

Research Article

Comparison of Activity Pattern of Zebra (*Equus quagga*) in Natural and Man-Made Glades in Arusha National Park, Tanzania

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Abstract

The study on the comparison of activity pattern of zebra in natural and man-made glades was conducted in Arusha National Park to assess group size composition, activity pattern between sexes and age groups. Scan and focal sampling methods were used for data collection. A total of 457 individuals across age and sex groups were observed and recorded. Out of this, 138 individuals were recorded in man-made and 319 individuals in natural glades. The result showed that movement between sex classes in natural glades differed significantly ($T=1.85$, $df=8$, $P<0.03$), and time spent grooming between males and females differed significantly ($T=1.85$, $df=8$, $P<0.01$). Time spent for feeding, resting and other activities such as defecating, urinating and irritating could not differ significantly and as well as formed-made glades. In natural glades, time spent for grooming across age classes differed significantly ($F=13.2$, $df=17$, $P<0.000$), as well for others activities such as (defecating, urinating and irritating) ($F=14.0254$, $df=17$, $P<0.0003$). In man-made glade, time spent for moving across age classes differed significantly ($F=8.3945$, $df=17$, $P<0.004$), feeding ($F=6.0863$, $df=17$, $P<0.01$), grooming ($F=22.02$, $df=17$, $P<0.000$) and other activities (defecating, urinating and irritating) ($F=11.25$, $df=17$, $P<0.0011$). Generally, much time was spent by zebra feeding between sex classes and across age classes compared to other activities. This implies that feeding is most important for energy requirement, as food resources provide energy to animals.

Keywords

Activity Pattern, Arusha National Park, Man-Made Glade, Natural Glade, Zebra

1. Introduction

Glade is open grassland patches in the natural forest that hold unique ecological roles and associated species in performing their activity pattern [14]. Glades are regularly grassy meadows beneath the cover of deciduous trees and they are very vital to herbivorous animals such as zebra, wildebeest, and buffalo [24]. Glades can be categorized as natural and man-made glades. Natural glades are characterized by great-

er abundance of grasses and forbs and are maintained by grazing animals whereas man-made glade are characterized by shrubs and are maintained by periodic slashing of the glade interior [14].

Large mammals are an integral part of the ecosystem and they occupy different trophic levels in a food chain [12, 16]. They serve and important ecological role in trophic level thus

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support ecosystem functioning. Zebra (*Equus quagga*) are among the larger animals native to Africa and they are regarded as a distinctive single hoofed ungulate with black and white striped coats that live in herds [16]. They inhabit eastern and southern Africa and can be found in a variety of habitats such as savannahs, grasslands, woodlands, shrub lands and mountainous areas [10]. Nevertheless, zebras can be found in numerous protected areas [11] and are also considered as one of the African most adaptable and successful grazers [28]. They are primary grazers feeding on both short young grasses and long flowering grasses [19]. Zebra (*Equus quagga*) conservation status is considered as near threatened as per IUCN Red List due to their population being driven to extinction [22].

The activity patterns of a species are an important aspect for their ecological functioning as it's reflecting physiological characteristics and ecological interactions [1]. The activity pattern of most mammals is regulated by endogenous biochemical processes that are mostly stimulated by environmental variation such as daily photoperiod [31]. Mammals regulate their activity pattern according to the daily light-dark cycle and can be specialized in a particular period, hence this allows their classification as diurnal or nocturnal [3]. The activity pattern of mammals can also be affected through elements apart from light, consisting of food availability, social stimulus, competition, predation and maternal behavior [26]. Also, human disturbances such as habitat fragmentation, tourism and hunting are the critical elements in figuring out mammalian activity sample [5]. Consequently, variation in activity pattern amongst populations can also additionally constitute techniques adopted by individual in a population to overcome elements such as ecological interactions, environmental cues and different intensities of threat [25]. Activity pattern of mammals involves range of behavior like resting, moving, feeding and social behavior such as grooming, playing, mating, aggression and greeting as well as other factors such as drinking, defecating and alerting [18]. Habitat quality might dictate the time allocation on performing behavioral activities pattern for different species. But it also dictates on the diurnal activity pattern of most species including zebra [11]. The adaptation of the species to habitat changes differs depending on their strategies [29].

Activity patterns of zebra (*Equus quagga*) can vary depending on seasons, the animal's sex, ages or reproductive state [20]. Behavioral pattern of zebra (*Equus quagga*) are influenced with variations in environmental conditions such as temperature, climate, biological cycles, light, feeding bouts, phases of the moon, time of day or year interactions and predation risk [23]. The time spent by zebra (*Equus quagga*) on feeding each day

depend upon extraordinary factors that includes its necessities of vitamins and energy, availability of digestible food and at what rate food may be ingested [36].

The effective conservation management of the species depend on the understanding on the way the species interact ecologically with its specific environment [16]. One of the maximum useful strategies of describing these activities is to quantify primary activities pattern which exist for any species at a given time and region throughout the specific seasons [16].

Arusha National Park is one of the famous Park in Tanzania recognized for harboring variety of mammal species including zebra (*Equus quagga*) that were introduced in the Park in 1990 for the purpose of having commercial value for tourism as they are part of wildlife which act as a tourist attraction in the park as other National Parks in Tanzania [20, 27]. Studying animal behavior is very important in ecology and conservation management, as animal behavior can act as an early warning sign of environmental degradation [7, 32]. So the activity pattern of the zebra should be assessed for effective management through understanding their ecological interaction with its specific locality and for commercial value in the park. Glades are mostly used by different animals in doing their activity pattern due to the nature of the Park which is largely covered by Montana forest. Based on this fact, the study aimed at comparing the activity pattern of zebra in man-made and natural glades in Arusha National Park, with the view to assess the group size composition, activity pattern between sexes and across age groups.

2. Methods

2.1. Study Site

The study took place in Arusha National Park (ANAPA) established in 1960, which covers an area of 552 Km² [19]. It lies on the eastern slope of Mt. Meru found in Arusha region, Tanzania (3° 15'S- 36° 45'E, Figure 1). The park is located 25 km kilometers on the north east of Arusha City and has got a broad variety of landscapes ranging from open savannah, acacia woodland, rainforest, forest glades (Natural and Man-made) and alpine. The park has high diversity of wildlife such as hippos, buffalo elephants, zebra, black and white colobus monkey and a home of world largest population of giraffe [23]. Park is also a perfect place for walking safaris due to rare or absence of predators.

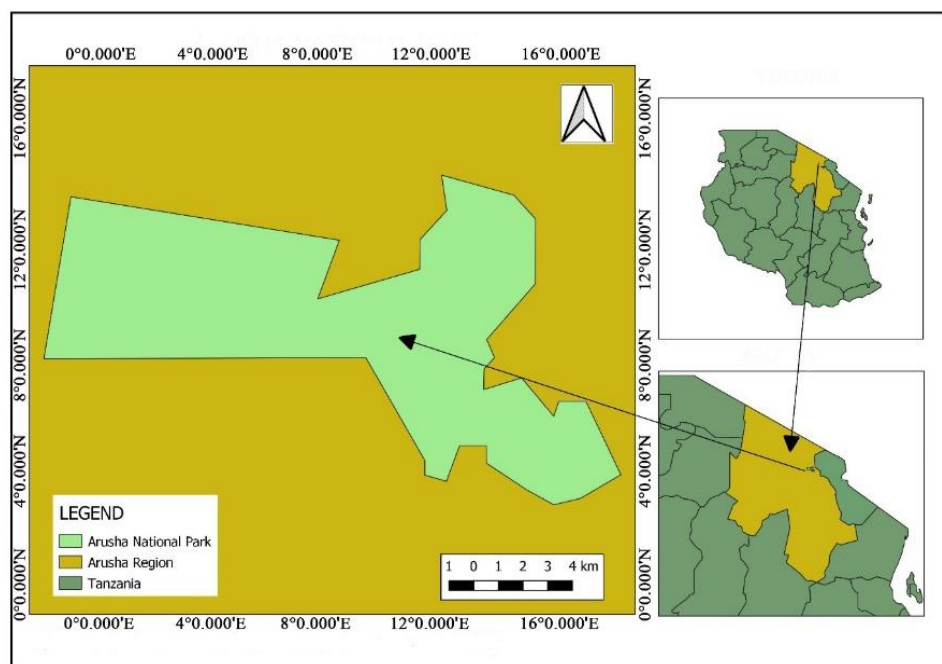


Figure 1. Map of the study area (Arusha National Park).

2.2. Zebra Survey in Man-Made and Natural Glades

The research designed compared the activity pattern of Zebra in man-made and natural glade. The survey was conducted in one- man-made glade and one natural glade, where by the order of visits followed a random design pattern between glade types [13]. Direct observations of zebra activity pattern were made from a hide at the forest edge using binocular in natural and man-made glades [13]. The observation was partitioned into three sessions namely morning (8:00-10:00 hours), afternoon (12:00-14:00 hours), and evening (16:00-18:00 hours). During each observation period behavioral activities performed by individuals or groups was recorded in a data sheet. In each day focal sampling and recording was done for 15 minutes with 5 minutes intervals throughout the day [33]. The same procedure was used for scan sampling across the groups whereby at the start of the observation dominant activity was recorded [4]. One minute was used for the individual to adjust to a change to its environmental condition before to start recording their activity pattern [9, 31]. The activities that were observed and recorded included resting, moving, feeding, grooming and other activities such as defecating, urinating and irritating, in which this activity were defined as follows; Resting was referred to laying down in a relaxing manner or standing still with head held horizontally as well as ears dropping. Moving was defined as the steady movement with the head held horizontally. Feeding referred to the entire process of searching and

fighting for food as well as biting and ingestion and was characterized by slight movements with the head down. Grooming was referred to standing close also with the head close to each other, characterized by pulling loose hairs off each other, rather they seen as they are biting each other. Other activities that were recorded together were also defined as follows; defecating referred to the removal of food remains that was not digested. Urinating was referred to the discharge of urine from the body. Irritating referred to the behavior displayed by zebra to counteract flies, as they were scratching themselves, swished their tails as well as frequent running away from fly's nuisance.

2.3. Statistical Analysis

Data were analyzed using inferential statistics Student T-test to test hypothesis on sex groups [35] and one way-ANOVA for activity pattern across age class (Juvenile, Sub adult and adult). Percentages and minutes for time spent for various activities were presented in tables and graphs [36].

3. Results

3.1. Age and Sex Group Composition

A total of 457 individual of zebra were recorded across age and sex groups in both man-made and natural glades in Arusha National Park (Table 1).

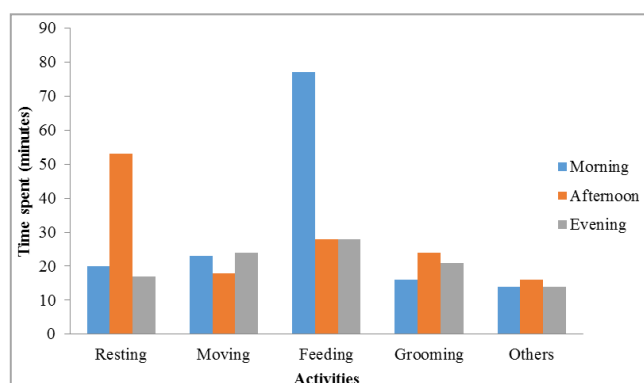
Table 1. Zebra group size composition in natural and man-made glades in Arusha National Park.

Glade types	No. males	No. females	No. adult male	No. sub-adult male	No. adult female	No. sub-adult female	No. juveniles	Total group size
Man-made	43	95	21	14	68	21	15	138
Natural	103	216	55	31	151	43	22	319
Overall Total								457

Source: Field data (2022)

3.2. Activity Pattern of Zebra in Natural Glade

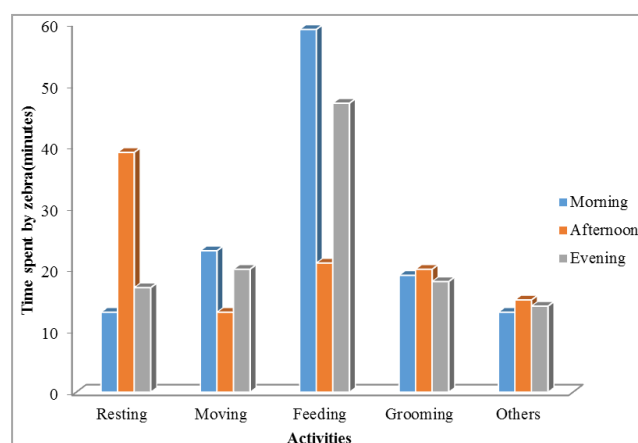
A total of 319 Zebra (females, males, sub-adult male and female and juveniles) were recorded in natural glade. The result revealed that zebra spent most of the time feeding in the morning, followed by resting in the afternoon and less time was spent for other activities (defecating, irritating and urinating) (Figure 2).

**Figure 2.** Activity pattern of zebra at different times in the morning, afternoon and evening in natural glade.

3.3. Activity Patterns of Zebra in Man-Made Glade

In man-made glade, Zebra spent most of the time feeding in the morning and evening. This was, followed by resting in the

afternoon and moving (morning and afternoon) and grooming (afternoon, morning and evening) and less time on other activities (Figure 3).

**Figure 3.** Activity pattern of zebra at different times in the morning, afternoon and evening in man-made glade.

3.4. Activity Pattern of Zebra in Natural Glade Between Sex (Male and Female)

The activity pattern of Zebra in natural glade between sexes (male and female) indicated that female Zebra spent 18% of its time moving while male Zebra spent 14.5%. Female Zebra spent a total of 17.1% of its time grooming while male spent 14.5%. The activity patterns of moving and grooming differed significantly between sexes (Table 2).

Table 1. Activity pattern of zebra in natural glade between sex classes (male and female).

Activity	Time spent by Male (minutes)	Time spent by Female (minutes)	Male (%)	Female (%)	T-test (t)	Df	P-value
Resting	37	51	22.4	22.4	1.8595	8	0.1052
Moving	24	41	14.5	18	1.8595	8	0.0370 ^a
Feeding	62	71	37.6	31	1.8595	8	0.1599
Grooming	24	39	14.5	17.1	1.8595	8	0.0121 ^b

Activity	Time spent by Male (minutes)	Time spent by Female (minutes)	Male (%)	Female (%)	T-test (t)	Df	P-value
Other activities	18	26	11.0	11.4	1.8595	8	0.0768
Total	165	228	100	100			

^ap< 0.05, ^bp< 0.01

3.5. Activity Pattern of Zebra Between Sexes in Man-Made Glade

The activity pattern of male Zebra in man-made glade spent 34.6% of its time feeding and 17.9% grooming, while female

Zebra spent 33.7% of its time feeding and 15.5% grooming. Female Zebra spent 21% resting, 17.1% moving and 12.7% for other activities (defecting, irritating and urinating) while male Zebra spent 19.8% of its time resting, 16% moving and 11.7% for other activities (defecting, irritating and urinating) and differed significantly (Table 3).

Table 3. Activity pattern of zebra between sexes in man-made glade.

Activities	Time spent by Male (minutes)	Time spent by Female (minutes)	Male (%)	Female (%)	T-test (t)	df	P-value
Resting	32	38	19.8	21.0	2.3060	8	0.4516*
Moving	26	31	16.0	17.1	2.3060	8	0.2145*
Feeding	56	61	34.6	33.7	2.3060	8	0.1700*
Grooming	29	28	17.9	15.5	2.3060	8	0.9068*
Others activity	19	23	11.7	12.7	2.3060	8	0.2721*
Total	162	181	100	100			

*p>0.05

Source: Field data (2022)

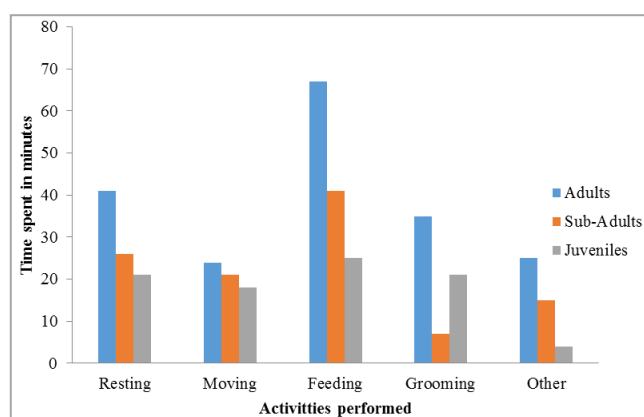


Figure 4. Activity pattern of zebra showing time spent across age groups (adults, sub-adults and juvenile) in natural glade (Source: Field data (2022)).

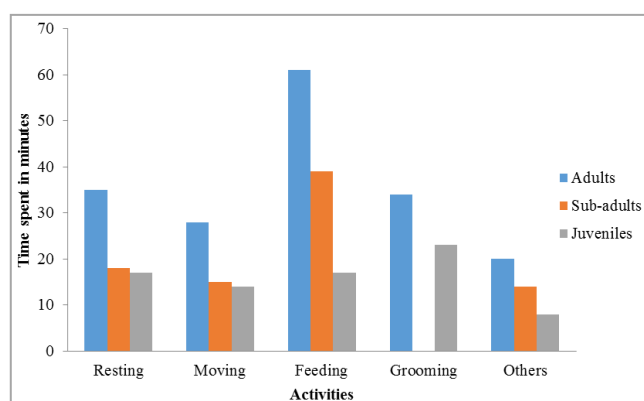
3.6. Activity Pattern of Zebra in Natural Glade Across Age Groups (Adults, Sub-Adults and Juveniles)

In natural glade, adult Zebra spent most of their time feeding, followed by resting, grooming and the least was moving and other activities. For sub-adult Zebra feeding was highest followed by resting, moving, other activities and the least was grooming. For Juvenile Zebra spent most of their time feeding, followed by resting, grooming, moving and the least was for other activities (Figure 4). Zebra other activities across age groups (adults, sub-adult and juvenile) differed significantly (ANOVA, $F=14.0254$, $df=17$, $P< 0.0003$) and also for grooming (ANOVA, $F=13.1838$, $df=17$, $P< 0.0004$).

3.7. Activity Pattern of Zebra in Man-Made Glade Across Age Classes (Adults, Sub-Adults and Juveniles)

In man-made glade, adult Zebra spent most of their time feeding, followed by resting, grooming, moving and the least was other activities. For sub-adult Zebra feeding was highest followed by resting, moving, and the least was other activities. For Juvenile Zebra spent most of their time grooming, followed by resting, feeding, moving and the least was for other activities (Figure 5).

Time spent feeding across age groups of zebras in man-made glade differed significantly. (ANOVA $F=6.0863$, $df=17$, $P < 0.0116$), also for grooming (ANOVA, $F=22.0244$, $df=17$, $P < 0.0003$), other activities (ANOVA $F=11.25$, $df=17$, $P < 0.0011$) and moving (ANOVA, $F=8.3945$, $df=17$, $P < 0.0036$). (Figure 5)



Source. Field data (2022)

Figure 5. Activity pattern of zebra showing time spent by adults, sub-adults and juveniles in man-made glade.

4. Discussion

4.1. Group Size Composition

Group size composition for zebra in Arusha National park was highest natural glade with a total of 319 individuals compared to 138 individuals in man-made glade. The differences in group size composition can be attributed by the minimal disturbance and tranquility afforded by natural glade of being not subjected to periodical clearance of forest glade edges and interior as it's done in man-made glades. This findings correspond to [15] who asserted that natural glades are maintained by flooding during rainy season, whereas man-made glades by periodic slashing of forest-glade edges and glade interior. The clearance of forest glades edge and interior by humans cause disturbances and therefore, contributed for the man-made glades to be less preferred over natural glade. Use of man-made glades requires an animal to be more vigilant when performing its daily activities due to disturbance as also noted by [27]. This

may account for the low usage of man-made glades by zebra in Arusha National Park.

4.2. Activity Patterns of Zebra in man-Made and Natural Glades

From the findings (figure 2) it was observed that in the natural glade, zebra used much of their time feeding in the morning and evening and resting time was at the peak in afternoon. This was probably due to the presence of sunlight and high temperature. This affects the activity pattern of Zebra that use the midday/ afternoon to chew the cud of food taken in the morning. This corresponds to the findings by [22, 25] who noted that animals use most of their time resting in afternoon than other activities. Resting behavior when it increases leads to decreased feeding behavior due to compositional tradeoffs [8]. Little time was taken by zebra grooming and a bit of time was spent in the morning doing other activities like (defecating, urinating and irritating) making it ready to start searching and fighting for food in the new day.

On the other hand, in man-made glade (figure 3), the findings revealed that, zebra spent most of their time feeding in the morning and evening. Man-made glades are associated with high diversity of food varieties associated with the action of clearing the forest-glade edge and interior. Hence zebra use this opportunity to take more food in order to compensate for their inferior food assimilation [4]. Zebra were observed to spend most of their time moving in the morning and evening probably in the search of food, as also noted by [30] who attributed that distribution of animals is dependent on food availability, water, cover and space.

4.3. Activity Pattern Between Sex Groups in Man-Made and Natural Glades

In this study, it was revealed that males and females in both glades almost spent the same time performing other activities (defecating, urinating and irritating). This implies that both males and females Zebra were removing out digested and undigested food materials from the stomach and at the same time flushing away nuisance flies biting them. Slight variation was observed in time spent by male and female Zebra in feeding. Female zebra spent more time feeding than male in man-made and natural glades. This could be attributed by the fact that female zebra take a lot of food to generate energy and nutritional food to feed their young infant zebra and assurance of their growth and survival as also noted by [17]. Males Zebra spent less time feeding as they use most of their time being vigilant [30].

Male zebra spent less time resting because of using most of their time for courting and vigilance [36] while female Zebra spent most of their time resting because of looking after their young and this may account for high resting time than males in both glades. This was quite different from the findings by [34] who noted that female use less time resting and more

time feeding to obtain high nutritional and energy requirements for lactation.

In made-made glade male zebra spent much time grooming than female. This was because female used most of their time feeding and resting in this type of glade. The presence of varieties of vegetation as a result of periodic clearances of man-made glade stimulate growth of varieties of vegetation as reported by [14]. This enables zebra to move into these glades to search for food. But in the natural glade, female spent much time grooming with their juveniles as a way to promote maternal instinct and inhibit aggressive behavior to female [34]. Female zebra used much time moving than males in both glades, this was attributed by searching and fighting for quality food resources.

4.4. Activity Pattern of Zebra Across Age Groups in Man-Made and Natural Glades

The findings show that, the time spent by Zebra for doing other activities in both glades varied across age groups. Adult Zebra spent most of their time doing other activities compared to sub-adults and juveniles. The other activities (defecating and urinating) performed by adults were probably due to high food intake rate compared to sub-adults and juvenile.

Adults were found spending much time in feeding in both glades, followed by sub adults and less time for juvenile feeding. This could be attributed by individual age class metabolic requirements that is related to body mass, as the body mass increases the rumen become proportionally large, thus needing to ingest more nutrients [28]. Sub-adults spent more time feeding than juvenile, implying that at this age class it is where reproductive organs are being formed, hence require more energy compared to juvenile that depend on suckling from their mother as source of energy and growth [22].

Adult zebra were found spending much time resting in both types of glades than sub adults and juveniles especially during afternoon; this was attributed by high intake rate of food in the morning hours as well as energy conservation strategies in the afternoon [2]. Also, as animal become older tend to become

less active, hence result to high resting time [35].

According to this finding it was revealed that in both glades, adults Zebra spent much time moving than sub-adults and juveniles for food searching. It was very prominent in man-made than natural glades. This was because of man-made glades of having diversity food varieties, associated with periodical clearance of the forest-glade edge and interior, which leads to growth of different vegetation type and therefore, enhancing Zebra to use much time searching for high quality food [12].

Furthermore, adult's zebra spent much time grooming, followed by juveniles and lastly sub-adult in both glades. This could be attributed by interaction between adults particularly females and juveniles as they can socialize to maintain maternal instinct compared to sub-adults as well as interaction between males and females' adults in which they can get more chance to perform grooming than sub-adults. The results conform to those of [6, 21] who noted that juvenile's zebra use most of their time grooming with adult zebra than sub-adult zebra as means of behavioral maintenance as well as to develop motor skills.

5. Conclusion and Recommendations

Generally, zebra preferred natural glades over man-made glades because of fewer disturbances. Feeding was observed to be dominant than other activities in both glades regardless of the differences in vegetation structure. This helped the animal to obtain energy required from food for physiological functions. Effective management should be employed to avoid the overuse of natural glades by animals, by ensuring periodic clearance of man-made glades for affording uniformity use of glades.

Conflicts of Interest

The authors declare no conflicts of interest.

Appendix

SAMPLE OF DATA SHEET

Time start..... Time end.....
Weather..... Glade type.....
Date.....

Table 4. Data sheet for recording the group size composition of zebra in man-made and natural glades.

Group Size	No. Males	No. Females	No. Adult-males	No. Sub-adult males	No. Adult-females	No. Sub-adult Females	Nojuveniles
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Table 5. Data sheet for recording diurnal activity pattern of zebra in man-made and natural glades according to their sex and age classes.

Sex and Age Classes	Activity Pattern and Time Spent				
	Resting	Moving	Feeding	Grooming	Other activities (defecating, urinating and irritating)
Male adults					
Male sub-adults					
Male juveniles					
Female adults					
Female sub-adults					
Female juveniles					

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