EXPEDITION REPORT FROM UGANDA: HERPETOLOGICAL SURVEYS AT EIGHT CENTRAL FOREST RESERVES (AGORO-AGU, BUDONGO, ECHUYA, MABIRA, MOUNT KADAM, MOUNT KEI, MOUNT MOROTO, AND MOUNT OTZE) AND FOUR NATIONAL PARKS (BWINDI IMPENETRABLE, MGAHINGA GORILLA, MOUNT ELGON, AND RWENZORI MOUNTAINS)

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INTRODUCTION

Although Uganda represents a small portion of the Earth's terrestrial surface, the country is remarkably important in terms of global biodiversity (Eilu and Winterbottom, 2006). In particular, the montane forests of Uganda are a significant reservoir of species diversity (Plumptre et al., 2003). The conservation importance Uganda's montane forests stem from the exceptionally high levels of threatened and endemic species (Plumptre et al., 2007). Uganda is widely celebrated as an international ecotourism destination because of its extensive network of protected areas that harbor charismatic vertebrate species. Uganda's birds, primates, and large mammals have received much more attention from the scientific and ecotourism communities compared to reptiles and amphibians. In accordance, the overall goal of this ongoing, long-term project is to assess the conservation value of protected areas in Uganda with respect to their herpetofaunal diversity. Initial surveys conducted by our team in 2014 have provided a major boost to herpetological research in Uganda, and preliminary results have led to numerous research products based on the data collected during those surveys (e.g., Hughes et al. 2016; Hughes et al. *in review*; Hughes and Behangana, *in review* (three articles); Larson et al. 2016; Medina et al. 2016). By increasing our sampling in 2015 to include Central Forest Reserves (National Forestry Authority), and additional National Parks (Uganda Wildlife Authority), we set out to considerably expand the results of our fruitful 2014 expedition. These surveys lay the foundation for improving the ecotourism value of Uganda's reptiles and amphibians so that these populations and native Ugandans can benefit.

MATERIALS AND METHODS

***Study areas*. (A) CENTRAL FOREST RESERVES: Agoro-Agu** (N03.81357, E32.94207) is a 23,600 ha protected area located in northern Uganda along the border with South Sudan. This reserve represents Uganda's portion of South Sudan's Imatong Central Forest Reserve. The elevation range for the reserve is 1,100–2,700 m. Precipitation in the Imatong Mountains increases with altitude, resulting in the transition of montane forest to the alpine zone. Rainfall is seasonal and begins in March and lasts until October. Major vegetation types range from woodland-savanna in the lowlands to thicket in the Ericaceous zone. Most animals were collected at the foothills of the Imatong Mountains around Agoro Village (ca. 1,000 m), and some were collected at several high elevation sites in the forest reserve (ca. 2,000 m). These sites were sampled from 4–7 July 2015.

Budongo (N01.768505, E31.573757) is a 42,500 ha protected area located in western Uganda. The reserve is composed of mostly tropical and subtropical broadleaf forest, of the moist semi-evergreen forest type. It is the largest surviving natural forest in Uganda. This reserve is a low-mid elevation montane forest in the Albertine Rift ecoregion. Annual rainfall in Budongo ranges from 1,200 mm to 2,200 mm. There are two rainy seasons, one March–May and another September–November. Sampling locations within Budongo included a flooded forest site (~1,000 m) and a swamp (~1,100 m), which were sampled from 1–3 July 2015.

Echuya (S01.25926, E29.79853) is a 3,400 ha protected area situated between Mgahinga Gorilla and Bwindi Impenetrable National Parks. The reserve ranges in elevation from 2,270 to 2,570 m. This region harbors the large Muchuya Swamp that runs north–south and drains to the southern portion of the reserve. The forest is part of the Albertine Rift ecoregion, and therefore shares a lot

of flora, fauna, and habitats with the larger, better studied protected areas of this region. The sampling location within the forest consisted of the high elevation Muchuya Swamp (ca. 2,200 m). This site was sampled during daylight hours on 22 June 2015.

Mabira (N00.44815, E32.88987) is a 30,000 ha protected area in Central Uganda, just north of Lake Victoria. The reserve consists largely of moist semi-deciduous forest. The general topography is low, ranging in elevation from 1070–1340 m, and most drainage is to the north. The reserve is threatened by agricultural land use and is generally isolated from other protected areas in Uganda. Mabira is home to approximately 312 tree species, 315 bird species, 218 butterfly species, 97 moth species, and 23 small mammal species. Sampling locations within the reserve included semi-disturbed areas in the Nagojje beat (ca. 1,100 m), sampled from 21–23 May 2015.

Figure 1: This Forest Gecko (*Cnemaspis* sp.) was found in the montane forest of Mount Kadam, and is likely a new species to science. Photo by DFH.

Mount Kadam (N01.79864, E34.74146) is a montane forest protected area in eastern Uganda, with peaks reaching > 3,000 m in elevation. This region is poorly known but seems to have high levels of species diversity (Howard et al., 2000). Sampling locations within the protected area

included a low elevation (~1,500 m) wetland site near Nakapiripirit, and high elevation (~2,200 m) forested sites. These sites were sampled from 31 May–2 June 2015.

Mount Kei (N03.59134, E31.09947) is a 38,400 ha protected area in northwestern Uganda, along the border with South Sudan. The reserve has an elevation range of 915–1,330 m. The region is largely undisturbed by human activities. The site contains no tropical forest, and the dominant habitat is wooded grasslands. The reserve is located in the Sudan-Guinea Savanna biome, which is reflected in its species composition. Nearly 175 bird species are known from the reserve, including several species only found in this area in Uganda. Sampling locations within the protected area included low elevation (~900 m) sites near the Kaya River, and a higher elevation site at the top of Mount Kei (~1300 m), which were sampled from 9–10 July 2015.

Mount Moroto (N02.51234, E34.70190) is a 43,800 ha montane forest protected area in eastern Uganda, near the Kenyan border. The reserve covers an elevation range from 960 to 3,008 m. The forest boasts nearly 200 species of trees and shrubs. Sampling locations within the protected area included high elevation (1,900–2,500 m) forested and non-forested sites, some near the St. Lawrence River. These sites were sampled from 4–6 June 2015.

Mount Otze (N03.61940, E31.85362) is a 18,800 ha protected area in northwestern Uganda, along the border with South Sudan and continuous with Nimule National Park. The reserve has an elevation range of 760–1,660 m. The reserve mostly consists of wooded savanna and undifferentiated semi-deciduous thicket. The region is largely undisturbed by human activities because of its rocky terrain. It is located in the Sudan-Guinea Savanna biome, which is reflected

in its species composition. Sampling locations within the protected area included sites along the trail to the top of Mount Otze (~1,500 m). These sites were sampled from 11–12 July 2015.

(B) NATIONAL PARKS: Bwindi Impenetrable (S01.04883, E29.79016) is a 32,100 ha protected area located in southwestern Uganda with an elevational range from 1,160–2,607 m, with 60% of the park over 2,000 m. The hillsides consist of primary Afromontane forest that contain more than 1,000 flowering plant species, including 163 species of trees and 104 species of ferns. The climate is tropical with annual mean temperature ranging from 20–27°C and annual rainfall ranging from 1,400–1,900 mm. The biannually peaking wet season occurs from March to April and September to November. This area protects an estimated 320 mountain gorillas, and over 120 mammal species, including elephants and antelopes. There are nearly 350 species of birds that can be found in this forest, including 23 Albertine Rift endemics. Sampling locations within the park included a low elevation (~1500 m) wetland site near the Ihihizo River, and a high elevation (~2200 m) site at Rwizi Swamp. These sites were sampled from 25–31 May 2014.

Rwenzori Mountains (N00.36247, E29.99863) is a 99,600 ha protected area located in western Uganda with an elevational range from 1,100–5,109 m. The Rwenzori Mountains reside along the DR Congo border, and are situated in the northern area of the Albertine Rift. The climate is tropical with annual rainfall averaging 2,500 mm. The biannually peaking wet season occurs from March to May and August to December. The diversity of ecosystems here includes equatorial snow peaks, lower elevation slopes of moorland, bamboo, and Afromontane forest. Five primary vegetation zones have been identified on the mountains and are associated with high elevations—montane forest, bamboo forest, tree heath-bog, *Hagenia-Rapanea* scrub, and afro-alpine moorland. The

park protects 70 mammals and 217 bird species, including 19 Albertine Rift endemics. Sampling locations within the park included a low elevation (~1,650 m) site comprising flooded and disturbed vegetation near the Ruboni Community Hotel, and a higher elevation (~2,000 m) site in primary forest along the Mubuku River. These sites were sampled from 31 May to 1 June 2014.

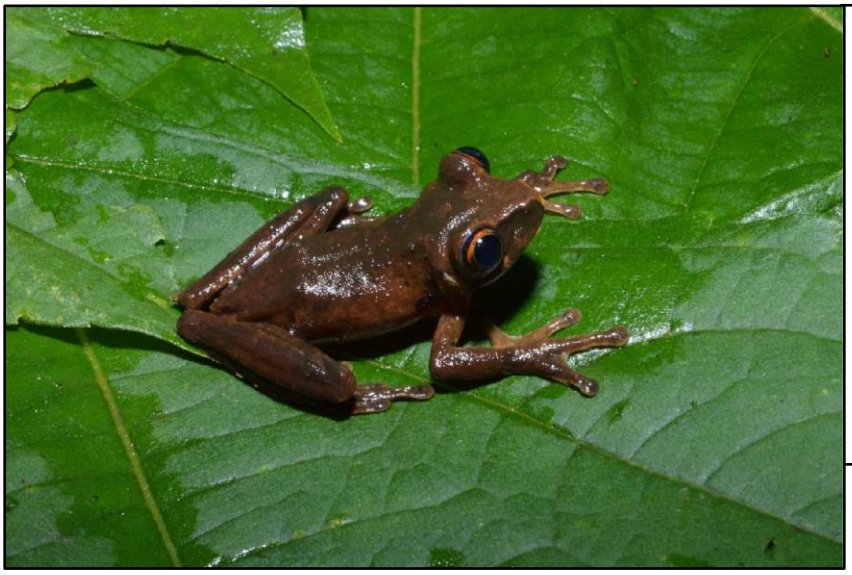

Figure 2: The Efulen Forest Tree Frog (*Leptopelis calcaratus*) was described from Equatorial Guinea in West Africa, thus the population found at Bwindi likely represents a new species. Photo by DFH.

Mount Elgon (N01.33513, E34.41092) is a 112,100 ha protected area located in eastern Uganda along the Kenyan border. This site is one of the largest solitary volcanoes in the world, and reaches an altitude of 4,321 m. Mean rainfall reaches over 1,270 mm per year, and rainfall ranges from 1,500 mm on the eastern/northern slopes, to 2000 mm in the southern/western slopes. The park's two dry seasons extend from June–August, and December–March. Thus the park's rainy season is bimodal, and the wettest period occurs from April–October. Mt. Elgon's vegetation reflects an altitudinal gradient associated with large mountains. Mixed montane forest extends up to 2,500 m elevation, low canopy montane forest from 2,500–3,500 m elevation, and bamboo/moorland above 3,500 m elevation. The park boasts over 300 species of birds, and it has been declared a UNESCO Man and Biosphere Reserve. Sampling locations within the park included a wetland site (~2,000

m) comprising flooded and disturbed vegetation near the park's gate, and sites near our camp next to the Kapkwai Exploration Center. These sites were sampled from 25–28 May 2015.

Mgahinga Gorilla (S01.35639, E29.62085) is a 3,370 ha protected area located in the extreme southwestern corner of Uganda, sharing a border with DR Congo and Rwanda. The elevational range for this park is high, extending from 2,227 m to 4,127 m. This site is part of the larger Virunga Volcanic province, and has several high-elevation crater lakes. The region is nearly exclusively Afromontane forest and is part of the Albertine Rift ecoregion. Large mammals, including the mountain gorilla, make this site exceptionally important in terms of biodiversity and conservation. Above the montane forest belt is the bamboo zone, then the *Hagenia-Hypericum* zone, then the Ericacious Belt, and lastly the Afro-Alpine Belt. Sampling locations within the park included sites along the park edge (~2,200 m) with moderately disturbed vegetation, and sites in the bamboo zone (~2,700 m), which were sampled from 18–21 June 2015.

Surveying and collecting. – Between 21 May and 12 July 2015, amphibians and reptiles were caught by hand or net during diurnal and nocturnal searches. The authors, with help from park rangers, local guides, and villagers, searched in forests, around small streams, and near flooded vegetation at each location. Notes were made regarding GPS coordinates, ecology, behavior, date, time, and habitat details of each collected specimen. Animals were preserved in 10% buffered formalin. Tissue samples were taken from most specimens and stored in 100% ethanol. On completion of the expedition, with proper permits, the specimens and tissues were transferred to the University of Texas at El Paso Biodiversity Collections in the United States. Genomic DNA

extraction from tissues and PCR reactions with gene-specific primers followed standard laboratory protocols.

***Species identification.* –** All animals were initially identified by external morphology and putative species ranges published in the literature (Branch, 1998; Schiøtz, 1999; Spawls et al., 2002; Spawls et al., 2006; Tilbury, 2010). Initial identifications were corroborated by experts (EG and MB). Phylogenetic analyses of genetic data were combined with published GenBank data and previously sequenced samples from nine years of expeditions to the DR Congo side of the Albertine Rift (EG), to confirm species identifications and to detect possible cryptic species.

RESULTS

A total of 350 specimens were collected during the 2015 sampling period from forests representing eight Central Forest Reserves and four National Parks in Uganda, and comprised 41 amphibian species (Table 1) and 38 reptile species (Table 2). Of these, a Forest Gecko (*Cnemaspis* sp. [**Fig. 1**]) from Mount Kadam is likely a new species to science, several frogs are also new to science (e.g., *Leptopelis* cf. *calcaratus* [**Fig. 2** – unpublished data] and *Afrixalus* cf. *laevis* [**Fig. 3** – unpublished data]), and one chameleon species has been confirmed as a new species that has only been found in Uganda so far (*Kinyongia* sp. nov. [Hughes et al., *in review*]). Several species were unique to each site, yet there was a large degree of overlap between the Albertine Rift sites. The degree of species overlap was far less at the sites in Karamoja and West Nile. The Sudanese Unicorn Chameleon (*Trioceros conirostratus* [**Fig. 4**]) was found at several montane localities and prior to our 2015 surveys it had not been recorded from Uganda.

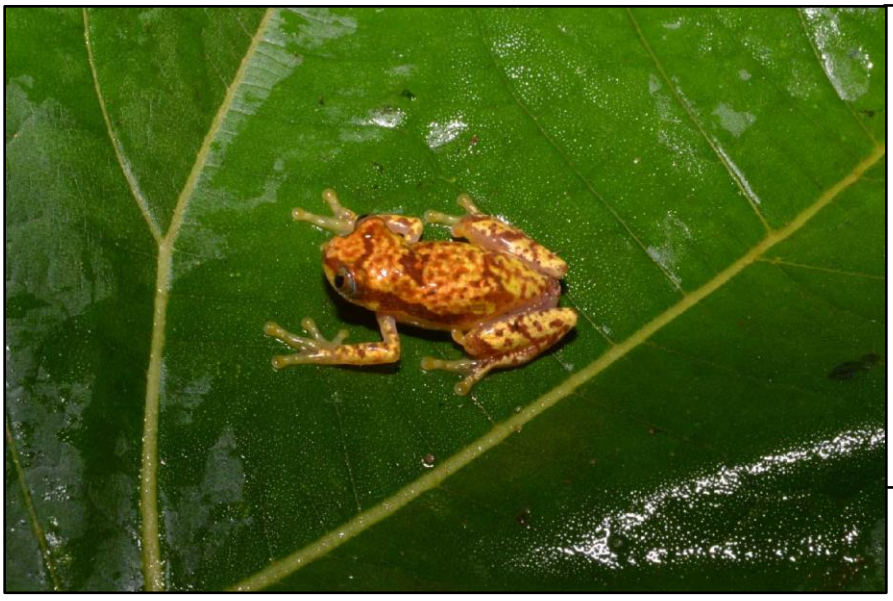

Figure 3: The Smooth Spiny Reed Frog (*Afrixalus laevis*) was described from Cameroon, and preliminary genetic data indicate that the population found at Bwindi is likely a new species. Photo by DFH.

AMPHIBIANS

		CENTRAL FOREST RESERVES								NATIONAL PARKS			
Species	**Common Name**	**Agoro-Agu**	**Budongo**	**Echuya**	**Mabira**	**Mt. Kadam**	**Mt. Kei**	**Mt. Moroto**	**Mt. Otze**	**Bwindi**	**Rwenzori**	**Elgon**	**Mgahinga**
Afrixalus osorioi	Osorio's Spiny Reed Frog		X		X								
Afrixalus cf. *laevis*	Smooth Spiny Reed Frog									X			
Amietia lubrica	River Frog				X					X			
Amietia cf. *lubrica*	River Frog	X	X	X		X		X				X	X
Amietia wittei	De Witte's River Frog											X	
Arthroleptis cf. *adelphus*	Foulassi Squeaker									X			
Arthroleptis cf. *adolfifriderici*	Adolf's Squeaker												X
Hoplobatrachus occipitalis	Crowned Bullfrog	X			X	X	X						
Hyperolius castaneus	Ahl's Reed Frog									X			X
Hyperolius cinnamomeoventris	Cinnamon Reed Frog		X		X	X							
Hyperolius frontalis	White-snouted Reed Frog									X			
Hyperolius kivuensis	Lake Kivu Reed Frog	X	X		X								
Hyperolius langi	Lang's Reed Frog		X		X								
Hyperolius lateralis	Side-striped Reed Frog									X			
Hyperolius viridiflavus	Common Reed Frog	X			X	X				X			
Hyperolius v. schubotzi	Common Reed Frog	X								X			
Kassina senegalensis	Running Frog												X
Leptopelis christyi	Christy's Tree Frog		X		X								
Leptopelis cf. *calcaratus*	Efulen Forest Tree Frog									X			
Leptopelis karissimbensis	Karissimbi Tree Frog												X
Leptopelis cf. *kivuensis*	Kivu Tree Frog										X		
Leptopelis sp. nov.	Forest Tree Frog			X						X			X
Phrynobatrachus auritus	Golden Puddle Frog				X								
Phrynobatrachus bequaerti	Vissoke Puddle Frog									X			

Phrynobatrachus natalensis	Natal Puddle Frog		X		X	X							
Phrynobatrachus cf. *parvulus*	Dwarf Puddle Frog												X
Phrynobatrachus petropedetoides	Ruwenzori Puddle Frog										X	X	
Phrynobatrachus scheffleri	Scheffler's Puddle Frog												X
Phrynobatrachus sp.	Puddle Frog	X											
Phlyctimantis verrucosus	Warty Striped Frog									X			
Ptychadena anchietae	Anchieta's Rocket Frog				X								
Ptychadena mascareniensis D	Mascarene Rocket Frog	X										X	
Ptychadena sp.	Rocket Frog		X			X	X			X			
Ptychadena taenioscelis	Small Rocket Frog					X							
Sclerophrys regularis	Common Toad												X
Sclerophrys kisoloensis	Kisolo Toad									X			
Sclerophrys pusilla	Striped Toad							X					
Sclerophrys sp.	Toad	X					X		X				
Xenopus laevis	Clawed Frog				X								
Xenopus sp.	Clawed Frog					X							
Xenopus cf. *wittei*	De Witte's Clawed Frog									X			

Table 1. – List of amphibian species collected from Central Forest Reserves and National Parks across Uganda during the 2015 expedition. Species collected were identified by morphology and phylogenetic analyses. Amphibian taxonomy follows Frost (2016).

REPTILES

		CENTRAL FOREST RESERVES								NATIONAL PARKS			
Species	**Common Name**	**Agoro-Agu**	**Budongo**	**Echuya**	**Mabira**	**Mt. Kadam**	**Mt. Kei**	**Mt. Moroto**	**Mt. Otze**	**Bwindi**	**Rwenzori**	**Elgon**	**Mgahinga**
Acanthocercus kiwuensis	Blue-headed Tree Agama									X			
Agama cf. *finchi*	Finch's Agama						X		X				
Agama sp.	Agama	X											
Adolfus jacksoni	Jackson's Forest Lizard							X		X		X	X
Atheris nitschei	Great Lakes Bush Viper										X		
Bitis arietans	Puff Adder								X				
Bitis nasicornis	Rhinoceros Viper				X								
Boaedon sp.	House Snake							X					
Broadleysaurus major	Rough-scaled Plated Lizard	X											
Causus resimus	Green Night Adder				X								
Chamaeleo gracilis	Graceful Chameleon	X					X	X	X				
Chamaeleo laevigatus	Smooth Chameleon	X							X				
Chamaesaura anguina	Cape Snake Lizard							X					
Cnemaspis elgonensis	Mt. Elgon Forest Gecko											X	
Cnemaspis sp.	Forest Gecko					X							
Cnemaspis cf. *quattuorseriata*	Sternfeld's Gecko									X			
Congolacerta vauereselli	Sparse-scaled Forest Lizard												X
Dendroaspis polylepis	Black Mamba						X						
Dipsadoboa cf. *weileri*	Weiler's Tree Snake				X								
Hemidactylus cf. *brookii*	Brook's House Gecko						X		X				
Kinyongia cf. *adolfifriderici*	Ituri Chameleon									X			
Kinyongia xenorhina	Strange-horned Chameleon										X		

Leptosiaphos meleagris	Rwenzori Four-toed Skink										X		
Lycophidion capense jacksoni	Cape Wolf Snake						X						
Lycophidion ornatum	Ornate Wolf Snake									X			
Lygodactylus cf. *gutturalis*	Chevron-throated Gecko	X											
Polemon cf. *christyi*	Chirsty's Snake Eater		X										
Psammophis sudanensis	Sand Snake	X											
Trachylepis cf. *megalura*	Grass-top Skink	X											X
Trachylepis striata	African Striped Skink							X				X	
Trachylepis varia	Variable Skink							X				X	
Trioceros conirostratus	Sudanese Unicorn Chameleon	X											
Trioceros cf. *conirostratus*	Sudanese Unicorn Chameleon					X		X					
Trioceros hoehnelii	High-casqued Chameleon											X	
Trioceros ituriensis	Ituri Chameleon		X										
Trioceros johnstoni	Johnston's Chameleon									X			X
Trioceros rudis	Rwenzori Side-striped Chameleon										X		X
Rhampholeon boulengeri	Boulenger's Pygmy Chameleon		X							X			

Table 2. – List of reptile species collected from Central Forest Reserves and National Parks across Uganda during the 2015 expedition. Species collected were identified by morphology and phylogenetic analyses. Reptilian taxonomy follows Uetz and Hošek (2016).

DISCUSSION

The species lists provided here can be used by the Uganda Wildlife Authority and the National Forestry Authority to update previous checklists for the herpetofauna of these protected areas. Many of the species collected during our preliminary assessments substantiate their purported presence in these areas (Branch, 1998; Schiøtz, 1999; Spawls et al., 2002; Spawls et al., 2006; Tilbury, 2010). Several of the collected species are new to science and further analyses need to be done to establish their taxonomic status. Some of the species are currently classified at the subspecies status and likely need to be elevated to full species pending future analyses.

Our preliminary surveys highlight the need for additional work in Uganda, especially with respect to its herpetofauna. This list, pooled with our 2014 list (Hughes et al., 2014), represents an extremely valuable resource for future studies into the distribution, taxonomy, and ultimately the conservation of Uganda's amphibian and reptilian wildlife. Our results most likely do not comprise the full diversity of the herpetofauna for these regions, nevertheless, several of the species may be new to science, and some of the species have not been observed in many years. These data serve to underscore the importance of surveying multiple regions to more comprehensively understand the diversity and distribution of Uganda's herpetofauna.

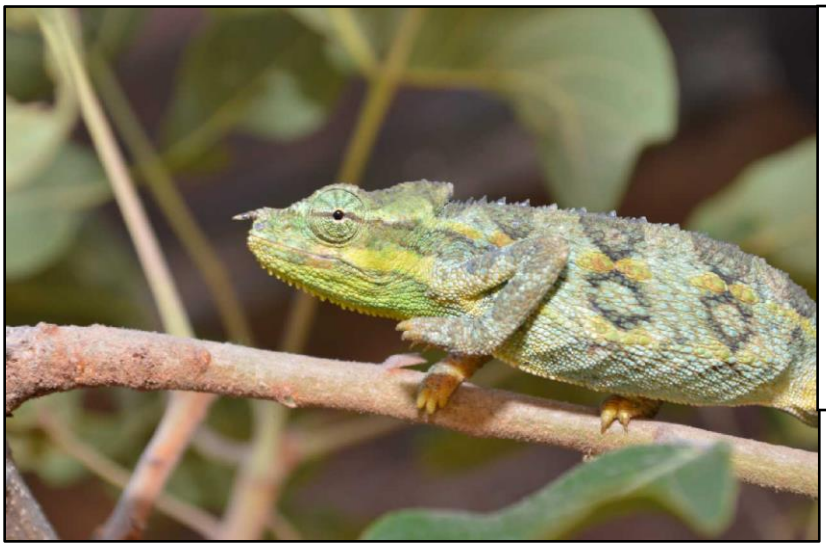

Figure 4: The Sudanese Unicorn Chameleon (*Trioceros conirostratus*) had not been recorded in Uganda prior to our 2015 expedition. Photo by DFH.

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