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Habitat Degradation of a Vulnerable Mammal, the Wild Goat, *Capra aegagrus*, in Kelardasht, Northern Iran

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Research Article

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Abstract
The population of the Wild Goat, *Capra aegagrus,* is decreasing in most areas of its range, including Iran. The present study area covered 16 sections of the Kelardasht area in northern Iran between 2000 and 2010–2014. A dramatic change was observed in Wild Goat numbers, elevation use, vegetation and habitat during the period. The flock size declined from 10–15 individuals in 2000 to 3–4 individuals in 2010. The elevation in use changed from 2,400–>4000 m to only >4000 m. Vegetation studies indicated plant density and abundance of 28 of the 35 species grazed by the Wild Goat declined strongly in 2010 and only some woody plants such as *Astragalus* were stable over the decade. In 2010 Wild Goats were observed only in three sections compared to 16 sections in 2000. It is suggested that overgrazing, illegal hunting and other threats caused Wild Goats move to unsuitable elevations, or migrate to adjacent habitats. Urgent management strategies are necessary to conserve the remaining populations of this species in order to avoid extinction of this species in Iran.

1. Introduction

The Wild Goat, *Capra aegagrus,* range varies widely, however, it is probably extremely rare or absent in much of its mapped range. At the present, the total population of the Wild Goat is believed to be about 30,000 individuals. The population trend across its range is significantly declining, perhaps as much as 30% over three generations (Shafigue *et al.* 2002). Therefore, it is listed as a vulnerable species because of its population decline and habitat destruction and degradation (Weinberg *et al.* 2008; Shackelton 1997). The major threat to *C. aegagrus* is illegal hunting. Although rocky slopes and ridges offer suitable habitats for this species, illegal hunting has greatly reduced its number. Other threats to the Wild Goat are competition for food resources with domestic livestock (Heroldo 1996; Shafigue & Barkati 2002), disturbance and habitat loss due to logging and land clearing (Genoy *et al.* 2009). The Mediterranean region and the Middle East are among the most degraded areas in the world due to their long history of heavy human settlement (Czudek 2006).

Population estimates vary, with three countries having the highest numbers of animals: Turkey (10,000), Turkmenistan (7,000), and Iran. In Iran, the population has been roughly estimated to be about 6,500 based on only two sites; 4,000 in Central Alborz Protected Area and 2,500 individuals in Golestan National Park (Weinberg *et al.* 2008). The Wild Goat is classified as a protected species by the Iran Department of Environment (DOE). Several studies have been conducted on the Wild Goat in Iran in recent years: Abbasian *et al.* (2004) studied the diet of this species, Sarhangzadeh *et al.* (2013) and Mahmoodi *et al.* (2015), Naderi *et al.* (2014), and Farashi *et al.* (2010). studied habitat suitability of this species in the Yazd area, Ardabil, and in Kolah Ghazi, Esfahan, respectively environmental factors (Ansari *et al.* 2014; Morovati *et al.* 2014) and habitat association for conservation (Shams *et al.* 2010).

In the present study, we studied changes in elevation use, vegetation cover and habitat of Wild Goats in the Kelardasht area as a representative of a habitat which was previously known to be suitable for the Wild Goat.

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2. Materials and Methods

2.1. Study area

Our study area was part of the Sardab-Rud basin, Mazandaran province in northern Iran (Fig. 1). The Sardab-Rud basin, about 425 km^2, limited to Chalus basin to the east, Namkab-Rud, Kazem-Rud and Azad-Rud basins in the upper, middle and down west, respectively. Alam-Kuh and Takhte-e Soleyman ridges also separate the Sardab-Rud basin from the Taleghan basin (Malekpour 1998). The study area lies at 50°58'– 51'05° E and 36°20'–36°25'N in the Kelardasht, Sardab-Rud basin. The total area consists of 16 sections from Alam-Kuh and Hasrachal up to Vandareben, about 5,000 ha. The area is a wide valley with numerous slopes with suitable habitat for the Wild Goat. These habitats offer various plant species from different families that are grazed by the Wild Goat in different seasons (Abbasian *et al.* 2004).

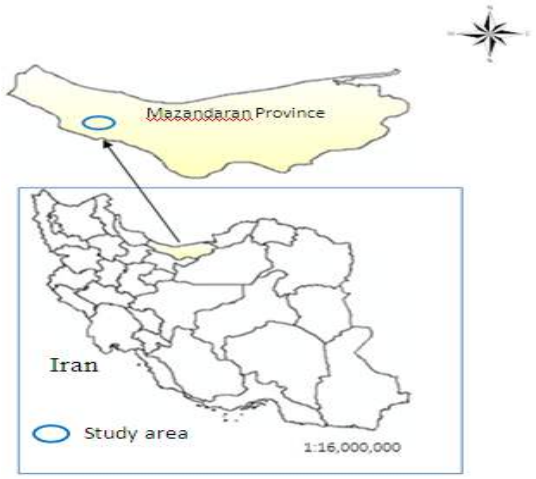

Fig. 1. A schematic view of the study area.

2.2. Methodology

The presence of Wild Goats in the study area was assessed by direct field observations and surveys assisted by the staff of the Department of the Environment (DOE) of the Kelardasht area. In order to evaluate distribution and population of the Wild Goat, we relied on DOE rangers who reported the largest group size. We validated these data by carrying out field surveys following methods of Sardar (1992). We performed line transects (Mesdaghi 2005) to estimate relative abundance of Wild Goats (Acevedo *et al.*, 2007). The average length of the line transects was 10 km which began from Avijdanak (2,400 m) and ended in Hasarchal (4,200 m). Our surveys were carried out by using binoculars in the main areas where the Wild Goat was present in Khorram-Dasht and Hasarchal during hours of maximum activities, (dawn and dusk). When Wild Goats were detected, we approached them as closely as possible and all activities and movements were recorded. We recorded the numbers of animals, gender, habitat name, elevation in use and behaviour both in 2000 and 2010. Plant samples were collected in 2000 and 2010 and assessed for dimension, vitality and sociability of plants measured in stable 2×2 m quadrates in elevations 2,800–3,800 m a.s.l. The number of plants in each quadrate was recorded into six 60° sectors for the main plants of each type such as *Ferula, Poa, Agrupyrum, Arabis, Allium, Alopecurus*, in addition to registration of changes in their distribution using coordinates. The mean change in frequency of plants was calculated. Finally, information obtained for habitat variables of 16 sections where the Wild Goats were present.

3. Results

In the Kelardasht area, we usually observed flocks of 10–15 individual wild goats during summer 2000 while in summer 2010 only 4 small groups of 3–4 individuals were observed.

3.1. Elevation

In 2000, Wild Goats were present in all elevations from 2,400 m up to more than 4,000 m. However, about 70% of these animals were detected at 2,400–2,800 m throughout winter (Fig. 2) where they were not observed in summer at this elevation. In summer, the goats were mainly (60%) dispersed at altitudes more than 3,200 m (a.s.l). Between 2000 and 2010, goat numbers declined drastically and changed their elevation preference. In summer 2010, goats were only observed above 4,000 m (Fig. 3).

3.2. Plant structure

In the Khorram-Dasht area, we could identify 88 plant species, 35 species of which were suitable as food resources (Table 1; Abbasian 2001; Abbasian *et al.* 2004). Complementary

studies during the 2001–2010 period showed some changes in the vegetation cover throughout the area. The diversity and density measurements indicated a drastic degradation of palatable species and only wintering plants remained stable. Comparison of plant species between 2000 and 2010 demonstrated that 28 species of plant species used by Wild Goats (Table 1; Abbasian *et al.* 2004) showed lower density in 2010.

3.3. Habitat variables

In 2000, Wild Goats were present in all 16 sections (Table 2) but in 2010 were observed only in three sections – only 8 males in Dalir-Sar ridge and some females and their yearlings were present in Marjikash and Cheshmekash (Fig. 4). Assessment of different habitats and qualitative comparison of habitat variables between 2000 and 2014 shows some dramatic degradation in all sections of the study area (summarized in Table 2). Although the number of livestock increased in one section, it has already been high at least in seven sections. Also, the condition of grassland decreased in 15 of 16 sections. Water resources seemed to be stable in all these sections as well as status of shelter. The safety decreased in 11 of 16 sections but the five remaining sections had already low safety, giving now all 16 sections low safety for the Wild Goat.

Table 1. Plants that have changed their relative density and dispersal from 2010 compared with 2000.

No.	Scientific name	Food resources (after Abbasian *et al.* 2004)	Presence in 2000	Change observed in 2010
1	*Allium capitellatum* Boiss. (1846)	Male	√	Stable
2	*Arenaria insignis* Litw. (1907)	Female	√	10% Decrease
3	*Dianthus mazanderanicus* Rech. f. (1983)	Male	√	20% Decrease
4	*Silene odontopetala* Fenzl (1842)	Female	√	40% Decrease
5	*Achillea millefolium* L. (1753)	Male, Female	√	5% Decrease
6	*Cousinia pterocaulos* (C.A.Mey.) Rech.f. (1972)	Male	√	30% Decrease
7	*Anchonium elichrysifoliumn* (DC.) Boiss. (1867)	Female	√	100% Decrease
8	*Arabis caucasica* Willd (1813)	Male	√	Stable
9	*Erysimum cuspidatum* (M.B.) DC. (1821)	Male, Female	√	Stable
10	*Cephalaria syriaca* (L.) Roemer & Schultes (1818)	Male, Female	√	10% Decrease
11	*Agropyrum long-aristatum* (Boiss) Boiss. (1884)	Male	√	50% Decrease
12	*Agropyrum trichophorum* (Link) Richter (1890)	Male, Female	√	50% Decrease
13	*Agrostis tenuis* Sibth. (1794)	Male, Female	√	10% Decrease
14	*Alopecurus myosuroides* Hudson (1762)	Male, Female	√	Stable
15	*Bromus cappadocicus* Boiss & Bal. (1857)	Male	√	20% Decrease
16	*Bromus tomentellus* Boiss. (1846)	Male, Female	√	20% Decrease
17	*Bromus tomentosus* Trin. (1818)	Male, Female	√	20% Decrease
18	*Hordeum leporinum* Link (1835)	Male, Female	√	10% Decrease
19	*Melica ciliata* L. (1753)	Female	√	10% Decrease
20	*Phleum paniculatum* Hudson (1762)	Male, Female	√	10% Decrease
21	*Poa bulbosa* L. (1753)	Male, Female	√	30% Decrease
22	*Leonurus cardiaca* L. (1753)	Female	√	10% Decrease
23	*Marrubium astracanicum* Jacq. (1781)	Female	√	30% Decrease
24	*Nepeta glomerulosa* Boiss. (1844)	Male, Female	√	30% Decrease
25	*Salvia atropatana* Bunge (1873)	Female	√	20% Decrease
26	*Thymus transcaucasicus* Ronniger (1932)	Male, Female	√	30% Decrease
27	*Astragalus aureus* Willd (1794)	Male, Female	√	20% Decrease
28	*Astragalus glaucacanthus* Fischer (1853)	Male, Female	√	Stable
29	*Astragalus rosellus* Sirj. & Rech. f.	Male	√	Stable

No.	Scientific name	Food resources (after Abbasian *et al.* 2004)	Presence in 2000	Change observed in 2010
	(1933)			
30	*Astragalus viridis* Olivier. (1807)	Female	√	Stable
31	*Vicia villosa* Roth. (1993)	Female	√	20% Decrease
32	*Plantago atrata* Hoppe (1799)	Male	√	5% Decrease
33	*Anthriscus nemorosa* (M.B.) Spreng (1813)	Female	√	30% Decrease
34	*Ferula persica* Willd (1798)	Male, Female	√	40% Decrease
35	*Trachydium pauciradiatum* (Boiss. & Hohen). Rech. f. (1987)	Male, Female	√	20% Decrease
		25 male, 27 female	**35**	**7 stable, 28 decrease**

Table 2. Habitat variables in 16 sections of the Kelardasht study area between 2000 and 2014.

Habitat name	Presence of Wild Goat		Livestock			Grassland			Water			Shelter			Safety		
	2000	2010	2000	2014	Trend	2000	2014	Trend	2000	2014	Trend	2000	2014	Trend	2000	2014	Trend
Avijdanak	+	-	Low	Med.	Incr.	Med.	Low	Decr.	Med.	Med.	Stabl.	Med.	Med.	Stabl.	Low	Low	Stabl.
Khoshkedar	+	-	High	High	Stabl.	Med.	Low	Decr.	Med.	Med.	Stabl.	Med.	Med.	Stabl.	Low	Low	Stabl.
Abidar	+	-	High	High	Stabl.	High	Med.	Decr.	High	High	Stabl.	High	High	Stabl.	Med.	Low	Decr.
Lezebenak	+	-	High	High	Stabl.	Med.	Low	Decr.	Med.	Med.	Stabl.	Med.	Med.	Stabl.	Low	Low	Stabl.
Pasandeh	+	-	High	High	Stabl.	Med.	Low	Decr.	Med.	Med.	Stabl.	Med.	Med.	Stabl.	Low	Low	Stabl.
Kelachband	+	-	Low	Low	Stabl.	High	Med.	Decr.	High	High	Stabl.	High	High	Stabl.	High	Low	Decr.
Chalan	+	-	High	High	Stabl.	High	Med.	Decr.	High	High	Stabl.	High	High	Stabl.	High	Low	Decr.
Cheshmekash	+	+	High	High	Stabl.	High	Med.	Decr.	High	High	Stabl.	High	High	Stabl.	High	Low	Decr.
Tang-e Galoo	+	-	High	High	Stabl.	Med.	Low	Decr.	Med.	Med.	Stabl.	Med.	Med.	Stabl.	Med.	Low	Decr.
Dalir-Sar	+	+	Low	Low	Stabl.	Med.	Med.	Stabl.	Med.	Med.	Stabl.	Med.	Med.	Stabl.	Med.	Low	Decr.
Gadook	+	-	Low	Low	Stabl.	Med.	Low	Decr.	Med.	Med.	Stabl.	Med.	Med.	Stabl.	Med.	Low	Decr.
Lashgarak	+	-	Low	Low	Stabl.	Med.	Low	Decr.	Med.	Med.	Stabl.	Med.	Med.	Stabl.	Med.	Low	Decr.
Menareh	+	-	Low	Low	Stabl.	Med.	Low	Decr.	Med.	Med.	Stabl.	Med.	Med.	Stabl.	Low	Low	Stabl.
Khersan	+	-	Low	Low	Stabl.	Med.	Low	Decr.	Med.	Med.	Stabl.	High	High	Stabl.	Med.	Low	Decr.
Siah-Kaman	+	-	Low	Low	Stabl.	Med.	Low	Decr.	High	High	Stabl.	High	High	Stabl.	High	Low	Decr.
Marjikash	+	+	Low	Low	Stabl.	High	Med.	Decr.	High	High	Stabl.	High	High	Stabl.	High	Low	Decr.

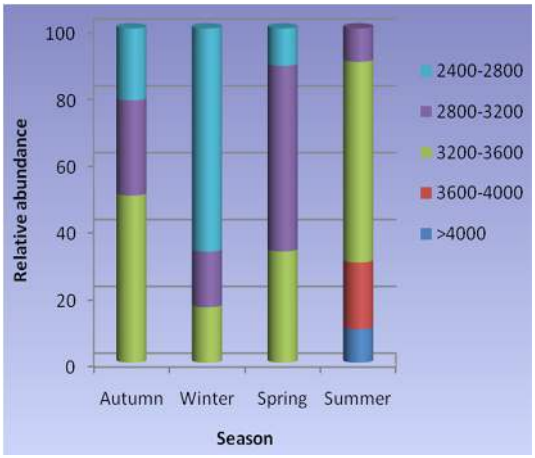

Fig. 2. Seasonal relative abundance of Wild Goat in different heights.

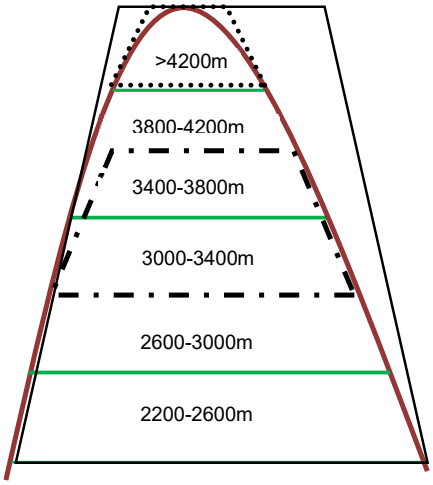

Fig. 3. Altitudinal use of Wild Goats in 2000 (solid line) and 2010 (dotted line) and livestock during the grazing period (dashed line).

Fig. 4. Alteration of altitudinal dispersal of Wild Goat.

Fig. 5. Migration of Wild Goats from Sardab-Rud to Se-Hezar basin.

4. Discussion

4.1. Elevation

The Wild Goat inhabits mountainous areas where there is a mixture of rocky outcrops (including scree slopes) and vegetation (Gundogdu 2010). It favours areas near rocky cliffs and steep slopes, and close to water resources (Shams *et al.* 2010; Sarhangzadeh *et al.* 2013). We concluded that in the Kelardasht area Wild Goats have shifted to higher elevations compared to 10 years ago. However, many factors, in particular grazing by domestic livestock, appear to have caused Wild Goats to now use higher elevations (Fig. 3). However, 4,000 m is the last elevation where this species is known to occupy but it is not very suitable for food resources. The change in altitude use reflects the lack of security throughout the area.

4.2. Plant structure

The type of vegetation plays an important role in habitat suitability of the Wild Goat (Mahmoodi *et al.* 2015). Thus, the severe decline of the Wild Goat population could be partly due to the shortage of sufficient food supply, temporally and spatially.

Seasonal changes play important role in the dispersal and distribution of the Wild Goat in different elevations associated with changes in density, diversity, and accessibility of palatable plants. In the study area, Wild Goats gradually change the parts of plants they utilize over the spring and summer. By winter with snowfall, most parts of herbaceous plants are buried in snowpack and these animals inevitably change their diet to nearly exclusively woody plants such as *Astragalus* sp.

At least 28 plant species declined in suitable growth, and now areas which were suitable Wild Goat habitats lack these plant species which now are found only in higher elevations such as Marjikash and Siah-Kaman. In the study area, collecting samples and identifying of plant species have been done since 1937. Several investigators collected more than 100 species of which 50% are native. A previous study showed that 35 species exist at elevations of 1,500–3,800 m, but that only 20 species exist in Wild Goat habitat (Kavousi 1990) possibly due to climate change, many species shifted to higher elevation of 3,000–3,800m. The decrease of the density and diversity of *Astragalus* and *Onobryshis* which are important for the maintenance and protection of many other plant species and play a shelter role for them. Lack of these vital species could reduce the carrying capacity of a habitat for the Wild Goat populations. In addition, overgrazing decreases the vegetation cover in the study area. In a result, only some woody, rocky and alpine plants such as *Arabis caucasica*, *Erysimum cuspidatum* and *Alopecurus mysouroides* remain. As a results, some invasive plants such as thorny and unpalatable plant species including *Euphorbia* sp., *Cirsium congestum* and S*ilybum marianum* gradually increase in the area.

4.3. Habitat management

In 2000, all the studied habitats had suitable water, plant cover and shelter which attracted Wild Goats living throughout the area. However, this species avoids regions with strong human presence (Kiabi 1975) as prefers areas away from roads (Shams *et al.* 2010) and cities (Ansari *et al.* 2014). Our study showed that all the 16 sections of the study area lacked safety for wild goats. Recent studies show that this species is using marginal habitats elsewhere (e.g. Agh-Dagh, Ardabil), principally because of the human settlements and road networks (Naderi *et al.* 2014). The use of marginal habitats indicates that this species is approaching extinction rapidly. Until the early 1980s, there were large flocks of wild goats in most mountainous areas of Iran. In southern Fars, Bushehr and western Iran there were thousands of wild goats, but now this animal is extinct in these areas (e.g. in Bisoton Protected Area extinct from over 10,000 individuals) or are dramatically decreased (e.g. in Bamu National Park from over 10,000 only a small population remained) (Ziaie 2008). Therefore, immediate actions to conserve the remaining populations of this species in Iran are needed.

In 2010, we observed more individuals in the adjacent basin, Se-Hezar, compared with 2000. In our study area, the Sardab-Rud basin lies in adjacant to the Dalir, Taleghan and Se-Hezar basians which form the main channels of the Chalus, Taleghan and Cheshmeh-Kileh rivers, respectively,. Similar to the Sardab-Rud basin, new studies have shown that the Dalir and Taleghan heights do not have suffiecient safety to protect Wild Goat populations. With increasing activities of tourists, climbers and ranchers within the study area, wild goat abundance was lowest in summer and highest in autumn. By contrast, we observed that the relative safety in the Se-Hezar basin allowed observation of an average of 50 individuals in most of field surveys. (Fig. 5). Two reasons might account for the increase in Wild Goat numbers in the adjacent basin of Se-Hezar; lack of security and stressful conditions throughout Khorram-Dasht and Hasarchal areas and the presence of active guards of the Department of the Environment (DOE) in Se-Hezar basin (Kalahoo and Navaskuh).

We observed grazing domestic animals throughout the area more frequently, in particular at the elevations of 3,000–3,800 m than other elevations (Fig. 3). The presence of domestic livestock has led to overgrazing of native plants. In addition, soil compaction also occurs with heavy grazing by domestic livestock. Unfortunately, overstocking continues to occur in this area and livestock move to higher elevations than the determined grazing line. For example, the Chalan, Marjikash are higher than 4,200m but we observed domestic animals there during summer. On 868 ha of the total area of Khorram-Dasht area produces 262 kg/ha dry forage. There are approximately 800 head of domestic livestock that stay about 100 days in the area. Assuming dry forage consumption by one animal unit to be about 2 kg, and a 50% harvest of the available forage, the present available forage would be 113,708 kg which would be sufficient for about 570 animal units for a 100-day period. With reference to the Lotka-Volterra equation ($\frac{dN}{dt} = rN(\frac{K-N}{K})$, Sinclair *et al.*, 2006), using more food resources more than the actual carrying capacity of the habitat would cause competition between domestic and wild animals. Temporal and spatial separation of domestic livestock and wild goats may help to allocate plant resources, because Wild Goats forage in early morning and towards the evening (Kiabi 1975) while domestic goats graze during the day. However, sufficient food resources for Wild Goats must be available in order to reduce spatial competition. If the current livestock numbers are maintained, it appears that Wild Goats would not be present in these habitats in spring and summer.

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