Habitat preference of the endangered Ethiopian walia ibex (*Capra walie*) in the Simien Mountains National Park, Ethiopia

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Abstract
Habitat preference of the endangered Ethiopian walia ibex (Capra walie) in the Simien Mountains National Park, Ethiopia.— Walia ibex (*Capra walie*) is an endangered and endemic species restricted to the Simien Mountains National Park, Ethiopia. Recent expansion of human populations and livestock grazing in the park has prompted concerns that the range and habitats used by walia ibex have changed. We performed observations of walia ibex, conducted pellet counts of walia ibex and livestock, and measured vegetation and classified habitat characteristics at sample points during wet and dry seasons from October 2009 to November 2011. We assessed the effect of habitat characteristics on the presence of pellets of walia ibex, and then used a spatial model to create a predictive map to determine areas of high potential to support walia ibex. Rocky and shrubby habitats were more preferred than herbaceous habitats. Pellet distribution indicated that livestock and walia ibex were not usually found at the same sample point (*i.e.,* 70% of quadrats with walia pellets were without livestock droppings; 73% of quadrats with livestock droppings did not have walia pellets). The best model to describe probability of presence of walia pellets included effects of herb cover (β = 0.047), shrub cover (β = 0.030), distance to cliff (β = –0.001), distance to road (β = 0.001), and altitude (β = 0.004). Walia ibexes have shifted to the eastern, steeper areas of the park, appearing to coincide with the occurrence of more intense, human–related activities in lowlands. Our study shows the complexities of managing areas that support human populations while also serving as a critical habitat for species of conservation concern.

Key words: Endemic, Ethiopia, Habitat preference, Simien Mountains, Walia Ibex

Resumen
*Preferencia de hábitat del íbice de Etiopía (*Capra wallie*), en peligro de extinción, en el Parque Nacional de las Montañas Simien, en Etiopía*.— El íbice de Etiopía (*Capra wallie*) es una especie en peligro de extinción endémica del Parque Nacional de las Montañas Simien, en Etiopía. La reciente expansión de las poblaciones humanas y el pastoreo de ganado en el parque han suscitado preocupación por que los límites y los hábitats utilizados por el íbice de Etiopía hayan cambiado. Se realizaron observaciones del íbice de Etiopía y conteos de excrementos de íbice y de ganado, asimismo, se describió la vegetación y se clasificaron las características del hábitat en los puntos muestrales durante las estaciones seca y húmeda, desde octubre de 2009 hasta noviembre de 2011. Se evaluó la influencia de las características del hábitat en la presencia de excrementos de íbice y posteriormente se utilizó un modelo espacial para crear un mapa predictivo de las zonas con mayor probabilidad de albergar a esta especie. Los hábitats preferidos fueron los rocosos y arbustivos en comparación con los herbáceos. La distribución de los excrementos indicaba que el ganado y el íbice de Etiopía no solían encontrarse en el mismo punto muestral (el 70% de los cuadrados que contenían excrementos de íbice carecían de defecaciones de ganado y el 73% de los cuadrados con defecaciones de ganado no contenían excrementos de íbice). El mejor modelo para describir la probabilidad de presencia del íbice tomaba en consideración el efecto de la cubierta herbácea (β = 0,047), la cubierta arbustiva (β = 0,030), la distancia a un acantilado (β = –0,001), la distancia a una carretera (β = 0,001) y la altitud (β = 0,004). Los íbices de Etiopía se han trasladado hacia

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las zonas más orientales y abruptas del parque, lo que parece estar relacionado con la concentración de actividades humanas más intensas en las tierras bajas. Nuestro estudio pone de manifiesto la complejidad de gestionar zonas habitadas por poblaciones humanas y que a la vez constituyen un hábitat fundamental para las especies en conservación.

Palabras clave: Endémico, Etiopía, Preferencia de hábitat, Montañas Simien, Íbice de Etiopía

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Introduction

Walia ibex (*Capra walie* Ruppell, 1835) is a species of conservation concern and one of the Palearctic ibex species in Ethiopia (Nievergelt, 1981; Last, 1982). Distribution of Caprinae has been influenced mainly by rapid environmental changes caused by glaciation (Geist, 1971). Simien Mountains National Park (SMNP) is the southern limit of the natural range of ibexes in the world and the only place where walia ibex occurs (Nievergelt, 1981; Gebremedhin et al., 2009). Walia ibex lives at higher altitudes and is adapted to partial forest life in the SMNP. Thus, it lives in areas with different habitats compared to other ibex species occurring in the other regions of the world (Nievergelt, 1981; Fiorenza, 1983; Yalden & Largen, 1992).

Ibexes, in general, prefer areas with steep slope and cliffs and avoid grasslands and flat hillsides (Feng et al., 2007). The presence of livestock usually has a negative effect on their relative abundance and distribution. Livestock act as a disturbance, and ibex retreat to less suitable habitats (Namgail, 2006; Pelayo et al., 2007). The behavioural responses are key to understanding animal–habitat interactions; the way individuals obtain food, seek shelter, escape from predators, find mates, and care for the young can provide clues to the effect of disturbances (Hickman et al., 1993).

Walia ibex has a restricted habitat, and its main distribution range is in the steep, rocky and topographically heterogeneous habitats of the mountains of Ethiopia (Nievergelt, 1981; Yalden & Largen, 1992).The walia ibex is an outstanding rock climber on steep cliffs, and it prefers to live in mountainous areas, sub–afroalpine grasslands, and areas with low vegetation cover (Last, 1982; Yalden & Largen, 1992; Hurni & Ludi, 2000). The distribution of walia ibex in the SMNP has shifted towards the east since the 1970s, and intensified use of the park for livestock grazing has contributed significantly to such changes in walia ibex distribution (Hurni & Ludi, 2000). Low protection efficiency of wildlife habitat is the main conservation problem in the park (Ludi, 2005).Thus, walia ibex prefer areas with little or no disturbances and occupy the most remote and inaccessible habitats (Hurni & Ludi, 2000). Simien Mountains National Park is heavily affected by livestock grazing, fuel wood collection and timber cutting, and crop cultivation (Hurni & Ludi, 2000; Ludi, 2005).

Habitat preference models for a species can be used effectively in their conservation and management (Krausman & Morrison, 2003; Doswald et al., 2007). Such models provide information to determine the species' ecological niche through the relationship between observed species locations and habitat variables that restrict or drive their distribution (Hirzel & Le Lay, 2008). Factors such as competition, predation, human disturbances and the type of habitat patches can affect the species' habitat preference (Ottaviani et al., 2004; Rhodes et al., 2005). Habitat loss is a critical threat to most endangered species and the problem becomes significant in the SMNP where walia ibex occurs. Identification of suitable habitats is an essential step to ensure sustainable conservation of species such as walia ibex (Huettmann & Calgary, 2003; Jean Desbiez et al., 2009).

Unless resources are abundant, two populations cannot occupy the same niche at the same place and time (Hardin, 1960). Some degree of competition can occur in natural populations (Namgail, 2006). Thus, negative interactions will increase the extinction probabilities of a species and result in population size reduction (Hickman et al., 1993). A similar scenario can also occur in SMNP, where the original habitats of walia ibex, especially in the lowlands, have been occupied by livestock. Thus, the walia ibex population is confined to relatively inaccessible areas within gorges and escarpments towards the eastern part of the park (Hurni & Ludi, 2000).

The goal of our research was to determine areas of potential habitats for walia ibex in the SMNP to support sustainable conservation and management plans. Our specific objectives were to: (1) use presence data based on direct observations to describe habitat used by walia ibex; (2) use presence/absence data from pellet counts to assess and compare habitat useand preference of walia ibex and livestock; and (3) develop a descriptive, spatial model of habitat preference to highlight areas of SMNP that are critical for protection and management of walia ibex.

Material and methods

Study area

Simien Mountains National Park is located in the Amhara National Regional State within the North Gondar Administrative Zone (UTM 376047 E to 444522 E, and 1458552 N to 1467230 N; fig. 1). The SMNP is composed of a broad undulating plateau and the highest point is Ras Dejen (altitude: 4,543 m). The park is known for its impressive escarpments (Nievergelt, 1981). The SMNP borders were established in 1966 (Hurni & Ludi, 2000; ANRSPDPA [Amhara National Regional State Park Development and Protection Authority], 2009). UNESCO declared SMNP as a World Heritage Site in 1978 based on its importance as a refuge for rare and endemic animals and plants, as well as its exceptional natural beauty (Yalden & Largen, 1992; Hurni & Ludi, 2000; Puff & Nemomissa, 2001; Debonnet et al., 2006). However, regulations adopted during the park's establishment allowed livestock grazing, agriculture, and human settlement in 80% of the park (Debonnet et al., 2006). The total area of the park is 412 km^2, and walia ibex habitats (mountainous regions and sub–afroalpine grasslands) are restricted to 94.1 km^2.

From 2000 to 2009, the mean annual rainfall at SMNP was 1,054 mm. The mean annual minimum and maximum temperatures were 8.7^{o}C and 19.9^{o}C, respectively (National Meteorological Agency, Addis Ababa, Ethiopia: http://www.ethiomet.gov.et/). Seasonal differences in temperature are minimal due to Ethiopia's proximity to the equator (Nievergelt, 1998).

The Simien Mountains form a contact zone between the Palearctic region in the north and the Ethiopian region in the south. This makes the flora and fauna of the area representative of both regions (Nievergelt, 1981). The mountain's geographical position and the presence of altitudinal belts as well as different topographic features in the SMNP results in a mosaic pattern of different habitats that can promote species diversity and richness (Puff & Nemomissa, 2001). The altitudinal variations in the SMNP can determine variations in the natural vegetation. The vegetation of the park consists mainly of *Erica arborea, Lobelia rhynchopetallum, Hypericumrevolutum*, *Helichrysum spp*., *Rosa abyssinica* and *Solanum* spp.

Endemic large mammals include walia ibex, Ethiopian wolf (*Caniss imensis*) and gelada baboon (*Theropithecus gelada*). The distribution of walia ibex in SMNP extends from Buyetras in the western parts of the park to the southeastern end of Sebatminch, which is 94.1 km^2 of the area. The density of walia ibex in its current range is 7.99 individuals/km^2, and counts of walia ibex during the last ten years (2002–2011) have indicated a gradual increase (ANRSPDPA, 2009).

Uncontrolled human use of natural resources in the park is the greatest threat to biodiversity. More than 75% of the SMNP is used by local human communities for grazing, agriculture and settlements, leaving only the highest peaks and inaccessible cliffs relatively undisturbed (Hurni & Ludi, 2000; Ludi, 2005). Barley is the main crop type in the area, and livestock species grazing in the park are cattle (7.49 individuals/km^2), sheep, goat and equine.

Data collection

We conducted our study of walia ibex at SMNP over 15 days every second month from October 2009 to November 2011. Our observations covered wet and dry seasons (wet: May–October; dry: November–April) and all hours of daylight. Data were collected by the primary investigator and two well–trained field assistants. Our study design was affected by the logistic hurdles presented by the rough terrain and remote locations of SMNP. First, we used a series of transects through portions of the park deemed most likely to contain walia ibex, as judged by anecdotal evidence and/or habitat characteristics. We followed transects to locate and observe walia ibex herds to document the sizes of groups and assess the habitats in which walia ibex were found. We used GPS to record the location and habitat classifications of individuals or herds, and morphological features —particularly horn shape of males, unique skin colour of some groups of individuals, and deformities such as swelling belly or broken horn— were used to identify the herd. We identified the topography (open plateau, bushy plateau, top of plateau, escarpment, or gorge/cave), and we visually scored the density of vegetation (sparse: < 25% cover, moderate: 25–50%, dense: 51–75%, very dense: > 75%) in the area of each individual or herd.

Second, we used randomly distributed, systematic transect surveys to describe habitat that was available for walia ibex. We established a total of 637 (319 during wet and 318 during dry seasons) quadrats to characterize vegetation along transects at 200 m intervals. We separated the parallel transects by 500 m in areas that allowed multiple transects (*e.g.,* plains and plateaus); we used single transects in gorges and escarpments and the direction of the transect was constrained by topography. Quadrats were square, and the boundaries of the 400 m^2 were marked by rope while we collected data. We visited each transect during wet and dry seasons, and each transect was visited every other month for two consecutive years. We determined the aspect and slope of each quadrat using a Clinometer (Gillen et al.,1984); we recorded the slope at each corner of the quadrat and used the mean of the four samples to represent the slope of the quadrat. The availability of water and food influences the distribution of animals (Kauffman & Krueger, 1984; Knight et al., 1988); thus, we visually estimated the distance from each quadrat to a cliff, water source, and nearest road and settlement (Rondinini et al., 2004). Ground cover (grass, herbs, shrubs, trees, rocks) was described as the percent cover of the quadrat.

We also used the vegetation transects and quadrats as sample locations to conduct observations of pellets of walia ibex and livestock. We identified pellets within each quadrat. Walia pellets were identified from livestock pellets (goat or sheep) based on their colour, shape and size. Sutherland (1996) suggested that pellet counts are the best indication of animal abundance when species are not easily observed. We used the presence of pellets rather than the number of pellets in our analysis, thus avoiding any problems (*e.g*., unknown defecation rates or decay rates) that may arise from trying to determine relative abundance from pellet counts.

Statistical analyses

We used Chi–square (χ^2), independent sample *t*–tests and means of samples to compare distribution between wet and dry seasons. We used $\alpha = 0.05$ for statistical significance, and data were analysed using SPSS software version 16.0.

Habitat preference is the measure of a species' disproportional use, relative to availability (Krausman, 1999). To evaluate habitat preference, we used two methods to compare levels of habitat use (locations of sightings or pellets) and habitat availability (quadrats, as representative of SMNP) to assess habitat preference of walia ibex following Harrett (1982) and Steinein et al. (2005). First, we compared the vegetation cover of quadrats in which walia ibex pellets were found with the cover of quadrats without pellets. Second, we used data from pellet surveys to describe the potential of habitat characteristics to predict the probability (with the ranges of 0–1) of detecting walia pellets in a quadrat. We summarized the pellet counts at each sample point as presence/absence data (success: pellet found, failure: pellet not found) for use in logistic regression models that predicted the probability (Ψ) of detecting walia pellets in a quadrat:

$$\Psi_{(\text{pellet})} = 1 / (1 + e^{-z})$$

where z is a linear model with intercept $ß_0$ and factors $ß_1$–$ß_n$:

$$Z = ß_0 + ß_1(x_1) + ß_2(x_2) + ß_3(x_3) + \ldots + ß_n(x_n)$$

We determined the best linear model to describe the probability of detecting walia pellets by *a priori*

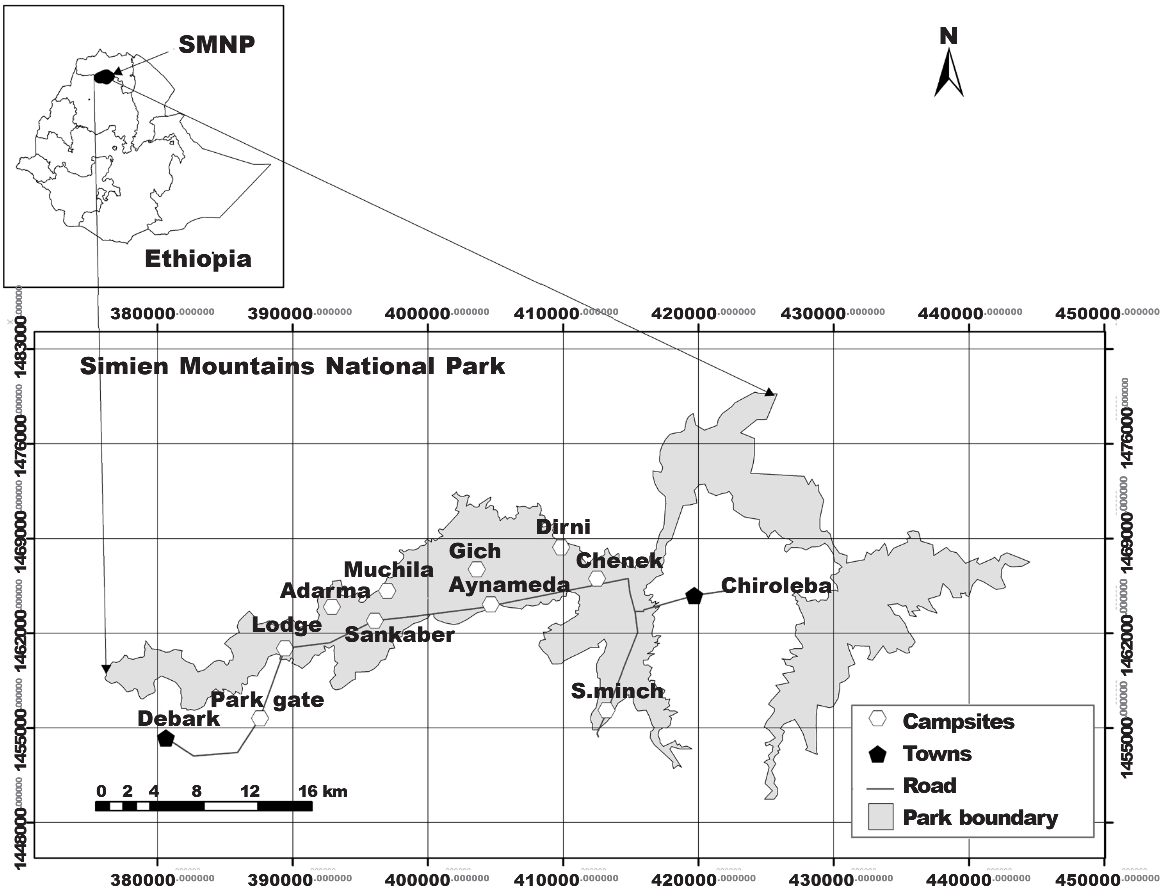

Fig. 1. The location of Simien Mountains National Park in Ethiopia, and Park boundary with associated towns, local campsites, and roads.

Fig. 1. La ubicación del Parque Nacional de las Montañas Simien en Etiopía y los límites del parque con las poblaciones, campamentos y carreteras cercanas.

describing 11 potential habitat variables: ground cover (grass cover, herb cover, shrub cover, tree cover and rock cover), altitude, slope, and distance from cliffs, water sources, roads and settlements. We used a backwards stepwise variable removal procedure to form the final model from the initial 11 variables. Prior to the analyses, we assessed colinearity ($r > 0.6$) among the variables under consideration.

We then applied the predictive model to our spatial data from the quadrats to visually determine areas of SMNP that had a high probability of walia presence. Quadrat–specific characteristics were then applied to the final regression model to calculate Ψ at each quadrat and characterize the probability of pellets of walia ibex across the study site. We assumed that areas of high probability of presence of pellets were also areas of high habitat preference; conversely, areas with a low probability of presence of pellets were areas of low habitat preference for walia ibex within their range at SMNP (Conroy, 1996). Finally, we used the ordinary kriging method with a spherical semi–variogram model in ArcMap (ESRI, Redlands, CA, USA) to spatially extrapolate habitat preference of walia ibex across points not sampled at SMNP. We displayed the probability of presence of pellets in the park as a gradient from low to high probability of presence as adopted by Rondinini et al. (2004).

Results

Herd size was variable (range 1–32 ibex per observation) and increased by approximately seven ibex per observation as altitude increased from our lowest observation (3,543 m) to our highest (4,361 m; $F_{1,261} = 9.9$, slope = 0.007, $P < 0.01$, $r^2 = 0.04$, $n = 263$). Similarly, we observed more walia pellets in quadrats at higher altitudes ($F_{1,381} = 19.9$, slope = 0.003, $P < 0.0001$, $r^2 = 0.05$) than quadrats at lower altitudes.

Most of our 267 independent observations (wet season: 132, dry season: 135) of walia ibexes were in open plateaus (42%) and escarpments (32%; fig. 2).

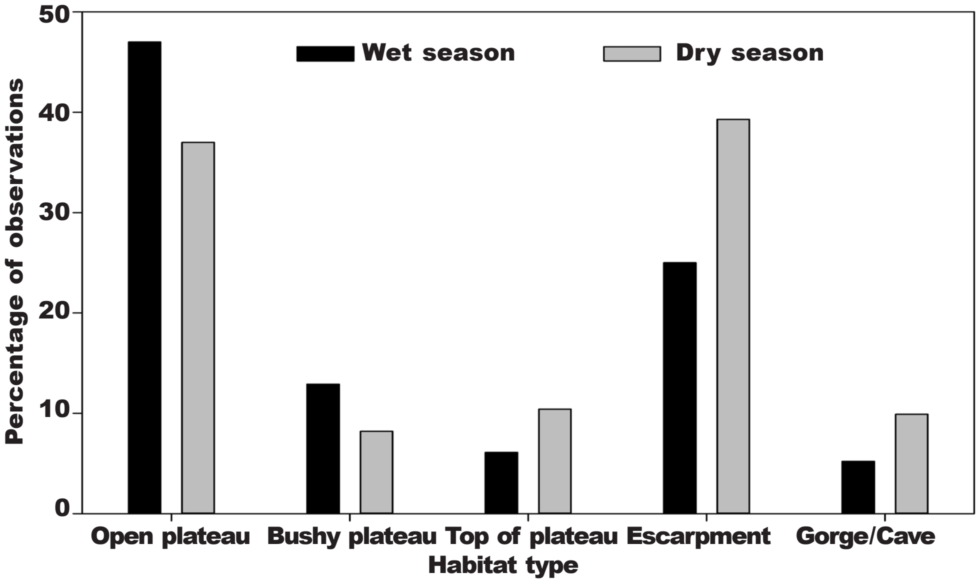

Fig. 2. Percentage of observations of walia ibex individuals or herds according to habitat type during wet and dry seasons at Simien Mountains National Park, Ethiopia, during 2009–2011.

Fig. 2. Porcentaje de observaciones de individuos o rebaños de íbice de Etiopía según el tipo de hábitat durante las estaciones seca y húmeda en el Parque Nacional de las Montañas Simien, en Etiopía, entre los años 2009 y 2011.

Use of open plateaus, bushy plataus, and gorges was higher during wet season, and the use of escarpments and tops of plateaus was higher in the dry season (χ^2 = 10.1, df = 4, P = 0.03). More observations of walia ibex tended to be from areas with dense vegetation cover (34.2% of observations) than other vegetation densities (sparse: 26.7%, moderate: 21.8%, very dense: 17.3%), and these observations did not vary by season (χ^2 = 5.94, df = 3, P = 0.11).

We collected samples from 319 and 318 quadrats during wet and dry seasons, respectively. Most of our quadrats (323, 50.7%) had west–facing aspects (north: 103, 16.2%; south: 94, 14.8%; east: 75, 11.8%; southwest: 16, 2.5%; northwest: 15, 2.4%; southeast: 7, 1.1%; northeast: 4, 0.6%). The mean slope at our quadrats was 23.3º (SE = 3.0) or 43.1% slope. Walia ibex and livestock pellets were not typically found in the same quadrat. In fact, 70% of quadrats with walia pellets had no livestock droppings, and 73% of quadrats with livestock droppings had no walia pellets.

Our quadrat samples were dominated by grass and rock cover. Quadrats with walia ibex pellets had less grass and trees but more rocks and shrubs than quadrats without pellets. In contrast, quadrats with livestock pellets had less grass and rocks and more trees than quadrats without livestock pellets (fig. 3). The only difference in habitat use between wet and dry seasons was that quadrats with pellets of walia ibex had 28.7% of rock cover in the wet season but only 14.4% in the dry season. Livestock habitat use varied only in tree cover; quadrats with livestock pellets had 13.2% tree cover during the wet season and 9.1% during the dry season.

Prior to the regression analysis, we removed 'tree' from the variable set, as altitude and tree were correlated (r = 0.64, P < 0.001). No other variable pairs were correlated above the level r = 0.6. The logistic regression analysis suggested that the habitat characteristics of herb cover, shrub cover, altitude, and distance of the sampled habitat from cliffs and roads were the best factors to describe the probability of walia pellets ($\Psi_{(pellet)}$). The values of the associated intercept and regression coefficients were: β_0 = –15.991, $\beta_{\%herb}$ = 0.047, $\beta_{\%shrub}$ = 0.030, $\beta_{dist\ to\ cliff}$ = –0.001, $\beta_{dist\ to\ road}$ = 0.001, $\beta_{altitude}$ = 0.004. The probability of presence of pellets ranged from 0.17 to 0.93 throughout the park. The spatial descriptive map indicated that the portion of the park with the highest probability of presence of walia ibex (as measured by pellets) occurred from Chenek–Buahit to Mesareri towards the eastern portion of the park (fig. 4).

Discussion

Walia ibex and livestock in SMNP

Ludi (2005) documented that walia habitats within SMNP had been affected by the increase of the human population within and around the park, which had

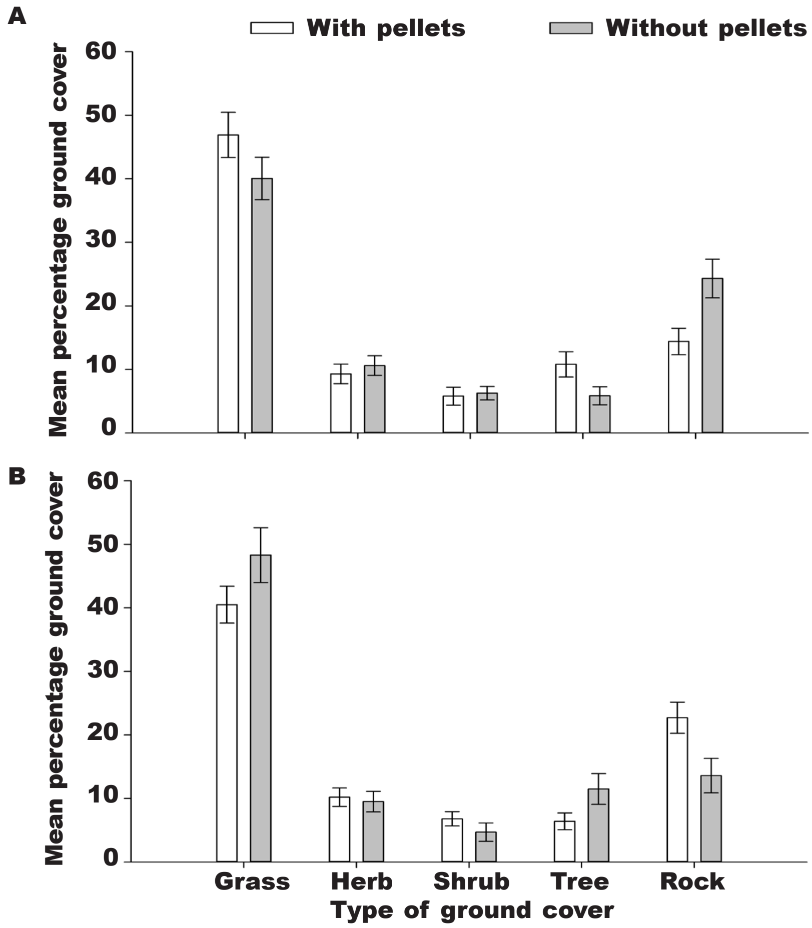

Fig. 3. Mean (95% confidence interval) percentage of types of ground cover in quadrats with and without pellets of livestock (A) and walia ibex (B) in Simien Mountains National Park, Ethiopia, during 2009–2011.

Fig. 3. Porcentaje medio (95% intervalo de confianza) de los tipos de cubierta vegetal en los cuadrados con y sin excrementos de ganado (A) y de íbice de Etiopía (B) en el Parque Nacional de las Montañas Simien, en Etiopía, entre los años 2009 y 2011.

resulted in heavier pressure from grazing of livestock. We found that herd size of walia ibex increased with altitude. Our data suggest that walia ibex use shrubby areas of open plateaus extensively and use rocky escarpments preferentially. Nievergelt (1981) reported that walia ibex prefer rocky terrains with no human related disturbances.

We suggest that walia ibex are responding to the impacts documented by Ludi (2005) by moving farther from human populations and into habitats that are less likely to overlap with livestock grazing. Indeed, we found that pellets of walia ibex and livestock did not tend to be found in the same sampling quadrat, which may indicate ibex are avoiding livestock areas. As expected, livestock in the SMNP tend to use areas with more grass cover. Many species of wildlife are threatened by intensification of agriculture and overgrazing of livestock on their habitats (Jean Desbiez et al., 2009).

Hurni & Ludi (2000) also suggested that severe human–related disturbance at lowlands force the movements of walia ibex towards inaccessible habitats. Currently, the distribution of walia ibex is towards Sebatminch in the eastern portion of the park (fig. 1), which has more highlands available. Walia were previously found further west in the park, and more forage plants are available in the lowlands. But human disturbance and livestock grazing at lowlands, especially in the Gich area (fig. 1), may have contributed to displacement of walia ibex to the east and to the highest, steepest areas of the park (Hurni & Ludi, 2000). Our study was not designed to determine the relative quality of habitats for walia ibex, but we encourage biologists to consider the possibility that presence of livestock in former ibex range within the park has forced walia ibex to select habitats of lesser quality (Pelayo et al., 2007). We concur with

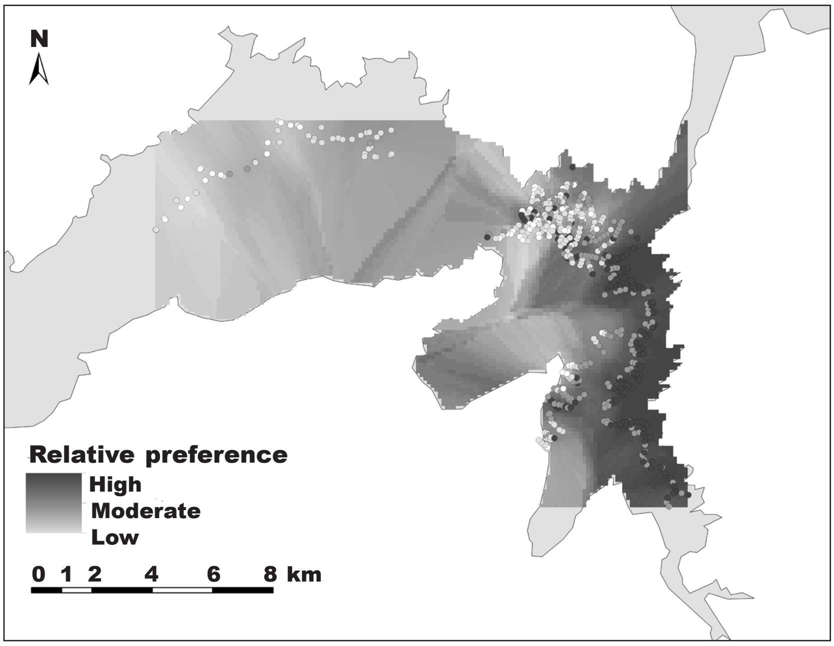

Fig. 4. Spatial representation of relative preference of walia ibex within Simien Mountains National Park (SMNP), Ethiopia, defined as the probability of finding a walia ibex pellet at a sample point. The predictive model was applied, *a posteriori*, to sample locations (dots) and then extrapolated from the sample points to the portion of SMNP in which samples were collected during 2009–2011. Dark areas indicate a higher preference for sample locations and landscape.

Fig. 4. Representación espacial de la preferencia relativa del íbice de Etiopía en el Parque Nacional de las Montañas Simien (SMNP), en Etiopía, definida como la probabilidad de encontrar excrementos de íbice de Etiopía en un determinado punto muestral. El modelo predictivo se aplicó, a posteriori*, a los lugares muestreados (puntos) y después se extrapoló a la porción del Parque en las que se recogieron muestras durante 2009 y 2011. Las áreas oscuras indican una preferencia alta para los lugares muestreados.*

previous suggestions that assessment of habitat preference for species can provide critical information for problems in conservation and management of a species (Morris, 2003).

As most mammals are highly selective in their habitats, degradation of habitat by domestic animals is a common problem (Jean Desbiez et al., 2009). Human activities interfere with animal distribution and anticipate access to critical habitat change (Williamson et al., 1988), and the animal's behavioural response to the presence of humans has often been used as an indication to its susceptibility to disturbance (Beale & Monaghan, 2004). As described by Brown (1971), coexistence between pastoralists and wildlife requires the maintenance of a very low–density of livestock and human populations. However, it is not achievable in developing countries as the local people raise a large number of livestock and practise free grazing; such is the case in the SMNP.

Seasonal trends of habitat use and preference

Identification of potential suitable habitats for wildlife is an essential step to insure sustainable conservation of species (Huettman & Calgary, 2003; Jean Desbiez et al., 2009). Human activity and wildlife food availability vary in space and quantity at the SMNP between wet and dry seasons. We observed only minor differences in the topography used by walia ibex during wet and dry seasons (fig. 2). However, these minor shifts may reveal important factors in the ecology of walia ibex. Regardless of season, ibex were found extensively in open plateaus. Nievergelt (1981) also reported that open areas with *L. rhyncopethalum* and *Festucamacrophylla* were used by ibex. We found that ibex were more often found on bushy plateaus during the wet season than the dry season. This may be because herbaceous plants such as *Thymus*, *Alchemillarothi* and *Simeniaacaulis,* the principal diet for walia ibex, become available in the bushy plateau during the wet season.

Similarly, we found that slopes and troughs had *Alchemilla rothi*, *Arabis alpine*, *Simenia acaulis* and *Festuca macrophylla*, all of which are used by walia ibex (Nievergelt, 1981). During the dry season, the abundance of herbs decreases. Thus, walia ibexes may have been forced to switch their diet to other plant species, causing them to move to escarpments and the top of the plateau. Indeed, herds of walia ibex were observed in less dense areas during the dry season.

Livestock pellets were found in areas with more tree cover during the wet season than during the dry season. We observed that livestock were restricted to tree–covered areas during the wet season because crops were grown in open areas. After harvesting, livestock were able to range into open fields to forage on leftover crops.

Predictive maps for conservation planning

We used pellet counts to survey habitat use of walia ibex, allowing us to assess vast spatial areas of the park at lower costs than radio–telemetry or other individual–based methods of habitat assessment. Walia ibex in the SMNP are a small population, and individuals are difficult to detect and capture. Furthermore, to determine whether they had used a specific sample location, pellet counts were more reliable than visual surveys of animals because individuals are constantly moving to new locations; detection of use at a given sample point would therefore be very low (Gu & Swihart, 2004). Pellet counts were more cost–effective and more logistically realistic than remote cameras. We designed our pellet survey to allow us to consider spatial processes, which would have been much more difficult logistically to conduct with direct observation of animals (Rhodes et al., 2005; Skarin, 2006). Consequently, we suggest that biologists consider pellet counts for similar assessments of habitat use and preference in remote areas that present logistical difficulties.

Walia ibex were previously described to be found in areas of the SMNP with altitudes of 2,800 to 3,400 m a.s.l. (Nievergelt, 1981). However, we found walia ibex to commonly occur at altitudes about 4,000 m a.s.l. and that their habitats have been shifted towards the eastern part of the park. Our predictive model shows the potential spatial extent of the park that could be defined as providing the remaining suitable habitat for walia ibex, and we believe this is a key piece of information in the process to establish a conservation plan for the species (Owen, 2009). We encourage biologists and managers of SMNP to consider further collection of demographic information, such as breeding success and survival. Such information can further refine and target management efforts, especially if demographic patterns can be related to habitat use (Peek, 1986).

The SMNP is a complex system that includes sensitive wildlife species and human activities, and management decisions to support the conservation of species of wildlife such as walia ibex are also complex. Our surveys of habitat use and preference serve to document recent changes in the range of walia ibex. Indeed, much of the process of habitat selection for a species may depend upon several limiting factors (Peek, 1986; Ottaviani et al., 2004).The disturbances within the park caused by human activities could be minimized by identifying zones to allow tourism, human use, and protection of critical biodiversity. Information provided by habitat use and selection data should enable more informed decisions about the conservation status of walia ibex and help to ensure its long–term survival.

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