

Population Size and Diet of Bush Hyrax *Heterohyrax brucei* (Gray 1868) in the Isolated Romanat Michael Church Forest in Northern Ethiopia, Implication for Conservation

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ABSTRACT

Fragmented sacred church forests in Ethiopia contribute about 5% of the vegetation cover in the country. These isolated forests harbour a variety of fauna and flora, including several indigenous species. A number of species in these forests however, are suffering from the effects of isolation and fragmentations which are poorly investigated issues. We studied population size and diet of bush hyrax, *Heterohyrax brucei*, in the isolated Romanat Michael church forest in Northern Ethiopia. The overall population size of the bush hyrax was about 20 individuals. The population suffered high adult mortality during the post-rainy season, between October and November. This season is also marked with the appearance of new pups. The bush hyraxes were observed predominantly browsing on the leaves, shoots, and flowers of 16 different plant species. There is a growing concern that the population may become locally extinct from demographic and/or genetic stochastic factors. We recommend immediate conservation measures to save the population from potential future factors causing an increase in the already high mortality rate.

Keywords: Population size, Church forest, Diet, *Heterohyrax brucei*, Ethiopia.

1. INTRODUCTION

In Ethiopian highlands, thousands of fragmented Orthodox Christian Church forests persist as scattered remnants of dry afro-montane forests which have been recently converted into open agricultural fields (Wassie et al., 2009, 2010; Cardelus et al., 2013). Some estimated the presence of about 35,000 church forests in Ethiopia (Bongers et al., 2006), some of which may date back to the fourth century (Wassie et al., 2005, 2010). In places such as South Gondar Zone (district) of the Amhara Region (province) where church forests are relatively better studied, the presence of 1,404 church forests were reported ranging in size from 1.6 to 100 ha (Wassie et al., 2010). The majority of these forests were about 5.2 ha in size (Cardelus et al., 2013).

The church forests are spiritually-protected by surrounding communities and are often named “biodiversity hotspots” because they harbour a variety of indigenous plants and animals, and contribute to about 5% of the vegetation cover in the country (Wassie et al., 2005, 2010; Cardelus et al., 2013). Nevertheless, the biggest threats to the forests come from the church

members and clergy who use them for firewood, charcoal, making sacred utensils, and grazing domestic animals (Bongers et al., 2006; Wassie et al., 2010; Cardelus et al., 2012, 2013). In addition the majority of the church forests are fragmented, highly susceptible to edge effects, and there is a growing concern about their resilience to further perturbations (Wassie et al., 2010; Cardelus et al., 2013). In particular, these threats may negatively affect the quality and quantity of resources available for the animals that depend on the forests, restrict their movement, range expansion, population growth, and decrease gene flow between populations (Van Buskirk and Willi, 2006; Verberk, 2011).

The hyrax is a medium-sized (*c.* 3.6 kg average adult weight), herbivorous mammal with short legs, a rudimentary tail, and round ears (Nowak, 1999; Barry and Hoeck, 2013) (see Fig 1). They belong to the order Hyracoidea, and family Procaviidae, which is the only living family of the order. The family Procaviidae is composed of three living genera, rock hyrax (*Procavia*), tree hyrax (*Dendrohyrax*) and bush hyrax or yellow-spotted hyrax (*Heterohyrax*). The genus *Heterohyrax* contains only one living species, *H. brucei* (Fig 1) (Barry and Shoshani, 2000). Within *H. brucei*, there are about 25 recognized subspecies (Barry and Hoeck, 2013). Ethiopia is a known type locality for three of these subspecies, *H. b. brucei*, *H. b. princeps* and *H. b. rudolfi* (Barry and Hoeck, 2013).



Figure 1. Photo of a bush hyrax (*H. brucei*) taken from Romanat Michael church forest on May 2012. (Courtesy: Y. Meheretu).

The bush hyrax (*H. brucei*) is a gregarious and diurnal species native to Africa, widely distributed from Ethiopia and Sudan southwards to the northern parts of South Africa (Barry et al., 2008). The bush hyrax inhabits rocky kopjes (small hills or outcrops), sheer cliffs or

precipices, and piles of large boulders (Barry and Shoshani, 2000). Modern hyraxes, which are small, rather inconspicuous African herbivores, were once the size of tapir and the most dominant terrestrial herbivore during the early tertiary African landscape for about 40 million years (Smith and Lyons, 2011). These large terrestrial forms were supposed to have been outcompeted by other herbivorous groups, Perissodactyla and Artiodactyla, arriving into Africa after the landmass connection between Africa and Asia in Oligocene (Grzimek et al., 2004; Smith and Lyons, 2011). The feeding of the modern bush hyrax is dominantly browsing on tree and shrub leaves, shoots, fruits, and bark near refuges (Hoeck, 1975).

The distribution of bush hyraxes in Ethiopia is poorly known. Studies on population status and diet are also scarce. From a human health point of view, several reports explained the reservoir role of hyraxes in the epidemiology of cutaneous leishmaniasis, a form of Old World leishmaniasis occurring in the highlands of Kenya and Ethiopia (Ashford et al., 1973; Lemma et al., 2009).

During a field excursion to Romanat Michael church forest (Fig 2) located on the outskirts of Mekelle city, capital of the Tigray Region in northern Ethiopia, we encountered a population of bush hyrax basking on trees of *c.* 15 m height. Romanat Michael church forest is located 13°34' N and 39°08' E (1,880 m mean elevation), *c.* 20 km northwest of Mekelle, following the road to Mesobo cement factory, with a total area of approximately 5 ha. The Mekelle area has a mean monthly maximum temperature range of 22° C (December) and 27° C (May), and a mean monthly minimum temperature range of 9° C (January) and 14° C (May). The mean annual rainfall is 610 mm. The objective of this study was to investigate the population size and diet of the hyraxes in the church forest, and in due course express the presence of conservation concerns potentially threatening the subsistence of the hyrax population in this small, isolated remnant forest.

2. MATERIALS AND METHODS

During a prior two week preliminary reconnaissance survey conducted in July 2012, we identified that the hyrax population was not distributed uniformly across the church forest; rather the population was congregated in five specific sites for feeding, basking and nesting (Fig 2). Hence, we opted to conduct a total count to determine total population size. Individual hyraxes were categorized into three age groups on the basis of comparative size as outlined in Chiweshe

(2007): young (pup < 1 year), sub-adult (about 2 years) and adult (≥ 3 years). Adults were sexed by morphological characteristics as given by Estes (1991); and Koren (2006).



Figure 2. Aerial photo of Romanat Michael church forest (top). The five white circles with asterisks in the bottom figure show the points where the hyraxes congregate for feeding, basking and nesting. (Figure reproduced from Google Earth 2014).

Census and diet data were collected for two consecutive days every two weeks, both in the morning (8:00-10:00 hrs) and in the afternoon (16:00-18:00 hrs), in the five sites identified while the hyraxes were feeding, basking and nesting, from August 2012 to January 2013. The months August and September 2012 represented the wet (rainy) season which generally runs from June to September. The months October and November 2012 represented the post-rainy season where there is no rain, but the church forest remained green with better understory cover relative to the dry season. The months December 2012 and January 2013 represented the dry season (which runs from December to May) where the area becomes relatively drier with poorer understory cover than compared to the wet and early-dry seasons. The latter months also coincide with the flowering period of most of the forest plants.

Feeding habit, i.e. plant species and parts of the plants consumed (leaf, flower, bark, fruit, seed), was recorded by following individuals from each age group for a period of 70 minutes (with 10 minutes interval after each 10 minutes observation), occasionally with the aid of binoculars. Individuals from the age groups were selected randomly and care was taken not to follow the same individual in subsequent recordings in the same season. Here, individuals were recognised by combinations of size and variations in pelage patterns. In addition, plant species preferred by the hyraxes for basking and nesting were identified.

3. RESULTS AND DISCUSSION

3.1. Population size

In the wet season the total number of the hyrax population was 17 individuals, composed of five adult males, six adult females, five sub-adults and one young (Table 1). In the post-rainy season the number increased to 22 individuals owing to five newly born pups. However, the number of individuals dropped to 16 in the dry season due to the disappearance of two adult males, three adult females and one sub-adult for an unknown reason. Even though we could not investigate the reason(s) for the reduction of the population during the dry season, we predict that the animals might have been predated upon or other potential mortality factors, such as diseases and parasites, might have affected them. Two of the priests residing in the church compound permanently contemplated that the missing hyraxes might have been predated by raptors. They also mentioned that in some nights they have heard elaborate distressed calls of the hyraxes that lasted for about five minutes, and opined that they might have been attacked by a leopard

(*Panthera pardus*). It was not possible to verify any of these claims, since remains of predated hyraxes have never been encountered during the study period. The presence of the latter mentioned predator in particular could be ruled out given the small size of the forest compared to the home range requirement of the predator. Furthermore, repeated attempts to sight predation or presence of indirect evidences (carcass, hair, bones, predators' foot prints, scat, and pellet) did not yield positive results. In Matobo National Park, Zimbabwe, adults of this species have selectively been predated by Verreaux's eagle (*Aquila verreauxii*) (Barry and Barry, 1996). Other predators of the species reported include, raptors, snakes and leopard (Barry and Hoeck, 2013). Migration of the animals to other sides of the forest was ruled out from the potential causes for the reduction in the abundance of the population since a subsequent total survey of the forest, evoked after this phenomenon, yielded no sighting of the missing hyraxes.

Table 1. Population size of bush hyraxes in Romanat Michael church forest in wet, post-rainy and dry seasons. AM: Adult male; AF: Adult female; SA: Sub-adult; YA: Young (including pups).

Season	Count	AM	AF	SA	YA
Wet	17	5	6	5	1
Post-rainy	22	6	6	5	5*
Dry	16	4	3	4	5**

* All five were newly born pups.

** Three were from the post-rainy season and two were newly born during the dry season.

3.2. Diet

The bush hyrax population was observed feeding on a total of 16 plant species belonging to 11 families (Table 2), of which the following six species accounted for about 70% of the diet: *Carissa spinarum* (16%), *Acacia sieberiana* (15%), *Olea europaea* (12%), *Justicia schimperiana* (9%), *Acokanthera schimperi* (9%), and *Ziziphus spina-christi* (8%).

During the wet season the diet of the hyraxes was dominated by browsed leaves (76%) and less grasses (16%) (Fig 3). During the post-rainy and dry seasons, they still predominantly browsed on leaves, but the proportion of flowers increased in the diet. The proportion of grass in the diet dropped towards the dry period. This finding is consistent with previous reports (Hoeck, 1975; Barry and Mundy, 2002). Note that, data on grazing (grasses) were kept separate from the other

plants consumed during the analysis (Fig 3) to show differences in browsing and grazing habit of the hyraxes and also to verify if understory growth has importance in their diet.

Table 2. List of plant species and plant parts consumed by bush hyraxes in Romanat Michael church forest, Tigray, northern Ethiopia, between August 2012 to January 2013. Data is pooled for all seasons and age groups to show the overall percentage contribution of each plant species. L: Leaf; B: Bark; Fl: Flower; Fr: Fruit).

Local name (Tigrigna)	Scientific name	Family	Type	Part/s consumed	Percentage contribution
Agam	<i>Carissa spinarum</i>	Apocynaceae	Tree	L, B, Fl, Fr	15.9
Che'a	<i>Acacia sieberiana</i>	Fabaceae	Tree	L, B, Fl	14.8
Awli'e	<i>Olea europaea</i>	Oleaceae	Tree	L, Fl, Fr	12.0
Simeja	<i>Justicia schimperiana</i>	Acanthaceae	Shrub	L, Fl	9.3
Mebti'e	<i>Acokanthera schimperi</i>	Apocynaceae	Tree	L, Fl	8.7
Geba	<i>Ziziphus spina-christi</i>	Rhamnaceae	Tree	L, B	8.2
Roman	<i>Punica granatum</i>	Lythraceae	Tree	L, B, Fl	6.0
At'at	<i>Maytenus undata</i>	Celastraceae	Shrub	L, B, Fl, Fr	4.9
Kuliaw	<i>Euclea racemosa</i>	Ebenaceae	Shrub	L	4.4
Taftafo	<i>Eragrostis papossa</i>	Poaceae	Grass	L	3.8
Atami	<i>Rhus natalensis</i>	Anacardiaceae	Tree	L, B, Fl	3.8
Keretatimo	<i>Grewia mollis</i>	Tilaceae	Shrub	L	3.3
Cheguri saeri	<i>Cymbopogon caesius</i>	Poaceae	Grass	L	2.7
Tahag	<i>Cynodon dactylon</i>	Poaceae	Grass	L	1.1
Akrima	<i>Eleusine floccifolia</i>	Poaceae	Grass	L	0.6
Saesa'a	<i>Avena abyssinica</i>	Poaceae	Grass	L	0.6

In Serengeti National Park, Tanzania, bush hyraxes consumed 64 plant species, of which 2–11 species comprised 90% of the diet locally (Hoeck, 1975). The most commonly consumed plant in the national park included *Cordia ovalis*, *Grewia fallax*, *Hibiscus lunarifolius*, *Ficus glumosa*, *Ficus ingens*, *Iboza* sp., and *Maerua triphylla*. In Matobo National Park, Zimbabwe, the diet of bush hyraxes was predominantly comprised of *Combretum molle*, *Commiphora marlothii*, *Elephantorrhiza goetzei*, *Flueggia virosa*, *Strychnos usambarensis*, *Kirkia acuminata*, *Croton*

gratissimus, *Mundulea sericea*, and *Rhus leptodictya* (Barry and Shoshani, 2000). These reports suggest that the diet of the specie notably varies locally.

During the day, the hyraxes were observed basking on the branches of four large tree species, *O. europaea*, *Mimusops kummel*, *A. schimperi* and *C. spinarum*. In the morning the hyraxes come out of excavated holes and tree crevices. Contrary to reports in other parts of Africa (Barry and Mundy, 1998; Barry and Shoshani, 2000; Barry and Hoeck, 2013), the hyraxes in the current study were not observed basking on rocky kopjes and rock crevices located in the forest, along the waterfall.

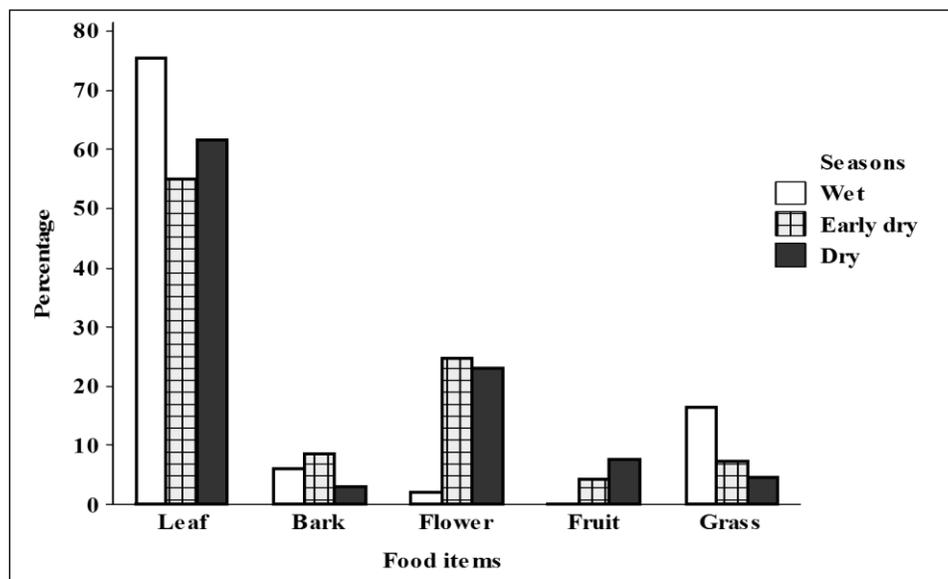


Figure 3. Relative contributions of plant parts to the diet of bush hyraxes in Romanat Michael church forest during the wet, early-dry and dry seasons.

3.3. Conservation concern

From conservation point of view, small populations are more likely vulnerable to a significant decline in genetic diversity on their own, let alone when the number of breeding individuals is very low (Frankham, 2003, 2010). Furthermore, in small populations inbreeding may increase the proportion of homozygous genes which could ultimately lead to a reduction in fitness (Crnokrak and Roff, 1999; Keller and Waller, 2002). For species like bush hyrax, which has a relatively long (24-30 weeks) gestation period (Barry and Hoeck, 2013) and reproduction synchronized with seasonal rainfall (Barry and Mundy, 1998), the loss of five adult individuals in just one season, raises a worrisome sustainability concern. Note that bush hyraxes are

susceptible to viral pneumonia and tuberculosis (Sale, 1966), they harbour Leishmania (Lemma et al., 2009), nematode and different arthropod ectoparasites (Barry and Shoshani, 2000). Even though we did not investigate this topic, the small hyrax population might have suffered genetic stochasticity that could be explained by compromised resistance to diseases and parasites, as some of the adult individuals looked unusually weak during the dry season a few days before the population count dropped.

In the sites where the bush hyrax population congregate, there were patches of remnant tall trees on which the hyraxes were continually observed feeding, basking and nesting. We observed two worrying signs there which could further endanger the sustainability of the population, (i) three *O. europaea* trees have dried out, suggesting that some of the remnant trees are getting older or diseased, and (ii) there were little signs of regeneration of the tree species, hampered by constant understory grazing by domestic animals belonging to the church priests. The latter problem has also been reported in other church forests in Ethiopia (see Wassie et al., 2009, 2010).

4. CONCLUSION

The presence of bush hyrax in this isolated remnant forest is puzzling given the absence of historical record of the presence of ideal large forest or riparian vegetation suitable for bush hyrax around Mekelle to consider a source population. Nevertheless, the bush hyrax population is small, experiencing high adult mortality from an unknown cause. Unfortunately, due to lack of historical population records it was not possible to substantiate whether the hyrax population has been fluctuating in the same manner in the past or if this was a onetime phenomenon. Even so, there is a growing concern that the hyrax population might lose its resilience due to inbreeding as the number of breeding individuals in the population continues to decline. Further study would help understand the causes for the population fluctuation and measure the resilience of the population to the intrinsic and extrinsic stresses so as to design effective management methods. Immediate conservation measures relieving the population from the potential mortality factors need to be undertaken in combination with afforestation to replace the aging indigenous trees.

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