| Caesalpiniaceae* | *Senna* | *multijuga* | 0 | 6 |
| Chrysobalanaceae | *Hirtella* | *racemosa* | 4 | 2 |
| Bixaceae* | *Cochlospermum* | *vitifolium* | 0 | 7 |
| Connaraceae | *Rourea* | *grosourdyana* | 1 | 4 |
| Dilleniaceae | *Curatella* | *americana* | 1 | 2 |
| Erythroxylaceae | *Erythroxylum* | *suberosum* | 2 | 2 |
| Fabaceae | *Centrolobium* | *paraense* | 0 | 2 |
| Fabaceae | *Clitoria* | *brachycalyx* | 1 | 3 |
| Fabaceae | *Platymiscium* | *trinitatis* | 0 | 6 |
| Salicaceae* | *Casearia* | *sylvestris* | 2 | 1 |
| Humiriaceae | *Humiria* | *balsamifera* | 2 | 3 |
| Malpighiaceae | *Byrsonima* | *coccolobifolia* | 1 | 4 |
| Malpighiaceae | *Byrsonima* | *crassifolia* | 2 | 5 |
| Malpighiaceae | *Byrsonima* | *schomburgkiana* | 3 | 7 |
| Fabaceae* | *Pithecellobium* | *roseum* | 1 | 3 |
| Myrtaceae | *Eugenia* | *punicifolia* | 5 | 4 |
| Polygalaceae | *Securidaca* | *diversifolia* | 0 | 5 |
| Rubiaceae | *Isertia* | *parviflora* | 3 | 4 |
| Rubiaceae | *Palicourea* | *rigida* | 3 | 1 |
| Rubiaceae | *Tocoyena* | *neglecta* | 2 | 2 |
| Rutaceae | *Zanthoxylum* | *caribaeum* | 0 | 5 |
| Sapindaceae | *Cupania* | *hirsuta* | 1 | 3 |
| Sapotaceae | *Pouteria* | *surumuensis* | 2 | 5 |
| Verbenaceae | *Lantana* | *canescens* | 0 | 3 |
| Lamiaceae* | *Vitex* | *schomburgkiana* | 1 | 3 |

*Rocky Outcrops*

Most of the rocky outcrops are relatively bare, but those with substrate can sustain plant life ranging from small species such as *Portulaca sedifolia* up to larger woody species such as those belonging to the genus *Clusia*. Often faced with harsh conditions, there are relatively more woody species to be found on these rocky outcrops than smaller herbs or grasses, although these can be quite commonly collected. Table 1.4 shows an overview of the most commonly found species on these rocky outcrops. The majority of species are found only in the South Rupununi, presumably a result of the greater number of rocky outcrops in this area (Jansen-Jacobs and ter Steege 2000).

Table 1.4 **Overview of the more abundant species found on the rocky outcrops, based on collections after Jacobs and ter Steege (2000), reprinted with permission. Names indicated with * represent changes in nomenclature based on the latest updates of the W3 Tropicos database using the TNRS (Boyle et al. 2013)**

| FAMILY | GENUS | SPECIES | N. RUP. | S. RUP. |
|---|---|---|---|---|
| Asparagaceae* | *Furcraea* | *foetida* | 0 | 1 |
| Anacardiaceae | *Cyrtocarpa* | *velutinifolia* | 0 | 2 |
| Apocynaceae | *Stemmadenia* | *grandiflora* | 0 | 4 |
| Bromeliaceae | *Pitcairnia* | *geyskesii* | 1 | 1 |
| Cactaceae | *Cereus* | *hexagonus* | 1 | 1 |
| Cactaceae | *Melocactus* | *smithii* | 0 | 3 |
| Dioscoreaceae | *Dioscorea* | *manicorensis* | 0 | 4 |
| Euphorbiaceae | *Cnidoscolus* | *urens* | 0 | 2 |
| Gesneriaceae | *Sinningia* | *incarnata* | 0 | 3 |
| Melastomataceae | *Miconia* | *rufescens* | 1 | 3 |
| Fabaceae | *Mimosa* | *brachycarpoides* | 0 | 2 |
| Moraceae | *Ficus* | *americana** | 0 | 3 |
| Orchidaceae | *Cyrtopodium* | *glutiniferum* | 0 | 2 |
| Polygalaceae | *Bredemeyera* | *floribunda* | 0 | 3 |
| Portulacaceae | *Portulaca* | *sedifolia* | 0 | 7 |
| Anemiaceae* | *Anemia* | *ferruginea* | 0 | 3 |
| Pteridaceae* | *Doryopteris* | *collina* | 0 | 3 |
| Solanaceae | *Cestrum* | *latifolium* | 0 | 2 |
| Passifloraceae* | *Turnera* | *odorata* | 0 | 7 |

*Gallery Forest*

The majority of the rivers in the Rupununi area (and other parts of Guyana) have forested borders, in general called gallery forests. These forests can be inundated for a prolonged period of time since there is extensive flooding of the savannah during the wet season. As a result, gallery forests are mostly dominated by woody species that often disperse by water. Many trees along these rivers, such as *Macrolobium acaciifolium* and *Senna latifolia* occur in other parts of Guyana as well, being able to travel relatively large distances by water. Table 1.5 shows again that many species found in the south Rupununi are not found or not collected in the northern Rupununi, such as *Echinodorus subalatus, Cabomba furcata, Thalia geniculata* and *Eichhornia diversifolia* (Jansen-Jacobs and ter Steege 2000).

Table 1.5 **Overview of the more abundant species found in gallery forest, based on collections after Jacobs and ter Steege (2000), reprinted with permission. Names indicated with * represent changes in nomenclature based on the latest updates of the W3 Tropicos database using the TNRS (Boyle et al. 2013).**

| FAMILY | GENUS | SPECIES | N. RUP. | S. RUP. |
|---|---|---|---|---|
| Alismataceae | *Echinodorus* | *subalatus* | 0 | 6 |
| Alismataceae | *Sagittaria* | *rhombifolia* | 2 | 4 |
| Cabombaceae | *Cabomba* | *furcata* | 0 | 4 |
| Euphorbiaceae | *Caperonia* | *castaneifolia* | 2 | 3 |
| Phyllanthaceae* | *Phyllanthus* | *stipulatus* | 1 | 7 |
| Fabaceae* | *Neptunia* | *plena* | 2 | 1 |
| Lentibulariaceae | *Utricularia* | *myriocista* | 5 | 3 |
| Marantaceae | *Thalia* | *geniculata* | 0 | 5 |
| Menyanthaceae | *Nymphoides* | *indica* | 3 | 5 |
| Onagraceae | *Ludwigia* | *inclinata* | 1 | 3 |
| Onagraceae | *Ludwigia* | *sedoides* | 3 | 2 |
| Pontederiaceae | *Eichhornia* | *diversifolia* | 0 | 5 |
| Pontederiaceae | *Pontederia* | *subovata* | 0 | 2 |
| Plantaginaceae* | *Benjaminia* | *reflexa* | 5 | 7 |

## Forest inventory – species composition

A total number of 448 individual trees with ≥ 10 cm DBH were recorded in the two plots combined. Based on positive identification, these belonged to a shared total of 35 shared families (GR_PB01 15 vs GR_PB02 27), 44 shared genera (GR_PB01 18 vs GR_PB02 33) and 75 shared different morphospecies in total (of which 36 were positively identified). Sampling the plot near Parabara over the Kuyuwini River (GR_PB01) resulted in recording a total of 249 individuals belonging to 40 morphospecies. In contrast, the plot near the Parabara base camp (GR_PB02) yielded a recording of 199 individuals belonging to 60 morphospecies. To compare the two plots in terms of community composition, i.e. the number of species and the number of individuals belonging to these species, we calculated Fisher's alpha. Fisher's alpha is a widely used biodiversity index, which is relatively independent of sample size and describes the relation between the number of species and their abundance within a sample (Fisher et al. 1943). The plot near Parabara base camp had higher diversity (Fisher's alpha of 14.50 vs 9.34 for the plot in the contiguous rain forest near Parabara village).

**Of all 36 positively identified species recorded in both plots, only 3 occurred in both plots, indicating a relatively high regional diversity concerning tree composition over a small geographic distance**. The most common species by far was *Pithecellobium collinum* (Fabaceae), locally called uridan, with a combined number of 61 individuals. However, it was only found in the GR_PB01 plot. It was followed by manicole palm (*Euterpe precatoria*; Arecaceae, 45 individuals), kokorite palm (*Attalea maripa*; Arecaceae, 39), itikiboraballi (*Swartzia* sp.*;* Fabaceae*,* 29), the sweetheart tree (spp., 25), bartaballi (Sapotaceae, 21), wina kakaralli (spp, 17), kurokai (*Protium* sp.; Burseraceae, 15) and the Kufiballi (*Guarea pubescens*; Meliaceae, 14). All other species had 10 or less individuals. Of all morphospecies, 33 were represented by a single individual (see Figure 1.5 for a rank abundance curve of all species).

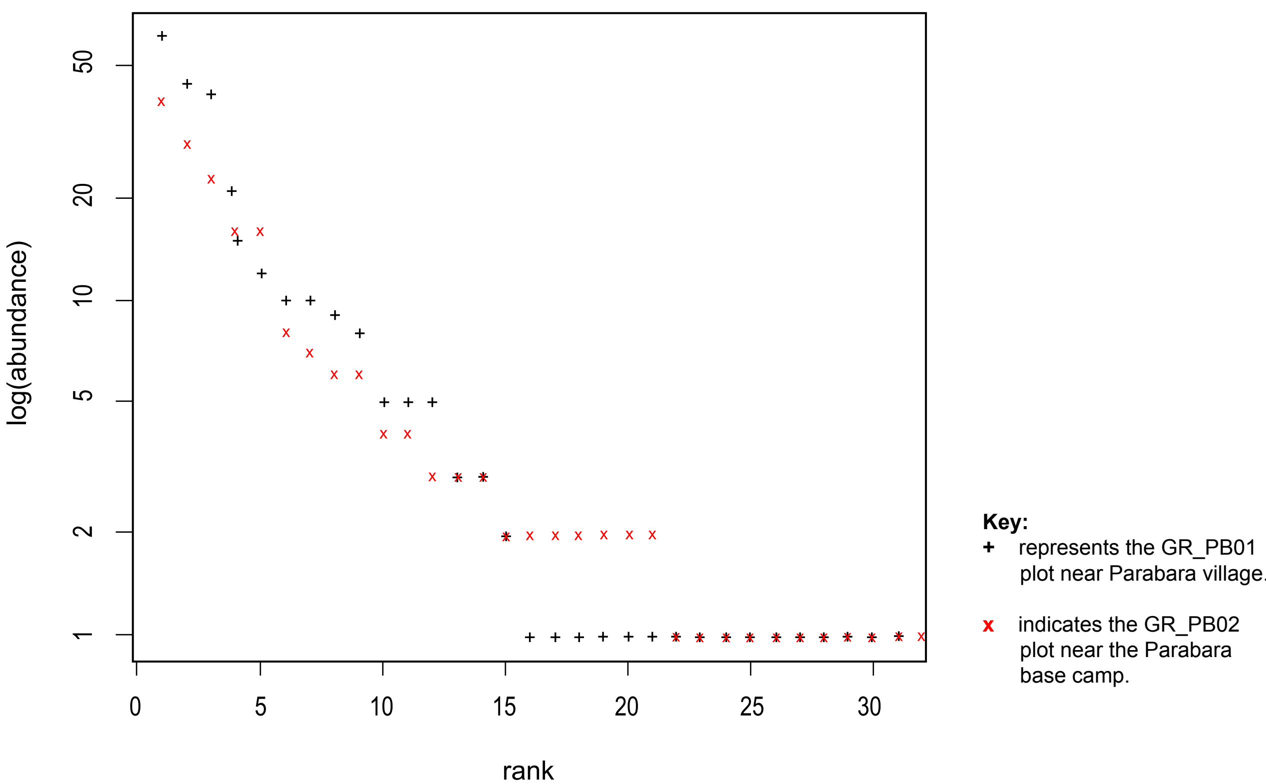


Figure 1.5 **Rank Abundance curve for the two 0.5 hectare plots. Both curves show the distinct pattern of a few dominant species and many singletons (i.e. species occurring only with one individual).**

## Conclusions

There are a number of similar savannah areas occurring throughout northern South America, for example the Cerrado of Brazil (for a detailed study of the floristic composition see Bridgewater et al. 2004), and the Sipaliwini savannah in Suriname (for a comparison between the latter and the Rupununi savannah also see van Donselaar 1969). Many genera such as *Curatella* and *Byrsonima* are not restricted to any specific savannah, but occur in most savannah areas in northern South America. **Most of the species documented during this study, however, are not as common across savannahs and have a more restricted range. As such, the Rupununi savannah adds to the floristic diversity and species richness of Guyana. In turn, this makes the Rupununi savannah a habitat worthy of conservation**. Conservation of areas like the Rupununi is not an easy task, and there are a number of possible threats and conflicts in the process; given these, if a conservation strategy is to be successful, it must take into account the need to secure the livelihoods of the indigenous people inhabiting the area and to foster their involvement in conservation management, in order to gain better protection of the area. As Jansen-Jacobs and ter Steege (2000) have stated, it might be an easier task to protect the overall vastness and clear views of the savannah than it will be to protect its unique flora, but **the Rupununi savannah adds a unique element to Guyana's diversity and as such deserves protection.**

## Recommendations

To be able to gain better insight into the community composition and structure of forests in the South Rupununi and the surrounding areas, more sampling surveys should be considered. This would lead to the inclusion of many more species, for all main vegetation types. Although this survey sampled a relatively large number of species, considering the limited time frame in which this was done, there still remains much to be discovered. For a more detailed view of the species diversity of the Rupununi savannah, more systematic sampling with plots in all vegetation types (stratified by using satellite data) would be necessary. With this information we will be able to gain a better understanding of gradients in species diversity and turnover of species over larger geographical scales.

Such information is vital for making informed decisions regarding conservation practices. **These initial results have shown that the southwest part of the Rupununi savannah is a highly diverse area, both in terms of habitats and occurring species.** The two plots sampled during this survey showed that there is high regional diversity even within relatively short distances. Earlier studies have already indicated that especially the rocky outcrops such as Kusad Mountain and Saddle Mountain are unique habitats within the interior of Guyana, and deserve special attention regarding conservation practices (Jansen-Jacobs and ter Steege 2000). **Overall, this survey revealed that there is much to be discovered and worth protecting in the Rupununi savannah and Parabara region.**

**Acknowledgements**

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# CHAPTER 2

# AMPHIBIANS AND REPTILES OF KUSAD MOUNTAIN AND THE PARABARA REGION IN THE SOUTH RUPUNUNI, GUYANA

*Andrew Snyder, Meshach Pierre, Edward Gomes, and Brice Noonan*

## Summary:

We recorded **a total of 60 species comprising 27 species of amphibians and 33 species of reptiles for the entire study area during this survey.** These numbers are average when compared to other better-sampled areas of the Guiana Shield, but are comparable with numbers recorded during other surveys to the region. It is important to note however, that these numbers were expected as our surveys were not confined to one particular habitat supporting specific taxa (i.e. savannah versus lowland forest), but instead focused on numerous habitats, which potentially biased our results. All of the amphibians encountered belong to the order Anura. One third of the anurans were tree frogs (Hylidae) with nine species, followed by the "southern frogs" (Leptodactylidae) with seven species, toads (Bufonidae) with four species, poison frogs (Aromobatidae, Dendrobatidae), three species, and single representatives of the families Pipidae, Ranidae, and Strabomantidae. Within the reptiles, we recorded one species each of crocodilians and tortoises, 13 species of lizards, and 17 species of snakes. **Myer's thin-toed frog, *Leptodactylus myersi*, was officially recorded for the first time in Guyana during this survey.** These require further genetic and morphological investigation before formal species assignation can be made. The four focal areas surveyed during this expedition differed in their herpetofaunal composition, with many species exclusive to a particular site. At each main survey site new species encounters occurred daily, with a lack of plateau, thus providing evidence of healthy and diverse habitats.

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**Prior to this expedition, the Myer's thin-toed frog (*Leptodactylus myersi*) was known from Brazil, Suriname and French Guiana in forested regions up to 600 m above sea level. In Guyana, this species has now been recorded from Kusad Mountain as well as the nearby Kanuku Mountains.**

**WHILE THE KNOWLEDGE OF GUIANA SHIELD HERPETOFAUNA IS INCREASING RAPIDLY, HERPETOFAUNAL SURVEYS TO THESE REGIONS OF GUYANA'S SOUTHERN RUPUNUNI SAVANNAH REGION HAVE NEVER BEEN CONDUCTED. THIS AREA IS HIGH PRIORITY BECAUSE OF ITS HIGH DIVERSITY OF HABITATS AND LOW LEVELS OF HUMAN ACTIVITY.**

## Introduction

Reptiles and amphibians are important components of Neotropical forests and savannahs. **While the knowledge of Guiana Shield herpetofauna is increasing rapidly, herpetofaunal surveys to these regions of Guyana's southern Rupununi savannah region have never been conducted. This area is high priority because of its high diversity of habitats and low levels of human activity.** The species diversity of reptiles and amphibians is related to habitat diversity because many species demonstrate strict habitat requirements (Tews et al. 2004).

Amphibians and reptiles (hereafter herpetofauna) are often conspicuous, vital components of healthy Neotropical forests and savannahs and the rivers that drain them. They are appropriate for rapid assessments due to their inherent biology (e.g. large population sizes, small to intermediate body size, microhabitat requirements). Additionally, amphibians are sensitive to impacts to their microhabitat and water quality, and as such are good indicators of environmental disturbance (Stuart et al. 2004). They are also well suited for rapid assessment surveys as even hard to collect species 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), making lizards reliable indicators of disturbance as well. Lastly, while snake community structure has been shown resilient to some degree of anthropogenic impacts (França and Araújo 2007), the presence of specialist predators and rare taxa (e.g. *Lachesis muta*) is evidence for a healthy ecosystem. It is also important to note that crocodilians, testudines (turtles), and both large lizards and large snakes are hunted and consumed by Amerindians, and thus the records of any of these species are an indication of hunting pressure in the area (Peres 2000).

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**The bushmaster (*Lachesis muta*) is the longest species of viper in the world. They also happen to be the only species of viper in the Americas that lays eggs, rather than giving birth to live young. After breeding, females will lay about a dozen eggs and will remain with them and incubate them until they hatch. *L. muta* is an adaptable species of snake, occurring in primary and secondary forests, as well as in fields and cleared areas, where they prey predominantly on small mammals.**

As a result of its topographical complexity and geological antiquity, the Guiana Shield has a distinctive herpetofauna (Salerno et al. 2012). Surveys conducted throughout Guyana have revealed a rich herpetofauna and high levels of endemism predominantly associated with uplands and highlands (e. g. Cole and Kok 2006, Kok et al. 2006, MacCulloch and Lathrop 2002). **Guyana hosts 324 described species (148 amphibians and 176 reptiles), 15% of which are endemic to Guyana** (Cole et al. 2013).

As part of the World Wildlife Fund-Guianas and Global Wildlife Conservation's Biodiversity Assessment Team (BAT) survey in the South Rupununi in Guyana, we surveyed the herpetofauna in and around Kusad Mountain and the Parabara region for five and six days, respectively. Each site was broadly subdivided into two main focal areas: savannah/mosaic and forest. Within these we sampled savannah, bush islands, gallery forests, rocky outcrops, riverine forest, human-modified secondary forest, and tropical rainforest.

GUYANA HOSTS 324 DESCRIBED SPECIES (148 AMPHIBIANS AND 176 REPTILES), 15% OF WHICH ARE ENDEMIC TO GUYANA

## Methods

We surveyed amphibians and reptiles during the period of 24 October - 5 November 2013. Our first surveys took place in and around Kusad Mountain from 24 to 29 October 2013, followed by Parabara from 31 October to 5 November 2013. The first step for our surveys consisted of a preliminary survey of the sites to identify and prioritize the areas worthy of the greatest search effort, due to short overall sampling time (Scott 1994). Transportation was available at both base camps, affording the opportunity to survey additional nearby locations. Our Kusad Mountain surveys were conducted within the forested mountain, in the surrounding Rupununi savannah, and two small savannahs located within the mountain at 545 m elevation, as well as at a nearby lowland savannah pond (included in the overall savannah species list). At our second site north of the Parabara area, we surveyed the savannah and surrounding bush islands and gallery forest, which herein are considered mosaic forest, as well as the lowland rainforest surrounding Parabara Village.

In order to encounter as many species as possible in a short period of time, opportunistic surveys were conducted at various times throughout the day and night, though primarily focused on the peak activity periods of dawn and dusk (Donnelly et al. 2004). Except when surveying the pre-established trails around Parabara Village, our team cut lines through the forest and savannah, or used lines cut by other BAT team members. Our surveys covered the primary habitats and microhabitats, especially those associated with water systems. The herpetological sampling also included carefully breaking apart rotting logs, turning over stones and logs, and raking through the leaf litter in order to uncover less conspicuous species.

When observed, reptiles and amphibians were captured by hand. For each specimen, a field number was assigned, and corresponding locality data, preliminary identification, and general descriptions of habitat were noted. When possible, specimens were photographed (by AMS) prior to euthanasia. The samples were anaesthetized and fixed using 10% formol, and subsequently stored in 70% ethanol as museum voucher specimens. The majority of collected specimens have been deposited in the collections of the National Museum of Natural History, Washington, DC, where they will undergo final morphological verification. A smaller reference collection of each species will be deposited at the Centre for the Study of Biological Diversity, University of Guyana, Georgetown. Prior to formalin fixation, we took samples of liver/muscle tissue for DNA analyses from each voucher specimen, which were preserved in 95% ethanol. These tissues were deposited in the University of Mississippi frozen tissue collection. Some photo voucher records of the herpetofauna were documented by other BAT team members and were included in the list only if an accurate identification could be made. In this report, the amphibian and reptile taxonomy follows that of Vitt and Caldwell (2013). All species assignments were checked with AmphibiaWeb (<www.amphibiaweb.org>) and The Reptile Database (<www.reptile-database.org>) which were last accessed 30 January 2015.

## Results

We recorded 27 species of amphibians and 33 species of reptiles for the entire study area during this survey (See Appendix 2). All of the amphibians that were found belonged to the order Anura. One third of the anurans were tree frogs (Hylidae) with nine species, followed by the Leptodactylidae (seven species), toads (Bufonidae, four species), poison dart frogs (Aromobatidae, Dendrobatidae, three species), and single representatives of the families Pipidae, Ranidae, and Strabomantidae (Appendix 2, Figure 2.1).

Within the reptiles, we recorded one species each of crocodilians and tortoises, 13 species of lizards, and 17 species of snakes. The snakes belonged to six families while the lizards represented seven different families. The focal areas explored during this survey show marked differences in their herpetofaunal composition and are discussed below (Figures 2.1- 2.2, Table 2.1).

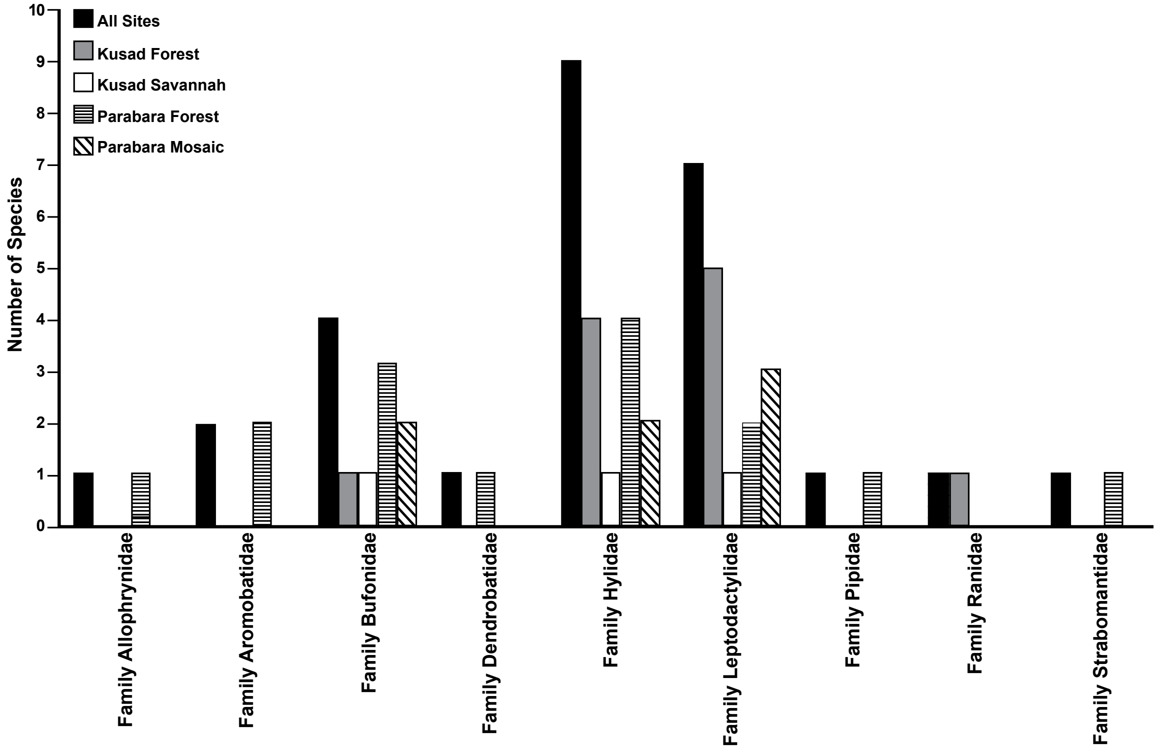


Figure 2.1 **Number of amphibian species, by family, recorded at each focal area during the 2013 BAT survey of the South Rupununi savannah, Guyana**

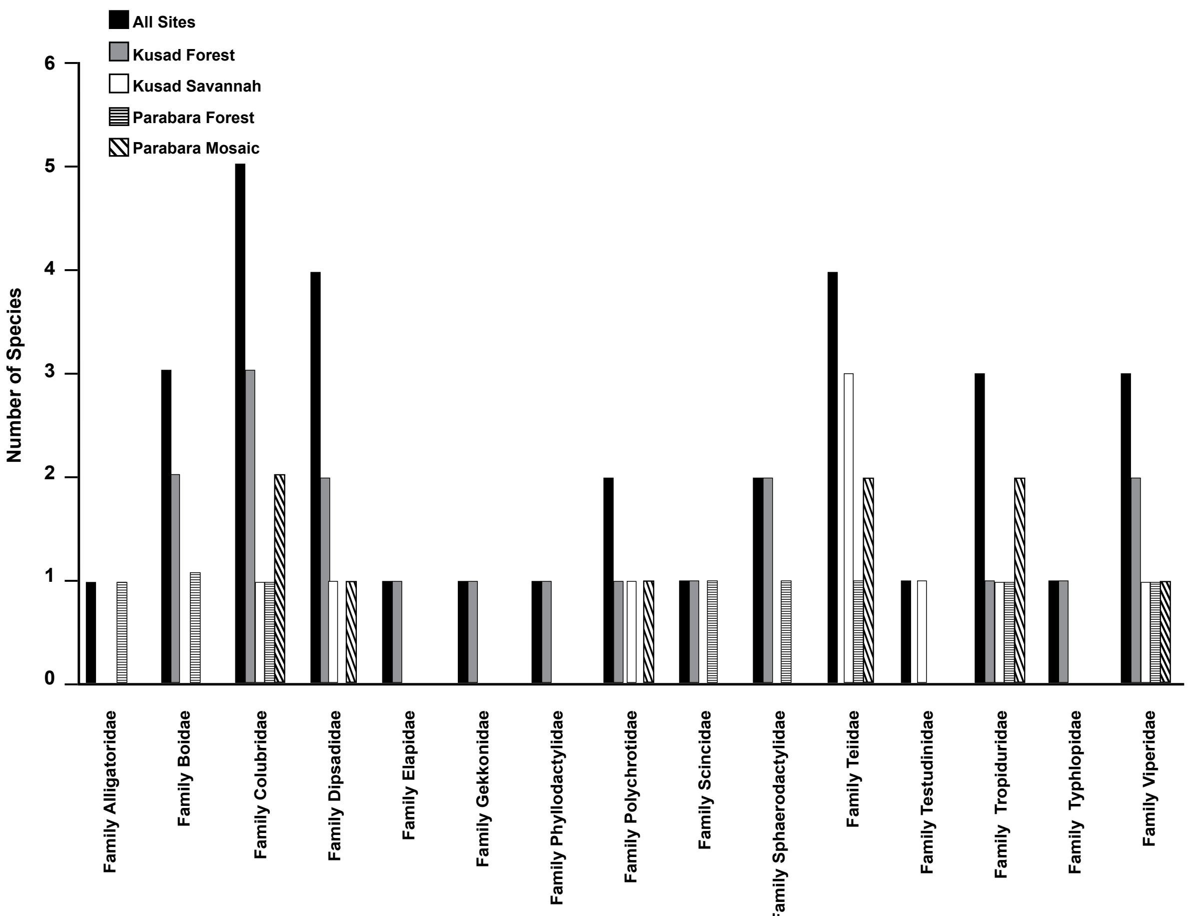


Figure 2.2 **Number of reptile species, by family, recorded at each focal area during the 2013 BAT survey of the South Rupununi savannah, Guyana**

Table 2.1 **Amphibian and reptile species of conservation concern documented during the survey**

| Species | Common name | Group | IUCN | CITES |
|---|---|---|---|---|
| ***Melanosuchus niger*** | Black caiman | Reptile | Lower Risk/Conservation Dependent | Appendix I and II |
| ***Chelonoidis carbonaria*** | Red-footed tortoise | Reptile | Not Evaluated | Appendix II |
| ***Tupinambis teguixin*** | Gold tegu | Reptile | Not Evaluated | Appendix II |
| ***Corallus caninus*** | Emerald tree boa | Reptile | Not Evaluated | Appendix II |
| ***Corallus hortulanus*** | Amazon tree boa | Reptile | Not Evaluated | Appendix II |
| ***Eunectes murinus*** | Green anaconda | Reptile | Not Evaluated | Appendix II |
| ***Ameerega trivittata*** | Three-striped poison frog | Amphibian | Least Concern | Appendix II |
| ***Allobates femoralis*** | Brilliant-thighed poison frog | Amphibian | Least Concern | Appendix II |
| ***Crotalus durissus*** | Neotropical rattlesnake | Reptile | Least Concern | Appendix III |

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**The gold tegu (*Tupinambis teguixin*), known locally as the salipenta, is a large lizard capable of reaching up to three feet in length. They are voracious predators that feed on invertebrates, small mammals, birds, and reptiles, and occasionally fruit. They are most at home in open areas that border forests as well as in secondary forests near areas cleared for agriculture.**

Based on our data from all sites excluding the Parabara forest, employing Chao's (1984) estimator, the total number of herpetofaunal species predicted to be present in the habitats associated with the southern Rupununi savannah was 67.1. No species were common to all four sites (see Appendix 2, Figures 2.1-2.2). Because sampling at each site was not long enough to result in a complete herpetofaunal inventory, Simpson's (1960) equation, correcting for incomplete sampling, was used to compare the amphibians and reptiles between each site (Table 2.2).

Table 2.2 **Comparisons of number of species of amphibians and reptiles found at seven lowland localities, including those surveyed during the South Rupununi Biodiversity Assessment Team expedition in 2013.**

**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).**

| | KF | KS | PF | PM | KaS | AiS | DuM |
|---|---|---|---|---|---|---|---|
| KF | ***29*** | 4 | 5 | 4 | 8 | 9 | 15 |
| KS | 36 | ***11*** | 2 | 4 | 9 | 7 | 9 |
| PF | 36 | 18 | ***14*** | 3 | 7 | 4 | 13 |
| PM | 15 | 36 | 21 | ***26*** | 5 | 4 | 11 |
| KaS | 28 | 82 | 50 | 19 | ***40*** | 19 | 27 |
| AiS | 31 | 64 | 29 | 15 | 59 | ***32*** | 23 |
| DuM | 52 | 82 | 93 | 42 | 68 | 72 | ***83*** |

**Key to sites:**
**KF**- Kusad forest;
**KS**- Kusad savannah;
**PF**- Parabara forest;
**PM**- Parabara mosaic;
**KaS**- Karanambo savannah;
**AiS**- Aishalton savannah;
**DuM**- Dubulay mosaic

Of the 60 species of reptiles and amphibians recorded from both survey sites, only a small proportion are classified by the IUCN Red List of Threatened Species as of conservation concern (see Table 2.1). The black caiman (*Melanosuchus niger*) is listed as Lower Risk/Conservation Dependent. All the other species are listed as either Least Concern due to their wide regional distribution 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. Nine species are currently listed by the Convention on the International Trade of Endangered Species (CITES; Appendix 2, Table 2.1), which means special concern is given to these particular species to ensure their long-term survival is not affected by international trade. As such, CITES listings fall into one of 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 the species' survival, and Appendix III- species that are protected in at least one country.

**Focal area 1: Kusad Mountain – Forest**

Located 40 miles southeast of Lethem, Kusad Mountain is a rocky mountain that reaches 750 m above mean sea level and is completely surrounded by savannah. Within the mountain, surveys were conducted in the forests around the base camp (125 m) and extended to 545 m above sea level. **Of the four focal areas that we surveyed, this site had the second highest species richness with 11 species of amphibians and 18 species of reptiles** (Appendix 2.). Thirty per cent of all amphibians and reptiles that were recorded during the BAT survey were found only in the Kusad Mountain forest focal area (see Figures 2.1-2.2, Table 2.3).

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**Kusad Mountain contains a variety of habitats with each harbouring a different composition of wildlife. At the higher elevations, the vegetation becomes more tropical, as seen around this small waterfall.**

## OF THE FOUR FOCAL AREAS THAT WE SURVEYED, THE KUSAD MOUNTAIN FOREST HAD THE SECOND HIGHEST SPECIES RICHNESS WITH 11 SPECIES OF AMPHIBIANS AND 18 SPECIES OF REPTILES

Table 2.3 **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 | Kusad Mountain forest | Kusad Mountain savannah | Parabara forest | Parabara mosaic |
|---|---|---|---|---|
| Total number of reptile and amphibian species encountered (% of total) | 29 (.48) | 11 (.18) | 26 (.43) | 14 (.23) |
| Total number of amphibian species encountered (% of total amphibians [27 sp.]) | 11 (.41) | 3 (.11) | 15 (.56) | 7 (.26) |
| Total number of amphibian species encountered that were exclusive to locality (% unique) | 6 (.22) | 1 (.04) | 10 (.37) | 3 (.11) |
| Total number of reptile species encountered (% of total reptile species encountered [33 sp.]) | 18 (.55) | 8 (.24) | 11 (.33) | 7 (.21) |
| Total number of reptile species encountered that were exclusive to locality (% unique) | 12 (.36) | 4 (.12) | 2 (.06) | 6 (.18) |



**The emerald-eyed frog (*Hypsiboas crepitans*) thrives in a variety of habitats, from tropical forests, to grasslands, to urban areas. They also occur across an incredibly vast range and exhibit variation in colour, size and call, which suggests that several distinct species are currently classified as *H. crepitans*.**

The diversity of reptiles and amphibians at this site reflects the variety of habitat types (e.g. small rocky streams, non-flooded forests, forest edges) and also suggests a healthy, pristine ecosystem. Although particular species that thrive around anthropogenic disturbances were recorded in the natural open areas within the Kusad Mountain forests (i.e. *Hypsiboas crepitans*), reptiles that are often considered "weedy species" that follow these disturbances were lacking from Kusad Mountain.

**Forty-one per cent of all the amphibians recorded during this BAT survey were found in the Kusad Mountain forest focal area, and six (22%) of them were unique to this site** (see Figure 2.1, Table 2.3). The terrestrial frogs (Leptodactlyidae) were the richest group observed with five species representing three genera (*Adenomera, Leptodactylus* and *Pseudopaludicola*). **We recorded one species, the Myers' thin-toed frog (*Leptodactylus mysersi*), which has not previously been documented for Guyana**. Four different species of tree frogs (Hylidae) were recorded, representing four different genera. Only a single specimen of the veined tree frog, *Trachycephalus typhonius,* was recorded; likely a result of their secretive, arboreal ecology during the dry season (Appendix 2).

**The Kusad Mountain forest focal area boasted a rich reptile fauna** (Appendix 2). Fifty-five per cent of all reptile species recorded during this BAT survey were documented for this focal area (see Figure 2.2, Table 2.1). Although many were single individuals, 11 of the 18 recorded species (representing six different families) were snakes. The family Colubridae comprised the majority of the species we encountered, including the most commonly encountered species – the banded cat-eyed snake (*Leptodeira annulata*). For the family Boidae, we encountered a single Amazon tree boa (*Corallus hortulanus*) and three green anacondas (*Eunectes murinus*) of different sexes and age classes.

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**The turnip-tailed gecko (*Thecadactylus rapicauda*) is a widely distributed gecko that ranges from Brazil northwards to Mexico. These nocturnal geckos are known to vocalize during the night, which is typically a series of chirps. When it is disturbed or agitated by a potential predator, this species will wave its tail back and forth to entice the would-be predator to attack the tail, which it can drop, rather than its head.**

**Focal area 2: Kusad Mountain – Savannah**

This focal area was surveyed in two locations, the savannah surrounding Kusad Mountain, and two small savannahs located at 545 m above sea level within the mountain. We were only able to conduct one day of sampling at both locations combined. **Even though this focal area had the least sampling effort, we still recorded three species of amphibians and eight species of reptiles** (see Appendix 2, Figures 2.1-2.2, Table 2.3). In a pond nearby to Kusad Mountain, the aquatic hylid frog *Lysapsus laevis* was abundant in very high numbers. Additionally, this location resulted in the only record of the brown-banded water snake (*Helicops angulatus*).



**Near Kusad Mountain was one of many of the small ponds that occur in the South Rupununi savannah. These bodies of water are very important for native wildlife, which typically rely on them for drinking water, and they may also support a unique biota.**

The savannahs isolated within Kusad Mountain yielded a single red-footed tortoise (*Chelonoidis carbonaria*), a frequent food source for local communities (Peres 2001), but also harboured other characteristic savannah herpetofauna, including the rainbow whiptail (*Cnemidophorus lemniscatus*) and Neotropical rattlesnake (*Crotalus durissus*).



**The red-footed tortoise (*Chelonoidis carbonaria*) is a large, land-dwelling species. Not a very active species, they often spend over half of the daylight hours at rest. They often seek shelter from predators or to thermoregulate around fallen trees, hollow logs, or even burrows of armadillos and agoutis.**

**Focal area 3: Parabara forest**

This focal region is defined as the lowland tropical forest in and surrounding Parabara Village and was only surveyed over the period of one morning and one night. **Despite the short sampling effort, this area had the second highest species richness, with 15 species of amphibians belonging to eight families** (Allophrynidae, Aromobatidae, Bufonidae, Dendrobatidae, Hylidae, Leptodactylidae, Pipidae, and Strabomantidae) and **11 species of reptiles were observed from ten families** (Alligatoridae, Sphaerodactylidae, Teiidae, Polychrotidae, Tropiduridae, Scincidae, Boidae, Colubridae, Dipsadidae, and Viperidae). **Forty-three per cent of all reptiles and amphibians recorded during this BAT survey were found exclusively in this location** (see Appendix 2, Table 2.3).

Thirty-seven per cent of all amphibians recorded during this BAT survey were exclusive to the forest habitats of the Parabara region (Figure 2.1, Table 2.1). All members of the superfamily Dendrobatoidea were unique to these sites including the three-striped poison frog (*Ameerega trivittata*), the brilliant-thighed poison frog (*Allobates femoralis*), and the rocket frog (*Allobates sumtuosus*). In addition, this focal area produced the only representatives from the genera *Allophryne, Rhaebo, Pipa,* and *Pristimantis* (Appendix 2).

Eighteen per cent of the recorded reptiles were also exclusive to the Parabara forest focal area (see Figure 2.2, Table 2.1). A sub-adult bushmaster (*Lachesis muta*) and emerald tree boa (*Corallus caninus)* were both found in close proximity to Parabara Village. These findings are promising as *Lachesis* are typically killed by local community members whenever encountered, whereas *Corallus* are frequently collected for the pet trade. **Despite anthropogenic disturbance and artisanal gold-mining, the forests surrounding Parabara Village appear healthy and still support infrequently encountered species. Additionally, one black caiman (*Melanosuchus niger*) was observed by the BAT fish team, who also noted an absence of river turtles, indicative of possible overharvesting by the community** (Peres 2001).

**43%**

**OF REPTILES AND AMPHIBIANS RECORDED DURING THIS BAT SURVEY WERE FOUND EXCLUSIVELY IN THE PARABARA FOREST**

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**The emerald tree boa (*Corallus caninus*) is the largest of the tree boas found in Guyana. The species name, *caninus*, is derived from the shape of the head and angle of the snout, thought by some to resemble that of a dog. In addition, they have very large maxillary teeth that also resemble the canine teeth of dogs. It is an arboreal species typically encountered in branches overhanging bodies of water. Its diet consists mainly of small mammals, but it will also consume lizards, frogs and small birds.**

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**The diving lizard (*Uranoscodon superciliosus*), also called the brown tree-climber or mop-headed iguana, is a semi-aquatic species always found near bodies of water. At home among the trees and branches at the water's edge, this species is capable of running for short distances across the surface of the water when threatened. They can also spend long periods of time underwater to avoid predators.**

**Focal area 4: Parabara – Mosaic**

The Parabara mosaic focal area is composed of the savannahs, bush islands, and gallery forests around our second base camp. **Despite numerous sampling days and the observations and collecting by other BAT team members, only seven species of amphibians and seven species of reptiles were recorded** (Appendix 2, Figures 2.1-2.2, Table 2.3). The only representative reptiles were the grass anole (*Anolis auratus*), the green vine snake (*Oxybelis fulgidus*), and Neotropical rattlesnake (*Crotalus durissus*).

## Discussion

For reptile and amphibian community composition, species diversity is related to habitat diversity. Many species exhibit specific habitat requirements and are thus confined to particular microhabitats. The results of this short dry season survey of Kusad Mountain and Parabara in the South Rupununi savannah unquestionably represents only a fraction of the herpetofaunal diversity within these areas. Repeated sampling, especially during the rainy season as well as the dry season, would increase the species list and better reflect the true species richness at these sites. When the results of our survey are compared to herpetological surveys of other lowland forest and savannah sites (both North and South Rupununi savannah) in Guyana, the diversity of species we encountered is low (Table 2.4). However, these surveys were considerably longer than ours, and either had extensive assistance from local children, or employed different survey methods (i.e. pitfall traps) that we were unable to use due to the limited survey time afforded to each site.

Table 2.4 **Herpetofaunal richness at eight lowland sites in Guyana. In each column, data are presented as raw species numbers/percentage of total herpetofauna.**

**Key to habitat type:** Forest- (**F**);Patchwork of forest/ savannah/ and gallery forest- (**M**); Savannah- (**S**)

| Site/Habitat type | Amphibians | Reptiles | Total |
|---|---|---|---|
| **Iwokrama (F)** | 47/0.40 | 71/0.60 | 118 |
| **Kurupukari (F)** | 23/0.58 | 17/0.42 | 40 |
| **Karanambo (S)** | 14/0.35 | 26/0.65 | 40 |
| **Aishalton (S)** | 13/0.41 | 19/0.59 | 32 |
| **Kusad (F)** | 11/0.38 | 18/0.62 | 29 |
| **Kusad (S)** | 3/0.27 | 8/0.73 | 11 |
| **Parabara (F)** | 15/0.58 | 11/0.42 | 26 |
| **Parabara (M)** | 7/0.50 | 7/0.50 | 14 |
| *Mean =* | 17 | 22 | 39 |

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**Throughout the Rupununi savannahs can be found a series of rivers and small creeks. Often surrounding these bodies of water are gallery forests of varying sizes. This gallery forest around a creek in the South Rupununi savannah harboured amphibians and reptiles typically associated with tropical forests rather than the surrounding savannah habitat.**

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**The Neotropical rattlesnake (*Crotalus durissus*) has the widest distribution of any rattlesnake with up to nine recognized subspecies. Their venom is highly neurotoxic, but the specific composition of the venom varies depending on the age of the snake, and the particular subspecies.**

The overall lack of rain during the surveys is largely responsible for the lower herpetofaunal diversity encountered during this expedition. Moderate to heavy rainfall in this region encourages amphibian species to emerge and chorus, and is also a requirement for particular inconspicuous amphibian taxa to breed. As is to be expected, the wet tropical forests surrounding Parabara Village supported greater richness than the dry forests of Kusad Mountain, Kusad savannah, and Parabara mosaic habitat.

Particular emphasis should be given to the higher elevations of Kusad Mountain as well as the contiguous rainforest surrounding Parabara Village. The elevation range in Kusad Mountain as well as its diversity of habitats - forest, savannahs, and mountain streams – undoubtedly harbour additional species not found during our brief survey, as well as unrecognized biodiversity. Our brief (one night and one morning) survey in the tropical forest surrounding Parabara Village yielded many representatives of Guyana's tropical herpetofauna, a large fraction of which were only found at this location.

The results indicate that there is low overlap in species composition between the sites; however this is more likely a result of our short sampling effort as opposed to the true species composition within each location. After employing Chao's (1984) estimator, the total number of herpetofaunal species predicted to be present in the habitats associated with the southern Rupununi savannah was 67.1. At none of our locations was our actual number of species observed close to this estimate. Excluding the Parabara forest site, if additional, yet proportional amount of time were spent surveying each of these sites, it is likely that the herpetofaunal composition in all sites would likely be more similar in both make-up and species' numbers. Relative to lowland tropical forest habitats that are known to support higher diversity, these habitats combine to yield average, yet expected herpetofaunal diversity. However, while the diversity encountered during the entirety of the survey may be considered average and many species may be considered common, many species are characteristic of Guyana's savannah habitats. **Guyana's savannahs are home not just to many iconic herpetofauna, but other flora and fauna as well, and at present no portion is included in Guyana's network of Protected Areas**. Relative to the North Rupununi, the Amerindian communities in the South Rupununi are more broadly distributed. Consequently, this region and its habitats have experienced less anthropogenic impacts throughout time. **It is thus recommended that a large region of the South Rupununi savannah including Kusad Mountain is included in a new protected area affording long-term protection to the distinctive fauna and flora of this region.**

GUYANA'S SAVANNAHS ARE HOME NOT JUST TO MANY ICONIC HERPETOFAUNA, BUT OTHER FLORA AND FAUNA AS WELL, AND AT PRESENT NO PORTION IS INCLUDED IN GUYANA'S NETWORK OF PROTECTED AREAS

IT IS THUS RECOMMENDED THAT A LARGE REGION OF THE SOUTH RUPUNUNI SAVANNAH INCLUDING KUSAD MOUNTAIN IS INCLUDED IN A NEW PROTECTED AREA AFFORDING LONG-TERM PROTECTION TO THE DISTINCTIVE FAUNA AND FLORA OF THIS REGION

## Conservation Recommendations

- Medium to large-bodied reptiles such as the caimans, turtles, and tortoises are frequent food sources for certain Amerindian groups. It was noted that fewer of these species than expected were observed, especially around Parabara Village. **There should be specific studies monitoring the current abundance of these species and to investigate the necessity of a sustainable management plan to ensure their long-term survival in these areas.**

- **Further water-quality monitoring with herpetofaunal surveys** should take place during the wet and dry seasons in Parabara Village **along streams and rivers associated with small-scale gold mining, which threatens the aquatic ecosystem**.

- Perhaps most importantly, **there should be continued training of the local Wapishana and Wai-Wai community members in the monitoring, conservation, and management of the region's herpetofauna to ensure that healthy populations persist into the future**. After reports from the fish team that only a single caiman was spotted during their surveys, it is recommended that river surveys be conducted near Parabara Village for large-bodied, river-dwelling herpetofauna, including caiman (*Melanosuchus, Caiman,* and *Paleosuchus*), turtles (*Podocnemis* sp.), and anacondas (*Eunectes murinus*) to estimate present abundance levels.

- **Include portions of the South Rupununi savannah in Guyana's official network of Protected Areas**.

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## CHAPTER 3

# ADDITIONS TO THE AVIFAUNA OF THE SOUTHERN RUPUNUNI REGION, GUYANA

*Brian J. O'Shea, Asaph Wilson, and Jonathan Wrights*

### Abstract

We report the results of ornithology surveys conducted at two localities in the southern Rupununi during October and November 2013. Birds were surveyed opportunistically over 15 field days, and documented by sound recording and specimen collection. Since both localities had been surveyed by previous researchers, we combined our results with existing species lists for each locality. Our combined list of 487 species includes 32 species previously unrecorded from the southern Rupununi, and is the longest species list recorded for any region of Guyana to date, a reflection of the exceptional diversity of habitats in the area. **The southern Rupununi is home to numerous rare and endemic bird species which are likely to continue to draw tourism revenue to local communities if their habitats remain intact.**

## Introduction

Birds are ideal subjects for rapid biodiversity assessments because most species are diurnal and easy to identify relative to other groups of organisms. A variety of resources exist to facilitate their identification by both sight and sound; nevertheless, the ecology and distribution of many tropical species are still poorly known. Data from rapid assessments can therefore contribute valuable information to inform conservation planning. Bird surveys also present outstanding opportunities to introduce students to ornithological research. This report summarizes findings from ornithology surveys conducted under the auspices of the South Rupununi Biodiversity Assessment Team (BAT), a group of scientists, students and community representatives that surveyed two localities in the southern Rupununi savannah of Guyana from 23 October – 6 November 2013.

The Rupununi savannah is part of an extensive savannah ecosystem covering approximately 54,000 km$^2$ in the northern Brazilian state of Roraima and adjacent southwestern Guyana. In Guyana, it is separated into northern and southern regions by the Kanuku Mountains. The northern Rupununi rests on sediments of the Takutu graben, an ancient rift valley, whereas the southern Rupununi savannahs are situated on much older Precambrian substrate (Hammond 2005). Today, both regions feature a complex mosaic of wetland, savannah, and forest habitats, with isolated mountains occurring throughout, particularly in the south. The Rupununi river flows northward through both regions, bisecting the Kanuku Mountains before emptying into the Essequibo River at Apoteri. The Rupununi is populated by Macushi and Wapishana people, who live in villages and isolated homesteads scattered across the landscape. Much of the savannah is used for cattle grazing, and fires are frequent in the dry season.

Previous bird survey work was conducted by the Smithsonian Institution and the University of Kansas (hereafter SI/KU) at five sites in the South Rupununi between 1995-2001; the results of these surveys are summarized in Robbins et al. (2004), who characterized the avifauna as most similar to that of the contiguous Gran Sabana of Venezuela. Prior to this work, the only published accounts of the region's avifauna were those of G.F. Mees (Mees and Mees-Balchin 1990; Mees 2000), who visited the South Rupununi briefly over three months between 1989-1992 (Robbins et al. 2004). Subsequent fieldwork by SI/KU documented 456 species in the region, including a previously unknown population of the Red Siskin (*Spinus cucullatus*; IUCN Critically Endangered; Robbins et al. 2003), as well as 10 species not recorded before in Guyana.

**THE SOUTHERN RUPUNUNI IS HOME TO NUMEROUS RARE AND ENDEMIC BIRD SPECIES WHICH ARE LIKELY TO CONTINUE TO DRAW TOURISM REVENUE TO LOCAL COMMUNITIES IF THEIR HABITATS REMAIN INTACT**

**MORE THAN HALF OF THE BIRD SPECIES KNOWN TO OCCUR IN GUYANA HAVE BEEN OBSERVED IN THE SOUTH RUPUNUNI**

Overall, **more than half of the bird species known to occur in Guyana have been observed in the South Rupununi**. Given this fact, **there is great potential for people of this region to capitalize on the recent increase in birding-oriented tourism in Guyana.** The purpose of this report is to provide additional information on birds of this region and to highlight species of particular interest for conservation and tourism. Taxonomy and nomenclature of species listed in this report, including the Appendix, follow Remsen et al. (2016).

## Study Sites and Methods

*Study Sites*. Our surveys were based from two main camps – Kusad Mountain (02.812 N, 059.867 W; 23-30 October) and Parabara savannah (02.182 N, 059.337 W, 31 October – 6 November). Both camps were within five kilometres of the camps established at Kusad and Parabara by SI/KU in October-November 2000 and March-April 2000, respectively (Robbins et al. 2004). Our Kusad camp was situated along a creek at the base of the north flank of the mountain. Due to limited accessibility of habitats around the Kusad camp, we also surveyed opportunistically along a walking trail up the mountain itself on 26-27 October; at a large marsh in the savannah roughly 7 km from the camp on 28 October; and very briefly at dawn along the Takutu River on 29 October (this latter survey was terminated by heavy rain shortly after dawn, forcing us to return to camp). Habitat at Kusad was a mix of forest and savannah, the latter ranging from dry to flooded; near the camp itself, the savannah was moderately wet with fairly dense stands of the dominant savannah tree (*Curatella americana*, Dilleniaceae) and long (>1m) grass. Waterways in the savannah were characterized by conspicuous linear stands of the Moriche or Ité palm (*Mauritia flexuosa*). Aside from a few small clearings, the entire mountain was covered by tall forest; on the lower slopes, this forest was quite dry on very rocky ground, with few large trees, whereas at higher elevations it was more humid, with a fairly substantial soil layer and somewhat greater stature and structural complexity.

The Parabara site was located in a large patch of savannah with many ‘bush islands’ of varying size; the camp itself was situated near a corridor of humid forest several hundred metres wide. From this camp, we were able to walk long distances across the savannah and along the road linking Parabara village with Karaudanawa and other settlements. Accordingly, most of our observations were made within a 3-km radius around the camp, although we did spend one day in and around the village of Parabara itself, roughly 11 km by road from the camp. Habitat in Parabara village was a mixture of mostly overgrown agricultural clearings and tall rainforest typical of the region.

*Field Methods.* We used a variety of methods to survey the avifauna. Our primary method was casual observation of birds while walking along roads and trails, or across the savannah itself, noting all species of birds seen and heard. We were active mainly during the first 2-3 hours of daylight, after which bird activity tapered off dramatically, especially in savannah, where it reached a near standstill by mid-day. We also used mist nets at both sites – 5 at Kusad, and 11 at Parabara – set in forest around each camp. We only opened nets when we could check them regularly, which was not every day, since we often spent entire days and nights away from the camps; furthermore, because we were typically afield during the early mornings, we usually opened nets only from mid-morning into the afternoon, when birds were less active. Birds captured in the nets were either collected or released. Specimens were prepared as study skins to be deposited at the National Museum of Natural History in Washington, DC, and at the Centre for the Study of Biological Diversity at the University of Guyana. Birds were also documented by sound recording, using a Marantz PMD-661 digital recorder and a Sennheiser ME-62 microphone. We made four recordings of the dawn soundscape using a stereo microphone pair (Sennheiser MKH-20 and MKH-30). Stereo recordings typically ran for approximately two hours, beginning 30-45 minutes before sunrise. Two stereo recordings were made from each site; one from an old agricultural clearing near the top of Kusad Mountain; another from a marsh in the savannah roughly 7 km from the Kusad camp; and two from the savannah in Parabara, 1-3 km from the camp. All recordings are deposited at the Macaulay Library at the Cornell Lab of Ornithology, Ithaca, NY, USA (MLNS). These recordings serve to document a substantial proportion of the bird species recorded during the survey.

## Results and Discussion

*Species totals.* Due to the short duration of our surveys at each locality and the proximity of our camps to those established by SI/KU, we integrated our species lists into the locality lists of Robbins et al. (2004), for a combined total of 439 species at the two sites. They reported 178 species from Kusad and 335 species from Parabara; we observed an additional 23 species at Kusad and 9 species at Parabara, raising the totals for these localities to 201 and 344 species, respectively. We observed 32 species not listed by Robbins et al. for the south Rupununi region (Table 3.1). The majority of these species are forest birds tht we observed primarily in the vicinity of Parabara village, and a subset of them are generally restricted to riverine forest; nevertheless, considering the large number of forest species recorded by SI/KU at their Parabara camp, there is no reason to suggest that many of these additional species do not also occur near the forest/savannah interface elsewhere in the region. **With our additions, 487 species are now known to occur in the South Rupununi. This is the highest number of species recorded from any surveyed region of similar size in Guyana.**

**487 SPECIES ARE NOW KNOWN TO OCCUR IN THE SOUTH RUPUNUNI. THIS IS THE HIGHEST NUMBER OF SPECIES RECORDED FROM ANY SURVEYED REGION OF SIMILAR SIZE IN GUYANA.**

Table 3.1 **Additions to the South Rupununi avifauna from the GWC/WWF BAT 2013 survey. These species were not listed by Robbins et al. (2004).**

**Key: K** = Kusad; **PS** = Parabara savannah camp; **PV** = Parabara village.
**X** denotes presence of taxon at site named.

| Scientific name | English name | K | PS | PV |
|---|---|---|---|---|
| ***Penelope marail*** | Marail Guan | X | | |
| ***Penelope jacquacu*** | Spix's Guan | | X | |
| ***Mitu tomentosum*** | Crestless Curassow | | X | |
| ***Tigrisoma lineatum*** | Rufescent Tiger-Heron | X | X | X |
| ***Spizaetus ornatus*** | Ornate Hawk-Eagle | X | | |
| ***Heliornis fulica*** | Sungrebe | | | X |
| ***Micrastur mirandollei*** | Slaty-backed Forest-Falcon | | X | X |
| ***Psittacara leucophthalmus*** | White-eyed Parakeet | X | | |
| ***Pyrrhura picta*** | Painted Parakeet | | | X |
| ***Touit purpuratus*** | Sapphire-rumped Parrotlet | | | X |
| ***Lurocalis semitorquatus*** | Short-tailed Nighthawk | | | X |
| ***Antrostomus rufus*** | Rufous Nightjar | | X | |
| ***Chaetura chapmani*** | Chapman's Swift | | | X |
| ***Campylopterus largipennis*** | Grey-breasted Sabrewing | | | X |
| ***Topaza pella*** | Crimson Topaz | | | X |
| ***Amazilia cf. brevirostris*** | White-chested Emerald | X | | |
| ***Chloroceryle aenea*** | American Pygmy Kingfisher | | | X |
| ***Picumnus exilis*** | Golden-spangled Piculet | | | X |
| ***Xiphorhynchus obsoletus*** | Striped Woodcreeper | | | X |
| ***Myrmotherula surinamensis*** | Guianan Streaked-Antwren | | | X |
| ***Microrhopias quixensis*** | Dot-winged Antwren | | | X |
| ***Hypocnemoides melanopogon*** | Black-chinned Antbird | | | X |
| ***Conopophaga aurita*** | Chestnut-belted Gnateater | | | X |
| ***Myiopagis flavivertex*** | Yellow-crowned Elaenia | | | X |
| ***Mionectes macconnelli*** | McConnell's Flycatcher | X | | X |
| ***Phoenicircus carnifex*** | Guianan Red-Cotinga | | | X |
| ***Pachyramphus surinamus*** | Glossy-backed Becard | | | X |
| **Tunchiornis ochraceiceps** | Tawny-crowned Greenlet | | | X |
| ***Atticora fasciata*** | White-banded Swallow | | | X |
| ***Turdus fumigatus*** | Cocoa Thrush | | | X |
| ***Saltator maximus*** | Buff-throated Saltator | | | X |
| ***Euphonia cayennensis*** | Golden-sided Euphonia | | | X |

*Habitat diversity.* **Our high species total reflects the great diversity of habitats in the south Rupununi**, **relative to many other areas in the eastern Guiana Shield lowlands.** At both Kusad and Parabara, savannah species contributed greatly to the total number of species observed. Gallery forest and bush islands also contributed to local diversity; many species found in these habitats do not occur in adjacent rainforest in the region. However, the lowland rainforest bordering the Rupununi savannah on the north, east, and south is by far the greatest contributor to the region's avian diversity. During one morning and early afternoon around Parabara village, we recorded 159 species, 82 of which we did not observe around either of our camps, although many of these species were recorded by SI/KU at their Parabara camp, which was situated adjacent to extensive forest.

The Kusad mountain avifauna was generally less diverse than that of the continuous rainforest around Parabara, although it contained some interesting species; during the BAT survey, 63 of 150 species observed at Kusad were not noted elsewhere. Robbins et al. (2004) reported little singing activity in the forest on Kusad during their survey in October and November 2000, and our observations were similar. Although generally speaking lack of singing can be accounted for in various ways such as a lack of activity from the birds at the time, or by seasonal variations, or by an actual scarcity of birds, in this case the latter explanation may be correct, in that many species typical of Guianan lowland rainforest do appear to be genuinely absent on Kusad, including most species of Furnariidae and Thamnophilidae. Particularly noticeable was the absence of understory mixed-species flocks dominated by *Thamnomanes* antshrikes and *Epinecrophylla* and *Myrmotherula* antwrens, and species that follow army ants. Instead, the forest avifauna was characterized by relatively few species, many of which occur patchily if at all in extensive lowland forest in the region, such as *Phaethornis augusti* (Sooty-capped Hermit), *Herpsilochmus rufimarginatus* (Rufous-winged Antwren), *Tolmomyias sulphurescens* (Yellow-olive Flycatcher), *Chiroxiphia pareola* (Blue-backed Manakin), and *Basileuterus culicivorus* (Golden-crowned Warbler). On the lower slopes in particular, where the forest was generally shorter and drier, the avifauna was similar to that found in gallery forest and bush islands elsewhere in the southern Rupununi. However, an interesting subset of the Guianan lowland forest avifauna was present in tall forest on the mountain, particularly at higher elevations, including *Crax alector* (Black Curassow), *Notharchus macrorhynchos* (Guianan Puffbird), *Monasa atra* (Black Nunbird), *Perissocephalus tricolor* (Capuchinbird), and *Turdus albicollis* (White-necked Thrush), as well as a single individual of *Lipaugus vociferans* (Screaming Piha) observed on the BAT survey (this species was not recorded for Kusad by Robbins et al. (2004)). Considering that many regional species that appear to be absent on Kusad are birds of forest interior known to have low potential for mobility across fragmented landscapes (Stouffer et al. 2011), we suggest that forest species occurring on Kusad are those most likely to disperse across the savannah via the network of gallery forests in the regional landscape. Although poorly documented, there are several anecdotal records of forest birds occurring in gallery forest far from extensive rainforest; for example, both *Jacamerops aureus* (Great Jacamar) and *Tyranneutes virescens* (Tiny Tyrant-Manakin) have been observed in gallery forest along the Rupununi River at Dadanawa (B. J. O'Shea and A. Wilson, *pers. obs.*). **The role of gallery forests as dispersal corridors in the Rupununi deserves more study.**

*Endemic, range-restricted, and migratory species*. Our combined list for Kusad and Parabara includes 38 species endemic to the Guiana Shield (see Appendix 3) and 16 species on the IUCN Red List (IUCN 2014; Table 3.2). Endemics represented approximately 8.4% of species observed, which is typical for the Guiana Shield lowlands.

Table 3.2 **IUCN Red List species known to occur in the South Rupununi. Endemics are indicated in the END column.**

**Key: NT** = Near Threatened; **VU** = Vulnerable; **CR** = Critically Endangered.

| Species | English name | END | IUCN |
|---|---|---|---|
| ***Tinamus major*** | Great Tinamou | | NT |
| ***Crax alector*** | Black Curassow | X | VU |
| ***Mitu tomentosum*** | Crestless Curassow | X | NT |
| ***Odontophorus gujanensis*** | Marbled Wood-Quail | | NT |
| ***Spizaetus ornatus*** | Ornate Hawk-Eagle | | NT |
| ***Psophia crepitans*** | Grey-winged Trumpeter | | NT |
| ***Patagioenas subvinacea*** | Ruddy Pigeon | | VU |
| ***Ramphastos tucanus*** | White-throated Toucan | | VU |
| ***Ramphastos vitellinus*** | Channel-billed Toucan | | VU |
| ***Pyrilia caica*** | Caica Parrot | X | NT |
| ***Epinecrophylla gutturalis*** | Brown-bellied Antwren | X | NT |
| ***Myrmotherula surinamensis*** | Guianan Streaked-Antwren | X | VU |
| ***Hypocnemis cantator*** | Guianan Warbling-Antbird | X | NT |
| ***Myrmornis torquata*** | Wing-banded Antbird | | NT |
| ***Polystictus pectoralis*** | Bearded Tachuri | | NT |
| ***Spinus cucullatus*** | Red Siskin | | CR |

Several species that occur in the southern Rupununi, despite having relatively large geographic ranges, are nonetheless patchily distributed due to low density, habitat specialization, or other ecological factors that remain unknown. These enigmatic species include *Micropygia schomburgkii* (Ocellated Crake), *Asio stygius* (Stygian Owl), *Polystictus pectoralis* (Bearded Tachuri), *Rhytipterna immunda* (Pale-bellied Mourner), *Xenopsaris albinucha* (White-naped Xenopsaris), and *Sporophila fringilloides* (White-naped Seedeater). In addition to the Red Siskin (*Spinus cucullatus*), these species figure prominently on the wish lists of many birdwatchers visiting the Rupununi. **We suggest these species be the focus of monitoring efforts by the South Rupununi Conservation Society, to better inform habitat management and guide tourism, with the goal of ensuring their persistence in the region**.

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**The White-naped Xenopsaris (*Xenopsaris albinucha*) is a poorly-known relative of the becards. A target species for many visiting birdwatchers, it is found locally in the Rupununi, but does not occur anywhere else in the Guianas.**

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**Although many savannah birds are considered ecological generalists, some, like this Bearded Tachuri (*Polystictus pectoralis*), have highly specialized habitat requirements. In the Rupununi, the Tachuri is restricted to those areas of seasonally wet savannah where fires are infrequent enough to allow growth of long grass and scattered shrubs.**

## THE RUPUNUNI HOSTS A REMARKABLY DIVERSE VARIETY OF MIGRATORY SPECIES FOR AN INTERIOR LOCALITY IN THE GUIANA SHIELD

The south Rupununi provides stopover habitat for at least ten species of migratory shorebirds that breed in North America (Robbins et al. 2004). The following Nearctic-Neotropical migrants have also been recorded in the region: *Buteo platypterus* (Broad-winged Hawk), *Falco columbarius* (Merlin), *Riparia riparia* (Bank Swallow), *Hirundo rustica* (Barn Swallow), *Catharus fuscescens* (Veery), *Catharus minimus* (Grey-cheeked Thrush), *Setophaga petechia* (Yellow Warbler), and *Piranga rubra* (Summer Tanager). During the austral winter, populations of several species of flycatchers and swallows migrate to the Rupununi from southern South America. These include *Myiarchus swainsoni* (Swainson's Flycatcher), *Myiodynastes maculatus* (Streaked Flycatcher), *Empidonomus varius* (Variegated Flycatcher), *Tyrannus albogularis* (White-throated Kingbird), *Tyrannus melancholicus* (Tropical Kingbird), *Tyrannus savana* (Fork-tailed Flycatcher), *Progne chalybea* (Grey-breasted Martin), and *Progne tapera* (Brown-chested Martin). Finally, many waterfowl, parrots, and seedeaters (e.g. *Sporophila* spp.) migrate seasonally within the tropics to track preferred resources, and occur in the Rupununi region for all or part of the year. Overall, **the Rupununi hosts a remarkably diverse variety of migratory species for an interior locality in the Guiana Shield.**

**Seasonally flooded areas of the Rupununi savannah provide critical habitat for waterfowl, such as these White-faced (*Dendrocygna viduata*) and Black-bellied (*D. autumnalis*) Whistling-Ducks.**

**Species Accounts**

Below we present detailed accounts for some of the more interesting species encountered during the GWC/ WWF BAT survey.

*Crypturellus undulatus* (Undulated Tinamou). We obtained a specimen of *C. undulatus* at the Kusad camp (USNM 651488). This is the first specimen taken from Guyana in modern times. Although this species has a wide range in South America, the subspecies occurring on the Guiana Shield (*C. u. simplex*) is poorly represented in museum collections. *Crypturellus* tinamous are shy and rarely seen; anecdotal accounts of this species' occurrence at other mixed forest/savannah localities in southern Guyana are complicated by the similarity of its vocalizations to those of *Crypturellus erythropus* (Red-legged Tinamou). **Our specimen confirms the occurrence of this species in the south Rupununi region, where it is likely an uncommon resident of lowland forest.**

*Mitu tomentosum* (Crestless Curassow). A pre-dawn recording near the Parabara camp on 2 November during the 2013 survey features this species singing simultaneously with the related *Crax alector* (Black Curassow). *Mitu tomentosum* was not listed by Robbins et al. (2004), who cite accounts of the species' occurrence in the region in the 1800s and more recent observations from the Essequibo drainage north of the Kanuku Mountains. **Our recording confirms the species' presence in the south Rupununi region, where it is evidently rare. We agree with Robbins et al. that this species has likely declined due to hunting pressure.**

*Jabiru mycteria* (Jabiru). We observed Jabirus at our Kusad camp and at several other locations in the South Rupununi. This spectacular bird is an icon of the savannah landscape and sightings are highly sought after by tourists.

**THE SPECTACULAR *JABIRU MYCTERIA* IS AN ICON OF THE SAVANNAH LANDSCAPE AND SIGHTINGS ARE HIGHLY SOUGHT AFTER BY TOURISTS**

**The massive Jabiru (*Jabiru mycteria*) can readily be found around shrinking pools of water in the dry season. Individuals can live for 40 years or more.**

*Micropygia schomburgkii* (Ocellated Crake). This poorly-known grassland specialist was heard, but not seen, at our Parabara camp; it was also recorded by Robbins et al. (2004) at their Parabara camp roughly five kilometres away, and also at Karaudanawa. **Like many grassland specialists, this species is vulnerable to habitat degradation from excessive use of fire, and is therefore of conservation concern in the Rupununi region.**

*Amazilia* cf. *brevirostris* (White-chested Emerald). Robbins et al. (2004) did not list *A. brevirostris* for the southern Rupununi, but recorded the related *A. versicolor* at four of their five study sites in the region, including Kusad. We found white-bellied *Amazilia* hummingbirds, which we tentatively identified as *A. brevirostris*, singing in dispersed leks in tall forest at higher elevations on Kusad Mountain, and they were especially common in secondary forest near a large semi-inhabited clearing on the mountain, where a dawn recording was made on 26 October (02.795 N, 059.846 W; see Methods). The song was distinct from known vocalizations of *A. versicolor*; although we did not obtain a clear recording, the song matched a recording, catalogued as *A. brevirostris*, made by D. Finch at Karanambu in the North Rupununi (MLNS 72480). We suggest that these closely related species may be locally sympatric in the southern Rupununi, with *A. versicolor* occurring along forest edge and in bush islands in the savannah, whereas *A. brevirostris* inhabits more extensive patches of humid forest. Specimen documentation should be sought to confirm the identity of *Amazilia* hummingbirds in the South Rupununi.

*Antrostomus rufus* (Rufous Nightjar). A pre-dawn recording from near our Parabara camp on 2 November features this species singing in the distance. *Antrostomus rufus* is not listed for the South Rupununi by Robbins et al. (2004), and to our knowledge has only been recorded previously in Guyana in the coastal savannahs near Timehri (C.M. Milensky, pers. comm.); it also occurs in the coastal savannahs of Suriname (BJO, pers. obs.).

*Haematoderus militaris* (Crimson Fruitcrow). **This species is one of the most sought-after birds among visiting birdwatchers, and having a reliable spot to observe one is an asset to any community.** Although it is a poorly known and low-density resident of lowland forest throughout the Guiana Shield, many recent Guyana records of *H. militaris* are from the Parabara area, suggesting that it may be more common there than elsewhere. Robbins et al. (2004) reported this species from forest near their Parabara camp; we did not observe it around our camp, where forest was much less extensive, but we did hear one during a short visit to Parabara village on 1 November.

*Cephalopterus ornatus* (Amazonian Umbrellabird). This species is listed for the southern Rupununi by Robbins et al. (2004) on the basis of a 2001 sight record at the north end of the Parabara savannah. Since that time, there has been at least one other sighting in the same area by L. Ignacio et al., and some local residents are familiar with the species. A distant bird can be heard on a dawn recording made on 5 November, approximately three kilometres NW of our Parabara camp, providing the first modern documentation of this species in Guyana (the only other record for the country is a specimen from the Kanuku Mountains cited by Cabanis (1848); *fide* Robbins et al. (2004)). Considering the lack of modern records from elsewhere in Guyana and adjacent Suriname, this widespread Amazonian species is likely close to its northern distributional limit in the South Rupununi.

*Pachyramphus surinamus* (Glossy-backed Becard). There are relatively few records of this low-density species for Guyana, and it was not listed for the South Rupununi by Robbins et al. (2004). On 1 November, we observed a pair foraging in forest canopy near the edge of an old agricultural clearing near Parabara village.

*Cyanerpes nitidus* (Short-billed Honeycreeper). We observed a pair of *C. nitidus* foraging in forest canopy near the edge of an old agricultural clearing near Parabara village on 1 November (see preceding species account). This species was reported by Robbins et al. (2004) from their Parabara camp, but we know of few other recent Guyana records. Ottema et al. (2009) list the species for Suriname and cite numerous records of birds trapped for the cage trade in the 1970s and 1980s. However, the species appears to be generally rare in that country, as one of us (BJO) has never observed it despite extensive fieldwork there. We suggest that this species may be more numerous in the South Rupununi region than elsewhere in the eastern Guiana Shield lowlands.

***SPOROPHILA CRASSIROSTRIS*, THE LARGE-BILLED SEED-FINCH, KNOWN AS TWA-TWA IN GUYANA, IS PERSECUTED RELENTLESSLY AS A CAGE BIRD IN THE GUIANAS AND ELSEWHERE ACROSS ITS NORTHERN SOUTH AMERICAN RANGE. AS A RESULT, IT NO LONGER OCCURS IN MANY AREAS WHERE IT WAS ONCE COMMON, AND MANY DETAILS OF ITS NATURAL HISTORY REMAIN UNKNOWN.**

Sporophila crassirostris (Large-billed Seed-finch). **This species, known as twa-twa in Guyana, is persecuted relentlessly as a cage bird in the Guianas and elsewhere across its northern South American range. As a result, it no longer occurs in many areas where it was once common, and many details of its natural history remain unknown.** By many accounts, *S. crassirostris* was once plentiful in the southern Rupununi, but has become exceedingly rare as birds have been trapped for singing competitions, principally along the coastal plain of Guyana and Suriname, although many are also exported illegally. **Although this species and many other seedeaters are notoriously nomadic, we consider our failure to find *S. crassirostris* as further evidence that the species has been largely extirpated from the southern Rupununi. Future conservation efforts should focus on identifying and protecting critical habitat for this species to restore its former abundance.**

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**Asaph Wilson of the South Rupununi Conservation Society (SRCS) instructs students from Potarinau Primary School on the use of field guides to identify birds. Founded in 2003, the SRCS is a grassroots organization dedicated to the protection of the ecosystems, environment, and heritage of the southern Rupununi region.**

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**Red Siskin, critically endangered worldwide. Discovery of a population in 2000 (Robbins et al.) in the South Rupununi gives hope for the survival of this species.**

**MANAGEMENT OF HABITATS SHOULD INCLUDE REDUCING THE FREQUENCY AND EXTENT OF FIRES, LIMITING HUNTING OF GAME BIRDS (PARTICULARLY DURING THEIR BREEDING SEASONS), AND PROTECTING FOREST HABITATS AND WATER QUALITY**

*Spinus cucullatus* (Red Siskin). **The discovery of a population of Red Siskins in the South Rupununi in April 2000 renewed hope for the conservation of this IUCN Critically Endangered species (Robbins et al. 2003). It has since become the flagship species of the South Rupununi Conservation Society (SRCS) and is the subject of much local interest.** We are pleased to report that Red Siskins continue to thrive in the region, where **their presence has spurred a substantial increase in ecotourism and contributed positively to the local economy**. We are hopeful that ongoing education and research projects by the SRCS will continue to enhance our knowledge of this species and ensure community support for its preservation.

## Recommendations

The South Rupununi harbours a high diversity of birds due to the presence of several habitat types including lowland rainforest, wet and dry savannah, dry hill forest, and gallery forest, all in close proximity. **The savannah avifauna is vulnerable to the widespread practice of burning, which occurs throughout the dry season across much of the Rupununi.** Although many savannah species are ecological generalists that can be common in human-dominated landscapes, a handful of them are restricted to particular habitats in the savannah and are vulnerable to local extinction. Sensitive species in the South Rupununi include *Micropygia schomburgkii* (Ocellated Crake) and *Polystictus pectoralis* (Bearded Tachuri); fortunately, these species are among the top targets of visiting birdwatchers, so reliable sites for seeing them are already afforded some protection in the region.

Overall, the high bird diversity of the South Rupununi can be maintained through the same community-based habitat management currently proposed to protect game animals, fish, and water sources (Gomes and Wilson 2012). Protecting bird habitats would improve quality of life by attracting tourism revenue and sustaining populations of species that control crop pests and provide food for people. **Management of habitats should include reducing the frequency and extent of fires, limiting hunting of game birds (particularly during their breeding seasons), and protecting forest habitats and water quality along rivers throughout the region.** All of these practices are known to residents of the South Rupununi, and should be easy to maintain provided the region resists the incursion of large-scale resource extraction and agriculture by outside interests.

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# CHAPTER 4

# SMALL MAMMALS OF THE SOUTH RUPUNUNI REGION, GUYANA

*Burton K. Lim, Chetwynd Osborne, and Abraham Ignace*

THE HIGHLIGHT OF THE SURVEY WAS THE NEW COUNTRY RECORD OF THE ORINOCO SWORD-NOSED BAT (*LONCHORHINA ORINOCENSIS*) THAT WAS PREVIOUSLY KNOWN FROM THE SAVANNAHS OF VENEZUELA AND COLOMBIA

## Summary

The total number of species of small mammals recorded was 37 for the Biodiversity Assessment Team (BAT) survey of the South Rupununi region in Guyana. This included 35 species of bats and two species of rodents. At the two primary sampling sites, the foot of Kusad Mountain had 22 species of bats and one species of rodent; and Bototo Wau near Parabara had 25 species of bats and one species of rodent. **The highlight of the survey was the new country record of the Orinoco sword-nosed bat (*Lonchorhina orinocensis*) that was previously known from the savannahs of Venezuela and Colombia.** Another interesting result was the fourth documentation of an undescribed species of free-tailed bat (*Molossus* sp. nov.) from Guyana. The overall general threat to small mammals is the loss of forested habitat where bats, rodents and opossums primarily live. **The conservation recommendation is the protection of the mosaic of gallery forests and bush islands within the larger Rupununi savannahs, which harbour a small but distinct assemblage of small mammals.**

## Introduction

Small mammals are loosely defined as species less than 1 kg in body mass, such as all bats and most rodents and opossums. In lowland tropical areas of South America, this group typically accounts for over half of the mammalian species diversity. **There are 222 species of mammals known from Guyana**, of which almost 80% are bats, rats, and opossums (Lim et al. 2005; Lim 2012).

**THERE ARE 222 SPECIES OF MAMMALS KNOWN FROM GUYANA**

**These species of small mammals are important for conservation because many are seed dispersers and flower pollinators responsible for ecosystem regeneration. Others are primary predators of nocturnal insects and keep in check these populations that may otherwise do damage to vegetation and have an economic impact**. Because of their high species diversity, relative abundance, and ease of capture, bats in particular are a good taxonomic group for the rapid assessment of biodiversity.

This was the first survey of small mammals in the Kusad Mountain and Parabara areas of the South Rupununi in Guyana. It was conducted from 23 October to 4 November 2013. Prior to this, there had been five other studies in this region: (*1*) an expedition in 2007 to three localities geographically intermediate to Kusad and Parabara (Lim unpublished data); (*2*) in 2001, a survey was done of the eastern Kanuku Mountains (Lim and Norman 2002); (*3*) in 1993, a survey was conducted in the western Kanuku Mountains (Emmons 1993); (*4*) an expedition in 1990 to Lethem and the western Kanuku Mountains (Lim unpublished data); and (*5*) collecting was done based primarily at Dadanawa Ranch from 1961-1974 in the surrounding savannah and rainforest (Emmons 1993, Lim and Catzeflis 2014).

## Methods

The small mammal biological assessment team comprised Burton Lim (mammal curator from the Royal Ontario Museum), Chetwynd Osborne (biology student from the University of Guyana), and Abraham Ignace (local field assistant from Shulinab village; Figure 4.1).



Figure 4.1 **Small mammal biological assessment team at Bototo Wau, near Parabara, for the 2013 South Rupununi survey: Abraham Ignace, Burton Lim, and Chetwynd Osborne.**

**THIS WAS THE FIRST SURVEY OF SMALL MAMMALS IN THE KUSAD MOUNTAIN AND PARABARA AREAS OF THE SOUTH RUPUNUNI IN GUYANA**

Survey methods included the use of H.B. Sherman traps (Tallahassee, Florida) set on the ground and in trees to sample both terrestrial and arboreal rats, mice and mouse opossums. Two sizes of Sherman folding live traps were used: LFATDG (3 x 3.5 x 9") and XLF15 (4 x 4.5 x 15"). Line transects were placed in both forest and savannah habitats with traps set approximately 5 metres apart and baited with unprocessed in-the-shell sunflower seeds. Larger opossums were targeted with Tomahawk traps (Hazelhurst, Wisconsin) that were strategically set on the ground near large trees with vines leading up to the crowns, to increase the chances of encountering animals. Two sizes of Tomahawk folding live traps were used and baited with sardines: 202 (6 x 6 x 19") and 205 (9 x 9 x 26"). There were a total of 1,713 Sherman trap-nights and 20 Tomahawk trap-nights. Traps were checked each morning.

For bats, Association of Field Ornithologists (AFO) Banding Supplies mist nets (Plymouth, Massachusetts) were set in the forest understory and at the savannah interface, typically in pairs with a short (DT108; 2.6 x 6 m) mist net set perpendicular to a long (AT104; 2.6x12m) mist net. A BatNets (Austin, Texas) triple high mist net system was used to stack three long nets on top of each other, and set in the savannah at the edge of the forest. Nets were typically opened from 6-10 p.m. and checked on a regular basis approximately every hour. There were a total of 184 understory net-nights and 11 canopy net-nights.

Voucher specimens were prepared as dried skins with skulls and skeletons, or as whole animals fixed in 10% formalin with long-term storage in 70% ethanol. These different preparation types maximize the examination of both osteological morphology and soft anatomy. Tissue samples of liver, heart, kidney, and spleen were frozen in liquid nitrogen and muscle in 95% ethanol with long-term storage in a –80C ultra-cold freezer for molecular study. A reference collection will be deposited at the University of Guyana's Centre for the Study of Biological Diversity and the Royal Ontario Museum as documentation of the biodiversity of mammals in the Rupununi savannah, and available for research to the international community. Initial field identifications were based on traditional assessment of morphological characters (Emmons and Feer 1997, Lim and Engstrom 2001).

Species were confirmed by genetic analysis using DNA barcoding of the cytochrome c oxidase subunit I (COI) gene, which is a taxonomic tool for species identification and discovery (Hebert et al. 2003). Molecular methodology follows that for small mammal studies in Guyana (Clare et al. 2007) and Suriname (Borisenko et al. 2008). COI sequences were summarized based on a neighbour-joining tree of Kimura 2-parameter pairwise differences with well-supported groupings identified by > 80% bootstrap support from 500 replicates as calculated in the phylogenetic and molecular evolutionary analysis program MEGA 6 (Tamura et al. 2013).

Estimates of biodiversity were calculated using the measures of species diversity and relative abundance computed in EstimateS (Colwell 2013).

## Study Sites

Two primary study sites were surveyed for small mammals. The first site was located in the isolated forest of Kusad Mountain (2.81245 N  59.8666 W, 125 m elevation) and was surveyed for six nights from 23- 28 October 2013. Three trap lines were set with one about 200 m along a trail in the forest that led to a dry, rocky creek bed with the headwaters originating at the approximately 500 m summit. A second trap line of 100 m was set in the adjacent savannah. The third trap line was 300 m in length and wound its way from the creek beside the camp, through forest and a small patch of savannah before ending in an abandoned banana field. There were more mist nets set in the forest than in the savannah.

The second site was situated approximately 90 km to the southeast of Kusad and 10 km north of the village of Parabara in savannah beside gallery forest, about 250 m in width, bordering the creek named Bototo Wau (2.18201 N 59.33704 W, 245 m elevation). It was surveyed for five nights from 31 October to 4 November 2013. Two trap lines of 100 m were set in savannah on either side of the gallery forest, following the wet course of palm trees. There were no trails in the gallery forest but three trap lines of 200-300 m of length were set. Because of the absence of trails, most mist nets were set in the savannah rather than in the forest.

## Results

**A total of 37 species were represented by 257 individuals of small mammals** (Table 4.1). This included 35 species of bats represented by 248 individuals and 2 species of rats documented by 9 individuals. All rats were prepared as voucher specimens to document the small mammal diversity but 75 individuals of the more common species of bats were released unharmed.

Table 4.1 **Preliminary checklist of small mammals from the biological assessment of the South Rupununi, Guyana, in 2013**

| Species | Kusad | Parabara | Total |
|---|---|---|---|
| **BATS:** | | | |
| ***Carollia perspicillata*** | 40 | 37 | 77 |
| ***Artibeus cinereus*** | 19 | 11 | 30 |
| ***Artibeus lituratus*** | 0 | 21 | 21 |
| ***Artibeus planirostris*** | 11 | 9 | 20 |
| ***Phyllostomus discolor*** | 5 | 5 | 10 |
| ***Artibeus bogotensis*** | 1 | 8 | 9 |
| ***Glossophaga soricina*** | 9 | 0 | 9 |
| ***Phyllostomus elongatus*** | 6 | 1 | 7 |
| ***Sturnira lilium*** | 4 | 3 | 7 |
| ***Glossophaga longirostris*** | 6 | 0 | 6 |
| ***Phyllostomus hastatus*** | 2 | 4 | 6 |
| ***Trachops cirrhosus*** | 6 | 0 | 6 |
| ***Artibeus concolor*** | 0 | 4 | 4 |
| ***Desmodus rotundus*** | 4 | 0 | 4 |
| ***Lophostoma silvicolum*** | 1 | 2 | 3 |
| ***Micronycteris megalotis*** | 2 | 1 | 3 |
| ***Rhinophylla pumilio*** | 0 | 3 | 3 |
| ***Choeroniscus godmani*** | 0 | 2 | 2 |
| ***Micronycteris minuta*** | 1 | 1 | 2 |
| ***Mimon crenulatum*** | 0 | 2 | 2 |
| ***Myotis nigricans*** | 1 | 1 | 2 |
| ***Saccopteryx bilineata*** | 2 | 0 | 2 |
| ***Ametrida centurio*** | 0 | 1 | 1 |
| ***Artibeus gnomus*** | 0 | 1 | 1 |
| ***Artibeus obscurus*** | 0 | 1 | 1 |
| ***Carollia brevicauda*** | 1 | 0 | 1 |
| ***Eptesicus furinalis*** | 1 | 0 | 1 |
| ***Lonchorhina orinocensis*** | 1 | 0 | 1 |
| ***Mesophylla macconnelli*** | 0 | 1 | 1 |
| ***Molossus molossus*** | 0 | 1 | 1 |
| ***Molossus* sp. nov.** | 0 | 1 | 1 |
| ***Phylloderma stenops*** | 0 | 1 | 1 |
| ***Pteronotus parnellii*** | 1 | 0 | 1 |
| ***Saccopteryx leptura*** | 1 | 0 | 1 |
| ***Uroderma bilobatum*** | 0 | 1 | 1 |
| **Total** | 125 | 123 | 248 |
| **RODENTS:** | | | |
| ***Proechimys guyannensis*** | 7 | 0 | 7 |
| ***Zygodontomys brevicauda*** | 0 | 2 | 2 |
| **Total** | 7 | 2 | 9 |

THE SHORT-TAILED FRUIT BAT (*CAROLLIA PERSPICILLATA*) WAS THE MOST ABUNDANT SPECIES CAUGHT

Of the 182 specimens, DNA barcodes were recovered from all but four individuals, which will be reattempted in the near future. Only one species (*Carollia brevicauda*) was not represented by barcode sequences. The 36 DNA-barcoded species (Figure 4.2) were highly supported by at least 90% bootstrap values and were separated by >3.2% sequence divergence, which was the average distance between the closely related fruit-eating bats *Artibeus lituratus* and *A. planirostris*. For the similarly evolving mitochondrial gene of cytochrome b, this sequence value was at the lower end of divergence for sister species of bats (Baker and Bradley 2006).

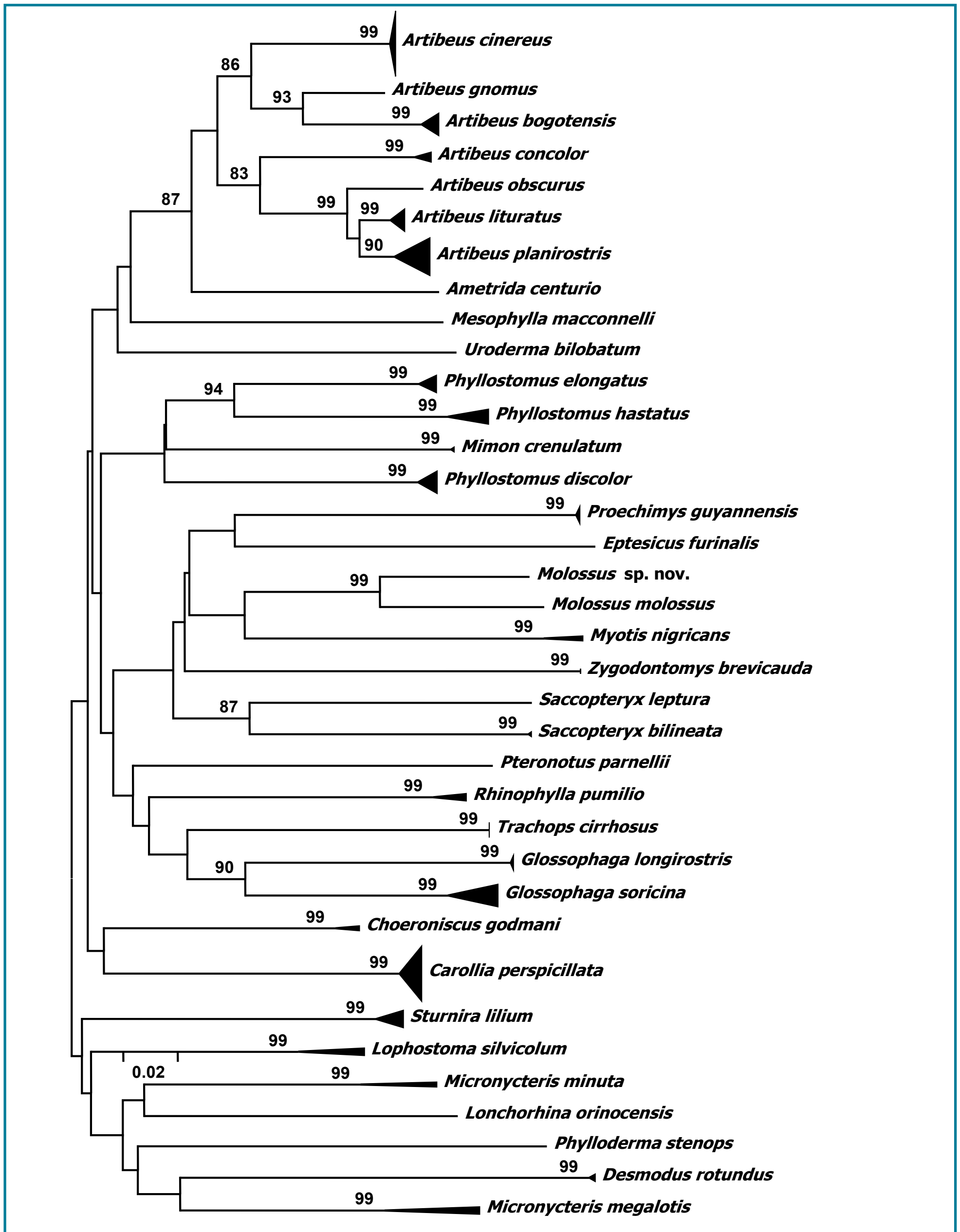


Figure 4.2 **Neighbour-joining tree of DNA barcode sequences for 36 species of small mammals, documented from a biological assessment of the South Rupununi, Guyana. Numbers above branches are bootstrap support values > 80%.**

The short-tailed fruit bat (*Carollia perspicillata*; Figure 4.3) was the most abundant species caught (77 individuals; see Table 4.1). It is widely distributed throughout the Neotropics and is a primary seed disperser of the colonizing plant shrub *Piper* that is commonly found in forest gaps or the edge of open areas, such as savannahs. This bat represented about 25% of the total captures in mist nets and was more than twice as common as the second most caught species (*Artibeus cinereus*; Figure 4.4), which is a fruit-eating bat that specializes on figs.



Figure 4.3 ***Carollia perspicillata*, Seba's short-tailed fruit bat (ROM 122611), from Bototo Wau, near Parabara, Guyana. This species of bat is the main seed disperser for important colonizing shrubs in the genus Piper, that allow for emergent canopy trees to form primary rainforest.**

The next two abundant species (*A. planirostris*, Figure 4.5; and *A. lituratus*, Figure 4.6) are larger than their more common congener and are also fig-eating specialists. These three species of *Artibeus* occur throughout most parts of tropical South America east of the Andes and *A. lituratus* also ranges into Central America.

At nine individuals, the trap success rate of Sherman and Tomahawk traps was low, as is usually typical in lowland areas of the Guiana Shield. In practical terms, it took on average 190 traps to catch one rodent. No opossums were captured and only one tegu lizard was caught in the Tomahawk traps. Similarly, species diversity was low with one species of terrestrial spiny rat (*Proechimys guyannensis*) caught in the forest surrounding Kusad, and one species of the short-tailed cane mouse (*Zygodontomys brevicauda*) caught in the savannahs near Parabara (see Table 4.1).



Figure 4.4 ***Artibeus cinereus,*** **a small fruit-eating bat (ROM 122541), from the base of Kusad Mountain, Guyana. This is an indicator species of drier, open habitats such as the Rupununi savannahs.**



Figure 4.5 ***Artibeus planirostris,*** **a larger fruit-eating bat (ROM 122625) from Bototo Wau, near Parabara, Guyana. This fig-eating specialist is common and widespread in the greater Amazonian rainforest of South America.**


Figure 4.6 ***Artibeus lituratus*, greater fruit-eating bat (ROM 122631) from Bototo Wau, near Parabara, Guyana. Another fig-eating specialist that is common and widely distributed in the Neotropics, but inexplicably was caught only in the vicinity of Parabara and not from Kusad.**

For bats, the Kusad site documented 22 species represented by 125 individuals, and the Parabara site documented 25 species represented by 123 individuals. Kusad had one more night of netting but the total number of nets set was slightly higher at the Parabara site. All richness estimators and diversity indices suggest that Parabara was more biodiverse than Kusad (Table 4.2).

Table 4.2 **Biodiversity measures (Colwell 2013) of small mammals from the biological assessment of the South Rupununi, Guyana, in 2013**

| Variable | Bats | | | Small non-volant mammals | | |
|---|---|---|---|---|---|---|
| | Kusad | Parabara | Total | Kusad | Parabara | Total |
| **Observed data:** | | | | | | |
| Individuals | 125 | 123 | 248 | 7 | 2 | 9 |
| Species | 22 | 25 | 35 | 1 | 1 | 2 |
| Trap-nights | 106 | 111 | 217 | 837 | 896 | 1733 |
| **Richness estimators:** | | | | | | |
| ACE | 32 | 41 | 49 | - | - | - |
| ICE | 30 | 41 | 48 | - | - | - |
| Chao 1 | 31 | 41 | 52 | - | - | - |
| Chao 2 | 29 | 33 | 48 | - | - | - |
| Jack 1 | 30 | 35 | 47 | - | - | - |
| Jack 2 | 34 | 39 | 53 | - | - | - |
| Bootstrap | 25 | 29 | 40 | - | - | - |
| Average richness | 30 | 37 | 48 | - | - | - |
| **Diversity indices:** | | | | | | |
| Alpha | 7.74 | 9.48 | 11.11 | - | - | - |
| Shannon | 2.39 | 2.45 | 2.65 | - | - | - |
| Shannon Exponential | 10.88 | 11.62 | 14.14 | - | - | - |
| Simpson | 6.65 | 6.96 | 7.47 | - | - | - |

The species accumulation curves for both sites were rising and had not reached asymptotes (Figure 4.7). Similar calculations could not be done for rodents and opossums because of the low trap success.

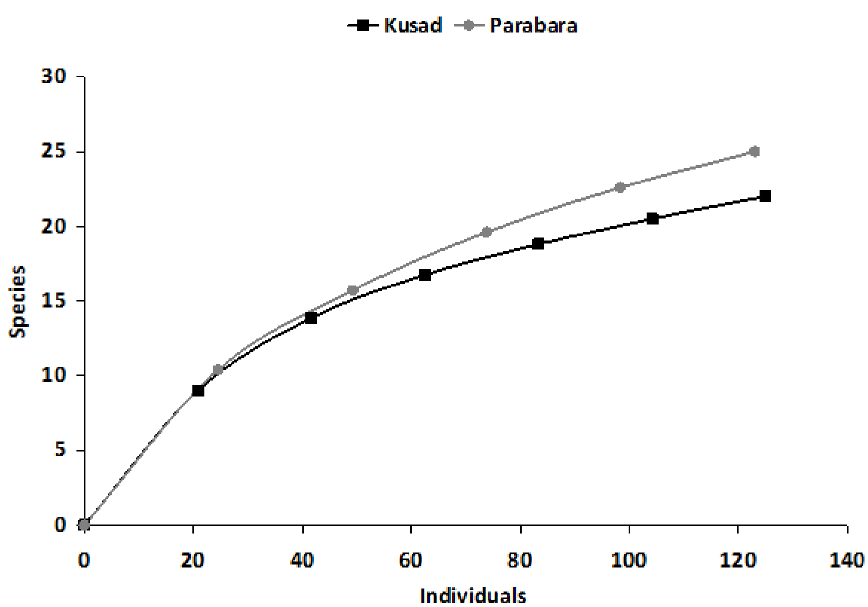


Figure 4.7 **Species accumulation curves for bats from the 2013 biological assessment of the South Rupununi, Guyana, at Kusad Mountain and Bototo Wau, near Parabara.**

## Discussion

**The most interesting species caught was the Orinoco sword-nosed bat (*Lonchorhina orinocensis*;** Figure 4.8**), which represents the first record for Guyana. This is a distributional range extension of approximately 700 km from its previous known occurrence in the savannahs of Venezuela and Colombia** (Williams and Genoways 2008). **It is listed as vulnerable on the IUCN Red List of Threatened Species because of declining populations and threatened habitats** (Ochoa and Molinari 2008). No other species of bats from Guyana are listed as threatened. Our specimen was caught in a small patch of savannah within the larger isolated forest surrounding Kusad Mountain. The five species of sword-nosed bats are insectivorous.



Figure 4.8 ***Lonchorhina orinocensis*, Orinoco sword-nosed bat (ROM 122490), from the base of Kusad Mountain, Guyana. Previously known from only the Llanos savannah of Venezuela, this is the first report of this poorly known species from Guyana.**

Another interesting find was an undescribed species of free-tailed bat (*Molossus* sp. nov.; Figure 4.9) that was previously reported from Nappi Creek in the Kanuku Mountains and Iwokrama Forest of Guyana (Lim and Engstrom 2001) and Amazonian Ecuador (unpublished data). It is the smallest species in the genus known from the Guiana Shield and is an aerial insectivore. Our specimen was caught in savannah near the edge of gallery forest at Bototo Wau. It has a sequence divergence of 9.3% (see Figure 4.2) from the common free-tailed bat (*M. molossus*) that was also captured in the same vicinity, and within the typical range of interspecific differences for bats (Baker and Bradley 2006). However, more study is needed to properly describe this cryptic species.



Figure 4.9 ***Molossus* sp. nov., undescribed species of free-tailed bat (ROM 122583) from Bototo Wau, near Parabara, Guyana. It has also been found in eastern Ecuador, but there are currently no reports of this species from the intervening 2,000 km of Amazonian rainforest.**

In addition to the new record of sword-nosed bat, another savannah endemic species is the nectar-feeding bat, *Glossophaga longirostris* (Figure 4.10), that was caught six times at Kusad but not in the Parabara area. The short-tailed cane mouse (*Zygodontomys brevicauda*) also occurs in only savannah habitats. It was caught twice in the Parabara area but not at Kusad. However, both of these species would be expected to occur in the Rupununi grasslands if trapping effort was increased. All other species of small mammals caught in the savannah region are also commonly found in typical lowland rainforest of Guyana.

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Figure 4.10 ***Glossophaga longirostris*, long-nosed nectar-feeding bat (ROM 122484), from the base of Kusad Mountain, Guyana. This is a species of bat closely associated with drier, open habitats in northwestern South America.**

Although widely occurring across the Guiana Shield, the relative abundance of small species of fruit-eating bats in the genus *Artibeus* is closely associated with habitat type. In a previous study by Lim et al. (2008), *A. cinereus* comprised 87%, *A. bogotensis* 13%, and *A. gnomus* none of the captures in interior savannah of Guyana. By contrast, *A. gnomus* comprised 80%, *A. bogotensis* 19%, and *A. cinereus* 1% of captures in the interior rainforest. Our biological assessment supported these findings with *A. cinereus* comprising 76%, *A. bogotensis* 22%, and *A. gnomus* 2% of captures. **This also represents the first report of *A. gnomus* in the gallery forests of the Rupununi savannahs.**

In terms of comparison, there were 12 species of bats that were caught at both sites. By contrast, 10 species were caught in only the Kusad Mountain area and 13 species were caught in only the Parabara area. This indicated that the bat faunal composition was different between the two sites, and all biodiversity measures suggested that Bototo Wau near Parabara was more diverse for bats than Kusad. A possible explanation is that the surrounding rainforest near Bototo Wau has more influence as a species source for higher diversity than the surrounding savannah that isolates Kusad.

Other biological assessments of small mammals in the Guiana Shield that used similar survey methods include the Kanuku Mountains in Guyana (Lim and Norman 2002), Kwamalasamutu in Suriname (Lim and Joemratie 2010), and Upper Palameu River in Suriname (Lim and Banda 2012). In comparison, the South Rupununi assessment had a significantly higher species richness (one-tailed z-test; p=0.998) for bats than the other localities (Table 4.3). By contrast, the South Rupununi had a significantly lower species richness (p=0.011) for small non-volant mammals. This is a negative correlation (-0.691) between bat and small non-volant mammal species richness among the localities.

Table 4.3 **Comparison of similarly surveyed sites in the Guiana Shield: Eastern Kanuku Mountains, Guyana (Lim and Norman 2002); Kwamalasamutu, Suriname (Lim and Joemratie 2010); Upper Palumeu River, Suriname (Lim and Banda 2012); and South Rupununi, Guyana (this study)**

| Locality | Bats | | | Small non-volant mammals | | |
|---|---|---|---|---|---|---|
| | Nights | Species | Individuals | Nights | Species | Individuals |
| Eastern Kanukus | 8 | 26 | 234 | 9 | 5 | 11 |
| Kwamalasamutu | 16 | 26 | 223 | 16 | 12 | 152 |
| Upper Palumeu | 16 | 28 | 334 | 16 | 11 | 20 |
| South Rupununi | 11 | 35 | 248 | 11 | 2 | 9 |

A notable observation overall was the increasing species accumulation on a daily basis except for the last night, which was affected by rain, and the nets were closed early at 8:30 p.m. Not surprisingly considering the short duration, the rising curves (see Figure 4.7) suggest that the survey at each site was not complete based on the methodology used. Extrapolation of rarefaction curves estimated asymptotes at 33 species for Kusad after 28 days of sampling, 35 species for Parabara after 26 days, and 48 species for both sites after 54 days. However, **the objective of the South Rupununi biological assessment was not to inventory all species but to conduct a representative survey that would enable the estimation of biodiversity for sustainable management purposes.** Extrapolating the combined rarefaction curve of both sites approximated the last addition of a full species on day 12, which suggests that the length of survey was adequate for analyzing species diversity.

## Conservation Recommendations

The distinction in small mammal diversity between the two survey sites suggests an ecological difference between the isolated forest within the savannah habitat of Kusad and the savannah with gallery forest habitat of Parabara. Coupled with the rising species accumulation curve, this suggests that **more surveying is required to better understand the biodiversity and heterogeneity of the Rupununi savannahs.**

The first documentation of the Orinoco sword-nosed bat (*Lonchorhina orinocensis*) in Guyana indicates that **there is undiscovered species diversity to be found in the South Rupununi.** However, the savannahs of Venezuela and Colombia are ecologically different with more exposed rocky outcrops and caves where this species roosts, and where it can be locally common. **The habitat requirements in Guyana need to be studied to reassess the conservation status of this vulnerable species**, which is endemic to savannah, and where it roosts in the absence of caves in the Rupununi. Possible roosting sites at Kusad are the forested rocky outcrops at the foot of the mountain.

Ecological requirements for the undescribed species of free-tailed bat (*Molossus* sp. nov.) are broader but more poorly known. It has a wide, disjunct distribution in the lowlands east of the Andes. The heterogeneous mosaic of primarily rainforest with patches of savannah characteristic of the Parabara area in the southern Rupununi may offer an important combination of roosting sites and foraging habitat for this aerial insectivorous species.

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# CHAPTER 5

# LARGE MAMMALS OF THE SOUTH RUPUNUNI REGION, GUYANA

*Evi A.D. Paemelaere, Diana Fernandes, Leroy Ignacio, and Angelbert Johnny*

## Summary

Large mammals contribute to the livelihoods of Rupununi inhabitants not only by serving as a food source, but also as a tourism attraction and through their role as ecosystem engineers. Information on mammal abundance is still rare for Guyana, and the diverse landscape of the Rupununi warrants more detailed studies. We evaluated relative abundance of mammals >1 kg using camera traps at Kusad Mountain – a forested mountain in the savannahs – and in the Parabara area – a savannah island in Guyana's southern forest connecting to the Amazon. In 850 camera trap nights at Kusad and 445 at Parabara, we detected 15 and 14 species, respectively, or a total of 17 large mammals for both sites combined. Considering the low number of trap nights, these represented the more common species. Nevertheless, they included threatened mammals such as the Brazilian tapir, white-lipped peccary, and giant armadillo. Species composition and relative abundance differed between sites, with larger ungulates being more common at Parabara, and smaller ones more common at Kusad. Under growing human population density, increased accessibility and anticipated increase of habitat conversion for farming and mining in the area, continued monitoring of wildlife will be essential for the development of sound management practices which will allow for the livelihoods dependent upon the populations of medium and large mammals to be supported.

## Introduction

Large mammals constitute a major source of dietary protein in the Rupununi region of Guyana, where indigenous communities still live a mostly traditional lifestyle of fishing and hunting. More recently, an additional role of mammals in local livelihoods has emerged. **As the (eco) tourism sector in the region started growing in the 1990s, larger mammals became one of the main attractions for international visitors to the Rupununi savannahs.** Considering hunting often drives depletion or even local extinction of mammalian populations (Peres 1990, Redford 1992, Cullen Jr et al. 2000, Hill et al. 2003), understanding their diversity and monitoring these species are essential for both traditional and modern local livelihoods. Importantly, **monitoring of large mammal species can also serve as a tool for assessing overall ecosystem function and integrity, since their large home range requirements and slow life histories render them particularly sensitive to hunting and other disturbances by humans** (Purvis et al. 2000, Brashares 2003, Cardillo et al. 2004).

Large mammal camera trap surveys were conducted in the north and south Rupununi savannahs in 2011 and 2012 (Paemelaere and Payán Garrido 2012, Payán et al. 2013). In addition, non-volant mammal surveys have been conducted in the Kanuku Mountains (M. Hallett pers. comm.). These results together with local knowledge of hunters and tourist guides indicate that the diversity of larger mammals in the general area is well known. **These studies indicate that the Rupununi region remains a stronghold for some threatened species, such as the giant anteater (*Myrmecophaga tridactyla*), Brazilian tapir (*Tapirus terrestris*), and jaguar (*Panthera onca*).** Nevertheless, the Rupununi has a highly diverse habitat, and still much research is needed to fully understand the spatial variability in species distribution and the potential effects of hunting on mammals. Furthermore, some of the more elusive species have not, or only rarely, shown up in camera trap studies or sightings by locals. These include, for example, the giant armadillo (*Priodontes maximus*), bush dog (*Speothos venaticus*), oncilla (*Leopardus tigrinus*), and badger (*Galictis vittata*). These species are generally poorly known.

**Kusad Mountain** is a forested island of about 50 $km^2$ amid savannah. The surrounding villages of Potarinau, Sawariwau and Katoonarib hunt and farm on Kusad, each in their own section. The combined population of the villages was about 1,600 individuals in 2011 (South Central and South Rupununi Districts Toshaos Councils 2012). These villages have fewer hunting areas available than most other Amerindian communities, which are located at the savannah-forest edge. Nevertheless, hunting might still be sustainable, when taking into consideration that there is also a large proportion of fish and livestock included in the diet of the people of this region.

**THESE STUDIES INDICATE THAT THE RUPUNUNI REGION REMAINS A STRONGHOLD FOR SOME THREATENED SPECIES,** SUCH AS THE GIANT ANTEATER (*MYRMECOPHAGA TRIDACTYLA*), BRAZILIAN TAPIR (*TAPIRUS TERRESTRIS*), AND JAGUAR (*PANTHERA ONCA*)

**The Parabara area** includes a savannah island surrounded by continuous forest as well as gallery forests. In the Parabara area, a similar-sized human population uses the land, but due to the extensive forest, this pressure may be more spatially diluted.

**The villagers of the South Rupununi are aware of their potential impact on wildlife, and they have produced a land-use management proposal** (SCSDTC 2012). Kusad Mountain is thought of as a link in a wildlife corridor from Brazil to the Kanuku Mountains (N. Fredericks, pers. comm.), and the Parabara area is part of the proposed Karaodaz Conserved Area, as part of indigenous titled land, and covering most of the forests of Region 9 south of the Kanuku Mountains and bordered by the Essequibo in the east. The land-use proposal not only refers to hunting locations (population sinks) but also to protected breeding populations (population sources): "Protect hunting and multiplying grounds and wildlife sites in mountain areas". Our study of large mammals at Kusad and Parabara offers a reference for future studies on the diversity and abundance of larger mammals, important in local livelihoods and in assessing conservation value of the areas.

## Methods and study sites

We used camera traps (Cuddeback Capture, USA) for detection of mammals > 1kg (Figure 5.1). For these larger land vertebrates, camera trapping is considered the best method for surveying (Rowcliffe et al. 2008, Diaz-Pulido and Payán 2011). Photographs from the motion-triggered cameras provide information on the species, time and location of its activity, and other information about individuals such as age and body condition. We set one camera per station along existing walking trails with 450-600 m straight line distances between stations. Sites with wildlife trails or creek beds along the trails were given preference. During camera trapping we also opportunistically recorded animal signs (tracks, scat) identified by local guides, and live sightings of terrestrial mammals and primates.



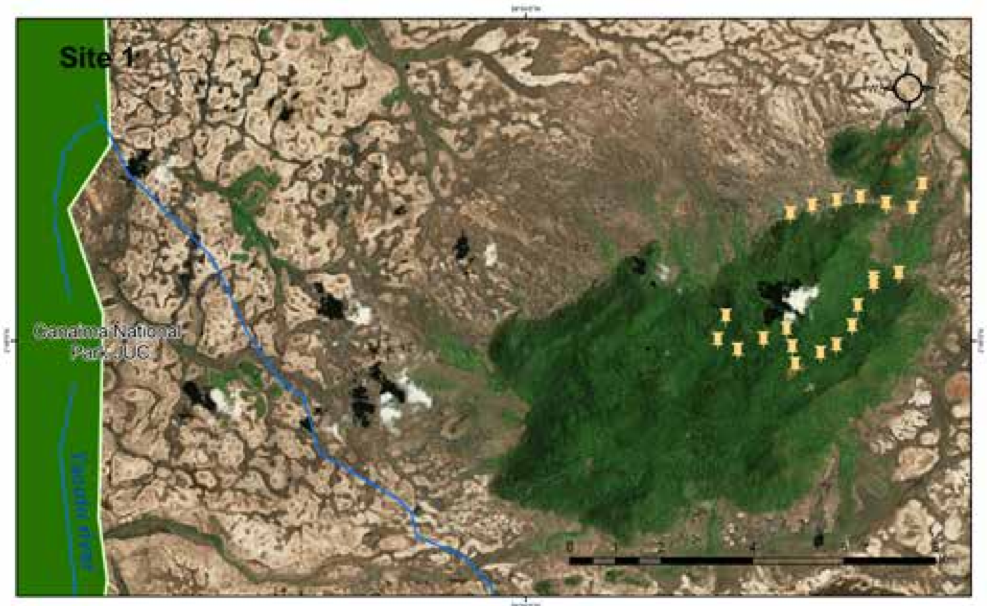
Figure 5.1 **Camera trap set-up process: (clockwise) clear viewing area; attach camera; test the camera with the crawl test; and record camera station data, including GPS point and habitat information.**

## Kusad Mountain (2.81 N 59.87 W)

During 24- 28 October 2013, we set 20 camera trap stations that remained in place until 10 December 2013, on three existing trails along the northeastern section of Kusad Mountain (Figure 5.2). The first trail gave walking access to two farm houses, one of which had been recently abandoned. This trail started at the mountain foot and went up a steep rocky hill along a creek. The trail crossed creeks three times before reaching a small savannah area and climbing further through forest to the top. The second trail continued through forest from the top and down the other side of the mountain. The last part of the trail was very steep and rocky and, thus, no additional cameras were set here. The third trail ran along the base of the mountain of the same peak, passing through savannah between this peak and a smaller somewhat isolated hill to the north of Kusad. In a cave at the start of the trail, two cameras were set up to cover different angles of the large chamber.

Figure 5.2 – 5.3

**Site 1: Camera trap stations at Kusad Mountain. Cameras were set about 500 m apart in forest and savannah from the mountain foot to the top.**





**Site 2: Camera trap stations in the Parabara area. Trails were selected leading from the savannah island towards Hungry Mountain.**

**Map sources: ESRI, Panthera, Global Forest Watch, Natural Earth, GGMC, Haimwant Persaud**

## THE VILLAGERS OF THE SOUTH RUPUNUNI ARE AWARE OF THEIR POTENTIAL IMPACT ON WILDLIFE, AND THEY HAVE PRODUCED A LAND-USE MANAGEMENT PROPOSAL

**Parabara area (2.18 N 59.34 W)**

On 4 and 5 November 2013, we set 19 stations along two trails that were cut in August 2012 (Figures 5.3-5.4). One trail started in the isolated savannah by Parabara, passing through riparian forest along creeks into the deep forest towards Hungry Mountain, which continues to the Amazon. The other trail branched off to the south-east towards another unnamed mountain. Cameras were collected on 2 December 2013. See location of camera trap stations in Fig. 5.2 -5.3 above.

Figure 5.4 **The large mammal biodiversity team, pictured after setting up camera traps in Parabara, with the location of the camera traps in the background.**



## Data analysis

All animal photographs from the camera traps were identified to species. The Relative Abundance Index (RAI) was calculated as number of individual animals from independent photographs obtained from the camera traps. Photographs of the same species were considered independent if taken more than 30 minutes apart (O'Brien et al. 2003). To assess completeness of the survey, rarefaction curves were produced with EstimateS 8.2. (Colwell 2006). These curves approach a slope of zero when the survey effort was sufficient. With the same software we estimated species richness and diversity.

## RESULTS

We achieved 850 camera trap nights at Kusad and 445 at Parabara. One camera at Kusad, and three at Parabara were found to be malfunctioning and were not considered in trap effort. A total of 17 mammal species were recorded for both sites combined (Figure 5.5). (See Appendix 5 for full list of species.) Jaguar, white-lipped peccary and coati were only detected by the cameras at Kusad. Fox and margay were only photographed at the Parabara site. In addition, we recorded a variety of tracks at both sites, but few live sightings.

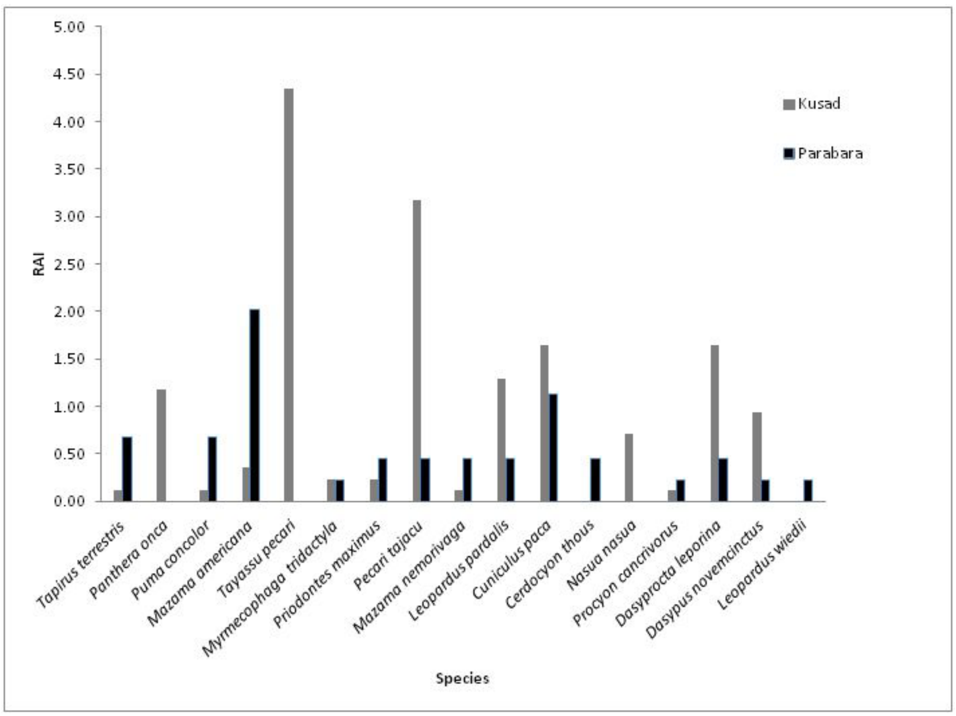



Figure 5.5 **Relative Abundance Indices (number of individuals per 100 camera trap nights) for Kusad and Parabara, listed from large to small. Abundance was overall lower at Kusad, and larger species were less common at Kusad compared to Parabara.**

**KUSAD MOUNTAIN IS THOUGHT OF AS A LINK IN A WILDLIFE CORRIDOR FROM BRAZIL TO THE KANUKU MOUNTAINS, AND THE PARABARA AREA IS PART OF THE PROPOSED KARAODAZ CONSERVED AREA**

**Kusad -** The cameras detected 15 species of medium to large mammals (Figure 5.5). Peccaries – both white-lipped and collared (Figure 5.6) – agouti and paca were the most common herbivores, with Relative Abundance Index (RAI) values similar to jaguar and ocelot (Figure 5.7). Deer had comparatively low abundance, and the cameras did not register tapir. Paca, agouti and armadillo were mostly photographed in forest near the top of the mountain. Deer, giant anteater and coati were photo-captured only in the forest, but spread over all heights of the mountain. This was also true for ocelots, but this cat species occurred in the savannah as well. Most jaguar photos were captured from the savannah and savannah-forest edge, while peccaries seemed to have no preference for habitat or elevation. One agouti had an injured nose. White-lipped peccaries, red brocket deer and paca included juveniles.




Fig. 5.6 **Collared peccaries, one of the main prey of jaguars, detected by camera trap in the open savannah by Kusad.**




Figure 5.7 **Our camera traps detected two jaguars roaming together in the open savannah by Kusad Mountain**

For the Kusad survey, the species accumulation curve indicated sufficient sampling effort to estimate species richness and diversity. Based on Jackknife Estimators, Kusad was estimated to contain 16.29 (SE = 3.28) medium-to-large mammal species. Diversity (considering both abundance and richness) of medium-large mammals at Kusad as calculated with the Simpson Index reached 10.39.

At **Kusad**, savannah fox (*Cerdocyon thous*) were observed by the team on several occasions. Other teams observed a white tayra near the camp. Howler monkeys (*Alouatta seniculus*) could be heard daily, but were never seen. The pungent scent of spider monkeys (*Ateles paniscus*) was noticeable along the trail, but we did not observe any individuals. Along the mountain trail, density of wildlife trails appeared to increase as we approached the top, where the habitat was less rocky and hills were less steep. We found one active burrow of a giant armadillo. Multiple sites with tracks of collared peccary (*Pecari tajacu*) and one with white-lipped peccary (*Tayassu pecari*) were seen before a large rocky creek outcrop. Beyond the outcrop, we crossed several small creeks with tracks of red brocket deer (*Mazama americana*), Brazilian tapir (*Tapirus terrestris*), agouti ('akuri'; *Dasyprocta leporina*), and paca ('labba'; *Cuniculus paca*) (Figure 5.8). One track of giant anteater (*Myrmecophaga tridactyla*) was seen near the top. In the savannah, we noticed prints of red brocket deer, tapir and paca (labba) in dense brush near a dried up water source. Old scat of jaguar was found along the savannah trail and in two separate caves (Figure 5.8). We also recorded a scrape mark of a giant anteater on the trunk of a caimbe tree (*Curatella americana*) along this trail (Figure 5.8).



Figure 5.8 **Various types of animal signs. From left to right: giant anteater scratch mark on tree; labba track near feeding spot; jaguar scat at latrine in cave.**

At **Parabara,** we photo-captured 14 species of mammals (Figure 5.5). Red brocket deer and paca were the most common species. Both species of brocket deer, as well as tapir and puma were more commonly detected here than at Kusad. We did not detect jaguars with the camera traps at Parabara. Puma and fox appeared in photos from the savannah. Agouti, brocket deer, labba, ocelot and peccary showed in photos from the forest, but the latter two occurred closer to the savannah edge. Tapir were detected in savannah and deep forest. Fresh wounds and scars were seen on both deer and tapir. Sampling effort was insufficient for conclusive results on richness and diversity, but preliminary results suggested values similar to those of Kusad with 16.17 (SE = 4.7) species estimated by the Jacknife Estimator and a Simpson Diversity Index of 10.44.

Live sightings in the **Parabara** area included savannah fox and a red brocket deer along the main road from the campsite to the village (Figure 5.9), and a labba on the camera trap trail at night. A kinkajou (*Potos flavus*) was heard by the team. Some team members reported a sighting of capuchin monkeys (*Cebus* sp.) near the camp and golden-handed tamarins (*Saguinus midas*) near Parabara village. Howler monkeys could be heard in the distance, but were not observed during the survey. Tracks along the forest trail were limited in contrast to the rather high density of wildlife trails, which appeared to be mostly armadillo (*Dasypus* sp.) trails. Scratch marks of armadillo were common. A burrow and two sites with tracks of giant armadillo were seen just off the walking trail and in a dry creek bed. In another dry creek bed, white-lipped peccaries had recently passed. In the savannah-forest edge, we detected many more tracks and signs of mammals, including feeding spots of labba, scrape marks and scat of jaguar, and tracks of tapir and red brocket deer. Along the vehicle road to Parabara in the continuous forest we found tracks of jaguar, deer and agouti (Figure 5.10).

Left: Figure 5.9 **Red brocket deer (*Mazama americana*) spotted along the road between the camp site and Parabara. The deer stared back at us for minutes before running back into the forest.**

Right: Figure 5.10 **Jaguar tracks along the road from Parabara landing. In this area, jaguars fully depend upon natural prey, and their population level is a good indicator of overall wildlife presence and ecosystem integrity.**

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**DEER AND TAPIR WERE COMPARATIVELY RARE AT KUSAD, WHILE PECCARIES WERE RELATIVELY RARE AT PARABARA**

## Discussion

Camera trapping, tracking and live sightings resulted in 17 terrestrial mammal species for both sites combined. While species composition was very similar between sites, we detected differences in relative abundance (RAI), especially for ungulates. **Deer and tapir were comparatively rare at Kusad, while peccaries were relatively rare at Parabara. Labba, the terrestrial bird powis (*Crax alector*) and agouti also had lower RAI at Kusad compared to a similar study in the South Rupununi savannah (Paemelaere et al. *in prep*). These are commonly hunted species. Differences between sites could thus be the result of hunting pressure, but also of habitat variation or a combination thereof.**

Kusad is a forest island with elevations up to 700 m and surrounded by savannah, while the Parabara site consisted of mostly continuous forest with a small savannah island. For forest species such as the brocket deer (Emmons and Feer 1990), the size of Kusad may not support as high a density as continuous forest. Peccaries and tapir, on the other hand, are generalists in their habitat use, roaming both forest and savannah. Seasonal distribution of fruits could have affected detection rates of these species. Our guides informed us that few trees were fruiting in the forest at the time, leaving the ité palm (*Mauritia flexuosa*), which lines the savannah creeks, as the major food source, thus mobilizing species such as tapir, paca and peccaries into these areas. At both sites, many tracks were seen at the forest-savannah edge. Limited availability of fruits in the forest may also partially explain the low number of monkey sightings, and this prevents us from making any inferences on the effects of habitat and disturbance based on this single, short-term survey. For terrestrial mammals, however, camera trap data showed no bias in distribution towards savannah or forest.

Species that were not detected at either site, but which are known to occur in similar habitats in Guyana include those that are naturally rare – such as bush dog (*Speothos venaticus*, DeMatteo et al. 2011), jaguarundi (*Herpailurus yagouaroundi*, Caso et al. 2008), and grison (*Galictis vittata*, Cuarón et al. 2008) - or semi-arboreal species such as the common opossum (*Didelphis virginiana*). Acouchi (*Myoprocta acouchy*) is also known to occur in forests and was expected to be seen at Parabara. While the species is not threatened, it is over-hunted in many locations throughout its range (Catzeflis et al. 2008). Interviews with villages in the area, however, did not indicate the acouchi as a major food item (Paemelaere and Payán Garrido 2012). Savannah or white-tailed deer (*Odocoileus virginianus*), known to roam the south Rupununi savannahs (Paemelaere and Payán Garrido 2012), were not detected by the cameras at either site, likely because this species tends to prefer the savannah over the forest, in contrast with both species of brocket deer. This notion is supported by the very low detection rates of savannah fox (*Cerdocyon thous*), also typically associated with the savannahs, and known to be very abundant in the Rupununi (Paemelaere and Payán Garrido 2012, Payán et al. 2013).

Some of the species not detected by the cameras were detected by tracks and vice versa. Tracks tend to be biased towards ungulates and the largest mammals, and can be difficult to quantify in areas with thick leaf litter or rocks, as was the case in our study sites. Camera trapping has proven the most efficient method for rapid surveys of terrestrial mammals (Silveira et al. 2003, Tobler et al. 2008). Nevertheless, limitations of this methodology must be recognized when interpreting results. Rapid surveys are unlikely to detect species that are naturally rare or rare in the study area. Such species would require 2000 or more trap nights (Tobler et al. 2008). Our results thus reflect the composition of the more common species at Kusad and Parabara. Furthermore, differences in biology and behaviour between species affect their photo-capture probability, and thus also the RAI (Trolle and Kéry 2003). Therefore, some discussion remains on how well RAIs reflect actual abundance of species (Carbone et al. 2001, Carbone et al. 2002, Jennelle et al. 2002). Nevertheless, RAIs can be effectively used in comparing populations between sites and over time (Carrillo et al. 2000).

## Conservation Implications

**This mammal study offered a baseline for Kusad and a preliminary assessment for the Parabara area. Results suggest that both areas have the expected diversity of wildlife and seemingly healthy populations.** While hunting pressure has not been quantified in either area, **reports suggest that Kusad has been a traditional hunting area for surrounding villages, and that the Parabara study site may have experienced lower hunting pressure per unit area. Wounded animals, potentially caused by hunters, were seen at both sites, but more so at Parabara.** Nevertheless, wildlife populations appeared to have sustained past and current pressures.

**The notion of sustainable use is supported by the presence of disturbance-sensitive species at both sites.** Tapir and white-lipped peccary are particularly sensitive to hunting (Bodmer 1995, Peres 2000). **The conservation status of the white-lipped peccary recently changed from Near Threatened to Vulnerable as a result of continued range-wide declines, for which the causes still remain unclear** (Altrichter et al. 2012). They are not always easy to detect, particularly in small-scale studies, because these animals live in large social groups in very large territories, sometimes exceeding 100 $km^2$ (Fragoso 1998, Carrillo et al. 2002, Keuroghlian et al. 2004, Reyna-Hurtado et al. 2009). They were recorded by cameras in the eastern Kanuku Mountains (Sanderson and Ignacio 2002), but not in a recent study in the western Kanukus (M. Hallett pers. comm.), or in the north or south savannahs (Paemelaere and Payán Garrido 2012). **The confirmed presence of white-lipped peccaries at both sites renders these locations essential in future management considerations for the species.**

**CONNECTIVITY PLAYS A KEY ROLE IN THE HEALTH OF WILDLIFE POPULATIONS, PARTICULARLY AS MORE OF THEIR HABITAT IS CONVERTED AND PROTECTED AREAS BECOME ISOLATED**

**Other disturbance-sensitive species detected included the jaguar and giant armadillo. The latter is naturally rare and threatened by hunting throughout its range** (Superina and Abba 2010). **The jaguar is a top predator, requiring large amounts of habitat with large quantities of prey, and thus offers a good proxy for overall wildlife density and ecosystem integrity** (Purvis et al. 2000, Carbone and Gittleman 2002, Crooks 2002, Sanderson et al. 2002, Cardillo et al. 2004, Cardillo et al. 2005)particularly in areas where no domestic livestock is available as an alternative food source, as was the case in Parabara. Non-detection of jaguars in camera traps at Parabara could be the result of the smaller scope in terms of time and geographic spread of cameras. Tracks of jaguar were seen at multiple locations, and further research is needed to evaluate jaguar populations and their prey in the southern forest of Guyana.

**The Parabara area lies at the northern edge of continuous forest from the Amazon, and thus plays an important role in the distribution of wildlife in Guyana.** The vast expanse of the mostly undisturbed forest offers prime habitat for wildlife. **Kusad, on the other hand, is one of the largest forest islands in the South Rupununi, and part of a chain of islands between those southern forests and the Kanuku Mountains Protected Area. Therefore**, **Kusad may promote gene flow by acting as a stepping stone for wildlife populations between these major forested sites. Such connectivity plays a key role in the health of wildlife populations, particularly as more of their habitat is converted and protected areas become isolated** (Newmark 1996, Schaller 1996, Seiferling et al. 2011).

Many of the large mammals are preferred hunting targets (Figure 5.11). Generally, with a human population density of less than 1 person per km$^2$ exercising only subsistence hunting, wildlife harvest is typically sustainable (Robinson and Bennett 2004). While human population density in the Rupununi meets this requirement (Guyana Bureau of Statistics 2012), **the population in the region is growing rapidly** (2.2%; WHO 2009). Furthermore, **ingression of hunters from outside adds to the pressure on wildlife.** While subsistence hunting levels have been studied in great detail (Read et al. 2010), there are no quantitative data on recreational or commercial hunting by non-residents in the region. Furthermore, **the estimate does not take into consideration other impacts on wildlife, such as habitat quality. Large scale agriculture in the savannahs and mining in the forests of the Rupununi are the largest threats to habitat availability and quality**; these activities still occur at a comparatively small scale.

Figure 5.11 **Skulls of tapir and collared peccary found at the farm in the small savannah on top of Kusad Mountain. These animals are the preferred prey of local hunters.**

**We recommend that populations of main hunted species are monitored, together with the monitoring of hunting rates. Respecting general good conduct in hunting will also help avoid depletion; avoiding the harvest of many individuals at once, such as is seen for peccaries (bush hog), and refraining from killing of females with young are key**. Especially for the larger mammals, which are very sensitive to human influence due to their high demand for areas of available habitat (Brashares 2003), **management of hunting and habitat are highly recommended**. These include tapir (bush cow), white-lipped peccary, the savannah-loving white-tailed deer (savannah deer) and giant anteater, and top predators like the jaguar. **Tapir, for example, have a one of the lowest sustainable harvest rates due to their very slow reproduction.** In undisturbed forest, these rates have been estimated at 0.9 individuals per 100 $km^2$ per year for French Guiana (Tobler et al. 2014), but local population estimates are needed to adjust this value for the Rupununi. This is true for all mammals; we lack sufficient data to tailor wildlife management to local conditions.

## Conclusion

The Rupununi savannahs of Guyana have a high mammalian diversity due to the mosaic of habitat that supports both forest dependent and open habitat loving species. Furthermore, forested mountains such as Kusad could be important stepping stones for migrating mammals. **Under growing pressures, however, mammalian diversity and abundance in the Rupununi are expected to decline, as is already ongoing based on anecdotal evidence**. With declining populations of ungulates and other prey species, jaguar populations will also be affected and they may search increasingly for alternative food sources, such as cattle, which is an important part of savannah livelihoods. **Rupununi's mammals and the livelihoods depending on them will increasingly rely on wildlife and habitat management strategies at a local, regional and national scale.**

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# CHAPTER 6

# ANTS OF THE SOUTH RUPUNUNI REGION, GUYANA

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14 ANT SPECIES (16% OF IDENTIFIED SPECIES) ARE NEW COUNTRY RECORDS FOR GUYANA, AND 10 SPECIES (12% OF IDENTIFIED SPECIES) ARE NEW RECORDS FOR THE GUIANAS AS A WHOLE (GUYANA, SURINAME AND FRENCH GUIANA)


## Summary

We collected 175 species of ants, representing 48 genera and 10 subfamilies, during the 2013 Biodiversity Assessment Team's survey of the South Rupununi savannah region in southwestern Guyana. This represents the most diverse ant fauna yet documented in Guyana or Suriname, and further sampling would undoubtedly show an increase in the total number of species. Fourteen species (16% of identified species) are new country records for Guyana, and 10 species (12% of identified species) are new records for the Guianas as a whole (Guyana, Suriname and French Guiana). Many species, perhaps over 25%, are likely undescribed. The high species richness compared to other surveys in the Guiana Shield is likely due to the habitat diversity of the South Rupununi region. Landscape heterogeneity leads to high species turnover, with 73% of species found in only one of two sites 100 km apart, and 61% of species collected in only one habitat. The ant fauna is ecologically diverse and characteristic of a relatively intact landscape with large interconnected blocks of suitable habitat. Several species have cultural or medicinal importance to the local Wapishana people. Effective conservation of the South Rupununi would best be achieved by a landscape-scale effort that protects component habitats as well. Information on the area's ant fauna will contribute to a broader understanding of patterns of ant diversity across the Guiana Shield and the Amazon, in an effort to determine global priority conservation areas for the region.

## Introduction

Ants (Insecta: Hymenoptera: Formicidae) are both diverse and abundant, with over 12,000 species (Bolton et al. 2006) occupying most terrestrial habitats. Their high abundance and nearly global distribution make ants one of Earth's most prominent groups of land animals. As such, ants contribute to many ecosystem processes such as seed dispersal, decomposition and soil turnover (Folgarait 1998), and interact with other organisms as predators, prey and mutualists. Because of these interactions, **the diversity of an area's ant fauna is often correlated with the diversity of other animal and plant taxa, making them useful ecological indicators** (Alonso 2000). Ecological importance, numerical dominance, ease of sampling at statistical scales, and sensitivity to environmental conditions (Kaspari and Majer 2000) make ants ideal organisms for biomonitoring programmes (Agosti et al. 2000). To this end researchers have developed standardized protocols for sampling and comparing ant faunas, allowing studies to be combined and analyzed at regional scales (Agosti and Alonso 2000).

Like the Guiana Shield in general, **the ant fauna of Guyana is diverse but poorly known** (Fisher 2010). **Previous surveys have found approximately 450 species and suggest that hundreds more remain to be discovered** (Kempf 1972, LaPolla et al. 2007). Several surveys in neighbouring Suriname have likewise indicated that hundreds of species remain to be discovered (Sosa-Calvo 2007, Alonso 2011, Alonso and Helms 2013). Here we survey the ants of the South Rupununi savannah region in southwestern Guyana, a relatively intact and unfragmented tropical grassland. Our survey—the first in the area—is an important step in mapping Guyana's ant diversity, and will contribute to a broader understanding of diversity patterns and conservation priorities across the Guiana Shield.

**THE ANT FAUNA IS ECOLOGICALLY DIVERSE AND CHARACTERISTIC OF A RELATIVELY INTACT LANDSCAPE WITH LARGE INTERCONNECTED BLOCKS OF SUITABLE HABITAT. SEVERAL SPECIES HAVE CULTURAL OR MEDICINAL IMPORTANCE TO THE LOCAL WAPISHANA PEOPLE.**

© Jackson Helms

**Carton nest of arboreal Azteca ants high up on the trunk of a tree**

## Methods and Study Sites

The South Rupununi savannah region is a mosaic of different habitats determined by local combinations of flood, fire, rain, elevation and human use. We collected ants at two sites within this landscape, the Kusad Mountain and the Parabara savannah, by hand collecting and with pitfall and leaf litter traps. To capture the landscape's diversity, we sampled a range of habitats within the two sites—dry forest, montane forest, rainforest, bush islands, tallgrass savannah and shortgrass savannah.

*Site 1: Kusad Mountain*

*2° 48' 43.46" N, 59° 52' 00.48" W, 135 m, 23-29 October 2013*

Kusad Mountain is an island of forest surrounded by grassland. Here we collected in dry forest on the lower slopes, in tallgrass savannah around the base of the mountain, and in nearby riparian areas. In addition, we sampled wetter forest and a patch of tallgrass savannah higher up the mountain at about 500 metres elevation.

*Site 2: Parabara Savannah*

*2° 10' 54.85" N, 59° 20' 13.52" W, 240 m elevation, 31 October - 5 November 2013*

The Parabara savannah is an island of grassland surrounded by rainforest. Here we collected in shortgrass savannah, riparian rainforest, and isolated bush islands within the savannah. Finally, we sampled nearby contiguous rainforest south of the Kuyuwini River beyond the savannah's edge.

*Collecting methods*

While hand collecting, we manually searched for ants on the ground, on vegetation, in soil, under rocks and logs, in rotting wood, and inside hollow twigs and plants.

To sample grasslands we placed pitfall traps every 10 metres along a 200-metre transect and collected the traps after 48-72 hours. Each trap consisted of a plastic cup buried with its lip level with the ground and filled with soap solution. We ran one transect in tallgrass savannah at Kusad (elevation 135 m) for 72 hours, and one in shortgrass savannah at Parabara for 48 hours (elevation 240 m).

For leaf litter sampling in forests we used the Winkler method adopted from the Ants of the Leaf Litter Protocol (Agosti et al. 2000). We created 200-metre transects and collected leaf litter from a square metre plot every 10 metres. The leaf litter from each plot was sifted and hung in a Winkler trap for 48 hours. We ran one transect in each of the three main forest habitats: lowland dry forest at Kusad (2° 48' 33.35" N, 59° 51' 51.76" W, 135-180 m elevation); montane forest at Kusad (2° 47' 42.69" N, 59° 50' 48.52" W, 500 m elevation); and lowland rainforest at Parabara (2° 5' 5.70" N, 59° 14' 10.44" W, 250 m elevation). We supplemented the standardized transects with targeted leaf litter collections in lowland dry forest at Kusad and a bush island in the Parabara savannah (2° 10' 59.42" N, 59° 20' 03.22" W, 256 m elevation).

**THE PRESENCE OF ARMY ANTS INDICATED LARGE BLOCKS OF INTACT HABITAT AS WELL AS THE PRESENCE OF ADEQUATE PREY SPECIES**

© Leeanne Alonso

**Samson Isaacs and Jackson Helms collect leaf litter to survey ants of the forest floor**

AT 175 ANT SPECIES FROM 48 GENERA, THE SOUTH RUPUNUNI SAVANNAH REGION MAY BE THE MOST DIVERSE SITE YET DOCUMENTED IN GUYANA OR SURINAME

*Specimens*

To determine whether species represented new country or regional records, we referred to the Guiana Shield ant collection at the Smithsonian National Museum of Natural History in Washington, D.C., where we deposited voucher specimens, and to known distributions from the literature (summarized in AntWiki 2015).

## Results

We collected 175 ant species in the South Rupununi, representing 48 genera and 10 subfamilies (Appendix 6). **Fourteen species (16% of positively identified species) are reported from Guyana for the first time, and 10 of those (12%) are new records for the Guianas as a whole (Guyana, Suriname and French Guiana).** 109 species were found at the Kusad site and 115 at Parabara (Table 6.1). Though only 100 kilometres apart, the two sites hosted greatly different ant communities, with 127 species (73% of the total) collected at only one site. We found similar species turnover among the habitats of the South Rupununi, with 106 species (61%) collected in only one habitat (Table 6.1).

Table 6.1 **Ant species richness and uniqueness per site and habitat**

| Sites | Species | Unique | Unique % |
|---|---|---|---|
| Kusad | 109 | 60 | 55 |
| Parabara | 115 | 67 | 58 |
| ***Site totals*** | *175* | *127* | *73* |
| **Habitats** | | | |
| Dry forest | 48 | 17 | 35 |
| Rainforest | 101 | 51 | 50 |
| Montane forest | 69 | 25 | 36 |
| Bush islands | 27 | 1 | 4 |
| Tallgrass savannah | 26 | 7 | 27 |
| Shortgrass savannah | 17 | 5 | 29 |
| ***Habitat totals*** | *175* | *106* | *61* |

**Key**

**Unique** denotes number of species collected only in that site/ habitat.

**Unique %** denotes percentage of unique species in that site/habitat.

Except for rainforest and bush islands, about 30-40% of the species found in each habitat were not collected elsewhere. Bush islands—small, isolated and relatively transient blocks of forest surrounded by grassland—contained few or no unique species. The one species collected only in bush islands—a cryptic fungus gardener (*Apterostigma pilosum*)—likely occurs in nearby rainforest. At the other extreme, rainforest was both the most species-rich habitat (101 species) and the most distinctive, with 51 unique species (50%). Shortgrass savannah was the most species-poor habitat with 17 species, 5 of which (29%) were unique. Of the 10 subfamilies collected, Myrmicinae was the most speciose at 91 species (52% of the total), followed by Formicinae at 26 (15%) and Ponerinae at 25 (14%, Figure 6.1a). Among genera *Pheidole* was the most speciose with 27 species (15% of total), followed by *Camponotus* with 12 (7%) and *Crematogaster* and *Pachycondyla* with 10 each (6%, Figure 6.1b).

**The composition of the ant fauna was representative of high quality habitat with intact ecological interactions.** The presence of many arboreal (*Camponotus*, *Cephalotes*, *Daceton armigerum*, *Pseudomyrmex*), leaf litter (*Apterostigma*, *Cyphomyrmex*, *Strumigenys*, *Trachymyrmex*), and specialized predatory (*Hypoponera*, *Leptogenys*, *Odontomachus*, *Pachycondyla*) species is typical of healthy diverse forests. The grasslands had healthy ant faunas as well, with leaf-cutters (*Acromyrmex* cf. *landolti, Atta laevigata*), scavengers (*Ectatomma brunneum* and *E. ruidum*), predators (*Gnamptogenys ammophila*, *Odontomachus, Pachycondyla*), and heat-tolerant species like *Dorymyrmex*, while scattered trees hosted arboreal species. Army

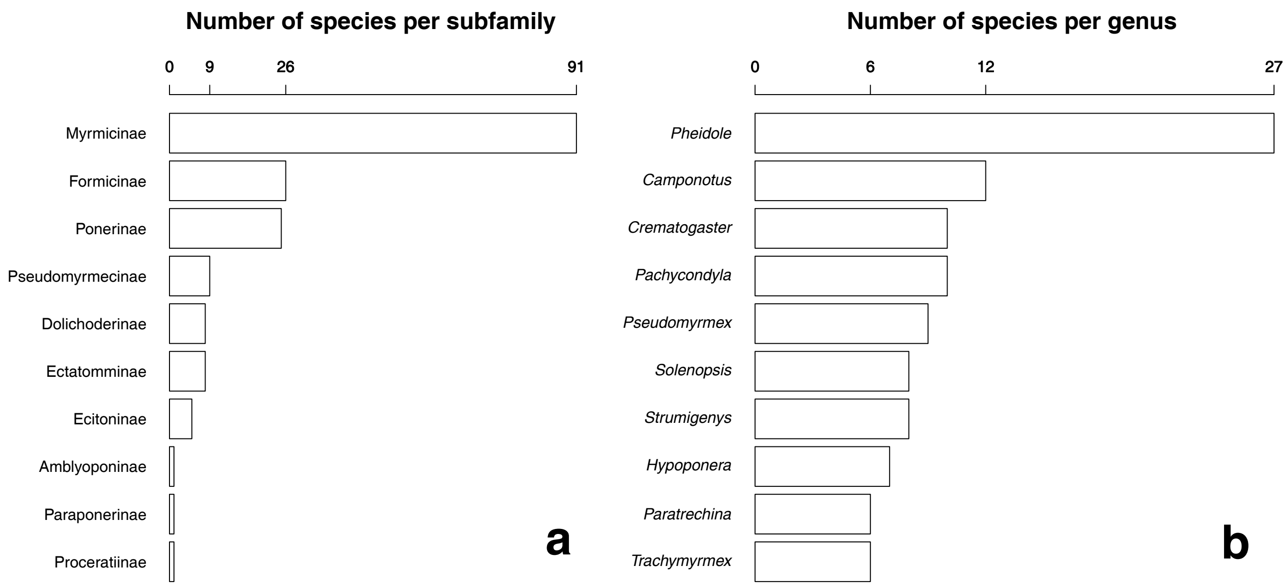


Figure 6.1 **Taxonomic composition of the ants of the South Rupununi**

Key:
**a)** Number of species per subfamily
**b)** Number of species in the ten most diverse genera

ants (*Eciton burchellii* and *E. hamatum*, *Labidus coecus* and *L. praedator*, *Neivamyrmex pilosus*) were present at both sites. **Army ants play important roles as top predators (Kaspari et al. 2011) and their nomadic hunting lifestyle and massive colonies require large territories (Boswell et al. 1998). These species thus indicate large blocks of intact habitat as well as the presence of adequate prey species.** Likewise, the massive bullet ant (*Paraponera clavata*) requires fairly large blocks of rainforest. From specialized ant plants (*Cecropia*, *Cordia nodosa*, *Hirtella*, and several Melastomataceae species) we collected ants such as *Allomerus octoarticulatus*, *Azteca*, *Crematogaster* and *Pseudomyrmex*, indicating intact ant-plant symbioses.

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**Canopy ants (*Daceton armigerum*) hunt prey in trees with their fast trap-jaws**

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**Yellow-tipped ants (*Pachycondyla apicalis*) nest in leaf litter and hunt prey on the forest floor.**

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**Army ants (*Eciton burchellii*) are swarm raiding predators that live in large nomadic colonies.**

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**Bullet ants (*Paraponera clavata*) reputedly have the world's most painful insect sting.**

© Andrew Snyder

***Dolichoderus decollatus*, a large ant with sharp spines, was collected in moist areas.**

Similarly, the presence of *Pseudomyrmex termitarius*, which nests in old termite mounds, and the specialized termite raider *Pachycondyla laevigata* suggest a healthy termite fauna.

In addition to those already mentioned, we collected several noteworthy or charismatic species. **The predator *Gnamptogenys ammophila* is unique in being the only grassland specialist in its genus. Since it was first described in 1986, the species was previously known only from cool, high altitude savannahs (>1,200 metres elevation) in a single watershed in the Gran Sabana of southeastern Venezuela** (Lattke 1990)**. This find, nearly 30 years later in lowland grasslands near**

**Before we collected it in the South Rupununi, this savannah specialist *Gnamptogenys ammophila* was known only from a single watershed in southeastern Venezuela**


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***Gigantiops destructor*** **is a typical Amazonian ant easily recognized by its huge eyes, yellow-tipped antennae and propensity to jump**

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**Gliding turtle ants (*Cephalotes atratus*) can glide to their home tree if they fall from the rainforest canopy.**

**Kusad Mountain** (Appendix 6), **represents the first Guyana record for this restricted-range species, and extends its known geographic range by ~400 km and its altitudinal range by over 1,000 metres.** *Gigantiops destructor*, a widespread and conspicuous Amazonian ant, is instantly recognizable by its huge eyes, yellow antennae and propensity to jump. The gliding turtle ant, *Cephalotes atratus*, is a large arboreal species with sharp spines that can glide to its home tree after falling from the canopy (Yanoviak et al. 2005). Finally, in Parabara we collected one valuable specimen of the rare *Thaumatomyrmex atrox*, a charismatic predator with pitchfork mandibles that specializes on polyxenid millipedes (Brandão et al. 1991).


© Emma Hanisch

**The rare predatory ant *Thaumatomyrmex atrox* hunts millipede prey with pitchfork-shaped mandibles.**

**THE PREDATOR *GNAMPTOGENYS AMMOPHILA* IS UNIQUE IN BEING THE ONLY GRASSLAND SPECIALIST IN ITS GENUS. SINCE IT WAS FIRST DESCRIBED IN 1986, THE SPECIES WAS PREVIOUSLY KNOWN ONLY FROM COOL, HIGH ALTITUDE SAVANNAHS IN A SINGLE WATERSHED IN THE GRAN SABANA OF SOUTHEASTERN VENEZUELA.**

## Discussion

**At 175 ant species from 48 genera, the South Rupununi savannah region may be the most diverse site yet documented in Guyana or Suriname.** A collection from three sites in Eastern Suriname yielded 169 species in 36 genera (Sosa-Calvo 2007), one from southwest Suriname 105 species in 32 genera (Alonso 2011), and one from southeast Suriname 149 species in 35 genera (Alonso and Helms 2013). A collection from eight sites across Guyana documented 230 species in 44 genera, with a maximum single site richness of 84 species (LaPolla et al. 2007). This high species richness is partly due to sampling methods, as many previous surveys were restricted to leaf litter collection. More important, however, is the habitat heterogeneity of the South Rupununi, as indicated by high species turnover among sites and habitats (see Table 6.1). **Overall, the diverse and healthy ant fauna indicates large blocks of natural vegetation, intact symbioses and a diverse landscape, highlighting the conservation value of the South Rupununi savannah region.**

Our visit represents the first systematic collection of the ant fauna of the South Rupununi and most or all of our specimens represent new range records. Because the ant fauna of the Guiana Shield is poorly known (Fisher 2010), many of our specimens are assigned to morphospecies, making it difficult to compare to published records. As a rough estimate based on previous studies (e.g. LaPolla et al. 2007) however, perhaps 25% to 50% of our specimens are undescribed species. **Among the species that are positively identified, 16% (14 species) are new country records for Guyana, and 12% (10 species) are new records for the Guianas as a whole, emphasizing the biological importance of the South Rupununi**. Further, the total species richness of the South Rupununi savannah region is undoubtedly higher than what we documented in two weeks of sampling. The New World tropics contain one of the richest ant faunas on Earth (Fernández and Sendoya 2004), and a single lowland rainforest site can contain nearly 500 species (Longino et al. 2002, Ryder Wilkie et al. 2010). Further museum work to determine species identities, describe new species, and compare results to prior surveys would greatly enhance our understanding of the region's ant fauna.

In addition to their biological importance, ants (Wapishana - mat) play cultural roles for the Wapishana people, with several species having ceremonial or medicinal uses. Leafcutter ants (*Atta laevigata* - koram) and small stinging fire ants (*Solenopsis* - kookbr) are recognized parts of the landscape. Stings of trap-jaw ants (*Odontomachus* - podizua) and *Pseudomyrmex* are used in traditional medicine. Carton nests of arboreal *Azteca* (ziido) species are likewise boiled to make a medicinal bath. Most dramatically, large stinging *Pachycondyla* (wiiko) species are used in coming of age ant stinging ceremonies for young men and women (Gomes and Wilson 2012).

OVERALL, THE DIVERSE AND HEALTHY ANT FAUNA INDICATES LARGE BLOCKS OF NATURAL VEGETATION, INTACT SYMBIOSES AND A DIVERSE LANDSCAPE, HIGHLIGHTING THE CONSERVATION VALUE OF THE SOUTH RUPUNUNI SAVANNAH REGION

**AS A RARE EXAMPLE OF UNFRAGMENTED TROPICAL GRASSLAND, THE SOUTH RUPUNUNI SAVANNAH REGION IS AN IMPORTANT COMPONENT OF THE BIODIVERSITY OF GUYANA AND THE GUIANA SHIELD AS A WHOLE**

## Conservation Recommendations

The most striking character of the South Rupununi savannah region is its diversity of habitats, reflected in the high species richness and ecological diversity of the ant fauna. This diversity flows from the unfragmented nature of the landscape, where natural processes such as fire and flood go unhindered to mould the landscape into a variety of forms. Varying local conditions create intermixed patches of different habitats, each harbouring a unique fauna, resulting in high species turnover within relatively small areas. Covered in forests and spanning a range of elevations, isolated mountains such as Kusad harbour many unique species, and the tallgrass savannahs at their bases differ from the more exposed shortgrass savannahs. Similarly, fingers of riparian forest allow rainforest communities to penetrate deep into the Parabara savannah. Even bush islands, a relatively transient habitat with few or no unique species, play an important role by sheltering a subset of forest species within a grassland matrix. Maintaining the large scale integrity of the landscape, rather than viewing its component parts in isolation, is therefore essential for its effective conservation.

**This landscape scale view aligns in many ways with the cultural goals of the Wapishana people. In particular the responsible use of fire, limitations on the construction of fences and roads, maintenance and growth of bush islands, and protection of forested areas from logging and mining** (Gomes and Wilson 2012) **would go far toward protecting the area's biological diversity as well as its cultural heritage. Isolated mountain ranges such as the Kusad and Shiriri Mountains are especially important for conservation, as they contain a range of elevations and habitats with corresponding unique species, isolated from the continuous forests at the savannah's edge.** Finally, the savannah's fringing lowland rainforests, such as those along the Kuyuwini River, contain the most species-rich and distinctive ant fauna and are the ultimate source of the species inhabiting the South Rupununi's riparian rainforests. **Protection of these lowland rainforests from logging and mining is essential for conserving the area's ant fauna.**

**As a rare example of unfragmented tropical grassland, the South Rupununi savannah region is an important component of the biodiversity of Guyana and the Guiana Shield as a whole. As such, it is both a conservation priority and a valuable opportunity for landscape scale conservation.** Protection of its component habitats is the most effective way of conserving its diversity into the future.

**Acknowledgements**

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**THE LANDSCAPE SCALE VIEW OF CONSERVATION ALIGNS IN MANY WAYS WITH THE CULTURAL GOALS OF THE WAPISHANA PEOPLE. IN PARTICULAR THE RESPONSIBLE USE OF FIRE, LIMITATIONS ON THE CONSTRUCTION OF FENCES AND ROADS, MAINTENANCE AND GROWTH OF BUSH ISLANDS, AND PROTECTION OF FORESTED AREAS FROM LOGGING AND MINING WOULD GO FAR TOWARD PROTECTING THE AREA'S BIOLOGICAL DIVERSITY AS WELL AS ITS CULTURAL HERITAGE.**

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# CHAPTER 7

# AQUATIC BEETLES OF THE SOUTH RUPUNUNI SAVANNAH AND PARABARA REGIONS, GUYANA

*Andrew Short*, *Shari Salisbury*, and *Timothy Isaacs*

## Summary

Aquatic beetles were collected over a 14-day period in October-November 2013 in the southern Rupununi region of Guyana, encompassing both open savannah and tropical forest habitats. We collected more than 7,500 specimens from a variety of aquatic habitats. From these samples, **we identified 201 species of aquatic beetles in 72 genera, an exceptionally rich and diverse fauna.** Both Kusad and Parabara base camps had similar numbers of species (127 and 125 respectively), but their communities were strongly dissimilar, with only 51 species shared between them**. Four genera and at least 15 species are new to science,** though many more of the morphospecies we identified are likely to ultimately prove to be undescribed taxa. The family Torridincolidae is recorded from Guyana for the first time. The exceedingly high richness of aquatic beetles in the region is likely the result of the habitat diversity, which ranges from large rivers to small streams, and from savannah lakes to dense forest pools. Hygropetric habitats (i.e. seepages and thin water films on rock) on Kusad Mountain also contributed to the high diversity.

## FOUR GENERA AND AT LEAST 15 SPECIES OF AQUATIC BEETLES ARE NEW TO SCIENCE

WE IDENTIFIED 201 SPECIES OF AQUATIC BEETLES IN 72 GENERA, AN EXCEPTIONALLY RICH AND DIVERSE FAUNA

## 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 Dryopoidae (or aquatic Byrroids). 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 (flowing waters) and lentic (still waters); rock outcrops, substrate, etc.).

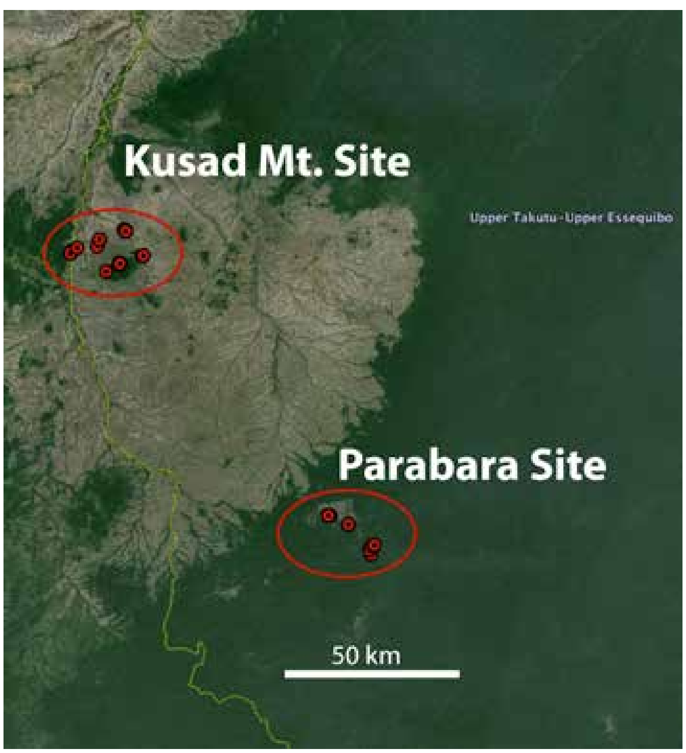


Figure 7.1 **Map of regions indicating sites where water beetles were collected for this survey.**

**Aquatic beetles in Guyana are very poorly known.** There has been some limited prior collecting, notably by Smithsonian researchers in 1983 (Takutu Mountains) and in 1994-95 (North Rupununi region). **There are no known records of aquatic beetles from the southern Rupununi.** By comparison, neighbouring Venezuela and Suriname have received significantly more attention in recent years, and have been the subject of numerous survey efforts (e.g. Short and Kadosoe 2011, Short 2013). Still, **the entire regional fauna is understudied and many new species are being discovered and remain to be described.**

## Methods and Study Sites

### Field methods

We employed a variety of mostly “active” collecting techniques. Active techniques, which include methods where beetles are collected in their habitat, are preferred as they allow gathering of ecological and water quality data as well as the specimens. We also used one “passive” method, UV lights, to assess diversity.

*Active methods.* Most of the collecting in marshes, ponds, and stream pools was done with aquatic dip nets. 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. A small strainer was used to collect insects that are not active swimmers, but float on the water’s surface when disturbed. Leaf-packs and submerged logs were examined in flowing streams. At one hygropetric surface in the Kusad Mountains, the rock was scrubbed with a brush into an aquatic net held downstream.

*Traps and other passive methods.* During two nights at the Kusad Mountain camp, and three nights at the Parabara camp, we collected in the evening hours until approximately 10 p.m. around a UV light mounted on a white sheet erected near the centre of each camp. Several dung traps were set out at the Parabara camp for two days, but no terrestrial hydrophiloid specimens were found.

**Site 1: Kusad Mountains and vicinity (Base camp: 2° 48' 42.9012" N, 59° 52' 0.5982" W, 24-28 October 2013)**

The Kusad study site (see Figure 7.1) had a broad range of aquatic habitats. Lotic habitats included a large river (Takutu River), several medium-sized creeks (e.g. Kato Wao) and numerous small creeks and streams, both forested and in the open savannah. All streams contained clear or slightly turbid water; no black water streams were encountered. Most of these had rocky or mud substrates. Five large “lakes” and marshes that were detached from streams were also investigated. These ranged from less than 0.5 m to more than 2 metres in depth, and all were without canopy cover; most had at least some emergent vegetation. Water levels in creeks and streams were relatively low, with some starting to form disjunct pools, though most still had some flow. Most lakes and marshes (e.g. Figure 7.2 B) were drawn down but not close to drying. Rain did not adversely affect collecting conditions, though rain on the day before the team left base camp caused significant flooding of low-lying marshes that previously had been dry.

HYGROPETRIC HABITATS AT KUSAD CONTAINED NUMEROUS LOCALIZED AND “RARE” SPECIES THAT ARE ENDEMIC TO THESE KINDS OF SEEP HABITATS, INCLUDING THE FAMILY TORRIDINCOLIDAE, WHICH IS RECORDED HERE FOR THE FIRST TIME FROM GUYANA




Figure 7.2 **Selected images of collecting events, with associated field numbers.**

**A Kusad Mt: Mokoro Creek near base camp, rock slide [GY13-1027-03]**

**B Near Kusad Mt: Ziida Karisihizi (lake) [GY13-1025-01A]**

**C Near Parabara: Mushai Wao (creek) [GY13-1101-01A]**

**D Near Parabara: small creek [GY13-1103-02A]**

*Habitats of Note*: One stream near the Kusad base camp flowed over a large rocky expanse, forming large areas of hygropetric habitat (Figure 7.2 A). **This habitat contained numerous localized and "rare" species that are endemic to these kinds of seep habitats, including the family Torridincolidae, which is recorded here for the first time from Guyana**. In the larger rivers, water-filled cracks and depressions in the large rocks that formed the banks and exposed margins contained particularly high densities of aquatic beetles, including some species that had previously only been recorded in similar habitats along the Orinoco River in Venezuela (e.g. *Berosus garciai*).

**Site 2: Parabara and surrounding forest and savannah (Base camp: 2° 10' 54.12" N, 59° 20' 32.8164" W), 31 October-5 November 2013**

The Parabara study site (see Figure 7.1) included several large rivers, including the Kuyuwini (though this was not sampled for beetles), and numerous small creeks and streams. All streams contained clear or slightly turbid water; no black water streams were encountered. In contrast to the Kusad site, nearly all these streams were in densely forested riparian zones, and had a predominantly sandy substrate and usually abundant detritus (e.g. see Figure 7.2 C, D). Several marsh areas were sampled in small savannah patches, but these were almost always draining into creeks and thus not as isolated. No large lakes or marshes were present as with the Kusad site. Several forested ponds with thick layers of detritus substrate were also sampled. The water level in creeks and streams was low. Some forested streams were reduced to detrital pools. Conditions were generally dry and rain did not adversely impact collecting.

*Habitats of Note*: **Several forested streams around the vicinity of Parabara village proved particularly good, with numerous rare and new species (e.g. *Lutrochus* sp. n.).** These streams included both sandy and mud/detritus substrates.

SEVERAL FORESTED STREAMS AROUND THE VICINITY OF PARABARA VILLAGE PROVED PARTICULARLY GOOD, WITH NUMEROUS RARE AND NEW SPECIES

**Sample collection and preservation**

A total of 43 samples of aquatic beetles were collected. The majority of aquatic beetles are less than 5 mm although some, including several species collected on this expedition, are significantly larger (50 mm). These small specimens required detailed study in the laboratory using a microscope for species identification; thus samples were collected and preserved from each camp for processing. Samples were initially preserved in 100% ethanol, with representatives from each collecting event mounted and labelled. Prepared 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.

## Results and Discussion

During the expedition, 201 species of aquatic beetles in 72 genera were collected (Table 7.1). **Both the Kusad and Parabara study regions had similar numbers of species (127 and 125 respectively), but the composition of these aquatic beetle communities differed sharply. Only 51 species were found at both sites, such that about 75% of species collected were only found in one of the two sites.** Four genera and at least 15 species are new to science, though many more of the morphospecies we identified are likely to ultimately prove to be previously undescribed taxa.

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

| | # Specimens | # Genera | # Species | Unique species |
|---|---|---|---|---|
| Kusad Region | 5,465 | 51 | 127 | 76 |
| Parabara Region | 2,073 | 55 | 125 | 74 |

### Taxa of Note

Torridincolidae: This represents the first report of this family as well as the suborder Myxophaga from Guyana. Two new species, including one that also represents an undescribed genus, were found in abundance on the rockslide near the Kusad base camp. The family was just recently recorded from Suriname (Short 2013).

*Fontidessus* (Dytiscidae): This is the first report of this hygropetric genus from Guyana. We collected two species on the rockslide on Kusad: *F. ornatus* (which was described from Venezuela) and *F. aquarupe*, which was recently described from this material (Miller and Montano 2014).



***Fontidessus ornatus:* This tiny but colorful beetle was only described a few years ago, and this is the first time the genus has been found in Guyana. This species lives on wet rocks on Kusad Mountain. Several similar new species in this genus have recently been found in Guyana.**

Oocyclus spp. (Hydrophilidae): While this is not the first record of the genus from Guyana (see Short et al. 2013), it is notable that five species co-occurred on the rockslide at Kusad. This represents the most species of the genus ever recorded from a single site.

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**Oocyclus coromoto:** **This species only occurs around waterfalls and on rock seepages. It is known in Guyana from only a handful of localities, including Kusad Mountain.**

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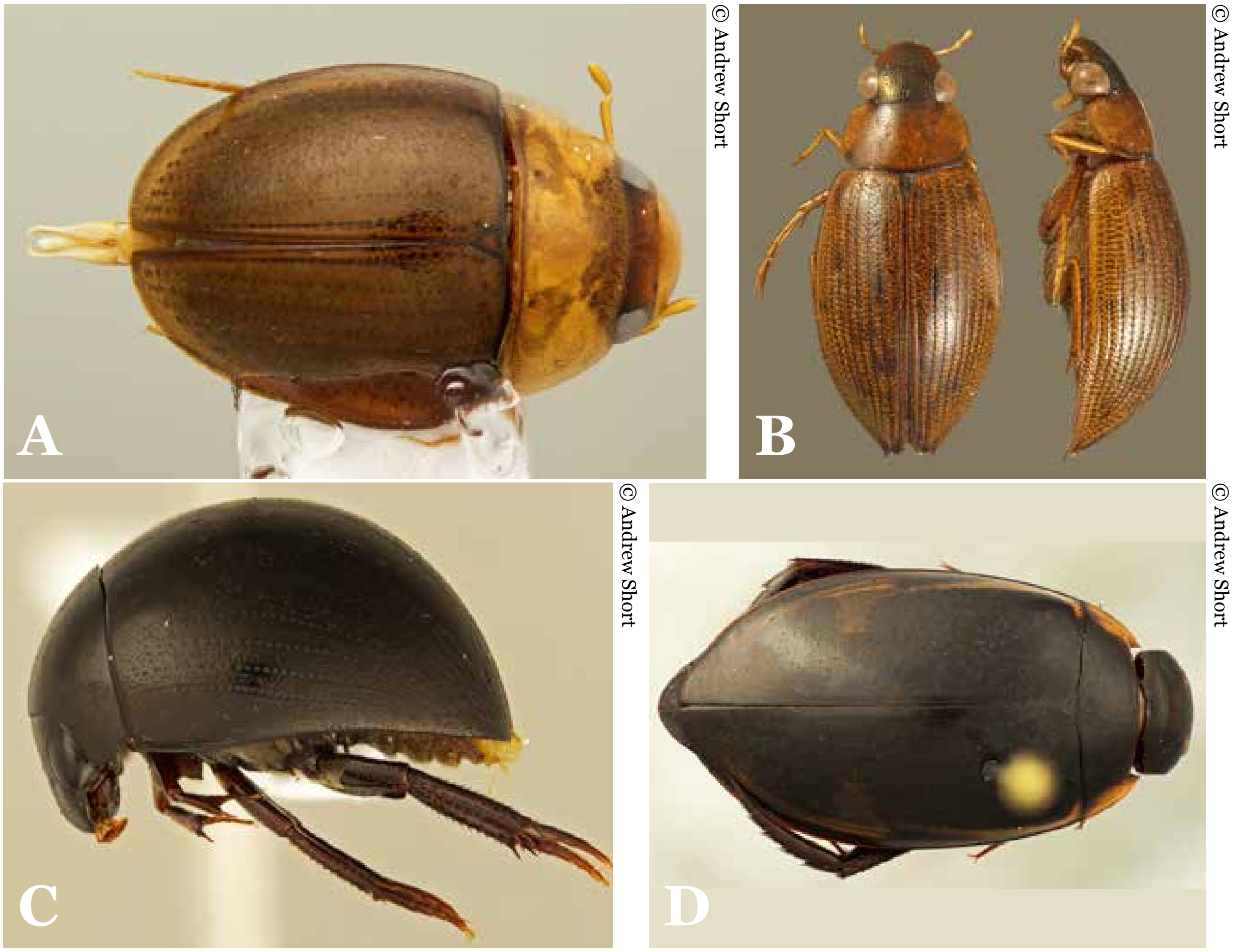
***Oocyclus floccus:*** **This species was named after the long clumps of hairs which stand up on its back. Like *Oocyclus coromoto*, it only lives in seepages.**

*Berosus garciai* (Hydrophilidae) and *Liodessus* sp. n. "fuzzy" (Dytiscidae): These two species were primarily collected along the margins of the Takutu River and the larger creeks near the Kusad base camp. Both of these species were previously only known from the Orinoco River in western Venezuela. Though this is a significant range extension, the habitat in which they were found (riverside rock pools) is identical to where they have been observed in Venezuela.

Hydrophilidae: New Genera: Two undescribed genera of water scavenger beetles were found at the Parabara site, both of which had also been collected previously in Suriname. They prefer forested streams.

Noteridae: Twenty-one species of noterids were recorded, an exceptionally high number considering there are only 258 species in the family (Nilssen 2011). At least three of these are new to science and one additional species needs to be moved to a new genus that has yet to be described.

Lutrochidae: A new species of *Lutrochus* was found in forested stream (Figure 7.2 D) at the Parabara site, which has now been described as *L. wao* (Maier and Short 2014).




A: ***Enochrus*** **sp. 1: This species is new to science, and does not yet have a proper name. It is found, sometimes in abundance, in forested pools.**

B: ***Berosus brevibasis: Berosus*** **is the largest genus of water scavenger beetles with nearly 300 species worldwide. This relatively rare species is known from ponds and marshes that occur in savannahs. It is a new country record for Guyana.**

C: ***Derallus intermedius:*** **This black, hunch-backed species resembles a bicycle helmet. It is a good swimmer, and lives in water holes filled with dead leaves.**

D: ***Hydaticus*** **cf.** ***lateralis:*** **This medium-sized water beetle is a fast swimmer and was found in densely forested pools around Parabara.**

## Conservation Issues and Recommendations

**The study region has an exceptionally high level of species richness for aquatic beetles. As one comparison, substantially more species were recorded here (201) than during either the south-eastern Suriname RAP survey (144 species), or the Grensgebergte/Kasikasima Suriname RAP survey (157 species), despite more sites being visited and more collecting methods being used on each of those expeditions** (Short and Kadosoe 2011, Short 2013). This is likely due to two factors: first, the region is relatively undisturbed. While there are visible human impacts to aquatic habitats at some collection sites, these seem to be discrete and limited. Most habitats in which we collected were pristine or nearly so. Second, there is a very high diversity of habitats in the region, each with distinctive aquatic beetle communities. For example, both the open savannah habitats around Kusad and the interior forests around Parabara village hosted large communities of aquatic beetles, but had very little in common. Thus, **by possessing a large number of habitats with distinct and intact communities, the area as a whole yields a very diverse species assemblage. As a consequence, conservation efforts should focus on maintaining integrity of the habitat mosaic that exists in the South Rupununi region.**

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CONSERVATION EFFORTS SHOULD FOCUS ON MAINTAINING INTEGRITY OF THE HABITAT MOSAIC THAT EXISTS IN THE SOUTH RUPUNUNI REGION

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# CHAPTER 8

# AN ASSESSMENT OF WATER QUALITY IN THE SOUTHERN RUPUNUNI REGION, GUYANA

*Denise Simmons and Nelanie La Cruz (University of Guyana)*

## Summary

Water quality surveys were conducted at 51 locations[2] on 19 water bodies at the Kusad Mountain and Parabara study areas, in the South Rupununi. Parameters measured were: temperature, pH, dissolved oxygen, conductivity, total dissolved solids, turbidity, chemical oxygen demand, nutrients, and metals. Water quality analyses and observations indicate that except for a few water bodies, namely Cocosabana Lake and Marudi Creek, located close to areas with human activities (where the turbidity levels exceeded 100 NTU and the concentration of mercury was high in the Marudi Creek), and possibly Mokorowau and Tarayara Creek (highest levels of conductivity), the water bodies sampled in the southern Rupununi were not subjected to intensive anthropogenic disturbance, and therefore, natural processes influenced the water quality of water bodies.

The range of pH values (5.03-7.96) was characteristic of rivers and creeks of the Amazon basin. The dissolved oxygen values ranged from 1.11 to 7.84 mg/L, with the lower values generally found in the ponds/wetlands and isolated/stagnant small creeks (e.g. Ants Creek), and higher levels where the waters were turbulent (e.g. Mokorowau and Small Sand Creek). Lower levels of conductivity and total dissolved solids were found in the ponds/wetlands, and higher values in the creeks as they were flowing down the Kusad Mountain (e.g. Mokorowau and Tarayara Creek). The source of higher conductivity levels requires further examination. The chemical oxygen demand (COD) levels were similar to that of the Amazon basin and probably mostly resulted from the input of organic material from the surrounding terrestrial vegetation. While iron was not detected in any of the waters sampled, zinc, cadmium, lead and mercury were detected. **For drinking purposes, the majority of water bodies did not satisfy Guyana's drinking water pH standard and the WHO and Guyana's heavy metals (cadmium, lead and mercury) requirements.** However, the concentrations of zinc and total dissolved solids (TDS) in all the water bodies

[2]Many (as yet ungazetted) place names and spellings are as provided by individual local inhabitants, and variations may be encountered. Coordinates have however been provided.

were acceptable according to Guyana's drinking water standard. Regarding turbidity, only the ponds/wetlands (e.g. Black Huri Lake and the unnamed wetland in the Parabara area) and isolated sections of small creeks (such as Daadawau and Bototowau) were acceptable since their turbidity levels were below the maximum turbidity requirement of 5 nephelometric turbidity units (NTU). **Our recommendations are for Cocosabana Lake and the Marudi Creek to be first targeted for action in terms of controlling human activities.** Further, we recommend the establishment of a water quality monitoring system, which would allow for this study to be repeated in the dry seasons, extended in the wet seasons and also expanded spatially; the inclusion of a hydrological assessment as part of the water quality monitoring; and testing of ground water (at wells) and microbiological testing. Importantly, research on the origin of heavy metals, and the levels in various media - water, soil and fish - is critical. **In establishing water quality standards for Guyana for various uses, such as ecosystem services, agriculture, and recreation, cognizance must be taken of the results of this study (and other studies), so that realistic values would be set for the parameters.**

**WATER IS AN INVALUABLE NATURAL RESOURCE. IT IS USED FOR NUMEROUS PURPOSES BY HUMANS AND IT SUPPORTS SPECIES DIVERSITY WITHIN ECOSYSTEMS. AN ASSESSMENT OF WATER QUALITY IS IMPORTANT NOT ONLY BECAUSE IT PROVIDES AN INDICATION OF THE STATUS (IN TERMS OF THE PHYSICAL AND CHEMICAL CHARACTERISTICS) OF THE WATER BODIES, BUT ALSO BECAUSE WATER QUALITY DETERMINES THE RELATIONSHIP BETWEEN SPECIES AND HABITAT.**

## Introduction

**Water is an invaluable natural resource. It is used for numerous purposes by humans and it supports species diversity within ecosystems. An assessment of water quality is important not only because it provides an indication of the status (in terms of the physical and chemical characteristics) of the water bodies, but also because water quality determines the relationship between species and habitat** (for example, chemical composition influences the development of aquatic biota in surface waters; Chapman 1996), and indicates possible sources of pollution and disturbances within ecosystems. The latter is possible once baseline data on the health of a water body has been collected. Further, **the rivers, creeks and wetlands of the South Rupununi are used by the indigenous peoples for domestic purposes, including drinking and food/beverage preparation (DTC 2012) and as such, a water quality assessment determines whether the waters are safe and acceptable for such uses.**

This water quality survey contributes to the limited baseline data that is available for consideration in relation to establishing water quality standards for surface waters in Guyana and the management of water resources. It also contributes significantly to our knowledge of the state of aquatic ecosystems in the South Rupununi since, unlike the North Rupununi, few formal studies have been done in the southern Rupununi. Mol (2002) reported on the water quality of the Rewa and Kwitaro Rivers which drain the eastern Kanuku Mountains. At that time, the rivers were in a pristine condition, with values of pH, conductivity and visibility being similar to what is known for Amazonian streams. More recently, Trotz (2008) surveyed the rivers and creeks of Konashen and noted that they were free of human or industrial pollution. The pH values of the majority of creeks, rivers and isolated pools were reportedly similar to those observed in the Amazon basin, although they were below the drinking water standards of the World Health Organization (WHO) or the United States Environmental Protection Agency (USEPA). These studies did not consider nutrients or metals.

During this Biodiversity Assessment Team (BAT) expedition to Parabara and the Kusad Mountain in the South Rupununi from 24 October to 5 November 2013, the water quality of nineteen (19) streams, ponds and rivers were assessed.

## Description of Study Sites

The water quality survey was conducted in the Kusad Mountain 24-29 October 2013, and from 31 October to 5 November 2013 in the Parabara area. The 19 water bodies surveyed included savannah and forest creeks, wetlands/ponds/lakes, and tributaries of the Takutu and Kuyuwini Rivers. We sampled 51 locations within these 19 water bodies (or sample sites). (See Tables 8.1 and 8.2).

Table 8.1 **Description of sampling sites at the Kusad Mountain**

**Note: Some place names and spellings are as provided by individuals from the local communities, and variations may be encountered; coordinates are however also provided.**

| Collection site ID | Name of water body | Location of sampling point | Elevation (m) | Description of sampling point |
|---|---|---|---|---|
| GY-131024-001-KM | Takutu River at Lukanani landing | N 02° 50.155' W 059° 59.429' | | River, fast current, sample collected from above rapids |
| GY-131027-016-KM | Takutu River at Lukanani landing | N 02° 50.152' W 059° 59.442' | 99 | River, fast current, above rapids, water at lower level than sample GY-131024-001-KM and aquatic vegetation visible |
| GY-131024-002-KM | Mokorowau, upstream of camp at Kusad Mountain | N 02° 48.720' W 59° 52.004' | 138 | Creek, clear water, overhanging vegetation, sandy substrate with some rocks |
| GY-131027-022-KM | Mokorowau, same as sample point GY-131024-002-KM | | | |
| GY-131024-003-KM | Mokorowau, further upstream of camp at Kusad Mountain | N 02° 48.566' W 59° 51.908' | 152 | Creek, clear water, flowing over rocks at the bottom of a sloping rock |
| GY-131027-020-KM | Mokorowau, same as sample point GY-131024-003-KM | | | |
| GY-131027-021-KM | Mokorowau, upstream of sample point GY-131027-020-KM | N 02° 48.539' W 059° 51.907' | 176 | Nearly isolated pool in lip of sloping rock, rock substrate |
| GY-131025-004-KM | Black Huri Lake (Suzukarishii) | N 02° 49.747' W 059° 48.320' | 121 | Wetland that contains rooted vegetation (grasses), clear water |
| GY-131025-005-KM | | N 02° 49.767' W 059° 48.259' | 121 | |
| GY-131025-006-KM | | N 02° 49.889' W 059° 48.295' | 123 | |
| GY-131025-007-KM | | N 02° 49.865' W 059° 48.354' | 121 | |
| GY-131025-008-KM | Ants Creek (Ziidawau) | N 02° 49.736' W 059° 48.557' | 117 | Creek, almost stagnant, moss in water, ité palms lining the creek |
| GY-131025-009-KM | Ants Creek (Ziidawau), downstream | N 02° 49.863' W 059° 48.632' | 108 | Creek, almost stagnant, moss and moco moco vegetation in the water, ité palms lining creek |
| GY-131028-028-KM | Ants Creek (Ziidawau), downstream of sample point GY-131025-009-KM | N 02° 49.806' W 059° 48.614' | 116 | Creek, almost stagnant, moco moco vegetation in the water, ité palms lining creek |
| GY-131028-029-KM | Ants Creek (Ziidawau), downstream of sample point GY-131023-028-KM | N 02° 50.764' W 059° 49.255' | 109 | Creek, almost stagnant, moco moco vegetation in the water, ité palms lining creek |

Table 8.1 **Description of sampling sites at the Kusad Mountain (**cont'd)

| | | | | |
|---|---|---|---|---|
| GY-131026-010-KM | Small Sand Creek (Katuwau), at Saddle Mountain crossing | N 02° 53.437' W 059° 51.043' | 104 | Creek, flowing moderately, downstream of water flowing over rocks in the water (used as vehicle crossing) |
| GY-131026-011-KM | | N 02° 53.419' W 059° 51.087' | 107 | Creek, flowing moderately, downstream of point GY-131026-010-KM |
| GY-131026-012-KM | | N 02° 53.426' W 059° 51.142' | 106 | Creek, flowing, downstream of water flowing over rocks and downstream of sample point GY-131026-011-KM |
| GY-131026-013-KM | | N 02° 53.400' W 059° 51.066' | 103 | Creek, flowing moderately, upstream of rocks in the creek and sample point GY-131026-010-KM |
| GY-131026-014-KM | Small Sand Creek (Katuwau) upstream of Saddle Mountain crossing, at Kodowidpau downstream | N 02° 52.499' W 059° 49.828' | 105 | Creek, fast current, downstream of water flowing over a rock in the creek |
| GY-131026-015-KM | Small Sand Creek (Katuwau) upstream of Saddle Mountain crossing, at Kodowidpau upstream | N 02° 52.468' W 059° 49.808' | 117 | Creek, fast current, upstream of a rock outcrop in the creek |
| GY-131028-027-KM | Small Sand Creek (Katuwau) downstream of Saddle Mountain crossing at Masorode | N 02° 53.714' W 059° 51.351' | 101 | Creek, flowing, downstream of water flowing over rocks (rapids) and downstream of sample point GY-131026-011-KM |
| GY-131027-017-KM | Daadawau | N 02° 50.571' W 059° 59.102' | 107 | Creek flowing to Takutu River, clear water, flowing slowly, downstream of a vehicle (rock) crossing in the creek, moco moco vegetation in creek |
| GY-131027-018-KM | | N 02° 50.545' W 059° 59.108' | 96 | Creek flowing to Takutu River, clear water, appeared stagnant, upstream of a vehicle (rock) crossing in the creek, moco moco vegetation in creek |
| GY-131027-019-KM | Matabanwau near discharge into Takutu River | N 02° 50.042' W 059° 59.432' | 90 | Creek flowing to Takutu River, steep sides, overhanging vegetation, leaf litter in water |
| GY-131028-023-KM | Tarayara Creek | N 02° 47.408' W 059° 54.007' | 123 | Creek, steep sides, water clear, overhanging vegetation, leaf litter, water flowing very slowly, shallow |
| GY-131028-024-KM | | N 02° 47.417' W 059° 54.042' | 138 | Creek, steep sides, water brown, overhanging vegetation, leaf litter, water flowing slowly |
| GY-131028-025-KM | | N 02° 47.430' W 059° 54.063' | 103 | Creek, steep sides, water brown, overhanging vegetation, leaf litter, water flowing slowly |
| GY-131028-026-KM | Cocosabana Lake (Taawaruo Lake) | N 02° 51.197' W 059° 55.337' | 108 | Wetland containing standing vegetation, water murky |

Table 8.2 **Description of sampling sites at Parabara**

**Note: Some place names and spellings are as provided by individuals from the local communities.**

| Collection site ID | Name of water body | Location of sampling point | Elevation (m) | Description of sampling point |
|---|---|---|---|---|
| GY-131031-001-PB | Mushaiwau | N 02° 09.564' W 059° 17.557' | 277 | Creek, water flowing fairly quickly around a rock in the water, upstream of bridge crossing creek |
| GY-131031-002-PB | | N 02° 09.591' W 059° 17.539' | 267 | Creek, water flowing fairly quickly, overhanging vegetation, upstream of Kamudi Creek (Packbywau) |
| GY-131031-003-PB | | N 02° 09.562' W 059° 17.567' | 264 | Creek water flowing fairly quickly, downstream of bridge crossing creek |
| GY-131031-004-PB | Wiriwiriwau | N 02° 09.050' W 059° 16.252' | 287 | Creek, water flowing fairly quickly, overhanging vegetation, upstream of bridge crossing creek |
| GY-131031-005-PB | | N 02° 09.069' W 059° 16.262' | 264 | Creek, water flowing fairly quickly, overhanging vegetation, downstream of bridge crossing creek |
| GY-131101-006-PB | Kuyuwini River | N 02° 05.763' W 059° 14.458' | 225 | River, rapid current, at landing on the left bank of river |
| GY-131101-008-PB | Kuyuwini River, downstream of Marudi Creek | | | River, rapid current |
| GY-131101-009-PB | Kuyuwini River, downstream of sample point GY-131101-008-PB | N 02° 04.541' W 059°11.131' | 238 | River, rapid current |
| GY-131101-011-PB | Kuyuwini River, upstream of Lmy Creek | N 02° 04.649' W 059° 11.974' | 243 | River, rapid current |
| GY-131101-013-PB | Kuyuwini River, upstream of Tiger Head Creek | N 02° 05.088' W 059° 13.317' | 230 | River, rapid current |
| GY-131102-014-PB | Kuyuwini River, upstream of landing | N 02° 05.906' W 059° 14.931' | 234 | River, rapid current |
| GY-131101-007-PB | Marudi Creek (mouth) | N 02° 04.725' W 059° 11.198' | 248 | Creek, water flowing slowly, overhanging vegetation, water is murky and has high sediment load |
| GY-131101-010-PB | Lmy Creek, upstream of Marudi Creek | N 02° 04.575' W 059°11.514' | 239 | Creek, water flowing slowly, overhanging vegetation |
| GY-131101-012-PB | Tiger Head Creek - Kohmara Fitho, upstream of sample point GY-131101-011-PB | N 02° 04.703' W 059°13.282' | 246 | Creek, water flowing slowly, overhanging vegetation |

Table 8.2 **Description of sampling sites at Parabara (**cont'd)

| | | | | |
|---|---|---|---|---|
| GY-131102-015-PB | Unnamed creek - Old Man's Farm, Henry's Mouth, upstream of point GY-131102-014-PB | N 02° 05.273' W 059° 15.204' | 224 | Creek, water flowing slowly, overhanging vegetation, leaf litter in the water |
| GY-131103-016-PB | Bototowau | | 283 | Creek, water clear and flowing, overhanging vegetation, litter visible at bottom of creek |
| GY-131103-017-PB | Bototowau, up-stream of sample point GY-131103-016-PB | N 02° 10.880' W 059° 20.314' | 290 | Creek, water clear and flowing, overhanging vegetation, litter visible at bottom of creek |
| GY-131103-018-PB | Bototowau, up-stream of sample point GY-131103-017-PB and upstream of the bridge crossing the creek | N 02° 10.878' W 059° 20.296' | 398 | Creek, water clear and flowing, overhanging vegetation, litter visible at bottom of creek |
| GY-131103-019-PB | Bototowau, up-stream of sample point GY-131103-018-PB | N 02° 10.935' W 059° 20.327' | 339 | Creek, water clear and flowing, overhanging vegetation, litter visible at bottom of creek |
| GY-131104-025-PB | Bototowau, up-stream of sample point GY-131103-019-PB | N 02° 11.315' W 059° 20.644' | 283 | Creek, water almost stagnant, at a fishing pond, overhanging vegetation |
| GY-131103-020-PB | Unnamed creek | N 02° 10.809' W 059° 20.271' | 361 | Creek, water clear and flowing, overhanging vegetation |
| GY-131104-021-PB | Unnamed creek, wetland | N 02° 10.905' W 059° 20.548' | 265 | Wetland, rooted vegetation present, water clear |
| GY-131104-022-PB | | | | |
| GY-131104-023-PB | | | | |
| GY-131104-024-PB | Unnamed creek, downstream of wetland | N 02° 10.930' W 059° 20.486' | 265 | Clear flowing water, overhanging vegetation, moss visible near bottom |

The nine water bodies in the **Kusad Mountain** are described hereafter. Sampling was conducted at a total of twenty-six (26) locations within these sampling sites; these are shown in Figure 8.1.


Figure 8.1 **Location of sampling sites at Kusad Mountain**

The Takutu River forms Guyana's southwestern border with Brazil and empties into the Rio Branco in Brazil. Sampling was done at one point called the Lukanani landing, just above rapids where the water was approximately 1.2 metres (4 feet) deep. The strong current resulted in the high turbidity of this water and there were Podostemaceae on the rocks near to the banks of the river.

Mokorowau originates from and flows down the Kusad Mountain and into the Taawaruo Creek in the savannah and thence into the Takutu River. Sampling sites were located along the creek in Kusad Mountain where there was overhanging vegetation, and at one point, at the bottom of a sloping rock.

Black Huri Lake is a wetland that contains emergent vegetation (grasses). At the sampling points the lake varied in depth from approximately 0.5 metres to 1.2 metres. It provides a source of water for animals, although none were present at the time of sampling.

Ants Creek (Ziidawau) flows down from the southeastern side of Kusad Mountain and flows around the eastern side of the Mountain. After joining other tributaries, it empties into Small Sand Creek (Katiwau). The water is clear and the substrate is sandy. At the points sampled, Ants Creek was almost stagnant and contained moss and moco-moco (*Montrichardia arborescens*). The ité palm (*Mauritia flexuosa*) borders this creek.

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Figure 8.2 **Ants Creek**

Small Sand Creek is a large creek with a strong current and turbid water, and it contains numerous rapids. It flows across the savannah and is a tributary of the Takutu River. Vehicles cross Small Sand Creek by driving through the creek, traversing the rocks at the bottom of the creek in the vicinity of Saddle Mountain.

Dadaawau is a tributary of the Takutu River and was sampled in the savannah. The clear water was almost stagnant and contained moco-moco plants and other aquatic vegetation on the sandy substrate.

Matabanwau was sampled close to its discharge into the Takutu River. It is a creek with steep sides, overhanging vegetation and contained leaf litter in the water. The water was turbid.

Tarayara Creek flows down from the eastern side of Kusad Mountain and was sampled near the foot of the mountain where the creek ranged from about 0.2 metres to 1.2 metres in depth. The sides were steep and the substrate was a mixture of rocks and sand. The water contained leaf litter from the overhanging forest vegetation. There was a farm on the western bank of Tarayara Creek at the foot of the mountain.

Cocosabana Lake (Taawaruo Lake) is a wetland in the savannah that contains turbid water. A holding pen for livestock is situated next to the lake and at the time of sampling, pigs were in the water. The water has a depth of about 1.2 metres in the centre.

In the **Parabara area,** ten (10) water bodies were surveyed. Within these, twenty-five locations were sampled (Figures 8.3 and 8.4).


Figure 8.3 **Parabara – savannah sampling sites**


Figure 8.4 **Parabara – Kuyuwini River sampling sites**

The Kuyuwini River is the major river flowing through the Parabara area, and it is a tributary of the Essequibo River. The river is deep with a strong current and has forest vegetation lining its banks. Sampling was done along the river in the vicinity of Parabara between the mouths of an unnamed creek (Old Man's Farm and the Marudi Creek). Sampling was also done near the mouths of some of the tributaries of the Kuyuwini River, including Marudi Creek (Figure 8.5) (where mining was reportedly occurring upstream), Lmy Creek [spelling as provided uncertain], Tiger Head Creek, and an unnamed creek. Most of these creeks had overhanging vegetation.

Mushaiwau is a tributary of the Kuyuwini River; Bototowau and Wiriwiriwau flow into Mushaiwau. These creeks have similar characteristics in that they have swift currents, steep banks and overhanging forest vegetation that almost completely shades the creeks in the localities where sampling was done (Figure 8.6). Most of the sampling was in the vicinity of bridges. In addition, a fishing area in Bototowau was sampled.

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Figure 8.5 **Mouth of the Marudi Creek**


Figure 8.6 **Mushaiwau (left) and Wiriwiriwau (right) creeks in Parabara**

A wetland containing emergent vegetation (grasses; 0.4 to 0.5 metres deep); an unnamed creek (0.4 metres deep) with clear water and moss visible at the bottom; and a second unnamed creek with clear water (0.3 metres depth) were sampled. In both of the unnamed creeks the water was flowing slowly.

## Methods

*Introduction*

The physical and chemical characteristics of the waters in the survey sites were assessed through the measurement of the following physical and chemical parameters: temperature, pH, dissolved oxygen, conductivity, total dissolved solids (TDS), turbidity, oxygen demand/organic matter – chemical oxygen demand (COD), nutrients (phosphate and nitrogen), and heavy metals (cadmium, iron, lead, mercury and zinc). These parameters were selected based on guidelines in Chapman (1996) and are briefly described below.

To assess the baseline or background quality of water (or the water quality of unpolluted waters), all of the parameters mentioned in the foregoing paragraph are recommended for measurement, except TDS and heavy metals. The background water quality is dependent on the local geological, biological and climatological conditions and it is necessary to assess the suitability of water for use and to detect future changes (Chapman 1996).

All of the parameters identified in the first paragraph of this section except phosphorous/phosphate are recommended for measurement to protect aquatic life and fisheries, while all of the parameters, except temperature, phosphate/phosphorous and COD are recommended for measurement for drinking water sources (Chapman 1996).

*Description of water quality parameters*

While the temperature of surface water bodies is influenced by a number of factors, such as latitude, altitude, season, time of day, air circulation, cloud cover and the flow and depth of the water body, the temperature, in turn, affects the rates of physical, chemical and biological processes in water bodies (Chapman 1996). Therefore, temperature affects the concentration of substances in the water, as well as the presence of aquatic organisms. While some aquatic organisms survive best in warmer water, others prefer colder water. Thus, if the temperature of the water is outside of the optimal range for a prolonged period of time, an organism can become stressed and die if it is unable to migrate.

The pH is a measure of the concentration of hydrogen ions in a solution, and, as such, is an indication of the acidity or basicity of the solution. The pH scale ranges from 0 to 14, with the acidity increasing as the pH gets lower. The pH influences biological and chemical processes within a water body. For instance, different organisms will flourish within different ranges of pH, and pH values outside their tolerance range can reduce their presence. Low pH values can also solubilise toxic elements and compounds and make them available for uptake by aquatic plants and animals. Chapman (1996) points out that the pH of most natural waters is between 6.0 and 8.5, while recognising that lower values can occur in dilute waters high in organic content, and higher values in eutrophic waters, groundwater brines and salt lakes. WHO (2011) does not propose a health-based guideline value for pH since the latter does not generally have an impact on humans; instead it is an important parameter to be controlled in a water treatment process, for which the range of 6.5–8.5 is recommended.

The oxygen content of natural waters depends on temperature, salinity, turbulence, atmospheric pressure and photosynthetic activity of algae and aquatic plants (Chapman 1996). Oxygen is essential to all fishes and aquatic animals. If the amount of oxygen declines to very low levels, then aquatic animals may migrate or die. Chapman (1996) notes that at sea level dissolved oxygen ranges from 15 mg/L at $0^{o}$C to 8 mg/L at $25^{o}$C. According to WHO (2011), there is no health-based guideline value recommended for dissolved oxygen.

Conductivity is the ability of water to conduct an electric current. It is dependent on the presence of inorganic dissolved solids, such as chloride, nitrate, sulphate and phosphate anions, and sodium, magnesium, calcium, iron and aluminium cations. Therefore, variations in the total dissolved solids in a water body would influence the conductivity of the water. Conductivity is also affected by temperature. The geology of an area through which water flows influences the conductivity of that water body. Chapman (1996) provides a conductivity range from 10 to 1,000 µS $cm^{-1}$ for freshwaters. While dissolved solids do not reportedly cause adverse health effects, their presence may affect the taste of drinking water (WHO 2003; WHO 2011). WHO (2011) notes that while the palatability of waters with TDS levels of less than 600 mg/L is generally considered to be good, there is no proposed health-based guideline value for TDS.

**EXCESSIVE AMOUNTS OF SUSPENDED MATERIALS COULD CLOG FISH GILLS; AND, AS THEY SETTLE, COULD BLANKET THE BOTTOM OF A WATER BODY, THEREBY SMOTHERING FISH EGGS AND BENTHIC MACROINVERTEBRATES**

Turbidity is a measure of the clarity or cloudiness of the water and is dependent on the type and concentration of suspended matter in water. Suspended matter includes “silt, clay, fine particles of organic and inorganic matter, soluble organic compounds, plankton and other microscopic organisms” (Chapman 1996). Therefore, turbidity is used as a measure of suspended solids. Turbidity could affect the temperature of water, and in turn, the concentration of dissolved oxygen and the photosynthetic activity of algae. **Excessive amounts of suspended materials could clog fish gills; and, as they settle, could blanket the bottom of a water body, thereby smothering fish eggs and benthic macroinvertebrates.** While no health-based guideline value has been recommended by WHO (2011) for turbidity, for “small water supplies where resources are very limited and where this is limited or no treatment” (WHO 2011, p. 229), a turbidity of less than five nephelometric turbidity units (NTU) is usually acceptable in terms of appearance to consumers. **Importantly, turbidity can interfere with the water treatment process and higher levels of turbidity are often associated with high levels of disease carrying organisms since the latter adsorb to particulate matter** (WHO 2011).

The chemical oxygen demand (COD) is used to indirectly measure the amount of organic compounds in water and it is widely used to determine organic (and inorganic) materials present in water bodies and in the effluents from sewage and industrial plants. The COD measures the oxygen equivalent of the organic (and inorganic) matter in a water sample that is susceptible to oxidation by a strong chemical oxidant, such as dichromate (Chapman 1996).

Nutrients are substances required by all organisms, including aquatic ones, for growth. Nitrogen and phosphorous are two essential nutrients for living organisms. In the aquatic environment, nitrogen can exist in inorganic and organic forms. Inorganic forms of nitrogen include nitrate, nitrite, ammonia (including both ionised and un-ionised forms) and nitrogen gas; organic forms of nitrogen are derived from living organisms and include amino acids and proteins (Chapman 1996). While nitrogen can enter aquatic systems via natural processes such as fixation, and anthropogenic activities such as agricultural practices and industrial activities, once in the aquatic environment, nitrogen can change from one form to another as part of the nitrogen cycle. Generally, aquatic plants and algae convert inorganic nitrogen, primarily ammonia, nitrate and nitrite, to organic forms. In this study, the total Kjeldahl nitrogen (TKN), ammonia and nitrate are measured. The TKN is the total ammonia nitrogen and the total organic nitrogen – therefore, it does not include nitrate or nitrite. While no health-based guideline value has been proposed for ammonia, **WHO (2011) has recommended the guideline values of 50 mg/L as nitrate and 3 mg/L as nitrite due to the significant health risk associated with these two inorganic forms.**

Phosphorous exists in water bodies in dissolved and particulate forms. The dissolved phosphorous consists of soluble orthophosphates and polyphosphates, and organically bound phosphates (Chapman 1996). The particulate phosphorous is formed when phosphorous becomes incorporated into particles or soil, algae and zooplankton that are suspended in the water. Plants take up soluble orthophosphate. Changes between the forms of phosphorous occur as part of the phosphorous cycle. Chapman (1996) identifies phosphorous as the limiting nutrient for algal growth; it therefore controls the primary productivity of a water body. Increased concentrations of phosphorous cause eutrophication. No health-based guideline value has been proposed by the WHO (2011) for phosphorous.

Heavy metals can be defined as metallic elements which have a relatively high density in comparison to water. Heavy metals are natural components of the earth's crust, and therefore natural processes, such as weathering, contribute to the presence of trace amounts of metals in freshwaters. However, anthropogenic activities, such as mining, industrial production and use, and domestic and agricultural use of metals and metal-containing compounds, have increased humans exposure to these metals (Chapman 1996; Tchounwou et al. 2014). **Importantly, heavy metals, unlike organic pollutants, are not degraded, and they are transferred from one environmental component to another, including soil and sediment, where they accumulate and can be ingested by aquatic biota. These metals then accumulate in humans as they consume aquatic species like fish.** (McComb et al. 2014). While some heavy metals are essential to biochemical and physiological functions in plants and animals, others have no established biological functions and are considered non-essential metals. However, increased concentrations of essential metals may, like non-essential metals, cause toxic effects. The Global Environment Monitoring System (GEMS) programme GEMS/WATER recommends the inclusion of ten (10) heavy metals in water quality assessment programmes (Chapman 1996). This study analysed five of these metals; of the five, two (iron and zinc) are essential metals and three (cadmium, lead and mercury) are non-essential metals (Tchounwou et al. 2014). The WHO (2011) has not proposed any health-based guideline values for iron or zinc, but guideline values of 0.003 mg/L, 0.01 mg/L and 0.006 mg/L have been established for cadmium, lead and mercury in drinking water, respectively.

*Overview of methods to measure the water quality parameters*

A Hach portable multi-parameter meter (Model number: HQ40d) was used to measure temperature, pH, dissolved oxygen, conductivity and TDS in the field. Turbidity was also measured in the field using a Hach portable turbidimeter (Model number: 2100P).

At selected locations, water samples were collected and stored for the analysis of oxygen demand, nutrients and metals at later date by the laboratories of the Guyana Sugar Corporation Incorporated Central Laboratory and the Institute of Applied Science and Technology (IAST). All stored samples were acidified

**IMPORTANTLY, HEAVY METALS, UNLIKE ORGANIC POLLUTANTS, ARE NOT DEGRADED, AND THEY ARE TRANSFERRED FROM ONE ENVIRONMENTAL COMPONENT TO ANOTHER, INCLUDING SOIL AND SEDIMENT, WHERE THEY ACCUMULATE AND CAN BE INGESTED BY AQUATIC BIOTA. THESE METALS THEN ACCUMULATE IN HUMANS AS THEY CONSUME AQUATIC SPECIES LIKE FISH.**

and held at temperatures below 4°C. Specifically, COD was determined using a titrimetric method; total Kjeldahl nitrogen (TKN), ammonia, nitrate, and phosphate were measured using colorimetric methods; and cadmium, lead, zinc and iron concentrations were determined by atomic absorption spectrometry. Two samples in the Parabara area were analysed for mercury using cold vapour atomic absorption spectrometry following a digestion. The two samples were the from the Kuyuwini River (upstream of Tiger Head Creek) and Marudi Creek (IDs GY-131101-013-PB and GY-131101-007-PB, respectively).

For this assessment, the researcher was assisted by Nelanie La Cruz (student, University of Guyana) and two local guides, Paul Francis (resident of Potarinau), and Alcido Isaacs (resident of Karaudanawa).

## Results

Tables 8.3 and 8.4 provide a summary of the data obtained from the sample sites in the Kusad Mountain and Parabara area, respectively; for the complete data tables, see Appendix 8.

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Nelanie LaCruz sampling

© Denise Simmons

Sampling in Kotawau

© Denise Simmons

Water quality sampling- Team 1

Figure 8.7 **Water quality team conducting assessments**

Table 8.3 **Summary of water quality results for sites at Kusad Mountain**

* ND – not detected

| Sample sites/ Parameters | Takutu River at Lukanani landing | Mokorowau | Black Huri Lake (Suzuka-rishii) | Ants Creek (Ziidawau) | Small Sand Creek (Katu-wau) | Daadawau | Matabanwau near dis-charge into Takutu River | Tarayara Creek | Cocosa-bana Lake (Taawaruo Lake) | Kusad Mountain area |
|---|---|---|---|---|---|---|---|---|---|---|
| **pH** | 6.78 - 7.12 | 6.90 - 7.96 | 5.03 - 5.60 | 5.44 - 6.20 | 6.67 - 6.96 | 6.14 - 6.27 | 7.01 | 5.93 - 6.40 | 6.61 | 5.03 - 7.96 |
| **Temp (°C)** | 29.0 – 30.4 | 25.6 – 28.4 | 29.3 – 30.6 | 27.9 – 34.0 | 30.5 – 34.4 | 28.6 – 29.1 | 32.2 | 25.9 – 26.0 | 29.5 | 25.6 – 34.4 |
| **DO (mg/L)** | 6.41 - 6.65 | 7.01 - 7.84 | 5.12 - 6.41 | 2.74 - 5.13 | 6.47 - 7.21 | 3.64 - 4.89 | 6.80 | 1.51 - 3.84 | 3.50 | 1.51 - 7.84 |
| **Cond (µS/cm)** | 31.80 | 51.10 - 60.00 | 4.49 - 6.00 | 11.41 - 27.80 | 17.35 - 21.92 | 14.32 - 14.86 | 24.60 | 64.40 - 68.10 | 26.00 | 4.49 - 68.10 |
| **TDS (mg/L) as NaCl** | 14.89 | 24.20 - 28.70 | 2.03 - 3.45 | 5.82 - 12.54 | 8.06 - 10.22 | 6.65 - 6.90 | 11.46 | 30.30 - 32.00 | 12.22 | 2.03 - 32.00 |
| **Turb (NTU)** | 22.00 - 25.20 | 6.76 - 9.18 | 1.69 - 3.92 | 3.96 - 6.89 | 17.20 - 22.40 | 1.92 - 3.04 | 21.00 | 11.30 - 16.80 | 129.00 | 1.69 - 129.00 |
| **$NO_3^-$ (mg/L)** | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| **$NH_4^+$ (mg/L)** | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| **TKN (mg/L)** | 3.23 | 3.27 - 4.87 | 4.96 | 3.79 - 4.95 | 3.68 - 5.80 | 3.73 - 4.50 | 2.71 | 4.20 | 3.89 | 2.71 - 5.80 |
| **P (mg/L)** | 0.68 | 0.11 - 0.44 | 0.40 | 0.34 - 0.44 | 0.41 - 0.69 | 0.38 - 0.81 | 0.33 | 1.07 | 0.47 | 0.11 - 1.07 |
| **COD (mg/L)** | 24 | 8 - 8 | 8 | 8 - 32 | 8 - 40 | 8 - 8 | 16 | 8 | 32 | 8 - 40 |
| **Cd (mg/L)** | 0.017 | 0.014 - 0.019 | 0.015 | 0.015 - 0.017 | 0.013 - 0.018 | 0.014 - 0.015 | 0.018 | 0.016 | 0.015 | 0.013 - 0.019 |
| **Pb (mg/L)** | 0.047 | 0.040 - 0.043 | 0.039 | 0.036 - 0.044 | 0.035 - 0.060 | 0.039 - 0.045 | 0.042 | 0.047 | 0.054 | 0.035 - 0.060 |
| **Zn (mg/L)** | 0.068 | 0.053 - 0.063 | 0.056 | 0.043 - 0.047 | 0.058 - 0.111 | 0.057 - 0.079 | 0.065 | 0.099 | 0.121 | 0.043 - 0.121 |
| **Fe (mg/L)** | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |

Table 8.4 **Summary of water quality results for sites at Parabara**

* ND – not detected

| Sample sites/ Parameters | Mushaiwau | Wiriwiriwau | Kuyuwini River | Marudi Creek (mouth) | Lmy Creek, upstream of Marudi Creek | Tiger Head Creek - Kohmara Fitho, mouth | Unnamed creek - Old Man's Farm, Henry's Mouth | Bototowau | Un-named creek | Unnamed wetland & creek | Parabara area |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **pH** | 6.12 - 6.27 | 6.15 - 6.16 | 6.34 - 6.41 | 6.46 | 6.21 | 6.08 | 6.02 | 5.46 - 6.08 | 5.84 | 5.58- 5.65 | 5.46 - 6.46 |
| **Temp (°C)** | 24.9 – 25.2 | 24.8 | 25.9 – 31.5 | 24.7 | 26.3 | 25.0 | 24.0 | 24.5 – 25.1 | 25.2 | 25.9 – 26.7 | 24.0 – 31.5 |
| **DO (mg/L)** | 5.63 - 5.76 | 6.14 - 6.18 | 5.45 - 5.77 | 6.36 | 5.35 | 5.34 | 1.11 | 2.75 - 6.18 | 6.30 | 1.43 – 4.67 | 1.11 - 6.36 |
| **Cond (µS/cm)** | 19.64 - 21.76 | 19.63 - 20.09 | 18.53 - 21.90 | 25.3 | - | - | 35.40 | 10.61 - 14.01 | 9.65 | 8.59 - 10.49 | 8.59 - 35.40 |
| **TDS (mg/L) as NaCl** | 9.14 - 10.14 | 9.14 - 9.35 | 8.62 - 20.20 | 11.79 | - | - | 16.55 | 4.90 - 6.49 | 4.49 | 3.94 - 4.85 | 3.94 - 20.20 |
| **Turb (NTU)** | 18.80 - 24.20 | 18.40 - 18.80 | 23.90 - 39.40 | 154.00 | 27.00 | 42.6 | 35.80 | 4.54 - 11.80 | 3.51 | 0.54 – 2.89 | 0.54 - 154.00 |
| **$NO_3^-$ (mg/L)** | ND | ND | ND | ND | ND | ND | ND | ND | - | ND | ND |
| **$NH_4^+$ (mg/L)** | ND | ND | ND | ND | ND | ND | ND | ND | - | ND | ND |
| **TKN (mg/L)** | 3.24 - 3.29 | 3.01 - 3.99 | 3.38 - 4.21 | 3.30 | 2.69 | 3.73 | 4.51 | 2.79 - 4.96 | - | 2.96 - 3.68 | 2.69 - 4.96 |
| **P (mg/L)** | 0.48 - 0.62 | 0.63 - 1.05 | 0.41 - 0.44 | 0.80 | 0.38 | 0.33 | 0.35 | 0.15 - 0.76 | - | 0.10 - 0.31 | 0.10 - 1.05 |
| **COD (mg/L)** | 16 - 16 | 24 - 24 | 8 - 16 | 16 | 8 | 8 | 16 | 8 - 16 | - | 8 - 16 | 8 - 24 |
| **Cd (mg/L)** | 0.015 - 0.017 | 0.017 - 0.017 | 0.014 - 0.017 | 0.018 | 0.020 | 0.016 | 0.017 | 0.014 - 0.016 | - | 0.013 - 0.014 | 0.013 - 0.020 |
| **Pb (mg/L)** | 0.052 - 0.059 | 0.057 - 0.061 | 0.064 - 0.070 | 0.057 | 0.054 | 0.056 | 0.065 | 0.046 - 0.055 | - | 0.033 - 0.047 | 0.033-0.070 |
| **Zn (mg/L)** | 0.064 - 0.072 | 0.064 - 0.066 | 0.065 - 0.065 | 0.065 | 0.067 | 0.065 | 0.066 | 0.068 - 0.068 | - | 0.065 - 0.068 | 0.064 - 0.072 |
| **Fe (mg/L)** | ND | ND | ND | ND | ND | ND | ND | ND | - | ND | ND |
| **Hg (µg/L)** | - | - | 4.55 | 4.64 | - | - | - | - | - | - | - |

*pH*

The pH of the sampled waters in the southern Rupununi ranged from 5.03 to 7.96. At Kusad Mountain the pH of the sampled water ranged from 5.03 to 7.96 and at Parabara between 5.46 and 6.46. In the study sites, the ponds/wetlands and the isolated/stagnant part of small creeks had lower pH values (for example, localities in Black Huri Lake and Ants Creek had pH values of 5.03 and 5.44, respectively), while the rivers and the creeks had higher values (for example Mokorowau, with a pH of 7.96 and Takutu River with a pH of 7.12). These results are similar to the findings of Mol (2002) and Trotz (2008).

*Water Temperature*

The water temperature ranged from 24.0°C at 9:06 hours in the shaded unnamed creek – Old Man's Farm, Henry's Mouth, to 34.4°C at 12:50 hours in the unshaded Small Sand Creek.

*Dissolved Oxygen*

The dissolved oxygen values for the two study sites ranged from 1.11 to 7.84 mg/L, with 1.51 to 7.84 mg/L at Kusad Mountain, and 1.11 to 6.36 mg/L in the Parabara area. The lower values were generally found in the ponds/wetlands and isolated/stagnant small creeks; this agrees with Trotz (2008). For instance, the unnamed wetland/creek in the Parabara area had a dissolved oxygen value of 1.43 mg/L and in the stagnant sections of Tarayara Creek and Ants Creek the dissolved oxygen levels were 1.51 mg/L and 2.74 mg/L, respectively. The highest dissolved oxygen reading of 7.84 mg/L was in the Kusad Mountain area where the water in Mokorowau was in free fall over rocks. The highest dissolved oxygen reading in the Parabara area (6.36 mg/L) was at the mouth of the Marudi Creek.

*Conductivity and Total Dissolved Solids (TDS)*

The conductivity of the sampled waters ranged from 4.49 to 68.10 µS/cm and the TDS between 2.03 to 32.00 mg/L. At Kusad Mountain, the conductivity ranged from 4.49 to 68.10 µS/cm and TDS from 2.03 to 32.00 mg/L, while in Parabara conductivity ranged between 8.59 and 35.40 µs/cm and TDS from 3.94 to 20.20 mg/L. The lower conductivity values were found in the ponds/wetlands, for instance in Black Huri Lake (4.49 µS/cm) and the unnamed wetlands in the Parabara area (5.59 µS/cm). The higher conductivity readings were found in the creeks as they flowed down from Kusad Mountain, Mokorowau (64.40 – 68.10 µS/cm) and Tarayara Creek (51.10 – 60.00 µS/cm).

THE WATER BODIES WITH THE HIGHEST TURBIDITY LEVELS IN BOTH STUDY SITES WERE THOSE WHERE THERE WERE HUMAN ACTIVITIES OCCURRING

*Turbidity*

Turbidity of the waters sampled ranged from 0.54 to 154.00 NTU; in the Kusad Mountain and Parabara areas the measured turbidity ranged from 1.69 to 129.00 NTU and from 0.54 to 154.00 NTU, respectively. The lowest turbidity values were associated with the pond/wetland areas and isolated/stagnant parts of small creeks. This was evident for Black Huri Lake (1.69 – 3.92 NTU), Daadawau (1.92 – 3.04 NTU), and the unnamed wetland in the Parabara area (0.54 – 0.65 NTU). **The water bodies with the highest turbidity levels in both study sites were those where there were human activities occurring,** namely the Cocosabana Lake (129.00 NTU), and the mouth of the Marudi Creek (154.00 NTU). In fact, **if the turbidity levels for these two water bodies are discounted, then the highest turbidity values measured in the Kusad Mountains and Parabara areas would have been in the Takutu (25.20 NTU) and Kuyuwini Rivers (39.40 NTU), respectively.**

*Nutrient levels*

Nutrient levels of TKN and total phosphate ranged from 2.69 to 5.80 mg/L and 0.10 to 1.07 mg/L, respectively. At Kusad Mountain, the TKN and total phosphate ranged from 2.71 to 5.80 mg//L and 0.11 to 1.07 mg/L, respectively, and in the Parabara area the TKN and total phosphate levels ranged from 2.69 to 4.96 mg/L and 0.10 to 1.05 mg/L, respectively. Ammonia and nitrate ions were not detected in any of the samples. At Kusad Mountain, there were lower levels of nutrients in the Matabanwau (TKN: 2.71 mg/L and total phosphate: 0.33 mg/L), and higher levels in the Tayara Creek (TKN: 4.20 mg/L and total phosphate: 1.07 mg/L) and Daadawau (TKN: 4.50 mg/L and total phosphate: 0.81 mg/L). Lower levels of nutrients were found in the unnamed wetland and creek (TKN: 2.96 mg/L and total phosphate: 0.10 mg/L) in the Parabara area and higher levels in Bototowau (TKN: 4.88 mg/L and total phosphate: 0.76 mg/L).

*Chemical Oxygen Demand (COD)*

The COD values ranged from 8 to 40 mg/L. It is likely that the input of organic material was both natural and anthropogenic. While at Kusad Mountain the COD ranged from 8 to 40 mg/L; in the Parabara area the COD ranged from 8 to 24 mg/L. The measure of total organic carbon was highest in the following areas: at the point in Katowau where vehicles used to cross from one bank to the other (COD: 40 mg/L); a stagnant part of the small creek, Ants Creek (COD: 32 mg/L); and the Cocosabana Lake (COD: 32 mg/L), indicating sources of organic input. Lower measures of organic carbon were found in the creeks flowing down from Kusad Mountain, Mokorowau (8 mg/L) and Tarayara Creek (8 mg/L). In the Parabara area, the highest COD levels recorded were from Wiriwiriwau (24 mg/L), and the COD levels varied between 8-16 mg/L in the tributaries of the Kuyuwini River.

*Metals*

The concentrations of the metals cadmium (Cd), lead (Pb) and zinc (Zn) were measured; their values ranged from 0.013 to 0.020 mg/L, 0.033 to 0.070 mg/L and 0.043 to 0.121 mg/L respectively in the two sites. The highest cadmium and lead levels were found in a sampling point in Mokorowau and Kuyuwini River, respectively. The highest concentration of zinc was found in Cocosabana Lake. **In Kuyuwini River (upstream of Tiger Head Creek) and Marudi Creek, high levels of mercury (Hg) were detected, 4.55 and 4.64 µg/L, respectively**. These were the only points assessed for mercury.

IN THE KUYUWINI RIVER (UPSTREAM OF TIGER HEAD CREEK) AND MARUDI CREEK, HIGH LEVELS OF MERCURY WERE DETECTED

## Discussion

Aquatic Ecology

There are three types of rivers in the Amazon watershed, namely white-water rivers, clear-water rivers and black-water rivers. Rivers draining the Guiana Shield are either clear-water rivers (generally transparent, with low conductivity and an almost neutral pH), or black-water rivers (characteristic dark colour, low pH, low conductivity and low dissolved oxygen) (Mol 2002). The United Nations Global Environment Monitoring System (GEMS) Water Programme provides access to the state and trends of global water resources by providing access to global water quality data; Table 8.5 provides the mean values for selected water quality parameters for rivers of the Amazon basin.

Table 8.5 **Mean values of selected water quality parameters in the Amazon Watershed**
Source: United Nations, undated.

| Parameter | Mean Value | Period |
|---|---|---|
| pH | 6.06 | 1975-2013 |
| Dissolved oxygen (mg/L) | 5.57 | 1975-2013 |
| Electrical conductance (µS/cm) | 58.71 | 1975-2013 |
| Turbidity (NTU) | 25.8 | 1978-2013 |
| COD (mg/L) | 18.7 | 1985-2012 |
| Total Phosphate (mg/L) | 0.21 | 1985-2012 |
| Total Kjeldahl Nitrogen (mg/L) | 0.36 | 2006-2012 |

**CURRENTLY, GUYANA HAS NO WATER QUALITY STANDARDS OR GUIDELINES FOR SURFACE WATERS FOR THE PROTECTION OF AQUATIC LIFE AND FISHERIES**

The waters sampled in this study could be grouped according to similar characteristics, as discussed in the paragraphs hereafter. The waters displayed characteristics similar to those of the rivers of the Amazon basin (as represented by the trends provided in the GEMS Water Programme). **Currently, Guyana has no water quality standards or guidelines for surface waters for the protection of aquatic life and fisheries**. As such, the results of this study could not be compared to standards for the protection of aquatic life and fisheries in Guyana. In addition, due to the absence of previous studies in these areas, it is difficult to conclude whether the water quality has declined or improved from its state prior to this study.

The wetland, Black Huri Lake, and the isolated/stagnant small creeks, Ants Creek and Daadawau of Kusad Mountain were acidic, with low dissolved oxygen levels, and the lowest levels of conductivity (except for one point on the Ants Creek) and turbidity of the water bodies sampled. The low levels of conductivity and turbidity mean that these waters have small amounts of dissolved as well as suspended materials. Bototowau and the unnamed creeks and wetland in the Parabara area had similar characteristics. The low levels of dissolved oxygen were likely due to the fact that they were lentic in the areas of sampling, and in some instances had high inputs of plant litter. For instance, Ants Creek had a high level of organic content (COD: 32 mg/L) in comparison to the mean COD levels for Amazon waters; these water bodies also generally had lower metal concentrations than the other water bodies sampled. Black Huri Lake, Ants Creek and Daadawau had comparable nutrient loads to those in all of the sampled waters; these concentrations were higher than the mean nutrient values of the rivers of the Amazon Basin. The source of organic input and nutrients was likely natural, from the vegetation that borders the creek and the aquatic vegetation.

The gallery forest creeks of the Parabara area, Mushaiwau and Wiriwiriwau, were similar to Amazon forest creeks; they exhibited acidity, low dissolved oxygen, and levels of conductivity comparable to those reported by Mol (2002). While the levels of nutrients and cadmium and zinc were similar to the levels in the water bodies discussed in the previous paragraph, the levels of turbidity and lead in Mushaiwau and Wiriwiriwau were higher than those levels in the water bodies discussed in the previous paragraph. However, the turbidity levels were below the mean value of 25.8 NTU for rivers of the Amazon basin. These forest creeks received organic and nutrient input from the surrounding and overhanging vegetation. Further, as posited by Horbe and da Silva Santos (2009), great amounts of forest organic matter help to produce solutions with low pH. The Kuyuwini River displayed similar characteristics to its two tributaries, except for higher levels of turbidity and slightly higher lead values. Additionally, the mouths of the tributaries of the Kuyuwini River, Lmy Creek, Tiger Head Creek and the unnamed creek (Old Man's Farm) also exhibited low acidity.

While Small Sand Creek at Kusad Mountain displayed similar levels of turbidity and conductivity to the forest creeks, Mushaiwau and Wiriwiriwau, the pH values were more neutral (possibly due to a reduced effect of organic input) and the dissolved oxygen values were higher than the forest creeks. The higher dissolved oxygen was possibly due to the presence of the rapids. The water quality at the mouth of Matabanwau was similar to the Small Sand Creek.

The Takutu River also had similar levels of dissolved oxygen and turbidity to those of Small Sand Creek; however, it exhibited a little higher level of conductivity (although the values agreed with the findings of Mol (2002)) and neutral pH values.

Of interest are the two creeks, Mokorowau and Tarayara Creek, which flow down Kusad Mountain. They both exhibited the highest levels of conductivity of the waters surveyed; in fact these results were higher than those obtained by Mol (2002) and Trotz (2008). These higher levels of conductivity could be related to the geology of the Kusad Mountain and the possibility that weathering of the material was occurring. The source and nature of the substances contributing to the conductivity should be further examined. The levels of turbidity in these two creeks were higher than those for the wetlands and isolated/stagnant small creeks, but lower than the Small Sand Creek and the gallery forest creeks in the Parabara area. It may be likely that human activity could have had an impact since there was a crop farm on the left bank of the Tarayara Creek and the research team was camping in the vicinity of Mokorowau at the time of sampling, but this also requires further examination.

**There are two water bodies that are of concern and possibly under threat because of the very high turbidity levels measured; while natural processes contribute to turbidity in waters, the levels measured were possibly due to the proximity to human activity since there was a livestock farm in the vicinity of the Cocosabana Lake and mining activities occurring in the upper reaches of the Marudi Creek.** However, the source and the nature of the turbidity should be further examined. **The presence of mercury in the Marudi Creek is also a cause of concern, but since only two samples were analysed, one cannot conclude as to the source of the mercury in this water body.**

In conclusion, **the water quality analyses and observations indicate that except for a few water bodies, namely Cocosabana Lake and Marudi Creek (evidence of very high turbidity and high mercury) and possibly Mokorowau and Tarayara Creek (highest levels of conductivity and higher levels turbidity), the water bodies sampled in the South Rupununi were not subjected to intensive anthropogenic disturbance.** The water quality was reflective of typical Amazonian rivers and natural processes, including if the water body was lentic, the presence of rapids, organic and nutrient inputs from the terrestrial and aquatic vegetation, among others, which primarily influenced the quality of water. This water quality data needs to be compared to the aquatic organisms and fisheries present in the water bodies to identify species-habitat relationships. **Importantly, the source(s) of heavy metals requires further examination.**

## IMPORTANTLY, THE SOURCE(S) OF HEAVY METALS IN WATER BODIES REQUIRES FURTHER EXAMINATION

*Drinking Water*

Since these untreated waters are used by the indigenous peoples for drinking purposes, albeit on a transient basis, their suitability for drinking was examined by comparing the water quality parameters to the WHO and Guyana's drinking water standards.

The pH values of all of the water bodies of the Parabara area and four of the water bodies at Kusad Mountain did not meet the requirement of the Guyana drinking water standard which indicate that for drinking purposes the pH of the water should fall between 6.5 – 8.5 (GNBS 2004). Therefore, these water bodies were more acidic than the pH requirement. However, all the water bodies sampled satisfied Guyana's drinking water requirement that water should not have TDS levels higher than 500 mg/L (GNBS 2004); all the measured TDS levels were less than 500 mg/L which means that the palatability of all the waters would be considered good (WHO 2011). Only the ponds/wetlands (e.g. Black Huri Lake and the unnamed wetland in the Parabara area) and isolated sections of small creeks (such as Daadawau and Bototowau) achieved the maximum turbidity requirement of 5 NTU (since their measured turbidity levels were less than 5 NTU), which is good. It should be noted that the Guyana standard allows a maximum turbidity level of 10 NTU in the absence of an alternative source of water (GNBS 2004). Importantly, turbidity in surface waters is "more likely to include attached microorganisms that are a threat to health" (WHO 2011, p. 228).

The heavy metals analysed are grouped into essential nutrients (iron and zinc) and non-essential metals (cadmium, lead and mercury) (Tchounwou et al. 2014). Regarding the two essential nutrients measured, all of the waters were acceptable according to the Guyana drinking water standards (GNBS 2004). However, **cadmium and lead in the majority of the sampled waters were at or slightly exceeded the Guyana maximum requirement for cadmium and lead in drinking water of 0.01 mg/L and 0.05 mg/L, respectively (GNBS 2004). If one considers the stricter WHO drinking water standards for cadmium and lead, all sampled waters exceeded the values of 0.003 mg/L and 0.01 mg/L, respectively (WHO 2011) and therefore would be considered unacceptable for drinking purposes.** In the Kuyuwini River (upstream of Tiger Head Creek) and Marudi Creek at Parabara, mercury levels exceeded the Guyana drinking water standard of 0.001 mg/L (GNBS 2004), but would be considered acceptable according to the WHO drinking water standard of 0.006 mg/L. It is necessary for more research to be conducted to establish whether the source of these non-essential metals is natural or anthropogenic. Based on observation, natural weathering may be the primary source since no intensive anthropogenic activities were evident in the area. However, with respect to mercury, as indicated previously, mining was reportedly occurring in the upper reaches of the Marudi Creek.

## Conservation Recommendations

Given the limited water quality information available for the South Rupununi, this survey has provided valuable data. Importantly, it provides scientific information that can be used by the indigenous peoples of the southern Rupununi in the management of their waters, creeks and wetlands, as articulated in their plan for the care of Wapishana territory in Guyana (DTC 2012). For instance, there is the goal of ensuring that villages, satellites and homesteads have clean water for drinking and bathing (from creeks, springs, wells and boreholes). This study has provided data on water quality at the time of study in 2013, and whether the waters could be considered 'clean' or acceptable for the purpose of drinking based on Guyana's and WHO's drinking water standards.

In view of the parameters analysed, it is recommended that **turbidity should be used as the criterion for determining whether these waters are acceptable for drinking, since turbid water can provide a medium for microbial growth which could cause water-borne disease outbreaks.**

**In light of the threat to water quality, primarily the turbidity levels of Cocosabana Lake and the presence of mercury in the Marudi Creek, these water bodies should be the first ones that are targeted by the Wapishana people for action in terms of controlling the human activities. They should definitely not be utilised for drinking water purposes.**

**Considering the presence of heavy metals in all of the waters sampled, a study should be commissioned to identify the origin of these metals and also include other heavy metals (such as chromium, arsenic, nickel, and copper).** Importantly, the metals in water and sediment should be quantified and the geology of the area assessed with a view to assessing the influence of the geological environment on the chemical composition of the water. Additionally, **given the threat of mining, there should be an assessment of the mercury levels in the sediment and fish of the Kuyuwini River, in particular.** Once available, this water quality data should be compared to the 2011 water and fisheries study (DTC 2012) in an effort to detect commonalities. Moreover, the presence of aquatic species should be studied in order to establish species-habitat relationships for these water bodies.

Notwithstanding the useful information contained herein, this is the first study that examined nutrients and metals in the waters of the southern Rupununi and one can only pronounce on the health of the water bodies at one point in time; that is, at the time the study was conducted (24 October to 5 November 2013). Therefore, more extensive studies are recommended; for instance, this water quality survey should be repeated in the dry season and also extended to the wet season to observe the seasonal variations in parameters. Measurements should also be taken along water bodies from the source to the mouth and at different depths and along the cross section.

Importantly, **this survey could form the basis for the establishment of a water quality monitoring system for the Wapishana territory since none currently exists**. Some of the sites could serve as a control for comparison with conditions at sites affected by anthropogenic activities. Establishment of a water quality monitoring system would provide information to detect trends in water quality, identify the cause(s) of the trends/changes, and establish and then compare to water quality standards for different uses, including protection of ecosystem services, human consumption, and agricultural activities. This water quality monitoring system would be critical to ensuring that safe water is available for the Wapishana people, and should also include microbiological testing. As recommended by Trotz (2008), water quality monitoring should be initially conducted on a quarterly basis at selected sampling sites.

Further, a hydrological survey of water courses which, at the very minimum, should assess water discharge measures and water levels, would support water quality data. The ground water provided by wells in the southern Rupununi should also be monitored. In light of the activities of the South Central Peoples Development Association in management of the resources of Wapishana traditional lands and communities in the south-central Rupununi, it is strongly recommended that this Association be included in the establishment and implementation of the recommended water quality monitoring system.

**IN LIGHT OF THE THREAT TO WATER QUALITY, PRIMARILY THE TURBIDITY LEVELS OF COCOSABANA LAKE AND THE PRESENCE OF MERCURY IN THE MARUDI CREEK, THESE WATER BODIES SHOULD BE THE FIRST ONES THAT ARE TARGETED BY THE WAPISHANA PEOPLE FOR ACTION IN TERMS OF CONTROLLING THE HUMAN ACTIVITIES. THEY SHOULD DEFINITELY NOT BE UTILISED FOR DRINKING WATER PURPOSES.**

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# CHAPTER 9

# A RAPID BIODIVERSITY SURVEY OF THE FISHES OF THE SOUTH RUPUNUNI SAVANNAH AREA, GUYANA

*Donald C. Taphorn and Matthew Kolmann*

## Summary

Twenty-four sites near two camps, (one near the Kusad Mountain, and the other in the Parabara area) in the southern Rupununi savannah region of Guyana, were sampled between 20 October and 6 November 2013 by an international team of researchers and local fishermen. We recorded 168 fish species (114 from sites near Kusad Mountain, 85 from the Parabara area mostly from the Kuyuwini River drainage) in 34 families. This very high species diversity is a result of the diversity of tropical freshwater aquatic habitats sampled, such as savannah and forest streams, forest pools, and flooded savannahs as well as larger rivers. We collected **18 species of fishes potentially new to science, 25 species endemic to Guyana, 19 that are rare (at least in museum collections), and six that are new records for the country.** The primary threats to the fishes of the South Rupununi vary with the area under consideration. **In the Kusad area, potential damage to the fish fauna comes from the periodic poisoning of streams with native poison by indigenous people in order to harvest fish for food. In the Kuyuwini River area the major threat is gold mining, which has already caused visible alteration in water quality, especially turbidity. Gold mining is undoubtedly causing as yet unmeasured mercury contamination of food fishes and of the local populations of indigenous people who frequently consume fish.**

## Introduction

Native peoples throughout the world depend upon freshwater fish as a frequent or essential food source, this also being the case for most indigenous peoples of Guyana, and, in particular, those who still live in isolated regions such as the southern Rupununi savannah. Fish of many species and all sizes are a key component of their nutrition, and a source of high quality protein. We have observed that when available, large predatory species like the aimara (*Hoplias aimara*) and tiger catfish (*Pseudoplatystoma fasciatum*) are favoured food fishes for both local consumption and sale to nearby towns. But many other species of all sizes are also harvested. Just about any species that can be caught, whether by hook and line, traps, or artisanal fish toxicants (Van Andel 2000), are eaten by local people. The largest and most popular food fishes can be overfished in river stretches near human settlements, and fishermen usually report that they must travel farther and farther to reach productive fishing areas. **Piscivorous predators, because of bioaccumulation of heavy metals in the aquatic food chain, are usually those found to have the highest concentration of mercury in regions where gold mining occurs** (Ouboter et al. 2012). **Unfortunately for fish biodiversity and human health, gold-mining is now present in several regions of Guyana, and mercury from the mines and gold processing sites can be dispersed by the winds to areas far from the source of gold** (Ouboter et al. 2012).

From 20 October to 6 November 2013, a team of researchers from the Royal Ontario Museum (M. Kolmann, D. Taphorn), the University of Toronto (M. Kolmann), the University of Guyana (Leanna Kalicharan) and a local resident who served as guide and assistant (Maximus Ignace), participated in a collaborative survey with other zoologists to catalogue the biodiversity of the watershed and tributaries of the South Rupununi savannah (Region 9).



**The fish team: L-R: Leanna Kalicharan, Donald Taphorn, Matthew Kolmann and Maximus Ignace.**

**THE RUPUNUNI WETLANDS REGION IS PARTICULARLY INTERESTING FROM EVOLUTIONARY AND BIOGEOGRAPHICAL STANDPOINTS, AS IT IS A POTENTIAL PORTAL FOR SPECIES EXCHANGE BETWEEN THE ESSEQUIBO AND AMAZON BASINS DURING THE RAINY SEASON**

Habitats surveyed were usually located near forest/savannah borders and included savannah and forest streams, savannah ponds and marshes, gallery forest creeks and main tributary rivers of the upper Kuyuwini and Rupununi River drainages (Essequibo Basin), and tributaries of the Takutu River (Amazon Basin). **The Rupununi wetlands region is particularly interesting from evolutionary and biogeographical standpoints, as it is a potential portal for species exchange between the Essequibo and Amazon basins during the rainy season**. Extensive flooding of the savannahs between the Takutu and Rupununi basins is thought to promote this route of species transfer and gene flow. Fishes then, provide a fascinating system in which to examine the history of faunal crossover and interaction in a complex geological and hydrological region (de Souza et al. 2012).

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**Rupununi marsh habitat**

We have known for over 100 years that many rivers of Guyana, especially those draining areas of the Guyana Shield like the Potaro River (Eigenmann 1912) harbour many endemic fishes. More recent surveys of the upper Mazaruni River (Alofs et al. 2014, López-Fernández et al. 2012, Maldonado-Ocampo et al. 2013, Netto-Ferreira et al 2013, Taphorn et al. 2008, 2010), the Kuribrong River (a tributary of the Potaro River) (Lujan et al. 2013), and the Berbice River (Hauser and López-Fernández 2013) prove that **the freshwater fish diversity of Guyana is seriously underestimated.** Thus, **with the increase of river degradation caused by the recent upswing in gold mining in Guyana, and documentation of the highly deleterious impacts of gold mining on aquatic ecosystems throughout South America** (Roach 2013 et al., Ouboter 2012, Mol and Ouboter 2004, Nico and Taphorn 1994), **it becomes imperative that additional regions be surveyed for fishes in order to catalogue local biodiversity before it disappears**. Further surveys will also help us to understand threats to species and their distribution, and will help to generate the vital baseline data needed to construct viable plans for sustainable conservation and development in the country.

WITH THE INCREASE OF RIVER DEGRADATION CAUSED BY THE RECENT UPSWING IN GOLD MINING IN GUYANA, AND DOCUMENTATION OF THE HIGHLY DELETERIOUS IMPACTS OF GOLD MINING ON AQUATIC ECOSYSTEMS THROUGHOUT SOUTH AMERICA, IT BECOMES IMPERATIVE THAT ADDITIONAL REGIONS BE SURVEYED FOR FISHES IN ORDER TO CATALOGUE LOCAL BIODIVERSITY BEFORE IT DISAPPEARS

## Study sites and methods

A total of 24 sites were sampled between 20 October to 6 November 2013; 15 near the first campsite established near Kusad Mountain, and nine further south in the Parabara area, as follows:

<u>Kusad mountain area collection sites</u>

GUY13-01. 23 Oct. 2013. Sandy creek at Kusad Mountain

Collectors: Taphorn, D.

GPS 02° 48 718' N -059° 52 000' W.

GUY13-02. 23 Oct. 2013. Mokorowau Creek at Kusad Mountain

Collectors: Taphorn, D., Kolmann, M., Ignace, M., Kalicharan, L.

GPS 02° 48 718' N -059° 52 000' W.

GUY13-03. 24 Oct. 2013. Takutu River at Lukunani Falls

Collectors: Taphorn, D., Kolmann, M., Ignace, M.

GPS 02° 50 158' N -059° 59 426' W.

GUY13-04. 24 Oct. 2013. Small stream feeding into Takutu River

Collectors: Taphorn, D.

GPS 02° 50 563' N -059° 59 113' W.

GUY13-05. 25 Oct. 2013. Black Huri Lake, west of Kusad

Collectors: Taphorn, D., Kolmann, M., Ignace, M., Kalicharan, L.

GPS 02° 49 786' N -059° 48 355' W.

GUY13-06. 25 Oct. 2013. Ant Creek, west of Kusad

Collectors: Taphorn, D., Kolmann, M., Ignace, M., Kalicharan, L.

GPS 02° 49 749' N -059° 48 537' W.

GUY13-07. 26 Oct. 2013. Sand Creek upstream of Katorwau River

Collectors: Taphorn, D., Kolmann, M., Ignace, M., Kalicharan, L.

GPS 02° 53 417' N -059° 51 031' W.

GUY13-08. 26 Oct. 2013. Katorwau River crossing, in Kodowidpao

Collectors: Taphorn, D., Kolmann, M., Ignace, M., Kalicharan, L.

GPS 02° 52 494' N -059° 49 837' W.

GUY13-09. 26 Oct. 2013. Upstream Katorwau River

Collectors: Taphorn, D., Kolmann, M., Ignace, M., Kalicharan, L.

GPS 02° 52 494' N -059° 49 837' W.

GUY13-10. 27 Oct. 2013. Marsh west of Takutu River

Collectors: Taphorn, D.

GPS 02° 52 204' N -059° 55 003' W.

GUY13-11. 27 Oct. 2013. Takutu River at Lukunani Falls

Collectors: Taphorn, D., Kolmann, M., Ignace, M., Kalicharan, L.

GPS 02° 50 142' N -059° 59 423' W.

GUY13-12. 27 Oct. 2013. Small stream feeding into Takutu River

Collectors: Taphorn, D., Kolmann, M., Ignace, M., Kalicharan, L.

GPS 02° 50 557' N -059° 59 118' W.

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**Rupununi morichal habitat.**

GUY13-13. 28 Oct. 2013. Tarayara Creek

Collectors: Taphorn, D., Kolmann, M., Ignace, M., Kalicharan, L.

GPS 02° 47 350' N -059° 54 035' W.

GUY13-14. 28 Oct. 2013. Cattle pond near ranch, west of Kusad

Collectors: Taphorn, D., Kolmann, M., Ignace, M., Kalicharan, L.

GPS 02° 51 197' N -059° 55 340' W.

GUY13-15. 28 Oct. 2013. Downstream Katorwau River

Collectors: Taphorn, D., Kolmann, M., Ignace, M., Kalicharan, L.

GPS 02° 53 719' N -059° 51 339' W.

Parabara region collection sites

GUY13-16. 31 Oct. 2013. Mushaiwau Creek

Collectors: Taphorn, D., Kolmann, M., Ignace, M., Kalicharan, L.

GPS 02° 09 559' N -059° 17 558' W.

GUY13-17. 1 Nov. 2013. Marudi Creek, off the Kuyuwini River, downstream of Parabara Collectors: Taphorn, D., Kolmann, M., Ignace, M., Kalicharan, L.

GPS: 02° 09 558' N -059° 17 560' W.

GUY13-18. 1 Nov. 2013. Lmy Creek [spelling as provided uncertain], off the Kuyuwini River, downstream of Parabara

Collectors: Taphorn, D., Kolmann, M., Ignace, M., Kalicharan, L.

GPS 02° 09 558' N -059° 17 560' W.

GUY13-19. 1 Nov. 2013. Jaguar Creek, off the Kuyuwini River, downstream of Parabara Collectors: Taphorn, D., Kolmann, M., Ignace, M., Kalicharan, L.

GPS 02° 04 643' N -059° 11 981' W.

GUY13-20. 1 Nov. 2013. Tiger Head Creek, off the Kuyuwini, downstream of Parabara Collectors: Taphorn, D., Kolmann, M., Ignace, M., Kalicharan, L.

GPS 02° 04 716' N -059° 13 265' W.

GUY13-21. 1 Nov. 2013. Kuyuwini River, downstream of Parabara (gillnet set along river) Collectors: Taphorn, D., Kolmann, M., Ignace, M., Kalicharan, L.

GPS 02° 53 719' N -059° 51 339' W.

GUY13-22. 3 Nov. 2013. Bototowau Creek (draining into marsh)

Collectors: Taphorn, D., Kolmann, M., Kalicharan, L.

GPS 02° 10.905' N -059° 20.547' W.

GUY13-23. 4 Nov. 2013. Kuyuwini River upstream of Parabara (gillnet set along river) Collectors: Taphorn, D., Kolmann, M., Ignace, M., Kalicharan, L.

GPS 02° 53 719' N -059° 51 339' W.

GUY13-24. 5 Nov. 2013. Baboon Creek (Rupununi drainage)

Collectors: Taphorn, D., Kolmann, M., Ignace, M., Kalicharan, L.

GPS 02° 05.662' N -059° 14.408' W.

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**Kuyuwini River at Parabara Landing**

Fish collections were made under the strictures of EPA collection permit # 102113 BR033 and were exported to the Royal Ontario Museum under EPA export permit 111413 SP: 009, for further study and identification. Several different sampling methods were used depending on the habitat and hydrological conditions. The primary method of fishing used was seine netting, whereby a small mesh net is pulled by two workers through shallow (maximum: waist- to chest-deep) water, while fish are corralled to the middle of the net. Gillnets were deployed in deeper water, targeting larger fishes. Gillnets, which are made from monofilament of varying mesh sizes, were often set in the evening, over the time period in which crepuscular, diurnal and nocturnal fishes are moving, to capture a wider variety of species. Hooks used with rod and reel, hand lines, and a small trot-line were also used to target larger species. Collecting sites were selected according to the ease with which these areas could be sampled (e.g. in areas shallow enough to deploy a seine) and with consideration towards habitat complexity. At some sites, an electric fish finder was also utilized to localize knifefish by homing in on their electrical signals (Crampton et al. 2007).

**IN SOME REGIONS, CERTAIN TAXA WERE REPORTED TO HAVE BEEN NEARLY EXTERMINATED (STINGRAYS - POTAMOTRYGONIDAE) BY LOCALS OR HAVE BEEN SEVERELY OVER-FISHED (AROWANA - OSTEOGLOSSIDAE)**

After capture, fishes were placed live in buckets until all gear was retrieved, and then euthanized with a clove oil solution. Specimens were hand-sorted and tentatively identified to species level when possible. They were then either preserved in a 10-15% solution of formalin, or small tissue samples were taken (either a clipped fin or a small piece of muscle tissue) and preserved in ethanol. Tissue samples are necessary for DNA extraction methods in later analyses for bar-code identification, population genetics, phylogenetic or other molecular studies. By collecting both whole specimens and tissue samples, we capture both the taxonomic and genetic diversity of a given habitat or locality.

## Results and Discussion

Collections were obtained from aquatic ecosystems spanning the Rupununi, Takutu, and Kuyuwini river basins. The expedition produced 168 species in 34 families and eight orders (Figure 9.1, Appendix 9). The majority of species (97%) documented belong to the following four orders: Characiformes (56%), Siluriformes (24%), Perciformes (11%) and Gymnotiformes (6%). At the family level, we found that almost half of the fishes of the southern Rupununi region belong to just three families: Characidae 26% (mostly small tetras), Cichlidae 11% (lukanani, sunfish, and patwa) and Loricariidae 9% (armoured suckermouth catfishes).

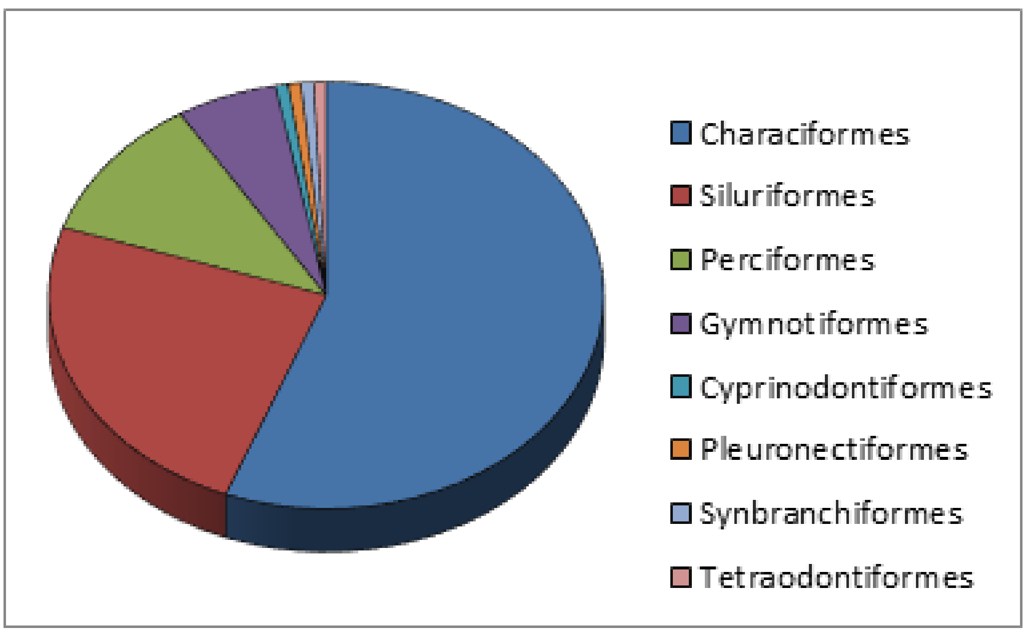


Figure 9.1 **Number of fish species documented per order**

**Some groups of fishes are conspicuously absent from our samples. For example, we found no freshwater stingrays (Potamotrygonidae), anchovies (Engraulidae), drum (Sciaenidae), needlefish (Belonidae), arowana (Osteoglossidae) or arapaima (Arapaimidae), all of which have been previously found to be common in the waters of the northern Rupununi savannah** (de Souza et al. 2012). Our inability to efficiently sample deeper bodies of water may have precluded collection of these groups of fishes. Alternatively, **in some regions, certain taxa were reported to have been nearly exterminated (stingrays - Potamotrygonidae) by locals or have been severely over-fished (arowana - Osteoglossidae).** Stingrays cause terrible wounds when stepped on, which usually lead to serious complications of infection and even death. They are generally reviled by local peoples as a result, and killed on sight when possible. Their continuous elimination by people from stream stretches above natural barriers, such as waterfalls, could conceivably have led to their removal. One of the most important local food fishes, the arapaima, is the subject of many local, national and international efforts that are currently underway to promote its recovery, including indigenous community-based management strategies (Fernandes 2006). **Arapaima conservation in Guyana is of particularly urgent importance in light of recent research (Stewart 2013; Watson et al 2013) indicating that the species of arapaima present in Guyana is probably distinct at the species level, which, if confirmed, would resurrect the name *Arapaima arapaima* Valenciennes 1847 and become another species endemic to Guyana that would merit protection under the CITES agreement.**

ARAPAIMA CONSERVATION IN GUYANA IS OF PARTICULARLY URGENT IMPORTANCE IN LIGHT OF RECENT RESEARCH INDICATING THAT THE SPECIES OF ARAPAIMA PRESENT IN GUYANA IS PROBABLY DISTINCT AT THE SPECIES LEVEL, WHICH, IF CONFIRMED, WOULD RESURRECT THE NAME *ARAPAIMA ARAPAIMA* VALENCIENNES 1847 AND BECOME ANOTHER SPECIES ENDEMIC TO GUYANA THAT WOULD MERIT PROTECTION UNDER THE CITES AGREEMENT




**An 182 cm total length arapaima from near Rewa, collected by Cynthia Watson and Dr D. Stewart in 2006 under a project on the population ecology and conservation of arapaima in the Essequibo and Branco river basins. Recent research (Stewart 2013; Watson et al 2013) indicates that the Guyana arapaima might be distinct at species level, warranting CITES protection**.

FISH POISONS KILL NOT ONLY ALL FISH SPECIES PRESENT, BUT ALSO THE INSECTS, CRUSTACEANS AND MOST OTHER WATER-BREATHING INHABITANTS

**It is also possible that some species have been negatively affected by the use of fish poisons by local indigenous people to harvest fish for food, as has been shown to be the case in some other regions of Guyana** (Forte 1996, Forte, Pierre, and Fox 1992, Iwokrama 1998, Van Andel 2000). We were informed by locals that in some places we sampled, there were fewer than usual fishes because they had been harvested using fish poisons, and that once poisons were used to capture the fishes from a stream, that fish would avoid recolonizing them for a time. Since **these poisons kill not only all fish species present, but also the insects, crustaceans and most other water-breathing inhabitants**, it may be the case that fish avoid poisoned streams until populations of invertebrates recover, since many fishes depend upon these for food.

More than 4,300 preserved specimens and almost 900 tissue samples for DNA analysis were collected. These specimens were incorporated into the ichthyological collections at the Royal Ontario Museum in Toronto, Canada, and voucher specimens will be returned to the Centre for the Study of Biological Diversity at the University of Guyana in Georgetown. **Several specimens have already been identified as new species, endemics, rare, or are new records of occurrence in Guyana** (Appendix 9).

**Fish diversity from both regions (Kusad - 114 spp. and Parabara - 85 spp.) was relatively high, with the Bototo Wau region (sampling site GUY13-22 Parabara/ Kuyuwini) being exceptional.** Detailed comparison with other regions of Guyana must await future surveys of the neighbouring drainages such as the Rewa and New Rivers, which are still virtually unexplored for fish diversity. All locality records are important documentation of the fish diversity of Guyana, and contribute to ongoing efforts to update the checklist of fish species present in Guyana. **Pollution from expanding human population centres, mining, deforestation and agriculture however threaten freshwater ecosystems in Guyana.** As such, the carrying out of further fish surveys is especially urgent to gather data which will help us to understand the nature and extent of these impacts, and improve conservation action and decision-making. Fisheries supplying local communities in isolated regions are traditionally less stressed by demand since human populations are usually low. However, as access to new markets improves, or new communities spring up around gold mines, demand increases**. Sale of fish to miners, and export to nearby communities often leads to overharvesting and eventual collapse of fish stocks. Top predators, such as the aimara and arapaima, are the first to disappear.**

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**Forest stream by manioc plantation reported to have reduced fish numbers due to fish poisons**

SEVERAL SPECIMENS HAVE ALREADY BEEN IDENTIFIED AS NEW SPECIES, ENDEMICS, RARE, OR ARE NEW RECORDS OF OCCURRENCE IN GUYANA. FISH DIVERSITY FROM BOTH REGIONS (KUSAD AND PARABARA) WAS RELATIVELY HIGH, WITH THE BOTOTO WAU REGION BEING EXCEPTIONAL.

**Some of the species collected in the Kusad and Parabara regions may be new to science,** e.g. *Leporinus friderici* group, *Brycon falcatus* group, *Aphyocharax* sp. "slender," *Hemigrammus* sp., *Jupiaba* cf. *essequibensis, Moenkhausia lepidura* group, *Serrapinnus* cf. *gracilis*, *Characidium* sp., *Apareiodon* sp., *Rivulus* (*Anablepsoides*) sp., *Gymnotus carapo* group, *Geophagus* "takutu," *Ancistrus* "net," *Ancistrus* "white dots", Heptapteridae, *Loricaria* sp., *Pimelodus blochii* group, and *Trichomycterus* sp.  Tissue samples and whole specimens of these taxa, as well as several other species, were collected from both regions. Further work at the Royal Ontario Museum, specifically the use of DNA assays, will allow comparison of specimens of purportedly similar ancestry, but from the two major drainages samples (Amazon and Essequibo). Potential differences in the genetic material from these taxa will hopefully reveal whether hereditary differences among these unique individuals might warrant specific taxonomic recognition.

© Andrew Snyder

***Ancistrus* sp.**


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***Ancistrus* sp. net.  This possibly new species of the family of sucker-mouthed armored catfishes (Loricariidae) is a member of the genus Ancistrus and has a distinctive network of spots on the ventrum and was collected from Mushaiwau Creek. These herbivores use rows of numerous tiny teeth to scrape algae from stones on the bottom of clear-water streams.  Their taxonomy is complex because their morphology is similar among species throughout South America, so biologists (see Leanna Kalicharan in background) take tissue samples to permit genetic analysis of DNA sequences. Each individual fish from which tissue samples are taken receive a special label to permit later identification.**

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***Geophagus* sp. "takutu". This is a possibly new species of Cichlidae of the genus *Geophagus*, which we called sp. "takutu". The specimen in the photo came from the Takutu River at Lukanani Falls.**

Furthermore, many of the species collected have potential value as ornamental fish. When properly managed and very carefully monitored, ornamental fisheries can create strong local support for the conservation of the aquatic habitats where the ornamental fishes are found. One limitation to this activity at this time is the ability to transport live fishes quickly to Georgetown for sale or exportation. Fishes sought for the ornamental trade vary widely, but many in the species list are sold as ornamentals, including the headstander, *Anostomus anostomus*, the spotted leporinus, *Leporinus ortomaculatus*, *Corydoras* catfish, the head- and tail-light tetra, *Hemigrammus ocellifer* and several other species of *Hemigrammus* tetras, a few of the diminutive but very colourful *Hyphessobrycon* species, several dwarf cichlids of the genus *Apistogramma*, and the different species of pencilfishes (*Nannostomus* spp.), to name just a few.

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***Leporinus* sp. at Kotorwau crossing**

## Conservation Recommendations

**Our first impression of the fish faunas in both regions visited is that they are well conserved and the streams and rivers are in almost pristine condition. However, one creek by a cassava farm in the Kusad region (GUY 13-13) that was sampled had very few fishes, and very low diversity, perhaps from the effects of pesticides or fertilizers from the adjacent agriculture, or as a result of previous poisoning by local fishermen, as was noted by the local people themselves**. This practice is still fairly common and reduces the abundance and diversity of fishes in the affected streams for months, or even years. A previous study done on this in Guyana's North West area, *The Diverse Uses of Fish-Poison Plants in Northwest Guyana,* Van Andel 2000, notes: "Although prohibited by law since the 1950s, recent anthropological studies indicate that fish poisoning is still an important activity in the life of Guyanese Amerindians today (Forte 1996; Reinders 1993; Riley n.d.; Sullivan 1997). The indiscriminate poisoning of creeks and ponds, however, has caused a decline in fish stocks around Amerindian settlements and has increased mortality among cattle that drink from poisoned pools (Forte 1996; Forte, Pierre, and Fox 1992; Iwokrama 1998)." Section 52 of Guyana's Summary Jurisdiction (Offences) Act Cap. 8:02 provides that everyone who "throws any substance poisonous to fish into any river, creek, or stream, for the purpose of poisoning, stupefying, taking, or destroying any fish" shall be liable to a fine of not less than twenty thousand dollars, although magistrates retain discretionary powers in the case of Amerindians. Section 14 (e) of the Amerindian Act 2006 also contains provision for Village Councils to make rules governing "the protection and sustainable management of wildlife including restrictions on hunting, fishing, trapping, poisoning, setting fires and other interference with wildlife."

The Kuyuwini River had an impressive abundance of those small and medium-sized fishes our gear could capture. **Reports from local inhabitants indicated that the fishery for the aimara (*Hoplias aimara*) is still active and productive. As a top predator, this species is susceptible to overfishing. It would also be expected to accumulate mercury released from gold mining activities.**

REPORTS FROM LOCAL INHABITANTS INDICATED THAT THE FISHERY FOR THE AIMARA (*HOPLIAS AIMARA*) IS STILL ACTIVE AND PRODUCTIVE. AS A TOP PREDATOR, THIS SPECIES IS SUSCEPTIBLE TO OVERFISHING. IT WOULD ALSO BE EXPECTED TO ACCUMULATE MERCURY RELEASED FROM GOLD MINING ACTIVITIES.

**Recommended actions:**

-As the incidence of gold mining activities increases, **local inhabitants and their principal food fishes should be monitored for the accumulation of mercury.**

**-Poisoning of streams should be discouraged because of lasting negative effects of the total removal of the fish population.** Locals informed us that migrating fish will avoid poisoned streams for several years after they have been fished out. **Educational seminars on the effects of this should be promoted locally, and Village Councils encouraged, for the benefit of their own communities and sustainability of resources, to make their own community rules against the use of fish-poison plants,** as is provided for in the Amerindian Act (2006).

- Ornamental fishes are common in both regions, and could support a local industry for export, supplying additional income for local families, provided this is very carefully monitored.
- Protect these rivers especially in light of their importance as a "free" protein source for local peoples. **Rivers provide constantly renewable sources of both clean water and abundant food when protected against mining- and agriculturally-related pollution.**
- A programme to monitor the composition and amount of fish catches from the Kuyuwini and other local rivers should be undertaken to document their importance to the nutrition and economies of local peoples, as well as to provide data for the construction of a sustainable fishery management plan.

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**The fish crew on the marsh shore. This shows a very different habitat from the typical streams we sampled. Fish density and diversity is low in these extensively flooded marshlands, but the huge areas covered by water can account for many fishes.**

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**Small specimens of two different species of piranha, *Pygocentrus nattereri* (L.) and *Serrasalmus rhombeus* (R.) were common in some samples, and did serious damage to our gill nets with their razor sharp teeth.**


© Vitus Antone

**The Dawalla Catfish, *Ageneiosus inermis*, can grow quite large, and are quite tasty. It is one of the few catfish with no or just two very short barbels near the mouth. They are unusual in having internal fertilization and sexual dimorphism. This one was caught from the Kuyuwini River.**

© Donald Taphorn

**Red-eyed tetra, *Moenkhausia oligolepis* group, from Mushaiwau Creek, near bridge.**

© Donald Taphorn

**Freshwater flatfish or flounders are found in sandy river habitats of streams and rivers. This is *Hypoclinemus mentalis* from the Kotorwau River crossing.**

© Donald Taphorn

***Leporellus vittatus* from the upper Takutu River at Lukanani Falls.This vividly marked fish is almost always associated with fast water rocky habitats.**

© Donald Taphorn

***Acestrorhynchus falcatus* from the Kuyuwini River near Parabara.**

© Donald Taphorn

***Boulengerella cuvieri***

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***Guianacara dacrya***

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***Hoplerythrinus unitaeniatus***

# CHAPTER 10

# A NATURAL RESOURCE USE ASSESSMENT IN THE SOUTH RUPUNUNI SAVANNAH, GUYANA

*Patricia Fredericks, Cedric Buckley and Juliana Persaud*

## Summary

We documented an incredible variety of plant and animal species, as well as other natural resources, found in and around the Kusad Mountain and Parabara savannahs area, that are a source of food, fuel, housing materials, income, and medicine for local indigenous communities. We recorded at least 59 species of plants (including cultivated species such as cassava) and 72 species of animals from our consultations with villagers at Potarinau, Sawariwau, Karaudanawa and Eropoimo (also known as Parabara) during the period 22 October – 6 November 2013. The results show how intricately indigenous culture and livelihoods in the southern Rupununi remain linked to the savannahs, wetlands, forests, rivers and the natural environment as a whole, even though the evolution of cultural norms has meant the adoption of western ideals. **Overharvesting and pollution from small-scale gold mining activities represent major threats to the continued security of livelihoods in the southern Rupununi.** Even now local people must travel further from conventional harvesting areas for hunting, fishing, collecting firewood, gathering leaves for housing and obtaining other resources. **There is an urgent need to begin actively managing resources in these areas, and in doing so, the need for community-led approaches is paramount. Effectively supporting communities to achieve this is critical for long-term survival of the Rupununi ecosystem.**

## Introduction

The wider Rupununi savannahs have been occupied for hundreds of years and are today home to and a source of livelihood for some 5,000 indigenous people, who still maintain largely traditional lifestyles (Watkins et al. 2010, Read et al. 2010). The complex relationships which have evolved from this prolonged co-existence with the environment and the defined spiritual beliefs and traditional rules connected to resource use have contributed to the maintenance of biodiversity and natural resources (Borgerhoff-Mulder and Coppolillo 2005). Indigenous Wai-Wai and Wapishana peoples have historically inhabited the Rupununi, an area known for its diverse landscapes and species. Today, they live in several communities within the southern Rupununi, including in the four we surveyed as part of this BAT expedition: Potarinau, Sawariwau, Karaudanawa and Eropoimo (locally referred to as Parabara). The communities depend on the resources found on their village lands as well as those in the surrounding forests, rivers and savannah grasslands to support livelihoods which, for the most part, are based on hunting game, fishing and shifting agriculture.

Assessing natural resource use helps to deconstruct the relationship between indigenous peoples and their environment, and yields valuable insights about the status of the species which are traditionally used, current and potential threats to biodiversity, and how ecosystems are contributing to local food and livelihood security. It can also be useful in informing planning efforts, since interest in the Rupununi for gold mining, petroleum extraction and large-scale agriculture has grown within the past two decades, with improved accessibility via land, air and river. In the past, its relative isolation had protected it from mainstream economic influences. Previous work by David et al. (2006), Conservation International - Guyana (2008), Read et al. (2010), and SCPDA and FPP (2012) with residents of communities in the South Rupununi, found that traditional use (and management) occur across a wide range of habitat types, and include a variety of plants and animals as well as abiotic components of the environment. Our work adds to this body of knowledge and represents the most current or first (in the case of Parabara and Karaudanawa) documentation in these four communities, and in this region of the southern Rupununi savannah. We used a rapid Resource-Use Assessment (RUA) framework formulated by Conservation International-Guyana to examine the relationship of communities with their natural environment. The RUA framework provides insights into critical resources used by the residents of the four target communities, and the factors influencing natural resource use and access. It identifies potentially unsustainable activities and conflicts and is valuable for initiating thinking about potential resource management interventions.

Our study will contribute valuable baseline information to the people of the southern Rupununi, policy makers, NGOs, CBOs and other actors working to promote more responsible use of natural resources.

**THERE IS AN URGENT NEED TO BEGIN ACTIVELY MANAGING RESOURCES IN THESE AREAS, AND IN DOING SO, THE NEED FOR COMMUNITY-LED APPROACHES IS PARAMOUNT. EFFECTIVELY SUPPORTING COMMUNITIES TO ACHIEVE THIS IS CRITICAL FOR LONG-TERM SURVIVAL OF THE RUPUNUNI ECOSYSTEM.**

## Methods and Description of Study Sites

*Methods*

We used a rapid Resource-Use Assessment (RUA) framework, previously implemented in the village of Konashen by CI-Guyana, to examine natural resource use in four indigenous communities within the vicinity of the two study sites – Kusad Mountain and Parabara – in the southern Rupununi savannah region. The RUA was done in Potarinau, Sawariwau, Karaudanawa and Eropoimo (Parabara) during the period 22 October – 6 November 2013 (Table 10.1 and Figure 10.1).

Table 10.1 **Villages participating in RUA workshops during the BAT survey**

| BAT Study-Site | Village | Date of RUA Workshops |
|---|---|---|
| **Kusad Mountain** | Potarinau | 22-24 October 2013 |
| | Sawariwau | 25, 27, 28 October 2013 |
| **Parabara** | Eropoimo (locally called Parabara) | 31 Oct.- 2 Nov. 2013 |
| | Karaudanawa | 4-6 November 2013 |

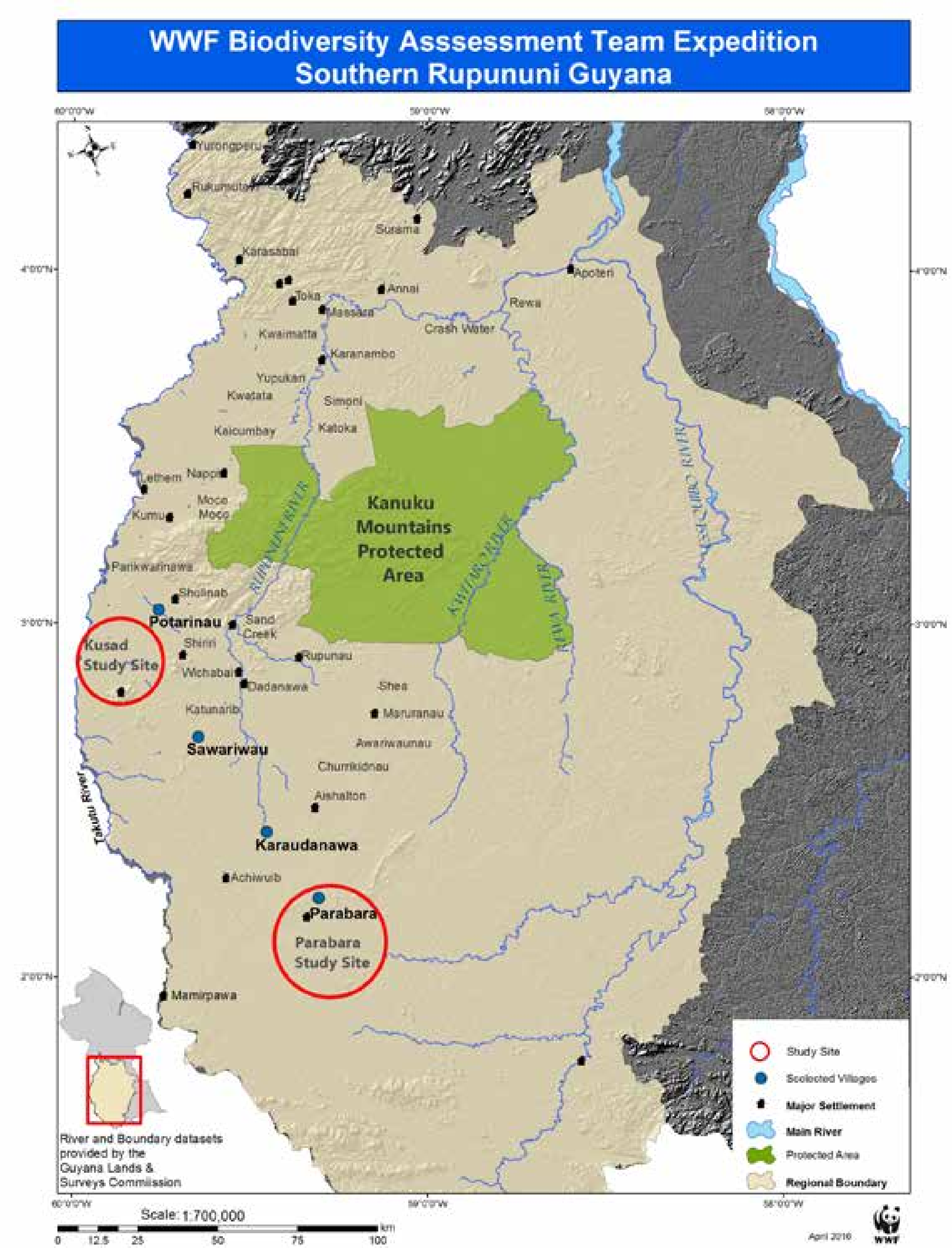


Figure 10.1 **Indigenous communities within the Rupununi savannahs, including the four participating villages at the BAT study sites, in the southern savannah area.**

Taking into account our brief period in the field and the need for a representative number of communities to be surveyed, as well as language barriers (particularly with older residents), we used a subset of the framework's methodology which would allow us to gain the most insight into natural resource use within the shortest time frame. Facilitated focus-group discussions were the main tool used – participants were divided by gender (male, female) and age categories (over 25, under 25/youths). Disaggregating allowed us to gain much deeper insights, since resource type, usage, knowledge and practices may not be homogenous throughout a community. Three major activities were completed, as follows:

1. The groups first **identified and recorded all resources** used, grouping them as important for food, shelter, business, or other. From this list, participants then listed critical resources, categorizing them as: 'scarce', 'overharvested', 'used for business' and 'potential for conflict when used'.

2. Participants discussed their **perceptions and interventions for the management** of these critical resources using the following questions to guide their discussions.

- How would you like to see your resources in fifteen years?
- What would you do if there were no longer any resources?
- What would you do to ensure there are many resources?
- How do you harvest these resources?
- What is the difference now about your resources from when your parents were your age?

3. Participants also discussed the level of **importance of these resources to their traditions and culture.** This activity was done with community members using concentric circles to group and illustrate how important the resources were to them with a decreasing order of importance from the inner-most to the furthest concentric circle.

*Study Sites*

Potarinau, formerly called Ambrose, is a titled village covering located along the Sawariwau Creek. It is a Wapishan village, founded over 70 years ago, with three satellite communities (small settlements located away from the main village), Katu'ur, Baitoon and Shiriri (MIPA 2015). Located south-west of Potarinau is Sawariwau, which is thought to be the oldest Wapishan village in the South Rupununi. Resource-use in Potarinau and Sawariwau is linked with the **Kusad Mountain** study site and its surrounding areas. Kusad provides a source of food, shelter, income and other livelihood needs to about 1,400 individuals in Potarinau and Sawariwau.

Eropoimo and Karaudanawa villages are associated with our second study site – the **Parabara savannahs.** Eropoimo is a small, mixed Wai-Wai and Wapishana settlement comprising individuals who migrated from different communities. The area, first settled around 1969, is not a titled community (MIPA 2015). It became much more recognized following an influx of illegal gold mining activity within surrounding areas in the mid-2000s (MNRE 2013), that involved both Guyanese and Brazilian miners. Rapidly climbing world market gold prices at the time incentivized the increased mining. Mining in the area has now dwindled, with most miners either stopping or relocating to other mine sites in the south Rupununi, such as Marudi and Wakadanawa (K. Husbands, pers. comm., December 2015). North-west of Eropoimo is Karaudanawa, a predominantly Wapishan village. Approximately 1,168 residents from these communities rely on the Parabara savannahs for their livelihoods.

With the exception of Eropoimo, all communities surveyed have secured their land tenure through the process of land titling, undertaken by the state through the Ministry of Indigenous Peoples' Affairs, (previously the Ministry of Amerindian Affairs). Secure tenure has empowered communities to more independently make decisions regarding the use and management of biodiversity, land and other resources within titled boundaries. Its absence can mean that there is no legal recourse against encroachment by outside interests, and can limit effective resource planning by community members.

Natural resource-use by indigenous peoples often extends beyond titled village boundaries into surrounding forests, savannah, and wetlands associated with state lands, as a result of socio-cultural practices. These rights are preserved in two key pieces of legislation - the Amerindian Act 2006 and the Protected Areas Act 2011.

## Results and Discussion

Natural resources found within the South Rupununi savannah are important sources of food, housing and other construction materials, fuel wood, fresh water, income, and medicines for the local indigenous communities associated with our study sties: Kusad Mountain – Potarinau and Sawariwau; and Parabara savannah – Eropoimo and Karaudanawa (Figure 10.2). **Several of these commonly used plants and animals, however, are considered to be 'overharvested' or 'scarce' (Table 10.2) because of growing threats to the area, making conservation efforts in this region a priority.**

SEVERAL OF THESE COMMONLY USED PLANTS AND ANIMALS, HOWEVER, ARE CONSIDERED TO BE 'OVERHARVESTED' OR 'SCARCE' BECAUSE OF GROWING THREATS TO THE AREA, MAKING CONSERVATION EFFORTS IN THIS REGION A PRIORITY

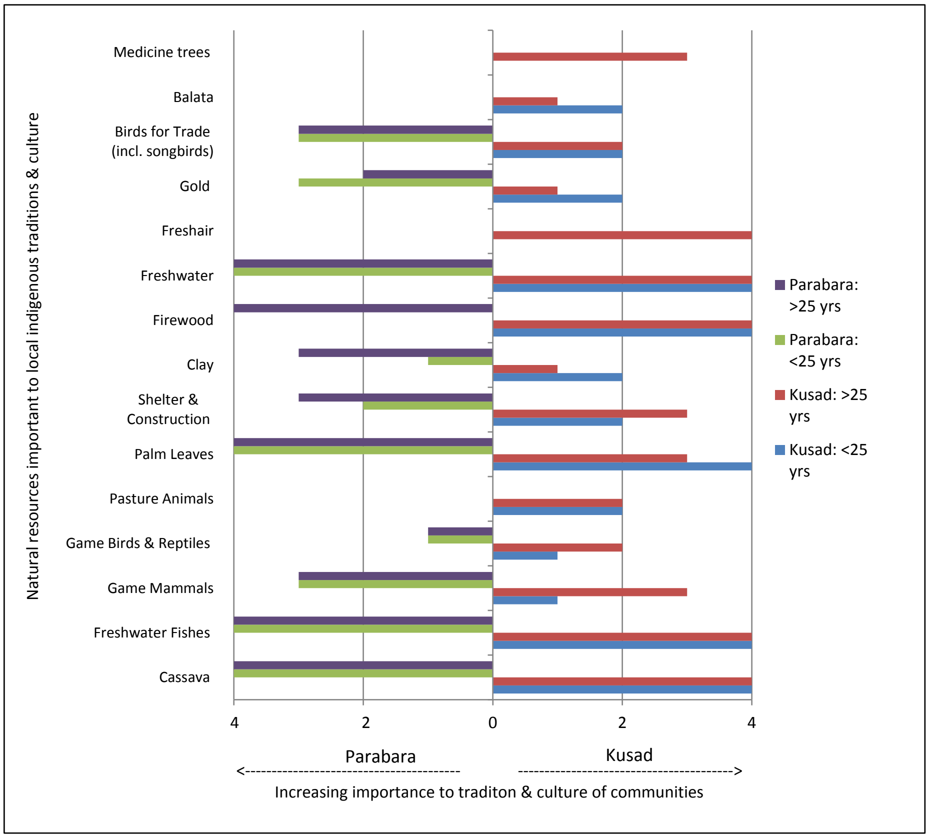


Figure 10.2 **Importance of natural resources to local indigenous culture and traditions – trends among the most commonly identified resources from communities in our two study sites: Kusad and Parabara savannah. (4 = highest levels of cultural/traditional importance).**

Table 10.2 **Resources considered by the communities to be 'scarce' or 'overharvested' in and around the Kusad and Parabara study sites.**

Key: **Pot.**-Potarinau; **Saw.**- Sawariwau; **Ero.**- Eropoimo; **Kar.**-Karaudarnau
* includes species which are likely to be affected, or species of uncertain reference.

| Resources used by indigenous communities and considered scarce and overharvested | | | Kusad Mountains | | Parabara Savannah | |
|---|---|---|---|---|---|---|
| | | | **Pot.** | **Saw.** | **Ero.** | **Kar.** |
| **Mammals** | Armadillo - big and small* | *Dasypus novemcinctus; Dasypus kappleri* | ■ | | ■ | ■ |
| | Deer (bush and savannah) | *Mazama americana; Odocoileus virginianus* | ■ | ■ | | ■ |
| | Labba | *Cuniculus paca* | ■ | ■ | | ■ |
| | Bush cow/Brazilian tapir | *Tapirus terrestris* | ■ | ■ | | ■ |
| | Peccary/Bush hog | *Pecari tajacu; Tayassu pecari* | | ■ | ■ | ■ |
| | Anteater* | *Myrmecophaga tridactyla* | | ■ | | |
| | Spider monkey* | - | | | ■ | |
| | Capybara | *Hydrochoerus hydrochaeris* | | | | ■ |
| **Birds** | Wild ducks (wisi-wisi and Muscovy ducks) | *Dendrocygna autumnalis; Cairina moschata* | ■ | ■ | | ■ |
| | Macaw/Parrots/Toucan* | - | ■ | | | ■ |
| | Towa-towa | *Sporophila angolensis* | ■ | ■ | | ■ |
| | Powis (Black curassow) | *Crax alector* | ■ | ■ | ■ | ■ |
| **Freshwater Fishes** | Arowana | *Osteoglossum bicirrhosum* | ■ | ■ | | ■ |
| | Lukanani | *Cichla* sp. | ■ | | ■ | ■ |
| | Tiger fish | *Pseudoplatystoma fasciatum* | ■ | | | ■ |
| | Haimara | *Hoplias aimara* | | | ■ | ■ |
| | Dawala | *Ageneiosus inermis* | | | | ■ |
| | 'Swordfish'/Mori | *Boulengerella cuvieri* | | | | ■ |
| **Reptiles** | Water and land turtles | *Chelonoidis carbonaria; C. denticulata* | ■ | ■ | | ■ |
| | Iguana | *Iguana iguana* | ■ | ■ | | ■ |
| **Plants** | Balata/Bulletwood | *Manilkara bidentata* | ■ | ■ | | ■ |
| | Kokerite palm | *Attalea maripa* | ■ | | | ■ |
| | Purpleheart | *Peltogyne* sp. | ■ | | | |
| | Turu palm | *Jessenia bataua* | ■ | | ■ | ■ |
| | Redwood | *Centrolobium paraense* | ■ | | | |
| | Ité palm (leaves) | *Mauritia flexuosa* | ■ | ■ | | |
| | Water cedar/White cedar | *Tabebuia insignis* | ■ | | ■ | ■ |
| | Mukuru/Mucru | *Ischnosiphon arouma* | ■ | ■ | | ■ |
| | Medicinal trees* | - | ■ | ■ | | ■ |

FISH DECLINES HAVE BEEN LINKED TO THE USE OF POISONS IN CREEKS, STREAMS, LAKES AND OTHER WATER BODIES; THE CAPTURE OF JUVENILES AND SPAWNING FEMALES; THE USE OF SEINES AND OVERUSE OF FISH TRAPS.

**Food and Health**

Many medium and large-bodied mammals such as labba/'oran' (Paca: *Cuniculus paca)*; bush deer (red brocket deer: *Mazama americana*): savannah deer/'aro' (white-tailed deer: *Odocoileus virginianus*), and bush hog/'bakaru' (collared peccary: *Pecari tajacu*) are hunted for food. These include threatened species like the bush-cow/'kodoi' (Brazilian tapir: *Tapirus terrestris*) and white-lipped peccary/'bakaru' (*Tayassu pecari*). Primates (Family: Cebidae, eaten by some Wai-Wai residents), anteaters (Family: Myrmecophagidae) and sloths (Order: Pilosa) are also hunted. However, these seem to be more common in the diets of the indigenous peoples of Eropoimo and Karaudanawa than in the communities around Kusad, since the latter did not report these as dietary items.

Freshwater fish are a fundamental food item for the indigenous people of the South Rupununi (see Figure 10.2), and more so for those who live closer to freshwater-rich areas. Fishing is done in major and minor water bodies and a variety of fishes are eaten – from small cichlids (hassar and patwa) to larger, predatory species such as lukanani (*Cichla* sp.); arowana (Family: Osteoglossidae); tiger fish (*Pseudoplatystoma fasciatum*) and huri (*Hoplias malabaricus*). Freshwater stingrays (Family: Potamotrygonidae), haimara (*Hoplias aimara*), swordfish (*Boulengerella cuvieri),* dawala (*Ageneiosus inermis*) and basha (*Plagioscion squamosissimus*) are some of the additions enjoyed by communities at the Parabara site. Some species like the haimara, lukanani and arowana have been identified as 'scarce' or 'overharvested' by the communities. **Fish declines have been linked to the use of poisons in creeks, streams, lakes and other water bodies; the capture of juveniles and spawning females; the use of seines and overuse of fish traps. Given the centrality of this resource to culture and livelihoods, it is not surprising that all of the communities are concerned about its status and long-term maintenance.**

Birds, including a variety of parrots, macaws and toucans; wisi-wisi ducks (black-bellied whistling duck: *Dendrocygna autumnalis*); Muscovy ducks/'bai' (*Cairina moschata*) and powis/'pawish' (*Crax alector*), and reptiles such as the green iguana/'sowan' (*Iguana iguana*), tortoises/'wurada' (*Chelonoidis* spp.) and river turtles are also part of local diets. The consumption of caiman, locally called 'alligator', was also reported by residents from each community. Hunting, however, is opportunistic and targets three species of caiman: dwarf (*Paleosuchus palpebrosus*), spectacled (*Caiman crocodilus*) and black (*Melanosuchus niger*) (N. Fredericks, pers. comm., February 2016).

In general, hunting game is done through the application of 'traditional' and some more 'modern' methods and tools. For larger game animals (mammals, reptiles and birds), bows and arrows, guns and hunting dogs are used. Bows are made from 'bow-wood', including bulletwood/wichabai (*Manilkara bidentata)* and letterwood (*Brosium* spp.), and arrows from 'arrow-cane' (I. Johnson, pers. comm., 2015). For added mobility, game hunters pursue prey (e.g. savannah deer) using horses and motorcycles. Fishing methods are just as diverse, and involve the use of arrow and bow, hook and line, seine, fish traps, and long line. The long line is deployed to capture deep water fishes such as the haimara (*Hoplias aimara)*; arrows and bows are used to shoot large species like the lukanani and dawala. Native fish poisons, derived from the leaves, roots and stems of several local plants have also been used (N. Fredericks, pers. comm., February 2016). These poisons have varying degrees of toxicity and are applied to streams, rivers, creeks and other water bodies to stun and kill fish. Their use, however, is not as prevalent today as it was several years ago. **Through the village councils, some communities have established rules to restrict the destructive use of these native poisons in fishing – possibly because of their persistence in slow-moving waters and broad-spectrum toxicity. The implementation and enforcement of community rules, however, is a challenge.** The use of diving guns for fishing was also reported in Karaudanawa by younger residents.

Beef from cattle adds to communities' food supplies. Cattle ranching is done on the savannahs by communities within the southern Rupununi. Herds are owned and managed by individual households or collectively by the village. The practice is small-scale, provides an alternative to game meat, and supplements household incomes (see discussion on business activities below). Large swatches of the savannah are required to sustain the herds, since grassland productivity is generally low. In Sawariwau and Potarinau, where ranching is more pronounced, grasslands are seen as an important resource which supports livelihoods and food security. Conflicts over grasslands do arise, usually when cattle from one community move across the savannah into grazing areas belonging to another community (N. Fredericks, pers. comm., February 2016). Agreements to share grazing areas are usually reached to mitigate conflict. Since cattle were introduced to the Rupununi by European settlers in 1860, ranching slowly became integrated with indigenous farming systems, and today it is one of the distinguishing features of communities in the Rupununi (Watkins et al. 2010, David et al. 2006). It is not surprising therefore that grazing lands are an important resource to the local people.

Local diets include insects as well. In Potarinau and Karaudanawa, larvae of the beetle *Rhynochophorus palmarum*, locally referred to as 'tacoma' or 'ité worm', were identified by older village members and youths (in Karaudanawa) as a source of food. For centuries indigenous peoples in South America have consumed the larvae which provide a source of protein, vitamins A and E, minerals and fat, (Allicock n.d., Cerda et al. 2001). They are 'farmed' by local Wai-Wai and Wapishana peoples. Mature ité (*Mauritia flexuosa*) and kokerite (*Attalea maripa*) trees are felled to provide food for the adult insects. After a few weeks the large larvae are collected and eaten raw or toasted; it is said to be delicious (N. Fredericks, pers. comm., February 2016, David et al. 2006, Allicock n.d., Cerda et al. 2001).

THROUGH THE VILLAGE COUNCILS, SOME COMMUNITIES HAVE ESTABLISHED RULES TO RESTRICT THE DESTRUCTIVE USE OF THESE NATIVE POISONS IN FISHING – POSSIBLY BECAUSE OF THEIR PERSISTENCE IN SLOW-MOVING WATERS AND BROAD-SPECTRUM TOXICITY. THE IMPLEMENTATION AND ENFORCEMENT OF COMMUNITY RULES, HOWEVER, IS A CHALLENGE.



Figure 10.3 **An indigenous family returning home from their farm with cassava which is being carried in a warishi (traditional backpack). Farms are often located in forested mountain foothills, considerable distances from the central village area, or in bush-islands in the savannah.**

Plants, too, play an important role in local food security and maintaining health. Fruits of the ité (*Mauritia flexuosa*), turu (*Jessenia bataua*), kokerite (*Attalea maripa)* and awara (*Astrocaryum vulgare*) palms, as well as bush-cashew (*Anacardium occidentale*) are some favourites – eaten uncooked or processed into drinks. Cultivated crops, like the cassava (*Manihot* sp.) in particular, are central to indigenous farming systems and culture (see Figure 10.2). As a staple, cassava is the primary source of carbohydrates and is grown along with sweet potatoes, peppers, eddoes, yam, sugarcane, pineapple, pumpkin, watermelon, avocado, peppers and citrus fruits in a rotational multi-crop farming system. Many cultivars of cassava are grown on local farms, each being suited for a different purpose (Watkins et al. 2010, Henkel 2004), a reflection of cassava's deep link with indigenous culture. It is consumed in a wide variety of forms – as traditional beverages (piwari, casiri, and parakari), food (farine, tapioca and cassava bread), and as a processed syrup called casareep, which is added to some meat and fish dishes (Figures 10.3 and 10.4).

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Figure 10.4 **Cassava being parched to make farine, one of the many products derived from this starchy root. This is done on an outdoor stove made of clay and using fire wood, the main source of fuel available for households.**

Not surprisingly, cassava has traditional medical applications such as in the treatment of cuts, malaria and skin infections (Watkins et al. 2010, DeFilipps et al. 2004). The leaves, stems, bark and fruits of many other plant species are consumed or made into medicinal preparations to treat a variety of maladies. The dependence on 'medicine trees' shows that indigenous people still value traditional medicine, even though state-supported, 'western' health care exists in communities. Other plants in the South Rupununi with medicinal value include (based on DeFilipps et al. 2004): bush cashew (*Annacardium occidentale)* for

THE CONTINUED ACCESS OF COMMUNITIES TO SUFFICIENT, CLEAN WATER SHOULD BE EXAMINED IN DETAIL BECAUSE OF THE GROWING CONCERN OVER MINING ACTIVITIES WHICH ARE ON-GOING IN PARTS OF THE SOUTH RUPUNUNI. MANY DROUGHT EVENTS WHICH HAVE OCCURRED OVER THE PAST TWO DECADES HAVE COMPOUNDED THE ISSUE.

fever, rashes and as an antiseptic; water/white cedar (*Tabebuia insignis*) bark for malaria and the stem for skin diseases and syphilis; crabwood (*Carapa guianensis*) oil for repelling insects and relieving coughs (see further discussion in (c) below); ité (*Mauritia flexuosa*) for dysentery and diarrhoea; the sandpaper tree (*Curatella americana*) for hepatitis, ulcers and jaundice; 'idin' (*Byrsonima crassifolia*) for rattlesnake bites and as a poultice for wounds and abrasions; bloodwood (*Vismia* spp.) for eczema, skin infections and bush yaws; and greenheart (*Chlorocardium rodiei*) for malarial fever and diarrhoea.

Communities' access to food resources, medicines and other environmental goods and services are improved by the presence of a special component of the savannah ecosystem – bush-islands. Bush-islands are fertile, (compared to savannah grasslands), forested patches in the savannah from which game are hunted and medicinal plants and firewood are gathered. Some households practice farming in the bush-islands as well. Frequent burning of the savannah was identified as the major threat to bush- islands and the services which they provide.

Clean water (and fresh air) are important to livelihoods and culture (see Figure 10.2). Water from rivers, creeks, springs and underground sources, accessed through dug wells, is used for washing, bathing, drinking, cooking, making drinks and other household activities. Households also rely on a ready supply of water for their kitchen gardens and farm animals, such as sheep and poultry. **The continued access of communities to sufficient, clean water should be examined in detail because of the growing concern over mining activities which are on-going in parts of the South Rupununi. Many drought events which have occurred over the past two decades – for example 1997, 1998, 2010, 2014, 2015, have compounded the issue. These have resulted in forest/savannah fires, collapse of crop production, food insecurity, and severely limited access to potable water for household use** (Wahlström and Weber 1998; Chabrol 2014; Marshall 2015; *Stabroek News* 2010).


Figure 10.5 **Palm fronds such as ite (*Mauritia flexuosa)*, kokerite/'pokoridi' (*Attalea maripa)*, and several species of hardwood are traditionally used to build benabs, houses and other dwelling spaces.**

### Shelter and Construction

Several species of palms and timber (along with clay bricks) are used to build houses, benabs, outdoor kitchens and fences (see Figure 10.5). Fronds of the ité (*Mauritia flexuosa*), turu/'mapuza' (*Jessenia bataua*), manicole (*Euterpe oleracea*) and kokerite/'pokoridi' palms (*Attalea maripa)* found in swampy areas of the savannah are woven to make thatched roofs for buildings. Communities at both study sites said that, like cassava, palm leaves are central to their culture and traditions. At the same time, residents also reported that their availability has declined around the more central village areas, and leaves must be collected further and further away from conventional locations. **The fact that harvesting of such a ubiquitously used resource is not actively managed has contributed to the declines observed by communities. The traditional method of climbing the trees to cut leaves is not practiced by all residents; some opt to fell trees with chainsaws in order to get leaves. This impacts on long-term resource availability, as both mature and young stands are affected. Conflicts also arise as villagers move into neighbouring community lands that are closer, to harvest the leaves.** Timber species such as redwood (*Centrolobium paraense),* water/white cedar (*Tabebuia insignis*), silverballi (*Ocotea* spp.), bulletwood ('wichabai'/balata tree; *Manilkara bidentata*), purple-heart (*Peltogyne* sp.), and greenheart (*Chlorocardium rodiei*) are used in the construction of buildings. Communities also depend on a variety of suitable species to fence farmlands; build benabs, farm houses and camps; construct corrals and pens for livestock; make canoes ('boat-wood'/'pite' trees), paddles and foot bridges, and to craft household tools. Many are also sold locally, which contributes to household income (see discussion in (c) below). **The diversity of species used in construction suggests the depth to which the livelihoods of communities remain linked with the savannahs and surrounding habitats.** Similar findings by David et al (2001), report that in the southern Rupununi, 169 species of hardwoods alone are used for canoe-making and other construction activities in communities.

**THE DIVERSITY OF SPECIES USED IN CONSTRUCTION SUGGESTS THE DEPTH TO WHICH THE LIVELIHOODS OF COMMUNITIES REMAIN LINKED WITH THE SAVANNAHS AND SURROUNDING HABITATS**

Clay is another primary raw material utilized in traditional building. It is moulded and fire-baked in pits to make bricks which are then used to construct exterior and interior walls of dwellings. The bricks are extremely durable and, along with the thatched roof, help keep indoor temperatures cool, which is important in these tropical savannah areas. Clay is plastered onto the walls as a finish. Household utensils for cooking and holding water and traditional beverages are made from clay as well.

Utility items needed for everyday activities in local households such as the matapi (cassava strainer), sifters, fans, baskets and warishi (traditional backpacks; see Figure 10.2) are constructed from palm fronds and lianas (Watkins et al. 2010). The mukuru/'mokoro'/mucru (*Ischnosiphon arouma*) vine, found in the surrounding rainforest, and tibisiri fibres from the young ité shoots are commonly used. Some of these household items are sold as craft in village and city shops (see discussion in (c) below).

**Business: Jobs and Income**

Many plants and animals which are utilized for food, shelter and making household items are also directly sold or processed to generate income for community members.


Figure 10.6 **Natural resources generate jobs and income for communities at the Kusad and Parabara study sites. These fall into six major business categories: food, medicine, mining and energy, construction, pet trade and craft. The outer ring lists some of the specific resources that are sold or processed to generate income.**

*Craft and construction*
Young leaves of the ité palm (*Mauritia flexuosa;* see Figure 10.7) are converted to tibisiri fibres (van Andel et al. 2003) and woven by skilled weavers into baskets, mats, bags and various decorative crafts for sale. Arrows and bows, sifters, fans and baskets made from mukuru/mucru 'mokoro' (*Ischnosiphon arouma*) as well as the vines themselves are sold by household and community business enterprises. Nibbi (*Heteropsis* spp.) provides the raw material for basketry and furniture manufacturing (locally or on the coastland). Their aerial roots are flexible and are woven between frames to make furniture (van Andel et al. 2003). It is common to see indigenous crafts on sale in shops around the capital, Georgetown.



Figure 10.7 **Young fronds of the ité palm (*Mauritia flexuosa*) provide raw materials for craft industries in communities. This tree, which grows in swampy savannah areas, is extremely versatile and is a central part of indigenous culture. Its fruits are a source of food and beverages; trunks are used for 'farming' tacoma larvae (*Rhynochophorus palmarum*); fronds provide roofing material.**

THE DECISION TO LIFT THE EXPORT BAN ON THE TOWA-TOWA (*SPOROPHILA ANGOLENSIS*) SHOULD BE RE-EXAMINED URGENTLY, SINCE COMMUNITIES IN BOTH THE KUSAD AND PARABARA AREAS HAVE INDICATED THAT THE STATUS OF THE BIRD IN THE RUPUNUNI IS UNDER THREAT - LISTED AS BOTH A 'SCARCE' AND 'OVERHARVESTED' RESOURCE

Hardwoods, such as silverballi (*Ocotea* spp.), kabukalli (*Goupia glabra*) and water/white cedar (*Tabebuia insignis*), bulletwood/balata tree (*Manilkara bidentata*), redwood (*Centrolobium paraense*), greenheart (*Chlorocardium rodiei*), simarupa (*Quassia simarouba*), purpleheart (*Peltogyne* sp.) and firewood are supplied by communities in response to local demand.

Balata ('iziari'), the milky latex of the bulletwood tree (which is also referred to as the balata tree, *Manilkara bidentata*), is collected and sold either as sap or as utility/craft items such as containers, by residents. Although the industry is small in the South Rupununi (N. Fredericks, pers. comm., February 2016), all of the communities which we surveyed, with the exception of Eropoimo at the Parabara study site, reported the use of balata. At the same time, communities also described the tree as being 'scarce' or 'overharvested', and said that its use sometimes causes conflict among users. Since bulletwood is a valuable timber species, fewer trees could mean that the sap is also becoming more difficult to access – residents of Karaudanawa noted a scarcity of balata.

*Medicine*

Seeds of the crabwood tree (*Carapa guianensis*) are the source of a valuable medicinal oil, locally called crab oil. Its properties give it a range of applications – as a mosquito and general insect repellent; for hair and skin care (also made into soap and creams); for treating coughs, colds, rashes and a number of other maladies (Martinborough 2002,van Andel 2003). Crab oil is offered for sale in shops within communities, as well as in Georgetown, albeit in a limited way. The sale of various medicinal leaves, stems and plant parts contributes to household income as well (see section (a) for a discussion on the medicinal value of plant species).

*Pet trade*

Wildlife trapping for the pet trade provides a source of jobs and income. Wild songbirds, parrots, macaws, toucans and monkeys are most commonly caught for the international and limited local pet trade. The 'Towa-towa' (*Sporophila angolensis*) is the most heavily traded songbird. Locals capture the birds using traps with sticky plant resins (gum), nets and guns. These finches are transported overland and by air to the coast, destined for entry into bird-singing competitions which are popular with coastland residents during weekends. Cash prizes for winners are significant and finches that win many contests fetch a hefty price on the local market – GY$100,000 or circa US$526 (Williams and Watkins 2000). The international trade of Towa-towa has been re-legalised in Guyana. An export ban was lifted to allow for limited international trade; in 2015, the export quota was 200 individuals. (Wildlife Management Authority, Guyana, 2015). However **this decision should be re-examined urgently, since communities in both the Kusad and Parabara areas have indicated that the status of the bird in the Rupununi is under threat - listed as both a 'scarce' and 'overharvested' resource. Conflicts which arise over its use also give an indication of its decline in the savannahs of the southern Rupununi. Smuggling is an issue for the species as well, and occurs partially because of their high monetary value.** In the United States, champion Towa-towa singers are worth as much as US$10,000 (Rueb 2015).

**As the trade persists, these finches may likely experience the same severe declines from overharvesting as its counterpart, *Sporophila crassirostris* or the Twa-twa songbird, whose export from Guyana was also re-legalised** (Wildlife Management Authority, Guyana, 2015). Although there is yet to be a formal survey, **Twa-twa populations have by all accounts declined considerably in the last 20-30 years** (O'Shea, pers. comm. 2015), **having been the preferred species for the songbird trade.** Watkins and Williams (2000) and van Andel (2003) had similarly reported that harvesting for the trade was causing growing concern about songbird decline in other parts of Guyana. **In neighbouring Suriname as well, trapping has almost extirpated Twa-twa populations, and despite ongoing efforts to protect the species, its population is unlikely to recover** (Ottema 2009). The Red Siskin (*Spinus cucullatus*) which is now globally endangered, due to intense, long-term pressure from trapping, was not reported to be part of the trade. **Burning of the savannah destroys critical habitats, including bush islands, and adds to the impact on populations of Towa-towa, Twa-twa and Red Siskins.**

BURNING OF THE SAVANNAH DESTROYS CRITICAL HABITATS, INCLUDING BUSH ISLANDS, AND ADDS TO THE IMPACT ON POPULATIONS OF TOWA-TOWA, TWA-TWA AND RED SISKINS

Psittacines (parrots, parakeets, macaws) and toucans are also part of the wild-bird trade. The Wildlife Management Authority in Guyana authorizes the export of over 20 species based on a quota system. **Residents of Sawariwau, Potarinau, Eropoimo and Karaudanawa have reported an increasing scarcity of these birds and conflicts over user rights – particularly for songbirds.** Overharvesting fuelled by the trade is the primary reason for the declines observed over the years in these communities. Appropriate management interventions which involve local residents should be urgently prioritised and implemented.

Capuchin and spider monkeys (Family: Cebidae) are also captured for the trade, but on a small scale.

*Bush meat and other food*

Freshwater fish, meat from game mammals, reptiles and birds, farine (processed cassava, *Manihot* sp.), and a variety of fruits and other farm produce are sold once there is enough to satisfy the own dietary needs of households. Indigenous communities trade among themselves and with gold miners and others who operate in the Rupununi. Species traded include peccaries/bush-hog (*Pecari tajacu* and *Tayassu pecari*), deer (*Mazama americana* and *Odocoileus virginianus),* labba (*Cuniculus paca*), capybara (*Hydrochoerus hydrochaeris*), tapir/bush-cow (*Tapirus terrestris),* powis (*Crax alector*), iguana (*Iguana iguana)*, tortoises, river turtles and fishes. **Many of these species have been identified as 'scare' or 'overharvested' by the communities. The use of fish poisons in water bodies, the use of seines, targeting juveniles, pregnant/gravid females, females with young and the increased use of guns and dogs by hunters were commonly perceived as the reason for fewer animals being available.** At the same time however, hunting is becoming more opportunistic in nature – residents may shoot peccaries and deer found raiding farm areas – and there are fewer targeted hunts. Hunting pressure could be contributing to some animals moving away from commonly accessed areas.

*Mining and energy*

Gold provides income for households in each of the communities we surveyed, through direct or indirect (such as the provision of goods and services) employment in the mining industry. The mining activities are largely small-scale and concentrated in the Marudi Mountain area (located just south-east of our study sites), and, to a lesser extent now, in Parabara. Mining is done using both mechanized methods which involve land dredges and other heavy machinery, and what communities consider more 'manual' methods which still include some degree of mechanization. **Although it provides income, gold mining activities often lead to contamination of freshwater and severe environmental degradation, which negatively affects the health and livelihoods of local people**. The impacts are already being felt, as participants from Karaudanawa were deeply concerned about the effects of gold mining on the resources of the entire southern Rupununi. Illegal mining and weak enforcement are major challenges to proper regulation of the industry. **It is important to note here that a license for a large mining operation was granted for the Marudi Mountain area.**

Firewood, which is the major source of energy for households, and charcoal are part of local commerce as well. A variety of trees are used and sourced from areas near homes such as the savannah, forest edge and bush islands, either by felling trees or collecting fallen material.

ALTHOUGH IT PROVIDES INCOME, GOLD MINING ACTIVITIES OFTEN LEAD TO CONTAMINATION OF FRESHWATER AND SEVERE ENVIRONMENTAL DEGRADATION, WHICH NEGATIVELY AFFECTS THE HEALTH AND LIVELIHOODS OF LOCAL PEOPLE. THE IMPACTS ARE ALREADY BEING FELT, AS PARTICIPANTS FROM KARAUDANAWA WERE DEEPLY CONCERNED ABOUT THE EFFECTS OF GOLD MINING ON THE RESOURCES OF THE ENTIRE SOUTHERN RUPUNUNI.

## Communities' recommendations for management interventions

The pressures on the savannah are growing. Already, there is consensus from residents that resource availability has declined compared to their parents' generation, or in their words that there are: 'fewer tortoises', 'less fish', 'armadillo and deer are scarcer', 'many resources were found close to our villages, today people must travel very far to get these'. There are a number of factors which account for these declines including: (i) overharvesting driven by growing external demands and greater access to previously isolated areas; (ii) burning of savannah grasslands more frequently; (iii) environmental degradation from small-scale gold mining; and (iv) cultural evolution and weak governance. Freshwater availability and climate-change are also major concerns.

The vision of the communities regarding the status of natural resources within the coming years relates to improving the status of biodiversity, especially critical resources, and securing their culture and livelihoods for future generations (see Figure 10.8). Communities acknowledge the need for stronger conservation-oriented management which incorporates traditional knowledge and customary laws, greater education and awareness about resources and improved governance, in order to ensure that ecosystems and species continue to provide services for the benefit of future generations.

| | |
|---|---|
| **Better practices** | • Rotate crops and farmlands<br>• Stop using poisons and seines<br>• Knowing how to better use resources like fish<br>• Have protected areas and conservation parks<br>• Savannah and forest burning stopped |
| **Caring for the land** | • Careful and vibrant management practised<br>• Management plan including customary laws; wise use of resources<br>• Follow village rules; education and training on resource management<br>• We must work cooperatively towards wildlife and forest conservation |
| **More resources for coming generations** | • Game animals multiplying, more deer and armadillo, more powis and labba for coming generations<br>• Critical plants and animals available for future generations<br>• Animals must be protected so they can reproduce<br>• More firewood near our homes |
| **Consuming more wisely** | • Reduce bird trapping and reduce hunting<br>• Ité palms no longer cut<br>• Reduce logging<br>• Stop killing young ones, pregnant ones or many animals at a time |

Figure 10.8 **A snapshot of the vision and ideas of indigenous communities for managing resources in the South Rupununi savannahs.**

## Conservation Recommendations and Conclusions

Protecting the resources of the southern Rupununi in a way which allows local indigenous people to sustain their way of life, protect their rights and to lead their own development is key to ensuring that landscapes, ecosystems and the livelihoods of communities remain resilient well into the future. Conservation recommendations for natural resources based on the desires of the communities and our observations are as follows:

(1) Share the results of this assessment with Village Councils so that they can use it to formulate or strengthen village rules pertaining to biodiversity and environmental management.

(2) Empower communities to develop and implement their natural resource use management plans – the Wapishan people of the South Rupununi have begun a process of planning to protect the land and natural resources which they use (*Thinking Together for Those Coming Behind Us – An outline plan for the care of the Wapishan territory in Guyana*, David et al. 2012). Building on this plan with the information provided by communities during our survey would likely achieve positive outcomes. All communities communicated their desire to see resources 'increasing' or 'multiplying' within the coming decade.

(3) Monitor hunting rates and factors which drive overharvesting.

(4) Promote environmentally responsible business initiatives as alternatives to gold mining and wildlife trading, and promote the use of alternative sources of protein to reduce hunting pressure on critical species.

(5) Effectively regulate and monitor gold mining activities so that these have minimal impacts on streams and rivers. Gold mining activities should not expand into vulnerable areas within the Rupununi.

(6) Discourage the poisoning of streams as a method of fishing, and the excessive burning of savannah grasslands (which causes loss of food, medicinal trees, firewood, loss of animal fodder and increased conflict over grazing lands and reduction of income flows).

(7) Expand non-timber forest product development and access to markets.

(8) Encourage the development of environmental clubs as an asset to communities to assist in awareness and education among youths.

The data gleaned on natural resource usage by local communities will be found in Appendix 10.

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**Appendix 1**

**Plant species documented during the South Rupununi savannah and Parabara region 2013 BAT survey**

**Key**

**(W)** = Wapishana names

*** Column** = Arawak and common names as supplied by Mr Issac Johnson, tree spotter.

**** Column** = Common / Wapishana names follow the *Check-list of woody plants of Guyana,* The Tropenbos Foundation,1988, hereby acknowledged.

**N.B.** Due to various difficulties encountered in the field, some specimens deteriorated and could only be identified as different morphospecies, but not up to genus or species level. These have been allocated a genus and species number unique to this 2013 expedition report. Specimens were deposited at the herbarium of the University of Guyana, as well as being prepared for deposit at the National Herbarium of the Netherlands, Naturalis Biodiversity Centre.

| Family | Genus | Species | **Common names/ Wapishana names | *Arawak and local names also used in other regions of Guyana | Kusad-savannah | Kusad River-gallery forest | Kusad Mountain-rocky outcrop | Parabara-bush | Parabara-gallery forest | Parabara-savannah | Parabara-bush island |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Anacard/ Meliaceae | Spec. 60 | sp. 103 | | - | | | | | x | | |
| Anacardiaceae | *Anacardium* | sp. 87 | | - | | | | | | | x |
| Anacardiaceae | *Anacardium* | *giganteum* | Wild cashew; Kawarui (W) | Ubudi | | | | | x | | |
| Anacardiaceae | *Loxopterygium* | *sagotii* | Aupar (W) | Hububalli | | | | | x | | |
| Anacardiaceae | *Spondias* | *mombin* | Hog plum; Rup (W) | Plum tree | | | x | | | | |
| Annonaceae | *Annona* | sp. 63 | | - | | | x | | | | |
| Annonaceae | *Annona* | *sericea* | | Koyechi | | | | | x | | |
| Annonaceae | *Annona* | *exsucca* | | Koyechi | | | | | x | | |
| Annonaceae | *Xylopia* | *amazonica* | | Saintia | | | | x | | | |
| Apocynaceae | *Ambelania* | sp. 91 | | Makoriro | | | | | | | x |
| Apocynaceae | *Aspidosperma* | sp. 212 | | Yarula | | | | | x | | |
| Apocynaceae | Spec. 35 | sp. 54 | | - | | x | | | | | |
| Apocynaceae | Spec. 89 | sp. 178 | | - | | | | | x | | |
| Apocynaceae | Spec. 95 | sp. 194 | | Kakarua | | | | | x | | |
| Arecaceae | *Attalea* | sp. 172 | | Kokorite | | | | | x | | |
| Arecaceae | *Euterpe* | sp. 125 | | Manicole palm | | | | x | | | |
| Asteraceae | Spec. 1 | sp. 1 | | - | x | | | | | | |
| Bignoniaceae | *Jacaranda* | sp. 52 | | - | | x | | | | | |
| Bignoniaceae | *Mansoa* | *alliacea* | Garlic rope | Wild garlic | | | x | | | | |
| Bignoniaceae | Spec. 22 | sp. 31 | | - | *x* | | | | | | |
| Bombacaceae | Spec. 41 | sp. 66 | | Savannah green heart | | | x | | | | |
| Bombaceae | Spec. 46 | sp. 72 | | - | | | x | | | | |
| Boraginaceae | *Cordia* | *nodosa* | Ants tree | Ant's Tree | | | | | | | x |
| Burseraceae | *Protium* | sp. 86 | | Haiawa | | | | | | | x |
| Burseraceae | *Protium* | sp. 174 | | Haiawa | | | | | x | | |
| Burseraceae | *Protium* | sp. 185 | | Kurokai | | | | | x | | |
| Burseraceae | *Protium* | *tenuifolium* | | Haiawaballi | | | | | x | | |

| Family | Genus | Species | **Common names/ Wapishana names | *Arawak and local names also used in other regions of Guyana | Kusad-savannah | Kusad River-gallery forest | Kusad Mountain-rocky outcrop | Parabara-bush | Parabara-gallery forest | Parabara-savannah | Parabara-bush island |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Burseraceae | Spec. 40 | sp. 62 | | Laridan/Glass tree | | | x | | | | |
| Celastraceae | *Hippocratea* | sp. 201 | | - | | | | | x | | |
| Chrysobalanaceae | *Hirtella* | sp. 98 | | Fat Pork | | | | | | | x |
| Chrysobalanaceae | *Licania* | sp. 41 | | Kauta | | x | | | | | |
| Chrysobalanaceae | *Licania* | sp. 82 | | Burada | | | | | | | x |
| Chrysobalanaceae | *Licania* | *micrantha* | Farsha | Marishiballi | | | | x | | | |
| Chrysobalanaceae | *Licania* | sp. 207 | | Smoothskin kauta | | | | | x | | |
| Chrysobalanaceae | *Licania* | sp. 217 | | Marishiballi | | | | | x | | |
| Clusiaceae | *Rheedia* | sp. 121 | | Asashi | | | | | x | | |
| Combretaceae | *Terminalia* | sp. 112 | | Coffee mortar | | | | | x | | |
| Cyperaceae | *Bulbostylis* | *paradoxa* | | - | x | | | | | | |
| Cyperaceae | *Scleria?* | sp. 171 | | - | | | | | | x | |
| Cyperaceae | Spec. 21 | sp. 30 | | - | x | | | | | | |
| Dichapetalaceae | *Tapura* | *guianensis* | | Waiaballi | | | | | x | | |
| Dilleniaceae | *Curatella* | *americana* | Sandpaper tree; Iminyar (W) | - | x | | | | | | |
| Elaeocarpaceae | *Sloanea* | sp. 56 | | - | | x | | | | | |
| Euphorbiaceae | *Chaetocarpus* | sp. 65 | | Wine tree | | | x | | | | |
| Euphorbiaceae | *Croton* | sp.189 | | - | | | | | x | | |
| Euphorbiaceae | *Maprounea* | *guianensis* | | Awati | | | | | | | x |
| Euphorbiaceae | *Sapium* | sp. 141 | | Haiahaia | | | | x | | | |
| Euphorbiaceae | *Croton?* | sp. 142 | | Maho | | | | x | | | |
| Fabaceae | *Bauhinia* | *ungulata*? | | - | | | | | x | | |
| Fabaceae | *Cassia* | sp. 89 | | Warua | | | | | | | x |
| Fabaceae | *Chamaecrista* | *rotundifolia* | | - | x | | | | | | |
| Fabaceae | *Cynometra* | *bauhiniifolia* | Sakaballi (Ar) | - | | x | | | | | |
| Fabaceae | *Desmodium* | sp. 25 | | - | x | | | | | | |
| Fabaceae | *Dialium* | *guianense* | Ironwood | Locust | | | | | x | | |

**Plant species documented during the South Rupununi savannah and Parabara region 2013 BAT survey (*cont'd*)**

| Family | Genus | Species | **Common names/ Wapishana names | *Arawak and local names also used in other regions of Guyana | Kusad-savannah | Kusad River-gallery forest | Kusad Mountain-rocky outcrop | Parabara-bush | Parabara-gallery forest | Parabara-savannah | Parabara-bush island |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Fabaceae | *Inga* | sp. 43 | | Whitey | | x | | | | | |
| Fabaceae | *Inga* | sp. 57 | | Whitey | | | x | | | | |
| Fabaceae | *Inga* | sp. 123 | | Inga | | | | x | | | |
| Fabaceae | *Inga* | sp. 180 | | Inga | | | | | x | | |
| Fabaceae | *Macrolobium* | *acaciifolium* | Sirkir (W) | - | | x | | | | | |
| Fabaceae | *Macrolobium/ Hymenea?* | sp. 135 | | Locust | | | | x | | | |
| Fabaceae | *Neptunia* | *plena* | | Shamebush | x | | | | | | |
| Fabaceae | *Parkia* | *nitida* | | Black manariballi | | | | x | | | |
| Fabaceae | *Pithecellobium* | *collinum* | | Uriridan | | | | x | | | |
| Fabaceae | Spec. 3 | sp. 3 | | | x | | | | | | |
| Fabaceae | Spec. 4 | sp. 4 | | - | x | | | | | | |
| Fabaceae | Spec. 30 | sp. 40 | | - | | x | | | | | |
| Fabaceae | Spec. 34 | sp. 50 | | - | | x | | | | | |
| Fabaceae | Spec. 36 | sp. 58 | | Bush parika | | | x | | | | |
| Fabaceae | Spec. 45 | sp. 71 | | - | | | x | | | | |
| Fabaceae | Spec. 47 | sp. 75 | | - | | | x | | | | |
| Fabaceae | Spec. 48 | sp. 76 | | Wizawara | | | x | | | | |
| Fabaceae | Spec. 49 | sp. 78 | | Wild tamarind | | | x | | | | |
| Fabaceae | Spec. 55 | sp. 90 | | Kokowizi | | | | | | | x |
| Fabaceae | Spec. 57 | sp. 93 | | Huruasa/ Soapwood | | | | | | | x |
| Fabaceae | Spec. 69 | sp. 118 | | Kokowizi | | | | | x | | |
| Fabaceae | Spec. 96 | sp. 195 | | Iron Mary | | | | | x | | |
| Fabaceae | Spec. 97 | sp. 196 | | - | | | | | x | | |
| Fabaceae/ Sapindaceae | Spec. 109 | sp. 129 | | Sweetheart | | | | x | | | |
| Fabaceae | *Swartzia* | sp. 83 | | - | | | | | | | x |
| Fabaceae | *Swartzia* | sp. 126 | | Itikiboroballi | | | | x | | | |
| Fabaceae | *Swartzia* | sp. 181 | | Itikiboroballi | | | | | x | | |
| Fabaceae | *Swartzia* | Sp. 193 | | Koraro | | | | | x | | |

| Family | Genus | Species | **Common names/ Wapishana names | *Arawak and local names also used in other regions of Guyana | Kusad-savannah | Kusad River-gallery forest | Kusad Mountain-rocky outcrop | Parabara-bush | Parabara-gallery forest | Parabara-savannah | Parabara-bush island |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Fabaceae | Unknown | sp. 147 | | - | | | | x | | | |
| Fabaceae | Unknown | sp. 223 | | Kaditiri | | | | x | | | |
| Fabaceae | *Zygia* | *cauliflora* | | Alikyu | | | x | | | | |
| Flacourtiaceae/ Sapindaceae | Spec. 77 | sp. 149 | | - | | | | x | | | |
| Gentianaceae | *Coutoubea* | *spicata* | | - | | | | | | x | |
| Gentianaceae | *Schultesia* | *benthamiana* | | - | x | | | | | | |
| Gentianaceae | *Tetrapollinia* | *caerulescens* | | - | | | | | | x | |
| Goupiaceae | *Goupia* | *glabra* | Stinkwood | Kabukalli | | | | | | | x |
| Heliconiaceae | *Heliconia* | *psittacorum* | | - | x | | | | | | |
| Hypericaceae | *Vismia* | sp. 99 | | Bloodwood | | | | | | | x |
| Lamiaceae | *Amasonia* | *campestris* | | - | | | | | | x | |
| Lamiaceae | *Vitex?* | sp. 64 | | Prickly red cedar | | | x | | | | |
| Lamiaceae | *Vitex* | *compressa* | | Hakiaballi | | x | | | | | |
| Lamiaceae | *Vitex* | *stahellii* | | Hakiaballi | | | | x | | | |
| Lauraceae | *Aniba* | sp. 85 | | Ginger gale | | | | | | | x |
| Lauraceae | *Aniba* | sp. 95 | | Silverballi | | | | | | | x |
| Lauraceae | *Aniba* | *excelsa* | | Greenheart gale | | | | x | | | |
| Lauraceae | *Ocotea* | sp. 105 | | Koreti/Silverballi | | | | | x | | |
| Lecithidaceae | *Gustavia* | sp. 73 | | Lanaballi | | | x | | | | |
| Lecithidaceae | Spec. 37 | sp. 59 | | Kakaralli | | | x | | | | |
| Lecythidaceae | *Eschweilera* | sp. 120 | | Kakaralli | | | | | x | | |
| Lecythidaceae | *Eschweilera* | sp. 187 | | Black Kakaralli | | | | | x | | |
| Lecythidaceae | *Lecythis* | *corrugata* | | Wina | | | | | x | | |
| Loganiaceae | *Spigelia* | sp. 221 | | - | | | | | | x | |
| Lygodiaceae | *Lygodium* | *volubile* | | Rankbush | x | | | | | | |
| Lythraceae | *Cuphea* | sp. 10 | | - | x | | | | | | |
| Malpighiaceae | *Byrsonima* | *verbascifolia* | | - | x | | | | | | |
| Malpighiaceae | *Byrsonima* | sp. 163 | | - | | | | | | x | |

**Plant species documented during the South Rupununi savannah and Parabara region 2013 BAT survey (*cont'd*)**

| Family | Genus | Species | **Common names/ Wapishana names | *Arawak and local names also used in other regions of Guyana | Kusad-savannah | Kusad River-gallery forest | Kusad Mountain-rocky outcrop | Parabara-bush | Parabara-gallery forest | Parabara-savannah | Parabara-bush island |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Malpigiaceae | Spec. 26 | sp. 36 | | - | x | | | | | | |
| Malpighiaceae | Spec. 106 | sp. 214 | | Swizzle stick | | | | | x | | |
| Malvaceae | *Catostemma* | *fragrans* | Baramanni; Koron (W) | Sand baromalli/Simana | | | | | | | x |
| Malvaceae | *Catostemma* | sp. 128 | | Baromalli | | | | x | | | |
| Malvaceae | *Guazuma* | *ulmifolia* | Wonam (W) | - | | | x | | | | |
| Malvaceae | *Pachira?* | sp. 137 | | Wild cocoa | | | | x | | | |
| Marcgraviaceae | *Schwartzia?* | sp. 150 | | - | | | | x | | | |
| Melastomataceae | *Miconia* | sp. 23 | | Waraia | x | | | | | | |
| Melastomataceae | *Miconia* | sp. 96 | | - | | | | | | | x |
| Melastomataceae | *Mouriri* | sp. 94 | | Kokoritiballi | | | | | | | x |
| Melastomataceae | *Mouriri* | sp. 197 | | Mamuriballi | | | | | x | | |
| Melastomataceae | *Tibouchina* | sp. 156 | | - | | | | | | x | |
| Melastomataceae | *Tibouchina* | Sp. 161 | | - | | | | | | x | |
| Melastomataceae | *Tibouchina* | Sp. 164 | | - | | | | | | x | |
| Melastomataceae | *Tibouchina* | Sp. 220 | | - | | | | | | x | |
| Meliaceae | *Guarea* | Sp. 74 | | Kufiballi | | | x | | | | |
| Meliaceae | *Guarea* | *pubescens* subsp. *pubescens* | | Kufiballi | | | | x | | | |
| Meliaceae | Spec. 108 | sp. 219 | | Aiomorakushi | | | | | x | | |
| Moraceae | *Brosimum* | sp. 48 | | Bastard Letterwood | | x | | | | | |
| Moraceae | *Cecropia* | sp. 104 | | Congo pump | | | | | x | | |
| Moraceae/ Euphorbiaceae | Spec. 29 | sp. 39 | | - | | x | | | | | |
| Moraceae | Spec. 59 | sp. 102 | | | | | | | x | | |
| Moraceae | Spec. 110 | sp. 139 | | | | | | | | | x |
| Moraceae | Unknown | sp. 186 | | - | | | | | x | | |
| Myristicaceae | Spec. 61 | sp. 106 | | Kurokai | | | | | x | | |
| Myristicaceae | Unknown | sp. 206 | | Kamahora | | | | | x | | |
| Myristicaceae | *Virola* | *michelli* | Irikwa (W) | Dalli | | | | x | x | | |

| Family | Genus | Species | **Common names/ Wapishana names | *Arawak and local names also used in other regions of Guyana | Kusad-savannah | Kusad River-gallery forest | Kusad Mountain-rocky outcrop | Parabara-bush | Parabara-gallery forest | Parabara-savannah | Parabara-bush island |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Myristicaceae | *Virola* | sp. 205 | | Hall Dalli | | | | | x | | |
| Myrtaceae | *Marlierea* | sp. 108 | | Kwako | | | | | x | | |
| Myrtaceae | *Calycolpus* | *goetheanus* | Kosararada (W) | Wild Guava | x | | x | | | | |
| Myrtaceae | *Marlierea* | sp. 188 | | Kwako | | | | | x | | |
| Myrtaceae | *Myrcia* | sp. 53 | | - | | x | | | | | |
| Nyctaginaceae | *Neea* | sp. 55 | | Mamudan | | x | | | | | |
| Ochnaceae | *Ouratea* | sp. 97 | | - | | | | | | | x |
| Olacaceae | Spec. 70 | sp. 119 | | - | | | | | x | | |
| Orchidaceae | *Epistephium* | sp. 158 | | - | | | | | | x | |
| Passifloraceae | *Passiflora* | sp. 12 | | Baby simitu | x | | | | | | |
| Poaceae | *Andropogon* | *bicornis* | | Horse tail | x | | | | | | |
| Poaceae | *Andropogon* | sp. 32 | | - | x | | | | | | |
| Poaceae | *Aristida* | sp. 24 | | - | x | | | | | | |
| Poaceae | *Panicum* | *bergii* | | - | x | | | | | | |
| Poaceae | Spec. 23 | sp. 33 | | - | x | | | | | | |
| Poaceae | Spec. 24 | sp. 34 | | - | x | | | | | | |
| Polygalaceae | *Polygala* | sp. 166 | | - | | | | | | x | |
| Polygalaceae | *Polygala* | sp. 167 | | - | | | | | | x | |
| Polygonaceae | *Coccoloba* | sp. 42 | | Matora | | x | | | | | |
| Polygonaceae | *Coccoloba* | sp. 101 | | Mabra | | | | | x | | |
| Polygonaceae | Spec. 94 | sp. 192 | | Matora | | | | | x | | |
| Polygonaceae | *Triplaris* | *weigeltiana* | | Long John | | | x | | | | |
| Quiinaceae | Spec. 78 | sp. 152 | | - | | | | x | | | |
| Quiinaceae | Spec. 91 | sp. 183 | | - | | | | | x | | |
| Rhamnaceae | Spec. 71 | sp. 122 | | Wild dunks | | | | | x | | |
| Rubiaceae | *Borreria* | sp. 29 | | Waraia | x | | | | | | |
| Rubiaceae | *Duroia* | *eriopila* | | Komaramara | | | | | x | | x |
| Rubiaceae | *Genipa* | sp. 45 | | Lana | | x | | | | | |

**Plant species documented during the South Rupununi savannah and Parabara region 2013 BAT survey (*cont'd*)**

| Family | Genus | Species | **Common names/ Wapishana names | *Arawak and local names also used in other regions of Guyana | Kusad-savannah | Kusad River-gallery forest | Kusad Mountain-rocky outcrop | Parabara-bush | Parabara-gallery forest | Parabara-savannah | Parabara-bush island |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Rubiaceae | *Palicourea* | *rigida* | | - | | | | | | x | |
| Rubiaceae | Spec. 19 | sp. 26 | | - | x | | | | | | |
| Rubiaceae | Spec. 27 | sp. 37 | | Kamadan | x | | | | | | |
| Rubiaceae | Spec. 58 | sp. 100 | | - | | | | | | | x |
| Rubiaceae | Spec. 81 | sp. 155 | | - | | | | | | x | |
| Rubiaceae | Unknown | sp. 144 | | - | | | | | x | | |
| Salicaceae | *Cassiaria* | sp. 28 | | - | x | | | | | | |
| Salicaceae | *Casearia* | sp. 51 | | - | | x | | | | | |
| Salicaceae | *Xylosma* | *tessmannii* | | - | | x | | | | | |
| Salicaceae | *Casearia?* | sp. 117 | | Taparau | | | | | x | | |
| Sapindaceae | *Cupania* | sp. 175 | | Kufiballi | | | | | x | | |
| Sapindaceae | *Matayba* | sp. 143 | | Kulishiri | | | | x | | | |
| Sapindaceae | *Matayba* | sp. 145 | | - | | | | x | | | |
| Sapindaceae | *Matayba* | *macrostylis* | | Kulishiri | | | | | x | | |
| Sapindaceae | Spec. 39 | sp. 61 | | Wild Genip | | | x | | | | |
| Sapindaceae | Spec. 62 | sp. 107 | | - | | | | | x | | |
| Sapindaceae | *Talisia* | sp. 114 | | Sweetheart tree | | | | | x | | |
| Sapotaceae | *Ecclinusa* | *sanguinolenta* | | Bartaballi | | | | | x | | |
| Sapotaceae | *Manilkara* | *bidentata* | | Bulletwood | | | | | x | | |
| Sapotaceae | *Pouteria* | sp. 70 | | - | | | x | | | | |
| Sapotaceae | *Pouteria* | sp. 124 | | Kamahora | | | | x | | | |
| Sapotaceae | *Pouteria* | sp. 127 | | Kokoritiballi | | | | x | | | |
| Sapotaceae | *Pouteria* | sp. 173 | | Kamahora | | | | | x | | |
| Sapotaceae | *Pouteria* | *reticulata* | | Kokoritiballi | | | | | x | | |
| Sapotaceae | *Pouteria* | sp. 216 | | Aiomorakushi | | | | | x | | |
| Simaroubaceae | *Simarouba* | *amara* | | Simarupa | | | | | x | | |
| Siparunaceae | *Siparuna* | *guianensis* | Fever bush | Muniridan | | | | | x | | |
| Tiliaceae | *Apeiba* | *echinata/aspera* | Romemand (W) | Duru | | x | | | | | |

| Family | Genus | Species | **Common names/ Wapishana names | *Arawak and local names also used in other regions of Guyana | Kusad-savannah | Kusad River-gallery forest | Kusad Mountain-rocky outcrop | Parabara-bush | Parabara-gallery forest | Parabara-savannah | Parabara-bush island |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Unknown 1 | Spec. 2 | sp. 2 | | - | x | | | | | | |
| Unknown 2 | Spec. 5 | sp. 5 | | - | x | | | | | | |
| Unknown 3 | Spec. 6 | sp. 6 | | - | x | | | | | | |
| Unknown 4 | Spec. 7 | sp. 7 | | - | x | | | | | | |
| Unknown 5 | Spec. 8 | sp. 8 | | - | x | | | | | | |
| Unknown 6 | Spec. 9 | sp. 9 | | - | x | | | | | | |
| Unknown 7 | Spec. 10 | sp. 13 | | - | x | | | | | | |
| Unknown 8 | Spec. 11 | sp. 14 | | - | x | | | | | | |
| Unknown 9 | Spec. 12 | sp 15 | | - | x | | | | | | |
| Unknown 10 | Spec. 13 | sp. 16 | | - | x | | | | | | |
| Unknown 11 | Spec. 14 | sp. 17 | | - | x | | | | | | |
| Unknown 12 | Unknown | sp. 18 | | - | x | | | | | | |
| Unknown 13 | Spec. 15 | sp. 19 | | - | x | | | | | | |
| Unknown 14 | Spec. 16 | sp. 20 | | - | x | | | | | | |
| Unknown 15 | Spec. 17 | sp. 21 | | - | x | | | | | | |
| Unknown 16 | Spec. 18 | sp. 22 | | - | x | | | | | | |
| Unknown 17 | Spec. 20 | sp. 27 | | - | x | | | | | | |
| Unknown 18 | Spec. 25 | sp. 35 | | - | x | | | | | | |
| Unknown 19 | Spec. 28 | sp. 38 | | - | x | | | | | | |
| Unknown 20 | Spec. 31 | sp. 44 | | - | | x | | | | | |
| Unknown 21 | Spec. 32 | sp. 47 | | - | | x | | | | | |
| Unknown 22 | Spec. 33 | sp. 49 | | Bastard purpleheart | | x | | | | | |
| Unknown 23 | Spec. 38 | sp. 60 | | - | | | x | | | | |
| Unknown 24 | Spec. 42 | sp. 67 | | Redwood | | | x | | | | |
| Unknown 25 | Spec. 43 | sp. 68 | | Freijo | | | x | | | | |
| Unknown 26 | Spec. 44 | sp. 69 | | Riariadan | | | x | | | | |
| Unknown 27 | Spec. 50 | sp. 79 | | - | | | x | | | | |
| Unknown 28 | Spec. 51 | sp. 80 | | - | | | x | | | | |

**Plant species documented during the South Rupununi savannah and Parabara region 2013 BAT survey (*cont'd*)**

| Family | Genus | Species | **Common names/ Wapishana names | *Arawak and local names also used in other regions of Guyana | Kusad-savannah | Kusad River-gallery forest | Kusad Mountain-rocky outcrop | Parabara-bush | Parabara-gallery forest | Parabara-savannah | Parabara-bush island |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Unknown 29 | Spec. 52 | sp. 81 | | Kokorite | | | | | | | x |
| Unknown 30 | Spec. 53 | sp. 84 | | Mabwa | | | | | | | x |
| Unknown 31 | Spec. 54 | sp. 88 | | | | | | | | | x |
| Unknown 32 | Spec. 56 | sp. 92 | | Devil's ear | | | | | | | x |
| Unknown 33 | Spec. 63 | sp. 109 | | - | | | | | x | | |
| Unknown 34 | Spec. 64 | sp. 110 | | Haiawaballi | | | | | x | | |
| Unknown 35 | Spec. 65 | sp. 111 | | - | | | | | x | | |
| Unknown 36 | Spec. 66 | sp. 113 | | - | | | | | x | | |
| Unknown 37 | Spec. 67 | sp. 115 | | - | | | | | x | | |
| Unknown 38 | Spec. 68 | sp. 116 | | - | | | | | x | | |
| Unknown 39 | Spec. 1 | sp. 136 | | - | | | | x | | | |
| Unknown 40 | Spec. 72 | sp. 130 | | Duru | | | | x | | | |
| Unknown 41 | Spec. 73 | sp. 131 | | Kereti Silverballi | | | | x | | | |
| Unknown 42 | Spec. 74 | sp. 132 | | Wina kakaralli | | | | x | | | |
| Unknown 43 | Spec. 75 | sp. 133 | | Kokorite | | | | x | | | |
| Unknown 44 | Spec. 76 | sp. 134 | | Waiaballi | | | | x | | | |
| Unknown 45 | Spec. 3 | sp. 138 | | Swizzle stick | | | | x | | | |
| Unknown 46 | Spec. 4 | sp. 140 | | Sand trysil | | | | x | | | |
| Unknown 47 | Spec. 19 | sp. 146 | | - | | | | x | | | |
| Unknown 48 | Spec. 21 | sp. 148 | | Hakia | | | | x | | | |
| Unknown 49 | Spec. 79 | sp. 153 | | - | | | | | | x | |
| Unknown 50 | Spec. 80 | sp. 154 | | - | | | | | | x | |
| Unknown 51 | Spec. 82 | sp. 157 | | - | | | | | | x | |
| Unknown 52 | Spec. 83 | sp. 159 | | - | | | | | | x | |
| Unknown 53 | Spec. 84 | sp. 160 | | - | | | | | | x | |
| Unknown 54 | Spec. 85 | sp. 162 | | - | | | | | | x | |
| Unknown 55 | Spec. 86 | sp. 165 | | - | | | | | | x | |
| Unknown 57 | *Borreria* | sp. 168 | | - | | | | | | x | |
| Unknown 58 | Spec. 87 | sp. 169 | | - | | | | | | x | |

| Family | Genus | Species | **Common names/ Wapishana names | *Arawak and local names also used in other regions of Guyana | Kusad-savannah | Kusad River-gallery forest | Kusad Mountain-rocky outcrop | Parabara-bush | Parabara-gallery forest | Parabara-savannah | Parabara-bush island |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Unknown 59 | Spec. 88 | sp. 170 | | - | | | | | | x | |
| Unknown 60 | Spec. 22 | sp. 151 | | Duka red | | | | x | | | |
| Unknown 61 | Spec. 90 | sp. 179 | | Fig | | | | | x | | |
| Unknown 62 | Spec. 92 | sp. 190 | | Saintia | | | | | x | | |
| Unknown 63 | Spec. 93 | sp. 191 | | Sweetheart | | | | | x | | |
| Unknown 64 | Spec. 98 | sp. 199 | | Wild cocoa | | | | | x | | |
| Unknown 65 | Spec. 99 | sp. 200 | | Kereti Silverballi | | | | | x | | |
| Unknown 66 | Spec. 100 | sp. 202 | | Baromalli | | | | | x | | |
| Unknown 67 | Spec. 101 | sp. 204 | | Kereti | | | | | x | | |
| Unknown 68 | Spec. 102 | sp. 208 | | Kabukalli | | | | | x | | |
| Unknown 69 | Spec. 103 | sp. 209 | | Maho (smooth leaf) | | | | | x | | |
| Unknown 70 | Spec. 104 | sp. 210 | | Sand baromalli | | | | | x | | |
| Unknown 71 | Spec. 105 | sp. 211 | | Asepoko | | | | | x | | |
| Unknown 72 | Spec. 107 | sp. 218 | | Duka | | | | | x | | |
| Unknown 73 | Spec. 23 | sp. 176 | | | | | | | x | | |
| Unknown 74 | Spec. 24 | sp. 177 | | - | | | | | x | | |
| Unknown 75 | Spec. 26 | sp. 182 | | - | | | | | x | | |
| Unknown 76 | Spec. 27 | sp. 184 | | - | | | | | x | | |
| Unknown 77 | Spec. 29 | sp. 198 | | - | | | | | x | | |
| Unknown 78 | Spec. 30 | sp. 203 | | Burn Tree | | | | | x | | |
| Unknown 79 | Spec. 34 | sp. 213 | | - | | | | | x | | |
| Unknown 80 | Spec. 35 | sp. 215 | | - | | | | | x | | |
| Urticaceae | *Cecropia* | sp. 46 | | Congo pump | | x | | | | | |
| Verbenaceae | *Lantana* | *camara* | | Sweet sage | x | | | | | | |
| Violaceae | *Rinorea* | sp. 222 | | - | | | | x | | | |
| Vitaceae | *Cissus* | sp. 11 | | - | x | | | | | | |

**APPENDIX 2**
**Amphibians and reptiles recorded during the South Rupununi BAT expedition**
**Key**
CITES listings fall into one of three categories depending on the degree of protection required:
Appendix I - species threatened with extinction
Appendix II - species that are not necessarily now threatened with extinction but that may become so unless trade is closely controlled.
Appendix III - species that are protected in at least one country that already regulates trade in the species and that needs the cooperation of other countries to prevent unsustainable or illegal exploitation
IUCN status: **CD** - Conservation Dependent **DD** - Data Deficient **LC** - Least Concern **LR** - Lower Risk **NE** - Not Evaluated
Distribution: **AGR**- Amazo-Guianan subregion **GS** - Guiana Shield **GS+** - Guiana Shield and nearby islands **W** - Widespread

| | | | | | | Distribution | IUCN Threat Status | CITES Status |
|---|---|---|---|---|---|---|---|---|
| **Taxon** | **cf.** | **Kusad Mountain-forest** | **Kusad Mountain-savannah** | **Parabara-savannah** | **Parabara-forest** | | | |
| **AMPHIBIA (27 species total)** | | **11** | **3** | **2** | **18** | | | |
| **ANURA** | | | | | | | | |
| **Allophrynidae** | | | | | | | | |
| *Allophryne ruthveni* | | | | | **X** | GS | LC | |
| **Aromobatidae** | | | | | | | | |
| *Allobates femoralis* | | | | | **X** | AGR | LC | Appendix II |
| *Allobates sumtuosus* | | | | | **X** | GS | DD | |
| **Bufonidae** | | | | | | | | |
| *Rhaebo guttatus* | | | | | **X** | AGR | LC | |
| *Rhinella marina* | | **X** | **X** | | **X** | W | LC | |
| *Rhinella martyi* | | | | | **X** | GS | LC | |
| *Rhinella merianae* | | | | **X** | | GS | | |
| **Dendrobatidae** | | | | | | | | |
| *Ameerega trivittata* | | | | | **X** | AGR | LC | Appendix II |
| **Hylidae** | | | | | | | | |
| | | **X** | | | | ? | ? | |
| *Hypsiboas boans* | | | | | **X** | AGR | LC | |
| *Hypsiboas crepitans* | | **X** | | | **X** | AGR | LC | |
| *Hypsiboas multifasciatus* | cf. | | | | **X** | W | LC | |
| *Lysapsus laevis* | | | **X** | | | GS | LC | |
| *Osteocephalus leprieurii* | | | | | **X** | AGR | LC | |
| *Osteocephalus taurinus* | | | | | **X** | AGR | LC | |
| *Phyllomedusa bicolor* | | **X** | | | **X** | AGR | LC | |
| *Trachycephalus typhonius* | | **X** | | | | AGR | LC | |
| **Leptodactylidae** | | | | | | | | |
| *Adenomera andreae* | cf. | **X** | | | | AGR | LC | |
| *Leptodactylus fuscus* | | **X** | **X** | **X** | | W | LC | |
| *Leptodactylus myersi* | | **X** | | | | GS | LC | |
| *Leptodactylus mystaceus* | | | | | **X** | AGR | LC | |
| *Leptodactylus pentadactylus* | | **X** | | | | AGR | LC | |
| *Leptodactylus petersi* | | | | | **X** | AGR | LC | |
| *Pseudopaludicola boliviana* | | **X** | | | **X** | GS | LC | |
| **Pipidae** | | | | | | | | |
| *Pipa pipa* | | | | | **X** | W | LC | |
| **Ranidae** | | | | | | | | |
| *Lithobates palmipes* | | **X** | | | | AGR | LC | |

| | | | | | | Distribution | IUCN Threat Status | CITES Status |
|---|---|---|---|---|---|---|---|---|
| Taxon | cf. | Kusad Mountain-forest | Kusad Mountain-savannah | Parabara-savannah | Parabara-forest | | | |
| **Strabomantidae** | | | | | | | | |
| *Pristimantis chiastonotus* | | | | | X | GS | LC | |
| **REPTILIA (33 species total)** | | 18 | 8 | 3 | 14 | | | |
| **CROCODYLIA** | | | | | | | | |
| **Alligatoridae** | | | | | | | | |
| *Melanosuchus niger* | | | | | X | AGR | LC | Appendix I & II |
| **SQUAMATA** | | | | | | | | |
| **Gekkonidae** | | | | | | | | |
| *Hemidactylus palaichthus* | | X | | | | GS+ | LC | |
| **Sphaerodactylidae** | | | | | | | | |
| *Gonatodes humeralis* | | X | | | X | W | NE | |
| *Pseudogonatodes guianensis* | | X | | | | AGR | NE | |
| **Phyllodactylidae** | | | | | | | | |
| *Thecadactylus rapicauda* | | X | | | | W | NE | |
| **Teiidae** | | | | | | | | |
| *Ameiva ameiva* | | | X | | X | W | NE | |
| *Cnemidophorus lemniscatus* | | | X | | | W | NE | |
| *Kentropyx calcarata* | | | | | X | AGR | NE | |
| *Tupinambis teguixin* | | | X | | X | W | LC | Appendix II |
| **Polychrotidae** | | | | | | | | |
| *Anolis auratus* | | | X | X | | W | NE | |
| *Anolis planiceps* | cf. | X | | | X | AGR | NE | |
| **Tropiduridae** | | | | | | | | |
| *Plica umbra* | | | | | X | AGR | NE | |
| *Tropidurus hispidus* | | X | X | | | W | NE | |
| *Uranoscodon superciliosus* | | | | | X | AGR | NE | |
| **Scincidae** | | | | | | | | |
| *Copeoglossum nigropunctatum* | | X | | | X | W | NE | |
| **Boidae** | | | | | | | | |
| *Corallus caninus* | | | | | X | AGR | NE | Appendix II |
| *Corallus hortulanus* | | X | | | | W | NE | Appendix II |
| *Eunectes murinus* | | X | | | | W | NE | Appendix II |
| **Colubridae** | | | | | | | | |
| *Chironius fuscus* | | | | | X | W | NE | |
| *Chironius exoletus* | cf. | X | | | X | W | NE | |
| *Dipsas catesbyi* | | | | | X | W | NE | |
| *Helicops angulatus* | | | X | | | AGR | NE | |
| *Leptodeira annulata* | | X | | | | W | NE | |
| *Mastigodryas boddaerti* | | X | | | | W | NE | |
| *Oxybelis aeneus* | | X | | | | W | NE | |
| *Oxybelis fulgidus* | | | | X | | W | NE | |

**Amphibians and reptiles recorded during the South Rupununi BAT expedition (*cont'd*)**

| | | | | | | Distribution | IUCN Threat Status | CITES Status |
|---|---|---|---|---|---|---|---|---|
| Taxon | cf. | Kusad Mountain-forest | Kusad Mountain-savannah | Parabara-savannah | Parabara-forest | | | |
| *Pseudoboa neuwiedii* | | X | | | | W | NE | |
| **Elapidae** | | | | | | | | |
| *Micrurus hemprichii* | | X | | | | W | NE | |
| **Typhlopidae** | | | | | | | | |
| *Typhlops minuisquamus* | cf. | X | | | | W | NE | |
| **Viperidae** | | | | | | | | |
| *Bothrops atrox* | | X | | | | AGR | NE | |
| *Crotalus durissus* | | X | X | X | | GS | NE | Appendix III |
| *Lachesis muta* | | | | | X | AGR | NE | |
| **TESTUDINES** | | | | | | | | |
| **Testudinidae** | | | | | | | | |
| *Chelonoidis carbonaria* | | | X | | | W | NE | Appendix II |

**Appendix 3**
**List of bird species known to occur at Kusad and Parabara in the southern Rupununi savannah of Guyana**
This list combines previous survey work by the Smithsonian Institution and University of Kansas (SI/KU; see Robbins et al. 2004), with observations by B. J. O'Shea, A. Wilson, and J.K. Wrights added during the 2013 GWC/WWF South Rupununi BAT survey. Taxonomy and linear sequence follow Remsen et al. (2014).
**Key:**
**K** = Kusad Mountain and surrounding savannah
**PS** = Parabara savannah camps of SI/KU and GWC/WWF
**PV** = Parabara Village and surrounding forest
**END** = endemic to the Guiana Shield

| Scientific name | English name | K | PS | PV | END |
|---|---|---|---|---|---|
| **Tinamidae** | | | | | |
| *Crypturellus cinereus* | Cinereous Tinamou | | X | | |
| *Crypturellus erythropus* | Red-legged Tinamou | | X | | |
| *Crypturellus soui* | Little Tinamou | | X | | |
| *Crypturellus undulatus* | Undulated Tinamou | X | | | |
| *Crypturellus variegatus* | Variegated Tinamou | | X | | |
| *Tinamus major* | Great Tinamou | X | X | | |
| | | | | | |
| **Anatidae** | | | | | |
| *Cairina moschata* | Muscovy Duck | X | | | |
| *Nomonyx dominicus* | Masked Duck | | X | | |
| | | | | | |
| **Cracidae** | | | | | |
| *Crax alector* | Black Curassow | X | X | | X |
| *Mitu tomentosum* | Crestless Curassow | | X | | X |
| *Ortalis motmot* | Variable Chachalaca | X | X | | |
| *Penelope jacquacu* | Spix's Guan | | X | | |
| *Penelope marail* | Marail Guan | | X | | X |
| *Pipile cumanensis* | Blue-throated Piping-Guan | | X | | |
| | | | | | |
| **Odontophoridae** | | | | | |
| *Colinus cristatus* | Crested Bobwhite | X | X | | |
| *Odontophorus gujanensis* | Marbled Wood-Quail | | X | | |
| | | | | | |
| **Ciconiidae** | | | | | |
| *Jabiru mycteria* | Jabiru | X | | | |
| | | | | | |
| **Ardeidae** | | | | | |
| *Ardea alba* | Great Egret | X | | | |
| *Ardea cocoi* | Cocoi Heron | X | | X | |
| *Bubulcus ibis* | Cattle Egret | X | | | |
| *Butorides striata* | Striated Heron | X | | | |
| *Egretta caerulea* | Little Blue Heron | | | X | |
| *Tigrisoma lineatum* | Rufescent Tiger-Heron | X | X | X | |

**List of bird species (*cont'd*)**

| Scientific name | English name | K | PS | PV | END |
|---|---|---|---|---|---|
| **Threskiornithidae** | | | | | |
| *Mesembrinibis cayennensis* | Green Ibis | | | X | |
| *Theristicus caudatus* | Buff-necked Ibis | X | | | |
| | | | | | |
| **Cathartidae** | | | | | |
| *Cathartes aura* | Turkey Vulture | X | X | | |
| *Cathartes burrovianus* | Lesser Yellow-headed Vulture | X | | | |
| *Cathartes melambrotus* | Greater Yellow-headed Vulture | X | X | | |
| *Coragyps atratus* | Black Vulture | X | X | | |
| *Sarcoramphus papa* | King Vulture | X | X | | |
| | | | | | |
| **Accipitridae** | | | | | |
| *Accipiter bicolor* | Bicoloured Hawk | X | | | |
| *Busarellus nigricollis* | Black-collared Hawk | X | | | |
| *Buteo albonotatus* | Zone-tailed Hawk | X | | | |
| *Buteo brachyurus* | Short-tailed Hawk | X | | | |
| *Buteo nitidus* | Grey-lined Hawk | X | | X | |
| *Buteo platypterus* | Broad-winged Hawk | X | | | |
| *Buteogallus meridionalis* | Savanna Hawk | X | X | | |
| *Buteogallus urubitinga* | Great Black Hawk | X | | | |
| *Elanoides forficatus* | Swallow-tailed Kite | | X | | |
| *Gampsonyx swainsonii* | Pearl Kite | X | | | |
| *Geranoaetus albicaudatus* | White-tailed Hawk | X | X | | |
| *Geranospiza caerulescens* | Crane Hawk | X | | | |
| *Ictinia plumbea* | Plumbeous Kite | | X | X | |
| *Pseudastur albicollis* | White Hawk | X | X | | |
| *Rupornis magnirostris* | Roadside Hawk | X | X | X | |
| *Spizaetus melanoleucus* | Black-and-white Hawk-Eagle | X | X | | |
| *Spizaetus ornatus* | Ornate Hawk-Eagle | X | | | |
| *Spizaetus tyrannus* | Black Hawk-Eagle | | X | | |
| | | | | | |
| **Psophiidae** | | | | | |
| *Psophia crepitans* | Grey-winged Trumpeter | | X | | |
| | | | | | |
| **Rallidae** | | | | | |
| *Anurolimnas viridis* | Russet-crowned Crake | | X | | |
| *Aramides cajaneus* | Grey-necked Wood-Rail | X | X | | |
| *Micropygia schomburgkii* | Ocellated Crake | | X | | |
| *Mustelirallus albicollis* | Ash-throated Crake | X | X | | |

| Scientific name | English name | K | PS | PV | END |
|---|---|---|---|---|---|
| **Heliornithidae** | | | | | |
| *Heliornis fulica* | Sungrebe | | | X | |
| | | | | | |
| **Eurypygidae** | | | | | |
| *Eurypyga helias* | Sunbittern | X | X | X | |
| | | | | | |
| **Charadriidae** | | | | | |
| *Vanellus chilensis* | Southern Lapwing | | X | | |
| | | | | | |
| **Burhinidae** | | | | | |
| *Burhinus bistriatus* | Double-striped Thick-knee | X | X | | |
| | | | | | |
| **Scolopacidae** | | | | | |
| *Bartramia longicauda* | Upland Sandpiper | | X | | |
| *Calidris fuscicollis* | White-rumped Sandpiper | | X | | |
| *Gallinago paraguaiae* | South American Snipe | | X | | |
| | | | | | |
| **Jacanidae** | | | | | |
| *Jacana jacana* | Wattled Jacana | X | | | |
| | | | | | |
| **Columbidae** | | | | | |
| *Claravis pretiosa* | Blue Ground Dove | X | X | | |
| *Columbina minuta* | Plain-breasted Ground Dove | X | | | |
| *Columbina passerina* | Common Ground Dove | X | X | X | |
| *Columbina talpacoti* | Ruddy Ground Dove | X | | | |
| *Geotrygon montana* | Ruddy Quail-Dove | | X | | |
| *Leptotila rufaxilla* | Grey-fronted Dove | | X | | |
| *Leptotila verreauxi* | White-tipped Dove | X | X | | |
| *Patagioenas cayennensis* | Pale-vented Pigeon | X | X | | |
| *Patagioenas plumbea* | Plumbeous Pigeon | | X | X | |
| *Patagioenas speciosa* | Scaled Pigeon | | X | | |
| *Patagioenas subvinacea* | Ruddy Pigeon | | X | X | |
| *Zenaida auriculata* | Eared Dove | X | X | | |
| | | | | | |
| **Cuculidae** | | | | | |
| *Crotophaga ani* | Smooth-billed Ani | X | X | X | |
| *Piaya cayana* | Squirrel Cuckoo | X | X | X | |
| *Tapera naevia* | Striped Cuckoo | X | X | | |

**List of bird species (*cont'd*)**

| Scientific name | English name | K | PS | PV | END |
|---|---|---|---|---|---|
| **Strigidae** | | | | | |
| *Asio stygius* | Stygian Owl | X | | | |
| *Athene cunicularia* | Burrowing Owl | X | | | |
| *Bubo virginianus* | Great Horned Owl | X | | | |
| *Ciccaba virgata/huhula* sp. | Mottled/Black-banded Owl sp. | | X | | |
| *Glaucidium brasilianum* | Ferruginous Pygmy-Owl | X | X | | |
| *Glaucidium hardyi* | Amazonian Pygmy-Owl | | X | X | |
| *Lophostrix cristata* | Crested Owl | | X | X | |
| *Megascops choliba* | Tropical Screech-Owl | X | X | | |
| *Megascops watsonii* | Tawny-bellied Screech-Owl | | X | | |
| *Pulsatrix perspicillata* | Spectacled Owl | X | X | X | |
| | | | | | |
| **Nyctibiidae** | | | | | |
| *Nyctibius grandis* | Great Potoo | | X | | |
| *Nyctibius griseus* | Common Potoo | X | X | | |
| | | | | | |
| **Caprimulgidae** | | | | | |
| *Antrostomus rufus* | Rufous Nightjar | | X | | |
| *Chordeiles acutipennis* | Lesser Nighthawk | X | | | |
| *Chordeiles nacunda* | Nacunda Nighthawk | X | | | |
| *Chordeiles pusillus* | Least Nighthawk | | X | | |
| *Hydropsalis cayennensis* | White-tailed Nightjar | X | X | | |
| *Lurocalis semitorquatus* | Short-tailed Nighthawk | | | X | |
| *Nyctidromus albicollis* | Common Pauraque | X | X | X | |
| | | | | | |
| **Apodidae** | | | | | |
| *Chaetura brachyura* | Short-tailed Swift | X | X | X | |
| *Chaetura chapmani* | Chapman's Swift | | | X | |
| *Chaetura cinereiventris* | Grey-rumped Swift | | X | | |
| *Chaetura spinicaudus* | Band-rumped Swift | | X | X | |
| *Panyptila cayennensis* | Lesser Swallow-tailed Swift | | X | | |
| *Tachornis squamata* | Fork-tailed Palm-Swift | X | X | X | |
| | | | | | |
| **Trochilidae** | | | | | |
| *Amazilia* cf. *brevirostris* | White-chested Emerald | X | | | X |
| *Amazilia fimbriata* | Glittering-throated Emerald | X | X | | |
| *Amazilia versicolor* | Versicolored Emerald | X | X | | |
| *Anthracothorax nigricollis* | Black-throated Mango | X | X | | |
| *Campylopterus largipennis* | Gray-breasted Sabrewing | | | X | |
| *Chlorostilbon mellisugus* | Blue-tailed Emerald | X | | | |
| *Chrysolampis mosquitus* | Ruby-topaz Hummingbird | | X | | |

| Scientific name | English name | K | PS | | PV | END |
|---|---|---|---|---|---|---|
| **Trochilidae** cont'd | | | | | | |
| *Florisuga mellivora* | White-necked Jacobin | | X | X | | |
| *Heliomaster longirostris* | Long-billed Starthroat | X | | X | | |
| *Heliothryx auritus* | Black-eared Fairy | | X | | | |
| *Hylocharis cyanus* | White-chinned Sapphire | | X | X | | |
| *Hylocharis sapphirina* | Rufous-throated Sapphire | | X | | | |
| *Lophornis ornatus* | Tufted Coquette | | X | | | |
| *Phaethornis augusti* | Sooty-capped Hermit | X | | | | |
| *Phaethornis bourcieri* | Straight-billed Hermit | | X | X | | |
| *Phaethornis ruber* | Reddish Hermit | | X | X | | |
| *Phaethornis superciliosus* | Long-tailed Hermit | X | X | | X | |
| *Polytmus guainumbi* | White-tailed Goldenthroat | X | X | | | |
| *Polytmus theresiae* | Green-tailed Goldenthroat | | X | | | |
| *Thalurania furcata* | Fork-tailed Woodnymph | X | X | | | |
| *Topaza pella* | Crimson Topaz | | | | X | X |
| | | | | | | |
| **Trogonidae** | | | | | | |
| *Trogon melanurus* | Black-tailed Trogon | | X | | X | |
| *Trogon rufus* | Black-throated Trogon | | X | | | |
| *Trogon violaceus* | Guianan Trogon | | X | | X | X |
| *Trogon viridis* | Green-backed Trogon | X | X | | X | |
| | | | | | | |
| **Alcedinidae** | | | | | | |
| *Chloroceryle aenea* | American Pygmy Kingfisher | | | | X | |
| *Chloroceryle amazona* | Amazon Kingfisher | X | | | X | |
| *Chloroceryle americana* | Green Kingfisher | X | | | X | |
| *Chloroceryle inda* | Green-and-rufous Kingfisher | X | | | | |
| *Megaceryle torquata* | Ringed Kingfisher | X | | | X | |
| | | | | | | |
| **Momotidae** | | | | | | |
| *Momotus momota* | Amazonian Motmot | X | X | | | |
| | | | | | | |
| **Galbulidae** | | | | | | |
| *Brachygalba lugubris* | Brown Jacamar | | X | | | |
| *Galbula albirostris* | Yellow-billed Jacamar | | X | | X | |
| *Galbula dea* | Paradise Jacamar | | X | | X | |
| *Galbula galbula* | Green-tailed Jacamar | X | | | | |
| *Galbula leucogastra* | Bronzy Jacamar | | X | | | |
| *Jacamerops aureus* | Great Jacamar | | X | | | |

**List of bird species (*cont'd*)**

| Scientific name | English name | K | PS | PV | END |
|---|---|---|---|---|---|
| **Bucconidae** | | | | | |
| *Bucco capensis* | Collared Puffbird | | X | | |
| *Bucco tamatia* | Spotted Puffbird | | X | | |
| *Chelidoptera tenebrosa* | Swallow-winged Puffbird | X | X | X | |
| *Malacoptila fusca* | White-chested Puffbird | | X | | |
| *Monasa atra* | Black Nunbird | X | X | X | X |
| *Notharchus macrorhynchos* | Guianan Puffbird | X | X | | X |
| *Notharchus tectus* | Pied Puffbird | | X | | |
| | | | | | |
| **Capitonidae** | | | | | |
| *Capito niger* | Black-spotted Barbet | | X | X | X |
| | | | | | |
| **Ramphastidae** | | | | | |
| *Pteroglossus aracari* | Black-necked Aracari | | X | | |
| *Pteroglossus viridis* | Green Aracari | | X | X | X |
| *Ramphastos tucanus* | White-throated Toucan | X | X | X | |
| *Ramphastos vitellinus* | Channel-billed Toucan | X | X | X | |
| | | | | | |
| **Picidae** | | | | | |
| *Campephilus melanoleucos* | Crimson-crested Woodpecker | X | X | X | |
| *Campephilus rubricollis* | Red-necked Woodpecker | X | X | X | |
| *Celeus elegans* | Chestnut Woodpecker | X | X | | |
| *Celeus flavus* | Cream-colored Woodpecker | | X | X | |
| *Celeus torquatus* | Ringed Woodpecker | | X | | |
| *Celeus undatus* | Waved Woodpecker | | X | X | |
| *Dryocopus lineatus* | Lineated Woodpecker | X | X | X | |
| *Melanerpes cruentatus* | Yellow-tufted Woodpecker | | X | X | |
| *Piculus chrysochloros* | Golden-green Woodpecker | | X | | |
| *Piculus flavigula* | Yellow-throated Woodpecker | | X | | |
| *Picumnus cirratus* | White-barred Piculet | X | X | | |
| *Picumnus exilis* | Golden-spangled Piculet | | | X | |
| *Veniliornis cassini* | Golden-collared Woodpecker | | X | | X |
| | | | | | |
| **Falconidae** | | | | | |
| *Caracara cheriway* | Crested Caracara | X | X | | |
| *Daptrius ater* | Black Caracara | | X | X | |
| *Falco columbarius* | Merlin | X | | | |
| *Falco femoralis* | Aplomado Falcon | X | X | | |
| *Falco rufigularis* | Bat Falcon | X | X | X | |
| *Falco sparverius* | American Kestrel | X | | | |
| *Herpetotheres cachinnans* | Laughing Falcon | X | X | | |

| Scientific name | English name | K | PS | PV | END |
|---|---|---|---|---|---|
| **Falconidaec** cont'd<br><br>*Ibycter americanus* | Red-throated Caracara | | X | | |
| *Micrastur gilvicollis* | Lined Forest-falcon | X | X | | |
| *Micrastur mirandollei* | Slaty-backed Forest-Falcon | | X | X | |
| *Micrastur ruficollis* | Barred Forest-Falcon | X | X | | |
| *Micrastur semitorquatus* | Collared Forest-Falcon | | | X | |
| *Milvago chimachima* | Yellow-headed Caracara | X | X | | |
| | | | | | |
| **Psittacidae** | | | | | |
| *Amazona amazonica* | Orange-winged Parrot | | X | X | |
| *Amazona ochrocephala* | Yellow-crowned Parrot | X | X | | |
| *Ara ararauna* | Blue-and-yellow Macaw | X | X | | |
| *Ara chloropterus* | Red-and-green Macaw | | X | X | |
| *Ara macao* | Scarlet Macaw | | X | X | |
| *Brotogeris chrysoptera* | Golden-winged Parakeet | | X | X | |
| *Deroptyus accipitrinus* | Red-fan Parrot | | X | X | |
| *Diopsittaca nobilis* | Red-shouldered Macaw | X | X | | |
| *Eupsittula pertinax* | Brown-throated Parakeet | X | X | | |
| *Orthopsittaca manilatus* | Red-bellied Macaw | X | X | | |
| *Pionites melanocephalus* | Black-headed Parrot | | X | | |
| *Pionus fuscus* | Dusky Parrot | | X | X | X |
| *Pionus menstruus* | Blue-headed Parrot | | X | X | |
| *Psittacara leucophthalmus* | White-eyed Parakeet | | | X | |
| *Pyrilia caica* | Caica Parrot | | X | X | X |
| *Pyrrhura picta* | Painted Parakeet | | | X | |
| *Touit purpuratus* | Sapphire-rumped Parrotlet | | | X | |
| | | | | | |
| **Thamnophilidae** | | | | | |
| *Cercomacra cinerascens* | Grey Antbird | X | X | X | |
| *Cercomacroides laeta* | Willis's Antbird | | X | | |
| *Cercomacroides tyrannina* | Dusky Antbird | X | X | X | |
| *Cymbilaimus lineatus* | Fasciated Antshrike | | X | | |
| *Epinecrophylla gutturalis* | Brown-bellied Antwren | | X | | X |
| *Euchrepomis spodioptila* | Ash-winged Antwren | | X | | |
| *Formicivora grisea* | White-fringed Antwren | X | X | | |
| *Frederickena viridis* | Black-throated Antshrike | | X | | X |
| *Gymnopithys rufigula* | Rufous-throated Antbird | | X | X | X |
| *Herpsilochmus rufimarginatus* | Rufous-winged Antwren | X | | | |
| *Herpsilochmus stictocephalus* | Todd's Antwren | | X | | X |
| *Herpsilochmus sticturus* | Spot-tailed Antwren | | X | X | X |
| *Hylophylax naevius* | Spot-backed Antbird | | X | | |

**List of bird species (*cont'd*)**

| Scientific name | English name | K | PS | PV | END |
|---|---|---|---|---|---|
| *Hypocnemis cantator* | Guianan Warbling-Antbird | | X | X | X |
| *Hypocnemoides melanopogon* | Black-chinned Antbird | | | X | |
| *Isleria guttata* | Rufous-bellied Antwren | | X | X | X |
| *Microrhopias quixensis* | Dot-winged Antwren | | | X | |
| *Myrmeciza ferruginea* | Ferruginous-backed Antbird | | X | X | X |
| *Myrmoborus leucophrys* | White-browed Antbird | | X | X | |
| *Myrmornis torquata* | Wing-banded Antbird | | X | | |
| *Myrmotherula axillaris* | White-flanked Antwren | | X | X | |
| *Myrmotherula brachyura* | Pygmy Antwren | | X | X | |
| *Myrmotherula longipennis* | Long-winged Antwren | | X | | |
| *Myrmotherula menetriesii* | Grey Antwren | | X | | |
| *Myrmotherula surinamensis* | Guianan Streaked-Antwren | | | X | X |
| *Percnostola rufifrons* | Black-headed Antbird | | X | X | X |
| *Pithys albifrons* | White-plumed Antbird | | X | X | |
| *Sakesphorus canadensis* | Black-crested Antshrike | X | X | | |
| *Taraba major* | Great Antshrike | | X | | |
| *Thamnomanes ardesiacus* | Dusky-throated Antshrike | | X | | |
| *Thamnomanes caesius* | Cinereous Antshrike | | X | X | |
| *Thamnophilus amazonicus* | Amazonian Antshrike | | X | X | |
| *Thamnophilus doliatus* | Barred Antshrike | X | X | | |
| *Thamnophilus murinus* | Mouse-coloured Antshrike | X | X | X | |
| *Thamnophilus punctatus* | Northern Slaty-Antshrike | X | X | | X |
| *Willisornis poecilinotus* | Common Scale-backed Antbird | | X | | |
| | | | | | |
| **Conopophagidae** | | | | | |
| *Conopophaga aurita* | Chestnut-belted Gnateater | | | X | |
| | | | | | |
| **Grallariidae** | | | | | |
| *Hylopezus macularius* | Spotted Antpitta | | X | | |
| *Myrmothera campanisona* | Thrush-like Antpitta | | X | X | |
| | | | | | |
| **Formicariidae** | | | | | |
| *Formicarius analis* | Black-faced Antthrush | | X | X | |
| *Formicarius colma* | Rufous-capped Antthrush | | X | | |
| | | | | | |
| **Furnariidae** | | | | | |
| *Automolus infuscatus* | Olive-backed Foliage-gleaner | | X | X | |
| *Automolus ochrolaemus* | Buff-throated Foliage-gleaner | | X | X | |
| *Automolus rufipileatus* | Chestnut-crowned Foliage-gleaner | | X | | |
| *Campyloramphus procurvoides* | Curve-billed Scythebill | | X | | |
| *Clibanornis rubiginosus* | Ruddy Foliage-gleaner | | X | | |

| Scientific name | English name | K | PS | PV | END |
|---|---|---|---|---|---|
| *Dendrocincla fuliginosa* | Plain-brown Woodcreeper | | X | X | |
| *Dendrocolaptes certhia* | Amazonian Barred-Woodcreeper | | X | X | |
| *Dendrocolaptes picumnus* | Black-banded Woodcreeper | | X | | |
| *Dendroplex picus* | Straight-billed Woodcreeper | X | X | | |
| *Furnarius leucopus* | Pale-legged Hornero | | | | |
| *Glyphorhynchus spirurus* | Wedge-billed Woodcreeper | | X | X | |
| *Lepidocolaptes albolineatus* | Guianan Woodcreeper | | X | | X |
| *Philydor erythrocercum* | Rufous-rumped Foliage-gleaner | | X | | |
| *Philydor pyrrhodes* | Cinnamon-rumped Foliage-gleaner | | X | X | |
| *Sclerurus rufigularis* | Short-billed Leaftosser | | X | | |
| *Synallaxis albescens* | Pale-breasted Spinetail | X | X | | |
| *Xenops minutus* | Plain Xenops | | X | X | |
| *Xiphorhynchus guttatus* | Buff-throated Woodcreeper | X | X | X | |
| *Xiphorhynchus obsoletus* | Striped Woodcreeper | | | X | |
| *Xiphorhynchus pardalotus* | Chestnut-rumped Woodcreeper | | X | | X |
| | | | | | |
| **Tyrannidae** | | | | | |
| *Arundinicola leucocephala* | White-headed Marsh Tyrant | X | | | |
| *Atalotriccus pilaris* | Pale-eyed Pygmy-Tyrant | X | | | |
| *Attila cinnamomeus* | Cinnamon Attila | | X | X | |
| *Attila spadiceus* | Bright-rumped Attila | X | X | X | |
| *Camptostoma obsoletum* | Southern Beardless-Tyrannulet | X | | X | |
| *Capsiempis flaveola* | Yellow Tyrannulet | X | | | |
| *Colonia colonus* | Long-tailed Tyrant | | X | | |
| *Conopias parvus* | Yellow-throated Flycatcher | | X | X | |
| *Contopus cinereus* | Tropical Pewee | | X | | |
| *Corythopis torquatus* | Ringed Antpipit | | X | X | |
| *Elaenia chiriquensis* | Lesser Elaenia | X | X | | |
| *Elaenia cristata* | Plain-crested Elaenia | X | X | | |
| *Elaenia flavogaster* | Yellow-bellied Elaenia | X | X | | |
| *Elaenia ruficeps* | Rufous-crowned Elaenia | | X | | |
| *Empidonomus varius* | Variegated Flycatcher | X | X | | |
| *Hemitriccus josephinae* | Boat-billed Tody-Tyrant | | X | | X |
| *Lathrotriccus euleri* | Euler's Flycatcher | | X | | |
| *Legatus leucophaius* | Piratic Flycatcher | | X | X | |
| *Lophotriccus galetus* | Helmeted Pygmy-Tyrant | | X | | |
| *Lophotriccus vitiosus* | Double-banded Pygmy-Tyrant | | X | X | |
| *Megarynchus pitangua* | Boat-billed Flycatcher | X | X | | |
| *Mionectes macconnelli* | McConnell's Flycatcher | X | | X | |
| *Mionectes oleagineus* | Ochre-bellied Flycatcher | | X | | |
| *Myiarchus swainsoni* | Swainson's Flycatcher | X | X | | |

**List of bird species (*cont'd*)**

| Scientific name | English name | K | PS | PV | END |
|---|---|---|---|---|---|
| *Myiarchus tuberculifer* | Dusky-capped Flycatcher | | X | | |
| *Myiarchus tyrannulus* | Brown-crested Flycatcher | X | X | | |
| *Myiobius barbatus* | Sulphur-rumped Flycatcher | | X | | |
| *Myiodynastes maculatus* | Streaked Flycatcher | X | X | | |
| *Myiopagis flavivertex* | Yellow-crowned Elaenia | | | X | |
| *Myiopagis gaimardii* | Forest Elaenia | X | X | X | |
| *Myiopagis viridicata* | Greenish Elaenia | X | X | | |
| *Myiophobus fasciatus* | Bran-coloured Flycatcher | X | X | | |
| *Myiornis ecaudatus* | Short-tailed Pygmy-Tyrant | | X | | |
| *Myiozetetes cayanensis* | Rusty-margined Flycatcher | X | X | X | |
| *Onychorhynchus coronatus* | Royal Flycatcher | | X | | |
| *Ornithion inerme* | White-lored Tyrannulet | | X | X | |
| *Phaeomyias murina* | Mouse-colored Tyrannulet | X | X | | |
| *Pitangus lictor* | Lesser Kiskadee | X | | | |
| *Pitangus sulphuratus* | Great Kiskadee | X | X | X | |
| *Platyrinchus saturatus* | Cinnamon-crested Spadebill | | X | | |
| *Poecilotriccus sylvia* | Slate-headed Tody-Flycatcher | X | | | |
| *Pyrocephalus rubinus* | Vermilion Flycatcher | X | X | | |
| *Ramphotrigon ruficauda* | Rufous-tailed Flatbill | | X | X | |
| *Rhynchocyclus olivaceus* | Olivaceus Flatbill | | X | | |
| *Rhytipterna immunda* | Pale-bellied Mourner | | X | | |
| *Rhytipterna simplex* | Greyish Mourner | | X | X | |
| *Sirystes subcanescens* | Todd's Sirystes | | X | X | X |
| *Sublegatus* cf. *modestus* | Scrub-Flycatcher sp. | X | | | |
| *Todirostrum cinereum* | Common Tody-Flycatcher | X | X | X | |
| *Todirostrum pictum* | Painted Tody-Flycatcher | | X | | X |
| *Tolmomyias assimilis* | Yellow-margined Flycatcher | | X | X | |
| *Tolmomyias flaviventris* | Yellow-breasted Flycatcher | X | X | | |
| *Tolmomyias poliocephalus* | Grey-crowned Flycatcher | | X | X | |
| *Tolmomyias sulphurescens* | Yellow-olive Flycatcher | X | X | | |
| *Tyrannopsis sulphurea* | Sulphury Flycatcher | X | X | | |
| *Tyrannulus elatus* | Yellow-crowned Tyrannulet | | X | X | |
| *Tyrannus albogularis* | White-throated Kingbird | X | X | | |
| *Tyrannus melancholicus* | Tropical Kingbird | X | X | X | |
| *Tyrannus savana* | Fork-tailed Flycatcher | X | X | | |
| *Zimmerius acer* | Guianan Tyrannulet | X | X | | X |
| | | | | | |
| **Cotingidae** | | | | | |
| *Cephalopterus ornatus* | Amazonian Umbrellabird | | X | | |
| *Cotinga cayana* | Spangled Cotinga | | X | X | |
| *Cotinga cotinga* | Purple-breasted Cotinga | | X | | |

| Scientific name | English name | K | PS | PV | END |
|---|---|---|---|---|---|
| *Gymnoderus foetidus* | Bare-necked Fruitcrow | | X | | |
| *Haematoderus militaris* | Crimson Fruitcrow | | X | X | |
| *Lipaugus vociferans* | Screaming Piha | X | X | X | |
| *Perissocephalus tricolor* | Capuchinbird | X | | | X |
| *Phoenicircus carnifex* | Guianan Red-Cotinga | | | X | X |
| *Procnias albus* | White Bellbird | X | | | X |
| *Querula purpurata* | Purple-throated Fruitcrow | | X | X | |
| *Xipholena punicea* | Pompadour Cotinga | | X | X | |
| | | | | | |
| **Pipridae** | | | | | |
| *Ceratopipra erythrocephala* | Golden-headed Manakin | | X | X | |
| *Chiroxiphia pareola* | Blue-backed Manakin | X | | | |
| *Dixiphia pipra* | White-crowned Manakin | | X | X | |
| *Lepidothrix serena* | White-fronted Manakin | | X | | X |
| *Manacus manacus* | White-bearded Manakin | | X | X | |
| *Tyranneutes virescens* | Tiny Tyrant-Manakin | | X | X | X |
| *Xenopipo atronitens* | Black Manakin | | X | | |
| | | | | | |
| **Tityridae** | | | | | |
| *Laniocera hypopyrra* | Cinereous Mourner | X | X | | |
| *Pachyramphus marginatus* | Black-capped Becard | | X | | |
| *Pachyramphus minor* | Pink-throated Becard | | X | | |
| *Pachyramphus polychopterus* | White-winged Becard | X | X | | |
| *Pachyramphus rufus* | Cinereous Becard | X | | | |
| *Pachyramphus surinamus* | Glossy-backed Becard | | | X | |
| *Schiffornis olivacea* | Olivaceous Schiffornis | | X | X | X |
| *Tityra cayana* | Black-tailed Tityra | X | X | | |
| *Tityra inquisitor* | Black-crowned Tityra | | X | | |
| *Xenopsaris albinucha* | White-naped Xenopsaris | X | | | |
| | | | | | |
| **Incertae Sedis** | | | | | |
| *Piprites chloris* | Wing-barred Piprites | | X | | |
| | | | | | |
| **Vireonidae** | | | | | |
| *Cyclarhis gujanensis* | Rufous-browed Peppershrike | X | X | | |
| *Hylophilus pectoralis* | Ashy-headed Greenlet | X | X | | |
| *Hylophilus thoracicus* | Lemon-chested Greenlet | | X | X | |
| *Pachysylvia muscicapina* | Buff-cheeked Greenlet | | X | X | |
| *Tunchiornis ochraceiceps* | Tawny-crowned Greenlet | | | X | |
| *Vireo olivaceus* | Red-eyed Vireo | X | X | | |
| *Vireolanius leucotis* | Slaty-capped Shrike-Vireo | | X | | |

**List of bird species (*cont'd*)**

| Scientific name | English name | K | PS | PV | END |
|---|---|---|---|---|---|
| **Corvidae** | | | | | |
| *Cyanocorax cayanus* | Cayenne Jay | X | X | | |
| | | | | | |
| **Hirundinidae** | | | | | |
| *Atticora fasciata* | White-banded Swallow | | | X | |
| *Hirundo rustica* | Barn Swallow | X | X | | |
| *Progne chalybea* | Grey-breasted Martin | X | X | X | |
| *Progne tapera* | Brown-chested Martin | X | X | | |
| *Riparia riparia* | Bank Swallow | | X | | |
| *Stelgidopteryx ruficollis* | Southern Rough-winged Swallow | | X | X | |
| *Tachycineta albiventer* | White-winged Swallow | X | X | | |
| | | | | | |
| **Troglodytidae** | | | | | |
| *Campylorhynchus griseus* | Bicoloured Wren | X | X | | |
| *Cantorchilus leucotis* | Buff-breasted Wren | X | | | |
| *Cyphorhinus arada* | Musician Wren | | X | | |
| *Henicorhina leucosticta* | White-breasted Wood-Wren | | X | | |
| *Microcerculus bambla* | Wing-banded Wren | | X | | |
| *Pheugopedius coraya* | Coraya Wren | | X | X | |
| *Troglodytes aedon* | House Wren | X | X | | |
| | | | | | |
| **Polioptilidae** | | | | | |
| *Microbates collaris* | Collared Gnatwren | | X | | |
| *Polioptila plumbea* | Tropical Gnatcatcher | X | X | | |
| *Ramphocaenus melanurus* | Long-billed Gnatwren | | X | X | |
| | | | | | |
| **Turdidae** | | | | | |
| *Catharus fuscescens* | Veery | | X | | |
| *Catharus minimus* | Grey-cheeked Thrush | X | | | |
| *Turdus albicollis* | White-necked Thrush | X | X | | |
| *Turdus fumigatus* | Cocoa Thrush | | | X | |
| *Turdus leucomelas* | Pale-breasted Thrush | X | X | | |
| *Turdus nudigenis* | Spectacled Thrush | X | | | |
| | | | | | |
| **Mimidae** | | | | | |
| *Mimus gilvus* | Tropical Mockingbird | X | X | | |
| | | | | | |
| **Motacillidae** | | | | | |
| *Anthus lutescens* | Yellowish Pipit | X | X | | |
| | | | | | |

| Scientific name | English name | K | PS | PV | END |
|---|---|---|---|---|---|
| **Thraupidae** | | | | | |
| *Coereba flaveola* | Bananaquit | X | X | X | |
| *Cyanerpes caeruleus* | Purple Honeycreeper | | X | | |
| *Cyanerpes cyaneus* | Red-legged Honeycreeper | X | X | X | |
| *Cyanerpes nitidus* | Short-billed Honeycreeper | | X | X | |
| *Cyanicterus cyanicterus* | Blue-backed Tanager | | X | | X |
| *Dacnis cayana* | Blue Dacnis | | X | | |
| *Dacnis lineata* | Black-faced Dacnis | X | | | |
| *Emberizoides herbicola* | Wedge-tailed Grass-Finch | X | X | | |
| *Hemithraupis guira* | Guira Tanager | | X | | |
| *Lamprospiza melanoleuca* | Red-billed Pied-Tanager | | X | | |
| *Lanio fulvus* | Fulvous Shrike-Tanager | | X | | |
| *Nemosia pileata* | Hooded Tanager | X | | | |
| *Ramphocelus carbo* | Silver-beaked Tanager | | X | X | |
| *Schistochlamys melanopis* | Black-faced Tanager | | X | | |
| *Sicalis luteola* | Grassland Yellow-Finch | X | | | |
| *Sporophila angolensis* | Chestnut-bellied Seed-Finch | X | X | X | |
| *Sporophila crassirostris* | Large-billed Seed-Finch | X | | | |
| *Sporophila fringilloides* | White-naped Seedeater | | X | | |
| *Sporophila intermedia* | Grey Seedeater | X | | | |
| *Sporophila minuta* | Ruddy-breasted Seedeater | X | X | | |
| *Sporophila nigricollis* | Yellow-bellied Seedeater | X | | | |
| *Sporophila plumbea* | Plumbeous Seedeater | X | X | | |
| *Tachyphonus cristatus* | Flame-crested Tanager | | X | | |
| *Tachyphonus phoenicius* | Red-shouldered Tanager | | X | | |
| *Tachyphonus surinamus* | Fulvous-crested Tanager | | X | X | |
| *Tangara cayana* | Burnished-buff Tanager | X | X | | |
| *Tangara chilensis* | Paradise Tanager | | X | | |
| *Tangara punctata* | Spotted Tanager | | X | | |
| *Tangara velia* | Opal-rumped Tanager | | X | X | |
| *Thraupis episcopus* | Blue-grey Tanager | X | X | X | |
| *Thraupis palmarum* | Palm Tanager | X | X | X | |
| *Volatinia jacarina* | Blue-black Grassquit | X | | | |
| | | | | | |
| **Incertae Sedis** | | | | | |
| *Saltator coerulescens* | Greyish Saltator | X | X | | |
| *Saltator grossus* | Slate-colored Grosbeak | | X | X | |
| *Saltator maximus* | Buff-throated Saltator | | | X | |
| | | | | | |
| **Emberizidae** | | | | | |
| *Ammodramus humeralis* | Grassland Sparrow | X | X | | |

**List of bird species (*cont'd*)**

| Scientific name | English name | K | PS | PV | END |
|---|---|---|---|---|---|
| *Arremon taciturnus* | Pectoral Sparrow | | X | | |
| | | | | | |
| **Cardinalidae** | | | | | |
| *Caryothraustes canadensis* | Yellow-green Grosbeak | | X | | |
| *Cyanocompsa cyanoides* | Blue-black Grosbeak | | X | X | |
| *Granatellus pelzelni* | Rose-breasted Chat | | X | | |
| *Piranga flava* | Hepatic Tanager | X | | | |
| *Piranga rubra* | Summer Tanager | X | | | |
| | | | | | |
| **Parulidae** | | | | | |
| *Basileuterus culicivorus* | Golden-crowned Warbler | X | | | |
| *Geothlypis aequinoctialis* | Masked Yellowthroat | X | | | |
| *Myiothlypis flaveola* | Flavescent Warbler | X | | | |
| *Myiothlypis rivularis* | Riverbank Warbler | | X | | |
| *Setophaga pitiayumi* | Tropical Parula | X | X | | |
| | | | | | |
| **Icteridae** | | | | | |
| *Cacicus cela* | Yellow-rumped Cacique | | X | X | |
| *Cacicus haemorrhous* | Red-rumped Cacique | | X | X | |
| *Icterus cayanensis* | Epaulet Oriole | X | X | | |
| *Icterus nigrogularis* | Yellow Oriole | X | X | | |
| *Molothrus bonariensis* | Shiny Cowbird | | X | | |
| *Molothrus oryzivorus* | Giant Cowbird | | X | X | |
| *Psarocolius decumanus* | Crested Oropendola | | X | X | |
| *Psarocolius viridis* | Green Oropendola | | X | X | |
| *Sturnella magna* | Eastern Meadowlark | X | X | | |
| *Sturnella militaris* | Red-breasted Blackbird | X | X | | |
| | | | | | |
| **Fringillidae** | | | | | |
| *Euphonia cayennensis* | Golden-sided Euphonia | | | X | |
| *Euphonia chlorotica* | Purple-throated Euphonia | | X | | |
| *Euphonia chrysopasta* | Golden-bellied Euphonia | | X | | |
| *Euphonia finschi* | Finsch's Euphonia | X | X | | X |
| *Euphonia violacea* | Violaceus Euphonia | | X | X | |
| *Spinus cucullatus* | Red Siskin | | | | |

**Appendix 4**
**Preliminary checklist of small mammals from the biological assessment of the South Rupununi, Guyana, in 2013**

| Species | Kusad | Parabara | Total |
|---|---|---|---|
| **BATS:** | | | |
| *Carollia perspicillata* | 40 | 37 | 77 |
| *Artibeus cinereus* | 19 | 11 | 30 |
| *Artibeus lituratus* | 0 | 21 | 21 |
| *Artibeus planirostris* | 11 | 9 | 20 |
| *Phyllostomus discolor* | 5 | 5 | 10 |
| *Artibeus bogotensis* | 1 | 8 | 9 |
| *Glossophaga soricina* | 9 | 0 | 9 |
| *Phyllostomus elongatus* | 6 | 1 | 7 |
| *Sturnira lilium* | 4 | 3 | 7 |
| *Glossophaga longirostris* | 6 | 0 | 6 |
| *Phyllostomus hastatus* | 2 | 4 | 6 |
| *Trachops cirrhosus* | 6 | 0 | 6 |
| *Artibeus concolor* | 0 | 4 | 4 |
| *Desmodus rotundus* | 4 | 0 | 4 |
| *Lophostoma silvicolum* | 1 | 2 | 3 |
| *Micronycteris megalotis* | 2 | 1 | 3 |
| *Rhinophylla pumilio* | 0 | 3 | 3 |
| *Choeroniscus godmani* | 0 | 2 | 2 |
| *Micronycteris minuta* | 1 | 1 | 2 |
| *Mimon crenulatum* | 0 | 2 | 2 |
| *Myotis nigricans* | 1 | 1 | 2 |

**Preliminary checklist of small mammals (*cont'd*)**

| Species | Kusad | Parabara | Total |
|---|---|---|---|
| *Saccopteryx bilineata* | 2 | 0 | 2 |
| *Ametrida centurio* | 0 | 1 | 1 |
| *Artibeus gnomus* | 0 | 1 | 1 |
| *Artibeus obscurus* | 0 | 1 | 1 |
| *Carollia brevicauda* | 1 | 0 | 1 |
| *Eptesicus furinalis* | 1 | 0 | 1 |
| *Lonchorhina orinocensis* | 1 | 0 | 1 |
| *Mesophylla macconnelli* | 0 | 1 | 1 |
| *Molossus molossus* | 0 | 1 | 1 |
| *Molossus* sp. nov. | 0 | 1 | 1 |
| *Phylloderma stenops* | 0 | 1 | 1 |
| *Pteronotus parnellii* | 1 | 0 | 1 |
| *Saccopteryx leptura* | 1 | 0 | 1 |
| *Uroderma bilobatum* | 0 | 1 | 1 |
| **Total** | **125** | **123** | **248** |
| | | | |
| **RODENTS**: | | | |
| *Proechimys guyannensis* | 7 | 0 | 7 |
| *Zygodontomys brevicauda* | 0 | 2 | 2 |
| **Total** | **7** | **2** | **9** |

**Appendix 5**
**Large mammal species detected at Kusad and Parabara by camera traps** (C), tracks (T), or live sightings (L).

For all species, we listed the IUCN status (LC: Least Concern; NT: Near Threatened; VU: Vulnerable; DD: Data deficient), and their protection in Guyana in the Schedule of the Environmental Protection (Wildlife Management and Conservation) Regulations, 2009.

| Species | Common Name | IUCN Status | Protected within Guyana | Kusad | Parabara |
|---|---|---|---|---|---|
| *Tapirus terrestris* | Brazilian tapir | VU | No | C, T | C, T |
| *Panthera onca* | Jaguar | NT | Yes | C, T | T |
| *Puma concolor* | Puma | LC | Yes | C | C |
| *Mazama americana* | Red brocket deer | DD | No | C, T | C, T, L |
| *Tayassu pecari* | White-lipped peccary | VU | No | C, T | T |
| *Myrmecophaga tridactyla* | Giant anteater | VU | Yes | C, T | C |
| *Priodontes maximus* | Giant armadillo | VU | Yes | C, T | C, T |
| *Pecari tajacu* | Collared peccary | LC | No | C, T | C, T |
| *Mazama nemorivaga* | Grey brocket deer | LC | No | C | C |
| *Leopardus pardalis* | Ocelot | LC | Yes | C | C |
| *Cuniculus paca* | Labba/Paca | LC | No | C, T | C, T, L |
| *Cerdocyon thous* | Savannah fox | LC | No | L | C, L |
| *Eira Barbara* | Tayra | LC | No | L | |
| *Nasua nasua* | Coati | LC | No | C | |
| *Procyon cancrivorus* | Crab-eating raccoon | LC | No | C | C |
| *Potos flavus* | Kinkajou | LC | No | | (heard) |
| *Dasyprocta leporina* | Agouti | LC | No | C, T | C, T |
| *Dasypus novemcinctus* | Nine-banded armadillo | LC | No | C, T | C, T |
| *Leopardus wiedii* | Margay | NT | Yes | | C |
| *Saguinus midas* | Golden-handed tamarin | LC | No | | L |
| *Cebus* sp. | Capuchin monkey | LC | No | | L |
| *Allouatta macconnelli* | Guianan red howler monkey | LC | No | (heard) | (heard) |

**Appendix 6**
**Ants of the South Rupununi savannah region**
**Key**
Sites: **K**-Kusad, **P**-Parabara
Methods: **H**-Hand-collecting; **P**-Pitfall traps; **W**-Winkler traps
Habitats: **B**-Bush island; **D**-Dry forest; **M**-Montane forest; **R**-Rainforest; **S**-Shortgrass savannah; **T**-Tallgrass savannah
Country record/Guianas record: **NA**-not available; **N**-no; **Y**-yes

| Subfamily | Genus | Species | Site (K/P) | Method (H/P/W) | Habitat (B/D/M/ R/S/T) | Country record | Guianas record |
|---|---|---|---|---|---|---|---|
| Myrmicinae | *Acromyrmex* | cf. *landolti* | P | H | S | NA | NA |
| Formicinae | *Acropyga* | *guianensis* | P | W | R | N | N |
| Formicinae | *Acropyga* | *smithii* | P | W | R | Y | Y |
| Myrmicinae | *Allomerus* | *octoarticulatus* | P | H | R | N | N |
| Ponerinae | *Anochetus* | *bispinosus* | K | W | M | N | N |
| Ponerinae | *Anochetus* | *mayri* | K | W | M | N | N |
| Myrmicinae | *Apterostigma* | *auriculatum* | P | W | R | N | N |
| Myrmicinae | *Apterostigma* | *pilosum* | P | H | B | Y | Y |
| Myrmicinae | *Apterostigma* | *pilosum* gr. | P | W | R | NA | NA |
| Myrmicinae | *Atta* | *laevigata* | K | H | D,M,T | N | N |
| Dolichoderinae | *Azteca* | 01 | K | H | M | NA | NA |
| Dolichoderinae | *Azteca* | 02 | K,P | H,W | B,R,S,T | NA | NA |
| Dolichoderinae | *Azteca* | 04 | P | H | B,R | NA | NA |
| Myrmicinae | *Basiceros* | *militaris* | P | W | R | N | N |
| Formicinae | *Brachymyrmex* | *coactus* | K | H | M | N | N |
| Formicinae | *Brachymyrmex* | *heeri* | K,P | H,W | B,M,S | N | N |
| Formicinae | *Brachymyrmex* | *obscurior* | K | H,P | T | N | N |
| Formicinae | *Brachymyrmex* | *pictus* | K | W | M | N | N |
| Formicinae | *Brachymyrmex* | 04 | K,P | W | M,R | NA | NA |
| Formicinae | *Camponotus* | 01 | K | H | D | NA | NA |
| Formicinae | *Camponotus* | 02 | K | H,P | D,T | NA | NA |
| Formicinae | *Camponotus* | 03 | K | H | D | NA | NA |
| Formicinae | *Camponotus* | 04 | K | H | D | NA | NA |
| Formicinae | *Camponotus* | 05 | K,P | H,W | D,M,R | NA | NA |
| Formicinae | *Camponotus* | 06 | K | H,W | M,T | NA | NA |
| Formicinae | *Camponotus* | 08 | K,P | H | M,R,S | NA | NA |
| Formicinae | *Camponotus* | 11 | P | H | R | NA | NA |
| Formicinae | *Camponotus* | 13 | K,P | H,W | D,R,S,T | NA | NA |
| Formicinae | *Camponotus* | 16 | P | H | S | NA | NA |
| Formicinae | *Camponotus* | 17 | P | H | R | NA | NA |
| Formicinae | *Camponotus* | 18 | K | P | T | NA | NA |
| Myrmicinae | *Carebara* | *reticulata* | K,P | W | D,M,R | Y | N |
| Myrmicinae | *Carebara* | *urichi* | P | W | R | N | N |
| Myrmicinae | *Cephalotes* | *atratus* | P | H | R | N | N |
| Myrmicinae | *Cephalotes* | *minutus* | K | H,W | D | N | N |

| Subfamily | Genus | Species | Site (K/P) | Method (H/P/W) | Habitat (B/D/M/ R/S/T) | Country record | Guianas record |
|---|---|---|---|---|---|---|---|
| Myrmicinae | *Cephalotes* | *persimilis* | P | H | R,S | N | N |
| Myrmicinae | *Cephalotes* | *pusillus* | K | H | D,T | N | N |
| Myrmicinae | *Cephalotes* | *spinosus* | P | H | R | N | N |
| Myrmicinae | *Crematogaster* | *brasiliensis* | K,P | H,W | B,D,R | N | N |
| Myrmicinae | *Crematogaster* | *distans* | K | H | D,T | Y | Y |
| Myrmicinae | *Crematogaster* | *flavosensitiva* | P | W | B,R | N | N |
| Myrmicinae | *Crematogaster* | *limata* | P | H,W | B,R | N | N |
| Myrmicinae | *Crematogaster* | *nigropilosa* | K | W | M | N | N |
| Myrmicinae | *Crematogaster* | *tenuicula* | K | W | M | N | N |
| Myrmicinae | *Crematogaster* | 05 | P | H | S | NA | NA |
| Myrmicinae | *Crematogaster* | 06 | P | H | R | NA | NA |
| Myrmicinae | *Crematogaster* | 07 | P | W | R | NA | NA |
| Myrmicinae | *Crematogaster* | 11 | K | W | D,M | NA | NA |
| Myrmicinae | *Cyphomyrmex* | *laevigatus* | P | W | R | N | N |
| Myrmicinae | *Cyphomyrmex* | *rimosus* | P | H,W | R | N | N |
| Myrmicinae | *Cyphomyrmex* | *peltatus* | K | P,W | M,T | Y | N |
| Myrmicinae | *Daceton* | *armigerum* | K | H | M,T | N | N |
| Proceratiinae | *Discothyrea* | *sexarticulata* | P | W | R | Y | N |
| Dolichoderinae | *Dolichoderus* | *bispinosus* | K,P | H,W | D,B | N | N |
| Dolichoderinae | *Dolichoderus* | *decollatus* | K,P | H | M,R | N | N |
| Dolichoderinae | *Dolichoderus* | 01 | K | H | D | NA | NA |
| Dolichoderinae | *Dolichoderus* | 02 | P | H | R | NA | NA |
| Dolichoderinae | *Dorymyrmex* | 01 | P | P | S | NA | NA |
| Ecitoninae | *Eciton* | *burchellii* | P | H | R | N | N |
| Ecitoninae | *Eciton* | *hamatum* | P | H | R | N | N |
| Ectatomminae | *Ectatomma* | *brunneum* | P | H,P | S | N | N |
| Ectatomminae | *Ectatomma* | *edentatum* | K | W | M | N | N |
| Ectatomminae | *Ectatomma* | *lugens* | K | W | M | N | N |
| Ectatomminae | *Ectatomma* | *ruidum* | K | H,P | D,T | N | N |
| Ectatomminae | *Ectatomma* | *tuberculatum* | K,P | H | B,D,M,R | N | N |
| Formicinae | *Gigantiops* | *destructor* | K,P | H | B,M,R, | N | N |
| Ectatomminae | *Gnamptogenys* | *horni* | P | W | R | N | N |
| Ectatomminae | *Gnamptogenys* | *ammophila* | K | P | T | Y | Y |
| Ectatomminae | *Gnamptogenys* | 03 | P | W | R | NA | NA |
| Myrmicinae | *Hylomyrma* | *longiscapa* | P | W | R | NA | NA |
| Ponerinae | *Hypoponera* | 01 | K | H | D | NA | NA |
| Ponerinae | *Hypoponera* | 02 | K,P | H,W | D,M,R | NA | NA |
| Ponerinae | *Hypoponera* | 03 | K,P | W | D,M,R | NA | NA |
| Ponerinae | *Hypoponera* | 04 | P | W | R | NA | NA |
| Ponerinae | *Hypoponera* | 05 | K,P | W | B,D,M,R | NA | NA |
| Ponerinae | *Hypoponera* | 06 | P | W | R | NA | NA |

**Ants of the South Rupununi savannah regions (*cont'd*)**

| Subfamily | Genus | Species | Site (K/P) | Method (H/P/W) | Habitat (B/D/M/ R/S/T) | Country record | Guianas record |
|---|---|---|---|---|---|---|---|
| Ponerinae | *Hypoponera* | 07 | P | W | B,R | NA | NA |
| Ecitoninae | *Labidus* | *coecus* | K | H,W | D,M | N | N |
| Ecitoninae | *Labidus* | *praedator* | P | H | R | N | N |
| Ponerinae | *Leptogenys* | *gaigei* | P | H | R | N | N |
| Ponerinae | *Leptogenys* | *unistimulosa* | P | H | R | N | N |
| Myrmicinae | *Megalomyrmex* | 01 | K | W | M | NA | NA |
| Myrmicinae | *Mycocepurus* | *smithii* | K | H | D | N | N |
| Myrmicinae | *Myrmicocrypta* | *buenzlii* | P | W | R | N | N |
| Myrmicinae | *Myrmicocrypta* | 01 | K | W | M | NA | NA |
| Ecitoninae | *Neivamyrmex* | *pilosus* | K,P | H,W | M,R | N | N |
| Myrmicinae | *Nesomyrmex* | 01 | P | H | R | NA | NA |
| Myrmicinae | *Ochetomyrmex* | *neopolitus* | P | W | R | N | N |
| Ponerinae | *Odontomachus* | *bauri* | K,P | H,P,W | D,S | Y | Y |
| Ponerinae | *Odontomachus* | *haematodus* | P | H,W | B,R | N | N |
| Ponerinae | *Odontomachus* | *meinerti* | K,P | H,W | B,M,R | N | N |
| Ponerinae | *Pachycondyla* | *apicalis* | K,P | H | B,M | N | N |
| Ponerinae | *Pachycondyla* | *arhuaca* | K | W | M | N | N |
| Ponerinae | *Pachycondyla* | *commutata* | K | H | M | N | N |
| Ponerinae | *Pachycondyla* | *constricta* | K | H,W | D | N | N |
| Ponerinae | *Pachycondyla* | *crassinoda* | K,P | H,W | M,S,T | N | N |
| Ponerinae | *Pachycondyla* | *harpax* | K,P | H,W | D,M,R | N | N |
| Ponerinae | *Pachycondyla* | *laevigata* | P | H | R | N | N |
| Ponerinae | *Pachycondyla* | *stigma* | P | H | R | N | N |
| Ponerinae | *Pachycondyla* | *unidentata* | K | H,W | M | N | N |
| Ponerinae | *Pachycondyla* | *verenae* | K,P | H,W | M,R | N | N |
| Paraponerinae | *Paraponera* | *clavata* | P | H | R | N | N |
| Formicinae | *Paratrechina* | 01 | K,P | H,W | B,D,M,R | NA | NA |
| Formicinae | *Paratrechina* | 02 | K | H | T | NA | NA |
| Formicinae | *Paratrechina* | 03 | P | H | R | NA | NA |
| Formicinae | *Paratrechina* | 04 | K,P | H,W | B,M,R | NA | NA |
| Formicinae | *Paratrechina* | 05 | P | W | R | NA | NA |
| Formicinae | *Paratrechina* | 06 | K,P | P | S,T | NA | NA |
| Myrmicinae | *Pheidole* | 01 | K,P | H | D,M,R | NA | NA |
| Myrmicinae | *Pheidole* | 02 | K | H,W | D | NA | NA |
| Myrmicinae | *Pheidole* | 03 | K | H | D | NA | NA |
| Myrmicinae | *Pheidole* | 04 | K,P | H,W | D,R | NA | NA |
| Myrmicinae | *Pheidole* | 05 | K,P | H,W | B,D,M,R | NA | NA |
| Myrmicinae | *Pheidole* | 06 | K,P | H,W | D,R | NA | NA |
| Myrmicinae | *Pheidole* | 07 | K,P | H | M,R | NA | NA |
| Myrmicinae | *Pheidole* | 08 | K | H | M | NA | NA |
| Myrmicinae | *Pheidole* | 09 | K,P | H | R,T | NA | NA |

| Subfamily | Genus | Species | Site (K/P) | Method (H/P/W) | Habitat (B/D/M/ R/S/T) | Country record | Guianas record |
|---|---|---|---|---|---|---|---|
| Myrmicinae | *Pheidole* | 10 | K | H | M | NA | NA |
| Myrmicinae | *Pheidole* | 11 | K | H | T | NA | NA |
| Myrmicinae | *Pheidole* | 12 | K,P | H,P,W | M,R,T | NA | NA |
| Myrmicinae | *Pheidole* | 13 | K,P | H,W | M,R | NA | NA |
| Myrmicinae | *Pheidole* | 14 | P | H,W | B,R | NA | NA |
| Myrmicinae | *Pheidole* | 15 | P | H,W | R | NA | NA |
| Myrmicinae | *Pheidole* | 16 | K,P | H,W | B,D,M,R | NA | NA |
| Myrmicinae | *Pheidole* | 17 | P | H | R | NA | NA |
| Myrmicinae | *Pheidole* | 18 | P | H,W | B,R | NA | NA |
| Myrmicinae | *Pheidole* | 19 | K,P | H,W | B,M,R | NA | NA |
| Myrmicinae | *Pheidole* | 20 | K,P | H,W | M,R | NA | NA |
| Myrmicinae | *Pheidole* | 21 | P | H | R | NA | NA |
| Myrmicinae | *Pheidole* | 22 | P | W | R | NA | NA |
| Myrmicinae | *Pheidole* | 23 | P | W | R | NA | NA |
| Myrmicinae | *Pheidole* | 24 | K | W | M | NA | NA |
| Myrmicinae | *Pheidole* | 25 | K | W | M | NA | NA |
| Myrmicinae | *Pheidole* | 26 | K | H,W | M | NA | NA |
| Myrmicinae | *Pheidole* | 27 | K | P | T | NA | NA |
| Amblyoponinae | *Prionopelta* | *marthae* | K,P | H,W | M,R | N | N |
| Pseudomyrmecinae | *Pseudomyrmex* | *termitarius* | K | H,P | T | N | N |
| Pseudomyrmecinae | *Pseudomyrmex* | 01 | K | H | D | NA | NA |
| Pseudomyrmecinae | *Pseudomyrmex* | 02 | K | H | D | NA | NA |
| Pseudomyrmecinae | *Pseudomyrmex* | 03 | K,P | H | B,S,T | NA | NA |
| Pseudomyrmecinae | *Pseudomyrmex* | 04 | P | H | R | NA | NA |
| Pseudomyrmecinae | *Pseudomyrmex* | 05 | P | H | R | NA | NA |
| Pseudomyrmecinae | *Pseudomyrmex* | 06 | P | H | R | NA | NA |
| Pseudomyrmecinae | *Pseudomyrmex* | 07 | P | H | R | NA | NA |
| Pseudomyrmecinae | *Pseudomyrmex* | 08 | P | H | R | NA | NA |
| Myrmicinae | *Rogeria* | *curvipubens* | K | W | M | Y | N |
| Myrmicinae | *Rogeria* | *foreli* | K | W | D | Y | Y |
| Myrmicinae | *Rogeria* | *subarmata* | P | W | R | Y | Y |
| Myrmicinae | *Sericomyrmex* | *harekulli* | K | H | M | N | N |
| Myrmicinae | *Solenopsis* | *saevissima* | K,P | H | R,S,T | N | N |
| Myrmicinae | *Solenopsis* | 01 | K | H,P | D,T | NA | NA |
| Myrmicinae | *Solenopsis* | 02 | K,P | H,W | B,D,M,R | NA | NA |
| Myrmicinae | *Solenopsis* | 03 | K,P | H,W | D,M,R | NA | NA |
| Myrmicinae | *Solenopsis* | 04 | K,P | H,W | B,M,R | NA | NA |
| Myrmicinae | *Solenopsis* | 05 | K,P | H,W | M,S | NA | NA |
| Myrmicinae | *Solenopsis* | 06 | K,P | H,W | M,R | NA | NA |
| Myrmicinae | *Solenopsis* | 07 | K,P | H,W | D,M,R | NA | NA |
| Myrmicinae | *Strumigenys* | *alberti* | K | W | M | N | N |

**Ants of the South Rupununi savannah regions (*cont'd*)**

| Subfamily | Genus | Species | Site (K/P) | Method (H/P/W) | Habitat (B/D/M/ R/S/T) | Country record | Guianas record |
|---|---|---|---|---|---|---|---|
| Myrmicinae | *Strumigenys* | *denticulata* | K,P | W | B,M,R | N | N |
| Myrmicinae | *Strumigenys* | *elongata* | K,P | H,W | D,M,R | N | N |
| Myrmicinae | *Strumigenys* | *halosis* | K | W | M | N | N |
| Myrmicinae | *Strumigenys* | *perparva* | K,P | P,W | D,M,R,T | N | N |
| Myrmicinae | *Strumigenys* | *stenotes* | K | W | M | N | N |
| Myrmicinae | *Strumigenys* | *subedentata* | P | W | R | N | N |
| Myrmicinae | *Strumigenys* | *trudifera* | P | W | B,R | Y | Y |
| Myrmicinae | *Tetramorium* | *simillimum* | K | W | D | Y | Y |
| Ponerinae | *Thaumatomyrmex* | *atrox* | P | W | R | N | N |
| Myrmicinae | *Trachymyrmex* | cf. *bugnioni* | P | W | R | NA | NA |
| Myrmicinae | *Trachymyrmex* | *relictus* | K | H,W | D | N | N |
| Myrmicinae | *Trachymyrmex* | cf. *zeteki* | K | H | D | NA | NA |
| Myrmicinae | *Trachymyrmex* | 03 | K | H | M | NA | NA |
| Myrmicinae | *Trachymyrmex* | 04 | P | H | R | NA | NA |
| Myrmicinae | *Trachymyrmex* | 05 | P | H | R | NA | NA |
| Myrmicinae | *Wasmannia* | *auropunctata* | K,P | H,P,W | D,M,R,S,T | N | N |
| Myrmicinae | *Xenomyrmex* | *stollii* | K | H | D | Y | Y |
| **Total** | | | | | | | |
| **10 subfamilies** | **48 genera** | **175 species** | | | | | |

**Appendix 7**
**List of water beetles collected during the 2013 BAT survey of the South Rupununi savannah and Parabara regions of Guyana**
**Key**
* Indicates species likely to be new to science
** Indicates species new to science
X Indicates presence of taxon at the location listed

| Taxon | Kusad | Parabara |
|---|---|---|
| **DRYOPIDAE** | | |
| *Dryops* sp. A | - | X |
| *Elmoparnus* sp. A | X | - |
| *Pelonomus* sp. A | - | X |
| **DYTISCIDAE** | | |
| *Agaporomorphus* sp. A | - | X |
| *Amarodytes* sp. E* | - | X |
| *Amarodytes* sp. X | X | - |
| *Anodocheilus* sp. A | X | - |
| *Anodocheilus* sp. B | X | X |
| *Anodocheilus* sp. X | X | X |
| *Bidessodes charaxinus* | - | X |
| *Bidessodes evanidus* | - | X |
| *Bidessodes franki* | X | X |
| *Bidessodes knischi* | X | - |
| *Bidessodes semistriatus* | - | X |
| *Bidessodes subsignatus* | X | X |
| *Bidessonotus dubius* | - | X |
| *Bidessonotus tibialis* | X | X |
| *Celina* sp. A | X | - |
| *Celina* sp. B | X | - |
| *Celina* sp. C | X | - |
| *Celina* sp. X | X | X |
| *Copelatus* sp. 1 | - | X |
| *Copelatus* sp. 2 | - | X |
| *Copelatus* sp. 3 | X | X |
| *Copelatus* sp. 4 | X | X |

**List of Water Beetles (*cont'd*)**

| Taxon | Kusad | Parabara |
|---|---|---|
| *Derovatellus lentus* | - | X |
| *Desmopachria* sp. A | X | X |
| *Desmopachria* sp. B | - | X |
| *Desmopachria* sp. C | X | X |
| *Desmopachria* sp. D | - | X |
| *Desmopachria* sp. E | X | X |
| *Desmopachria* sp. F | X | X |
| *Desmopachria* sp. G | X | X |
| *Desmopachria* sp. H | X | - |
| *Desmopachria* sp. I | X | - |
| *Fontidessus aquarupi** | X | - |
| *Fontidessus ornatus* | X | - |
| *Hydaticus* cf. *lateralis* | - | X |
| *Hydaticus subfasciatus* | X | X |
| *Hydaticus xanthomelas* | X | - |
| *Hydrodessus* sp. 7 | - | X |
| *Hydrodessus* sp. 9 | - | X |
| *Hydrovatus* sp. 1 | X | X |
| *Laccodytes apalodes* | - | X |
| *Laccomimus* sp. A | X | X |
| *Laccomimus* sp. B | X | - |
| *Laccophilus* sp. 1 | - | X |
| *Laccophilus* sp. 2 | - | X |
| *Laccophilus* sp. 3 | - | X |
| *Laccophilus* sp. 5 | - | X |
| *Laccophilus* sp. 6 | X | X |
| *Laccophilus* sp. 7 | X | X |
| *Laccophilus* sp. 8 | X | X |
| *Laccophilus* sp. 10 | - | X |
| *Laccophilus* sp. 11 | - | X |
| *Laccophilus* sp. 12 | X | X |
| *Laccophilus* sp. 13 | - | X |
| *Laccophilus* sp. 14 | X | - |
| *Laccophilus* sp. 15 | X | - |
| *Laccophilus* sp. 16 | X | X |
| *Laccophilus* sp. 17 | X | - |
| *Laccophilus* sp. 18 | X | - |
| *Liodessus microscopicus* | X | X |
| *Liodessus* sp. "fuzzy"* | X | X |

| Taxon | Kusad | Parabara |
|---|---|---|
| *Megadytes fraternus* | X | - |
| *Megadytes giganteus* | X | - |
| *Megadytes laevigatus* | X | - |
| *Microdessus atomarius* | - | X |
| *Neobidessus alternatus* | X | X |
| *Neobidessus* sp. E* | - | X |
| *Neobidessus surinamensis* | X | X |
| *Pachydrus* sp. 3 | X | X |
| *Queda* sp. 1 | X | - |
| *Rhantus calidus* | X | X |
| *Thermonectus circumscriptus* | - | X |
| *Thermonectus leprieuri* | - | X |
| *Thermonectus nobilis* | X | - |
| *Thermonectus succinctus* | X | - |
| *Thermonectus variegatus* | - | X |
| *Thermonectus* sp. A | - | X |
| *Vatellus amae* | - | X |
| *Vatellus grandis* | - | X |
| *Vatellus tarsatus* | - | X |
| **ELMIDAE** | | |
| *Cylloepus* sp. 1 | X | - |
| *Cylloepus* sp. 2 | - | X |
| *Cylloepus* sp. 3 | X | - |
| *Heterelmis* sp. X | X | X |
| *Macrelmis* sp. 1 | - | X |
| *Neoelmis* sp. X | - | X |
| Nr. *Macrelmis* sp. 1 | - | X |
| Nr. *Macrelmis* sp. 2 | X | - |
| *Stegoelmis stictoides* | - | X |
| *Stenhelmoides* sp. 1 | - | X |
| **EPIMETOPIDAE** | | |
| *Epimetopus* sp. X | X | - |
| **GYRINIDAE** | | |
| *Gyretes* sp. 1 | - | X |
| *Gyretes* sp. 4 | X | - |
| *Gyretes* sp. A | - | X |
| *Gyretes* sp. B | X | - |
| *Gyretes* sp. C | X | X |

**List of Water Beetles (*cont'd*)**

| Taxon | Kusad | Parabara |
|---|---|---|
| **HYDRAENIDAE** | | |
| *Hydraena* sp. 1 | X | - |
| *Hydraena* sp. 2 | X | - |
| *Hydraena* sp. 3 | - | X |
| **HYDROCHIDAE** | | |
| *Hydrochus* sp. A | - | X |
| *Hydrochus* sp. B | X | - |
| *Hydrochus* sp. C | X | - |
| *Hydrochus* sp. D | - | X |
| *Hydrochus* sp. E | X | - |
| *Hydrochus* sp. F | - | X |
| **HYDROPHILIDAE** | | |
| *Anacaena* cf. *suturalis* | X | - |
| *Berosus ambogynus* | X | - |
| *Berosus avernus* | X | - |
| *Berosus brevibasis* | X | - |
| *Berosus garciai* | X | - |
| *Berosus megaphallus* | X | - |
| *Berosus patruelis* | X | - |
| *Berosus* sp. 2 | X | - |
| *Berosus* sp. 3 | X | - |
| *Chaetarthria* sp. 1 | - | X |
| *Chasmogenus* sp. X* | - | X |
| *Chasmogenus* sp. B | X | - |
| *Derallus intermedius* | - | X |
| *Derallus perpunctatus* | - | X |
| *Derallus* sp. 3 | X | X |
| *Derallus* sp. 5 | - | X |
| *Derallus* sp. X | X | X |
| *Enochrus* sp. 1* | - | X |
| *Enochrus* sp. 2 | X | - |
| *Enochrus* sp. 3 | - | X |
| *Enochrus* sp. 6 | - | X |
| *Enochrus* sp. 11 | X | - |
| *Enochrus* sp. 12 | X | - |
| *Enochrus* sp. 13 | X | - |
| *Enochrus* sp. 14 | X | X |
| Gen. Nov. "Crossternum" sp. 1* | - | X |
| Gen. Nov. "tiny" sp. A* | - | X |

| Taxon | Kusad | Parabara |
|---|---|---|
| *Hydrocanthus marmoratus* | X | - |
| *Hydrocanthus socius* | X | X |
| *Hydrocanthus* cf. *sharpi* | X | X |
| *Liocanthydrus bicolor* | | X |
| *Liocanthydrus clayae* | X | X |
| "Gen. Nov." *buqueti* | - | X |
| *Notomicrus gracilipes* | | X |
| *Notomicrus sharpi* | X | - |
| *Notomicrus traili* | - | X |
| *Prionohydrus* sp. A* | X | X |
| *Suphis* cf. *ticky* | X | - |
| *Suphis* n. sp.* | X | - |
| *Suphisellus majusculus* | X | - |
| *Suphisellus nigrinus* | X | X |
| *Suphisellus pereirai* | X | X |
| *Suphisellus* sp. 11 | - | X |
| *Suphisellus* sp. 13 | X | X |
| *Suphisellus* sp. 16 | - | x |
| *Suphisellus* sp. 17 | X | - |
| **TORRIDINCOLIDAE** | | |
| *Claudiella* sp. A* | X | - |
| Gen. Nov. sp. A* | X | - |

**Appendix 8**
**Water quality measurement table**
**A. Water quality measurement for Kusad Mountain**

| Sample Point Location # | Collection site ID | Name of water body | Location of sampling point | Elevation (m) | Description of sampling point | Date | Time | Weather condition | Temp (°C) | pH | DO (mg/L) | DO (% sat) | Cond (uS/cm) | TDS (mg/L) as NaCl | Turb (NTU) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | GY-131024-001-KM | Takutu River at Lukanani landing | N 02° 50.155' W 059° 59.429' | | River, fast current, sample collected from above rapids | 24-Oct-13 | 8:00 | Sunny | 29.0 | 7.12 | 6.65 | 87.7 | | | 25.20 | |
| 2 | GY-131024-002-KM | Mokorowau upstream of camp at Kusad Mountain | N 02° 48.720' W 59° 52.004' | 138 | Creek, clear water, overhanging vegetation, sandy substrate with some rocks | 24-Oct-13 | 15:57 | Sunny | 28.4 | 6.90 | 7.01 | | 54.70 | 26.20 | 9.18 | |
| 3 | GY-131024-003-KM | Mokorowau further upstream of camp at Kusad Mountain | N 02° 48.566' W 59° 51.908' | 152 | Creek, clear water, flowing over rocks at the bottom of a sloping rock | 24-Oct-13 | 16:40 | Sunny | 27.1 | 7.63 | 7.65 | 99.1 | 60.00 | 28.70 | 6.76 | |
| 4 | GY-131025-004-KM | Black Huri Lake (Suzukarishii) | N 02° 49.747' W 059° 48.320' | 121 | Wetland that contains rooted vegetation (grasses), clear water | 25-Oct-13 | 7:00 | Sunny | 29.3 | 5.03 | 5.32 | 70.3 | 6.00 | 3.45 | 1.69 | It is a water source for animals; none were present at the time of sampling |
| 5 | GY-131025-005-KM | | N 02° 49.767' W 059° 48.259' | 121 | | 25-Oct-13 | 7:35 | Sunny | 29.9 | 5.21 | 5.12 | 68.7 | 5.02 | 2.30 | 3.92 | |
| 6 | GY-131025-006-KM | | N 02° 49.889' W 059° 48.295' | 123 | | 25-Oct- | 8:10 | Sunny | 30.5 | 5.55 | 6.36 | 85.5 | 4.49 | 2.03 | 2.51 | |
| 7 | GY-131025-007-KM | | N 02° 49.865' W 059° 48.354' | 121 | | 25-Oct-13 | 8:40 | Sunny | 30.6 | 5.60 | 6.41 | 87.0 | 5.45 | 2.49 | 1.71 | |
| 8 | GY-131025-008-KM | Ants Creek (Ziidawau) | N 02° 49.736' W 059° 48.557' | 117 | Creek, almost stagnant, moss in water, ité palms lining the creek | 25-Oct-13 | 10:20 | Sunny | 28.9 | 5.44 | 2.74 | 37.0 | 11.41 | 5.82 | 6.89 | Creek was disconnected from downstream section |
| 9 | GY-131025-009-KM | Ants Creek (Ziidawau), downstream | N 02° 49.863' W 059° 48.632' | 108 | Creek, almost stagnant, moss and moco moco vegetation in the water, ité palms lining creek | 25-Oct-13 | 11:03 | Sunny | 34.0 | 5.89 | 4.83 | 69.9 | 13.57 | 6.19 | 4.32 | |
| 10 | GY-131026-010-KM | Small Sand Creek (Katuwau), at Saddle Mountain crossing | N 02° 53.437' W 059° 51.043' | 104 | Creek, flowing moderately, downstream of water flowing over rocks in the water (used as vehicle crossing) | 26-Oct-13 | 8:12 | Sunny | 30.5 | 6.68 | 6.47 | 87.1 | 17.50 | 8.11 | 19.99 | |

| Sample Point Location # | Collection site ID | Name of water body | Location of sampling point | Elevation (m) | Description of sampling point | Date | Time | Weather condition | Temp (°C) | pH | DO (mg/L) | DO (% sat) | Cond (uS/cm) | TDS (mg/L) as NaCl | Turb (NTU) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 11 | GY-131026-011-KM | | N 02° 53.419' W 059° 51.087' | 107 | Creek, flowing moderately, downstream of point GY-131026-010-KM | 26-Oct-13 | 8:42 | Sunny | 30.7 | 6.67 | 6.50 | 87.8 | 17.40 | 8.11 | 19.50 | |
| 12 | GY-131026-012-KM | | N 02° 53.426' W 059° 51.142' | 106 | Creek, flowing, downstream of water flowing over rocks and downstream of sample point GY-131026-011-KM | 26-Oct-13 | 9:15 | Sunny | | 6.96 | 7.21 | 98.8 | 17.35 | 8.06 | 18.60 | |
| 13 | GY-131026-013-KM | | N 02° 53.400' W 059° 51.066' | 103 | Creek, flowing moderately, upstream of rocks in the creek and sample point GY-131026-010-KM | 26-Oct-13 | 10:55 | Sunny | 31.8 | 6.77 | 6.52 | 90.5 | 19.24 | 9.96 | 19.40 | |
| 14 | GY-131026-014-KM | Small Sand Creek (Katuwau) upstream of Saddle Mountain crossing, at Kodowidpau downstream | N 02° 52.499' W 059° 49.828' | 105 | Creek, fast current, downstream of water flowing over a rock in the creek | 26-Oct-13 | 11:20 | Sunny | 32.4 | 6.79 | 6.76 | 95.2 | 20.97 | 9.77 | 22.40 | |
| 15 | GY-131026-015-KM | Small Sand Creek (Katuwau) upstream of Saddle Mountain crossing, at Kodowidpau upstream | N 02° 52.468' W 059° 49.808' | 117 | Creek, fast current, upstream of a rock outcrop in the creek | 26-Oct-13 | 12:50 | Sunny | 34.4 | 6.70 | 6.60 | | 17.64 | 8.22 | 22.20 | |
| | GY-131027-016-KM | Takutu River at Lukanani landing | N 02° 50.152' W 059° 59.442' | 99 | River, fast current, above rapids, water at lower level than sample GY-131024-001-KM and aquatic vegetation visible | 27-Oct-13 | 8:45 | Sunny | 30.4 | 6.78 | 6.41 | 86.4 | 31.80 | 14.89 | 22.00 | |
| 16 | GY-131027-017-KM | Daadawau | N 02° 50.571' W 059° 59.102' | 107 | Creek flowing to Takutu River, clear water, flowing slowly, downstream of a vehicle (rock) crossing in the creek, moco moco vegetation in creek | 27-Oct-13 | 10:15 | Sunny | 29.1 | 6.27 | 4.89 | 65.4 | 14.32 | 6.65 | 3.04 | |

**A. Water quality management for Kusad Mountain (*cont'd*)**

| Sample Point Location # | Collection site ID | Name of water body | Location of sampling point | Elevation (m) | Description of sampling point | Date | Time | Weather condition | Temp (°C) | pH | DO (mg/L) | DO (% sat) | Cond (uS/cm) | TDS (mg/L) as NaCl | Turb (NTU) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 17 | GY-131027-018-KM | | N 02º 50.545' W 059º 59.108' | 96 | Creek flowing to Takutu River, clear water, appeared stagnant, upstream of a vehicle (rock) crossing in the creek, moco moco vegetation in creek | 27-Oct-13 | 10:40 | Sunny | 28.6 | 6.14 | 3.64 | 48.5 | 14.86 | 6.90 | 1.92 | |
| 18 | GY-131027-019-KM | Matabanwau near discharge into Takutu River | N 02º 50.042' W 059º 59.432' | 90 | Creek flowing to Takutu River, steep sides, overhanging vegetation, leaf litter in water | 27-Oct-13 | 11:30 | Sunny | 32.2 | 7.01 | 6.80 | 95.2 | 24.60 | 11.46 | 21.00 | |
| | GY-131027-020-KM | Mokorowau, same as sample point GY-131024-003-KM | | | | 27-Oct-13 | 15:38 | Sunny | 27.4 | 7.96 | 7.84 | 100.8 | 52.90 | 24.80 | 7.38 | |
| 19 | GY-131027-021-KM | Mokorowau, upstream of sample point GY-131027-020-KM | N 02º 48.539' W 059º 51.907' | 176 | Nearly isolated pool in lip of sloping rock, rock substrate | 27-Oct-13 | 16:00 | Sunny | 25.6 | 7.13 | 7.56 | 95.0 | 51.10 | 24.20 | 7.97 | |
| | GY-131027-022-KM | Mokorowau, same as sample point GY-131024-002-KM | | | | 27-Oct-13 | 16:40 | Sunny | 27.1 | 7.06 | 7.02 | 90.2 | 53.70 | 25.20 | 8.13 | |
| 20 | GY-131028-023-KM | Tarayara Creek | N 02º 47.408' W 059º 54.007' | 123 | Creek, steep sides, water clear, overhanging vegetation, leaf litter, water flowing very slowly, shallow | 28-Oct-13 | 8:54 | Sunny | 26.5 | 5.93 | 2.47 | 31.3 | 67.50 | 31.70 | 14.40 | |
| 21 | GY-131028-024-KM | | N 02º 47.417' W 059º 54.042' | 138 | Creek, steep sides, water brown, overhanging vegetation, leaf litter, water flowing slowly | 28-Oct-13 | 9:20 | Sunny | 25.9 | 6.29 | 1.51 | 19.0 | 64.40 | 30.30 | 16.80 | |
| 22 | GY-131028-025-KM | | N 02º 47.430' W 059º 54.063' | 103 | Creek, steep sides, water brown, overhanging vegetation, leaf litter, water flowing slowly | 28-Oct-13 | 9:42 | Sunny | 26.0 | 6.40 | 3.84 | 48.0 | 68.10 | 32.00 | 11.30 | |
| 23 | GY-131028-026-KM | Cocosabana Lake (Taawaruo Lake) | N 02º 51.197' W 059º 55.337' | 108 | Wetland containing standing vegetation, water murky | 28-Oct-13 | 10:36 | Sunny | 29.5 | 6.61 | 3.50 | 46.6 | 26.00 | 12.22 | 129.00 | Pigs were in the water; a holding pen for livestock is situated next to lake |

| Sample Point Location # | Collection site ID | Name of water body | Location of sampling point | Elevation (m) | Description of sampling point | Date | Time | Weather condition | Temp (°C) | pH | DO (mg/L) | DO (% sat) | Cond (uS/cm) | TDS (mg/L) as NaCl | Turb (NTU) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 24 | GY-131028-027-KM | Small Sand Creek (Katuwau) downstream of Saddle Mountain crossing at Masorode | N 02° 53.714' W 059° 51.351' | 101 | Creek, flowing, downstream of water flowing over rocks (rapids) and downstream of sample point GY-131026-011-KM | 28-Oct-13 | 12:03 | Sunny | 31.6 | 6.81 | 6.83 | 95.1 | 21.92 | 10.22 | 17.20 | |
| 25 | GY-131028-028-KM | Ants Creek (Ziidawau), downstream of sample point GY-131025-009-KM | N 02° 49.806' W 059° 48.614' | 116 | Creek, almost stagnant, moco moco vegetation in the water, ité palms lining creek | 28-Oct-13 | 17:25 | Sun was beginning to set | 29.8 | 5.88 | 3.46 | 46.5 | 14.88 | 6.91 | 3.96 | |
| 26 | GY-131028-029-KM | Ants Creek (Ziidawau), downstream of sample point GY-131023-028-KM | N 02° 50.764' W 059° 49.255' | 109 | Creek, almost stagnant, moco moco vegetation in the water, ité palms lining creek | 28-Oct-13 | 17:45 | Sun was beginning to set | 27.9 | 6.20 | 5.13 | 66.8 | 27.80 | 12.54 | 5.55 | |

**B. Water Quality Management for Kusad Mountain**

| Sample Point Location # | Collection site ID | Name of water body | TKN (mg/L) | P (mg/L) | $NO_3^-$ (mg/L) | $NH_4^+$ (mg/L) | COD (mg/L) | Cd (mg/L) | Pb (mg/L) | Zn (mg/L) | Fe (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | GY-131024-001-KM | Takutu River at Lukanani landing | | | | | | | | | |
| 2 | GY-131024-002-KM | Mokorowau, upstream of camp at Kusad Mountain | | | | | | | | | |
| 3 | GY-131024-003-KM | Mokorowau, further upstream of camp at Kusad Mountain | 4.87 | 0.11 | ND | ND | 8 | 0.019 | 0.040 | 0.053 | ND |
| 4 | GY-131025-004-KM | Black Huri Lake (Suzukarishii) | 4.96 | 0.40 | ND | ND | 8 | 0.015 | 0.039 | 0.056 | ND |
| 5 | GY-131025-005-KM | | | | | | | | | | |
| 6 | GY-131025-006-KM | | | | | | | | | | |
| 7 | GY-131025-007-KM | | | | | | | | | | |
| 8 | GY-131025-008-KM | Ants Creek (Ziidawau) | 3.79 | 0.44 | ND | ND | 32 | 0.015 | 0.036 | 0.047 | ND |
| 9 | GY-131025-009-KM | Ants Creek (Ziidawau), downstream | 4.95 | 0.34 | ND | ND | 8 | 0.017 | 0.044 | 0.043 | ND |
| 10 | GY-131026-010-KM | Small Sand Creek (Katuwau), at Saddle Mountain crossing | 4.51 | 0.47 | ND | ND | 40 | 0.013 | 0.035 | 0.085 | ND |
| 11 | GY-131026-011-KM | | | | | | | | | | |
| 12 | GY-131026-012-KM | | | | | | | | | | |
| 13 | GY-131026-013-KM | | 5.80 | 0.69 | ND | ND | 8 | 0.018 | 0.06 | 0.111 | ND |
| 14 | GY-131026-014-KM | Small Sand Creek (Katuwau) upstream of Saddle Mountain crossing, at Kodowidpau downstream | | | | | | | | | |

| Sample Point Location # | Collection site ID | Name of water body | TKN (mg/L) | P (mg/L) | $NO_3^-$ (mg/L) | $NH_4^+$ (mg/L) | COD (mg/L) | Cd (mg/L) | Pb (mg/L) | Zn (mg/L) | Fe (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | GY-131026-015-KM | Small Sand Creek (Katuwau) upstream of Saddle Mountain crossing, at Kodowidpau upstream | 3.79 | 0.43 | ND | ND | 16 | 0.013 | 0.039 | 0.058 | ND |
| | GY-131027-016-KM | Takutu River at Lukanani landing | 3.23 | 0.68 | ND | ND | 24 | 0.017 | 0.047 | 0.068 | ND |
| 16 | GY-131027-017-KM | Daadawau | 4.50 | 0.81 | ND | ND | 8 | 0.015 | 0.045 | 0.057 | ND |
| 17 | GY-131027-018-KM | | 3.73 | 0.38 | ND | ND | 8 | 0.014 | 0.039 | 0.079 | ND |
| 18 | GY-131027-019-KM | Matabanwau near discharge into Takutu River | 2.71 | 0.33 | ND | ND | 16 | 0.018 | 0.042 | 0.065 | ND |
| | GY-131027-020-KM | Mokorowau, same as sample point GY-131024-003-KM | | | | | | | | | |
| 19 | GY-131027-021-KM | Mokorowau, upstream of sample point GY-131027-020-KM | | | | | | | | | |
| | GY-131027-022-KM | Mokorowau, same as sample point GY-131024-002-KM | 3.27 | 0.44 | ND | ND | 8 | 0.014 | 0.043 | 0.063 | ND |
| 20 | GY-131028-023-KM | Tarayara Creek | | | | | | | | | |
| 21 | GY-131028-024-KM | | 4.20 | 1.07 | ND | ND | 8 | 0.016 | 0.047 | 0.099 | ND |
| 22 | GY-131028-025-KM | | | | | | | | | | |
| 23 | GY-131028-026-KM | Cocosabana Lake (Taawaruo Lake) | 3.89 | 0.47 | ND | ND | 32 | 0.015 | 0.054 | 0.121 | ND |

**B. Water quality management for Kusad Mountain (*cont'd*)**

| Sample Point Location # | Collection site ID | Name of water body | TKN (mg/L) | P (mg/L) | $NO_3^-$ (mg/L) | $NH_4^+$ (mg/L) | COD (mg/L) | Cd (mg/L) | Pb (mg/L) | Zn (mg/L) | Fe (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 24 | GY-131028-027-KM | Small Sand Creek (Katuwau) downstream of Saddle Mountain crossing at Masorode | 3.68 | 0.41 | ND | ND | 24 | 0.014 | 0.052 | 0.085 | ND |
| 25 | GY-131028-028-KM | Ants Creek (Ziidawau), downstream of sample point GY-131025-009-KM | | | | | | | | | |
| 26 | GY-131028-029-KM | Ants Creek (Ziidawau), downstream of sample point GY-131023-028-KM | | | | | | | | | |

### C. Water Quality Management for Parabara Area

| Sample Point Location # | Collection site ID | Name of water body | Location of sampling point | Elevation (m) | Description of sampling point | Date | Time | Weather condition | Temp (°C) | pH | DO (mg/L) | DO (% sat) | Cond (uS/cm) | TDS (mg/L) as NaCl | Turb (NTU) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | GY-131031-001-PB | Mushaiwau | N 02º 09.564' W 059º 17.557' | 277 | Creek, water flowing fairly quickly around a rock in the water, upstream of bridge crossing creek | 31-Oct-13 | 9:25 | Sunny | 24.9 | 6.22 | 5.63 | 71.0 | 19.86 | 9.24 | 24.20 | Gallery forested area - forest vegetation lining creek |
| 2 | GY-131031-002-PB | | N 02º 09.591' W 059º 17.539' | 267 | Creek, water flowing fairly quickly, overhanging vegetation, upstream of Kamudi Creek (Packbywau) | 31-Oct-13 | 10:00 | Sunny | 24.9 | 6.27 | 5.76 | 72.0 | 21.76 | 10.1 4 | 21.20 | Gallery forested area - forest vegetation lining creek |
| 3 | GY-131031-003-PB | | N 02º 09.562' W 059º 17.567' | 264 | Creek water flowing fairly quickly, downstream of bridge crossing creek | 31-Oct-13 | 10:45 | Sunny | 25.2 | 6.12 | 5.74 | 72.0 | 19.64 | 9.14 | 18.80 | Gallery forested area - forest vegetation lining creek |
| 4 | GY-131031-004-PB | Wiriwiriwau | N 02º 09.050' W 059º 16.252' | 287 | Creek, water flowing fairly quickly, overhanging vegetation, upstream of bridge crossing creek | 31-Oct-13 | 12:05 | Sunny | 24.8 | 6.15 | 6.14 | 76.9 | 20.09 | 9.35 | 18.40 | Gallery forested area - forest vegetation lining creek |
| 5 | GY-131031-005-PB | | N 02º 09.069' W 059º 16.262' | 264 | Creek, water flowing fairly quickly, overhanging vegetation, downstream of bridge crossing creek | 31-Oct-13 | 12:22 | Sunny | 24.8 | 6.16 | 6.18 | 77.4 | 19.63 | 9.14 | 18.80 | Gallery forested area - forest vegetation lining creek |
| 6 | GY-131101-006-PB | Kuyuwini River | N 02º 05.763' W 059º 14.458' | 225 | River, rapid current, at landing on the left bank of river | 1-Nov-13 | 9:20 | Sunny | 31.5 | 6.35 | 5.73 | 72.4 | | | 28.90 | Forested area - forest vegetation lining river |

**C. Water quality management for Parabara area (*cont'd*)**

| Sample Point Location # | Collection site ID | Name of water body | Location of sampling point | Elevation (m) | Description of sampling point | Date | Time | Weather condition | Temp (°C) | pH | DO (mg/L) | DO (% sat) | Cond (uS/cm) | TDS (mg/L) as NaCl | Turb (NTU) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7 | GY-131101-007-PB | Marudi Creek (mouth) | N 02° 04.725' W 059° 11.198' | 248 | Creek, water flowing slowly, overhanging vegetation, water is murky and has high sediment load | 1-Nov-13 | 11:35 | Sunny | 24.7 | 6.46 | 6.36 | 79.6 | 25.30 | 11.79 | 154.00 | Forested area - forest vegetation lining Creek. Mining is being done in the creek |
| 8 | GY-131101-008-PB | Kuyuwini River, downstream of Marudi Creek | | | River, rapid current | 1-Nov-13 | | Sunny | 26.3 | 6.36 | 5.66 | 72.5 | 19.69 | 9.17 | 32.70 | Forested area - forest vegetation lining river |
| 9 | GY-131101-009-PB | Kuyuwini River, downstream of sample point GY-131101-008-PB | N 02° 04.541' W 059° 11.131' | 238 | River, rapid current | 1-Nov-13 | 12:20 | Sunny | 29.3 | 6.41 | 5.77 | 76.2 | 18.53 | 8.62 | 27.30 | Forested area - forest vegetation lining river |
| 10 | GY-131101-010-PB | Lmy Creek, upstream of Marudi Creek | N 02° 04.575' W 059° 11.514' | 239 | Creek, water flowing slowly, overhanging vegetation | 1-Nov-13 | 13:05 | Sunny | 26.3 | 6.21 | 5.35 | 69.2 | | | 27.00 | Forested area - forest vegetation lining creek |
| 11 | GY-131101-011-PB | Kuyuwini River, upstream of Lmy Creek | N 02° 04.649' W 059° 11.974' | 243 | River, rapid current | 1-Nov-13 | 13:45 | Sunny | 27.0 | 6.34 | 5.45 | 71.3 | | | 39.40 | Forested area - forest vegetation lining river |
| 12 | GY-131101-012-PB | Tiger Head Creek - Kohmara Fitho, upstream of sample point GY-131101-011-PB | N 02° 04.703' W 059°13 .282' | 246 | Creek, water flowing slowly, overhanging vegetation | 1-Nov-13 | 14:40 | Sunny | 25.0 | 6.08 | 5.34 | 68.5 | | | 42.60 | Forested area - forest vegetation lining creek |
| 13 | GY-131101-013-PB | Kuyuwini River, upstream of Tiger Head Creek | N 02° 05.088' W 059° 13.317' | 230 | River, rapid current | 1-Nov-13 | 15:00 | Sunny | 29.1 | 6.34 | 5.45 | 70.5 | | | 32.00 | Forested area - forest vegetation lining river |

| Sample Point Location # | Collection site ID | Name of water body | Location of sampling point | Elevation (m) | Description of sampling point | Date | Time | Weather condition | Temp (°C) | pH | DO (mg/L) | DO (% sat) | Cond (uS/cm) | TDS (mg/L) as NaCl | Turb (NTU) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 14 | GY-131102-014-PB | Kuyuwini River, upstream of landing | N 02º 05.906' W 059º 14.931' | 234 | River, rapid current | 2-Nov-13 | 8:49 | Sunny | 25.9 | 6.37 | 5.74 | 72.5 | 21.90 | 20.2 | 23.90 | Forested area - forest vegetation lining river |
| 15 | GY-131102-015-PB | Unnamed creek - Old man's Farm, Henry's Mouth, upstream of point GY-131102-014-PB | N 02º 05.273' W 059º 15.204' | 224 | Creek, water flowing slowly, overhanging vegetation, leaf litter in the water | 2-Nov-13 | 9:06 | Sunny | 24.0 | 6.02 | 1.11 | 13.6 | 35.40 | 16.5 5 | 35.80 | Forested area - forest vegetation lining creek |
| 16 | GY-131103-016-PB | Bototowau | | 283 | Creek, water clear and flowing, overhanging vegetation, litter visible at bottom of creek | 3-Nov-13 | 9:45 | Sunny | 24.5 | 6.05 | 6.16 | 77.1 | 12.64 | 5.86 | 8.26 | Gallery forested area - forest vegetation lining creek |
| 17 | GY-131103-017-PB | Bototowau, upstream of sample point GY-131103-016-PB | N 02º 10.880' W 059º 20.314' | 290 | Creek, water clear and flowing, overhanging vegetation, litter visible at bottom of creek | 3-Nov-13 | 10:10 | Sunny | 24.6 | 5.90 | 5.48 | 68.2 | 14.01 | 6.49 | 10.90 | Gallery forested area - forest vegetation lining creek |
| 18 | GY-131103-018-PB | Bototowau, upstream of sample point GY-131103-017-PB and upstream of the bridge crossing the creek | N 02º 10.878' W 059º 20.296' | 398 | Creek, water clear and flowing, overhanging vegetation, litter visible at bottom of creek | 3-Nov-13 | 10:35 | Sunny | | 6.08 | 5.38 | 67.2 | 13.15 | 6.11 | 11.80 | Gallery forested area - forest vegetation lining creek |

**C. Water quality management for Parabara area (*cont'd*)**

| Sample Point Location # | Collection site ID | Name of water body | Location of sampling point | Elevation (m) | Description of sampling point | Date | Time | Weather condition | Temp (ºC) | pH | DO (mg/L) | DO (% sat) | Cond (uS/cm) | TDS (mg/L) as NaCl | Turb (NTU) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 19 | GY-131103-019-PB | Bototowau, upstream of sample point GY-131103-018-PB | N 02º 10.935' W 059º 20.327' | 339 | Creek, water clear and flowing, overhanging vegetation, litter visible at bottom of creek | 3-Nov-13 | 10:57 | Sunny | 24.8 | 6.06 | 6.18 | 77.3 | 13.38 | 6.21 | 11.20 | Gallery forested area - forest vegetation lining creek |
| 20 | GY-131103-020-PB | Unnamed creek | N 02º 10.809' W 059º 20.271' | 361 | Creek, water clear and flowing, overhanging vegetation | 3-Nov-13 | 11:25 | Sunny | 25.2 | 5.84 | 6.30 | 79.0 | 9.65 | 4.49 | 3.51 | Gallery forested area - forest vegetation lining creek |
| 21 | GY-131104-021-PB | Unnamed creek, wetland | N 02º 10.905' W 059º 20.548' | 265 | Wetland, rooted vegetation present, water clear | 4-Nov-13 | 9:30 | Cloudy | 26.2 | 5.59 | 1.43 | 18.3 | 10.49 | 4.85 | 0.65 | At edge of gallery forested area |
| 22 | GY-131104-022-PB | | | | | 4-Nov-13 | | Cloudy | 26.1 | 5.65 | 2.36 | 30.4 | 9.14 | 4.21 | 0.61 | At edge of gallery forested area |
| 23 | GY-131104-023-PB | | | | | 4-Nov-13 | | Cloudy | 26.7 | 5.58 | 2.89 | 37.1 | 8.59 | 3.94 | 0.54 | At edge of gallery forested area |
| 24 | GY-131104-024-PB | Unnamed creek, downstream of wetland | N 02º 10.930' W 059º 20.486' | 265 | Creek, clear water, water flowing, overhanging vegetation, moss visible near bottom, water clear | 4-Nov-13 | 10:11 | Cloudy | 25.9 | 5.60 | 4.67 | 59.8 | 8.85 | 4.08 | 2.89 | At edge of gallery forested area |
| 25 | GY-131104-025-PB | Bototowau, upstream of sample point GY-131103-019-PB | N 02º 11.315' W 059º 20.644' | 283 | Creek, water almost stagnant, at a fishing pond, overhanging vegetation | 4-Nov-13 | 11:00 | Cloudy | 25.1 | 5.46 | 2.75 | 34.6 | 10.61 | 4.90 | 4.54 | Gallery forested area - forest vegetation lining creek; fishing area |

**D. Water Quality Measurements for Parabara area**

| Sample Point Location # | Collection site ID | Name of water body | TKN (mg/L) | P (mg/L) | $NO_3^-$ (mg/L) | $NH_4^+$ (mg/L) | COD (mg/L) | Cd (mg/L) | Pb (mg/L) | Zn (mg/L) | Fe (mg/L) | Hg (ug/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | GY-131031-001-PB | Mushaiwau | 3.29 | 0.48 | ND | ND | 16 | 0.015 | 0.052 | 0.072 | ND | |
| 2 | GY-131031-002-PB | | 3.24 | 0.62 | ND | ND | 16 | 0.017 | 0.059 | 0.064 | ND | |
| 3 | GY-131031-003-PB | | | | | | | | | | | |
| 4 | GY-131031-004-PB | Wiriwiriwau | 3.01 | 1.05 | ND | ND | 24 | 0.017 | 0.057 | 0.064 | ND | |
| 5 | GY-131031-005-PB | | 3.99 | 0.63 | ND | ND | 24 | 0.017 | 0.061 | 0.066 | ND | |
| 6 | GY-131101-006-PB | Kuyuwini River | | | | | | | | | | |
| 7 | GY-131101-007-PB | Marudi Creek (mouth) | 3.30 | 0.80 | ND | ND | 16 | 0.018 | 0.057 | 0.065 | ND | 4.64 |
| 8 | GY-131101-008-PB | Kuyuwini River, downstream of Marudi Creek | | | | | | | | | | |
| 9 | GY-131101-009-PB | Kuyuwini River, downstream of sample point GY-131101-008-PB | | | | | | | | | | |
| 10 | GY-131101-010-PB | Lmy Creek, upstream of Marudi Creek | 2.69 | 0.38 | ND | ND | 8 | 0.020 | 0.054 | 0.067 | ND | |
| 11 | GY-131101-011-PB | Kuyuwini River, upstream of Lmy Creek | | | | | | | | | | |
| 12 | GY-131101-012-PB | Tiger Head Creek - Kohmara Fitho, upstream of sample point GY-131101-011-PB | 3.73 | 0.33 | ND | ND | 8 | 0.016 | 0.056 | 0.065 | ND | |
| 13 | GY-131101-013-PB | Kuyuwini River, upstream of Tiger Head Creek | 4.21 | 0.44 | ND | ND | 16 | 0.017 | 0.070 | 0.065 | ND | 4.55 |
| 14 | GY-131102-014-PB | Kuyuwini River, upstream of landing | 3.38 | 0.41 | ND | ND | 8 | 0.014 | 0.064 | 0.065 | ND | |

**D. Water Quality Measurements for Parabara area (*cont'd*)**

| Sample Point Location # | Collection site ID | Name of water body | TKN (mg/L) | P (mg/L) | $NO_3^-$ (mg/L) | $NH_4^+$ (mg/L) | COD (mg/L) | Cd (mg/L) | Pb (mg/L) | Zn (mg/L) | Fe (mg/L) | Hg (ug/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | GY-131102-015-PB | Unnamed creek - Old Man's Farm, Henry's Mouth, upstream of point GY-131102-014-PB | 4.51 | 0.35 | ND | ND | 16 | 0.017 | 0.065 | 0.066 | ND | |
| 16 | GY-131103-016-PB | Bototowau | 4.96 | 0.41 | ND | ND | 8 | 0.015 | 0.055 | 0.068 | ND | |
| 17 | GY-131103-017-PB | Bototowau, upstream of sample point GY-131103-016-PB | | | | | | | | | | |
| 18 | GY-131103-018-PB | Bototowau, upstream of sample point GY-131103-017-PB and upstream of the bridge crossing the creek | | | | | | | | | | |
| 19 | GY-131103-019-PB | Bototowau, upstream of sample point GY-131103-018-PB | 4.88 | 0.76 | ND | ND | 16 | 0.016 | 0.046 | 0.068 | ND | |
| 20 | GY-131103-020-PB | Unnamed creek | | | | | | | | | | |
| 21 | GY-131104-021-PB | Unnamed creek, wetland | 3.68 | 0.31 | ND | ND | 16 | 0.014 | 0.047 | 0.065 | ND | |
| 22 | GY-131104-022-PB | | | | | | | | | | | |
| 23 | GY-131104-023-PB | | | | | | | | | | | |
| 24 | GY-131104-024-PB | Unnamed creek, downstream of wetland | 2.96 | 0.10 | ND | ND | 8 | 0.013 | 0.033 | 0.068 | ND | |
| 25 | GY-131104-025-PB | Bototowau, upstream of sample point GY-131103-019-PB | 2.79 | 0.15 | ND | ND | 8 | 0.014 | 0.054 | 0.068 | ND | |

**Appendix 9**
**List of 168 fish species of the South Rupununi region, Guyana**
**<u>Key</u>**
**Species possibly new to science are highlighted in pale green**

| | | | | Kusad Area (Amazon Basin) | | | | | | | | | | | | | | | Both | Parabara Area (Essequibo Basin) | | | | | | | | | Endemic | Rare | New Record |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | GUY13- | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | | | |
| **Order** | **Family** | **Genus** | **species** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Characiformes | Acestrorhynchidae | *Acestrorhynchus* | *falcatus* | | | | | | | | | | | | | | | | | 1 | | | | 1 | 1 | | 1 | | | | |
| Characiformes | Acestrorhynchidae | *Acestrorhynchus* | *microlepis* | | | | | | | | | | | | 1 | | | 1 | 1 | | | | | | 1 | | 1 | | | | |
| Characiformes | Acestrorhynchidae | *Acestrorhynchus* | sp. | | | | | | | | | | | | | | | | | | | | | | 1 | | | 1 | | | |
| Characiformes | Anostomidae | *Anostomus* | *anostomus* | | | | | | | | | | | | | | | | | | 1 | | | | 1 | | | | | | |
| Characiformes | Anostomidae | *Leporellus* | *vittatus* | | | | | | | | | | | 1 | | | | | | | | | | | | | | | | | |
| Characiformes | Anostomidae | *Leporinus* | *friderici* group | | | | | | | | | | | | | | | | | 1 | | | | | 1 | | 1 | | | | |
| Characiformes | Anostomidae | *Leporinus* | *ortomaculatus* | | | 1 | | | | 1 | 1 | 1 | | 1 | | | | 1 | | | | | | | | | | | 1 | 1 | |
| Characiformes | Anostomidae | *Leporinus* | *nigrotaeniatus* | | | | | | | | | | | 1 | | | | | 1 | | | | | | | | 1 | | | | |
| Characiformes | Bryconidae | *Brycon* | *falcatus* group | | | | | | | | | | | | | | | 1 | | | | | | | | | | | | | |
| Characiformes | Chalceidae | *Chalceus* | *macrolepidotus* | | | | | | | | | | | | | | | | | | | 1 | | | 1 | | 1 | | | | |
| Characiformes | Characidae | *Aphyocharax* | *erythrurus* | | | 1 | | | 1 | 1 | 1 | | | | | | | 1 | 1 | | 1 | 1 | | 1 | | | | | | | |
| Characiformes | Characidae | *Aphyocharax* | sp. "slender" | | | | | | | | | | | | | | | | | 1 | | | | | | | | | | 1 | |
| Characiformes | Characidae | *Astyanax* | *guianensis* | | | | | | | | | | | | | | | 1 | | | | | | | | | | | 1 | 1 | |
| Characiformes | Characidae | *Astyanax* | *rupununi* | | 1 | | | | 1 | | | | | | | | | | 1 | | | | | | | | | 1 | 1 | | |
| Characiformes | Characidae | *Bryconamericus* | *hyphesson* | | | 1 | | | | 1 | 1 | | | | | | | | | | | | | | | | | | 1 | 1 | |
| Characiformes | Characidae | *Charax* | sp. | | | | | | | | | | | | | | | | | | | | | | 1 | | | | | | |
| Characiformes | Characidae | *Creagrutus* | *melanzonus* | | | 1 | | | | | | | | | | | | | | | | | | | | | | | 1 | 1 | |
| Characiformes | Characidae | *Ctenobrycon* | *spilurus* | | | 1 | | | 1 | | 1 | | | | | | | | | | | | | | | | | | | | |
| Characiformes | Characidae | *Cynopotamus* | *essequibensis* | | | | | | | | | | | 1 | | | | | 1 | | | | | | 1 | | 1 | | 1 | | |
| Characiformes | Characidae | *Exodon* | *paradoxus* | | | 1 | | | | | | | | 1 | | | | | | | | | | | | | | | | | |
| Characiformes | Characidae | *Gnathocharax* | *steindachneri* | | | | | | 1 | | | | | | 1 | | | | | | | | | | | | | | | | |
| Characiformes | Characidae | *Hemigrammus* | *bellottii* | | | | | | 1 | | | | | | 1 | 1 | | | 1 | 1 | | | | | | 1 | | | | | |
| Characiformes | Characidae | *Hemigrammus* | *levis* | | | 1 | | | 1 | | 1 | | | | 1 | | | 1 | | | | | | | | | | | | | |
| Characiformes | Characidae | *Hemigrammus* | *micropterus* | | | 1 | | | | | 1 | | | | | | | | | | | | | | | | | | | | 1 |
| Characiformes | Characidae | *Hemigrammus* | *ocellifer* | | | | | | | | | | | | | | | | | | 1 | | 1 | 1 | | | | | | | |
| Characiformes | Characidae | *Hemigrammus* | *orthus* | | | | | | | | | | | | 1 | | | | | | | | | | | | | | | 1 | |
| Characiformes | Characidae | *Hemigrammus* | *rodwayi* | | | | | | 1 | | 1 | | | | | | | | | | | | | | | | | | | | |
| Characiformes | Characidae | *Hemigrammus* | sp. | | | | | | | | | | | | | | | | | 1 | | | | | | | | | | | |
| Characiformes | Characidae | *Hemigrammus* | *stictus* | | | | | | 1 | | | | | | 1 | | | | | | | | | | | | | | | | |
| Characiformes | Characidae | *Hemigrammus* | *unilineatus* | | | | | | | | | | | | | | | | | | | | | | | | | 1 | | | |
| Characiformes | Characidae | *Hemigrammus* | *vorderwinkleri* | | | | | | | | | | | | | | | | | | | | | | | 1 | | | | | |

## List of 168 fish species of the South Rupununi region, Guyana (*cont'd*)

| | | | | Kusad Area (Amazon Basin) | | | | | | | | | | | | | | | Both | Parabara Area (Essequibo Basin) | | | | | | | | | Endemic | Rare | New Record |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Characiformes | Characidae | *Hyphessobrycon* | *bentosi* | | | | | | | | | | | | | | | | | | | 1 | | | | | | | | 1 | 1 |
| Characiformes | Characidae | *Hyphessobrycon* | cf. *gracilis* | | | 1 | | | | | | | | | | | | 1 | | | | | | | | | | | | | |
| Characiformes | Characidae | *Hyphessobrycon* | *minor* | | | | | | 1 | | | | | | 1 | | 1 | | 1 | | 1 | 1 | 1 | 1 | | | | | | | |
| Characiformes | Characidae | *Jupiaba* | *abramoides* | | | | | | | | | | | | | | | | | 1 | | | | | | | | | | | |
| Characiformes | Characidae | *Jupiaba* | cf. *essequibensis* | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | 1 | |
| Characiformes | Characidae | *Jupiaba* | *essequibensis* | | | | | | | | 1 | | | | | | | | 1 | | | 1 | | | | | | | 1 | | |
| Characiformes | Characidae | *Jupiaba* | *mucronata* | | | | | | | | | | | | | | | | | 1 | | | | | | | | | 1 | 1 | |
| Characiformes | Characidae | *Jupiaba* | *pinnata* | | | | | | | 1 | | | | | | | | | | | | | | | | | | | 1 | | |
| Characiformes | Characidae | *Jupiaba* | *polylepis* | | | 1 | | | | 1 | 1 | | | | | | | 1 | 1 | | | | | | 1 | | | | | | |
| Characiformes | Characidae | *Jupiaba* | *potaroensis* | | | | | | | | 1 | | | | | | | | | | | | | | | | | | 1 | | |
| Characiformes | Characidae | *Microschemobrycon* | *casiquiare* | | | 1 | | | | | | | | | | | | 1 | | | | | | | | | | | | | |
| Characiformes | Characidae | *Moenkhausia* | *collettii* | | | | | | | | 1 | | | | 1 | | | 1 | | | | | | | | | | | | | |
| Characiformes | Characidae | *Moenkhausia* | *copei* group | | | 1 | | | 1 | | 1 | | | | | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | | | | | |
| Characiformes | Characidae | *Moenkhausia* | *lepidura* group | | | 1 | | | | | 1 | | | | | | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | | | | |
| Characiformes | Characidae | *Moenkhausia* | *oligolepis* | | | | | | 1 | | | | | | | | | | 1 | 1 | 1 | | | | | | | 1 | | | |
| Characiformes | Characidae | *Moenkhausia* | sp. | | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | |
| Characiformes | Characidae | *Parapristella* | *aubynei* | | | | | 1 | 1 | | 1 | | 1 | | 1 | | 1 | 1 | | | | | | | | | | | | | |
| Characiformes | Characidae | *Phenacogaster* | *carteri* | | | | | | | | 1 | | | | | | | | 1 | | 1 | | | 1 | | | | | | | |
| Characiformes | Characidae | *Phenacogaster* | *microstictus* | | | | | | 1 | | | | | | | | | 1 | 1 | 1 | | | 1 | | | | | 1 | | | |
| Characiformes | Characidae | *Poptella* | *longipinnis* | | | | | | 1 | | | | | | | | | | 1 | | | | | 1 | 1 | | 1 | | | | |
| Characiformes | Characidae | *Roeboides* | *thurni* | | | | | | | | | | | | | | | | | | | | | | | | 1 | | 1 | 1 | |
| Characiformes | Characidae | *Serrapinnis* | cf. *gracilis* | | | | | | 1 | | 1 | | | | | | | 1 | 1 | | 1 | | | | | | | | | | |
| Characiformes | Characidae | *Tetragonopterus* | *chalceus* | | | | | | | | | | | 1 | | | | | 1 | | | | | | | | 1 | | | | |
| Characiformes | Chilodontidae | *Caenotropus* | *maculosus* | | | | | | | | | | | | | | | | | | | | | | | | 1 | | | | |
| Characiformes | Chilodontidae | *Chilodus* | *punctatus* | | | | | | | | | | | | 1 | | | | | | | | | | | | | | | | |
| Characiformes | Crenuchidae | *Characidium* | *hasemani* | | | 1 | | | | | 1 | | | | | | | | | | | | | | | | | | 1 | | |
| Characiformes | Crenuchidae | *Characidium* | sp. | | | | | | | | | | | | | | | | | | 1 | | | | | | | | | 1 | |
| Characiformes | Crenuchidae | *Characidium* | *steindachneri* | | | | | | | | | | | | | | | | | 1 | | 1 | 1 | 1 | | | | | | | |
| Characiformes | Ctenoluciidae | *Boulengerella* | *cuvieri* | | | 1 | | | | 1 | 1 | | | 1 | | | | 1 | | | | | | | | | | | | | |
| Characiformes | Curimatidae | *Curimata* | *cyprinoides* | | | 1 | | | | | | | | 1 | | | | | | | | | | | | | | | | | |
| Characiformes | Curimatidae | *Curimatella* | *immaculata* | | | | | | 1 | | | | | | 1 | | | 1 | | | | | | | | | | | | | |
| Characiformes | Curimatidae | *Cyphocharax* | *microcephalus* | | | | | | | | | | | | | | | | | 1 | | | 1 | | | | | | | 1 | |
| Characiformes | Curimatidae | *Cyphocharax* | sp. | | | | | | | | | | | | | | | | | | 1 | | | | | | | | | | |
| Characiformes | Curimatidae | *Cyphocharax* | *spilurus* | | | 1 | | | 1 | 1 | 1 | | | | 1 | | | 1 | 1 | 1 | 1 | 1 | | 1 | 1 | | 1 | | | | |
| Characiformes | Curimatidae | *Psectrogaster* | *essequibensis* | | | | | | | | | | | | | | | | | | | | | | 1 | | | | | | |
| Characiformes | Erythrinidae | *Erythrinus* | *erythrinus* | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | |
| Characiformes | Erythrinidae | *Hoplerythrinus* | *unitaeniatus* | | | | | | 1 | | | | | | | 1 | | | 1 | 1 | | | | | | | | | | | |

| | | | | Kusad Area (Amazon Basin) | | | | | | | | | | | | | | | Both | Parabara Area (Essequibo Basin) | | | | | | | | | Endemic | Rare | New Record |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Characiformes | Erythrinidae | *Hoplias* | *aimara* | | | | | | | | | | | | | | | | | | | | | | | | 1 | | | | |
| Characiformes | Erythrinidae | *Hoplias* | *malabaricus* | | | | | | 1 | | | 1 | | | | | 1 | 1 | 1 | | 1 | | | 1 | 1 | | 1 | 1 | | | |
| Characiformes | Hemiodontidae | *Argonectes* | *longiceps* | | | | | | | | | | | 1 | | | | | | | | | | | | | | | | | |
| Characiformes | Hemiodontidae | *Bivibranchia* | *fowleri* | | | | | | | 1 | 1 | 1 | | | | | | 1 | | | | | | | | | | | | | |
| Characiformes | Hemiodontidae | *Hemiodus* | *argenteus* | | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | |
| Characiformes | Hemiodontidae | *Hemiodus* | *goeldii* | | | | | | | 1 | 1 | | | | | | | | | | | | | | | | | | | | 1 |
| Characiformes | Hemiodontidae | *Hemiodus* | *unimaculatus* | | | 1 | | | | | 1 | 1 | | 1 | | | | 1 | 1 | | | | | | 1 | | 1 | | | | |
| Characiformes | Iguanodectidae | *Bryconops* | *affinis* | | | | | | 1 | | | | | | 1 | | | | 1 | 1 | | 1 | 1 | | 1 | | | | | | |
| Characiformes | Iguanodectidae | *Bryconops* | *alburnoides* | | | | | | | 1 | 1 | | | | | | | | | | | | | | | | | | | | |
| Characiformes | Iguanodectidae | *Bryconops* | *caudomaculatus* | | | 1 | | | | | | | | | | | | | 1 | | | | | | | | 1 | | | | |
| Characiformes | Iguanodectidae | *Bryconops* | *giacopinii* | | | | | | | | | | | | | | | 1 | | | | | | | | | | | | | |
| Characiformes | Lebiasinidae | *Copella* | *meinkeni* | | | | | | | | | | 1 | | 1 | | | | | | | | | | | | | | | | |
| Characiformes | Lebiasinidae | *Nannostomus* | *harrisoni* | | | | | 1 | | | 1 | | | | | | | | | | | | | | | | | | 1 | | |
| Characiformes | Lebiasinidae | *Nannostomus* | *marginatus* | | | | | | 1 | | | | | | 1 | | | | 1 | 1 | | 1 | | 1 | | 1 | | | | | |
| Characiformes | Lebiasinidae | *Nannostomus* | sp. | | | | | | | | | | | | 1 | | 1 | | 1 | | 1 | | | | | | | | | | |
| Characiformes | Lebiasinidae | *Nannostomus* | *trifasciatus* | | | | | | | | | | | | 1 | | | | | | | | | | | | | | | | |
| Characiformes | Lebiasinidae | *Pyrrhulina* | cf. *lugubris* | | | | | | 1 | | | | | | | | | | | | | | | 1 | | | | | | | |
| Characiformes | Lebiasinidae | *Pyrrhulina* | *filamentosa* | | | | | | | | | | | | | | | | | 1 | 1 | | | | | | | | | | |
| Characiformes | Lebiasinidae | *Pyrrhulina* | sp. | | | | | | | | | | | | | 1 | | | | | | | | | | | | | | | |
| Characiformes | Lebiasinidae | *Pyrrhulina* | *stoli* | 1 | 1 | | | | | 1 | 1 | | | | | | | | 1 | | | | | 1 | | | | 1 | | | |
| Characiformes | Parodontidae | *Apareiodon* | sp. | | | | | | | | | | | | | | | | | 1 | | | | | | | | | | 1 | |
| Characiformes | Parodontidae | *Parodon* | *bifasciatus* | | | 1 | | | | | | | | | | | | | | | | | | | | | | | 1 | 1 | |
| Characiformes | Parodontidae | *Parodon* | cf. *apolinari* | | | | | | | | | 1 | | | | | | | | | | | | | | | | | | 1 | |
| Characiformes | Prochilodontidae | *Prochilodus* | *nigricans* | | | | | | | | | 1 | | | | | | | | | | | | | | | | | | | 1 |
| Characiformes | Prochilodontidae | *Prochilodus* | *rubrotaeniatus* | | | | | | | | | | | | | | | | | | | | | | | | 1 | | | | |
| Characiformes | Serrasalmidae | *Myloplus* | *rubripinnis* | | | | | | | | | | | 1 | | | | | 1 | | | | | | 1 | | 1 | | | | |
| Characiformes | Serrasalmidae | *Myloplus* | sp. | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | |
| Characiformes | Serrasalmidae | *Pristobrycon* | sp. | | | | | | | | | | | | | | | 1 | | | | | | | | | | | | | |
| Characiformes | Serrasalmidae | *Pygocentrus* | *nattereri* | | | | | | | | | | | | | | | 1 | | | | | | | | | | | | | |
| Characiformes | Serrasalmidae | *Pygopristis* | *denticulata* | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | |
| Characiformes | Serrasalmidae | *Serrasalmus* | *rhombeus* | | | | | | | | 1 | | | 1 | | | | | 1 | | | | | | 1 | | 1 | | | | |
| Characiformes | Serrasalmidae | *Serrasalmus* | sp. | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | |
| Characiformes | Triportheidae | *Triportheus* | *brachipomus* | | | | | | | | | | | | | | | | | | | | | | 1 | | 1 | | | | |
| Cyprinodontiformes | Cynolebiidae | *Rivulus (Anablepsoide* | sp. | | | | | | | | | | | | | | | | | | | | | | | | | 1 | 1 | 1 | |
| Gymnotiformes | Apteronotidae | *Porotergus* | *gymnotus* | | | | | | | | | | | 1 | | | | | | | | | | | | | | | | 1 | |
| Gymnotiformes | Gymnotidae | *Gymnotus* | *carapo* group | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | |
| Gymnotiformes | Hypopomidae | *Brachyhypopomus* | *brevirostris* | | | | | | 1 | | | | | | | | 1 | | | | | | | | | | | | | | |

**List of 168 fish species of the South Rupununi region, Guyana (*cont'd*)**

| | | | | Kusad Area (Amazon Basin) | | | | | | | | | | | | | | | Both | Parabara Area (Essequibo Basin) | | | | | | | | | Endemic | Rare | New Record |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Gymnotiformes | Hypopomidae | *Hypopygus* | *lepturus* | | | | | | 1 | | | | | | | | | | 1 | 1 | | | | | | | | | | | |
| Gymnotiformes | Hypopomidae | *Hypopygus* | sp. | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | |
| Gymnotiformes | Rhamphichthyidae | *Gymnorhamphichthys* | *hypostomus* | | | | | | | | | | | | | | | | | 1 | | | | | | | | | | | |
| Gymnotiformes | Sternopygidae | *Eigenmannia* | cf. *macrops* | | | | | | | | | | | | | | | | | | | | | | 1 | | | | | | |
| Gymnotiformes | Sternopygidae | *Eigenmannia* | *virescens* | | | | | | 1 | | | | | | 1 | | | | 1 | 1 | | | | | | | | | | | |
| Gymnotiformes | Sternopygidae | *Sternopygus* | *macrurus* | | | | | | | | | | | | | | | | | 1 | | | | | | | | | | | |
| Perciformes | Cichlidae | *Acaronia* | *nassa* | | | | | | 1 | | 1 | | | | | | | | | | | | | | | | | | | | |
| Perciformes | Cichlidae | *Aequidens* | *tetramerus* | | | | | | | | | | | | | | | | | | | | | | 1 | | | | | | |
| Perciformes | Cichlidae | *Apistogramma* | sp. | | | | | | | | | | | | | | | | | | | 1 | | | | | | | | | |
| Perciformes | Cichlidae | *Apistogramma* | *steindachneri* | | | | | | 1 | 1 | 1 | | 1 | | | | 1 | | 1 | | | | | 1 | | | | | | | |
| Perciformes | Cichlidae | *Biotodoma* | *cupido* | | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | |
| Perciformes | Cichlidae | *Caquetaia* | *spectabilis* | | | | | | | | | 1 | | | | | | | | | | | | | | | | | | | 1 |
| Perciformes | Cichlidae | *Cichla* | sp. | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | |
| Perciformes | Cichlidae | *Cichlasoma* | *amazonarum* | | | | | | 1 | 1 | | | | | | | | | | | | | | | | | | | | | |
| Perciformes | Cichlidae | *Crenicichla* | *alta* | | | | | | 1 | | | | | | | | 1 | | 1 | 1 | | | | 1 | | | 1 | 1 | | | |
| Perciformes | Cichlidae | *Crenicichla* | cf. *alta* | | | | | | | | | 1 | | | | | | | | | | | | | | | | | | | |
| Perciformes | Cichlidae | *Crenicichla* | *lenticulata* | | | | | | | | | | | | | | | | | | | | | 1 | | | 1 | | | | 1 |
| Perciformes | Cichlidae | *Crenicichla* | *lugubris* | | | | | | | | | | | | | | | 1 | 1 | | | | | 1 | | | | | | | |
| Perciformes | Cichlidae | *Crenicichla* | *wallacii* | | | | | | 1 | | | | | | 1 | | | | | | | | | | | | | | | | |
| Perciformes | Cichlidae | *Geophagus* | sp. | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | |
| Perciformes | Cichlidae | *Geophagus* | sp. "takutu" | | | 1 | | | | | | 1 | | 1 | | | | 1 | | | | | | | | | | | 1 | | |
| Perciformes | Cichlidae | *Guianacara* | *dacrya* | | | 1 | | | | 1 | 1 | 1 | | | 1 | | | 1 | 1 | 1 | | | | 1 | 1 | | 1 | | 1 | | |
| Perciformes | Cichlidae | *Mesonauta* | *guyanae* | | | | | | 1 | | 1 | 1 | | | 1 | | | 1 | | | | | | | | | | | 1 | | |
| Perciformes | Cichlidae | *Satanoperca* | sp. | | | | | | | | | | | | | | | 1 | | | | | | | | | | | | | |
| Pleuronectiformes | Achiridae | *Hypoclinemus* | *mentalis* | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | |
| Siluriformes | Auchenipteridae | *Ageneiosus* | *inermis* | | | | | | | | | | | | | | | | | | | | | | 1 | | 1 | | | | |
| Siluriformes | Auchenipteridae | *Tatia* | *intermedia* | | | | | | | | | | | | | | | | | | | | | | | | 1 | | | | |
| Siluriformes | Auchenipteridae | *Trachelyopterus* | *galeatus* | | | | | | 1 | | | | | | | | | 1 | 1 | 1 | | | | | | | | | | | |
| Siluriformes | Callichthyidae | *Callichthys* | *callichthys* | | | | | | | | | | | | | 1 | | | | | | | | | | | | | | | |
| Siluriformes | Callichthyidae | *Corydoras* | cf. *breei* | | | | | | | | | | | | | | | | | | 1 | | | | | | | | 1 | 1 | |
| Siluriformes | Callichthyidae | *Megalechis* | *thoracata* | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | |
| Siluriformes | Cetopsidae | *Cetopsidium* | *soniae* | | | | | | | | | 1 | | | | | | | | | | | | | | | | | 1 | 1 | |
| Siluriformes | Cetopsidae | *Cetopsis* | sp. | | | | | | | | | | | | | | | 1 | | | | | | | | | | | | | |
| Siluriformes | Doradidae | *Doras* | *carinatus* | | | | | | | | | | | | | | | | | | | | | | 1 | | 1 | | | | |
| Siluriformes | Doradidae | *Leptodoras* | *linnelli* | | | | | | | | | | | 1 | | | | | | | | | | | | | | | | | |
| Siluriformes | Doradidae | *Tenellus* | *leporhinus* | | | | | | | | | | | 1 | | | | | | | | | | | | | | | | | |
| Siluriformes | Heptapteridae | *Imparfinis* | cf. *hasemani* | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | |

| | | | | Kusad Area (Amazon Basin) | | | | | | | | | | | | | | | Both | Parabara Area (Essequibo Basin) | | | | | | | | | Endemic | Rare | New Record |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Siluriformes | Heptapteridae | *Pimelodella* | sp. | | 1 | | | | | | | 1 | | | | | | | 1 | | 1 | | | 1 | 1 | | 1 | | | | |
| Siluriformes | Heptapteridae | *Rhamdia* | *quelen* | | 1 | | | | | | | 1 | | | | | | | 1 | 1 | | | | | | | | | | | |
| Siluriformes | Heptapteridae | | | | | | | | | | | | | 1 | | | | | | | | | | | | | | | | | |
| Siluriformes | Loricariidae | *Ancistrus* | sp. "net" | | | | | | | | | | | | | | | | | | | | | | | | | 1 | 1 | | |
| Siluriformes | Loricariidae | *Ancistrus* | sp. "white dots" | | | | | | | | | | | | | | | | | 1 | | | | | | | | | 1 | | |
| Siluriformes | Loricariidae | *Aphanotorulus* | *emarginatus* | | | | | | | 1 | | | | 1 | | | | | | | | | | | | | | | | | |
| Siluriformes | Loricariidae | *Hypostomus* | *hemiurus* | | | 1 | | | | | | | | | | | | | 1 | 1 | | | | | | | 1 | | | | |
| Siluriformes | Loricariidae | *Hypostomus* | *macushi* | | | 1 | | | | | | | | | | | | | | | | | | | | | | | 1 | | |
| Siluriformes | Loricariidae | *Hypostomus* | sp. | | | 1 | | | | | | | | | | | | | 1 | | | | | | 1 | | | | | | |
| Siluriformes | Loricariidae | *Hypostomus* | *taphorni* | | | | | | | | | | | | | | | 1 | 1 | | | | | | | | 1 | | | | |
| Siluriformes | Loricariidae | *Leporacanthicus* | sp. | | | | | | | | | | | | | | | 1 | | | | | | | | | | | 1 | | |
| Siluriformes | Loricariidae | *Loricaria* | sp. | | | | | | | | | | | 1 | | | | 1 | | | | | | | | | | | | | |
| Siluriformes | Loricariidae | *Parotocinclus* | *britskii* | | | 1 | | | | | 1 | | | | | | | 1 | | | | | | | | | | | | | |
| Siluriformes | Loricariidae | *Peckoltia* | *braueri* | | | 1 | | | | | | | | 1 | | | | 1 | | | | | | | | | | | 1 | | |
| Siluriformes | Loricariidae | *Peckoltia* | *sabaji* | | | | | | | | | | | 1 | | | | 1 | | | | | | | | | | | | | |
| Siluriformes | Loricariidae | *Rineloricaria* | *fallax* | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | |
| Siluriformes | Loricariidae | *Rineloricaria* | sp. | | | | | | | | | | | | 1 | | | 1 | 1 | 1 | | | | | | | | | | | |
| Siluriformes | Pimelodidae | *Pimelodus* | *blochii* group | | | | | | | | | | | 1 | | | | | 1 | | | | | | 1 | | 1 | | | | |
| Siluriformes | Pimelodidae | *Pimelodus* | *ornatus* | | | | | | | | | | | | | | | | | | | | | | 1 | | 1 | | | | |
| Siluriformes | Pimelodidae | *Pseudoplatystoma* | *fasciatum* | | | | | | | | | | | | | | | | | | | | | | | | 1 | | | | |
| Siluriformes | Trichomycteridae | *Ochmacanthus* | *flabelliferus* | | | | | | | | | | | | | | | | | | | | | 1 | | | | | | | |
| Siluriformes | Trichomycteridae | *Ochmacanthus* | sp. | | | | | | | | | | | | | | | | | | 1 | | | | | | | | | | |
| Siluriformes | Trichomycteridae | *Trichomycterus* | sp. | | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | |
| Siluriformes | Trichomycteridae | *Vandellia* | *beccarii* | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | |
| Synbranchiformes | Synbranchidae | *Synbranchus* | *marmoratus* | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | |
| Tetraodontiformes | Tetraodontidae | *Colomesus* | *asellus* | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | 1 | 5 | 35 | 1 | 3 | 36 | 18 | 34 | 14 | 3 | 22 | 22 | 4 | 7 | 37 | 42 | 30 | 18 | 12 | 8 | 21 | 28 | 3 | 32 | 10 | 25 | 19 | 6 |
| | | | | Total Kusad: 114 spp | | | | | | | | | | | | | | | | Total Parabara: 85 spp | | | | | | | | Grand Total 168 spp | | | |

**Appendix 10**
**Natural resource use tables**
Natural Resources used by communities at the Kusad and Parabara study sites, South Rupununi savannah.
Note: Amerindian languages are oral languages; spellings encountered will therefore sometimes vary. The names in the following Appendices to Chapter 10, "A Natural Resource Use Assessment in the South Rupununi Savannah, Guyana", are as provided by workshop participants.

| Local Name of Resource (W=Wapishana name) | English Common Name (description of resource as necessary) | Scientific Name | Community Use of Resource K=Kusad Mountain; P=Parabara Savannah | | |
|---|---|---|---|---|---|
| | | | Food | Shelter | Business |
| **Mammals** | | | | | |
| Kapashi (W) - Armadillo | Giant armadillo; Nine-banded armadillo; Greater long-nosed armadillo | *Priodontes maximus, Dasypus novemcinctus, Dasypus kappleri* | K, P | | K, P |
| Aro (W) - Savannah deer | White-tailed deer | *Odocoileus virginianus* | K,P | | K ,P |
| Bakaru (W) - Bush pig/hog | Collared peccary; White-lipped peccary | *Pecari tajacu, Tayassu pecari* | K,P | | K,P |
| Sokoru (W)- Agouti | Red-rumped agouti | *Dasyprocta leporina* | K,P | | K |
| Oran (W) - Labba | Spotted paca | *Cuniculus paca* | K,P | | K,P |
| Kodoi (W) - Bush cow | Brazilian tapir/Low-land tapir | *Tapirus terrestris* | K,P | | K |
| Koshara - Bush deer | Red brocket deer; Grey brocket deer | *Mazama americana; Mazama nemorivaga* | K,P | | K,P |
| Watrash/Capybara | Capybara | *Hydrochoerus hydrochaeris* | | | K,P |
| Monkey | | | P | | K, P |
| Kochui | Acouchi | *Myoprocta acouchy* | P | | |
| Sloth | | | P | | |
| Baboon | Howler monkey | *Alouatta seniculus* | P | | |
| Spider monkey | | | P | | P |
| Anteater | | *Myrmecophaga tridactyla* | K,P | | |
| Pigs | Domesticated | | K | | |
| Cows | Domesticated | | K | | K |
| **Reptiles** | | | | | |
| Turtle/Water Turtle/Dazao | Yellow-spotted river turtle | *Podocnemis unifilis* | K,P | | K,P |
| Land turtle | Red-footed tortoise; Yellow-footed tortoise | *Chelonoidis carbonaria, C. denticulata* | K,P | | K |

| Local Name of Resource (W=Wapishana name) | English Common Name (description of resource as necessary) | Scientific Name | Community Use of Resource K=Kusad Mountain; P=Parabara Savannah | | |
|---|---|---|---|---|---|
| | | | Food | Shelter | Business |
| Alligator/Caiman | Black caiman; Spectacled caiman; Dwarf caiman | *Melanosuchus niger; Caiman crocodilus; Paleosuchus palpebrosus* | K,P | | K,P |
| Land/Water camoudi | | | | | K |
| Sowan/Iguana | Green iguana | *Iguana iguana* | K, P | | K |
| Salipenter | Gold tegu | *Tupinambis teguixin* | K,P | | |
| Birds | | | | | |
| Pigeon | | | K, P | | |
| Dove | | | | | |
| White-tailed duck | | | K,P | | |
| Wild duck | Muscovy duck | *Cairina moschata* | K,P | | |
| Powis/Pawish | Black curassow | *Crax alector* | K,P | | P |
| Parrot | | | K,P | | K,P |
| Bididi /Wisi-wisi duck | Black-bellied whistling duck | *Dendrocygna autumnalis* | K,P | | |
| Macaw | | | K,P | | K,P |
| Maam | Great Tinamou | *Tinamus major* | K,P | | K |
| Toucan | | | K,P | | K,P |
| Marudi | Little Chachalaca | *Ortalis motmot* | P | | |
| Crane | | | P | | |
| Waracabra | Grey-winged Trumpeter | *Psophia crepitans* | P | | |
| Towa-towa | Chestnut-bellied Seed-finch | *Sporophila angolensis* | | | K,P |
| Kokitara | | *Theristicus caudatus* | K | | |
| Invertebrates | | | | | |
| Crab/Land crab/Mountain crab | | | K | | K |
| Kakutuba (ant) | | | | | |
| Cocorid worm/Ité worm/Sorom | | *Rhynchophorus palmarum* | K | | P |
| Freshwater Fishes | | | | | |
| Lukanani | | *Cichla* sp. | K,P | | P |
| Tiger fish | | *Pseudoplatystoma fasciatum* | K,P | | P |
| Arowana | | *Osteoglossum bicirrhosum* | K, P | | |

**Natural resource use tables (*cont'd*)**

| Local Name of Resource (W=Wapishana name) | English Common Name (description of resource as necessary) | Scientific Name | Community Use of Resource K=Kusad Mountain; P=Parabara Savannah | | |
|---|---|---|---|---|---|
| | | | Food | Shelter | Business |
| Kuthy | | | K | | |
| Yakutu | | *Prochilodus rubrotaeniatus* | K | | |
| Dari (Dare)/Kamanar | | *Leporinus friderici* | K | | |
| Hassar | | | K,P | | |
| Huri | | *Hoplias malabaricus* | K,P | | |
| Patwa | | | K | | |
| Cat fish | | | P | | |
| Baiara | | *Hydrolycus* sp. | P | | |
| Paku | | | P | | |
| Haimara | | *Hoplias aimara* | P | | P |
| Perai | | *Serrasalmus* sp. | P | | |
| Larima | | *Pimelodus blochii* | P | | |
| Koii | | | P | | |
| Eel | | | P | | |
| Stingray | | *Potamotrygon* sp. | P | | |
| Dawala | | *Ageneiosus inermis* | P | | P |
| Red pacu | | *Myleus pacu* | P | | |
| Butterfish | | | P | | |
| Banana fish | | | P | | |
| Basha | | *Plagioscion squamosissimus* | P | | |
| Krashy (Yarrow) | | *Hoplerythrinus unitaeniatus* | P | | |
| White pacu | | *Metynnis hypsauchen* | P | | |
| Sunfish | | *Crenicichla alta* | P | | |
| Kasi (Kassi) | | *Rhamdia quelen* | P | | |
| Logo-logo | | | P | | |
| Plants | | | | | |
| Pokoridi (W), Pokorid leaves, fruit | Kokerite palm | *Attalea maripa* | K,P | K,P | |
| Cashew/Bush cashew/Wild cashew | Cashew-nut tree | *Anacardium occidentale* | K,P | | |
| Mapuza (W) - Turu palm fruit, leaves | Turu | *Jessenia bataua* | K,P | P, K | P |
| Ité ball, Ité drink, Ité leaves, Ité trunk, Tibisiri | Ité palm | *Mauritia flexuosa* | K,P | K,P | K,P |

| Local Name of Resource (W=Wapishana name) | English Common Name (description of resource as necessary) | Scientific Name | Community Use of Resource K=Kusad Mountain; P=Parabara Savannah | | |
|---|---|---|---|---|---|
| | | | Food | Shelter | Business |
| Waba/Manicole | Manicole palm | *Euterpe oleracea* | K,P | K,P | |
| Balata/Wichabai/ Bulletwood tree (incl. Balata and Balata fruit) | | *Manilkara bidentata* | P | K,P | K,P |
| Mukuru/Mokoro/ Mucru | | *Ischnosiphon arouma* | | | K, P |
| Wazi/Awara | | *Astrocaryum vulgare* | K, P | | K,P |
| Minau/Brazil nut | | | P | | |
| Locust | | | P | P | |
| Redwood | | *Centrolobium paraense* | | K | K |
| Tapuzai | | | | P | |
| Cotton | | | | K | K |
| Cedar/Water cedar | | *Tabebuia insignis* | | K,P | K,P |
| Purpleheart | | *Peltogyne* sp. | | K, P | K |
| Silverballi | | *Ocotea* spp. | | K,P | K,P |
| Bitter cedar | | | | K, P | K |
| Bamboo | | *Guadua* spp. | | K | K |
| Simarupa/Chimarida | | *Quassia simarouba* | | P | |
| Bloodwood /Pitoro | | *Vismia* sp. | | P | K |
| Kabocalli/Kabukali | | *Goupia glabra* | | P | P |
| Savannah greenheart | | | | P | P |
| Nibbi | | *Heteropsis* spp. | | P | K,P |
| Crabwood timber & Crabwood oil | | *Carapa guianensis* | | P | K |
| Kufa | | | | P | |
| Idin | | *Byrsonima crassifolia* | | P | |
| Sandpaper tree | | *Curatella americana* | | | |
| Greenheart (chipizi) | | *Chlorocardium rodiei* | | | |
| Calabash | | | | | |
| Arrow cane | | | | | |
| Farine, cassava bread, cassava, tapioca | Cultivated | *Manihot* sp. | K,P | | K,P |
| Pepper | | - | K,P | | K ,P |
| Coconut | | *Cocos nucifera* | P, K | | |
| Wild Genip | | *Muellera urens* | P | | |
| Plum | | | P | | P |
| Wild whitee | | *Inga* sp. | P | | |

**Natural resource use tables (*cont'd*)**

| Local Name of Resource (W=Wapishana name) | English Common Name (description of resource as necessary) | Scientific Name | Community Use of Resource K=Kusad Mountain; P=Parabara Savannah | | |
|---|---|---|---|---|---|
| | | | Food | Shelter | Business |
| Wild pineapple | | | F | | |
| Wild guava | | | P | | |
| Jamoon | | *Syzygium cumini* | P | | |
| Wild cherry | | | P | | P |
| Banana | Cultivated | *Musa* sp. | K,P | | K,P |
| Eddoe | | | | | |
| Yam | | | | | |
| Potato (sweet) | | | | | |
| Eschallot | | | | | |
| Soursop | | | | | |
| Bora | | | | | |
| Sugar cane | | *Saccharum* sp. | | | |
| Pineapple | | *Ananas* sp. | | | |
| Pumpkin | | | | | |
| Watermelon | | | | | |
| Dasheen | | | | | |
| Peanut | | | | | |
| Orange | | | | | |
| Grapefruit | | | | | |
| Guava | | | | | |
| Coconut | | | | | |
| Pear (avocado) | | | | | |
| Firewood | | | B | | P |
| Medicine trees | | | | | K,P |
| Honey | | | | | K ,P |
| Charcoal | | | | | K |
| **Others** | | | | | |
| Clay bricks | | | K | | K, P |
| Gold | | | | | K,P |

## Resources used by Communities at the Parabara and Kusad Study Sites

**A. Community: Eropoimo (Parabara) Village – Parabara Study Site**
Participants at this workshop consisted mainly of persons from Eropoimo village, which is also commonly called Parabara. Twenty-seven persons (11males, 16 females) participated in the discussions, which were held from 31 October to 2 November 2013. Residents are mainly from the Wai Wai and Wapishana tribes. The resources described at this workshop were listed mainly in the Wai Wai language.

**1. The following is a list of resources as discussed by the homogenous groups.**

| **Women over 25** | | |
|---|---|---|
| **Food** | **Shelter** | **Others** |
| Cassava | Purple wood | Arapapitu |
| Toru | Silverballi | Morru |
| Eta/Ité | Sarayi (house material) | Clay |
| Banana | Mapata (timber) | Pit (boat wood) |
| Eddo | Kupa (house material) | Bow |
| Yam | Karatako (house material) | Weyu |
| Potatoes | Woyko (timber) | Marawa (fire wood) |
| Sugar cane | Crab wood | Talatala (fire wood) |
| Pineapple | Kukwa (boat wood) | Tunayare (fire wood) |
| Pumpkin | Dolly tree | Eretawana (fire wood) |
| Watermelon | Giant tree | Pashliyirekor (fire wood) |
| Dasheen | Water cedar | Mento (awara) |
| Cassareep | | Cotton |
| Pepper | | Woosa (beads) |
| Kokorite | | Arrow |
| Plum | | Wax |
| Small eta/ Ité | | Annato |
| Whitey | | Warapesh (fire wood) |
| Kewe (yellow fruit) | | Crab wood |
| Karamtu (fruit) | | Kalabash |
| Owawapito (fruit) | | Sharawo (tibisiri) |
| Sawakwa (fruit) | | Mina (leaves) |
| Aparapicho (fruit) | | Karakru (beads) |
| Brazilian nut (Guyana nut) | | Yeuta (red and black beads) |
| Peanut | | Pishkoyeru (beads) |
| Nipow (fruit) | | Waka waka (beads) |
| Tawana (fruit) | | Eyupu (tree for arrow point) |
| Wid, wu (fruit) | | Kaiku (tree for axe handle) |
| Kakapu (fruit) | | |

| Women over 25 | | |
|---|---|---|
| **Food** | **Shelter** | **Others** |
| Osaku (fruit) | | |
| Orange (fruit) | | |
| Grapefruit | | |
| Guava | | |
| Coconut | | |
| Pears | | |
| Cashew | | |
| Cherry | | |
| Shawo | | |
| Haimara | | |
| Lukanani | | |
| Basha | | |
| Tiger fish | | |
| Hori | | |
| Karashy (yarrow) | | |
| Perai | | |
| Dari | | |
| Larima | | |

| Men Over 25 | | |
|---|---|---|
| **Food** | **Shelter** | **Others** |
| Fish | Miina, cocorite leaves, palm, manicole, watab (wood bark), nibbi, madi, waoko, oran kaozu, ziim, kofa (bulletwood), pewar | Cokwa, katowari ckanawa, yefo, lepord, okorofo waiyo, tarafa, cotton, mocoro, manii, ziini (crawa), youta, karakro, crab wood, eta leaf, anato, fishcoyeuro, wayafoyefo, arrow cane, powis feathers, eagle feathers (macaw feathers), bamboo kolokim yefo, gold |
| Haimarah, lukanani, tiger fish, peri, red & white paco, huri, basha, patwa, yarou, sun fish, kuror, hasar, piau, larima,eel, kasi, biara, logo-logo, idari, koi, emery, dawala, kinid dari, pashishi | | |
| Animals | | |
| Tapir, labba, accori, armadillo, bush hog, peccary, monkey, bush deer, giant armadillo, turtle, iguana, koati, anteater, salipenter | | |
| Birds | | |
| Powis, manidi,mam, macaw, trumpet bird, pigon, anacwa, duck, kuyauzi, onaowa, korim toucan, karawo, tarton, parrot, eta macaw | | |
| **Fruits** | | |
| Eta, oro, wild cashew, Guyana nut, cawa, whity, balata fruit, apala filcho, awara, cocorite, small eta | | |

**Resources used by Communities at the Parabara and Kusad Study Sites**
A. Community: Eropoimo (Parabara) Village – Parabara Study Site cont'd

| **Youths Under 25** | | |
|---|---|---|
| **Food** | **Shelter** | **Others** |
| Labba | Mena | Waka waka (beads) |
| Tapir | Nibbi | Karakro (beads) |
| Bush hog | Kufa | Wosa (beads) |
| Powis | Karatoko | Pite (boat wood) |
| Macaw | Saraie | Marawa (fire wood) |
| Spider monkey | Tuna yapo | Waiupotoru (arrow point wood) |
| Armadillo | Shbari yapo (board) | Wayamto |
| Parrot | Okrofo (balata tree) | Towa |
| Marudi | Mafata (post) | Sharawu |
| Mam | Manaka yapo | Gold |
| Tiger fish | Cocorite leaf | |
| Himara | Mento | |
| Lukanani | | |
| Poni eel | | |
| Makafa (fish) | | |
| Wayamo (tortoise) | | |
| Pore (smoke hassar) | | |
| Otifa (hassar) | | |
| Quate (fish) | | |
| Alligator | | |
| Plantain | | |
| Yam | | |
| Potato | | |
| Eddo | | |

**B. Community: Karaudanawa Village– Parabara Study Site**
Participants at this workshop consisted mainly of persons from Karaudanawa Village. Eighty-three persons (38 males, 45 females) participated in the discussions which were held from 4 to 6 November 2013. Residents are mainly from the Wapishana tribe. The resources described at this workshop were listed mainly in **Wapishana** language.

### 1. The following is a list of resources as discussed by the homogenous groups

| **Females ≥ 25 years** | | |
|---|---|---|
| **Food** | **Shelter** | **Others** |
| **Fishes-** haimara, tiger fish, lukanani, larima, koii | Tapuzai | Dyuwuza (eta leaves) |
| | Atoruba- cedar | Maroaiba |
| **Animals-** labba, bush-deer, tortoise, savannah-deer, armadillo | Dyuwuza- eta leaves | |
| | Pokoridi-cocorite leaves | Pii (beads tree) |
| **Birds-** powis, shaakoo (macaw) katorizo (macaw), kazaru (macaw), koyaru (macaw), bai (duck) | Wichabai | Natu-aiba ( locust sap) |
| | Iziiaru- balata | Pino-kun-aiba ( medicine oil) |
| **Plants-** toru, minau (Brazilian nut), kawarori (wild cashew), shoroko (fruit), wazi (awara), wun-bau (fruit), pokoridi (kokorite), wawashi (fruit), chiiki (eta worms), soorom (tucoma), sowan (iguana), alligator | Komaro-tree | Izi aru-aiba (balata sap) |
| | Pinao-kun- tree | Kaziman-aiba (balata sap) |
| | Dodori- tree | Zini |
| | Dyo-kunuda-eta ball | Tiba (nibbi) |
| | Chimarida-simarupa | Mokoru (mocru/mucru) |
| | Pitoro- blood wood | Wazi-idiba (awara shoot) |
| | Idina-kun- tree | Kinaridii (cotton) |
| | Waba- palm | Powizi |
| | Bokotoru- tree | Bairii (arrow cane) |
| | Wataba- wood bark | Takuba (bow wood) |
| | Komita anaba- leaves | Paizu |
| | Mapuza- Toro | Yoroo |
| | Piiwaru- leaves | Maru-shoo (medicine - malaria) |
| | Wurado-poza | Baarai- (medicine) |
| | Owazu- house material | Idin- (fire wood) |
| | Baizu- house material | Chipizi- (green heart) |
| | Oran koozoo- house post | Shaaoi (medicine) |
| | | Kaorowada (medicine for sores) |
| | | Manaka (medicine) |
| | | Waruzo-tain (medicine) |
| | | Tapuzai- (treasure) |
| | | Iminaru |
| | | Aishara- (medicine) |
| | | Kubai- (clay) |
| | | Korowach- ( calabash) |
| | | |

| **Men ≥ 25 years** | | |
|---|---|---|
| **Food** | **Shelter** | **Others** |
| Eta | Eta leaves | Crab wood |
| Small eta (borokosh) | Kokooridi leaves | Pinaokun oil |
| Turo (big & small) | Komitan leaves | Kamaro oil |
| Burush | Chawuda anaba | Kaorowai |
| Waza | Bulush anaba | Maroiba |
| Wunbau | Waba anaba | Natuiaba |
| Pokoridi | Water cedar | Kiamba bark |
| Waba | Bitter cedar | Machi mada |

| **Men ≥ 25 years** | | |
|---|---|---|
| **Food** | **Shelter** | **Others** |
| Wild cashew | Silverballi | Wurada pozo |
| Brazil nut | Etaballi | Macha para |
| Owawash | Locust | Torara iba |
| Widiko | Cabbage tree | Mucru |
| Plum | Wichabai tree | Nibbi |
| Wichabai | Kabokaly | Tibisiri |
| Komaro | Savannah greenheart | Waza-idiba |
| Irim | Wazawar | Bitter cedar |
| Wild whytee | Takuba | Water cedar |
| Wild pineapple | Machi | Silverballi |
| Tikazii | Ma'as | Simarupa |
| Genip | Shuwu | Kabakali |
| Omizi | Zuma | Savannah greenheart |
| Waipipi | Wazadara | Bullet wood |
| Shoroko | Idinkun | Wuzawaro |
| Kumirri | Nibbi | Etaballi |
| Lucust | Watabamada | Yarola |
| Shododo | Bush rope | Fish rod |
| Jamoon | Korimaro | Takuba |
| Wild guava | Kobada | Gold |
| Deer | Ichimaru | Amythis |
| Armadillo | Piuta tree | |
| Labba | Tapurii tree | |
| Water and land turtle | | |
| Agouti | | |
| Watrash | | |
| Bush cow | | |
| Bush hog | | |
| Alligator | | |
| Iguana | | |
| Monkey | | |
| Powis | | |
| Marudi | | |
| Mami | | |
| Macaw | | |
| Parrot | | |
| Eta worm | | |
| Tiger fish | | |
| Cat fish | | |
| Biara | | |
| Pako | | |
| Himara | | |
| Kuti | | |
| Larima | | |
| Pirai | | |
| Hassar | | |
| Lukanani | | |
| Moroi | | |
| Paraowarin | | |
| Orauz | | |
| Torudu | | |
| Orododo | | |
| Kinuda | | |
| Chariri | | |
| Cassava | | |
| Provision | | |
| Muckru | | |
| Wild duck | | |

**C. Community: Potarinau Village. Kusad Mountains**

Participants at this workshop consisted mainly of persons from Potarinau with one person attending from the satellite community of Kaitur. Forty-nine persons (21males, 28 females) participated in the discussions which were held from 22 to 24 October 2013.

**1. The following is a list of resources as discussed by the homogenous groups**

| **Women below 25 years** | | | |
|---|---|---|---|
| **Food** | **Shelter** | **Business** | **Others** |
| Koshara (bush deer) | Eta leaves | Gold | Mapaza (toru) |
| Labba | Cotton | Balata wood | Awara |
| Kapashi (armadillo) (tortoise) | Kokoridi leaves | Balata wood (cassava) (farine) | Mokoro/mucru |
| Wurada | Eta shoot | Cedar wood | |
| Pawish (powis) | Red wood | | |
| Kodoi (bush cow) | Cedar | | |
| (Cassava) (Farine) | Purpleheart wood | | |
| Bididi ( wisi wisi duck) | | | |

| **Men below 25 years** | | | |
|---|---|---|---|
| **Food** | **Shelter** | **Business** | **Others** |
| Eta | Eta leaves | Eta ball | Eta bark for garden |
| Savannah deer | | Eta drink | Eta shoot for tibisiri |
| Bush deer | | Craft- baskets, ornaments, jewellery | Mapuza |
| Bush-pig | Wood | Mukru cane | Drink |
| Armadillo | Red wood | Sifter, matapi | Fire wood |
| Tapir | House materials | | Garden posts |
| Labba | Furniture | | Ropes |
| Parrot | Water cedar | Furniture | Saddles |
| Macaw | House materials | Meat | Pet |
| | Furniture | Skin-leather | Tawa tawa |
| | | Sockets-cutlass, knife | Pet |
| | | Bags and for costumes | Pet |
| | | Parrot | Feathers used for heritage time |
| | | Tawa tawa | |
| | | Macaw | |

| Women over 25 years | | | |
|---|---|---|---|
| **Food** | **Shelter** | **Business** | **Others** |
| Eta (fruits) | Eta palm (leaves) | Eta (fruits) | Eta trunk |
| Wild hogs | Red wood | Wild hogs | Deer |
| Deer | Cedar wood | Deer | Clay |
| Laba | Penaokum | Labba | Parikaran |
| Armadillo | Silverballi | Armadillo | Merishi |
| Lukanani | Cocorid leaves | Crab | Penaokun |
| Tiger fish | Wabba | Cedar | Arawa |
| Arawana | | Arawa | Mocuro |
| Kuthy | | Silverballi | Gold |
| Yakutu | | Tawa-Tawa | Purpleheart wood |
| Dari/Kamanar | | Toucan | Quawa |
| Crab | | Tortoise | Macaw |
| Cocorid | | Water turtle | Parrot |
| Wild duck | | Land/water camoudi | Powis |
| Macaw | | Bow wood | Wamoroo |
| Parrot | | Macaw | Mam |
| Powis | | Parrot | Kawaroo |
| Wamaroo | | Quawa | Cotton |
| Mam | | Wamorro | Lucas milk |
| Tapir | | Mam | Blood wood |
| Toroo | | Tapir | Sand paper |
| Water turtle | | Hassar | Tree |
| Alligator | | Pepper | |
| Plum | | | |
| Awara | | | |
| Toucan | | | |
| Hassar | | | |
| Kawaroo | | | |
| Wabba | | | |
| Pepper | | | |
| Lucas (fruits) | | | |

| Men above 25 years | | | |
|---|---|---|---|
| **Food** | **Shelter** | **Business** | **Others** |
| Eta fruits | Leaves | Tibisiri | Trunk |
| Torro fruits | Cocorid | Basket weaving | Mocru |
| Oil | Leaves | Bow wood | Bow wood |
| Cocorid worm | Fruits | Balata tree | Incense |
| Fishes | Oil | Milk | Grazing ground |
| Houri | Torro palms | Gold | Balata wood |
| Tiger fish | Shingle | Silverballi | Nibbi |
| Lukanani | Red wood | Water cedar | Honey |
| Hassar | Water cedar | Bitter cedar | Kama-waur |
| Patwa | Bitter cedar | Honey | Gold |
| Wild meat | Bamboo | Land turtle | Alligator |
| Powis | | Parrot | Sacred sites |
| Land turtle | | Macaw | |
| Water turtle | | Toucan | |
| Mountain crab | | Powis | |
| Birds | | Iguana | |
| Parrot | | | |
| Macaw | | | |
| Toucan | | | |
| Alligator | | | |
| Salipenter | | | |
| Iguana | | | |

| **Women below 25 years** | | | |
|---|---|---|---|
| **Food** | **Shelter** | **Business** | **Others** |
| Koshara (bush deer) | Eta leaves | Gold | Mapaza (toru) |
| Labba | Cotton | Balata wood | Awara |
| Kapashi (armadillo) (tortoise) | Kokoridi leaves | Balata wood (cassava) (farine) | Mokoro/mucru |
| Wurada | Eta shoot | Cedar wood | |
| Pawish (powis) | Red wood | | |
| Kodoi (bush cow) | Cedar | | |
| (Cassava) (Farine) | Purpleheart wood | | |
| Bididi ( wisi wisi duck) | | | |

| **Men below 25 years** | | | |
|---|---|---|---|
| **Food** | **Shelter** | **Business** | **Others** |
| Eta | Eta leaves | Eta ball | Eta bark for garden |
| Savannah deer | | Eta drink | Eta shoot for tibisiri |
| Bush deer | | Craft- baskets, ornaments, jewellery | Mapuza |
| Bush-pig | Wood | Mukru cane | Drink |
| Armadillo | Red wood | Sifter, matapi | Fire wood |
| Tapir | House materials | | Garden posts |
| Labba | Furniture | | Ropes |
| Parrot | Water cedar | Furniture | Saddles |
| Macaw | House materials | Meat | Pet |
| | Furniture | Skin-leather | Tawa tawa |
| | | Sockets-cutlass, knife | Pet |
| | | Bags and for costumes | Pet |
| | | Parrot | Feathers used for heritage time |
| | | Tawa tawa | |
| | | Macaw | |

| Women over 25 years | | | |
|---|---|---|---|
| **Food** | **Shelter** | **Business** | **Others** |
| Eta (fruits) | Eta palm (leaves) | Eta (fruits) | Eta trunk |
| Wild hogs | Red wood | Wild hogs | Deer |
| Deer | Cedar wood | Deer | Clay |
| Laba | Penaokum | Labba | Parikaran |
| Armadillo | Silverballi | Armadillo | Merishi |
| Lukanani | Cocorid leaves | Crab | Penaokun |
| Tiger fish | Wabba | Cedar | Arawa |
| Arawana | | Arawa | Mocuro |
| Kuthy | | Silverballi | Gold |
| Yakutu | | Tawa-Tawa | Purpleheart wood |
| Dari/Kamanar | | Toucan | Quawa |
| Crab | | Tortoise | Macaw |
| Cocorid | | Water turtle | Parrot |
| Wild duck | | Land/water camoudi | Powis |
| Macaw | | Bow wood | Wamoroo |
| Parrot | | Macaw | Mam |
| Powis | | Parrot | Kawaroo |
| Wamaroo | | Quawa | Cotton |
| Mam | | Wamorro | Lucas milk |
| Tapir | | Mam | Blood wood |
| Toroo | | Tapir | Sand paper |
| Water turtle | | Hassar | Tree |
| Alligator | | Pepper | |
| Plum | | | |
| Awara | | | |
| Toucan | | | |
| Hassar | | | |
| Kawaroo | | | |
| Wabba | | | |
| Pepper | | | |
| Lucas (fruits) | | | |

| **Men above 25 years** | | | |
|---|---|---|---|
| **Food** | **Shelter** | **Business** | **Others** |
| Eta fruits | Leaves | Tibisiri | Trunk |
| Torro fruits | Cocorid | Basket weaving | Mocru |
| Oil | Leaves | Bow wood | Bow wood |
| Cocorid worm | Fruits | Balata tree | Incense |
| Fishes | Oil | Milk | Grazing ground |
| Houri | Torro palms | Gold | Balata wood |
| Tiger fish | Shingle | Silverballi | Nibbi |
| Lukanani | Red wood | Water cedar | Honey |
| Hassar | Water cedar | Bitter cedar | Kama-waur |
| Patwa | Bitter cedar | Honey | Gold |
| Wild meat | Bamboo | Land turtle | Alligator |
| Powis | | Parrot | Sacred sites |
| Land turtle | | Macaw | |
| Water turtle | | Toucan | |
| Mountain crab | | Powis | |
| Birds | | Iguana | |
| Parrot | | | |
| Macaw | | | |
| Toucan | | | |
| Alligator | | | |
| Salipenter | | | |
| Iguana | | | |

**D. Community: Sawariwau Village – Kusad Mountain Study Site**

Participants at this workshop consisted mainly of persons from Sawariwau Village. Forty-five persons participated in the discussions (12 males, 33 women), which took place on 25, 27 and 28 October 2013. Some resources here are listed in the Wapishana Language. This village has a resource use management plan which was developed with the assistance of the South Central People's Development Association of the Rupununi (SCPDA), and in which the resources are named in the Wapishana language.

**1. The following is a list of resources as discussed by the homogenous groups**

| **Females below 25 years** | | |
|---|---|---|
| **Food** | **Shelter** | **Other** |
| Kapashi | Eta leaves | Guava leaves |
| Pokorid | Pokorid leaves | Achiwi |
| Fish | Boards | Idin madi |
| Aro | Roofs material | Cashew skin |
| Bush pig | Mud bricks (black mud) | Waruzu tain |
| Sokoru | Red wood | Pinaukun madi |
| Turtle | Tapuzai | Naata-laba |
| Oran | Rafters | Monkey |
| Barara | | Kazara |
| Cashew | | Chaakoi |
| Waro | | Arrow and bow |
| Dove | | Basket |
| Pigeon | | Sifter |
| Wakoko | | Dopauwai |
| Mapuzu | | Fan |
| Eta ball | | Pepper |
| Eta drink | | Crocodile |
| Farine | | Balata |
| Cassava bread | | Timber |
| Pepper | | Bamboo |
| Koshara | | Crawa |

| **All Men (below and above 25 years)** | | |
|---|---|---|
| **Food** | **Shelter** | **Other** |
| White tail duck | Eta leaves | Gold |
| Armadillo | Red heart | Sand |
| Land turtle | Mud brick | Gravel |
| Agouti | Boards | Grass |
| Labba | Tapuzai | Bush island |
| Fishes | Pokorid leaves | Armadillo |

| All Men (below and above 25 years) | | |
|---|---|---|
| **Food** | **Shelter** | **Other** |
| Wild duck | | White tail deer (savannah deer) |
| Water turtle | | Land turtle |
| Iguana | | Balata |
| Eta | | Timber |
| Cassava | | |
| Bush cow | | |
| Bush deer | | |
| Alligator | | |
| Powiss | | |
| Crab | | |
| Bush hog | | |
| Parrot | | |
| Wakoko | | |
| Bididi | | |
| Katoriz | | |
| Sorom | | |
| Chiziki | | |
| Odoi | | |
| Tapiizi | | |
| Water | | |
| Cashew | | |
| Kokitara | | |
| Maaba | | |

| Females more than 25 years | | |
|---|---|---|
| **Food** | **Shelter** | **Other** |
| Mapuza | Waba | Balata (Iziara) |
| Waba | Sawarau/kobawi | Waza |
| Waza | Baizi | Mokoro/Mucru |
| Wun-bau | Chikida | Naata |
| Balata | Rapirapa | Punaokin aba |
| Naata | Wataba | Tawa-tawa |
| Armadillo | Punaokin | Parrot |
| Fish | Eta leaves | Minerals (gold) |
| Turtle | Wooden materials | Boards (cedar) |
| Deer (aro) | Shaporodai | Eta |

| Females more than 25 years | | |
|---|---|---|
| **Food** | **Shelter** | **Other** |
| Wild duck | Cocorid leaves | Coconut |
| Alligator | Wichabai | Wooden materials |
| Parrot | Machiwu | Fish |
| Eta | | Pig |
| Coconut | | Cows |
| Pigs | | Deer |
| Cows | | Maorowaibo |
| Widoko | | Naata aaba |
| Genip | | Wachi chip |
| Annarao | | Chipizi |
| Kokitara | | Water (Kadorara) |
| Widoko | | Pitor |
| Shawazoiimiz | | Clay pot |
| Mozil | | Wood bark |
| Soromo | | Achiwi |
| Chika | | Grass |
| Wakoko | | Manaka |
| Karapo | | Mini |
| Maam | | Pepper |
| Katorizi | | Kaziman |
| Oran | | |
| Sokuru | | |
| Chiziki | | |
| Atokara | | |
| Sowan | | |
| Atoru | | |
| Kodoi | | |
| Bakuru/ kasho | | |
| Komaro | | |
| Kizamadari | | |
| Iribi | | |
| Shrimp, pepper, farine, cassava, tapioca | | |

# BIODIVERSITY ASSESSMENT SURVEY OF THE SOUTH RUPUNUNI SAVANNAH, GUYANA

**Why we are here**
To stop the degradation of the planets's natural environment and to build a future in which humans live in harmony with nature.

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