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Research Article

Feeding Habits and Activity Patterns of Grivet Monkey (*Chlorocebus aethiops* L.) in Batiero Church Forest, Northern Ethiopia

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Grivet monkeys (*Chlorocebus aethiops*) are restricted to fragmented forests where food and space are limiting factors. The study investigated the feeding and activity patterns of grivet monkeys in Batiero Church Forest, northern Ethiopia, using focal and scan sampling techniques. Both focal and scan animal sessions lasted 15 min, with 5 min rest intervals between sessions. During the early dry season, grivet monkeys mainly fed on *Acacia sieberiana* (26.5%) and *Juniperus procera* (17.5%). Dry season food selection was significantly different, *J. procera* (20.5%), *Acacia mearnsii* (15.6%), *A. sieberiana* (14.2%), and *Cyperus bulbosus* (12.7%). The predominant plant parts eaten were seeds (42.6% and 33.3% in early dry and dry seasons, respectively) followed by leaves (34.5% and 22.5% in early dry and dry seasons, respectively). The activity patterns showed no significant seasonal variation, and the most frequent activity was feeding (33.3% and 32.6%, in early dry and dry seasons, respectively). The preferred food source tree species are threatened, and the survival of the grivet monkeys depends on the conservation of indigenous plants and trees.

1. Introduction

Primates are a relatively small order, but they occupy a wide range of habitats and ecological niches. Studying the feeding habit of primates is important for a better understanding of habitat selection and helps to identify the areas that are suitable for a given species within their geographical range [1]. Monkeys vary their diet to cope with fluctuations in food availability [2]. The feeding habit of primates not only gives information for the survival of the species but also it indicates the level of dietary specialization. The more specialized the primate's diet, the greater is its risk of extinction [3]. Understanding of the dietary preferences of primates may be used to reduce human-wildlife conflict because farmers can plant agricultural crops that are not preferable to grivet monkeys around the edge of the forest where they reside, and appetising trees can be planted in the forest to support their diet there. Studies of primate feeding habit have revealed a great deal of flexibility in ecological patterns [4].

The activity patterns of primates, including the time spent for resting, feeding, travelling, and socializing provides information on how primates interact with the environment and invest time and energy for reproduction and survival [5]. Recognizing the activity patterns of primates in their habitat helps to guide monitoring strategies for threatened and elusive primates [6]. The activity patterns of most primates show variation in time allocation. Some species travel short distances and allocate more time to resting and feeding, especially where food is locally abundant. Other species allocate more time to travel long distances and spend much of their time in foraging on high-quality food sources [5]. Studying the activity patterns of primates helps to identify the time that the species are most active and

researchers can focus their censusing efforts on the species during these times [6].

Studies on the feeding habit and activity patterns are useful for understanding the habitat requirements to maintain declining populations and may also contribute to our understanding about the population dynamics and carrying capacity of a particular area [4]. Currently the climate change and deforestation increase alarmingly, in response to these effects most primate species have the ability to develop behavioural modifications in their activity patterns to resist both climatic change and deforestation [5]. Due to human encroachment on wildlife habitats, protected areas become smaller, scarcer, and more threatened [7]. The extinction rate of wildlife is increasing due to depletion of food resources, loss of habitat, and destruction of the breeding sites of the species [8].

2. Methods

2.1. Study Site. The study was conducted in Batiero Church Forest, Eastern zone of Tigray, Northern Ethiopia. It is situated 65 km northeast of Mekelle City, the regional capital of Tigray Regional State. The area is geographically located between 13°30′-13°45′N and 39°0′-39°45′E and covers 45 ha. Altitude ranges from 1,800 m to 3,000 m above sea level. The average temperature of the area is 18°C. Rainfall is erratic but usually intense in July and August, with an annual average of about 667.8 mm. The region is severely denuded forest patches only remain at sites with special cultural significance, such as the immediate vicinity of churches (Church forests, see [9]).

3. Data Collection and Analysis

3.1. Feeding Habits. The feeding habits and activity patterns of the grivet monkeys were recorded from September 2012 to February 2013. Data were collected for eight consecutive days per month covering both early dry and dry seasons. The diet composition and food preference studies were conducted based on physical observation sampling, using focal and scan animal sampling. A total of 57 and 50 individual grivet monkeys were counted in early dry and dry season in the forest, respectively. There were 15 to 20 individuals of grivet monkeys living together in the forest. Troops were sampled opportunistically, by moving in the study area until a troop was spotted. Focal animal sessions lasted 15 minutes, with 5 minutes rest intervals between sessions, from 06: 30–12:30 hr in the morning and 14:00–18:30 hr in the afternoon [10, 11]. Individuals of troops were observed directly using 10×50 binocular at a distance of 10 to 50 metres. The adult males, adult females, subadults, and juveniles were studied separately. When a grivet monkey fed at the time of a scan, the plant species and food item upon which it was feeding was recorded. Feeding is any occasion during which a monkey plucked food items, pulled food items towards its mouth, masticated, or swallowed. The food items were identified as leaf, root, fruit, seed, flower, bark, or others (like gum, eggs of birds, rodents, insects, and lizards). The place where the animal fed was marked, and immediately after the animal moved, freshly cut plants were carefully examined; then, samples were taken for identification.

3.2. Activity Patterns. Scan sampling was used to collect behavioural data, as described by Mekonnen et al. [6]. The method involved observation of multiple group members. The focal group members were identified by the natural marking, size, coat colour, and facial features of some distinctive members of each of these groups. All age and sex categories were included in the scan (adult males, adult females, subadults, and juveniles). The activity patterns of the grivet monkeys were studied all day, with observations from 6:00 to 18:00 hr. During activity scan sampling, the activities of monkeys were recorded for 15 minutes at a sampling gap of 5 minutes. The group was scanned each time from left to right to avoid possible biases towards eye-catching activities like playing, grooming, or fighting. The activity recorded for each visible individual was the first activity that lasted for 5 seconds. The following behavioural categories were recorded: feeding, movement, resting, social behaviour, and reproductive behaviour.

Movement was scored when a grivet monkey was walking or running leading to a net change in position. Resting was scored when a grivet monkey was standing, lying down, or sleeping. Social behaviour was scored when grivet monkeys were communicating, grooming, playing, and aggression (fighting). Communication was recorded when a grivet monkey performed activities such as vocalization or communicated visually with each other including shouting, shattering, and screaming to escape from a predator or searching for food. Grooming was recorded when a grivet monkey used its hands to explore or to clean its body or the body of another grivet monkey. Playing included chasing, hitting, and other vigorous activities involving exaggerated movements and gestures by a grivet monkey interacting with others in a nonaggressive manner. Aggression was recorded when a grivet monkey chased, bit, displaced, or threatened another grivet monkey. Playing was distinguished from aggression interactions by the lack of screams from the participants and the lack of spectator interest from the rest of the troop. Feeding is a monkey pulling food items towards its mouth, masticating, or swallowing. Reproductive behaviour was recorded when monkeys were sniffing or mating.

3.3. Data Analysis. Statistical Package for Social Sciences (SPSS version 20.0) and Microsoft Excel were used to analyse the survey data. At a 95% confidence level, the chi-square test was used to examine the significance of seasonal differences in feeding and activity trends ($P = 0.05$). The chi-square test was used to compare what grivet monkeys chose

to eat during the dry and early dry seasons. In addition, the grivet monkey's behavioural actions in both seasons were being indicated by the chi-square test.

4. Results

4.1. Feeding Habits. A total of 1,368 behavioural records from focal and scan samplings were scored from the observational sampling of grivet monkeys. Of these, 720 were feeding habit records and the remaining 648 records were activity patterns.

During the course of the study period, grivet monkeys consumed a total of 19 plant species belonging to 11 families, of which 14 species were in the forest and five species were crops in the farmland around the forest (Table 1). Four of the plant species were trees, three species were shrubs, five species were grasses, and 2 species were herbs in the forest and five species of crops in the farmland. The grivet monkeys fed on 18 plant species during the early dry season and nine plant species during the dry season. In the early dry season, the grivet monkey population mainly fed on two plant species: *Acacia sieberiana* (26.5%) and *Juniperus procera* (17.5%). They also fed on crops in the early dry season (19.6%), whereas in the dry season, they mainly fed on four plant species, *J. procera* (20.5%), *Acacia mearnsii* (15.6%), *A. sieberiana* (14.2%), and *Cyperus bulbosus* (12.7%) (Table 1). The plant species consumed differed significantly with early dry and dry seasons ($X^2 = 2.783$, d$f = 18$, and $P < 0.001$).

The adult males, adult females, and subadults fed a total of 19 plant species and juveniles fed on 15 species of plants during the course of the study period (Table 2).

4.2. Seasonal Food Sources (Plant Parts) Preferred by Grivet Monkeys. In the early dry season, the grivet monkey predominantly fed on seeds of different plants (42.6%), followed by leaves (34.5%). Other food sources (termites, beetles, mouse, and lizards), fruits, and roots were less important in this season (Figure 1). In the dry season, the importance of other food sources increased to 6.4%, they were not seen feeding on fruits in this season. There was a significant difference between food sources of grivet monkeys with the season ($X^2 = 77.192$, d$f = 6$, and $P < 0.001$).

5. Activity Patterns of Grivet Monkey

5.1. Seasonal Variation in Activity Patterns. The most frequently observed activity pattern during the observation periods (early dry and dry seasons) was feeding followed by social behaviour which was a combination of grooming, playing, communication, and aggression (Figure 2).

Sexual activity was the least observed activity pattern in both early dry and dry seasons (3.8% and 2.4%, respectively). There was no significance variation in the activity patterns with the season ($X^2 = 15.059$, d$f = 10$, and $P = 0.130$).

5.2. Activity Patterns Based on Age-Sex Category. The adult males were frequently observed feeding, followed by resting. The activity patterns of adult females were dominated by feeding followed by social activities. For both sexes, sexual activity was least observed (Table 3). The activity patterns of the grivet monkey varied significantly with age and sex ($X^2 = 70.269$, d$f = 12$, and $P < 0.001$).

6. Discussion

6.1. Seasonality in Feeding Habits. Feeding habits varied seasonally with availability; grass was only available during the early dry season while other items were found only in the dry season, such as roots of *C. bulbosus*. Primates are well known for their ability to modify their behaviour and diet in response to the prevailing environmental conditions [12], such as seasonal variation in food availability in response to changes in rainfall patterns [13]. Grivet monkeys fed on a variety of food resources that is important for overcoming harsh environmental conditions. However, the grivet monkeys faced shortage of food sources in the forest as the season progressed towards the dry season; hence, they searched outside of the forest, including crops and crop residues in agricultural fields. According to Linkie et al. [14] crop damage by wild animals can make communities antagonistic and intolerant towards wildlife, which can result in killing of the problem species as well as undermining and impeding conservation strategies. Similarly Aschalew and Meheretu [15] reported that due to habitat loss and fragmentation, the grivet monkeys were forced to feed on agricultural crops, exacerbating conflicts. This led to conflict with communities living around the Batiero Church Forest. According to Dunbar [16] and Stanislaus [17], animals move smaller distances when food and water are abundant, which reduces predation and conflict with local communities.

During the early dry season, grivet monkeys mainly fed on two plant species, namely *A. sieberiana* and *J. procera*. They fed on the seeds, seed pods, bark, and gum of these trees in the forest. *J. procera* was not only the main food source of the grivet monkeys, but also served as a sleeping tree both at night and day times. Trees are important as sources of food and shelter for primates [16,18]. Unfortunately, *J. procera* is a slow growing and endangered indigenous species. Long-lasting and persistent human influence has considerably depleted *J. procera* stands and reduced their occurrence to some isolated patches [19]. The consumption of leaves probably meets the requirement of essential nutrients and protein because they contain a high percentage of crude protein and have low fiber, tannin, and toxin levels [13]. Woie [20] also reported that leaves are more nutritious with high moisture content and easily digested because of low fiber content as opposed to bark and other dry parts. According to Oates [21], the variation in seed eating is due to high availability of seeds and low abundance of young leaves as the dry season progresses. Seeds are high-quality food items, and their nutrient content and digestibility are usually relatively high. Therefore, in the dry season, when leaves are inadequate, primates sustain themselves on flowers and seeds [22]. In the present study, however, it was noted that the grivet monkeys mainly depended on seeds of *A. sieberiana* and *J. procera* during the study period. As the season progressed, drought reduced the availability of leaves and

Table 1: Plant species contributing to the diet of grivet monkeys during the early dry and dry seasons.

Local name (Tigrigna)	Species name	Family	Type	Plant parts consumed	Early dry season (%)	Dry season (%)
Tsadache'a	*Acacia sieberiana* D.C.	Fabaceae	Tree	S, B, Fl, L	26.5	14.2
Tshidi	*Juniperus procera* Hochst.	Cupressaceae	Tree	S, L, B	17.5	20.5
Akacha	*Acacia mearnsii* De Wild.	Fabaceae	Tree	Fl, L	2.2	15.7
Tifraria	*Sida schimperiana* Hochst.	Malvaceae	Herb	L, S	3.9	9.2
Ateat	*Maytenus ovatus* (Schweinf.)	Celastraceae	Shrub	B, L	3.2	8.6
Kuenti	*Cyperus bulbosus* Vahl	Cyperaceae	Grass	R	—	12.7
Mengolhats	*Dovyalis abyssinica* E.Mey.	Salicaceae	Tree	L, S	1.6	8.6
Tehag	*Cynodon dactylon* (L.) Pers.	Poaceae	Grass	L	7.2	—
Hareg	*Zehneria scabra* (L.f.)	Cucurbitaceae	Herb	L, S	2.5	5.7
Ketketa	*Dedonaea viscose* Jacq.	Sapindaceae	Shrub	Fl, S, L	2.7	4.8
Enkiuzibi	*Galium aparinoides* Forssk	Rubiaceae	Grass	S, L	6.1	—
Efan	*Vicia faba* L.	Fabaceae	Crop	S, L	5.3	—
Senday	*Triticum aestivum* L.	Poaceae	Crop	S, L	6.4	—
Belus	*Opuntia ficus-indica* Mill	Cactaceae	Shrub	Fr	3.5	—
Ater	*Pisum sativum* L.	Fabaceae	Crop	L, S	3.5	—
Sigem	*Hordeum vulgare* L.	Poaceae	Crop	S, L	3.0	—
Sifetsar	*Eleusine jaegeri* Gaertn	Poaceae	Grass	L	1.9	—
Serdy	*Pennisetum schimperi* Steud	Poaceae	Grass	L	1.6	—
Birisen	*Lens culinaris* Medikus	Fabaceae	Crop	S, L	1.4	—
Total					100%	100%

Note: S = seed, B = bark, Fl = flower, L = leaf, Fr = fruit, and R = root.

Table 2: Percent contribution of plant species for the diet of grivet monkeys based on age-sex category.

Plant species	Adult males	Adult females	Subadults	Juveniles
A. sieberiana	21.3	22.2	18.4	17.9
J. procera	17.2	21.1	18.5	19.5
A. mearnsii	10.1	9.4	9.5	6.6
S. schimperiana	5.2	5.3	6.6	9.1
M. ovatus	5.1	4.8	7.3	6.4
C. bulbosus	5.8	4.9	8.3	6.5
D. abyssinica	4.5	5.4	5.3	5.3
C. nlemfuensis	3.4	3.3	3.5	5.4
Z. scabra	3.5	4.3	2.7	5.5
D. viscose	3.7	3.7	3.3	4.3
G. aparinoides	3.2	2.3	2.9	4.1
V. faba	2.2	2.0	2.1	4.5
T. aestivum	4.2	2.5	3.1	3.2
O. ficus-indica	2.4	2.1	1.1	1.4
P. sativum	2.8	2.7	1.2	—
H. vulgare	2.1	1.8	2.1	—
E. jaegeri	0.6	0.4	2.7	—
P. schimperi	1.2	1	1.1	—
L. culinaris	1.5	0.8	0.3	0.3
Total	100%	100%	100%	100%

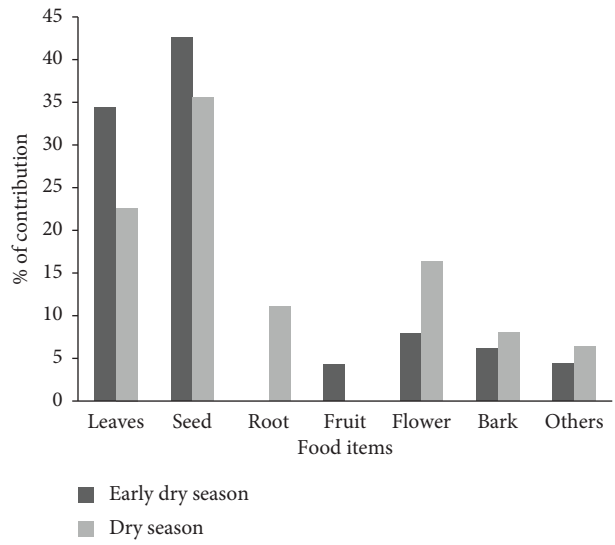

Figure 1: Seasonal food preferences of grivet monkeys in Batiero Church Forest.

the grivet monkeys shifted to available seeds, flowers, and bark of *D. abyssinica* and *D. viscose*.

Grivet monkeys fed mainly on leaves, roots, fruits, seeds, flowers, and bark, but also other sources of food were included as a food source such as termites, beetles, mouse, and lizards during the dry season than the early dry season because during the dry season the food availability was low and grivet monkeys compensated the scarcity of food by feeding on these animals. The types of invertebrate species provide a good source of fat and protein [18]. Most primates feed on fairly diverse diets because a single plant food item may not fulfil all nutrient and mineral requirements [23].

6.2. Seasonality in Activity Patterns and Age Category. Grivet monkeys devoted more time to feeding than to any other activity over both early dry and dry seasons. Mekonnen et al. [6] and Yonatan [24] obtained similar results in a behavioural study of Bale monkeys (*Chlorocebus djamdjamensis*) and Gelada baboon (*Theropithecus gelada*) in Bale Mountains National Park and in South Wollo,

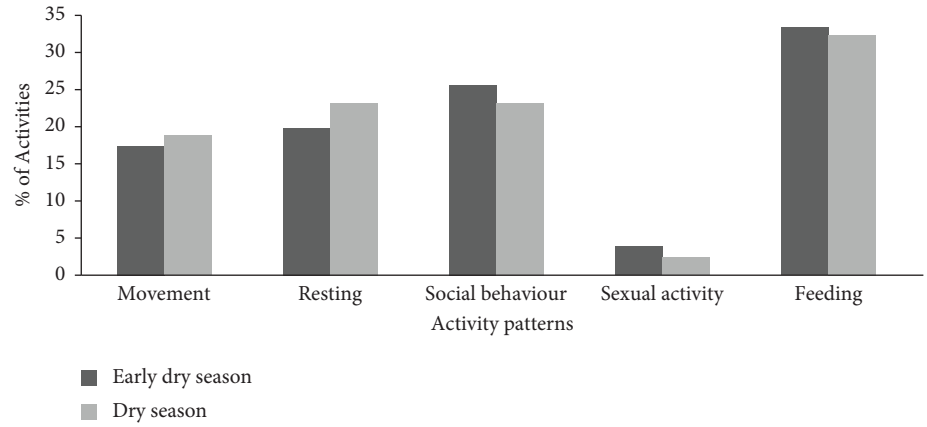

Figure 2: Seasonal activity patterns of grivet monkey in Batiero Church Forest.

Table 3: Activity patterns of grivet monkey based on age-sex category during the early dry and dry seasons.

Age-sex groups	Seasons	Activity patterns (%)				
		Feeding	Movement	Resting	Social behaviour	Reproductive behaviour
Adult males	EDS	29.7	22.9	24.3	14.9	8.1
	DS	33.3	18.4	26.4	17.2	4.6
	Mean	31.5	20.5	25.5	16.2	6.3
Adult females	EDS	40.4	11.5	15.4	28.8	3.8
	DS	42.6	9.3	20.4	25.9	1.8
	Mean	41.5	10.4	17.6	27.3	2.7
Subadults	EDS	36.6	18.3	16.9	28.2	—
	DS	27.8	19.4	33.3	19.4	—
	Mean	32.2	18.8	25.1	23.8	—
Juveniles	EDS	28.6	17.5	19.0	34.9	—
	DS	23.8	25.4	20.6	30.2	—
	Mean	26.2	21.4	19.8	32.5	—

Note: EDS = early dry season and DS = dry season.

Ethiopia, respectively. Animals that graze on undigested cellulose are compensated by feeding large amount of grass [24]. Howler monkeys were also spending most of their time for feeding 63%, followed by resting and travelling 9% [25]. Grivet monkeys were often found on the edges of the forest surrounded by agricultural farmlands and human settlement [15].

The grivet monkeys spent less time on movement than other activities like feeding, social activities, and resting. They stayed in the forest for feeding and resting, which may be associated with the potential for energy conservation, food resource availability, and structural characteristics of the forest to escape predators like feral dogs and jackal which were frequently observed as potential predators in the forest during the study period. According to Fashing [26], primates are travelling short distances each day, spending most of the day resting and feeding on relatively ever-present food items. Adult males of grivet monkey spent less time for feeding compared to adult females. Similar results were found in most primates due to better access of food resources [27]. Social behaviour in some primates shows that adult males rank above adult females (the reverse was sometime found: [28, 29]. As a result, higher ranking animals will have better access to food and other resources.

The grivet monkeys also displayed different social activities (24.1%); of this, grooming (13.5%) was frequently observed. Grivet monkeys use both fore limbs and hind limbs for scratching their body. Primates' frequent body scratching suggests that they are living with a considerable amount of ectoparasites [16]. Among activity patterns, sexual activity was the least recorded because the reproductive period was not included in our study. The grivet monkeys fed on diverse plant species and exhibited seasonal variation in food preferences, largely influenced by availability and quality of the food resources. The availability of food sources for grivet monkeys in Batiero Church Forest was in short supply; hence, the population spent most time feeding, followed by social activities and resting.

Conservation and rehabilitation, especially indigenous tree planting in and around Batiero Church Forest, are important for local biodiversity, including grivet monkeys.

Data Availability

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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