

TEMPORAL AND SPATIAL DISTRIBUTION OF GREVY'S ZEBRA AND HABITAT USE OVERLAP WITH LIVESTOCK IN HALLAYDEGHE ASEBOT PROPOSED NATIONAL PARK, ETHIOPIA

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ABSTRACT: Knowledge on distribution and habitat use overlap with livestock in time and space is crucial for planning the conservation of Grevy's zebra. The objective of this study was to determine the temporal and spatial distributions of Grevy's zebra and of livestock with reference to habitat use overlap in Hallaydeghe Asebot Proposed National Park. Habitat use overlap map was determined by projecting the Grevy's zebra and livestock GPS points in ArcGIS. One-way ANOVA was applied to test seasonal variation in mean abundances of livestock and Grevy's zebra. Habitat use similarity between livestock and Grevy's zebra was computed by S18 Kulczynski, and Pearson correlation coefficient was used to examine the degree of similarity in their habitat use. The habitat use overlap area covered an area of 110 square kilometers in the wet season and 272 square kilometers in the dry season. Results showed that the mean abundance of livestock in dry and wet season was 2.4 ± 0.1 and 3.1 ± 0.1 , respectively. The mean abundance of Gravy's zebra in dry and wet season was 0.6 ± 0.1 and 0.2 ± 0.2 respectively. Degree of habitat use similarity between Grevy's zebra and livestock was 50.53% in dry, and 50.32% in wet season. Pearson correlation coefficient result showed that the degree of habitat use similarity between livestock and Grevy's zebra was $r = 0.232$ in the dry season and $r = 0.243$ during the wet season. This study concluded that there was habitat use overlap between livestock and Grevy's zebra in Hallaydeghe Asebot Proposed National Park in time and space.

Keywords: *Equus grevyi*, Habitat use overlap, Livestock.

INTRODUCTION

Wild equids play a significant role in maintaining semi-arid and desert ecosystem processes in Africa and Asia. However, their population has declined significantly due to habitat loss and unsustainable hunting (Williams, 2002; Moehlman et al., 2008; IUCN, 2010). The Grevy's zebra (*Equus grevyi* Oustalet) is one of the world's most threatened wild equids and is listed in IUCN's red-list as

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endangered species (Rubenstein et al., 2016). Historically, the Grevy's zebra ranged from east of the Rift Valley in Kenya to western Somalia and northern Ethiopia (Bauer et al., 1994; Kebede et al., 2012). Today it is extinct in Djibouti and Somalia, and its existence in Sudan is uncertain (Rubenstein et al., 2016). In Ethiopia, populations of Grevy's zebra declined from an estimated 1900 in 1980 to 577 in 1992 (Rowen and Ginsberg, 1992) and to 106 in 2003 (Williams et al., 2003; Kebede et al., 2012). The trend from 1980 to 2003 represented a decline of about 94% (Moehlman et al., 2008). The largest population of Grevy's zebra in Ethiopia, in the early 1970s, was in the *Chew Bahir*, which had an estimated 1500 animals but this number has declined to 30 over time (Khalatbari, 2013). Recent data indicated that the number of adult individuals is about 1956 (Rubenstein et al., 2016).

The principal objective for the establishment of the Hallaydeghe Asebot Proposed National Park (here after HAPNP) was to protect the endangered Grevy's zebra and other important grazing wild herbivores and carnivores in the area. The area is home to the Ethiopia's largest population of Grevy's zebra and serves as a buffer zone for the Awash National Park and the Awash West control hunting area. It was established in the 1960s when most of the Ethiopian protected areas were designated (Hillman, 1993; Kebede, 2008).

Competition with livestock for forage and water pose major threats to the survival of Grevy's zebra. The livelihoods of pastoral communities in the HAPNP and surroundings are dependent on livestock production, and livestock numbers are a social indication of the owner's wealth (Kebede, 1999; Mulder et al., 2010). Large numbers of livestock depend on the HAPNP rangelands, resulting in territorial disputes among pastoral communities. Some individuals from local pastoral communities occasionally hunt Grevy's zebra illegally to be used for medicinal purposes and for food (Kebede et al., 2003). The spread of the invasive species *Prosopis juliflora*, especially near villages and cattle trails, has also resulted in loss of forage and habitat degradation (Kebede, 2009). Urban development along the road

and recent water borehole and rangeland development project inside the HAPNP are also becoming conservation threats.

Information on the temporal and spatial distribution of the endangered Grevy's zebra, the types of vegetation they live in and their habitat use overlapping areas with respect to livestock encroachments were lacking in HAPNP. Hence, to conserve the endangered Grevy's zebra and their habitats in the face of existing and developing conservation challenges, there is a need to develop a management oriented ecological threat monitoring programs based on the temporal and spatial distribution of Grevy's zebra and livestock. Such study will serve as an important tool for the conservation and management of this endangered species in HAPNP.

The objectives of this study were hence to determine the temporal and spatial distributions of Grevy's zebra and livestock with reference to habitat used overlap in HAPNP and map the habitat use overlapping areas of Grevy's zebra and livestock in time and space at HAPNP.

MATERIALS AND METHODS

Location of the study area

The HAPNP is one of the protected areas in Ethiopia. It is located in the Great Rift Valley of Ethiopia (approximately 8°30' to 9°30'N, 39°30' to 40°30'E) (Figure 1) and located within the Inter-Tropical Convergence Zone. The area exhibits both temporal and spatial variability in rainfall, humidity and temperature. It is a semiarid ecosystem with annual rainfall ranging between 400 and 700 mm (Kebede, 2008). The area is known for two distinct rainy seasons, the small rains usually begin in February and last until the end of April and the big rains occur from July to September. The mean seasonal temperature ranges from 25 to 30°C, but the daily maximum temperature may be as high as 38°C in June, while the minimum daily temperature can drop to 15°C in December (Kebede, 2008).

The land cover types of HAPNP are open grassland, forest (Mountain Asebot forest in the eastern part), woodland, wooded grassland and bushland. Most of the plain is dominated by two species of perennial

grasses *Chrysopogon plumulosus* and *Sporobolus cladus*. The southern, eastern and western edges of the proposed park are dominated by mixed shrub and grasslands shaded by *Acacia senegal* (Kebede et al., 2003). The HAPNP area coverage has been reduced from 1832 to 1099 square kilometer after re-demarcation work in 2014.

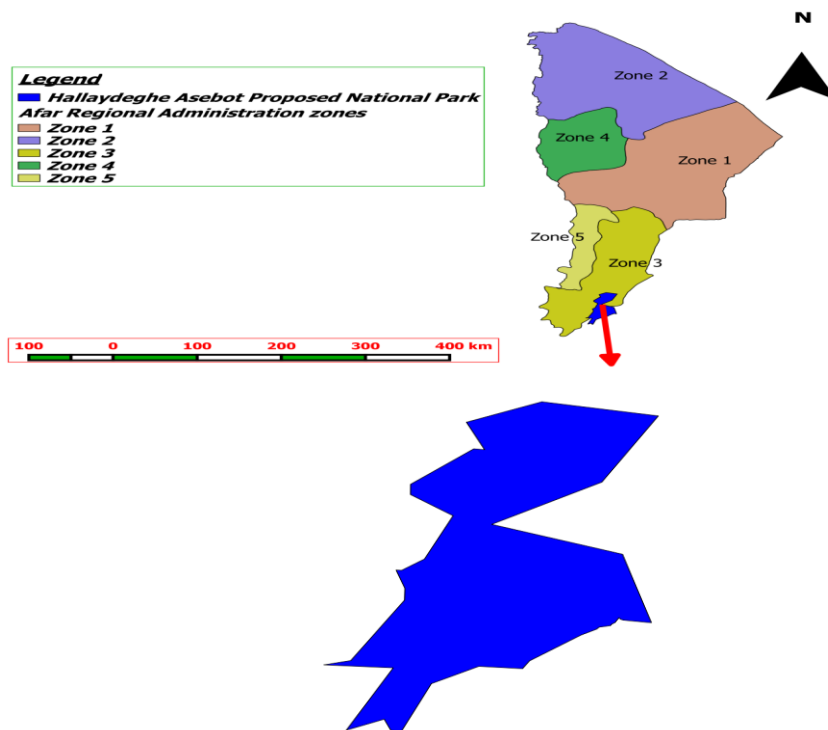


Figure 1. Map of the study area.

Data collection and analysis

Grevy's zebra and livestock distribution data

Grevy's zebra and livestock distribution was studied by collecting data in dry and wet seasons in the HAPNP. These data were collected using 11 ground transect lines in dry season (September 2020 to January 2021) and 10 transect lines in wet season (February to August, 2021). Since the HAPNP is open grassland plain, off-road driving along transect lines which was suggested to be the most efficient method for conducting a survey (Kebede et al., 2012) was used for conducting the census (Figure 2). The driving speed was 10 to 20 km per hour throughout the census period. The dry and wet seasons

Grevy's zebra and livestock transect line census results were obtained from the raw data GPS locations of Grevy's zebra and livestock. Whenever Grevy's zebra and livestock were sighted together, the date, time, GPS location, and total number of individual animals were recorded in open vegetation types. Transects were driven from 06:00 to 10:00 am in the morning and from 3:00 to 5:00 pm in the late afternoon, which are the hours where Grevy's zebra were most active. Site locations of the boreholes and seasonal illegal human settlements were also recorded with a GPS.

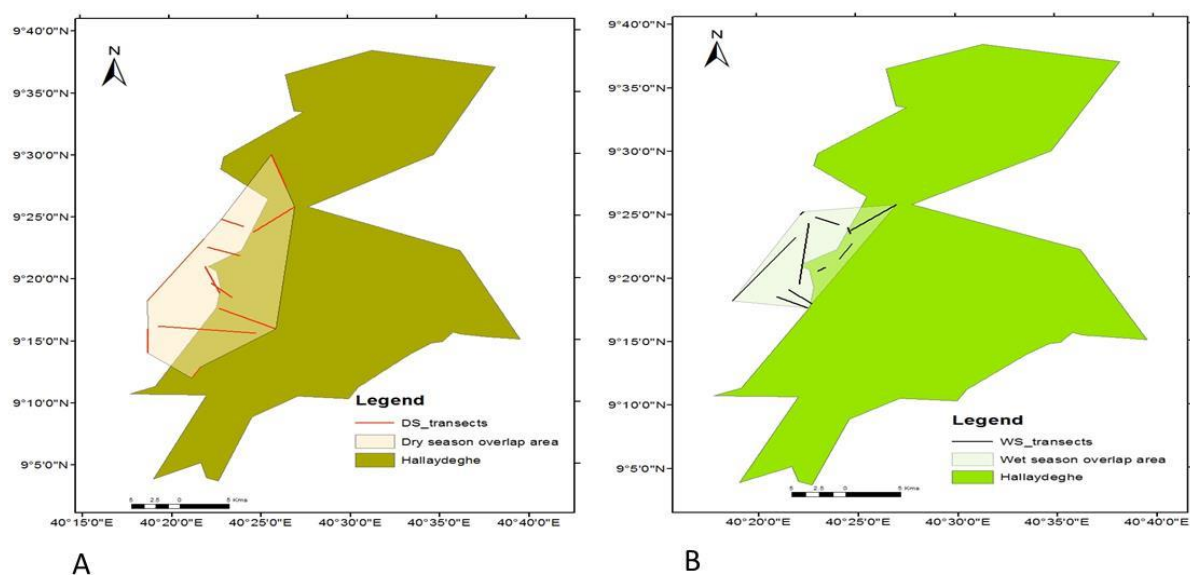


Figure 2. Transects lines used for Grevy's zebra and livestock census in the dry season (A) and wet season (B).

Maps of Grevy's zebra and livestock habitat use overlap

Distribution maps of Grevy's zebra and livestock in their habitat use overlap areas were generated from the GPS locations that were recorded where the zebras and livestock were sighted in HAPNP. This was achieved by initially adding the GIS shape files of HAPNP in ArcMap and overlaying Grevy's zebra and livestock GPS locations onto the shape files of HAPNP. By intersecting the Grevy's zebra and livestock habitat use maps in dry and wet seasons, the final map that identifies the habitat use overlap was developed.

Seasonal variation in mean abundance of livestock and Grevy's zebra

To test whether mean abundance of livestock and of Grevy's zebra differ between dry and wet seasons one-way analysis of variance (ANOVA) was computed using Statistical Package for Social Science SPSS (IBM Corporation, 2011). Data was log transformed before the comparison was made to ensure normality of means. Habitat use similarity between livestock and Grevy's zebra was computed to examine the degree of habitat use similarity between the two. To assess the degree of habitat use similarity for each season, S18 Kulczynski similarity index and Pearson correlation coefficient indexes were computed using Primer software (Clarke and Gorley, 2006).

RESULTS

Grevy's zebra and livestock distribution in dry season and wet seasons

Grevy's zebra and livestock counted in the opened grassland, woodland and wooded grassland were 56 and 4401 in dry season and 101 and 15043 in wet seasons, respectively. Among the 56 Grevy's zebra encountered in the dry season, 39.28% were in open grassland, 35.7% were woodland and 25% were in wooded grassland. Among Grevy's zebra encountered the wet season, 76.24% were in open grassland, 16.8% were in woodland and 6.9% were in wooded grassland. The maximum and minimum group sizes of Grevy's zebra counted in this study were 27 and 1 in the wet season, and 9 and 1 in the dry season respectively. Livestock counted result in the dry season (4401) showed that 26.53%, 58.96% and 14.49% of livestock numbers were found within open grassland, woodland and wooded grassland vegetation types respectively. During the wet season, 62.1% were in open grassland, 20.95% were in woodland and 16.96% were in wooded grassland.

Maps of habitat use overlap of Grevy's zebra and livestock in dry and wet seasons

Gravy's zebra and livestock have a wider area of habitat use overlap during dry season compared to the wet season (Figures 3& 4). The habitat use overlap area covered was 110 Km² in wet season of which 32 Km² (29%) was inside HAPNP, and 78 Km² (71%) was in the buffer zone. The habitat use overlap area

covered was 272 Km² in dry season of which 155 Km² (57%) was inside HAPNP, and 117 Km² (43%) was in the buffer zones. The habitat use overlap area coverage in the buffer zones was wider in wet season (71%) compared to dry season (43%).

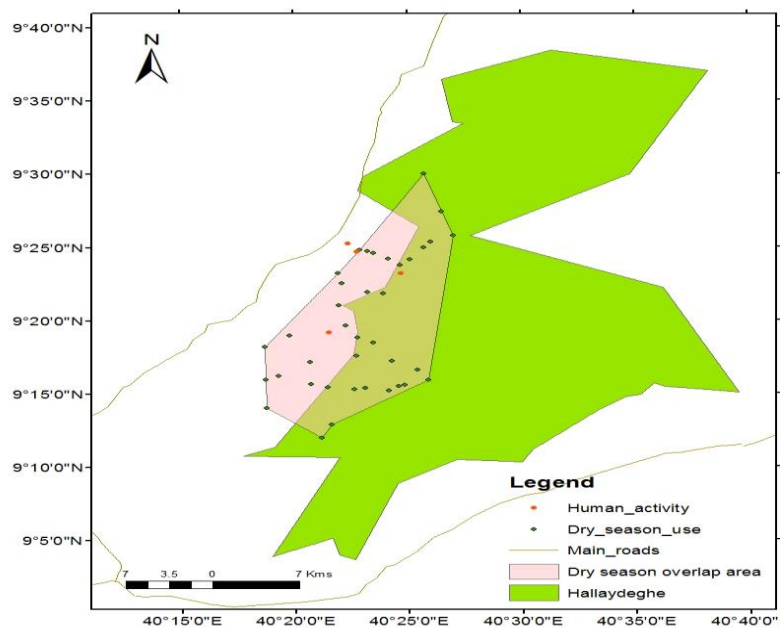


Figure 3. Map of the habitat use overlap between Grevy's zebra and livestock in the dry season.

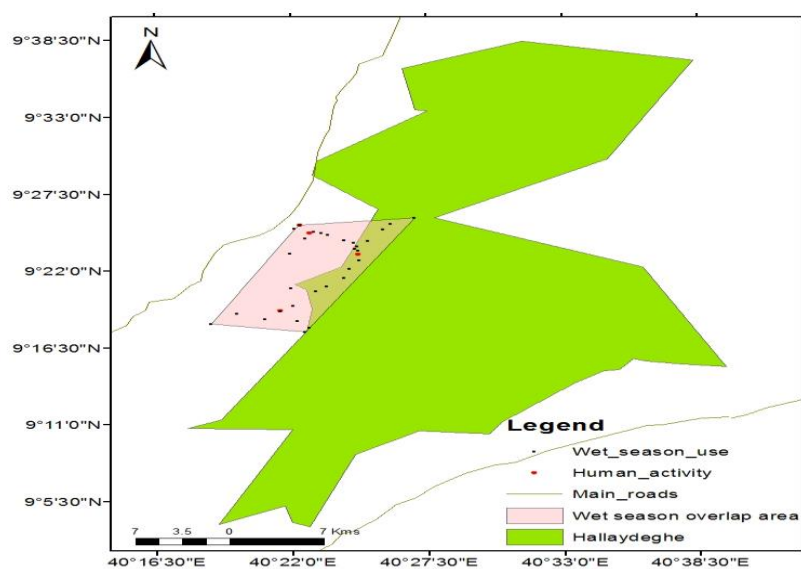


Figure 4. Map of the habitat use overlap between Grevy's zebra and livestock in the wet season.

Seasonal variation in mean abundance of livestock and Grevy's zebra in HAPNP in dry and wet seasons

One-way analysis of variance (ANOVA) results showed that there was a significant ($p < 0.01$) seasonal variation in mean abundance of livestock distribution in HAPNP (Table 1). The mean abundance of livestock in the HAPNP in the dry and wet seasons was 2.4 ± 0.1 and 3.1 ± 0.1 (Mean \pm SE) respectively. The mean abundance variation value between groups and within groups was 2.12 and 2.77 respectively, where the total mean abundance variation of the livestock was 4.89.

Table 1. Seasonal variation in mean abundance of livestock in HAPNP.

Descriptive		ANOVA					
Season	Mean \pm SE	Source of Variation	SS	df	MS	F	P-value
Dry	2.4 ± 0.1	Between Groups	2.12	1	2.12	14.55	0.010
Wet	3.1 ± 0.1	Within Groups	2.77	19	0.15		
		Total	4.89	20			

SS-sum of squares; df-degrees of freedom; MS- mean squares.

The seasonal variation in mean abundance of the Grevy's zebra in dry and wet season results showed that there was seasonal variation in mean abundance of Grevy's zebra distribution in the HAPNP (Table 2). The mean abundance of Grevy's zebra in their preferred vegetation types in dry and wet season was 0.6 ± 0.1 (Mean \pm SE) and 0.2 ± 0.2 (Mean \pm SE) respectively. The mean abundance variation value between groups and within groups was 0.41 and 2.63 respectively, where the total mean abundance variation of the Grevy's zebra was 3.04 (SS).

Table 2. Seasonal variation in mean abundance of Grevy's zebra in dry and wet seasons

Descriptive		ANOVA					
Season	Mean \pm SE	Source of Variation	SS	df	MS	F	P-value
Dry	0.6 ± 0.1	Between Groups	0.41	1.0	0.41	2.10	0.05
Wet	0.2 ± 0.2	Within Groups	2.63	19.0	0.14		
		Total	3.04	20.0			

SS-sum of squares; df-degrees of freedom; MS- mean squares.

Habitat use similarity between livestock and of Grevy's zebra

The S18 Kulczynski similarity index and Pearson correlation coefficient result showed that there was habitat use similarity between livestock and Grevy's zebra in dry and wet season. The S18 Kulczynski similarity index showed that the degree of habitat use similarity between livestock and Grevy's zebra in dry and wet season was 50.53% and 50.32% respectively. Pearson correlation coefficient results showed that there was similarity in the habitat use between livestock and Grevy's zebra with coefficient value $r=0.232$ in the dry and $r= 0.243$ in the wet seasons. Although five different land cover types were found in HAPNP that vary in their importance for wildlife survival, Grevy's zebra and livestock shared the three land cover types which are opened grassland, woodland and wooded grassland.

DISCUSSION

The findings of this study showed that Grevy's zebra and livestock were found in open vegetation in HAPNP, which was in agreement with Sundaresan et al. (2007). This study revealed that currently in HAPNP, the population encompasses 101 Grevy's zebra. The numbers of Grevy's zebra in HAPNP has declined from about 300 in 1978 (Stephenson 1978) to 177 (Thouless, 1995). In 2011, at least 143 Grevy's zebra were reported (Kebede et al, 2012).

During the dry and wet seasons, Grevy's zebra were found both outside and inside the HAPNP boundary. Similar observations were also reported from Kenya. According to the Kenyan Wildlife Service, the majority of Grevy's zebra populations in Kenya live on non-protected community owned lands such as the pastoralist's ranches and private conservancies (KWS, 2012). Williams (2002) also reported that only 0.5% of 57 Grevy's zebra range in Kenya falls within protected areas with the majority of populations occurring in community owned land.

The distribution of most wild animals is often more dispersed during the wet season because of increased availability of resources across landscapes (Jachmann, 1988; Hema et al., 2010). However, in HAPNP, Grevy's zebra were confined to a smaller geographic area in the wet season and had a wider

dispersal in the dry season. The reason for this is that large numbers of livestock were brought to the HAPNP through the establishment of illegal settlement in wet seasons (Kebede et al., 2012). As a result, competition for grazing land and water resources between livestock and wildlife increased in the wet season compared to the dry season, which ultimately reduced the amount of available habitat for the Grevy's zebra. During the wet season, available resources were more plentiful, allowing the Grevy's zebra to persist in relatively high number and confined to a smaller area in HAPNP. During the dry season, when the numbers of livestock was reduced, the Grevy's zebra were widely dispersed and generally were found in smaller numbers. This allowed the Grevy's zebra to adjust to the scarcity of available resources.

In terms of spatial coverage, according to Kebede et al. (2012), the distribution of Gravy's zebra covered 437 square kilometers during the wet season and 563 square kilometers during the dry season. In the present study, the distribution of Gravy's zebra covered 272 square kilometers in the dry season and 110 square kilometers in the wet season. The reason for the difference between the two studies could be due to size variation on the park. The earlier study by Kebede et al. (2012) was done before HAPNP's boundary was re-demarcated while the current study was done after the boundary re-demarcation work was completed in 2014 which resulted in a reduction of the total area from 1832 Km² to 1099 Km².

As revealed by the S18 Kulczynski similarity index and Pearson correlation coefficient, there exist habitat use overlap between Grevy's zebra and livestock in both seasons. They shared the opened grassland, woodland and wooded grassland. Williams (1998) also reported that Grevy's zebra competes for resources with pastoral communities and their livestock in northern Kenya. Loss of access to critical resources due to competition with livestock, and an increasing scarcity of these resources is one of the causes that resulted in the decline of Grevy's zebra population (Williams and Low, 2004).

CONCLUSION AND RECOMMENDATIONS

This study concluded that Grevy's zebra shared common grazing forage resources with pastoral livestock during both wet and dry seasons in Hallaydeghe Asebot Proposed National Park. This habitat use similarity was wider in area coverage in the dry season than the wet season while the seasonal variation in mean abundance of Grevy's zebra and of livestock in dry and wet seasons was seen. Competition with livestock for forage and water pose major threats to the survival of Grevy's zebra. To avoid seasonal livestock pressure formation of alternative rangelands outside the park is recommended. There should be a continuous awareness creation programs for the local pastoral communities about seasonal sharing of grazing land between livestock and Grevy's zebra. Creation of additional income generating activities for the local communities could also be used to alleviate the pressure on the park.

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