

Full Length Research Paper

Diurnal activity patterns of Burchell's zebra (*Equus quagga*, Gray 1824) in Yabello Wildlife Sanctuary, Southern Ethiopia

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A study on the diurnal activity pattern of Burchell's zebra (*Equus quagga*, Gray 1824) was carried out in the Yabello Wildlife Sanctuary, Southern Ethiopia during October 2009 to March 2010 including wet and dry seasons. Scan sampling methods were used to collect the data peaks in daily activity that occurred in early morning, mid day and late afternoon. Data on activity time budget were analyzed by assessing time allocated for different activities at different hours of the day as well as different seasons. Differences in seasonal and hourly time budget were tested using one way ANOVA, followed by Tukey multiple comparison test. The time devoted to grazing was peaked during the dry season and gradually decreased during the wet season. There was a significant difference in the amount of hours devoted to different activities ($t = 76.4$, $p < 0.05$). The proportions of time budget varied between two seasons. Grazing accounted for more than 55.5%. Peak activities were observed in early morning and late afternoon hours with resting peak during the mid-day. A well comprehensive management plan should be taken for zebras to ensure their continued existence in the sanctuary.

Key words: Diurnal activity pattern, Burchell's zebra, season, time budget.

INTRODUCTION

The plains zebra (*Equus quagga*) is considered as one of Africa's most adaptable and successful grazers (Estes, 1991). Zebras are primarily grazers and have dental adaptations for feeding on both short young shoot and long flowering grasses (Bauer et al., 1994; Arsenaault and Owen-Smith, 2002; Moehlman, 2003). Its diet composed of 90-92% C4 plants (Eltringham, 1979; AWLF, 2008; Sponheimer et al., 2003), and they may not significantly alter the diet to browsing, even though they browse more

during dry season to compensate for grass poor quality. They graze for up to sixteen hours a day due to the ineffective way they digest food (Hack and Rubenstein, 1998). Zebra must go to a water source once a day, which is where aggressive encounters are more likely to occur (Rubenstein, 1993). Burchell's zebra is a diurnal species. Its activity patterns can vary depending on seasons, the animal's sex, age or reproductive state. According to Kamler et al. (2007) and Joubert (1972),

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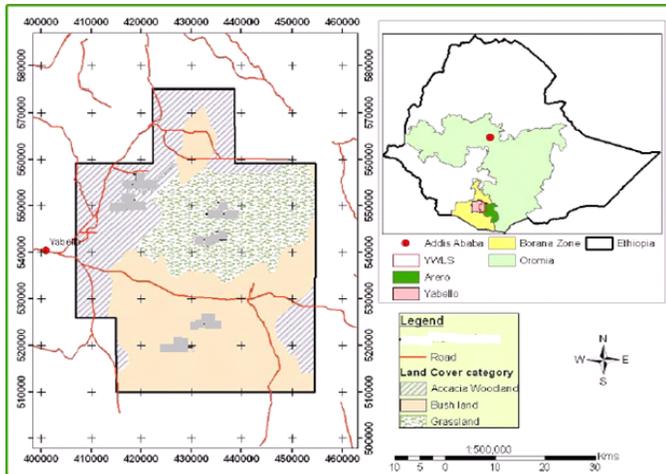


Figure 1. Map of Yabello Wildlife Sanctuary. Inset: the map of Ethiopia showing the location of YWLS. YWLS = Yabello Wildlife Sanctuary.

there are many factors that can influence the activity pattern of an animal such as temperature, climate, biological cycles, light and darkness, feeding bouts, phases of the moon, time of day/year, interactions and predation risks. The time Burchell's zebra have to spend on feeding every day can depend on different factors such as its requirements of nutrients and energy, the availability of digestible food and at what rate the food can be ingested (Beekman and Prins, 1989). As a single species may show different behavioural patterns in different environmental conditions (Delany and Happold, 1979), effective management of species depends on the knowledge of the way in which it interacts with its specific environment (Leuthold, 1977). One of the most useful methods of describing this interaction is to quantify the basic activity patterns, which exist for any species at a given time and place during the different seasons (Jarman and Jarman, 1973; Leuthold and Luthold, 1978; Norton, 1981). Annual cycles in ungulate activity are influenced by forage quality and quantity, digestive system constraints and energy conservation needs (Jarman and Jarman, 1973; Owen-Smith, 1982; Leuthold, 1977). There is no documented information regarding the diurnal activities and time budgets of Burchell's zebra in Ethiopia in general and the study area in particular. Therefore, the objective of this study was to investigate diurnal activity pattern of Burchell's zebras at different time of the day and season and give guidelines for a more comprehensive management plan for zebras in the sanctuary.

MATERIALS AND METHODS

The study area

Yabello Wildlife Sanctuary (4° 37'-5° 12' N and 38° 09'- 38° 37' E) is

one of the protected areas and Wildlife Sanctuaries in southern Ethiopia. It has an area of 2496 km² located in the Borana Zone of the Oromia Region, east of the town of Yabello and it has an approximate North-South distance of 65 and 48 km East-West with an average altitude between 1800 and 2000 m above sea level. The area is not fenced and the boundary is not clearly demarcated. Borana lowland is mostly covered with East African evergreen and semi-evergreen bushland and thickets along the high lying areas with relatively higher rainfall (Agrotec-C, 1974). The commonest habitat inside the Yabello Sanctuary is savanna woodland dominated by various species of thorny acacia (*Acacia tortilis*, *Acacia brevispica*, *Acacia horrida*, and *Acacia drepanolobium*) and *Commiphora*, and broad leaved *Terminalia* and *Combretum* (Borghesio and Giannetti, 2005). In addition, small patches of juniper (*Juniperus procera*) forest can also be found in high altitude just outside the boundaries of the sanctuary, although grazing and logging threaten its persistence (Borghesio et al., 2004).

The present study identifies three major types of habitats: Acacia woodland, bushland and grassland (Figure 1). The rain fall regime in Borana dry lands is bimodal with two rainfall seasons. The main rainy season, known as the long rainy season is between March and May with the peak in April, and short rainy season is between September and November, with peak in October (Figure 2). The mean annual rain fall for the period 2000-2009 was 612.36 mm. The peak mean monthly rainfall was in April (152.9 mm) and October (127.6 mm). The least mean monthly rainfall was in January (17.6 mm). The hottest months were from January to February and temperature fluctuates between 27.9 and 28.9°C. The weather remains pleasant between June-August. The mean annual maximum temperature was 28.9°C and the mean annual minimum temperature was 12.2°C (Figure 2).

Methods

A study on diurnal activity pattern of Burchell's zebra was carried out in the Yabello Wildlife Sanctuary, Southern Ethiopia from October 2009 to March 2010 including wet and dry seasons. Observations on diurnal activity pattern of Burchell's zebra were made using unaided eye and/or 8 x 30 binoculars. Observation was facilitated by the animal's preference for short grass areas during the wet season and tall grass during the dry season and by selecting a strategic site on the hill; this enabled observation of more than one group. Scan sampling methods were used as adopted by Martin and Bateson (1993) and Altmann (1974). The activities recorded were grazing, walking, standing, resting, grooming and other activities. The latter included all activities that did not feature strongly in the general activity pattern such as playing, fighting, suckling and urinating.

The activity of each individual zebra in each group under observation was recorded and ticked on the sheet at ten minutes intervals. When unique activity was observed, it was recorded on a separate notebook. If the observed animals in the field disappeared from view, the time interval that the animals being observed out of sight was recorded. When the out of sight period was of longer duration than the duration of the common activities, it was deleted from the sample and duration of the sample period was deleted accordingly. The time budget and habitat association were analyzed using SPSS15.0 for windows.

RESULTS

The time budget of Burchell's zebra was recorded in each hour of the day during a sample of 20 days (10 in dry and 10 in wet seasons) over six months of the study period. A

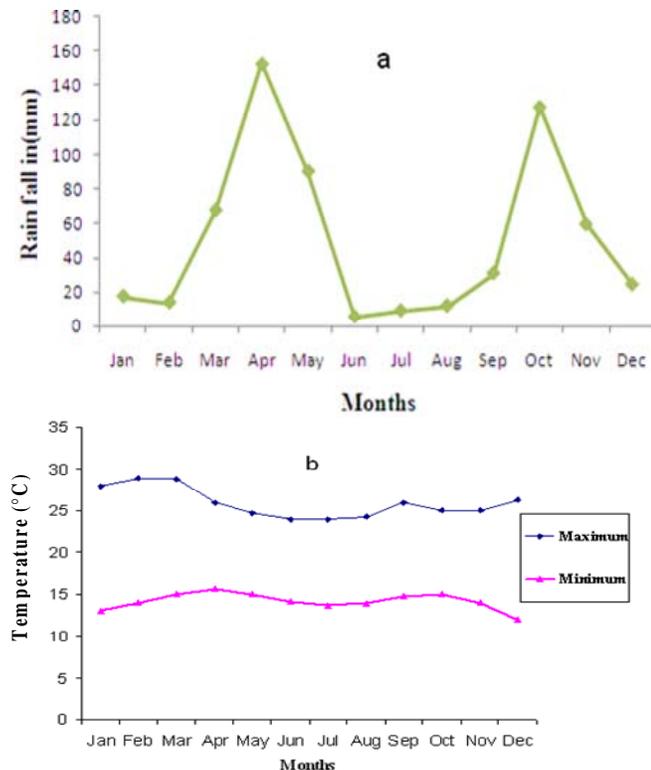


Figure 2. Monthly mean rainfall (mm) (a) and Monthly mean minimum and maximum temperature (b) in Yabello Wildlife Sanctuary from 2000-2009.

Table 1. Comparison of the different activities between dry and wet season using ANOVA.

Activity	F-value	P-value
Grazing	13.183	0.000
Standing	2.218	0.000
Walking	14.227	0.00
Resting	23.346	0.003
Grooming	2.144	0.144
Others	0.185	0.667

total of 1440 observations were taken between 0600 and 1800 h. The activities were recorded every 10 min and six observation unit per hour. Data on the various activity patterns recorded in the study period were grouped into form six major activities: grazing, walking, standing, resting/lying in the open or in the shade, grooming and other activities.

Grazing

There was an observed increase in the amount of time spent grazing during the 06:00-10:00 h and 15:00-18:00

h both in dry and wet seasons. Grazing activity remained at similar levels during the 06:00-11:00 and 14:00-18:00 h with a decrease observed during the 12:00-13:00 h time period during dry seasons. During the wet season, the animals significantly allocated more time to grazing at 09:00 h than 12:00, 11:00 and 13:00 h. In addition, time allocated for grazing at 09:00 h was significantly higher than 8:00, 15:00 and 18:00 h. There were two peaks in grazing during wet season, one between 06:00-1:00 h and the other is 14:00-18:00h. Over the dry season, grazing showed two peaks one is in the early morning between 06:00-10:00 h and the other is in the late afternoon between 14:00-18:00 h. The differences in the time devoted for each activity during different hours of the day during dry and wet season were significantly different for grazing, standing, walking and resting ($p < 0.05$), but there was no significant difference between, grooming and others ($p > 0.05$). The time devoted to grazing during the dry season was significantly greater ($t=13.183$, $p < 0.05$) than the wet season. Multiple pair-wise comparisons using the Tukey test indicated that Burchell's zebras spent more time in grazing in dry season than in wet season, and more time grazing during the time period. The difference in time allocation among six activity categories was statistically significant for grazing, standing, walking and resting ($F = 67.512$, $d.f. = 11$, $p < 0.05$) during dry season and ($F = 47.532$, $d.f. = 11$, $p < 0.05$) during the wet season. The total time budget for each activity also showed significant difference for grazing, standing, walking and resting ($t = 69.265$, $p = 0.001$, $t = 19.058$, $p < 0.004$, $t = 22.572$, $p = 0.03$, $t = 16.357$, $p < 0.002$) over the two seasons, respectively (Table 1).

Walking

The animals walk for shorter distances and recommence grazing after 2-6 min. The adult male, which often acts as a guard, is frequently the one that leads the harem away during a disturbance.

Walking showed two peaks during the dry and wet seasons, respectively. Over the dry season, walking peaked in the early morning between 07:00-9:00h and in the late afternoon 15:00-18:00h and during the wet season, it peaked early in the morning 06:00-10:00h and late afternoon at 14:00-18:00 h.

The maximum time allocated to walking throughout the day during the wet season was 14% while over the dry season it was 9%. There was significant difference in time allocated to walking in both seasons ($p < 0.05$). Tukey multiple comparison tests indicated that time allocation for walking was significantly lower at 12:00 and 13:00 h as compared to 14:00 and 15:00 h. The majority of the walking activity during the wet and dry seasons was during the cooler periods 06:00 - 10:00 h and 15:00 - 18:00h of the day. The level of walking activity was at maximum during the 06:00-10:00 h and 15:00-18:00 h

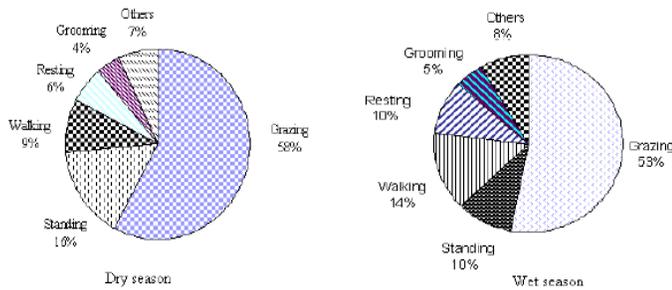


Figure 3. The average daily time budgets of Burchell's zebra during the wet and dry seasons.

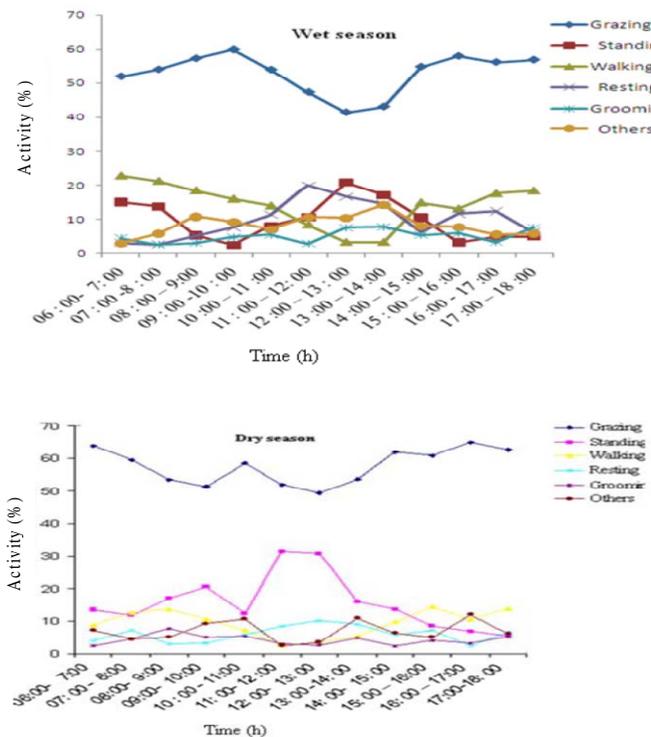


Figure 4. Diurnal time budget of Burchell's zebra during different hours of the day in the wet and dry seasons.

time periods and decreased during the 11:00-14:00 h time period. The maximum time allocated for walking throughout the day among the Burchell's zebras during the wet season was 24% (06:00 h) while over the dry season it was 14% (08:00 and 15:00 h).

Standing

In the study areas, when the Burchell's zebras were not grazing, they spend most of the time standing. Standing was the second frequent activity of Burchell's zebra next to grazing during the dry season, but the third frequent

activity during the wet season next to grazing and walking. They were engaged in standing during the hottest part of the day during dry season (Figure 3). The time allocated to standing varies significantly with time of the day both in the wet and dry seasons ($p < 0.05$).

Resting

Resting was frequent during the hottest part of the day and the zebras at this time would spend more than 30 min in the bush and Acacia woodland.

Resting was increased in the middle of the day from 12:00-14:00 h (Figure 4). Data shows that Burchell's zebra were engaged more in resting for an extended time in the wet season than in the dry season. In the study area, adult zebras were never seen resting, but the young zebras spent more time in resting than adults.

Grooming

The time allocated to grooming did not vary significantly with time of the day either in the wet season or dry season. The maximum time allocated to grooming throughout the day in the dry season was 8% (08:00 h) while over the wet season it was 7, 8 and 6.5% at 12:00, 13:00 and 17:00 h, respectively. However, there was no significant difference in time allocated to grooming ($p > 0.05$) for both dry and wet seasons.

Other activities

During the wet and dry seasons, an increase in social activity was observed during the 12:00 -14:00 h time period. This can probably be attributed to the aggregation of Burchell's zebra under available acacia woodland shades, thus allowing a greater opportunity for interaction. Levels of social activity were higher during the wet season throughout the time period with peaks in the mid day from 11:00-13:00 h. Over the dry season, social activities were allocated less time at 11:00 and 12:00 h as compared to 07:00 and 08:00 h, but more time was allocated at 09:00, 10:00, 13:00 and 16:00 h respectively.

Burchell's zebras spent 58% of their time grazing, 16% standing, 10% walking, 6% resting, 4% grooming and 7% other activities in the dry season, while in the wet season, 53% in grazing, 10% in standing, 14% in walking, 10% in resting, 5% in grooming and 8% in other activities. In the dry season, grazing and standing were allocated significantly more time than other activities. Where as in the wet season, grazing and walking were allocated significantly more time than other activities.

The variation in trends between the time allocated for grazing, walking, standing, resting, grooming and other activities of Burchell's zebra of different age and sex

Table 2. Karl Pearson correlation coefficient between six activity patterns of Burchell's zebra in different hours of the day in the wet and dry seasons.

Activity	Correlation value
Grazing	-0.78(**)
Standing	0.290(**)
Walking	-0.313(**)
Resting	0.290(**)
Grooming	-0.210(**)
Other activity	0.167(**)

**Correlation is significant at the 0.01 level (2-tail).

categories in the three periods of the day showed significant differences ($p < 0.05$). The time allocated for different activities also showed significant differences ($t = 76.4$, $p = 0.004$) during the wet and dry seasons.

The pattern of diurnal grazing was inversely correlated with walking, standing, resting, grooming and others ($r = -0.178$, $p < 0.01$; $r = -0.631$, $p < 0.01$; $r = -0.472$, $p < 0.01$; $r = -0.210$, $p < 0.01$; $r = -0.428$, $p < 0.01$) respectively, reaching a peak in the morning and afternoon periods during dry and wet seasons (Table 2). The result of correlation analysis using Karl Pearson correlation coefficient showed statistically significant positive correlation between the pattern of diurnal resting and standing ($r = 0.29$, $p < 0.01$). The time allocated to walking activity was inversely correlated with standing, resting and grooming ($r = -0.313$, $r = -0.370$ and $r = -0.207$), respectively, during the wet and dry seasons. Standing activity also inversely correlated to grazing and walking ($r = -0.631$, $r = -0.313$, respectively). Furthermore, the time devoted to resting and grooming activities during different hours of the day were inversely correlated with grazing and walking ($r = -0.472$, $r = -0.370$, $r = -0.210$, $r = -0.207$), respectively. The diurnal activity budgets of other activities were inversely correlated with grazing ($r = -0.428$).

Diurnal habitat preference of Burchell's zebra

Out of the total 1440 observations, Burchell's zebras were observed in the grassland (48.2%), woodland (39.9%) and bushland (11.8%). There was no significant change ($t = 4.32$, $p > 0.05$) in the pattern of habitat association of Burchell's zebra at Yabello wildlife Sanctuary. However, their habitat preference differed significantly in the morning, mid-day and afternoon ($t = 39.167$, $p < 0.05$). They spent most (57.9%) of the morning hour in the grassland while most (55.4%) of the mid-day hours in the woodland. In the afternoon 52.4% was spent in the grassland and 39.9% in the woodland. Habitat preference exerted a considerable impact on the daily

time budget of Burchell's zebra. ($t = 117$ $df = 5$ $p < 0.05$). Time of the day was also associated with activity patterns of Burchell's zebras ($t = 232.245$, $df = 11$, $P < 0.05$) (Table 3).

Livestock abundance

Livestock is the most commonly observed animal in the sanctuary. The increased number of livestock around the sanctuary was one of the important factors affecting the activity patterns and time budget of Burchell's zebras in Yabello Wildlife Sanctuary. Thousands of livestock competes directly for food with Burchell's zebras and other wildlife in the Sanctuary. Livestock distribution throughout the Sanctuary increased especially during the wet and late dry seasons, when the grasses were at grazable size. During the wet season, the number of livestock counted inside the Sanctuary was 6110 and during the dry season, these were only 4053.

Bush encroachment

Several native *Acacia* species such as *Acacia drepanolobium*, *Acacia oerfota*, *Acacia mellifera* and many others were observed to be an emerging rampant species replacing some of the valuable species at Yabello Wildlife Sanctuary. Due to its rapid expansion, *A. drepanolobium* was the most serious problem in the area. It had been observed during the field survey that this species had formed a pure stand replacing all other species that used to grow in the area.

DISCUSSION

Variations were observed in the activity patterns and time budget of Burchell's zebras during dry and wet seasons at different time of the day. There was significant differences in the amount of hours devoted to different activities ($t = 76.4$, $p < 0.05$). Burchell's zebra devoted more time to grazing than any other activities during both seasons. Grazing was observed to be lowest at midday. The possible reason may be the influence of temperature which affects the turgidity of plants which in turn affects the plants' palatability. Grazing activity was minimum during the wet season. Decrease in grazing time with increase food availability during the wet season has been observed.

The difference in the distribution of time budgets of the wet and dry season may lead to the conclusion that temperature and food availability seem to be the determinant factors governing the activities of Burchell's zebra. Seasonal variations in daily activities were perhaps related to temperature, rainfall and ground plant biomass in reedbuck (Roberts and Dunbar, 1991). Resting reached a peak between 12:00-14:00h. No

Table 3. Diurnal habitat preference of Burchell's zebra in YWLS.

Time	No. of observation	Habitat		
		Grassland (%)	Woodland (%)	Bushland (%)
Morning	580	57.9	34.4	11.7
Mid-day	480	34.3	55.4	10.3
Afternoon	380	52.4	34.1	13.5
Total	1440	48.2	39.9	11.8

periods of rest were observed early in the morning and in the late afternoon. Resting is high during the midday in the dry season as the activities are affected by temperature. This behaviour was significantly different between wet and dry seasons. Around the middle of the day, Burchell's zebras remain standing or resting/lying down about 35 and 25% in dry and wet seasons, respectively under the shade of Acacia woodland to escape the intense heat of the day. The distribution of day time activity for Burchell's zebras in Yabello Wildlife Sanctuary with increased activities of grazing and walking concentrated in the early morning and late afternoon and a major resting/lying period during the middle of the day is similar to that observed elsewhere (Joubert, 1972; Sandra, 2009; Beekman and Prins, 1989; Gakahu, 1984; Grogan, 1978). The present study in Yabello Wildlife Sanctuary indicates that Burchell's zebra spent most of its time for grazing as evident from the activity time budget. Standing and walking were other major components of activity of the zebra. Grazing peak was in the morning from 06:00 to 10:00 h and after noon from 14:00-18:00 h.

Activity patterns of animals are determined by numerous factors. Biotic environmental factors such as light and temperature may influence optimum daily and seasonal activity patterns (Nielsen, 1983; Patterson et al., 1999). Body mass, human disturbance, social behaviour, predator avoidance, prey acquisition and competition also may affect activity in different forms (Rocowitz, 1997). Hence, important time when animals are active may be important for understanding their ecological niche and hence to develop conservation plans for imperiled species (Hwang and Garshelis, 2007). The common trend in the diurnal activity patterns of Burchell's zebra at Yabello Wildlife Sanctuary was generally to rest more in the middle of the day, and to graze more in the morning and afternoon.

Much of the time is generally spent feeding in mammalian herbivores (Beekman and Prins, 1989). Grazing Equidae spend up to 18 h of their time per day to graze (Fowler and Miller, 2003; Houpt et al., 1986; Pratt et al., 1986; Crowell-Davis et al., 1985; Sweeting et al., 1984). Three studies on Plains zebra shows that they devote around 60-70% of their time (out of a 24 h period) to grazing (Beekman and Prins, 1989; Gakahu, 1984; Grogan, 1978). The time devoted to grazing was peaked

during the dry season and gradually decreased during the wet season. The increase in grazing time with decreasing food availability in the dry season has been reported for several African grazers (Owen-Smith, 1982). In the present study, the annual mean proportion of time spent grazing by Burchell's zebras at Yabello Wildlife Sanctuary was estimated to be 55.5%. This is in line with the findings of Kivai (2006) in which Grevy's zebras spent most of their time feeding than other activities in Northern Kenya; Rubeinstein et al. (2004) obtained similar results in a behavioral study of Grevy's and Plains zebras in Lewa Wildlife Conservancy, as did Moehlman (1998) where the adult Feral Asses spent 30.7 to 57.6% more of their time feeding. This finding was contradicts with the findings of Degu (2007) where Grevy's zebras spent more time for vigilance than any other activities in Chew Bahir, Southern Ethiopia.

Burchell's zebras were standing most in the midday; this may be due to the hot temperature. Standing was least in the afternoon, probably due to the higher need of grazing. This is consistent with Sandra (2009) in which Burchell's zebras were standing most in the midday and least in the afternoon. The activity budget of an animal varies in response to both internal and external factors that influence its survival strategy (Knoop and Owen-Smith, 2006). The diurnal activity of Burchell's zebras depends on variation in climatic condition. Seasonal changes affect the timing of grazing and resting (lying down) activities. The foraging efficiency of ungulates may also be influenced by factors such as the time of day, temperature, season, vegetation type and reproductive status (Wobeser, 2006; Neuhaus and Ruckstuhl, 2002). Reta and Solomon (2013) reported that Burchell's zebra showed high preference for open grassland habitats and the distribution of the animal varied according to the season.

The activity pattern of Burchell's zebra in the study area was highly influenced by human activity, livestock over grazing and encroachments. Overgrazing increases competition for pastures especially during dry seasons. Ubiquitous presence of thousands of livestock competes on the same area with Burchell's zebra for food especially at Government cattle ranch in the Yabello Wildlife Sanctuary. Grazing activity became more difficult for Burchell's zebras when livestock arrived and occupied the more suitable habitat transformed into unsuitable

habitat which forced zebras to feed on lower quality pastures.

Some authors propose that there are four factors which influence ungulate activity budgets: seasonal changes of a pasture's biomass and quality (Moncorps et al., 1997); temperature variations throughout daytime hours and seasons (Shi et al., 2003); yearly life cycle (growth and reproduction (Duncan, 1980, Maher, 1991) and livestock movements and human activity (Schaller, 1998). Bush encroachments are the most serious problem that affects the time budget of Burchell's zebras in the study area to date. In the Borana rangelands of southern Ethiopia, a progressive increase in bush encroachment and loss of grass cover is associated with changes in patterns of livestock grazing (Bille et al., 1983; Coppock, 1994). Heavy livestock grazing in turn has reduced the herbaceous vegetation cover (Coppock, 1993).

Grazing was the dominant activity of the zebras, although the time spent in grazing differed significantly between the seasons. It occupied most of the time and, together with walking, standing and resting accounted for at least 90% of all diurnal activities. Diurnal grazing behaviour was strongly biphasic, with animals showing strong avoidance of energy consuming activities such as grazing and walking during the hottest period of the day. Such activities increased in the early morning and late afternoon hour and correlated with lower ambient temperatures. Energy conserving activities, such as resting and standing showed a strong inverse correlation with grazing and walking.

The study recommends that different conservation measures should be taken to decrease the number of livestock and encroachments in the sanctuary to create special areas for Burchell's zebras which are free from livestock movement and bush encroachments.

Conflict of Interests

The author(s) have not declared any conflict of interests.

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