Goitered Gazelle *Gazella subgutturosa* Guldenstaedt, 1780: its habitat preference and conservation needs in Miandasht Wildlife Refuge, northeastern Iran

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Abstract

The present paper discusses the habitat preference of Goitered gazelle using a combination of Geographical Information System (GIS) and statistical analysis of its spatial distribution in Miandasht Wildlife Refuge. The critical habitat for gazelles in Miandasht Widlife Refuge is composed of hilly terrain near flat plains where they prefer to feed; the nearby hilly escape terrain decreases their susceptibility to poachers. Meantime, the gazelles' "catchability" increases among hilly areas where their limited eyesight increases the cheetahs' chance to approach them. However, given the low density of the cheetahs, it seems that predators do not greatly affect gazelle spatial distribution in Miandasht. Marginal cultivated lands attract the gazelles from early summer till early winter which increases the frequency of gazelle sightings in tamarisk plains leading to farmlands. Poaching records indicate that a majority of gazelles have been taken on the open plains, usually en route to cultivated lands where suitable escape terrain is not available The area is well-known for its large gazelle population in the past as well as its small cheetah population at present; therefore, immediate law enforcement is necessary to control the present decline in gazelle numbers, particularly in marginal habitats.

Keywords: Goitered gazelle, *Gazella subgutturosa*, Jacob's selectivity index, habitat, Miandasht Wildlife Refuge, Iran.

Introduction

Probably one of the most intensively investigated mammals of Iran, Goitered gazelles have long attracted constant attention of zoologists and research has progressed over the past quarter-century on various aspects such as taxonomy (ETEMAD 1985; GROVES 1993; KARAMI & GROVES 1993; HEMAMI 1994, KARAMI *et al.* 2002), habitat selection (HEMAMI 1994; FARAHMAND 2001; FAKHERAN 2002, KARAMI *et al.* 2002; AKBARI 2002; HAZERI 2007), population status and viability (HEMAMI 1994; HEMAMI & GROVES 2001; SHAMS 2004) and food preference (AJAMI 2001). These studies have been mainly conducted in central Iran.

Globally as a vulnerable species (IUCN 2008), the species roams throughout Iran except in the far northwest, along the Caspian Sea, and in the southeast (KARAMI *et al.* 2002). In spite of the fact that Miandasht Wildlife Refuge (MWR) has been known to be one of the main habitats for the species in the northeastern part of the country (JAMSHID 1976) with a

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population of 3600 before the 1980s (BAYAT 1984), no investigation has been carried out on the species in this area, even though it is of high conservation importance because of the presence of the critically endangered Asiatic cheetah *Acinonyx jubatus venaticus* (FARHADINIA & ABSALAN 2004) in the reserve.

Goitered gazelles mainly live in steppe country, particularly where it is dominated by *Artemisia*, as well as plains covered by *Salsola* in the vicinity of low rolling hills (HEMAMI 1994). According to KARAMI *et al.* (2002), they occur in halophytic desert and semi-desert with saxaul *(Haloxylon)* and other low shrub vegetation such as *Anabasis, Artemisia, Zizyphus* and *Salsola*.

This paper addresses habitat preference and relevant ecological issues of the Goitered gazelle in MWR where absence of mixture of plain and mountainous terrain in majority of the gazelles' range has made it a unique area for the species in the country. We hope it will fill a gap not only in our theoretical knowledge on the species ecology, but also in its management and conservation; the Goitered gazelle is the most important and dominant ungulate species within the desert ecosystems throughout Iran as well as other countries in both the Middle East and Central Asia, as far as northeast as Mongolia and western China.

Materials and Methods

Study Area

Located near the city of Jajarm (N 36 45' to 37 05' & E 56 25' to 56 57') in North Khorasan Province, northeastern Iran (figure 1), this 84435 hectares area was designated as a wildlife refuge in November 1973 by the Iranian Department of the Environment (DoE). The area is composed of vast expanses of flat plains with rolling hilly areas which have divided the reserve into northern and southern halves. The region is scarred with a thick net of dry river beds and depressions, and intermingled with clusters of small hills and plateaus. Hilly regions inside the reserve form a core zone covered dominantly with shrubs, and some low mountain ridges form the southern borders. A seasonal salty river, the Jajarm Kalshur forms the northern boundary, providing a useful refuge for wildlife. The altitude range of MWR is 900-1340 meters, mainly less than 1000 meters. The mean annual temperature and precipitation of 14°C and 150 mm respectively have resulted in an arid climate in the region (DARVISHSEFAT 2006). It is highly important to emphasize that MWR is unique among Iranian reserves, because in that more than 90% of the area has a slope less than 10% forming flat plains, while slopes more than 30% are rare (FARHADINIA 2007). The area is surrounded by a number of human settlements, mostly in the south and northeast and a total of 15000 heads of livestock, mainly sheep graze the area's pastures in winter.

The reserve consists of desert and kavir ecosystems with xerophyte and halophyte species, mainly from families *Leguminoseae, Salsolaceae, Chenopodiaceae*, and *Graminae* (SALEHI 1994). MWR is dominantly covered with wormwood *Artemisia sieberi*, feather grass *Stipa spp.*, and saltwort *Salsola spp.* with saxaul trees *Haloxylon*, scattered on sand plains as well as tamarisk *Tamarix* along the dried watercourses. Meanwhile, invasive plant species such as *Peganum spp.* and *Sophora alopecuroides* are in process of extending from the southern degraded pastures toward the northern part of the reserve.

The critically endangered Asiatic cheetah is the most charismatic carnivore in the area. Also, striped hyeana *Hyaena hyaena*, *grey* wolf *Canis lupus*, caracal *Caracal caracal*, wild

cat *Felis silvestris*, common fox *Vulpes vulpes* and golden jackal *Canis aureus* are known to exist in the area (FARHADINIA 2007). Low numbers of wild sheep *Ovis orientalis*, and wild boar *Sus scrofa* occur in the area as well. A high density and diversity of rodents as well as Cape hare *Lepus capensis* live throughout MWR. Long-legged buzzard *Buteo ruffinus* and golden eagle *Aquila heliaca* are the main raptors (HOSSEINI *et al.* 2008).

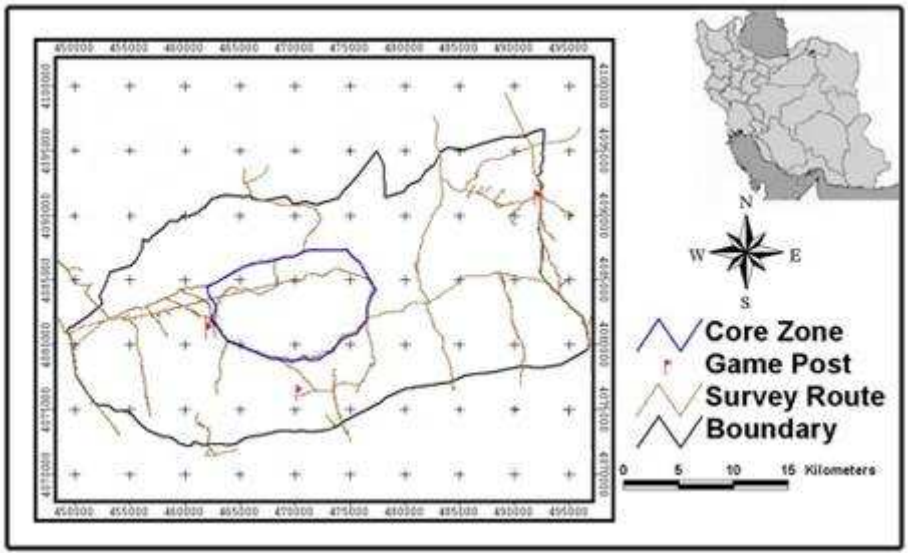

Fig.1. Map of Miandasht Wildlife Refuge and its location in Iran

Methods

Field surveys were carried out during a five year period (2003-2008) in MWR. According to FARAHMAND (2002), the Goitered gazelle prefers open plain habitats with a slope range of between 0 and 30 percent; therefore, we excluded those parts of MWR with slope more than 30% as potential habitat, by means of GIS Software ILWIS ver.3 (mountainous terrains: 62.1 $km^2 \approx 7\%$ of the region's area). During the survey period, 12 transects crossing different habitats of the gazelles were established and each transect was surveyed on vehicle or motorbike on the average of 20 times. The total length of all transects was approximately 134 km. Every 500 m a GPS coordinate was taken and a digital map showing all transects was produced using the program ArcView GIS 3.2 (ESRI Inc.).

With respect to landform parameters (slope, elevation and aspect), the gazelles' area in MWR is relatively homogenous without much noteworthy variation throughout the region. KARAMI *et al.* (2002) regarded *Artemisia siberi* together with representatives from families *Salsolaceae*, *Chenopodiaceae* and *Graminae* as suitable foods for the Goitered gazelles which are the dominant plant communities throughout the area; therefore, we defined three habitat types based on landscape features (vegetation structure and topographic conditions) (table 1).

Table 1. Characteristics of the three defined habitat types in Miandasht.

Habitat type	Topographic features	Slope range (%)	Area (km^2)	Percentage of habitat type to total gazelle habitat (%)
Flat plains	None significant within a radius of at least 1 kilometer	<10%	233.7	30
Hilly plins	Including scattered hills, mountains, watercourses or depressions present within a distance of a maximum of 1 kilometers	0-30%	422.3	54
Tamarisk plains	Dissected by a thick network of dry watercourses and depressions; small trees, particularly tamarisk *(Tamarix sp.)*	<10%	125.8	16
Total			781.8	100

We mapped the area's habitat types using field data in GIS ArcView and calculated the area of each of the three categories (figure 2).

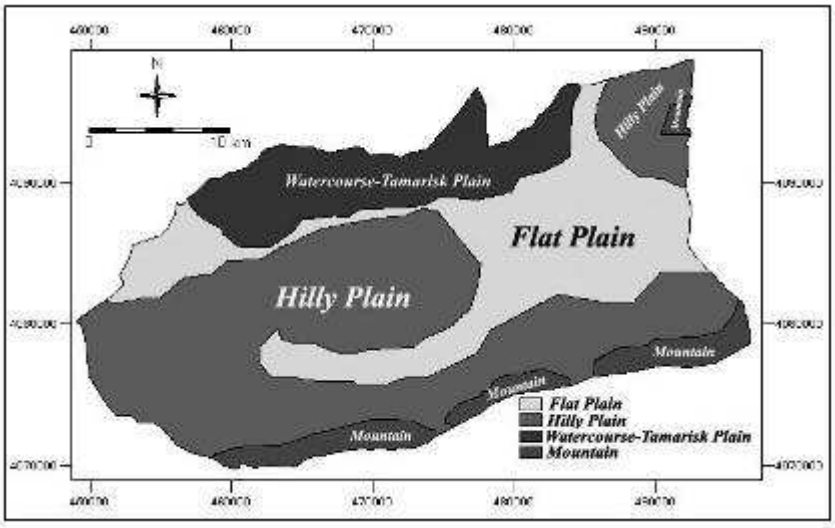

Fig. 2. Map of habitat types in Miandasht Wildlife Refuge

The geographical coordinates (position fixes) of all gazelles sighted were determined by GPS and then plotted on the GIS landscape map of MWR by means of ESRI ArcView GIS 3.2a software. Habitat preference was assessed by Jacob's selectivity index D (JACOBS 1974):

$$D = (r - p) / (r + p - 2rp)$$

where r is the ratio of the number of gazelle sightings in a specific habitat type to the number of all gazelle sightings in all habitat types, and p is the ratio of the area of a specific habitat type where the given sightings are made to the area of all habitat types within the gazelle range. Jacob's selectivity index ranges from –1 (exclusively avoids) through 0 (indifference) to +1 (exclusively prefers).

A chi-square goodness of fit test (ZAR 1999) was used to determine if the observed frequencies of habitat use differed significantly from expected frequencies based on the proportion of area contributed by each habitat within the gazelles' area using SPSS 14.0 for Windows software package. .

In order to explore predation impact on gazelles, data on spatial distribution of main predators, including Asiatic cheetah and grey wolf was gathered. Also, gazelle kills were investigated for the cause of death and predators' feces were analyzed for gazelle remains.

Results

During the survey period, a total of 137 gazelle sightings were made in MWR. Gazelles' escaping behavior was seen in 82.5% (n=113) of the total observations, mostly to the nearest hilly terrain and occasionally to watercourses and dense vegetation patches. For the rest of gazelle sightings, the animals were spotted from a long distance using the binocular and they kept their grazing. We never saw any gazelle to fast run over flat surface to escape.

We had only 1 sighting in the southern mountainous areas (less than 1%) which were excluded from the analysis. Also, 14% (n=14) of sightings took place during nighttime, totally in hilly plains. Among 122 daytime sightings, relatively similar proportions occurred in both hilly and flat plains, 46.7% and 44.2%, respectively. Meanwhile, around 9% of total daytime sightings belonged to northern marginal habitats cut by thick network of watercourse covered with tamarisk trees connecting to cultivated lands (table 2).

Table 2. Abundance of gazelle sightings in different habitat types in Miandasht.

Habitat type	**Time**				**Total**
	Morning	**Noon**	**Evening**	**Night**	
Flat plains	25	7	22	0	54
Hilly plains	19	20	18	14	71
Tamarisk plains	1	4	6	0	11
Mountain	0	0	1	0	1
Total	45	31	47	14	137

Based on the proportion of area contributed by each habitat within the gazelles' area in MWR, the number of gazelles sighted in the three habitats was significantly different (χ^2=13.42, df=2, P=0.001). However, the size of each habitat could affect the number of sightings in that habitat. Therefore, the Jacobs' selectivity index was used to see whether the selection of each habitat proportional to its size is different from the pattern indicated by the abundance of observed gazelles in each habitat. Based on analysis of daytime sightings, Jacob's selectivity index was positive for flat plains (0.29) and negative for hilly and tamarisk plains (table 3 and figure 3).

Table 3. Distribution of habitat types in Miandasht Wildlife Refuge and relevant Jacobs' selectivity index *D*

Habitat type	Area (Km^2)	Abundance of sightings	R	p	D
Flat Plain	233.7	54	0.44	0.30	0.29
Hilly Plain	422.3	57	0.47	0.54	-0.14
Tamarisk Plain	125.8	11	0.09	0.16	-0.32

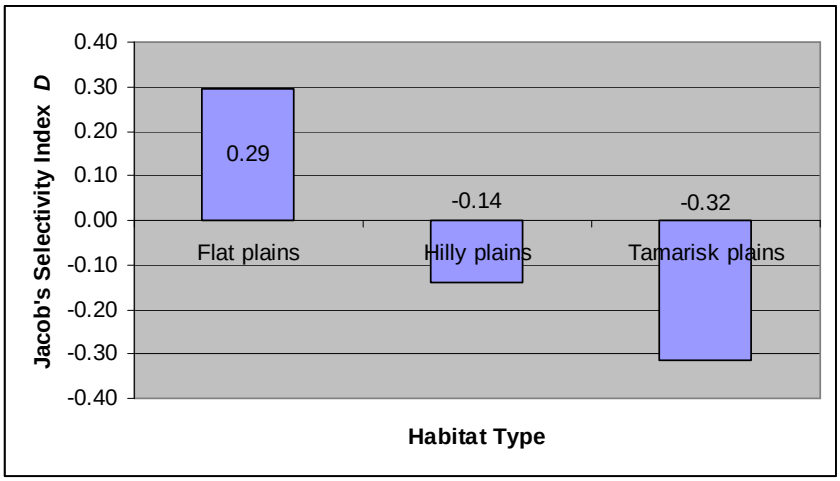

Fig.3. Jacobs' selectivity index *D* for each habitat type in Miandasht

We found a total of 7 carcasses of gazelles killed by cheetahs which 6 cases were in hilly plain habitats (85.7%). Also, fecal analysis of predators based on 35 cheetah and 9 wolf samples revealed that 26% of cheetah and more than 22% of wolf samples consisted of gazelle remains.

Fig.4. Goitered gazelle *Gazella subgutturosa,* at Miandasht Wildlife Refuge

Hunting of gazelles has been sighted 6 times by cheetahs in MWR, all of them making use of the cover provided by watercourses, but never by the wolves. Because of the abundance of scavengers such as striped hyaena and golden jackal, it is very rare to find the remains of kills.

Discussion

Goitered gazelles roam throughout most of MWR, except for the southern and northeastern mountainous regions. Although, they sometimes can be seen entering the fringes of rough country or use marginal mountainous valleys to pass through in order to travel inside or outside of the area's boundaries. Furthermore, it is not strange to see the gazelles outside the area's boundaries, where they spend the nighttime feeding on cultivated lands near the villages.

All the gazelle sightings during nighttime were in hilly plains where are difficult for the poachers to pursue the gazelles on powerful motorbikes. Presence of hilly terrain and light topographic conditions provide what we may call escape terrain for gazelles, where they can flee from dangers, particularly poachers. Available escape terrain for gazelles in MWR mainly consists of hill ridges. Our observation of cheetah hunting through watercourses among or at the fringes of hill-plains areas probably indicates a higher "catchability" of gazelles in this kind of habitat for the cheetah which may support the gazelles' avoidance of this habitat type during daytime when diurnal cheetahs are looking for preys. The low density of gazelles in MWR, means that the predators can probably meet only a small proportion of their food needs in the area and they have to obtain a majority of their food requirements from livestock and occasionally small mammals.

Flat plains with useful escape terrain are sparse, but still attract gazelles and this habitat type holds the highest Jacob's selectivity index for daytime sightings. The higher concentration of food resources on flat plains attracts gazelles and this habitat type, gives them the advantage of seeing and approaching enemy from a considerable distance with their keen eyesight (JAMSHID 1976).

Lack of food resources in tamarisk plain habitats is probably the main cause of low occurrence of gazelles in these areas. A majority of the gazelles' sightings in this habitat type may result from their role as corridors to the northern cultivated lands in summer and fall. The occurrence of gazelles therefore need not imply a preference: they have no option but to pass through in order to reach green crops.

Thus, hilly terrain offer higher security against poachers; but this is where they are exposed to greater predation risk by cheetahs; while flat plains present them with the advantage of a vast field of view to avoid predators but more threats from poachers because of the lack of necessary escape terrain. Accordingly, a combination of flat plains with hilly areas seems the most preferred habitat, but it seems that the low density of cheetahs in hilly areas has resulted in significantly higher occurrence of the gazelles in hilly habitats, even during daytime. The escape terrain concept has been much discussed for mountain ungulates such as wild sheep (e.g. SAFYAN 2001), wild goat (e.g. TOHIDI 2001), but it has not been hitherto considered as an important concept to describe gazelle habitat preference.

Water sources are supposed to be important habitat parameters for Goitered gazelles and FARAHMAND (2002) found in the ecologically similar Kolah Qazy National Park, that they are distributed homogenously in a radius of 5 kilometers around water sources. Goitered gazelles also tend to obtain a proportion of their water demands using plants with high water content, like Arabian gazelles *(Gazella gazella)* (WILLIAMSON & DELIMA 2001) and even in hot summers, they did not regularly visit water sources in MWR, as indicated by their very infrequent presence in photos taken by camera traps at waterholes in summer. Since the *Salsolaceae* with their high water content, constitute a dominant family in a proportion of the gazelles' habitat in MWR (SALEHI 1994), a hypothesis can be generated as it may be an alternative source of water for the species in MWR.

Spending normally nighttime among hilly terrain and mountainous fringes, they begin to walk toward flat parts of the habitats as sun rises. The most remarkable movement of the gazelles in MWR is probably their daily migrations up to more than 10 kilometers to surrounding cultivated lands to find alfalfa, wheat, melon, watermelon, etc. which increase upon the arrival of summer. ALMESH (1994) noted that Goitered gazelle distribution is highly correlated with cultivated lands.

A total of more than 15000 heads of livestock graze over most of the area's rangelands, mainly flat plains during winter which force gazelles to concentrate in hilly terrains. Here, the restriction of the gazelles' field of view perhaps increases their susceptibility to predators, particularly the cheetah and most observations of hunting have been recorded during this period of year. With respect to small population size of gazelles in MWR (ca. <400), it seems that the animals do not suffer from severe competition with livestock which once numbered more than 50000 head. Herd dogs tend to chase the gazelles; therefore, it makes them leave their habitat.

Confiscation records by the area's law enforcement guards since early 1990s indicate that most of the successful poaching incidents occurred on flat plains where suitable escape terrains are limited, revealing the high susceptibility of gazelles in open flat plains. JAMSHID (1976) noted that in MWR the gazelles keep very close to the low, rigged hills all through the night in order to protect themselves from jeeps and their spotlights which practically blind the weary animals.

In sum, it seems that the gazelles' habitat is somewhat different from the open flat plains that it has traditionally been supposed to be. They prefer to graze in flat areas which give them the advantage of seeing the approaching diurnal predators from far away with their

keen eyesight and dependence on their speed to escape from predators; but they prefer hilly areas and rougher country to benefit from the cover provided on hillsides and along water-courses, particularly during nighttime when poachers are active with spotlights. The gazelles regularly visit cultivated lands for a considerable proportion of year in search for crops. Water sources seem to have a major effect on gazelle's spatial distribution across the area, and larger concentrations can be seen in regions where water is present, particularly in hot summers. They are susceptible to poachers on flat plains and en route to and from cultivated lands through the marginal regions, while their main predator, the cheetah is more successful in hunting them near hilly terrains by taking advantage of the topographic conditions to approach their victims. Accordingly, it seems that the most serious threat is imposed by poachers from the adjacent villages on motorbikes and this needs immediate enforced conservation action to stop the present decreasing trend of the gazelle population in the reserve.

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