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Potential impacts of refugee camps on wetland herpetofauna in Uganda

MATHIAS BEHANGANA[1,2,4], RAYMOND KATUMBA[1], ANKE BARAHUKWA[2], JIMMY MUHEEBWA[2], ACHILLES BYARUHANGA[2], PEARSON MCGOVERN[3,4], DANIELE DENDI[4,5,6] & LUCA LUISELLI[4,5,6*]

[1]Department of Zoology, Entomology and Fisheries Sciences, Makerere University, PO Box 7062, Kampala, Uganda
[2]Nature Uganda, Plot 1, Katalima Crescent Lower Naguru, PO Box 27034, Kampala, Uganda
[3]African Chelonian Institute, BP 80 Joal, Thies, 23015, Senegal
[4]Institute for Development, Ecology, Conservation & Cooperation, via G. Tomasi di Lampedusa 33, I-00144, Rome, Italy
[5]Department of Zoology, University of Lome, Togo
[6]Department of Environmental and Applied Biology, Rivers State University of Science and Technology, P.M.B. 5080, Port Harcourt, Nigeria

[*]Corresponding author e-mail: l.luiselli@ideccngo.org

ABSTRACT – Wetlands are one of the world's fastest shrinking ecosystems, yet they are home to roughly 43% of all reptile and amphibian species. Sub-Saharan Africa has the fastest growing human population on the planet while also experiencing significant internal migrations of displaced peoples who settle in refugee camps. These camps are often in remote and previously undisturbed areas where interactions with wildlife are common. Reptiles and amphibians can be used to assess the health and resilience of habitats as a result of their sensitivity to environmental conditions. We sampled the herpetofauna of five wetlands located around two major refugee camps in Uganda using time-constrained visual encounter surveys during both nighttime and daytime. We provide baseline data on these wetland populations and compared them using alpha and beta diversity indices. These are the first data for refugee camp herpetofaunal communities, allowing for future comparisons of the effects of increased human pressure within these camps as well as the ability to better incorporate education and management to help conserve these wetlands and the species that inhabit them.

INTRODUCTION

Wetlands have been disappearing at alarming rates and their ecosystem services, including regulation of both local and global climate, biodiversity protection, maintenance of local hydrology, water filtration and many more are being degraded or lost (Costanza et al., 2014). These critical ecosystems contend with many anthropogenic threats such as damming, canalisation, deteriorating water quality due to various pollutants, and ever-increasing development and urbanisation (Davidson, 2014). Though wetlands play a vital role for many species, including humans, they are fragile ecosystems that must be managed and protected to sustainably harvest the many benefits they provide. It is estimated that over 55% of the world's natural wetlands have been lost, increasing the importance of safeguarding what remains (Davidson, 2014; Dixon et al., 2016). One of the most important environmental benefits that wetlands provide is habitat for a great diversity of fauna and flora, including roughly 43% of all herpetofauna species (Hails, 1997; Villamarin et al., 2022).

Reptiles and amphibians use both the aquatic and terrestrial environments and are important indicators of local ecosystem health (Wilson & McCranie, 2003; Mifsud, 2014; Paudel et al., 2022). Many species are sensitive to changes in their environment, allowing researchers to examine the effects of habitat alterations or human activities based on the response of the local herpetofauna. Unfortunately, due to many of the above-mentioned threats affecting wetlands, these groups of organisms are also declining around the world, with roughly 41% of amphibians and 21% of reptiles classified as threatened by the IUCN Red List (Cox et al., 2022; IUCN, 2023). Given their roles in the environment, their status as indicator species of habitat health, and their global plight, reptiles and amphibians warrant increased research and conservation action.

Africa is home to 2,123 reptile and 1,189 amphibian species, with new species being discovered constantly (IUCN, 2023), but also has the most rapidly expanding human population on the planet and, consequently, high rates of human displacement and habitat conversion (Adepoju, 2000; Crisp, 2000; Burgess et al., 2007; Brandt et al., 2017; Kaba, 2020). These displacements and internal migrations have created sites of high human density, often in remote and previously wild areas. To find safe, permanent settling grounds, millions of people have fled and continue to flee conflicts, bringing people and wildlife and their habitats into closer and closer association. Uganda, a relatively small nation in central Africa, has the greatest biodiversity per unit area in Africa (Eilu & Winterbottom, 2006; Plumptre et al., 2018). It is also the country with the greatest number of endemic vertebrates on mainland Africa (Plumptre et al., 2007). At the same time, twelve officially recognised refugee settlements, with over 1.5 million refugees (as of

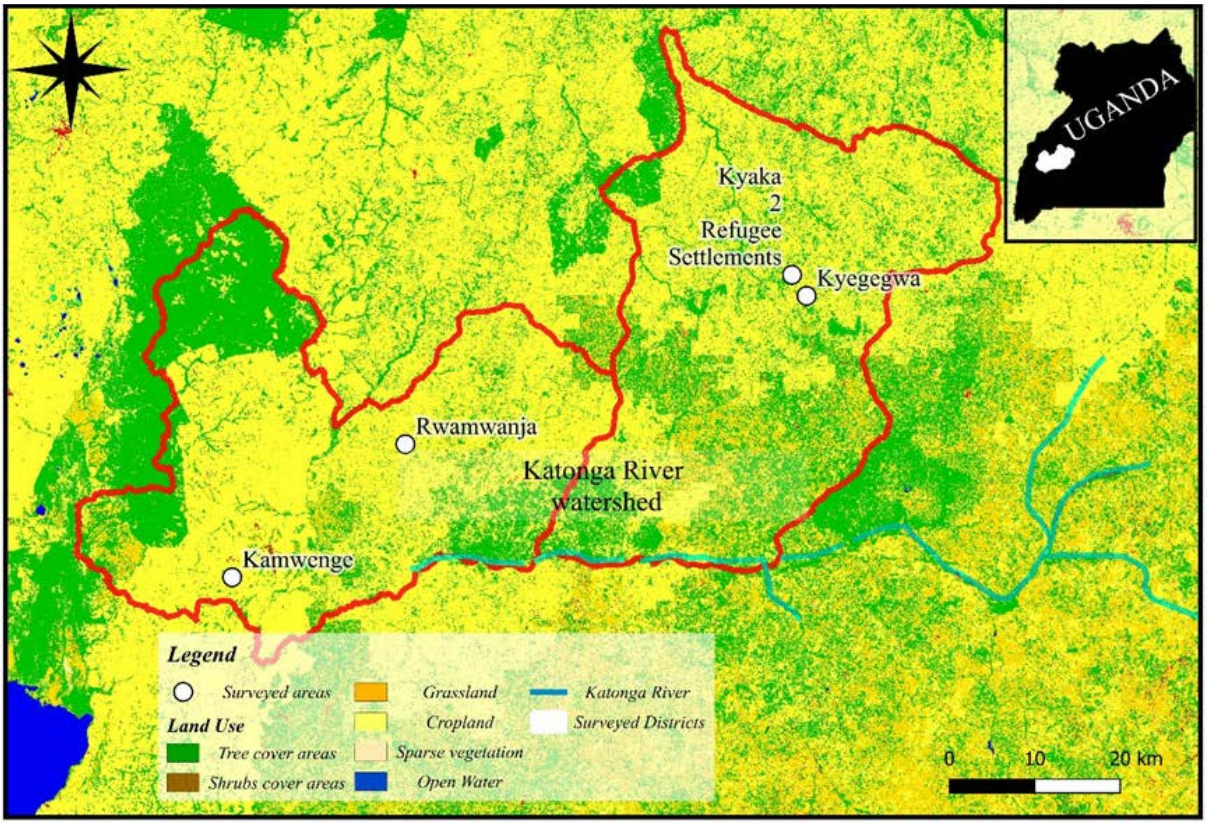

Figure 1. The study area in Uganda showing the locations of the refugee camps and surrounding land cover

30 September 2023, https://data.unhcr.org/en/country/uga), are located in Uganda, many of which have greatly expanded of late due to the political instability and civil wars in Sudan and South Sudan. As refugee numbers increase, local ecosystems must cope with added pressure and use, with clear evidence of increased disturbance closer to refugee camp centres. To begin the process of restoring wetlands located around refugee settlements, our team sampled the herpetofaunal communities of five wetlands within 15 km of two major refugee camps in Uganda. By identifying the species using these habitats, we can make inferences on the status of the wetlands as well as make informed decisions on how to improve them. Herein, we present the first data on herpetofaunal communities associated with refugee camp wetlands and suggest possible improvements for these vital and dwindling ecosystems.

MATERIALS & METHODS

Site Description

We sampled five wetlands in the districts of Kamwenge and Kyegegwa, Uganda, around the Rwamwanja and Kyaka 2 refugee settlements (Fig. 1). Rwamwanja, established in 1964 to host Rwandan refugees, is located in Kamwenge district in south-western Uganda and is home to roughly 70,000 refugees. Kyaka 2, located in Kyegegwa district, has nearly quadrupled in size since 2017 and now houses around 121,000 refugees (https://data.unhcr.org/en/country/uga). Around Rwamwanja we sampled two wetlands, Rushango wetland (RusKam) in Kabingo parish, Bihanga subcounty and Kajororo wetland (RwaKam), the primary water source for the settlement, in Nkoma-Katayelba subcounty just at the border of Rwamwanja settlement. Around Kyaka 2, we sampled Komuchwezi wetland (KomKye), Kyakatwanga wetland (KyaKye) and Sweeswe wetland (SweKye), all of which are associated with the Katonga river watershed. Most of the water used by Kyaka 2 is drawn from Sweeswe wetland. All wetlands were within 15 km of the refugee camps and were known to be used by people living in the camps. The refugee settlements are located along well organised road networks, forming areas that look like small towns or Rural Growth Centres (RCGs), built using mud or bricks, with iron sheet roofs. Refugees and their families are usually given between ¼ of an acre to an acre for subsistence farming and for building a home, with each parcel separated by a hedge or fence. The refugees tend to have better sanitation systems than the surrounding local communities, with more reliable access to freshwater, which can often create resentment amongst local communities. Due to the burgeoning numbers of refugees, many will venture outside their homesteads to acquire firewood and building materials, impacting the local environment. Refugees often also compete with locals for jobs, given their willingness to work for lower pay rates, causing animosity between locals and refugees and also increasing the use of natural resources from the surrounding environment by locals.

Sampling

From 13–25 October 2021, there were herpetological surveys in the five wetlands, undertaken by three-person field teams each day. Overall, each team member spent 90 hours in the field for a total of 270 man-hours. Predominantly for amphibian fauna, we surveyed the study areas from 18:00–21:00 h, as this is when most amphibians are active. To improve our chances of catching diurnal species, especially reptiles emerging to bask, we also surveyed the study area in the mornings (06:00–09:30 h). For the Visual Encounter Surveys (VES), each field researcher was positioned 5 metres apart and walked designated 500 m paths around the wetlands (Heyer et al., 1994; Freeman et al., 2003). Transects were variable depending on the length of wetland features at each site, but each transect at each site was separated by a minimum distance of 500 m. This included examining all possible refugia such as, turning over rocks and fallen logs, peeling tree bark, digging through leaf litter, and searching through trees, rotten tree stumps, tree buttresses, inside termite mounds and burrows. All refugia were replaced after inspection. Additionally, we used dip-netting to document any aquatic species, including tadpoles. We released all captured specimens unharmed apart from those that were not identifiable in the field, which we preserved in alcohol for later identification. We also opportunistically examined locally used Papyrus funnel traps (traditionally used for catching mudfish) when we encountered them at the field sites; these traps often caught certain frog species (e.g. *Xenopus*, Behangana et al., 2023). We also incorporated all opportunistic encounters into our dataset. Though we attempted to use pitfall traps to supplement our sampling effort, this method unfortunately failed due to vandalism.

We identified all captured individuals by referencing Schiøtz (1999), Spawls et al. (2002; 2006), Channing & Howell (2006), AmphibiaWeb (2021), the Reptile Database (Uetz et al., 2021) and Frost (2021).

Table 1. Anuran species and counts at five wetlands around two refugee camps in Kamwenge and Kyegegwa Districts, Uganda

Taxa	KomKye	KyaKye	SweKye	RwaKam	RusKam	Total
Hyperoliidae						
Afrixalus fulvovittatus	11	1	8	4	2	26
Hyperolius balfouri			1			1
Hyperolius cinnamomeoventris	5	3	4	3	3	18
Hyperolius kivuensis	9	1	2	5	6	23
Hyperolius viridiflavus	2	2	2	5	2	13
Kassina senegalensis	9	2		1		12
Pyxicephalidae						
Amietia nutti		2		1		3
Arthroleptidae						
Arthroleptis cf. poecilonotus			1			1
Leptopelis bocagii		1	1	2	1	5
Dicroglossidae						
Hoplobatrachus occipitalis				1		1
Phrynobatrachidae						
Phrynobatrachus cf. acridoides	5	12	3		2	22
Phrynobatrachus cf. bullans					1	1
Phrynobatrachus cf. parvulus	1					1
Phrynobatrachus mababiensis	8	2			2	12
Phrynobatrachus natalensis	15	10	5	2	1	33
Ptychadenidae						
Ptychadena cf. schillukorum		1				1
Ptychadena cf.bibroni		2				2
Ptychadena nilotica	27	25	11	8	7	78
Ptychadena oxyrhynchus	1					1
Ptychadena porosissima	2	3	1	1	2	9
Bufonidae						
Sclerophrys maculata	1	1		1	2	5
Sclerophrys pusilla					1	1
Sclerophrys regularis	5	5	2	5	3	20
Pipidae						
Xenopus cf. fischbergi			1			1
Xenopus victorianus	1		1	5		7
Total	**102**	**73**	**43**	**44**	**35**	**297**

Table 2. Reptile species and counts at five wetlands around two refugee camps in Kamwenge and Kyegegwa Districts, Uganda

Taxa	KomKye	KyaKye	SweKye	RwaKam	RusKam	Total
Serpentes						
Bitis arietans			1		1	2
Dendroaspis jamesoni			1		1	2
Hapsidophrys smaragdina			1		1	2
Philothamnus battersbyi			1		1	2
Psammophis mossambicus	2		1	1	2	6
Python sebae			1		1	2
Naja subflava	4		2	1	2	9
Sauria						
Acanthocercus ugandaensis	3			3		6
Chamaeleo gracilis	1	1			1	3
Hemidactylus mabouia					1	1
Trachylepis maculilabris		2	1	2	1	6
Trachylepis striata	4	2	1	2	1	10
Trioceros ellioti				1	1	2
Varanus niloticus				1	1	2
Chelonia						
Pelomedusa neumanni	1			1	1	3
Total	**15**	**5**	**10**	**12**	**16**	**58**

To compare the diversity and evenness of herpetofauna between refugee settlements and to allow comparisons with previously published results from the country, we calculated the following indices: the relative abundance of each species at each wetland, the Shannon-Weiner Index (H), the Simpson Diversity Index (λ), Margalef's Index (D) and Pielou's Evenness Index (E).

RESULTS

We recorded a total of 355 individuals (297 amphibians all of which were anurans and 58 reptiles) representing 18 families (8 amphibian, 10 reptile), 25 genera (11 amphibian, 14 reptile) and 40 species (25 amphibian, 15 reptile; Tables 1 & 2). Eight anurans and only one reptile (*Trachylepis striata*) were present at all five sampling sites. *Ptychadena nilotica* was the most common anuran species encountered, representing both the most abundant species at each sampling site and in the study (n = 78). With the exception of SweKye, Kyegegwa District wetlands had higher abundances of amphibians than the two wetlands in Kamwenge District. Only two species of amphibians constituted more than 10% of all individuals encountered amongst all five sites (*P. nilotica* and *Phrynobatrachus natalensis*). Interestingly, however, eight amphibian species were represented by a single individual, with each sampling site providing at least one of these singleton species records. For amphibians, both Shannon index and Margalef's index (Table 3) did not differ significantly between sites (in both cases $P > 0.05$ using ANOSIM). However, RwaKam and RusKam both had significantly higher evenness values ($P < 0.05$ using ANOSIM) than all other sites. Only one reptile (*Hemidactylus mabouia*) had a single record in the study, although 10 species were only represented by single individuals at each of the sites where they were encountered (but each was documented at more than one site). Five of the 15 reptile species observed in this study (Table 3; *T. striata*, *Trachylepis maculilabris*, *Psammophis mossambicus*, *Naja subflava*, *Acanthocercus ugandaensis*) amounted to 64% of all individuals found, with each of the five species representing more than 10% of the individuals found in the study. Statistical comparisons of univariate indices between sites could not be done due to small sample sizes for reptiles.

Table 3. Anuran and reptile diversity and evenness indices for five wetlands around two refugee camps in Kamwenge and Kyegegwa Districts, Uganda

Site	# of species	Shannon Index	Simpson Index	Margalef Index	Evenness
			Anurans		
All sites combined	25	2.53	0.88	4.22	0.79
KomKye	15	2.28	0.87	3.03	0.84
KyaKye	16	2.17	0.82	3.50	0.78
SweKye	14	2.27	0.86	3.46	0.86
RwaKam	14	2.41	0.90	3.44	0.91
RusKam	14	2.43	0.89	3.66	0.92
			Reptiles		
All sites combined	15	2.49	0.90	3.45	0.92
KomKye	6	1.66	0.79	1.85	0.92
KyaKye	3	1.06	0.64	1.24	0.96
SweKye	9	2.16	0.88	3.47	0.98
RwaKam	8	1.98	0.85	2.82	0.95
RusKam	14	2.60	0.92	4.69	0.99

DISCUSSION

Even with limited sampling over a period of just two weeks in the rainy season, we documented roughly 15% of Uganda's 262 reptile and amphibian species, of which 84 are amphibians and 178 reptiles (IUCN, 2023) although other authors provide slightly differing counts: 85 amphibians (Frost et al., 2022), 174 reptiles (Uetz et al., 2022). While all five sites harboured roughly equal numbers of amphibian species, Kyakatwanga and Komuchwezi wetlands had the fewest reptile species. Komuchwezi wetland is the most degraded of the sampled wetlands with heavy disturbance due to brick making and sand mining activities. Not only do these activities degrade the habitat, but they also increase human presence which may have reduced the presence of reptiles. Kyakatwanga wetland, though less disturbed than Komuchwezi, is nevertheless frequented by locals who access banana and rice plantations along its edges, likely resulting in human-reptile encounters. This assumption, that these interactions have reduced the abundance and presence of certain reptile species, is further supported by the absence of large, sedentary and easily-hunted reptiles found at almost all of the other sites (i.e. *Bitis arietans*, *Python sebae*) as well as the large, and often consumed, *Varanus niloticus*. Many previous studies have found lower diversity at more disturbed sites (Lieberman & Dock, 1982; Lieberman, 1986; Lenart et al., 1997; Glor et al., 2001).

Amongst amphibians, the most common species in the study seemed to also be the most common at each of the sampled sites, resulting in highly similar communities that differed only slightly due to singleton or low-abundance species being present at certain sites. This could possibly be a result of under sampling, as the low abundances of these species may have precluded their detection at sites where they were not encountered. Certainly, our short sampling period did not allow for perfect detection of all species present. However, if in fact the presence of some of the low-abundance or singleton species documented in this study is a true indication of their status at a site, it would be interesting to investigate the micro-conditions at each location that may be allowing these species to survive at one site rather than another. Ultimately, the consistency we saw among sites in the number of amphibian species does suggest that even highly-disturbed, and anthropogenically-impacted wetlands still act as refugia for a number of anuran species. The presence of singleton species also suggests that with habitat improvement and local support and education, these wetlands could provide refuge for more seldom-seen species. Most amphibians recorded in the study areas are typical wetland species, many of which are tolerant of anthropogenic changes to their habitats, with some even increasing in abundance in association with human disturbance, e.g. *Afrixalus fulvovittatus*, *Hyperolius kivuensis*, *Hyperolius viridiflavus*, *Kassina senegalensis*, *Phrynobatrachus mababiensis*, *Phrynobatrachus natalensis*, *Ptychadena nilotica* and *Sclerophrys regularis*. However, few reptilian species are tolerant of human disturbance and the species recorded are typical of the indigenous natural vegetation (Langdale-Brown, 1964).

This is the first study to sample multiple wetlands close to refugee camps in an effort to list the amphibian and reptile communities in these areas with a view to improve their status in the future. We found that although wetlands in refugee areas are often heavily degraded and play an important role in the acquisition of resources for locals, they still provide habitat to many species of herpetofauna. With this knowledge, we can begin to transform how these wetlands are used to better ensure the continued presence of species living alongside the extractive activities that will surely continue to expand. Activities such as subsistence farming, water extraction, channelisation, hunting and mining are constant pressures on the wildlife in these dwindling ecosystems, but with increased education and support, the impacts of these activities can be reduced. The timing and extent of these pressures on refugee area wetlands must be managed if the more sensitive species are to survive, and if habitat improvements are added to this management, then intact and healthy herpetofaunal communities can surely coexist on refugee area lands.

The refugee crisis, in fact, is contributing to the extinction of Africa's rarest turtle species *Cyclanorbis elegans* in Uganda and South Sudan (Luiselli et al., 2024; Walde et al., 2024), and therefore it is clear that the initiation of conservation projects directly targeting refugees and their activities will be of priority importance in the years to come.

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