

## Research Article

# Activity Budgets of Impala (*Aepyceros melampus*) in Closed Environments: The Mukuvisi Woodland Experience, Zimbabwe

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Activity pattern plasticity in ungulates serves as an evolutionary adaptation to optimize fitness in inconsistent environments. Given that time is a limited and valuable resource for foraging wildlife species, provisioning and attraction may affect the activity pattern plasticity and reduce complexities of time partitioning for different activities by impala in closed environments. We assessed activity budgets of free-ranging impala social groups in a closed environment. Social group type had an influence on the activity budgets of impala except for foraging and moving activity states. Both the harem and bachelor groups spent more than 30% of their daily time foraging. Bachelor groups spent more time exhibiting vigilance tendencies than the harem groups. Season influenced the activity budgets of social groups other than vigilance and foraging activity states. Foraging time was highly correlated with vigilance, resting, and grooming. We concluded that provisioning and attraction may have reduced the influence of seasonality on the proportion of time spent on different activity states by impala social groups. There is a need to establish long-term socioecological, physiological, and reproductive consequences of provisioning and habituation on impala under closed environments.

## 1. Introduction

Impalas (*Aepyceros melampus melampus*, Lichtenstein, 1812) are regarded as the most common, widely distributed, and abundant medium-sized antelope species throughout southern and east Africa [1, 2]. Classified as intermediate feeders, impalas are adapted to browsing and grazing, thus making them successful inhabitants of the savanna ecosystems [3, 4]. Favoured for game farming as well as hunting, the subspecies has been widely introduced to privately owned land and game reserves in Zimbabwe, South Africa, and Namibia [1]. For that reason, impalas are extremely important to the game ranching and conservation sector of southern Africa.

In natural ecosystems, time is a valuable limited resource for all animals, and its partitioning might be influenced by sociality and as such may constrain sociality of free-ranging individuals [5]. Nakayama et al. [6] assert that the allocation of time for multiple activities has significant effects on the

survival of wildlife species. Consequently, individuals adapt to environmental changes, such as food availability and temperature, by adjusting the amount of time spent in different behavioural activities [7]. The seasonality of activity budgets might be highly flexible in response to seasonal fluctuations in food supply and corresponding temperature [8]. However, the influence of seasonality on food quality and availability in some environments seems to be affected by the current trends of attraction, provisioning, and habituation of some species [9–12]. Consequently, we expect that provisioned individuals would ultimately spend less time searching for food and foraging during the dry season compared to those occurring in non-provisioned environments.

Attraction is the process of luring wild animals with food handouts to a strategic site, “feeding spot,” to increase the likelihood of viewing the animals [13]. Closely related to attraction is the concept of provisioning which is an interaction where humans exploit the animal’s appetites and desire

for food to offset or neutralise their aversion to humans [11, 14]. Habituation is the waning of response to repeated, neutral stimuli such as human presence that ultimately render hitherto elusive animals susceptible to regular, proximate and protracted human viewing [11]. We argue that the level of provisioning and attraction for wildlife species in some systems may reduce seasonal variations in activity budgets of impala social groups. Observations made by Pays et al. [15] indicate that improving forage patch quality modifies the trade-offs between vigilance and foraging in favour of feeding. Animals invest time in the acquisition of information about forage resources within their environmental setting thus affecting the proportion of time allocated to other activities [16]. It is essential to know how impala social groups interact with their environment and invest energy as well as time for survival and reproduction by exploring their activity budgets.

Pollard and Blumstein [5] assert that time budgets can be divided into four mutually exclusive and exhaustive behavioural categories, namely, (1) subsistence (foraging or feeding), (2) locomotion (moving or traversing), (3) rest (inactivity), and (4) "other" which includes active social and nonsocial behaviours. However, other researchers [17–19] have used specific behavioural states (e.g., foraging, vigilance, resting, grooming, ruminating, moving, flight, excretion, mating, and social interaction among others) to infer the contribution of a set of certain treatments on wildlife species. We conducted an ethological study of free-ranging impala social groups in a closed environment, Mukuvisi Woodlands, an environmental education centre and ecotourism facility where attraction and provisioning are practised. We hypothesised that impala social groups at Mukuvisi exhibit different activity budgets according to seasons and that the activity budgets of bachelor and harem groups are different.

## 2. Materials and Methods

**2.1. Study Area.** The study was conducted in Mukuvisi Woodlands Wildlife & Environmental Centre (17° 50' 10.39" S and 31° 05' 18.41" E), located southeast of the city of Harare in Zimbabwe. The Centre is a 263-hectare woodland preserve home to a variety of Zimbabwe's indigenous flora and fauna including impala, zebra (*Equus burchellii*), giraffe (*Giraffa camelopardalis*), eland (*Taurotragus oryx*), and common duiker (*Sylvicapra grimmia*). Average rainfall ranges between 650–850 mm/annum, and mean annual temperatures is 9°C for winter and 40°C for summer [20]. The woodland are a typical Miombo and open savanna grassland. Due to the size of the preserve and the number of resident species, management interventions such as provision of dietary supplements were introduced.

**2.2. Behaviour Definition.** The activities of impala social groups were classified into nine categories based on other studies [17–19, 21] and personal observations. In this study, social interaction, mating behaviour, and nursing were combined (Table 1).

**2.3. Behavioural Observations.** Observations on the activity budgets of four impala social groups (2 harem herds and 2

TABLE 1: Ethogram for *Aepyceros melampus* activity states used in the study.

Activity	Operational definition
Foraging	Actively ingesting food or drink, or processing (chewing) food items during a grazing bout and or food searching with head below the vertebral column
Vigilant	Individuals scanning their surroundings and exhibiting agonistic displays
Resting	Standing or sleeping in the sun or shade, neither ruminating nor scanning its environment
Grooming	Scratching, stroking, massaging self or others
Ruminating	Chewing cud while standing, lying, or in locomotion
Moving	Locomotion between foraging source or within study area
Excretion	Defecating or urinating
Flight	Animal running away galloping out of observer sight
Others	Social interaction (necking), nursing, and mating

bachelor herds) were done during the wet season (7 January–27 March 2012) and dry season (4 July–24 September 2012). The group sizes for the harem herds were 24 and 16 whilst; those of the bachelor herds were 5 and 7 individuals. We combined the focal animal sampling and instantaneous scan sampling techniques [22, 23] to collect data on the activity budgets of impala social groups. Using two observation teams, we monitored each group type two times a week simultaneously for the wet and dry season. Since individuals were free ranging and not marked, we arbitrarily selected an active animal from a group as suggested by other researchers [24]. Focal individuals were rapidly scanned instantaneously for 30 minutes at thirty seconds intervals as described by Martin and Bateson [25]. We systematically shifted our focus, with a time lag of two minutes, to different animals in a group to avoid resampling of the same individual, whilst different groups were observed on different days of the week to avoid pseudoreplication [24].

The behavioural states of each focal animal were observed with the aid of Nikon 10 × 50 binoculars and reported to an assistant for recording to reduce errors. We spread observations across the daylight hours, (0700 Hours to 1700 Hours), to avoid over estimating or underestimating behavioural activities associated with time budgets of ungulates [26]. Observations were carried out either from a platform or on foot from a hidden position to reduce observer interferences on the behaviour of the group under observation. Accordingly, care was taken not to disturb the animals prior to or during the observations. If the animals were disturbed, behavioural recording was delayed until they appeared to ignore the observers. A total of 1344 hours of focal animal observations were recorded across all groups during the study.

**2.4. Data Analysis.** We calculated time of activity by determining proportion of time, expressed as a percentage, that each focal group or individual spent on an activity state. To

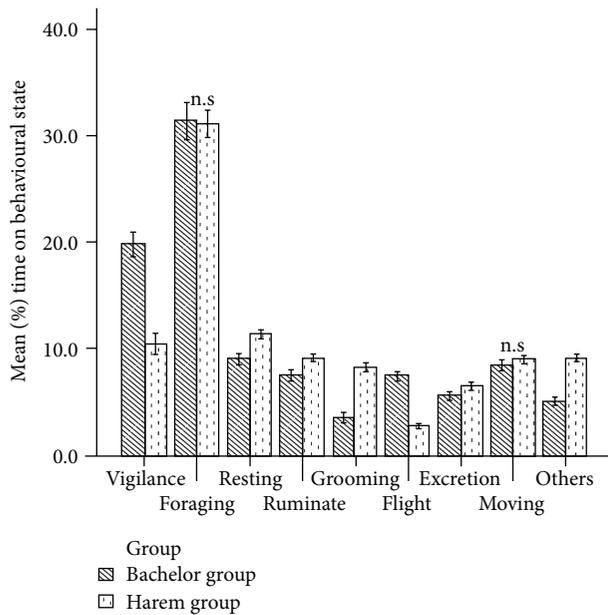


FIGURE 1: Proportion of time spent on behavioural states by the social groups, (n.s = not significant,  $P > 0.05$ ).

derive activity budgets for the wet and dry season, data on behavioural state occurrences from the three months of each season under each category (i.e., harem and bachelor group) were pooled to produce two data sets: wet season (January–March) and dry season (July–September). Data were tested for normality using one sample Kolmogorov-Smirnov test and satisfied the normality assumptions. We computed a general linear model to test the effect of group type and season on the activity budgets. Pearson correlation was done to test the relationship between activities. All statistical analyses were performed using SPSS release 16.0 (SPSS Inc., 2007).

### 3. Results

The proportion of time spent on different behavioural states, (e.g., vigilance, resting, ruminating, grooming, flight, excretion, and others) by the harem and bachelor groups were significantly different (Post Hoc test,  $P < 0.05$ ; Figure 1). However, the proportion of time spent foraging by the harem groups ( $31.157 \pm 0.757$ ) and bachelor groups ( $31.450 \pm 0.757$ ) was not significantly different ( $F_{(1,262)} = 0.075$ ,  $P = 0.784$ ). Similarly, no significant differences ( $F_{(1,262)} = 3.189$ ,  $P = 0.075$ ) were noted on the proportion of time spent moving by harem ( $9.023 \pm 0.222$ ) and bachelor groups ( $8.463 \pm 0.222$ ).

The proportion of time apportioned for different behavioural states by impala varied with season except for vigilance, foraging, and ruminating as shown in Table 2.

Although group type had no effect on the proportion of time spent moving, we noted that the season had an influence on the proportion of time spent by the impala groups moving. Comparable to group type, season had a significant effect ( $P < 0.005$ ) on the activities like resting, grooming, flight, excretion, and other behavioural states. Females generally

TABLE 2: The mean ( $\pm$  SE) proportion of time (%) spent on different activities by impala social groups for the dry and wet season.

Activity	Dry season	Wet season	$F_{1,262}$	$P$
Vigilant	$15.35 \pm 0.53$	$15.013 \pm 0.54$	0.197	0.658
Foraging	$30.88 \pm 0.75$	$31.723 \pm 0.77$	0.613	0.434
Resting	$9.51 \pm 0.23$	$10.978 \pm 0.24$	19.340	0.0001**
Ruminating	$8.34 \pm 0.22$	$8.356 \pm 0.23$	0.003	0.953
Grooming	$5.59 \pm 0.23$	$6.323 \pm 0.24$	4.830	0.029*
Flight	$5.69 \pm 0.15$	$4.473 \pm 0.15$	33.944	0.0001**
Excretion	$6.96 \pm 0.17$	$5.140 \pm 0.18$	54.029	0.0001**
Moving	$9.33 \pm 0.22$	$8.155 \pm 0.22$	14.035	0.0001**
Others	$6.89 \pm 0.19$	$7.422 \pm 0.19$	3.975	0.047*

Statistical significance ( $P$  value), \* $P < 0.05$ , \*\* $P < 0.001$ .

spent more time resting, grooming, and other social activities than their male counterparts did for the two seasons (Figure 2).

The proportion of time spent by impala social groups being vigilant was negatively correlated with foraging, resting, ruminating, grooming, excretion, and others (see Table 3). However, there was no correlation between the time spent foraging and flight behavioural states.

### 4. Discussion

The activity budgets of harem and bachelor groups in Mukuvi Woodlands were significantly different except for the proportion of time spent foraging and moving. Generally, our findings are similar to observations made elsewhere [27, 28]. It is acknowledged that males tend to spend more of their time being vigilant compared to their female counterparts [21, 29]. Similar observations have been witnessed in impala (e.g., [27, 28]), springbok (*Antidorcas marsupialis*, e.g., [30]), gazelles (*Procapra picticaudata* e.g., [31, 32]), ring-tailed coati (*Nasua nasua*, e.g., [33]), among others. However, contrary to our findings, Burger and Gochfeld [34] reported no significant differences in the levels of vigilance in male and female springbok. We argue that the proportion of time spent on vigilance and consequently other behavioural states (e.g., foraging, resting, locomotion, and grooming, among others), tends to vary with the degree of disturbance stimuli [35, 36] and perceived predation risk [37–39] within an environments and that it varies with time and space. However, observations elsewhere indicate that nursing female ungulates exhibit elevated vigilance tendencies compared to their non-nursing counterparts [28, 40]. This phenomenon is as an adaptation mechanism to protect and defend the calves.

Although the time spent on vigilance by impala males in this study was significantly different from the females, the proportion spent on foraging did not differ. Other researchers have noted that vigilance comes as a cost to individuals by conflicting with other activities such as feeding, resting, and grooming [16, 41–44]. Although Frid and Dill [36] consider ecotourism as a form of predation risk that reduces time spent on other important activities, arguing that impalas in

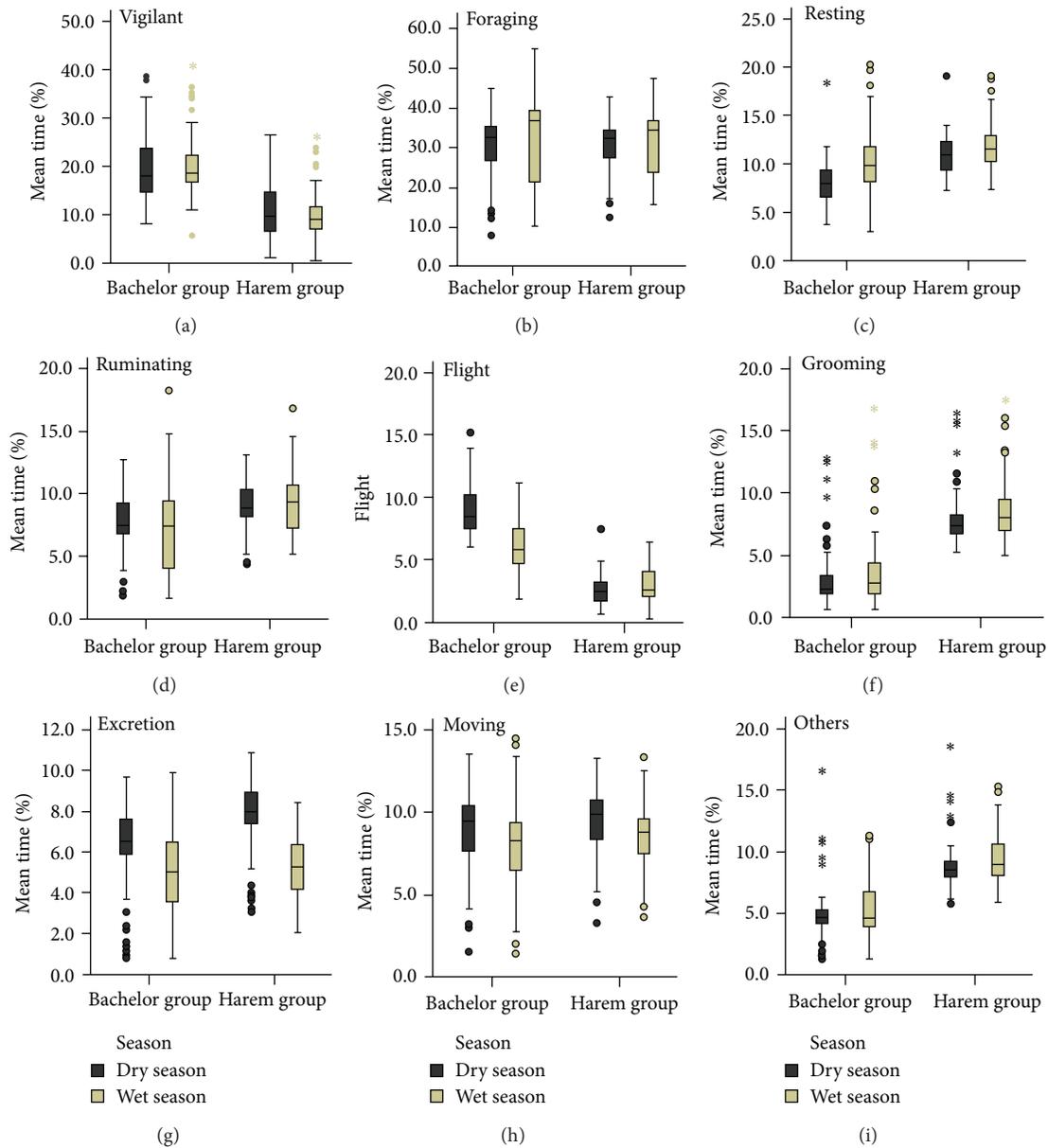


FIGURE 2: Influence of season and group type on the proportion of time spent on activity states by impala social groups.

TABLE 3: Pearson correlation of proportion of time spent on different activity states by impala social groups.

	Vigilant	Foraging	Resting	Ruminating	Grooming	Flight	Excreting	Moving	Others
Vigilant	—	-.488**	-.189**	-.125*	-.361**	.417**	-.423**	-.080	-.446**
Foraging	—	—	-.287**	-.409**	-.366**	.019	-.028	-.308**	-.251**
Resting	—	—	—	.296**	.390**	-.439**	-.092	-.164**	.222**
Ruminating	—	—	—	—	.306**	-.296**	.019	.017	.224**
Grooming	—	—	—	—	—	-.556**	.103	.044	.536**
Flight	—	—	—	—	—	—	-.186**	-.071	-.539**
Excreting	—	—	—	—	—	—	—	.362**	.244**
Moving	—	—	—	—	—	—	—	—	.128*
Others	—	—	—	—	—	—	—	—	—

\*\* Correlation is significant at the 0.01 level (2-tailed). \* Correlation is significant at the 0.05 level (2-tailed).

Mukuvisi Woodlands seem to have habituated themselves to neutral disturbance stimuli (i.e., the presence of humans). According to Whittaker and Knight [45], habituation occurs when individuals are constantly exposed to repeated neutral stimuli over time. This therefore implies that disruptions on resting, foraging, or other activities may not be altered by the level of vigilance given that the impala social groups would not consider presence of humans as a threat. Behavioural habituation has also been observed in Serengeti National Park where the flight initiation distance (FID) for nonprovisioned impala, topi, Thomson's gazelle, zebra, and wildebeest in the Central Serengeti was less than fifty metres compared to the Western corridor with FID of above 150 m [46].

We consider Mukuvisi Woodlands as a "predation-free" environment where anthropogenic disturbances are the sole disturbance stimuli source from elevated levels of ecotourism and related activities. We argue that the combination of attraction [46] and provisioning [47] and ultimately human habituation through supplementary feeding have altered the activity budgets of impala at the centre. Although these interventions increase visitor satisfaction [47, 48], the long-term socioecological implications and unintended consequences remain uncertain. Knight [11] asserts that habituated or provisioned animals are not brought only within viewing range but also within nuisance range. This challenge occurs when human invitation to animals to come closer ends up as an animal intrusion into human space where they tend to exhibit "begging" behaviours towards tourists [49]. In some cases, long-term provisioning of wild animals may lead to aggressive violent behaviours towards people [50]. The time it would take for these and many other unintended consequences of provisioning and habituation to be expressed by the impala in Mukuvisi Woodland is uncertain. It is important therefore to have monitoring and control mechanisms to deal and reduce the chances of such inadvertent consequences.

Season had no significant effect on the proportion of time spent on foraging, vigilance, and ruminating. These findings are different from observations made in Hwange National Park, Zimbabwe for impala where the group size and season influenced the frequency of vigilance [51]. Likewise, Wronski [52] revealed that impala in Mburo National Park, Uganda spent less time browsing during the wet season than in the dry season and increased the foraging time during the dry season. These observations buttress the notion that in natural systems feeding time by ungulates tends to increase during the dry season, a period when feed quality and quantity will be limiting [33]. Animals therefore spend relatively more time searching for food to fulfil their daily energy requirements. The effect of seasonality in forage quality [53] on the foraging and vigilance activity by impala was not visible for impala in Mukuvisi Woodland. We therefore argue that the forage quality hypothesis as described by Blanchard et al. [54] may not apply in closed environments where attraction and provisioning is practised. However, our findings are similar to observations noted in goitered gazelle (*Gazella subgutturosa*) by Xia et al. [29] where seasonal factors had no considerable effect on the level of vigilance but affected other behavioural states. Our findings are contrary to those of Dunham [55] who

argue that during the dry season individuals are supposed to spend more time moving and foraging due to insufficient food supply compared to the wet season. We attribute this deviation to the level of provisioning in Mukuvisi, which may neutralise the effects of seasonal variation in feed quality for the impala. However, the variations in the proportion of time spent moving may be due to the location of water and the supplementary points in relation to the respite areas or shaded areas during the dry season. Although bachelor groups spent more time on flight in the dry season compared to the wet season, we speculate that this could be related to the rutting season when males are generally aggressive to each other [56].

Impala social groups spent relatively more time resting during the wet season, than during the dry season and these findings are similar with observations made elsewhere [57, 58]. We noted that bachelor groups spent less time resting compared to harem groups. This corresponds to the proportion of time spent on other activities such as flight and vigilance compared to females. Nevertheless, a large component of resting serves no physiological or ecological function other than energy conservation [59]. Although in natural settings, food searching time is high during the dry season [58] due to reduction in quality, we attribute high mobility of males during the dry season due to the mate searching behaviour during rutting. This is essential in males because females are regarded as a seasonally available, fitness-limiting resource [17, 60, 61]. Our findings indicate that males tend to rest more during the wet season, a time when they are compensating for the condition loss during rutting season through foraging, resting, ruminating among other activities.

Grooming is a useful measure of social relationships in impala as it ushers two main functions, (1) removal of ectoparasites that an animal is not able to reach by itself and, (2) maintenance or establishment of social relationships through increase in psychological and physiological wellbeing and the rewarding effect [62, 63]. In this study, the levels of grooming were more pronounced in females than in males. Similar observations where females spend more time grooming compared to males have been reported elsewhere [64, 65]. Given that the bachelor groups were small compared to the harem groups, we argue that the variation exhibited in the time spent grooming was also because of the group size effect. Grooming rate may vary as a function of group size or interindividual spacing, thus larger groups might stimulate grooming through a social facilitation effect compared to smaller groups [66, 67]. Our findings were related to the assertions of Lehmann et al. [66] that grooming seldom exceeds 15% of daytime activity of most social species. Although Bridges et al. [61] argue that activity pattern plasticity of social species varies with seasons, the level of attraction and provisioning practiced at Mukuvisi Woodlands seems to have diluted this effect. The activity budgets of impala in Mukuvisi are slightly different from those in natural settings, where seasonality plays a crucial function in determining how species allocate their time and energy towards different activities for survival. Serious attempts by reserve managers should be made to reduce the effects of provisioning on the socio-ecology of impala in Mukuvisi Woodland.

## 5. Conclusion

We conclude that impala social groups at Mukuvisi Woodland spend more time foraging in the dry and wet seasons than any other activity. Season had no effect on the time apportioned during foraging and vigilance behaviour by impala social groups. The activity budgets of impala in closed environments under provisioning and attraction seem to be predictable and less dynamic than those in other natural settings. Although management intervention of attraction and provisioning may promote conservation, scientific tourism, and educational initiatives of the centre, the long-term socioecological, physiological, and reproductive behaviour of impala under provisioning and attraction should not be overlooked. We recommend continuous behavioural monitoring of the impala social groups under similar conditions to provide long-term information for use in adaptive management initiatives of closed environments.

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