

Habitat preferences of Bezoar wild goats (*Capra aegagrus*) in Agh-Dagh protected area, Iran

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Abstract. We studied the habitat selection of Bezoar wild goats (*Capra aegagrus*) in the Agh-Dagh protected area in northwestern Iran. This species lives in mountainous areas. The species' habitat selection was modeled by incorporating various physical and biological variables in a logistic regression. Topographic features including aspect and slope, ranked better than components of vegetation in explaining habitat selection throughout the year, and were often excellent predictors of habitat use. During winter, aspect was selected by logistic regression as a significant variable.

Key words: wild goats, habitat associations, habitat variables, logistic regression, habitat selection, presence-absence data, Iran.

Introduction

Modeling wildlife habitat relationships is central to ecological studies and essential for wildlife conservation and management (Johnson 1980). Such habitat models should aid in understanding species survival requirements and provide a basis for further management policies. Animals use habitats in a way to maximize net energy intake for growth and reproduction, minimize predation risk and thermal stress, and maintain social contacts (Fryxell & Lundberg 1994, Kie 1999). Such modeling follows a hierarchical fashion and varies over multiple spatial and temporal scales (Senft et al. 1987, Kie et al. 2002, Boyce et al. 2003). Habitat selection is, therefore, a complicated process involving several spatial scales, and levels of discrimination. For instance, factors such as steep slopes, area near rocky substrates (escape terrains), distribution of water resources, west facing slopes and areas far from roads mainly affect *Capra aegagrus* habitat selection in the Haftad-Gholle protected area, Iran (Shams 2010). Different variables such as terrain characteristics, climate and degree of human disturbance have been measured in other studies too. For example habitat selection by East Caucasian tur (*Capra cylindricornis*), was studied using a Geographical Information System (GIS) and logistic regression (Gavashelishvili 2004). This study showed that the occurrence of East Caucasian tur is affected mainly by climate, terrain, human disturbance and habitat

fragmentation. Gross et al. (2002) used logistic regression to develop habitat models for Mountain goats (*Oreamnos americanus*) in alpine habitats. They showed that areas near escape terrains and southerly exposures were the most important variables in habitat modeling. In spite of recording the study area as a legal protected area by the Iranian Department of the Environment, largely based on the presence of Bezoar wild goats (*Capra aegagrus*), there is no documented report about the ecology of the goats in the area. Considering the importance of knowing about the ecological characteristics of wild goats as a focal species in choosing the area for protection, we explored the factors affecting habitat selection by wild goats at the study area in winter, summer and yearlong as well.

Material and Methods

Study Area

The Agh-Dagh protected area (37° 37' N and 48° 31' E) is located around 85 km from south of Ardabil, northwestern Iran (Fig. 1). Agh-Dagh is the only area that had been recorded as a legal protected area in the Ardabil province. Elevations in the area average 1900 m and range from the highest peak in the area (3230 m a.s.l.) to valleys that are located around 500 m a.s.l. The climate is markedly Mediterranean, with prolonged cold wet winter and relatively dry summer. But Hyrcanian and Irano-Turanian climates affect its overall climate regime too. The vegetation of the area is a mixture of shrubs, different woodland trees, and native grassland. There are three main vegetation types

in the study area, dominated by *Astragalus*, *Paliurus* and *Juniperus* respectively. Wildlife occurring in the study area includes game birds (e.g. *Alectoris chukar*, *Amoperdix griseogularis* and *Coturnix coturnix*) and several small mammalian herbivores (e.g., the common hare, *Lepus capensis*). Several carnivores also occur in the area, such as the common weasel (*Mustela nivalis*), the common fox (*Vulpes vulpes*), the golden jackal (*Canis aureus*), the gray wolf (*Canis lupus*), the brown bear (*Ursus arctos*) and the leopard (*Panthera pardus*). Wild boars (*Sus scrofa*) and wild goats are the only known ungulate species in the study area.

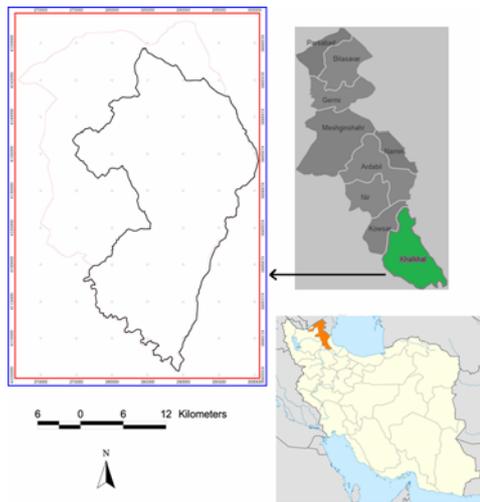


Figure 1. Study area in Ardebil province. The solid and pale lines show protected area and hunting prohibited area borderline respectively.

Data collection procedures

Throughout the period from May 2009 to December 2010, we located wild goats using binoculars. Because of huge climatic differences, data were recorded for two distinct periods (from May to September as moderate and warm summer period, and from October to April as harsh season or winter period). When wild goats were sighted, we recorded the location of the individuals on a topographic map. In some cases, we could record the individual standing points directly using GPS. Since there are no ungulate species in the study area other than wild goats and wild boar, it was possible to record indirect evidence of goat presence. The location of indirect evidence (fresh pellets and feeding damage) was recorded using GPS and then situated on the topographic map. To determine the overall characteristics of the habitat available for use by wild goats, random sites were selected at least 300 m from the nearest recorded goat's presence points in a random direction. Absence (randomly selected) and presence (wild goats was observed or their sign detected) sites were characterized with respect to a number of habitat and anthropogenic variables. We plotted all variables as layer files in GIS with a 50×50 m cell resolution. For each

site (both presence and absence), the habitat variables recorded were elevation, slope, aspect, vegetation type, distance from the nearest anthropogenic features (DHS) and distance from the nearest water resources. Elevation was derived from a digital elevation model mapped at a 50×50 m resolution (Azad 2008). From this model, we also calculated slope and aspect for each sampling site using ArcGIS 9.2. Distances from the nearest anthropogenic features, land uses, settlements and water resources were calculated in increments of 100 m using the "Buffer" function, and were mapped on a 50×50 m resolution GIS raster layer. In order to avoid temporal autocorrelation, samplings were carried with an interval of at least 10 days. To avoid spatial autocorrelation and pseudo replication, we only considered recorded individuals at least 150 m apart from each other during the study period.

Statistical analysis

To determine the effects of physical and biological resources and anthropogenic effects on the habitat preferences of wild goats, we developed binary logistic regression models from goat presence and absence data, following a presence-versus-absence habitat sampling protocol (Manly et al. 2002). We chose the best-performing model from among an *a priori* model set with all possible variables included. Models were evaluated using the Akaike information criterion (AIC, Burnham and Anderson 2002). To validate the model, we used unprocessed data (at least 20% of the data set), which determines whether a model generated from a partial data set predicts the frequency distribution of values in the remaining data set. Specifically, we assigned habitat-selection values to the study area based on the selection function presented above (with coefficients derived from the logistic model of the partial data set), and then tested whether sites in the remaining portion of the data set had higher habitat selection values by running a Spearman rank correlation between the frequencies of the habitat selection values for these sites. SPSS version 16.0 (SPSS Inc., Chicago, Illinois) was used for statistical analysis.

Results

In total, the presence of goats was recorded at 114 locations. Based on AIC, the model that included the effect of aspect and distance to human settlements and roads best fitted the data for habitat use throughout the year (Table 1). Aspect was highly significant in the derived models, especially in winter season ($p < 0.001$). Logistic regression correctly classified 94.5% of total cases. Of the variables used for logistic regression, three variables (aspect, slope and DHS) were the most important. A Hosmer-Lemeshow goodness-of-fit test ($\chi^2 = 12.58$, $p = 0.68$) indicates a relatively good fit of the data to the model. In our models, habitat use of wild goats had a significantly positive relationship with aspect in winter (Table 2). This suggests a

Table 1. Derived models for habitat use for wild goats throughout the year.

	Model variables	K ^a	AIC ^b	ΔAIC
Yearlong	Slope, DHS ^d , DWR ^e	4	65.3	0.0
	Slope, VT ^c , DWR, Aspect, VT, EL ^f	7	89.8	4.0
	Slope, Aspect, DHS	4	70.1	3.5
	Slope, DHS, Aspect, DWR	5	112.3	53.69
Summer	Slope, DWR, DHS	4	87.9	0.0
	VT, DWR, Slope	4	90.2	4.1
	Slope, DWR, Aspect, DWR	5	98.8	4.3
	Slope, VT, Aspect, DHS, DWR	6	92.1	12.5
	Slope, DWR, EL	4	97.5	14.6
	Slope, VT, Aspect, DHS	5	98.4	16.3
	Slope, DHS, DWR	4	100.2	19.4
	Slope, DWR, VT, EL	5	105.3	25.4
Winter	Slope, DHS, Aspect	4	19.4	0.0
	Slope, VT, DHS, Aspect	5	32.3	1.4
	Slope, Aspect, Aspect, EL	5	35.5	1.9
	Slope, Aspect, VT	4	42.4	2.4
	Slope, EL, Aspect, DHS ^c	5	44.5	3.2
	Slope, EL, DHS, Aspect	5	48.5	4.5
	Slope, Aspect, DWR, VT, DHS	6	50.2	8.3
	Aspect, Slope, VT, DHS, DWR	6	78.5	17.9
Slope, Aspect, DHS, VT, EL	6	87.7	23.5	

^a Number of parameters, ^b Akaike's Information Criterion, ^c Vegetation types, ^d Distance to human settlements, ^e Distance to water resources, ^f Elevation a.s.l

Table 2. Coefficients and significance values of yearlong and seasonal logistic regression models of habitat use by wild goats in Agh-Dagh protected area.

Model	%Classified correctly	Parameter	Estimate	SE	P
Yearlong	94.5	Intercept	26.4	5.46	<0.001
		Slope	0.38	0.09	<0.001
		DHS	0.42	0.12	<0.001
Winter	94.2	Intercept	17.5	2.35	<0.001
		Aspect	0.43	0.13	<0.001
		DHS	0.18	0.03	<0.073
Summer	91.9	Intercept	13.65	1.92	<0.005
		Slope	0.43	0.12	<0.001
		DHS	0.45	0.18	<0.005
		DWR	0.65	0.19	<0.001

preference for both warmer microclimate and areas with less snow cover. There was only a weak correlation between vegetation types and elevation within the study area ($r = 0.26$, $r = 0.21$), suggesting that the effects of these variables on the species habitat use were likely independent of one another. A positive relationship with slope also was detected (Table 2), suggesting that wild goats chose habitats near steep areas, although this relationship was not as strong as the relationship with aspect and DHS. Finally, a significantly positive relationship was detected between wild goat indirect evidence and distance from water resources, indicating a preference for proximity to water resources (particularly springs). With regard to hu-

man activity, the presence of wild goats was negatively related to distance from trails and settlements, indicating decreased activity in the proximity of human activity. The main vegetation consumed by wild goats in the study area are the foliage of plants such as *Juniperus communis*, *Pyrus communis*, *Pistacia atlantica*, *Paliurus spina-cristi*, *Astragalus* sp., and *Cousinia pterocaulos*.

Discussion

When we modelled habitat use of wild goats, we found that aspect was the most important variable for describing habit use, especially during the win-

ter. The significance of aspect is likely to be due to the role of thermal regulation in maximizing wild goats' growth and survival (Fryxell & Lundberg 1994, Kie 1999). Slope, and distance to human settlements and infrastructures in turn were included in all seasonal and year-long models, and the coefficient values indicated strong selection for steep slopes. Distance to water resources affects wild goats habitat selection during summer. This finding coincides with a large body of research that has documented the importance of escape terrain for wild goats (Gross et al. 2002, Kie et al. 2002, Gavashelishvili 2004, Anderson et al. 2005, Shams 2010). These variables clearly have broad applicability in describing habitat use across the geographic range of wild goats. Ruggedness and its parameters such as slope and elevation has been thought to be important components of escape terrain for wild goats and avoiding from predation risk (Fryxell & Lundberg 1994, Kie 1999), indeed it has been documented that wild goats use rugged terrain (Shams 2010). Distance to water resources influenced the distribution of wild goats in the study area only in summer season, although only those of water resources were important where they located near steep terrains. Similar results have been reported in other areas (Shams 2010). Developing habitat models for wild goats at the study area will be very useful in their conservation and management. These models will enable the identification of the critical areas of the habitat for wild goats. As these goats are a focal species in the Agh-Dagh protected area, this knowledge will affect land use planning in the study area. The major threat for *C. aegagrus* is illegal hunting, competition for food with domestic livestock and stress and disturbance from human settlements especially during the breeding season. Although rocky slopes and ridges offer suitable habitats for the species, over-hunting has greatly reduced its number.

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