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Monitoring, roost occupancy, and diet of the straw-coloured fruit bat *Eidolon helvum* in Kigali, Rwanda

Eric Leeuwerck

Independent researcher
Corresponding author email address: eleeuwerck@yahoo.fr

ABSTRACT

Kigali, the capital of Rwanda hosts a colony of Straw-coloured Fruit Bats (*Eidolon helvum)* that is divided over two roost sites inside the neighbourhood of Kiyovu. This colony is under high pressure due to increasing urbanisation of the city. Even with the status of Near Threatened species, hardly any attention is given to the straw-coloured fruit bats in Kigali and recently the roost sites have been highly affected by human activities.
Little is known about the *Eidolon helvum* colony in Kigali. In the course of this study, a mapping of the roost site has been undertaken, regular visits to the colony were made from September 2016 to October 2018 and a formal monthly count of the bats was carried out from May 2017 to June 2018. Important fluctuations in the number of bats have been observed seasonally. The colony reached its maximum between April to June 2018 (7,800 bats were counted in June 2018) and population decreases between December 2017 and February 2018 where no bats were detected at the roost sites. *E. helvum* in Kiyovu feeds on fruits from at least 11 plant species belonging to six families. The cutting down of trees is the major threat to *E. helvum* in Kigali.

Keywords: *Eidolon helvum, r*oost, diet, Kigali.

INTRODUCTION

The Straw-coloured Fruit Bat, *Eidolon helvum* (KERR, 1792), is an African fruit bat species that forms large colonies which are mainly found in sub-Saharan countries and on some offshore islands. *Eidolon helvum* has also been reported in southern and northern parts of the continent and in the surroundings islands (DEFREES and WILSON, 1988). SELTZER *et al.* (2013) reported that Old World fruit bats are important seed dispersers and pollinators of a wide range of economically important tree species providing important ecosystem services for the maintenance and regeneration of vegetation. *Eidolon helvum*, as suggested by BOLLEN *et al.* (2004, cited in WEBALA *et al.*, 2014), plays a role in pollinating some tree species. It has been recognised by NEWMAN *et al.* (2011) that the species plays an important role in regenerating cleared areas and maintaining forests. When foraging, *E. helvum* can spread seeds 59 km or more (RICHTER and CUMMING, 2008). FAHR *et al.* (2015) reported that *E. helvum* can foraging at distances of 87.9 km and pollinates trees for up to 88 km. The greatest cumulative distance travelled by a single bat observed was 2,518 km in 149 days during the long annual migrations of an estimated 5–10 million *E. helvum* into the Kasanka National Park in Zambia (RICHTER and CUMMING, 2006).

Despite the important role that *E. helvum* plays in African ecosystems, this species is listed as Near Threatened (NT) in the IUCN Red List of threatened species (MICKELBURGH *et al.*, 2008). Increasing human activities and increasing human populations are the most important threat to bat colonies generating losses and profound modifications of their foraging, feeding and roosting sites (MICKLEBURGH *et al.*, 2002).

The presence of *E. helvum* in Rwanda was mentioned by BAETEN *et al.* (1984) who also refer to older observations of the species in the country. Kigali hosts a colony of *E. helvum* inside the neighbourhood of Kiyovu, district of Nyarugenge.

The Kigali urban masterplan is deeply transforming the city design and organisation (BUNDERVOET *et al.* 2017) and Kiyovu, traditionally being a residential neighbourhood with tree filled gardens, is highly transformed by the masterplan: old houses are destroyed, gardens are cleared, trees are cut.

Colonies of straw-coloured fruit bats are frequently found inside urban settlements in large towns (BARANGA and KIREGYERA, 1982; WEBALA *et al.*, 2014). This is also the case in Kigali, largely due to the presence of fruit trees, especially in residential neighbourhoods

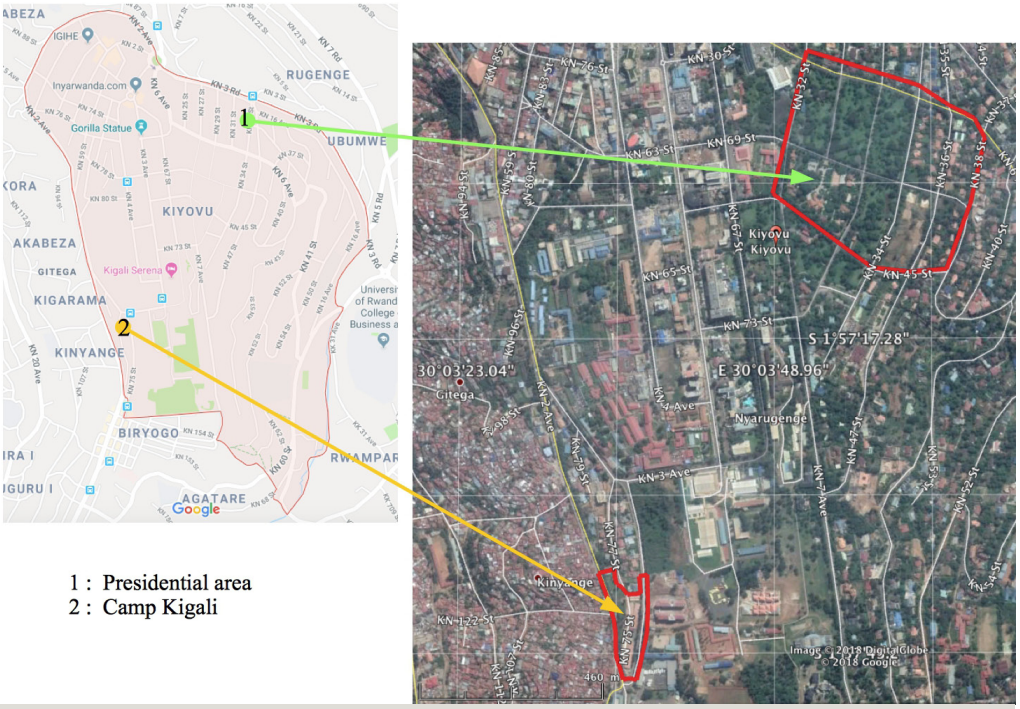

Figure 1: Roost sites of *E. helvum* in Kiyovu.

like Kiyovu. By reducing the surface of treed gardens in Kiyovu a loss in food availability for the straw-coloured fruit bat is generated.

The colony of *E. helvum* in Kiyovu used to roost in two different sites: the "Presidential Area", inside and bordering the grounds of the Presidential house, and "Camp Kigali" bordering Biryogo. These two roost sites have been drastically affected by tree felling during July and August 2017. Again later, the "Camp Kigali" site has suffered another major tree felling episode in October 2018 and no bats have been observed roosting in the site since then.

This study's objectives were to map the roosts of *E. helvum* in Kiyovu, to monitor monthly and annual fluctuations at roost sites, establishing a general view of the bat's diet, documenting the day roosts characteristics inside Kiyovu, and document the nature of the threats they are facing.

These observations were collected under the umbrella of Afribats and the Eidolon Monitoring Network, citizen science projects documenting bat distributions in Africa and surrounding islands. Therefore, this report aims to be a citizen science-based project.

MATERIAL AND METHODS

Study area and roost sites

This monitoring was conducted in the neighbourhood of Kiyovu in Kigali with a high human population density (1,552/km^2 – CITY POPULATION, 2018) and activities. Kigali rises at an average altitude of 1,500 m with an annual average precipitation of 1,028 mm and annual average temperature of 20.5°C . The precipitation regime is characterised by two rainy seasons and two dry seasons, the most important dry season occurs from June to mid-September (RWANDA CLIMATEMPS, 2018).

Two sites were selected in Kigali (Figure 2): "Presidential area" (Lat: -1.950737, Lon: 30.067638) and "Camp Kigali" (Lat: -1.960965, Lon: 30.05994).

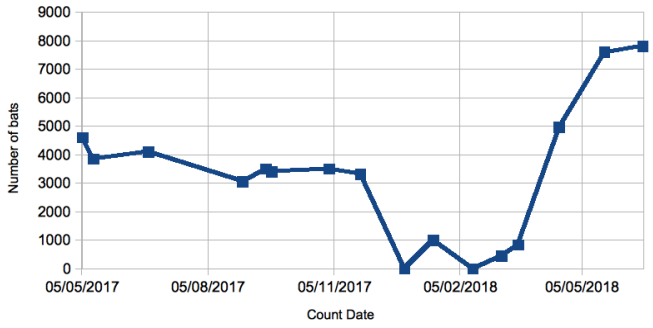

Figure 2: Population fluctuations of *E. helvum* at the roost site "Camp Kigali" from May 2017 to July 2018

Monitoring of the roost sites and the bat colony

Two active roost sites used by *E. helvum* were mapped and monitored from May 2017 to June 2018 (regular observations without counting were made from September 2016 to October 2018).

Each roost site was mapped with google location using an android phone and Google Earth Pro (Figure 1).

A bat count was carried out at the "Camp Kigali" site. At the "Presidential area", counting was not possible due to the proximity to the Presidential's domain.

The estimation of bat population was carried out on a monthly basis according to a method described by UTZURRUM *et al.* (2003), by counting the bats in each cluster and estimating the number of clusters in each tree. The average bat number in each cluster was multiplied by the number of clusters in each tree. The calculation was performed for each tree.

Informal interviews were conducted during monthly field visits: cleaners, employees, teachers and local inhabitants were questioned. The owner of a part of the field "Camp Kigali" and the Vice-Mayor of Kigali were also informally interviewed.

Tree species and loss of roost sites

Tree species at the roost site were identified with the help of the iNaturalist and Afribats communities.

Loss of day roosts sites were observed and reported during the monthly visits at the roost sites.

Diet observations

Direct observations were undertaken at night under foraging and feeding roosts in Kiyovu, using strong flashlights. Several droppings, ejecta and excretions were observed, photographed and collected under foraging and feeding sites during both day and night visits. Characteristics of the samples as colour and type of seeds were observed and reported. Observations were submitted to the

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iNaturalist and Afribats community.

RESULTS

Roost sites and bat counts

Important fluctuations of the population number of bats have been observed seasonally. The colony is at its maximum between April to June 2018 (7,800 bats been counted in June 2018) and lowest between December 2017 and February 2018, where no bats have been observed at the roost sites (Figure 2).

During visits to the site outside the counting period, the total absence of bats was also noted for the months of January and February 2017.

Roost characteristics and tree loss

The *E. helvum* colony roosts mostly in exotic trees in Kiyovu. The species prefer *Cupressus lusitanica* (Mexican White Cedar) for day roost but has also been found roosting in other tree species (Table 1): *Araucaria* sp., *Elais guineensis* (African oil palm), *Markhamia lutea* (Nile tulip), *Jacaranda mimosifolia* (Blue jacaranda), *Casuarina equisetifolia*, (Australian pine tree), *Terminalia mantaly* (Madagascar Almond or Umbrella tree), *Persea americana* (Avocado), *Ficus benjamina* (Benjamin fig), *Grevillea robusta* (Southern silky oak) and *Syzygium guineense* (Waterberry).

Table 1: Tree species used by *E. helvum* as day roost.

Family	Plant species	Exotic/Indigenous
Araucariaceae	*Araucaria* sp.	Exotic
Arecaceae	*Elaeis guineensis*	Exotic
Bignoniaceae	*Jacaranda mimosifolia*	Exotic
	Markhamia lutea	Indigenous
Casuarinaceae	*Casuarina equisetifolia*	Exotic
Combretaceae	*Terminalia mantaly*	Exotic
Cupressaceae	*Cupressus lusitanica*	Exotic
Lauraceae	*Persea americana*	Exotic
Moraceae	*Ficus benjamina*	Exotic
	Syzygium guineense	Indigenous
Proteaceae	*Grevillea robusta*	Exotic

The "Camp Kigali" day roost site consisted of 165 trees, mostly *C. lusitanica* (Table 2). In July-August 2017, a number of trees were felled, reducing the number of trees to 116. Since then, 11 additional trees (*C. lusitanica*) have died. The remaining trees were not in good condition and branches were regularly broken due to the presence of bats. In October 2018, tree felling was performed at the site reducing the number of surviving trees to 71 (Table 2).

Table 2: Losses of trees due to cuts in "Camp Kigali" roost site.

Tree species	Number of trees alive			% loss since June 2017
	June 2017	After		
		Sep 2017	Oct 2018	
Araucaria sp.	7	6	6	14.29
C. equisetifolia	4	4	4	0.00
C. lusitanica	119	72	27	77.31
F. cycomorus	1	0	0	100.00
M. lutea	7	7	7	0.00
Pinus sp.	9	9	9	0.00
S. campanulata	1	1	1	0.00
T. mantaly	17	17	17	0.00
Total of trees	165	116	71	56.97

Diet

Direct sample collection and observations at active foraging night roosts sites revealed that *E. helvum* consumes fruits from at least 11 plant species belonging to six families (Table 3) : *Mangifera indica* (Mango), *Carica papaya* (Papaya), *Persea americana* (Avocado), *Ficus sur* (Cape fig), *Ficus sycomorus* (Sycamore fig), *Ficus thonningii* (Wild fig / Strangler fig), *Morus alba* (Mulberry), *Musa acuminata* (Sweet banana), *Psidium guajava* (Guava), *Syzygium cordatum* (Red berry), *Syzigium guineense* (Waterberry).

During these observations, it seems that *E. helvum* is also attracted by the flowers of trees from the Bignoniaceae family: *Spathodea campanulata* (Nandi flame/African tulip tree) and *Kigelia africana* (Sausage tree).

Table 3: Plant species whose fruits were fed on by *E. helvum* in Kigali.

Family	Plant species	Exotic/Indigenous
Anacardiaceae	*Mangifera indica*	Exotic
Caricaceae	*Carica papaya*	Exotic
Lauraceae	*Persea americana*	Exotic
Moraceae	*Ficus sur*	Indigenous
	Ficus sycomorus	Indigenous
	Ficus thonningii	Indigenous
	Morus alba	Exotic
Musaceae	*Musa acuminata*	Exotic
Myrtaceae	*Psidium guajava*	Exotic
	Syzygium cordatum	Indigenous
	Syzygium guineense	Indigenous

DISCUSSION

The *E. helvum* colony in Kiyovu, Kigali has suffered severe tree felling since the beginning of this study. The nocturnal foraging and feeding sites are also affected by the urban changes that are occurring in Kiyovu. The Kiyovu *E. helvum* population has been affected negatively by these urban changes. This study, however, has collected valuable information on *E. helvum* habits in the neighbourhood of Kiyovu before the clearance of the roost sites.

The present study has revealed that *E. helvum* in Kigali consumes fruits from 11 plant species of six families, (Table 3) including indigenous trees like *F. sur, F. sycomorus, F. thonningii* (Moraceae), *S. cordatum* and *S. guineense* (Myrtaceae). It was also observed that *E. helvum* probably interacts with the flowers of two tree species from the same family, *S. campanulata* and *K. africana* (Bigogniaceae); observations showing the role of the species in the pollination of tree flowers have been reported before (FAHR *et al.* 2015).

The roost sites were located on private and public lands with, in the case of "Camp Kigali" site, high urban activities. *E. helvum* seems to prefer *C. lusitanica* (Cupressaceae) for day roost. However, the major concerns of people having daily activities around the "Camp Kigali" roost site are the smell and fear of sickness that the bat could bring (KANAMUGIRE, 2016). Informal interviews with teachers and inhabitants surrounding the site confirms that the disturbances caused by the bats are the noise, the smell from the guano droppings; the pupils attending the primary school inside "Kigali Camp" are afraid of the bats. The Vice Major of Kigali declared during an informal interview in June 2017 that the bats are a "nuisance" to him. The last clearance of trees in October 2018 was performed in a context of the Ebola crisis in the Democratic Republic of Congo and the links between fruit bats in general with Ebola (HAYMAN *et al.* 2012) and between Straw-coloured Fruit Bats and the transmission of zoonotic viruses (PEEL *et al.* 2013). According to informal interviews, many people are afraid that bats could bring Ebola to Rwanda.

Since the beginning of this study, a total of 57% tree loss has been reported at the "Camp Kigali" roost site, targeting *C. lusitanica,* the tree species preferred by *E. helvum* for roosting. The total loss of *C. lusitanica* in "Camp Kigali" being 77%.

The informal interviews also reveal that this colony has been well known by the neighbourhood's inhabitants since at least the end of the 1970s and indicate that the current colony is very small compared to its size back in the nineties.

There is seasonal variation in the size of the *E. helvum* population in Kiyovu. The bats are in higher abundance during the months of May and June (7,800 in June 2018 and 4,600 in May 2017) and no bats were observed in the months of January, February, December 2017 and February 2018. After December, the decrease in number of bats seems to correspond with a decline in food availability from the fruit trees in Kigali, fruit production tends to decrease around December until the end of February in the city. This decrease in population may also be a result of migration to other areas, where food is available. In June 2018, the number of bats rose to 7,800 which represents an estimation of 3,200 additional bats compared with the highest seasonal observation made in May 2017. The monitoring period of this study was too short to draw a clear conclusion about the origin of the bat influx.

Eidolon helvum is extremely loyal to its roost choice and even chooses the same trees each year (HUGGEL-WOLF and HUGGEL-WOLF, 1965). It is therefore evident that habitat destruction with the loss of roost trees is breaking up the bat colonies, forcing the bats to find alternative roost sites. POIANI *et al.*, (2000) reported that *E. helvum* needs a functional network of roosting and foraging sites for its survival. The loss of roost trees is the major threat to *E. helvum,* making the future of this bat colony uncertain in Kigali.

In view of the important ecological role that the Straw-coloured Fruit Bats are playing in the region, measures must be taken to protect the *Eidolon helvum* colony in Kigali.

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