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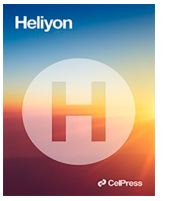

Research article

Diurnal activity time budget of Grevy's zebra (*Equus grevyi,* Oustalet 1882) in a protected savannah area

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ABSTRACT

Understanding natural history such as diurnal activity of wildlife species is important for their conservation intervention. The aim of the current study was to examine Grevy's zebra diurnal activity time budget in Hallaydeghe Asebot Proposed National Park (HAPNP) considering both wet and dry seasons. Scan sampling method was used. Activities of the species were recorded based on age and sex. Species were observed for 15 min (10 min activities recording followed 5 min rest). Analysis of Variance (ANOVA) was used to analysis data. Grazing (31.26%) was the highest followed by resting (30.24%) during the wet season and grazing (37.13%) was the highest followed by moving (27.25%) during dry season. The peak grazing time of species was morning 6:00–9:00 a.m. and late afternoon 16:00–18:00 p.m. while resting was observed during midday. The time the species spent over grazing ($df = 1$, $F = 27.15$, $p = 0.000132$), Grooming ($df = 1$, $F = 24.082$, $p = 0.000231$), mating ($df = 1$, $F = 24.850$, $p = 0.0002$) and moving ($df = 1$, $F = 5.550$, $p = 0.0336$) activity during both seasons were significantly different. There is statistical difference for grazing ($df = 2$, $F = 9.336$, $p = 0.002653$), mating ($df = 2$, $F = 6.216$, $p = 0.0117$), moving ($df = 2$, $F = 5.604$, $p = 0.0163$) and other ($df = 2$, $F = 5.006$, $p = 0.0229$) activities based on sex of species. The current study examined only diurnal activity time budget of the species. As a result, future research shall be conducted by taking into account the impact of different factors (temperature and livestock) that can influence the activity time budget of Grevy's zebra in HAPNP. Lastly, we recommend thorough species management plan in HAPNP for sustainable conservation of Grevy's zebra.

1. Introduction

Natural cycles of light and darkness influence animal diurnal activity, which reflects adaptations and interactions [1,2]. Diurnal activity patterns vary across species and are influenced by factors like daytime length, temperature, precipitation, predator-prey interactions, and human activities [3,4]. Understanding and comparing activity patterns helps understand behavioral trade-offs and potential temporal niches [5], while also aiding in understanding behavioral ecology and conservation of large mammals [6].

Human activities can influence wildlife behavior, leading to decreased forage intake and reproductive success [7]. Tropical forests and their animals are threatened by rapid forest conversion and degradation. National parks and protected areas are often used to preserve natural heritage and biodiversity. However, these areas are still subject to anthropogenic disturbances like roads, recreation,

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and resource extraction [8]. Protecting areas from these threats requires a suitable political environment, often leading to their conversion to other uses [9].

Diurnal time budgets of mammals are studied using various sampling methods [10]. Brown bears' daily activity patterns were monitored using radiotelemetry from 1993 to 2006 [11]. Equus zebra, also known as the plains zebra, has been studied in various articles [12,13]. Studies on related species within the genus and other mammals offer insights into potential diurnal activity patterns [14]. Therefore, further research is required to fully understand these patterns and their potential variations among individuals and populations.

Grevy's zebras show variability in their daily activity patterns that are driven by environmental variation in their habitat [15]. The diurnal activity of Grevy's zebra varies based on the season, age, sex and time of day. Temperature, climate, biological cycle, time of day, interaction, and predation risk may all have an impact on animal's activity pattern in the wild [16]. Studies show that the species spend 60–80% of their time searching for food [17]. Because diverse environmental circumstances may lead a single species to exhibit a range of behavioural patterns, effective species management requires an understanding of how each species interacts with its particular habitat [18]. Therefore, quantifying the fundamental activity that every species exhibits at a specific time and location during the different seasons is one of the most helpful ways to describe this interaction.

There has been no documented information on Grevy's zebra's daily activities and time allocations in HAPA. As a result, the objective of this research was to examine the Grevy's zebra's diurnal activity time budget in HAPNP during different seasons. This allows the study area personnel and other important partners to develop a more comprehensive management plan for the long-term protection of species in the HAPA. We hypothesize that 1) there is variation in the proportion of time spent on diurnal activity of Grevy's zebra across seasons, 2) there is variation in Grevy's zebra diurnal activity across sex, and 3) there is variation in Grevy's zebra diurnal activity across different age group. The time allotted by Burchell's zebra for different daily activities was predicted to be varied throughout seasons [12].

1.1. Study area description

The study area is found at 280 km away from Addis Ababa, capital city of Ethiopia to the southeast direction. It is found in Amibara, Meiso and Haruka Woredas (administrative division of Ethiopia, managed by a local government). The community surrounding the area practice pastoral mode of lifestyle. Geographically, it lies between latitude of 8^{o} 92′ and 9^{o} 48′ and longitude 40^{o} 25′ and 40^{o} 63'. The area was formerly established as wildlife reserve to conserve, and manage wildlife within it. However, in 2006, the area was changed to proposed national park to enhance its contribution to conservation at large. The area can serve as a corridor to Awash National Park and the surrounding plains [19]. The climatic condition of the area is semi-arid. To the eastern parts of the site there is mountain and the rest of the area is covered by alluvial plain [20]. The area is home to a number of wildlife species. The key wild animals inhabiting the study area includes; Grevy's zebra *Equus Grevyi*, Beisa oryx *Oryx gazella*, Soemmering's gazelle *Gazella soemmeringi*, Gerenuk *Litocranius walleri*, Salt's dikdik *Madoqua saltiana*, African wolf *Canis lupaster*, Spotted hyena *Crocuta Crocuta*, Aardwolf *Proteles cristatus* and Ostrich *Struthio camelus*. The area does not only provide wildlife habitat but is also important grazing land for the Afar and Issa pastoral communities where livestock numbers are a social indication of the owner's wealth status [21]. The major vegetation covering the area are; grasslands, bushland, shrubland, wooded grassland, riverine forest and highland forest. *Chrysopogon plumulosus* and *Sporobolus lusiocladus comprise* a relatively most percentage of herbaceous vegetation on the plains [22]. Except eastern edges of the area, shrublands with *Acacia senegal* is available in the dominant. The woody plant species in the plains of this study site includes *Acacia senega*l, *A.tortilis, A.mellifera, Balanitis aegyptiaca, Cadaba* spp. and Grewia spp. Some of the mountainous forest areas of mount Asebot includes *Croton macrostachyus, Cordia africana, Juniperus procera, Erythrina abyssinica, Podocarpus falcatus*, *Olea europaea* and *Rhus vulgaris* [23].

2. Method

Scan sampling method was used to collect data on the diurnal activities of Grevy's zebra following [10,24]. Observations of species diurnal activities were conducted using unaided eye and/or binoculars. The field data was collected by the team of three individuals (animal activities observer, stop watch time keeper and data recorder) to make fieldwork easy and minimize missing of data. The activities recorded were grouped as moving (walking, jumping or running), grazing, resting (inactive, either standing or lying down), grooming (used its teeth/tongue to explore or to clean its body or the body of another), mating (when an individual is engaged in copulatory behaviour) and other activities (chased, bite, grabbed, displaced, threatened another zebra or vocalized in an aggressive context). To compare the proportion of time spent on a particular behavior and how it varies with sex, age, and season, we collected observational data on Grevy's zebra diurnal behavioral activities. We coded the diurnal activities observed for each individual in our dataset and assigned the appropriate behavior categories to each recorded behavior event. Additionally, we recorded the sex, age, and season information for each individual.

The observation of the species activity was taken for 10 min and the 5 min rest. Furthermore, the 10 min sampling period was broken down into 20 intervals of 30 s and all the actions of all the individuals in the group were recorded at that 'instant'. Then the activities made in the intervals second were noted and ticked on a data collection sheet. The identification of sex and age category was carried out in the field by using body size such as the size and external genitalia as adopted by Ref. [25]. If the observed animals in the field disappeared from the observer view, the time interval that the animals being observed out of sight was recorded. When the out of sight period was longer than the duration of the common activities, it was deleted from the sample and duration of the sample period was deleted accordingly.

2.1. Data analysis

Once we have coded the behaviors and relevant demographic information, we proceeded with data analysis. Since the behavioural data recorded was not normally distributed, we applied the log transformation of the proportion of time spent on diurnal activity time budget to conduct the analysis. Analysis of Variance (ANOVA) was used to compare the means of the proportion of time spent on a behavior across multiple groups (e.g., different age groups, sex and or seasons). We test whether there are any differences in proportion of time spent in a behavior among the three categories of sex (i.e., male, female and unidentified) and among the two groups of seasons (wet and dry) using two-way ANOVA. One-way ANOVA was also computed to test whether there are any differences in proportion of time spent in a behavior among the three categories of age. Tukey multiple comparisons of means were computed to identify the mean difference in proportion of time spent among the groups with 95% of confidence intervals. Data were analysed using statistical package of R software version 4.1.2. The dependent/response variable was a proportion of Grevy's zebra diurnal activities whereas an independent variables were age, sex and season of the year.

3. Results

3.1. General description of Grevy's zebra diurnal activities

A total of 2016 observations were carried out during 504 h of the study period and 11223 individual diurnal activities of Grevy's zebra were recorded. Grazing (37.13%) and moving (27.25%) activities were highest during the dry season, while grazing (31.26%) and resting (30.24%) were highest during the wet season (Fig. 1).

During the wet season, morning 07:00–08:00 (52.29%), 08:00–09:00 (50.63%) and afternoon 16:00–17:00 (42.29%) were the optimal grazing time for the species. The midday time, 12:00–13:00(6.7%) was the lowest time allocated for grazing activity during the season. Optimal resting time of the species was 13:00–14:00 (65.67%), 12:00–13:00(63.5%) and 14:00–15:00(56.88%) respectively. The time from 11:00–12:00(47.3%), 10:00–11:00(39.38%) and afternoon 15:00–16:00(37.5%) was the peak time for the species moving activity. Least time was allocated for moving 07:00–08:00(13.72%). Grooming was highest 15:00–16:00(18.31%) (Fig. 2).

During the dry season, the peak grazing time of the species was morning 07:00–08:00(58.69%), 08:00–09:00(58.21%) and 09:00–10:00(55.63%). In the afternoon 17:00–18:00(47.5%) and 16:00–17:00 (45.83%) the highest time was budgeted for grazing. The lowest time was budgeted for grazing during 13:00–14:00(10.33%). The species highest resting time during the dry season was 12:00–13:00(71%), 13:00–14:00(68.21%) and 14:00–15:00(61.64%). The Grevy's zebra moving activity was peak between 11:00–12:00(40.08%), 06:00–07:00 (35.63%) in the morning and afternoon 16:00–17:00(34.35%) and 17:00–18:00(33.54%).

The highest time was budgeted for mating and grooming activities by species during 15:00–16:00(5.63%) and 11.66%. The animal peak time for other activity was between 08:00–09:00 (3.75%) and 15:00–16:00(3.34%) (Fig. 3).

3.2. Grevy's zebra activities comparison based on seasons

During the wet season, the most frequent activities of adult female Grevy's zebra were grazing (35.63 ± 2.7), resting (27.09 ± 3.7)

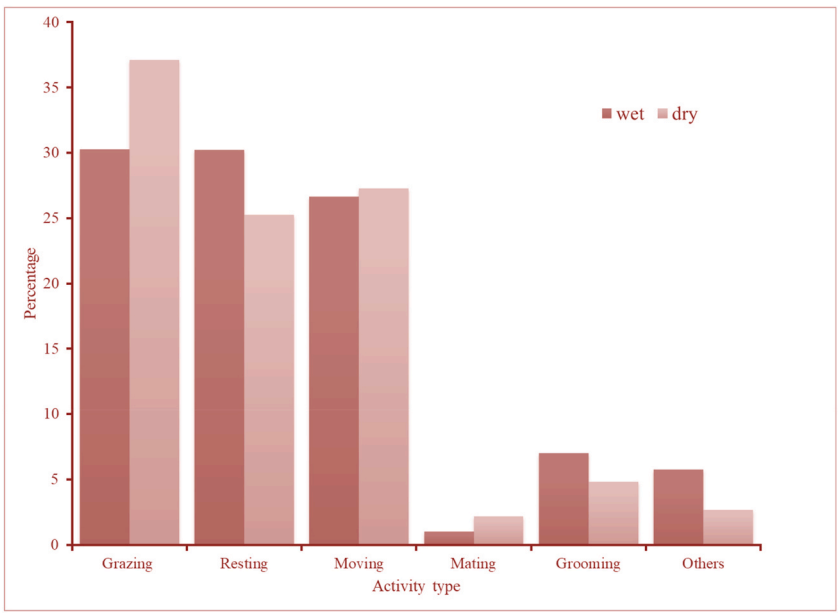

Fig. 1. Percentage of activities performed by Grevy's zebra during the wet and dry seasons.

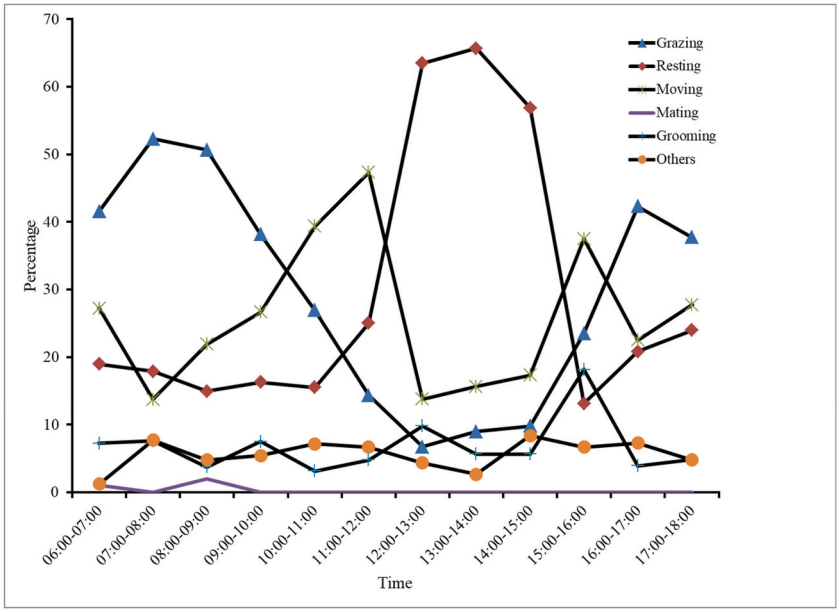

Fig. 2. Activity time budget of the Grevy's zebra during the wet season.

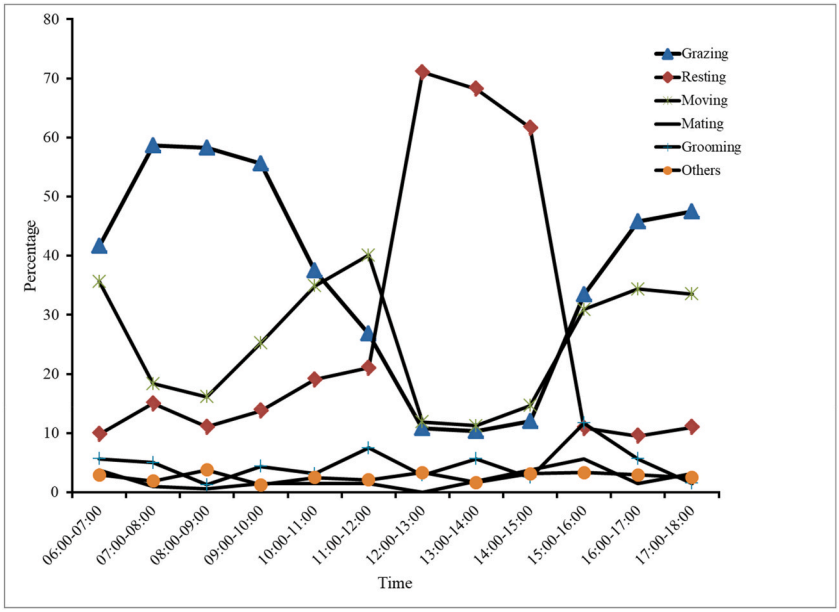

Fig. 3. Activity time budget of the Grevy's zebra during the dry season.

Table 1
Individual Grevy's zebra activities during both seasons.

Activities	Adult Female		Adult Male		Sub-adult		Juvenile	
	Wet (%)	Dry (%)	Wet (%)	Dry (%)	Wet (%)	Dry (%)	Wet (%)	Dry (%)
Grazing	35.63 ± 2.7	43.7 ± 5.4	32.45 ± 3.9	40.23 ± 1.7	32.43 ± 4.6	46.03 ± 2.5	20.15 ± 3.9	26.73 ± 3.3
Grooming	1.00 ± 8.4	1.30 ± 11.1	4.59 ± 4.8	4.27 ± 5.4	1.45 ± 5.8	0.47 ± 0.00	5.50 ± 4.2	4.44 ± 5.2
Mating	1.17 ± 0.00	2.00 ± 6.7	2.57 ± 3.7	4.50 ± 5.4	0	0.32 ± 8.1	0	0
Moving	25.34 ± 2.9	37.00 ± 3.2	26.14 ± 2.7	25.76 ± 4.2	24.55 ± 7.5	38. 23 ± 2.7	21.03 ± 4.1	25.39 ± 3.8
Others	5.78 ± 2.8	2.11 ± 5.1	3.57 ± 5.6	7.26 ± 4.7	4.11 ± 4.1	2.57 ± 5.6	9.03 ± 5.3	8.03 ± 4.3
Resting	27.09 ± 3.7	22.21 ± 10.5	30.35 ± 6.0	23.68 ± 10.8	31.39 ± 8.4	21.95 ± 11.5	45.02 ± 3.6	39.72 ± 5.9

and moving (25.34 ± 2.9) whereas, during the dry season, the top three activities of the species were grazing (43.7 ± 5.4), moving (37.00 ± 3.2) and followed by resting (22.21 ± 10.5). The time devoted for grazing and moving time during the dry season was much greater for adult females than the wet season. However, the species spent more time on resting during the wet season than the dry season (Table 1).

Adult male Grevy's zebra highest activities during wet season were grazing (32.45 ± 3.9), resting (31.39 ± 8.4) and moving (26.14 ± 2.7). While during the dry season, grazing (40.23 ± 1.7), moving (25.76 ± 4.2) and resting (23.68 ± 10.8) were the highest activities for the species (Table 1).

Sub-adult Grevy's zebra highest activities during the wet season include grazing (32.43 ± 4.6), resting (31.39 ± 8.4) and moving (24.55 ± 7.5). On the other hand, during the dry season grazing (46.03 ± 2.5), moving (38. 23 ± 2.7) and resting (21.95 ± 11.5) were top activities for the species (Table 1).

Juvenile top three activities during the wet season were resting (45.02 ± 3.6), moving (21.03 ± 4.1) and grazing (20.15 ± 3.9). During the dry season the top three activities of the species were resting (39.72 ± 5.9), moving (25.39 ± 3.8) and grazing (26.73 ± 3.3). Generally, energy conserving activities, like resting showed a strong inverse correlation with grazing and moving activities (Table 1).

Statistical test was conducted to know if there were significance differences on each activity of Grevy's zebra based on seasons. Accordingly, the time the species spent over grazing ($df = 1$, $F = 27.15$, $p = 0.000132$), Grooming ($df = 1$, $F = 24.082$, $p = 0.000231$), mating ($df = 1$, $F = 24.850$, $p = 0.0002$) and moving ($df = 1$, $F = 5.550$, $p = 0.0336$) activity during dry and wet seasons were significantly different. However, the time the species spent over resting ($df = 1$, $F = 57.02$, $p = 0.06$) and other activities ($df = 1$, $F = 80.140$, $p = 0.07$) during both seasons has statistically no differences. During dry season since there is scarcity of food availability compared to wet season the species spent much time to grazing activity.

3.2. Grevy's zebra activities comparison based on sex structure

Statistical test was made to know if there were significant differences on activity of Grevy's zebra based on sex. The result evidenced as there are statistically significant differences on time devoted to grazing ($df = 2$, $F = 9.336$, $p = 0.002653$), mating ($df = 2$, $F = 6.216$, $p = 0.0117$), moving ($df = 2$, $F = 5.604$, $p = 0.0163$) and other ($df = 2$, $F = 5.006$, $p = 0.0229$) activities based on sex of species. However, there is no statistical difference on resting activity based on sex of species ($df = 2$, $F = 44.18$, $p = 0.07$).

The time female Grevy's allotted for grazing was greater and statistically different from other groups of Grevy's zebra ($df = 2$, $F = 35.88$, $p = 0.032$). Male and juveniles were devoted more time to grooming and statistically different when compared with other groups of Grevy's zebra ($df = 2$, $F = 21.01$, $p = 0.02$). Compared to other categories of Grevy's zebra, male Grevy's zebra spend highest time to mating and there is statistically differences ($df = 2$, $F = 58.25$, $p = 0.012$). Male zebra spent less time to moving when compared with others and statistically there are significant differences ($df = 2$, $F = 22.33$, $p = 0.004$).

3.3. Grevy's zebra activities comparison based on age structure

The impact of age on Grevy's zebra activity was tested and there is no significant differences on activities of the species based on age structure ($df = 3$, $F = 13.73$, $p = 0.359$). Specifically, grazing ($df = 3$, $F = 23.63$,$p = 0.259$),grooming($df = 3$,$F = 1.134$,$p = 0.651$), mating ($df = 3$,$F = 2.75$, $p = 0.0697$), moving($df = 3$,$F = 54.07$,$p = 0.094$),other($df = 3$, $F = 1.43$,$p = 0.264$) and ($df = 3$,$F = 17.29$,$p = 0.063$).

4. Discussion

Variations were observed in the activity time budget of Grevy's zebra during dry and wet seasons at different time of the day. The current research revealed that Grevy's zebras in HAPNP spend most of their time on grazing, resting and moving. The animal budgeted time for grazing was 31.26% and 37.13% during the wet and dry season, respectively. The time devoted to grazing was greater during dry season compared to wet season. This indicates that as during dry season Grevy's zebra feeding resource is scarcely available in the area compared to wet season. The increase in grazing time with decreasing food availability in the dry season has been reported for several African grazers [12,26–28]. The animal most preferred time for grazing activity was morning 06:00–10:00 and afternoon 15:00–18:00. The time was preferred by species due to different factors including; avoid the competition that may occur over resources with livestock and human induced impacts since livestock and human movement in the area is limited during this time. Moreover, the weather of the day during this time is very encouraging for energy consuming activities since midday is known by hot temperature in the area. This finding was in line with [12], Burchell zebra spending more than 50% of their time on grazing in Yabello wildlife sanctuary and most of their activities were in the morning and afternoon with resting during day time.

Grevy's zebra allotted time for resting was 30.24% and 25.25% during the wet and dry season, respectively. During the wet season, the species spent higher time on resting compared to dry season. Relatively, during the wet season enough feeding resource was present and species do not travel long distance in search for feeding resources. The midday time, 12:00–14:00, was the peak resting time for the species. This can be justified by different factors, for instance, during midday the weather becomes severe and Grevy's employed resting as a means of adaptation mechanism. The other reason that the species uses midday for resting is that the area was occupied by thousands of livestock and they avoid busyness. This finding was in line with [12] in that Burchelle's zebra in Yabello wildlife sanctuary spend significant time on resting during the midday.

Grevy's zebra budgeted time for moving activity was 26.64% during the wet and 27.25% during the dry season. The moving

activity was higher during dry season compared to the wet season. During dry season for search of water points and to overcome shortage of resources the species devoted higher time to moving compared to wet season when resources are relatively abundant. One of the peak time for moving activity was 06:00–07:00. This time the species travel from the site they overnight to grazing area. The other peak time for the moving activity was 11:00–12:00 and they used this time to move from grazing site to shade area to hide themselves from harsh weather and pastoralist intimacy. Afternoon the species peak time for moving activity was 15:00–16:00 and 17:00–18:00. During the former time the species travel from shade area where they hide themselves from harsh climate during midday to grazing area for grazing purpose. In the later time, they travel from feeding site to the place they might overnight. The difference in the distribution of time budgets of the wet and dry season may lead to the conclusion that harsh climate and resource availability seem to be the determinant factors governing the activities of Grevy's zebra. In addition human activities also influence the diurnal activities of Grevy's zebra. Numerous factors influence the activity patterns of animals. Optimal daily and seasonal activity patterns may be influenced by biotic ambient elements including light and temperature [29,30].

5. Conclusion

The present study was designed to determine a detailed 12-h activity budget of Grevy's zebra in Hallaydeghe Asebot Proposed National Park (HAPNP). This study has identified energy consuming activities including grazing and moving as the most daily activities for the species. The evidence from this study suggests that, there is a need to have Grevy's zebra comprehensive management in the site. Before this study, evidence of Grevy's zebra diurnal activity in HAPNP was purely anecdotal. The study certainly adds to our understanding of the biological activity patterns of Grevy zebra, which may be used in a subsequent step to analyze and enhance management or animal welfare conditions. This would be a fruitful area for further work. The findings of this study have a number of important implications for future practice.

Ethical clearance

The study was not requiring ethics approval since it does not involve of killing, capturing or any damaging acts on wildlife as stated by Ethiopian Wildlife Conservation Authority.

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Data availability statement

Data will be made available on request.

Additional information

No additional information is available for this manuscript.

CRediT authorship contribution statement

Tolera Abriham: Writing – original draft, Methodology, Conceptualization. **Afework Bekele:** Writing – review & editing. **Mesele Yihune:** Writing – review & editing, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationship that could have shown up to influence the work reported in this manuscript.

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