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Research Article

Foraging Ecology and Diurnal Activity Patterns of Klipspringer (*Oreotragus oreotragus*) in Yetefet Woyenat Forest, East Gojjam, Ethiopia

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The foraging ecology and diurnal activity patterns of the klipspringer (*Oreotragus oreotragus)* were studied in Yetefet Woyenat Forest from September 2017 to August 2018 during the dry and wet seasons. Data were collected by visual observation using focal and scan sampling methods. The result indicated that klipspringers were observed feeding on grasses, herbs, trees, and shrubs, but were primarily browsers during both wet and dry seasons. *Carissa edulis* was the most consumed plant species in the study area, followed by *Rosa abyssinica* and *Maytenus arbutifolia*. Despite moderate ambient temperatures, klipspringers were mostly active during early morning and late afternoon, feeding 45.56% of the daylight hours during the dry season and 43.75% during the wet season. Klipspringers were facing threats due to human activities in the study area. Thus, appropriate conservation measures should be taken to reduce disturbance of their ecology.

1. Introduction

The klipspringer (*Oreotragus oreotragus*) is a small, sturdy antelope, exhibiting a shoulder height of 43–60 cm and a body mass of ca. 10 kg for adult males and 13 kg for adult females [1, 2]. The species has a wide distribution ranging from north-eastern Sudan, Eritrea, northern Somalia, and the Ethiopian Highlands, southwards through East and southern Africa [3]. Klipspringers do not consume excessive amount of food because their stomach are small. As a consequence, they selectively browse on highly nutritious plants and plant parts, including fruits and flowers [4]. They forage between 15% and 41% of the daytime hours [5]. When klipspringers feed, one of the group members stands and remains vigilant. During feeding, klipspringers never stand and forage in one place but rather move from plant to plant. They drink very little and obtain most of their water from their food. They occasionally feed on succulents with thick fleshy leaves or stems for their water, but not for their nutrient content [6].

Klipspringers are active during both the day and night but are considered mostly active during early morning and late afternoon. Throughout the remainder of the day, they tend to hide in the shade to avoid the heat. When temperatures are cool, they remain active throughout the day [7]. Male and female pair bond relationships might be an adaptive trait allowing greater vigilance in open habitats. Although klipspringers remain in close proximity and are aware of each other's behaviour and location, actual contact between members is quite rare [8].

Studying foraging ecology and activity patterns of klipspringers is crucial to develop appropriate monitoring protocols and eventually better management strategies. The activity budget reflects a combination of factors including individual physical condition, social structure, and environmental conditions [9]. Understanding of the foraging behaviour of a species becomes a fundamental step in understanding the biology of the species and more precisely its ecological niche [10]. There is very little information on the

ecology and behaviour of the klipspringer in Yetefet Woyenat Forest. Accordingly, the aim of the present study is to investigate the foraging ecology and activity patterns of the species in this area of East Gojjam, Ethiopia. The study will enhance our knowledge of foraging ecology and activity patterns of klipspringers and also contribute to the conservation of the species in the area.

2. Material and Methods

2.1. Study Area. The present study was carried out in Yetefet Woyenat Forest, located at 10 km (10°52′ N, 38°17′ E) from the town of Mertule Maryam in East Gojjam Zone, Amhara Regional state, Ethiopia (Figure 1). With a surface area of 102 ha and an elevation of 2200 m above sea level, the forest is characterized by rough topography, deeply incised valleys, escarpments, and plateau [11]. Precipitations range from 941 to 1203 mm per year (average: 1053 mm) [12], with a single maximum in August and a minimum in January-February. The mean monthly temperature varies between 9.5°C and 27.5°C [11] and is higher during the wet season (June to September) than the dry season (October to May).

Vegetation cover is dense and mainly composed of medium- and short-sized woody plants. Dominant plant species are *Carissa edulis*, *Rosa abyssinica*, *Myrsine africana*, *Acacia* sp., *Dodonaea angustifolia, Albizia schimperiana, Syzygium guineense*, *Allophyllus abyssinicus*, *Croton macrostachyus*, *Euclea racemosa, Olea europaea*, and *Gymnosporia arbutifolia* [13]. Besides, mammals such as bushbuck (*Tragelaphus scriptus*), vervet monkey (*Cercopithecus aethiops)*, spotted hyena (*Crocuta crocuta*), aardvark (*Orycteropus afer*), hares (*Lepus starki*), and rock hyrax (*Procavia capensis*) and birds including Hardwood's francolin (*Francolinus harwoodi*) reside in the study area [13]. A total of 72 individuals of klipspringers were recorded in Yetefet Woyenat Forest. Of these, 32 (44.4%) were males and 36 (50%) were females while the remaining 4 (5.6%) individuals were unidentified sex. The sex ratio of adult males to adult females was 1.00 : 1.23 [14]. There is no natural predator for klipspringers in the study area [14].

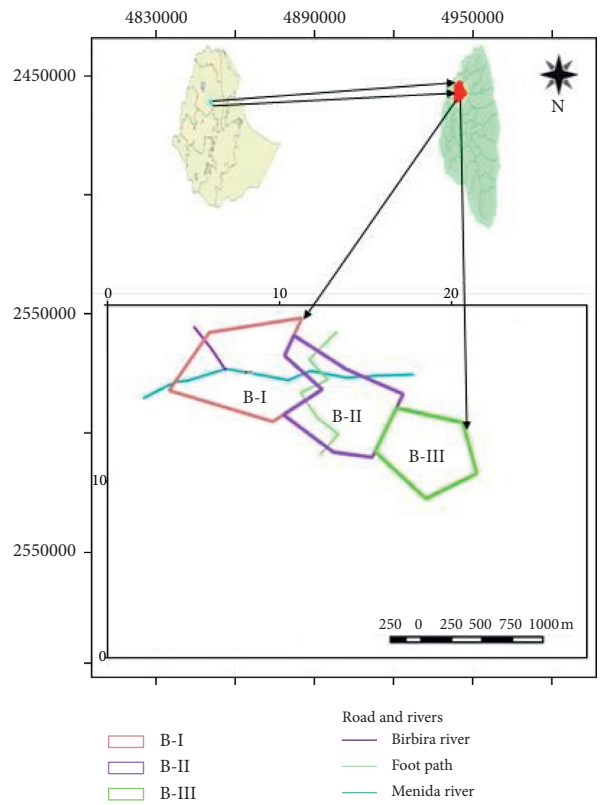

Figure 1: Map of Ethiopia, Amhara regional state, Yetefet Woyenat forest, and sample areas (B-I = block I; B-II = black II, and B-III = block III).

2.2. Methods

2.2.1. Foraging Ecology. The overall data were collected from September 2017 to August 2018 during the wet and dry seasons. To assess the foraging ecology of klipspringers, direct observation of the study animal was carried out. Information such as types of food items, parts of plant species consumed, and time spent for foraging were recorded during the wet and dry seasons. Part of the plant species consumed was classified based on the parts of the plant they ate, and their foraging types including browsing and grazing were also recorded [15]. An animal was followed during active feeding time to observe the plant species that were consumed [16]. For this, a focal animal was chosen and observed for 10 minutes, with the help of binoculars when necessary [17]. The focal animals were identified with the help of individual markings including horn shape, pelage colour, and scar on the fur. The focal animals were classified and chosen for observation according to their age and sex. Those selected were carefully studied and identified in the field to avoid confusion. Observations used to estimate the foraging ecology of klipspringers were homogeneously distributed throughout the study period. Observation was made for 12 days per month from 6:00 to 18:00 hrs. The animal was observed from a strategic place while consuming a particular plant species, and immediately after the animal moved away from the site, freshly cut plants were carefully examined; samples were collected, pressed, and brought to the Debre Markos University for identification.

2.2.2. Activity Patterns. Data on diurnal activity patterns were recorded using the scan sampling method [18]. The study animals were followed and data on their diurnal activities were recorded every 15 minutes from 6:00 to 18:00 hr using fixed interval time point sampling [19] during the wet and the dry seasons. The observations used to estimate the activity patterns were homogeneously distributed throughout the study period. Observation was made for 12 days per month. The study animal was followed at a distance between 20 and 200 m and observed by the naked eye or a binuclear depending on the distance between the observer and the focal animal as well as the topography of the habitat. To facilitate observation, vantage points were chosen which provide a broader view than low landscape positions. At each sampling point, the activity of the monitored animal was

classified as "feeding" (defined as the animal standing or advancing slowly while grazing or browsing), "moving" (if the animal was walking at a steady place), "resting," "standing," "grooming," "vigilance," or "other" (for activities such as courtship, defecating, sniffing of genitalia, running, and antagonism towards other klipspringers) [20].

2.3. Data Analysis. Data were analyzed using SPSS software version 20 and Microsoft Excel. The food items consumed was compared by using a Chi-square test across seasons. The activity pattern was also compared within a day and between seasons. Hourly time budget was calculated by using percentage utilization of each activity done by the focal individuals observed.

3. Results

3.1. Foraging Ecology. A total of 2,880 hr feeding observations were made. Klipspringers were observed feeding on 8 different plant species belonging to 7 families during the whole study period (Table 1). The species consumed were grasses, herbs, trees, and shrubs. The shrub *Carissa edulis* was the most consumed plant species which accounted for 23.5% during the dry season followed by the shrubs *Rosa abyssinica* (20.6%) and *Gymnopsoria arbutifolia* (19.6%). The grasses *Andropogon gayanus* (1.9%) and *Oplismenus compositus* (2.9%) were the least consumed plant species. There was a significant statistical difference in food items consumed during the dry season ($\chi^2 = 38.55$, df = 7, $P < 0.0001$). On the other hand, *Carissa edulis* was also the most consumed plant species during the wet season which accounted for 21.3% of the overall diets, while *Oplismenus compositus* 4.9% and *Andropogon gayanus* 5.4% were the least consumed plant species. There was a significant statistical difference in food items consumed during the wet season ($\chi^2 = 26.33$, df = 7, $P < 0.001$) (Table 1).

The frequency of plant part eaten by klipspringers was significantly different between both dry and wet seasons ($\chi^2 = 214.7$, df = 5, $P < 0.05$). Young leaves contributed 38.9% of the overall diet followed by mature leaves (35.5%) and shoots (18.42%). Stem, flowers, and fruits were consumed rarely during both dry and wet seasons. Young leaves were highly consumed during the wet (52.53%) and dry seasons (50.12%) out of the overall diet. On the other hand, fruits were not consumed during the dry season, and flowers were least consumed (0.23%) during the wet season (Figure 2).

Klipspringers were observed more often browsing than grazing in both dry and wet seasons. They spent 66.3% of their time browsing during the wet season and 64.4% during the dry season. However, there was no significant difference in the proportion of browsing and grazing during the wet season ($\chi^2 = 1.52$, df = 1, $P > 0.20$) and dry season ($\chi^2 = 2.44$, df = 1, $P > 0.10$).

There was a significant difference between age-sex classes in the proportions of the different plant parts consumed. Juveniles primarily fed on young leaves (63.2%), whereas their elders primarily fed on mature leaves (subadults: 47.3%; adults: 44.4%). Furthermore, adults fed more often on shoots than did younger animals (Table 2).

There was a significant difference ($\chi^2 = 405.3$, df = 4 and $P < 0.0001$) in feeding preference between male and female individuals in both seasons. Females primarily fed on young leaves, whereas males mainly fed on mature leaves (Table 3).

3.2. Diurnal Activity Patterns. A total of 3,600 hr observations of diurnal activities were made. There was no significant difference in activity budget between the seasons ($\chi^2 = 0.14$, df = 1, $P > 0.05$). Of the total activities recorded during the dry season, feeding was the highest (45.56%) recorded activity followed by resting (17.85%). There was a significant statistical difference in different activities carried out during the wet season ($\chi^2 = 745$, df = 6, $P < 0.05$). On the other hand, the klipspringer was recorded during the wet season. 43.75% represented feeding followed by moving (14.8%). There was a significant statistical difference among the various activities carried out during the dry season ($\chi^2 = 576.36$, df = 6, $P < 0.05$) (Table 4).

All age-sex classes spent most of their time on feeding and then resting, whereas least frequent activities were grooming, vigilance, and others (Figure 3). Nevertheless, young spent less time feeding and more time resting than elders.

There was significant difference ($\chi^2 = 12.3$ and $P < 0.05$) in terms of hourly time budget for activities during both dry and wet seasons. Klipspringers spent more time for feeding from 8:00–9:00 h and 16:00–17:00 h. Furthermore, they rested from 12:00 h to 16:00 h (Figure 4).

4. Discussion

For developing effective management strategy of wildlife species, information on feeding habits and activity patterns are essential [21]. The present study shows that the time spent for foraging was higher during the dry season. An increase in feeding time with decreasing food availability in the dry season has been reported for several African antelopes [22]. Klipspringers feed primarily during the early morning and late afternoon and feed for brief periods throughout the day. Similarly, according to [5], klipspringers spend up to 41% of their day feeding. In the present study, female klipspringers spent more time for feeding than males. As with all antelope, the female klipspringer needs extra energy to develop a fetus or suckle a lamb. Studies on the energy requirements of domestic and wild ruminants have shown that gestation requires considerably more energy than the energy predicted by the total body mass and that lactating females use energy up to 2–3 times the basal metabolic rates [23]. Thus, the nutritional requirements of a female klipspringer should be greater than those of the male for nine to ten months of the year, since they normally have one offspring a year [4], are pregnant for five and a half to six months, and then lactate for about four months. For the remaining months, they probably have to replace reserves that have been utilized during this period.

Table 1: Seasonal percentage contribution of plant species consumed by klipspringers during the dry and wet seasons.

Species consumed	Common name	Family	Relative percentage	
			Wet season (%)	Dry season (%)
Dovyalis abyssinica	Abyssinica gooseberry	Flacourtiaceae	13.1	12.7
Gymnosporia arbutifolia	Confettie tree	Celastraceae	19.6	19.6
Carissa edulis	Carandas pulm	Apocynaceae	21.3	23.5
Rosa abyssinica	Abyssinian rose	Rosaceae	16.4	20.6
Myrsine africana	African box wood	Myrsinaceae	10.6	11.9
Olea europea	Wild olive	Oleaceae	8.4	6.9
Oplismenus compositus	Running mountain grass	Poaceae	4.9	2.9
Andropogon gayanus	Gamba grass	Poaceae	5.7	1.9
Total			100	100

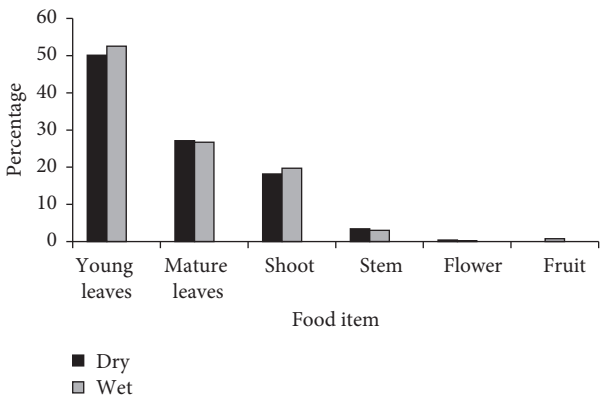

Figure 2: Percentage of plant part consumption by klipspringers during dry and wet seasons.

Table 2: Percentage of plant parts consumed by klipspringers.

Age	% part consumed					
	Young leave	Mature leave	Shoot	Stem	Fruit	Flower
Adult	30.7	44.41	17.76	5.44	2	—
Subadult	31.16	47.33	15.77	4.33	1.38	—
Juvenile	63.2	29.24	5.66	1.88	—	—

Table 3: Percentage of plant parts consumed by male and female klipspringers.

Sex	% of plant part consumed					
	Young leave	Mature leave	Shoot	Stem	Flower	Fruit
Female	34.9	44.2	15.3	4.4	1.2	—
Male	31.59	44.39	16.9	5.2	2	—

Klipspringers preferred browsing than grazing during dry and wet seasons. Similarly, klipspringers are primarily browsers and they prefer young plants, fruits, and flowers [24]. Grasses, which were mainly eaten in the wet season, form a minor portion of the diet. They depend largely on succulent plants, and not on water bodies, to meet their water requirement. According to the present finding, klipspringers foraged on 8 different species of grasses, herbs, trees, and shrubs. However, there was seasonal difference in food items consumed. They are frugivores and folivores, feeding primarily on the fruits and flowers of plants. Klipspringers eat more leaves because nutritious plants are not abundant in winter [6]. Food availability and preference may be the major reason for the seasonal variation in food items consumed. Food varies in quality and quantity between seasons and habitats. In the present study, klipspringers utilized some food items in a relatively lower quantity during the dry season than the amount they took during the wet season and vice versa. Several authors have shown that it is important to assess the quantity and quality of the most and the least eaten plant species that makes the bulk of the diet of herbivores [25]. The data available on foraging behaviour are used to specify the proportion of the diet containing different food items.

Table 4: Activity budgets of the observed klipspringers during the wet and dry seasons.

Activity	Season	
	Dry (%)	Wet (%)
Feeding	45.56	43.75
Standing	7.74	10.59
Resting	17.85	14.4
Moving	15.8	14.8
Grooming	4.81	6.93
Vigilance	4.12	5.43
Others	4.12	4.1
Total	100	100

The activity patterns of animals are correlated to their daily mode of life [26]. The activity patterns of klipspringers change on hourly and daily bases. This signifies that activity change varies in response to environmental factors, the most important of which is ambient weather conditions. Klipspringers devoted more time for foraging than any other activities during both seasons. Foraging activity reduced at midday. The possible reason may be the influence of temperature, which affects the turgidity of plants which in turn affects the palatability of plants. Dankwa-Wiredu and Euler [27] found that at a temperature under 30°C, foraging plants of animal remained turgid. However, when the temperature exceeded 31°C, the plants became flaccid due to loss of water and probably less palatable. Resting is high during the midday as the activities are affected by temperature. This behaviour was significantly different between wet and dry

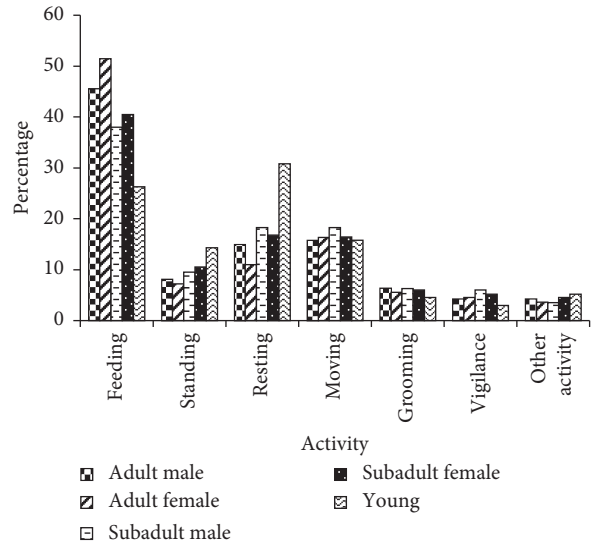

Figure 3: Percentage of different activities conducted across different age and sex groups.

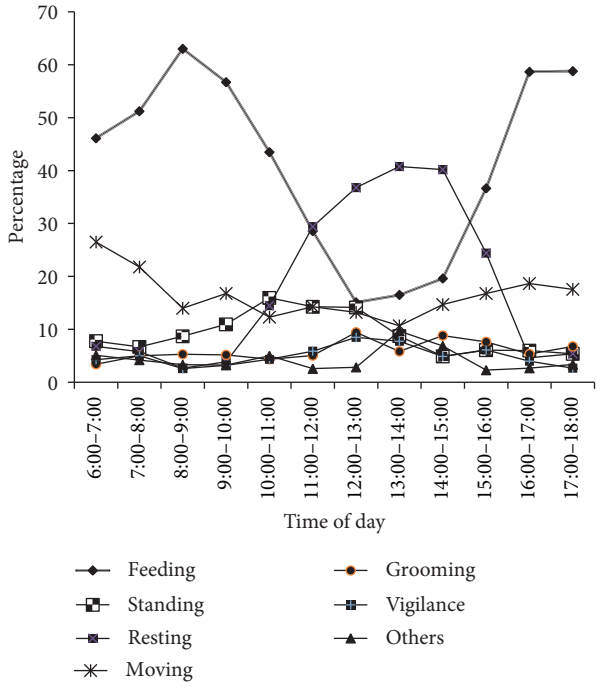

Figure 4: Timely activity budget of klipspringers during dry and wet seasons in the study area.

seasons. Resting showed a similar pattern, maximum during the dry season and minimum during the wet season, whereas moving displayed with maximum values recorded during the dry season 15.6% and minimum values 14.8% during the wet season. The reason is probably due to better food availability, which requires less movement in search of suitable pastures.

The characteristic behaviour of klipspringers is surveillance of the surrounding terrain from a prominent site by an individual while the rest of the group feed or rest [28]. The activity of vigilance accounted for 5.3% of adult male activities and 5.2% of adult female activities done during the study period. Males are generally more vigilant than females. In most activities, klipspringers show some forms of vigilance, usually from a site that provides a clear view of the surrounding terrain. Females apparently depend on male vigilance for protection, especially while foraging, and it has been shown that males are vigilant significantly more often than other group members, both in Ethiopia and in the Kuiseb river canopy. But females and occasionally subadult offsprings also are vigilant. This is an important reciprocal advantage for the male, especially during the foraging activity when klipspringers are more vulnerable [7].

5. Conclusion

Klipspringers spend larger portion of their time feeding and resting. They are restricted to cliff habitats and may not get enough food. So as to fulfil their energy requirements, they spent more time feeding. Adult females of klipspringer spend a longer time for feeding and moving than adult males. They feed mostly on herb leaves, but if they are not available, they feed on grass. Klipspringers move less when food availability is very high, but when food scarcity occurs klipspringers explore a larger area in search of food. The results of the present study have several conservation and management implications for the species and their habitat. Local people use the forest as a source of income. This accelerated deforestation from time to time, led to loss of food items and then loss of habitat for klipspringers. Therefore, appropriate conservation measures should be taken into consideration in order to enhance the habitat of klipspringers and reduce their contact with the local people and livestock.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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