DETERMINATION OF HOME RANGE SIZE AND HABITAT SELECTION OF GAZELLES (*Gazella subgutturosa*) BY GPS TELEMETRY IN ŞANLIURFA

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DETERMINATION OF HOME RANGE SIZE AND HABITAT SELECTION OF GAZELLES (*Gazella subgutturosa*) BY GPS TELEMETRY IN ŞANLIURFA

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ABSTRACT

DETERMINATION OF HOME RANGE SIZE AND HABITAT SELECTION OF GAZELLES (*Gazella subgutturosa*) BY GPS TELEMETRY IN ŞANLIURFA

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Goitered gazelle is one of the threatened species of Turkey living in only Şanlıurfa region. In this study, goitered gazelles have been released to their previous habitat in Şanlıurfa-Suruç region and seven of females were collared with GPS collars. These individuals were monitored for a year and their seasonal habitat selection and home range sizes are determined by using location data recorded on the collars. In addition to 4 seasons of the year, home range and habitat selection are estimated for mating and calving periods. Also, summer period is divided to two as summer1 and summer 2 because of changing availability of water resources in study area.

Seasonal home range sizes of GPS collared gazelles are estimated as average 3.61 ± 0.47 km^2 for winter, 3.96 ± 0.44 km^2 for spring, 4.55 ± 1.35 km^2 for summer1, 2.26 ± 0.20 km^2 for summer2, 3.38 ± 0.44 km^2 for autumn, 1.37 ± 0.50 km^2 for mating season, and 1.66 ± 0.50 km^2 for calving season.

Seven habitat variable layers were prepared for the evaluation of seasonal habitat selection of GPS collared female gazelles. Gazelles were selected east aspects in summer and west aspects in winter seasons and, north and flat aspects were avoided in all seasons for a year. Water can be considered the key habitat variable for the goitered gazelles.

The results show that some home ranges are outside of the protected area and gazelles do not use large areas in the protected area. In order to improve conservation of gazelles, protected area should be re-arranged and shifted to more intensely used areas by gazelles.

Keywords: Home Range Size, Habitat Selection, GPS Telemetry, *Gazella subgutturosa*

ÖZ

ŞANLIURFA'DA CEYLANLARIN (*Gazella subgutturosa*) YAŞAM ALANI BÜYÜKLÜĞÜ VE HABİTAT SEÇİMLERİNİN GPS TELEMETRİ İLE BELİRLENMESİ

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Kursaklı ceylan, Türkiye'de tehdit altında olan sadece Şanlıurfa bölgesinde yaşamakta olan türlerden birisidir. Bu çalışmada, kursaklı ceylanlar eski yaşam alanları olan Şanlıurfa-Suruç bölgesine serbest bırakılmış ve dişilerin yedi tanesine GPSli tasma takılmıştır. Bu bireyler bir yıl boyunca takip edilmiş ve tasmalara kaydedilen coğrafi konum verileri kullanılarak mevsimsel habitat seçimleri ve yaşam alanı büyüklükleri belirlenmiştir. Yılın 4 mevsimine ek olarak çiftleşme ve yavrulama dönemleri için de yaşam alanı büyüklüğü ve habitat seçimleri tahmin edilmiştir. Ayrıca, su kaynağı varlığının değişmesi nedeniyle, yaz dönemi yaz1 ve yaz2 olmak üzere ikiye ayrılmıştır.

GPS tasmalı ceylanların mevsimsel yaşam alanı büyüklükleri kış için ortalama 3.61 ± 0.47 km^2, ilkbahar için .96 ± 0.44 km^2, yaz1 için 4.55 ± 1.35 km^2 , yaz2 için 2.26 ± 0.20 km^2, sonbahar için 3.38 ± 0.44 km^2, çiftleşme dönemi için 1.37 ± 0.50 km^2, ve yavrulama dönemi için 1.66 ± 0.50 km^2 olarak tahmin edilmiştir.

GPS tasmalı dişi ceylanların mevsimsel habitat seçimlerini değerlendirmek için, yedi habitat değişkeni katmanı hazırlanmıştır. Ceylanlar bir yıl boyunca yaz mevsimi için doğu, kış için batı bakılarını seçmiş, ve, kuzey ve düz bakılardan kaçınmıştır. Su, kursaklı ceylanlar için anahtar habitat değişkeni olarak düşünülebilir.

Sonuçlar bazı GPS tasmalı kursaklı ceylanların yaşam alanlarının koruma alanının dışında kaldığını ve ceylanların koruma alanı içindeki geniş bölgeleri kullanılmadıklarını göstermiştir. Ceylanların korunmasını iyileştirmek için, koruma alanı yeniden düzenlemeli ve ceylanların daha yoğun kullandıkları alanlara kaydırılmalıdır.

Anahtar Kelimeler: Yaşam Alanı Büyüklüğü, Habitat Seçimi, GPS Telemetri, *Gazella subgutturosa*

To my family

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CHAPTER 1

Introduction

1.1 Conservation Status and Taxonomy of *Gazella subgutturosa*

Goitered gazelle, *Gazella subgutturosa* (Güldenstaedt, 1870), is classified as vulnerable in the IUCN Red List and has 4 subspecies on all over the world; *Gazella subgutturosa marica* (Thomas, 1897), *Gazella subgutturosa hillieriana* (Heude, 1894), *Gazella subgutturosa yarkandensis* (Blanford, 1875), and the nominate form *Gazella subgutturosa subgutturosa* (Groves, 1985; Kingswood and Blank, 1996; Mallon and Kingswood, 2001; Mallon, 2008). Identification of subspecies is based on morphological characters. Although *G. s. marica* is reported to be closer to the Slender-horned Gazelle (*G. leptoceros,* Cuvier, 1842) (Hammond et al., 2001), it is considered in the traditional context in this thesis as a subspecies of *G. subgutturosa*. Taxonomic status, common names, scientific names of *G. subgutturosa spp.* are listed in table 1, table 2.

Table 1. Taxonomic status of *Gazella subgutturosa* (Mallon, 2008)

Kingdom	Animalia
Phylum	Chordata
Class	Mammalia
Order	Cetartiodactyla
Family	Bovidae
Subfamily	Antilopinae
Genus	Gazella
Species	*Gazella subgutturosa*

Table 2. The subspecies and distribution of *Gazella subgutturosa* (Groves, 1985; Kingswood and Blank, 1996; Mallon and Kingswood, 2001; Clark et al., 2006)

Common Name	Scientific Name	Synonyms	Distribution
*Goitered gazelle *Persian Gazelle *Sand Gazelle *Black-Tailed Gazelle	*G. s. subgutturosa*	**G. Seistanica* (Lydekker, 1910) **G. s. Typica* (Lydekker, 1900) **G. Gracilicornis* (Stroganov, 1956) **G. persica* **Antelope dorcas* var. *persica* (Gray, 1843) **Antelope gutturosa* (Güldenstaedt, 1780)	Turkey, Iran, Syria Iraq, Azerbaijan, Uzbekistan, Tajikistan, Turkmenistan, Kyrgyzstan, Kazakhstan, Mongolia, Pakistan, Afghanistan, China
*Arabian Sand Gazelle *Saudi Goitered Gazelle *Reem *Rheem	*G. s. marica*	**G. marica* (Thomas, 1897)	Yemen, Oman, United Arab Emirates, Bahrain, Jordan, Saudi Arabia, Iraq
*Mongolian Goitered Gazelle *Hillier's Goitered Gazelle	*G. s. hillieriana*	**G. mongolica* (Heude,1894) **G. hilleriana* (Heude,1894) **G. reginae* (Adlenberg, 1931) **G. sairensis* (Lydekker, 1900)	Mongolia, China
*Yarkand Goitered Gazelle *Xinjiang Goitered Gazelle	*G. s. yarkandensis*		China

Two of the subspecies, *G. s. subgutturosa* and *G. s. marica* have been evaluated in the IUCN Red List, only the nominate form *G. subgutturosa* is considered in The Convention on the Conservation of European Wildlife and Natural Habitats known as BERN (Council of Europe, 1979), Convention and The Convention on the Conservation of Migratory Species of Wild Animals also named as CMS or Bonn Convention (UNEP, 2002). Goitered gazelle is not taken into account in The Convention on Trade in Endangered Species of Wild Flora and Fauna (CITES) (Table 3). *G. s. hillieriana* and *G. s. yarkandensis* live in very restricted areas in China and Mongolia. There is not detailed information in literature about distribution and current status of *G. s. hillieriana* and *G. s. yarkandensis* (Kingswood and Blank, 1996). It is also considered that hybrid forms of G. *s.*

subgutturosa and *G. s. marica* exist in Iraq, Syria, and United Arab Emirates (Mallon and Kingswood, 2001).

Table 3. IUCN Red List Category and Status in the International Conventions of *G. subgutturosa* and subspecies (Mallon, 2008; IUCN, 2009)

	IUCN Red List	CITES	BERN	CMS
G. subgutturosa	VU A2ad	-	II	II
G. s. subgutturosa	-	-	-	-
G. s. marica	VU C2a(i)	-	-	-

Box 1. Explanation of vulnerable category (IUCN, 2008)

VULNERABLE(VU) → A taxon is Vulnerable when the best available evidence indicates that it meets any of the criteria A to E for Vulnerable and it is therefore considered to be facing a high risk of extinction in the wild.

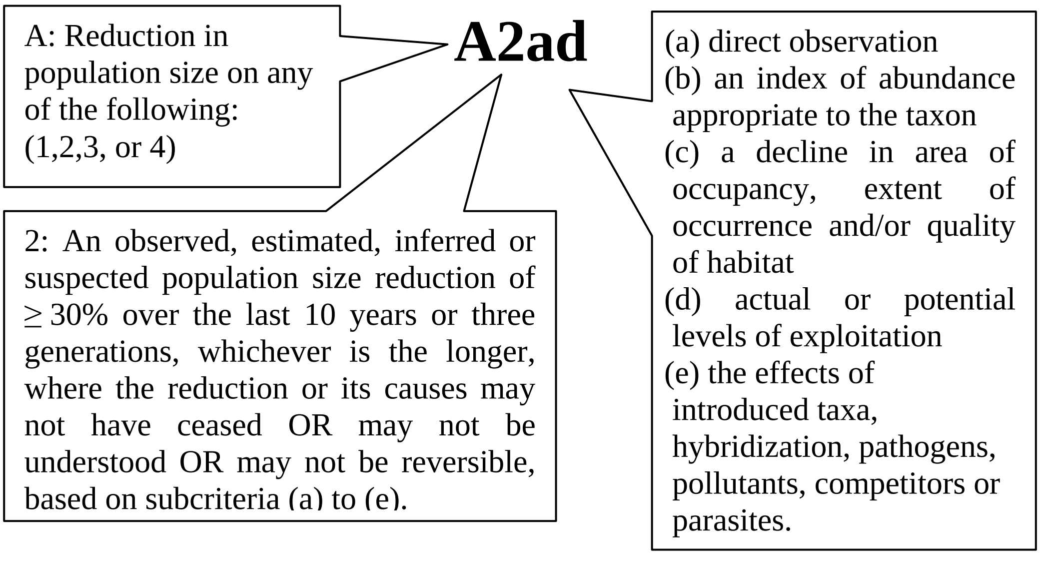


Figure 1. Explanation of the IUCN Red List category of *G. subgutturosa* (IUCN, 2008)

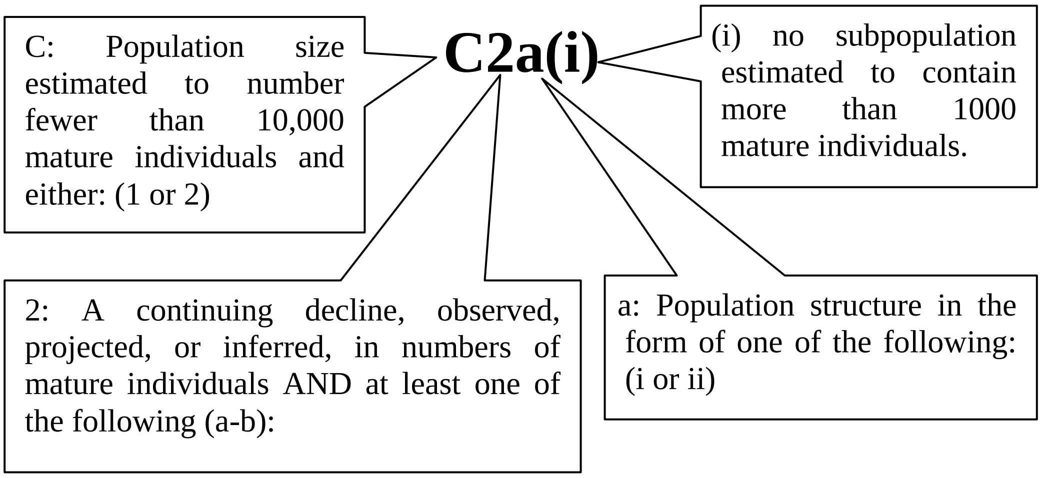


Figure 2. Explanation of the IUCN Red List category of *G. s. marica* (IUCN, 2008)

The countries signed the BERN Convention should take many conservation actions. The species listed in Appendix I, II, and III are conserved and Contracting Parties should take legislative and administrative measures (Council of Europe, 1979) (Box 2).

Box 2. Conservation actions should be taken by Contracting Parties for the species in Appendix II (Council of Europe, 1979)

Article 6

Each Contracting Party shall take appropriate and necessary legislative and administrative measures to ensure the special protection of the wild fauna species specified in Appendix II. The following will in particular be prohibited for these species:

a. all forms of deliberate capture and keeping and deliberate killing;
b. the deliberate damage to or destruction of breeding or resting sites;
c. the deliberate disturbance of wild fauna, particularly during the period of breeding, rearing and hibernation, insofar as disturbance would be significant in relation to the objectives of this Convention;
d. the deliberate destruction or taking of eggs from the wild or keeping these eggs even if empty;
e. the possession of and internal trade in these animals, alive or dead, including stuffed animals and any readily recognisable part or derivative thereof, where this would contribute to the effectiveness of the provisions of this article.

Members of CMS should take conservation measurements about migratory species; Box 3 shows some of them (UNEP, 2002).

Box 3. Some entries in CMS (UNEP, 2002)

In Article II.

In particular, the Parties:
a) should promote, co-operate in and support research relating to migratory species;
b) shall endeavour to provide immediate protection for migratory species included in Appendix I; and
c) shall endeavour to conclude AGREEMENTS covering the conservation and management of migratory species included in Appendix II.

In Article IV.

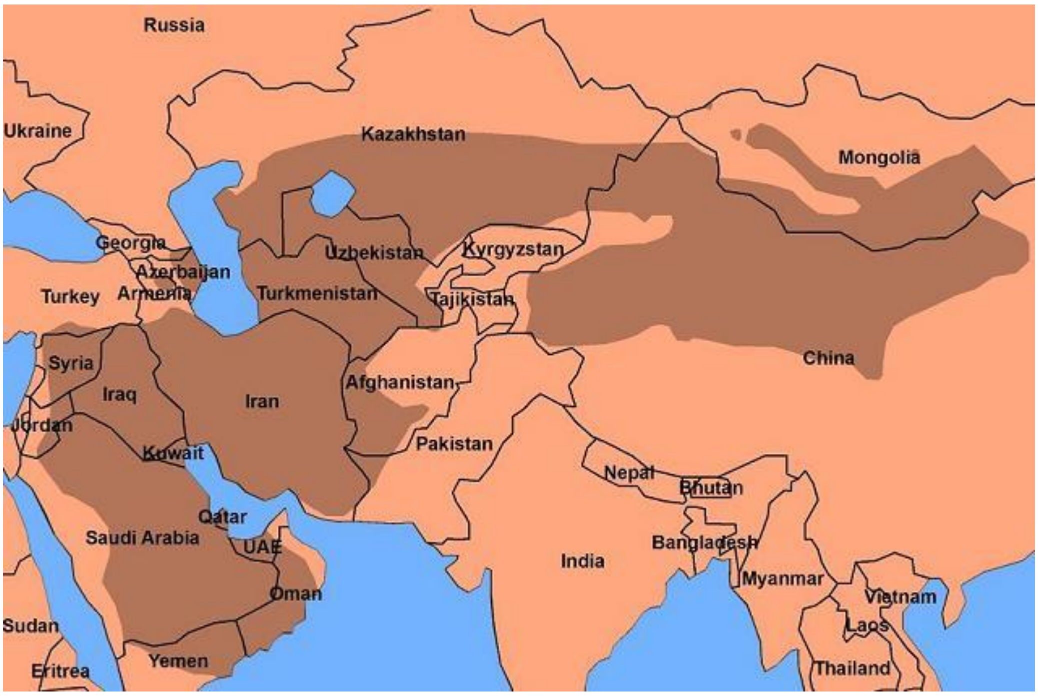
3. Parties that are Range States of migratory species listed in Appendix II shall endeavour to conclude AGREEMENTS where these would benefit the species and should give priority to those species in an unfavourable conservation status.

4. Parties are encouraged to take action with a view to concluding agreements for any population or any geographically separate part of the population of any species or lower taxon of wild animals, members of which periodically cross one or more national jurisdictional boundaries.

1.2 Worldwide Distribution and Threats Faced by Goitered Gazelle

Goitered gazelle lives in 20 countries (Table 4-5) inhabiting in a wide region on the earth from Arabian Peninsula to Central Asia across the Middle East (Figure 3). It may be extinct in Kyrgyzstan, Pakistan, Afghanistan and Yemen; and extinct in Georgia, Armenia and Kuwait; and extinct in the wild in Qatar. Their number is estimated as 120.000 – 140.000 all over the world and reported as decreasing in many countries (Mallon and Kingswood, 2001).

The main reasons of decrease in population size are poaching and habitat destruction. Habitat destruction includes agricultural expansion, animal husbandry, human settlement, and industrial enterprise expansion, road, canal, and pipeline construction, mining, and wars (Mallon and Kingswood, 2001). These are not only the case for goitered gazelle populations, but also for almost all wild species on the earth.



* Digitized from IUCN 2009 *G. subgutturosa* distribution map, Georgia, and Armenia are added although the species is extinct in these countries.

Figure 3. The distribution of *G.subgutturosa* in the world (Shaded Areas)

Illegal hunting is one of the most important factors that decreases the population size and range of goitered gazelle in the Arabian Peninsula, Central Asia and China during the last century. New inventions in firearm and vehicle technology, and road construction make the hunting easier (Kingswood and Blank, 1996; Mallon and Kingswood, 2001).

Increasing human population leads to more intense use of natural resources. As a result of increasing demands for food, more natural areas have been turned into arable lands. Decrease in suitable habitat, water and food resources are among the negative effects on the gazelles. Gazelle habitat is also deteriorated by pesticide use. Moreover, desertification as a result of intense use of groundwater resources and increasing salinity in soil is another big problem (Moulton and Sanderson, 1999; Mallon and Kingswood, 2001; Czudek, 2006).

Raising the number of domestic livestock intensifies the competition between domestic livestock and herbivores for food and water. Especially water is not abundant in desert, semi-desert and arid regions and herbivores of these regions like gazelles are more vulnerable to water scarcity. Also, overgrazing by domestic livestock creates food shortage for wild herbivores and contributes to degradation of habitats and desertification (Mallon and Kingswood, 2001; Czudek, 2006). The other damaging effect of animal husbandry on wild animal populations is epidemics. Most of the time, domestic livestock and wild animal population interactions give rise to disease outbreaks on both sides (Dazsak et al., 2000).

In addition to these disturbances, human settlement and industrial enterprise development cause to habitat loss and degradation. Besides, road, canal, and pipeline construction are resulted in habitat degradation, disintegration and isolation of wild species populations. It is more problematic for migratory species like goitered gazelles (Mallon and Kingswood, 2001; Czudek, 2006).

Furthermore, some natural causes lead to decrease in population size such as heavy snowfall, drought and ice crust known as "*dzhut*" that affects foraging of gazelles negatively. Dzhut occurs periodically approximately once every 10 – 12 years (Antipin, 1941, 1996; Heptner et al., 1988; Zhevnerov, 1984 all cited in Kingswood & Blank, 1996; Robinson and Milner-Gulland, 2003).

1.3 Recent Conditions of Goitered Gazelle in The Countries They Inhabit, Local Threats and Conservation

Goitered gazelle populations in the world are under thereat of extinction in most of inhabiting countries.

1.3.1 *G. s. marica*:

The countries *G. s. marica* is found, its conservation status, number, and threats faced are given in table 4.

Table 4. Global condition of *G. s. marica*

D: Decreasing, In (Indeterminate): Which one is true for species is unknown; endangered, vulnerable or rare.

Codes of Threats: **1** Poaching, **2** Habitat Destruction, **2a** Agricultural Expansion, **2b** Animal Husbandry – Overgrazing, **2c** Urban Expansion, **2d** Industrial Enterprises Construction, **2e** Road Construction, **2f** Pipeline Construction, **2g** War, **2h** Mining, **2i** Canal Construction, **2j** Railway Construction, **3** Live Catching of Calves, **4** Feral Dogs

Superscripts indicate the related references as follows: [1](Mallon and Al-Safadi, 2001), [2](Insall, 2001), [3](Fischer, 1999 cited in Massolo et al., 2008), [4](Mallon, 2008), [5](TERC, 2005), [6](Samour, 2001), [7](EPAA, 2003), [8](Al Hamar and Almutai, 2001), [9](SCENR, 2007), [10](Mohamed and Al Dosari, 2001), [11](Dunham et. al, 2001), [12](Kiwan et al., 2001), [13](Kingswood et al., 2001a), [14](Kingswood et al., 2001b), [15](Al-Robaae and Kingswood, 2001)

Countries	Conservation Status	Number	Trend	Threats
Yemen	EX?[1]	?	?	1[1], 2d[1], 2e[1]
Oman	EN[2]	<2500[3]	D[4]	1[2], 2a[2], 2b[2], 2c[2], 2d[2]
United Arab Emirates	VU[5]	up to 1000[4]	?	1[6], 2b[6], 2d[6], 2e[5]
Qatar	EW[7]	>2000 in fenced reserves and private collections [8,9]	?	2a[8,9], 2b[8,9], 2d[8,9]
Bahrain	Satisfactory[10]	800 – 900[4]	?	2c[10]
Saudi Arabia	VU[11]	2650- 3050[4]	?	1[11], 2b[11]
Jordan	EN[12]	< 100[12]	D[12]	1[12], 2a[12], 2b[12]
Kuwait	EX[13]	-	-	1[13],2a[13],2b[13], 2c[13], 2d[13], 2g[13]
Syria	In [14]	-	?	1[14], 2 a[14],2b[14]
Iraq	VU[15]	up to 1000[15]	?	1[15],2a[15],2b[15], 2d[15], 2f[15], 2g[15]

1.3.1.1 Yemen:

There is not any specific scientific study related to Arabian sand gazelle in Yemen. Mallon and Al-Safadi (2001) stated that, the first conservation action for goitered gazelles in Yemen was the hunting prohibition of all gazelle species in the country for 10 years in 1977. However, the law has not been revised in following years, and today there is not a conservation law or protected area for gazelles. The gazelles which were sighted in 1997 lastly were probably Arabian sand gazelle.

1.3.1.2 Oman:

The first attempt to protect wild fauna of the Oman was prohibition hunting of some mammal species including antelopes of the country in 1976. The hunting law was updated and extended in 1993. Arabian Oryx Sanctuary was found in 1994 and contains Arabian Oryx (*Oryx leucoryx*), Arabian sand gazelle, and mountain gazelle (*Gazella gazella*). An advisory group was formed for antelope conservation action and management plans called "Terrestrial Mammal Group" in 1996. There is a national park containing Arabian sand gazelle in Jebel Samhan region and two reserves also contain gazelle populations; The Jiddat – al- Harasis and Al Hikman. Al Hikman population may be extinct. Also, ranger units protect the gazelle in some regions of the country (Insall, 2001; EPAA, 2003).

1.3.1.3 United Arab Emirates:

Samour (2001) reported that, rheem gazelle is rare or extinct in many of the previous inhabited areas since 1950s; they live on some offshore islands and a few protected areas in UAE. The first governmental action for specific conservation covering Arabian sand gazelle is hunting prohibition law at 1983, which is still in operation. One of the important breeding centers of Arabian Peninsula, Breeding Centre for Endangered Arabian Wildlife (BCEAW) was established in 1998 by a private company called Animal Management Consultancy, and it contains important species of Arabian Peninsula including Arabian sand gazelle (BCEAW, date unknown). Also, there is a captive rheem gazelle population in some protected areas in UAE (El-Keblawy, 2009). Rheem gazelle still survives in the wild in Umm Al Zummoul region (TERC, 2005).

1.3.1.4 Qatar:

Rheem gazelle does not exist in the wild in Qatar. The largest population is living in a private collection (Al Hamar and Almutai, 2001; EPAA, 2003). There are also two captive breeding centers namely Shahaniya – 1000 individuals-, Mas'habia – 500 individuals-. They live also in Ras Osheirij and Khor Al Odaid Protected Areas. In 2002, 100 and in 2004, 30 Arabian sand gazelles were reintroduced to some protected areas where hunting was banned (SCENR, 2004; SCENR, 2007).

1.3.1.5 Bahrain:

Rheem gazelle status in Bahrain is satisfactory according to Mohamed and Al Dosari (2001). Establishment of Al Areen Wildlife Park where Arabian sand gazelle also survive was the first attempt of conservation at 1976. Also, in Bahrain, all kinds of hunting have been prohibited. (Mohamed and Al Dosari, 2001) They are also reintroduced to several open protected deserts and Hawar Islands, and they are being monitored effectively (PCMREW, 2006).

1.3.1.6 Saudi Arabia:

G. s. marica has been living in several protected areas in Saudi Arabia. Gazelle hunting is banned throughout the country. King Khalid Wildlife Research Centre (KKWRC), Al-Sudairy Gazelle Centre and Qassim Research Centre have captive rheem gazelle populations (Mallon and Kingswood, 2001; EPAA, 2003, NCWCD, 2005). Between the years 1991-94, 164 and in 1995-96 210 Arabian sand gazelles were released to some of the protected areas (Haque and Smith 1996; Dunham et al., 2001; Czudek, 2006).

1.3.1.7 Jordan:

There is not much information about the Arabian sand gazelle in Jordan. All information, even if few, are in the IUCN Antilopinae Specialist Group publication of “Antelopes: Global Survey and Action Plans” and Convention on Biological Diversity reports of Ministry of Environment. Hunting of Jordanian gazelles has been banned since 1973. *G. s. marica* is conserved in several wildlife reserves in Jordan. There may be a small population of rheem in Burqu region (Kiwan et al., 2001; MoE, 2009).

1.3.1.8 Kuwait:

Arabian sand gazelle is considered as extinct in Kuwait. Before 1990, a faunal survey was performed covering the whole country, but any gazelle was recorded. The last record of Arabian sand gazelle was dated to 1972 (Kingswood et al., 2001a).

1.3.1.9 Syria:

Two subspecies, *G. s. subgutturosa* and *G. s. marica* are found in Syria; also it is possibly hybrid forms between these are present. Small populations still survive in several protected areas. Considering the geographical distribution of the two subspecies, records of goitered gazelle from south and central part of the country are Arabian sand gazelle and populations in northern Syria are probably Persian gazelle populations. There are two wild small populations of Arabian sand gazelle in central and southwest Syria near Syria-Jordan border. The other records can be Arabian sand gazelle, Persian gazelle or hybrids of them. (Kingswood et al, 2001b). A FAO (Food and Agriculture Organization of The United Nations) project covering the re-introduction of Arabian sand gazelle into the At Talila Wildlife Reserve has been conducted between the years 1996 – 2004 and 30 were reintroduced to same reserve in 1996. Their number has increased to 367 in 2004 (ICARRD, 2006).

1.3.1.10 Iraq:

Iraq has also two subspecies of goitered gazelle as in Syria, *G. s. subgutturosa* and *G. s. marica*. It is possible that they can be hybrids of these subspecies. Arabian sand gazelles live in near the southeast region of the country, the area along the Jordanian border. The size of that population was estimated as 1000 in 1996 (Al-Robaae and S.C. Kingswood, 2001). Their condition after the Iraq occupation by USA in 2003 is unknown, their habitat is probably deteriorated.

1.3.1 *G. s. subgutturosa*:

The countries *G. s. subgutturosa* is found, its conservation status for country, number, and threats faced are given in table 5.

Table 5. Global condition of *G. s. subgutturosa*

D: Decreasing, I: Increasing, S: Stable, In (Indeterminate): Which one is true for species is unknown; endangered, vulnerable or rare. Satisfactory: Population size is not lower than viable population size.

Codes of Threats: **1** Poaching **2** Habitat Destruction, **2a** Agricultural Expansion, **2b** Animal Husbandry – Overgrazing, **2c** Urban Expansion, **2d** Industrial Enterprises Construction, **2e** Road Construction, **2f** Pipeline Construction, **2g** War, **2h** Mining, **2i** Canal Construction, **2j** Railway Construction, **3** Live Catching of Calves, **4** Feral Dogs

Superscripts indicate the related references as follows: [1] (Ölçer, 2001), [2](Çobanoğlu, 2010), [3](TİGEM, 2009), [4](Turan, 1977), [5](Kingswood et al., 2001a), [6](Al-Robaae and Kingswood, 2001), [7](Hemami and Groves, 2001), [8](Nowzari et al., 2007), [9](Zachos et al., 2009), [10](Mallon, 2008), [11](Mallon and Kingswood, 2001), [12](Zazanashvili et al., 2006), [13](Shchadilov and Hadjiev, 2001), [14](Burmester, 2005), [15](Shavgulidze, 2001), [16](NBSAP, 2005), [17](Sheikh and Molur, 2004), [18](Habibi, 2001), [19](MoAIL, 2009), [20](Habibi, 2001), [21](Gorelov, 2001), [22](Marmazinskaya and Mardanov, 2001), [23](Bekenov et al., 2001), [24](Czudek, 2006), [25](Abdusalyamov, 2001), [26](Toktosunov and Mallon, 2001), [27](Jiang and Sung, 2001), [28](Clark et al., 2006), [29] (Lhagvasuren et al., 2001)

Countries	Conservation Status	Number	Trend	Threats
Turkey	EN[1]	317 wild[2] 1530 captive[3]	S[2]	1[2,4], 2a[2,4], 2b[2,4], 3
Syria	In [5]	?	?	1[5], 2a[5], 2b[5]
Iraq	VU[6]	500[6]		1[6], 2a[6], 2b[6], 2d[6], 2f[6]
Iran	VU[7]	> 9045 in protected areas[7], extinct outside the protected areas[8,9]	D[10]	1[7,8,9], 2a[7,8], 2b[7,8], 2g[7], 2h[7]
Armenia	EX[11,12]	-	-	1[12], 2a[12],2d[12]
Azerbaijan	EN[13]	4000[10]	?	1[13],2a[14], 2b[14], 2d[14], 2e[14], 2g[13], 2i[14]

Table 5. (cont.)

Countries	Conservation Status	Number	Trend	Threats
Georgia	EX[15]	-	-	1[15, 16], 2a[16]
Pakistan	CR[17]	< 50[17]	?	1[17,18], 2a[17], 2b[17], 2h[15]
Afghanistan	EX?[19,20]	-	-	1[19,20], 2a[20], 2e[20], 2g[20]
Turkmenistan	VU[21]	4000 – 5600[21]	?	1[21], 2e[21], 2i[21]
Uzbekistan	EN[22]	8000 - 10000[22]	?	1[22], 2a[22], 2b[22], 2c[22], 2d[22], 2e[22], 2j[22]
Kazakhstan	VU[23]	< 15000[10]	D[10]	1[23,24],2a[23,24],2b[23,24], 2d[23,24]
Tajikistan	EN[25]	70 - 80[25]	D[25]	1[25], 2b[25],2c[25]
Kyrgyzstan	EX? [26]	?	?	1[26], 2b[26],2e[26], 4[26]
China	VU[27]	?	?	1[27],2a[27],2b[27],2c[27],2e[27]
Mongolia	VU[28]	60000[28]	?	1[29], 2b[29], 2j[28]

1.3.2.1 Syria

The condition of goitered gazelles in Syria is explained in part 1.3.1.9.

1.3.2.2 Iraq

The condition of goitered gazelles in Iraq is explained in part 1.3.1.10.

1.3.2.3 Iran

Most of the goitered gazelle populations in Iran have been living in several national parks, wildlife refuges and protected areas. Hunting is banned in specified times of the year (Hemami and Groves, 2001). According to Nowzari et al. (2007) and Zachos et al. (2009), Persian gazelle is extinct or nearly extinct outside the protected areas.

1.3.2.4 Armenia

Goitered gazelle is extinct in Armenia (Mallon and Kingswood, 2001). They were found in Araz (Araks) Valley in Armenia. The major causes of extirpation Persian gazelle in Armenia are poaching, habitat loss by agriculture and expansion of oil industry (Zazanashvili et al., 2006).

1.3.2.5 Azerbaijan

Persian gazelles live in Shirvan Nature Reserve and Gerchay Wildlife Sanctuary in Azerbaijan and survive outside the protected areas only in Kura Lowlands (Zazanashvili et al., 2006). Establishment of the Shirvan Nature Reserve in 1969 is the most important conservation action for the gazelles of Azerbaijan, they were almost extinct in those years. Conservation studies have continued to recent years and Shirvan Nature Reserve was closed to domestic livestock grazing and artificial water sources were built in 2000s.Gazelle hunting is illegal since 1959 (Shchadilov and Hadjiev 2001; Burmester, 2005).

1.3.2.6 Georgia

Persian gazelle is extinct in Georgia. The last records are dated to 1980s. In 1988, 10 goitered gazelles were transferred from the Bukhara Captive-Breeding Centre-Uzbekistan, and reintroduced to Vashlovani Nature Reserve where they formerly inhabit, but the result was not successful because of disease and wolf predation (Shavgulidze, 2001).

1.3.2.7 Pakistan

Goitered gazelle populations in Pakistan have drastically decreased due to mainly hunting. Current condition is unknown but the remnant goitered gazelle population size is considered to be less than 50 (Sheikh and Molur, 2004). Hunting is prohibited in the country but it is not effectively implemented (Habibi, 2001).

1.3.2.8 Afghanistan

Although all hunting activities were banned for five years in 2005, goitered gazelle is possibly extinct in Afghanistan The prolonged war in the country and illegal hunting are the major causes of extirpation, current status is unknown (Habibi, 2001; MoAIL, 2009).

1.3.2.9 Turkmenistan

The decrease in goitered gazelle number has continued throughout the century in Turkmenistan. The largest remnant populations survive in southern part of Turkmenistan and and smaller populations may be living in northern Turkmenistan. Hunting gazelles was banned in 1950 and the law was updated in 1991 (Gorelov, 2001; Czudek, 2006). In 2001, they were living in five nature reserves, and one hunting reserve (MoNP, 2002).

1.3.2.10 Uzbekistan

The specific conservation action is a goitered gazelle breeding centre near the city Bukhara. This centre was established in 1977 and named Goitered Gazelle Ecocentre. Number of the founder individuals was 36, and reached to 621 in 1996 (Pereledova, 1998; Marmazinskaya and Mardanov, 2001**).** In addition, there are some small gazelle populations in Kyzylkum Nature Reserve, Tudakul Nature Sanctuary, and Dengizkul Nature Sanctuary. Hunting goitered gazelles has been banned since 1950 (Marmazinskaya and Mardanov, 2001).

1.3.2.11 Kazakhstan

The second largest goitered gazelle population is living in Kazakhstan even though there is a decreasing trend of population size. The gazelles live on both in and outside of the protected areas. There are 5 protected areas inhabited by goitered gazelles. Hunting goitered gazelles was banned in 1951 (Bekenov et al., 2001).

1.3.2.12 Tajikistan

Tajikistan is not very suitable for goitered gazelles because of the mountainous landscape of the country. In spite of this and human caused difficulties, Persian gazelle has still survived in Tajikistan. They are found in a Nature Reserve and small groups are also seen unprotected areas. Goitered gazelles have protected by law in the country (Abdusalyamov, 2001).

1.3.2.13 Kyrgyzstan

Like Tajikistan, Kyrgyzstan has also unsuitable habitats for goitered gazelle; most of the country is mountainous. Goitered gazelles were very abundant in suitable areas of the country in 1930s – 1940s, and in the 1950s they started to decrease. Gazelle population size was estimated as 50 in 1985. They are protected by law but whether or not they exist in Kyrgyzstan is unknown (Toktosunov and Mallon, 2001).

1.3.2.14 China

Like in the other countries, the number of goitered gazelle has decreased drastically in China in the last century. Current number is unknown but it is reported that they occur in small numbers both in and outside protected areas. Threatened species of China was categorized in two classes according to “Namelist of State Key Protected Wildlife Species” drawn up 1989. Category I includes the most threatened species, and Category II covers the lesser concern species. Hunting of Category I species is banned and controlled hunting may be allowed for Category II species. Goitered gazelle is in Category II, and also it has been under legal protection since 1980 (Jiang and Sung, 2001).

1.3.2.15 Mongolia

Mongolia has the largest goitered gazelle population in the world. However, the number has declined since the middle of the century. They live both in and outside of the protected areas. There are four protected areas. Hunting of goitered gazelles was prohibited in 1965 (Lhagvasuren et al., 2001).

1.3.3 *G. s. hillieriana* and *G. s. yarkandensis*

The least known *G. subgutturosa* subspecies are *G. s. hillieriana* and *G. s. yarkandensis,* even though *G. s. hillieriana* is one of the largest numbered population of the subspecies. Mallon (2008) stated that their number is higher than 60000. There is some information on their morphology but none on their ecology. *G. s. hillieriana* lives in two countries; China and Mongolia, and *G. s. yarkandensis* only in China (Groves, 1985; Kingswood and Blank, 1996; Clark et. al, 2006).

1.4 Distribution History of *G. s. subgutturosa* in Turkey, and Local Threats

Goitered gazelle had been living in the area extended from Hatay to Cizre (Şırnak) and Iğdır lowland at the beginning of 1900s (Turan, 1984; Ölçer, 2001). However, the gazelle species in Hatay is recently identified as *G. gazella* and map shows the distribution from Gaziantep to Cizre (Figure 4). In 1940 - 50s, the distribution became narrower from Suruç (Şanlıurfa) to Cizre along the Syria border (Figure 5) (Turan, 1977; 1984; Ölçer, 2001). Ongoing years, the gazelle population has continued to decline and today, they are living only in Şanlıurfa. The reasons of this decrease are illegal hunting, live catching of calves, agricultural expansion and pesticide use (Turan, 1977; Ölçer, 2001).

Figure 4. Distribution of *G. s. subgutturosa* in Turkey at the beginning of 20.th century (bright orange areas) (Turan, 1977; 1984; Ölçer, 2001)

Figure 5. Distribution of *G. s. subgutturosa* in Turkey between the years 1940 - 1950 (bright orange area) (Turan, 1977; Ölçer, 2001)

Illegal hunting is the problem of many large mammals as for goitered gazelle. This is one of the major causes of the decrease in goitered gazelle population in Turkey (Turan, 1977). In spite of hunting ban, most of the goitered gazelle populations of other countries have suffered from poaching (Mallon and Kingswood, 2001; Mallon, 2008).

Another reason is live catching of newborns in the breeding season. Some people are interested in calves as a pet, since they are good-looking and easily domesticated animals. They can also be caught easily in the field by motorcycles and off-road vehicles and using a powerful floodlight projector (Turan, 1977).

The last major reason is the pesticides; they were heavily used by farmers in 1950s (Turan, 1977). The chemicals in pesticides can be harmful not only for pests, but also for many nontarget organisms living near the areas pesticides used, since they are dispersed to soil and water, and taken up by plants and therefore, herbivores and carnivores also take them (Pollock, C. G., 2001).

In addition to these historical causes of decrease, overgrazing pressure by domestic livestock and feral dogs also affects goitered gazelle populations negatively today. Campos-Arceiz et al. (2004) showed that there is competition for food between domestic livestock and Mongolian gazelle (*Procapra gutturosa*). They found big food overlap between domestic sheep and goats, and Mongolian gazelle and it is possible that the case is similar in goitered gazelles and domestic livestock. Shepherd's and villagers' dogs are also a problem for gazelles. They are also a potential threat for calves. Manor and Saltz (2003) showed clearly the negative correlation between feral dog presence and kid/female ratio of mountain gazelles (*Gazella gazella gazella*) in Israel.

1.5 Conservation Actions in Turkey

The first conservation action of *G. s. subgutturosa* in Turkey was a hunting prohibition law, put into practice at 1957 in order to prevent the critical decrease in goitered gazelle population. In the field survey of Turkish General Directorate of Nature Conservation and National Parks in 1968, population size was estimated near 3000. After this year, as a result of continuing decrease in size in spite of conservation efforts, a breeding centre was established in the Ceylanpınar Agriculture Enterprise – Şanlıurfa at 1977 when the population size dropped to 300. One year later, 3 female, 1 male, and 1 calf were placed into the centre (Turan, 1977; Ölçer, 2001). The gazelle had increased in number in this centre for years (Table 6) (TİGEM, 2009) and some of them were transferred to other breeding centers in Şanlıurfa, Malatya, and Gaziantep. In 2005, 86 individuals were released to wildlife in the Kızılkuyu Wildlife Development Area that they had lived previously (TÜBİTAK, 2006). The second release was performed in 2008 and 15 individuals, 7 of adult females GPS collared, were released to the same area and monitored frequently. The composition of the released animals is, 12 adult (a male, 9 female) and 3 calve (2 male and 1 female). Today, the number of Ceylanpınar captive population is 1530 (TİGEM, 2009) and native and released population size is estimated as 317 in 2009 (Çobanoğlu, 2010).

Table 6. The number of gazelles in the Ceylanpınar Breeding Centre between the years 1978 – 2009 (Turan, 1977; Ölçer, 2001; TİGEM, 2009)

Year	Total Number of Gazelles	Number of Females	Number of Males	Number of Calves
1978	5	3	1	1
1995	812	?	?	?
2006	1219	501	718	?
2008	1569	?	?	392
2009	1530	?	?	?

1.6 Description of *G. s. subgutturosa*

The name "Goitered gazelle" comes from the male outward swelling of larynx in the rut period. Some of the body measurements presented in literature for males and females respectively; weight, 20 – 43 kg, and 18 - 33 kg (Heptner et al., 1988 cited in Kingswood and Blank, 1996); body length 94 – 126 cm, and 94 – 120 cm (Zhevnerov and Bekenov, 1983 cited in Baskin and Danell, 2003); and shoulder height 58 – 79.5 cm, and 56 – 76.5 cm (Kingswood and Blank, 1996). Male individuals have formal horn with 20.3 – 43 cm long, but some females also have asymmetric deformed horn (Kingswood and Blank, 1996). Colour of horn is black and curved backward as gazelle grows, and its tips curled up. Their life span is 5 – 6 years for males, and 8-12 years for females (Zhevnerov and Bekenov, 1983 cited in Kingswood and Blank, 1996).

Their pelage colour is variable and depends on the soil colour of the living area and season. It changes from light brown to shades of grey. Their winter pelage is longer, denser and paler than summer pelage. They molt two times in the year; spring and autumn**.** Whitish parts of the body are chest, belly, inner forelegs, and body part between hind legs and tail. Dorsal part is brownish till belly. The forehead and nose are whitish and there is a dark line between eye and nose. Tip of nose and mouth part are darker (Turan, 1984; Kingswood and Blank, 1996; Baskin and Danell, 2003; Clark et al., 2006).

1.7 Ecology, Social Organization, Ontogeny and Behaviour

Goitered gazelle lives in arid semi-desert, hilly plains (Figure 8) and feed on steppe plants, roots, and grasses (Figure 9). Most of the gazelle activity, walking and grazing occurs in the early morning and late afternoon all over the year. Especially in summer, they rest in shades if there are and among rocks in the hottest midday. In winter, midday resting time can be reduced (Kingswood and Blank, 1996; Baskin and Danell, 2003).

They are mostly found in groups, but size and composition of groups change with season. Generally, groups consist of females, offspring and young males. In the rutting season, females and young form larger groups than anytime of the year. Single adult males join the group and establish its harem consisting of 2-12 females. Adult males are more territorial in rutting and not allowed other males to come closer. They frequently chase females in order to keep them in territory. Frequent bellows and marking their territory by dung piles, urines, or some glandular secretions are characteristic behaviours of the adult males in this season. Sub-adult males gather in bachelor groups. Bachelors do not have territories; they walk, graze and rest in all day. After the rut, adult males can join bachelor groups or remain single (Kingswood and Blank, 1996; Baskin and Danell, 2003).

Goitered gazelle is very vigilant and when they detect a threat near, immediately runs away about 200 – 300 meters, and stops to look backward to assess the threat. They can recognize danger at 2 km distance by sight and 300 – 400 m by sound. They are good runners; they can reach the speed of 60 kmph. They have a characteristic gait when disturbed; they run away by jumping called “stotting” However, they are not stotting when galloping (Kingswood and Blank, 1996; Baskin and Danell, 2003).

Since goitered gazelles are adapted to arid climates, they are very resistant to thirst. However, they need water even in lesser amount to survive; they can search for water sources in summer (Kingswood and Blank, 1996; Baskin and Danell, 2003). In Central Asia, they migrate from northern steppes to southern deserts in winter for finding best food availability because of the deep snow cover and reverse movement in summer for searching for water (Kingswood and Blank, 1996).

Figure 6. A grazing male

Figure 7. A calf and a horned mother

Figure 8. General view of the goitered gazelle habitat in Şanlıurfa

Figure 9. Vegetation covers of goitered gazelle habitat in Şanlıurfa

The predators of goitered gazelles are wolves, caracals, hyena and historically tigers. Newborns can be prey for foxes, feral dogs and birds of prey (Kingswood and Blank, 1996; Baskin and Danell, 2003).

Because of the wide distribution of goitered gazelle and climatic differences in distribution area, mating and parturition times are different in northern and southern populations. Southern populations mate earlier, between September and November, than northern populations, between December and January, and so parturition is also earlier, between March and May in southern, and, May and July in northern populations. (Heptner et al., 1988, cited in Kingswood and Blank, 1996). Parturition takes place after 5-6 months gestation period. Calving season coincides with richest food availability following heaviest rainy period. Females leave the groups for a few weeks to give birth, and then join the groups again. After birth, calves are hidden in the shrubs, cavities, and behind the stones by their mothers to camouflage (Figure 10). Females can give birth to single calf or twin calves. Lactation period takes place for 2 – 3 months, nursing periods decrease as calf grows. After 5-10 days newborns feed on grasses in addition to milk, and after 3 months, they feed only plants. Mother grazes near the calf carefully, and is more sensitive to any changes in the environment. After calves gaining strength nearly in 1 week, they start to give up hiding and stay in their mothers. Females reach sexual maturity at 6-18 months of age and males at 12 months. (Kingswood and Blank, 1996; Baskin and Danell, 2003). Testicle diameter of 20 mm determines the sexual maturity in males, but they do generally not mate before the 1.5 – 2.5 age (Kingswood and Blank, 1996).

Figure 10. A hidden calf

1.8 Supplementation, Re-introduction and Captive Breeding

In the IUCN Guidelines re-introduction is defined as “an attempt to establish a species in an area which was once part of its historical range, but from which it has been extirpated or become extinct…” and supplementation as “addition of individuals to an existing population of conspecifics” (IUCN, 1998). The guideline covers both re-introductions and supplementation and both types of study are so similar that they can be considered in the same context in many aspects. Due to the closeness of two concepts, the term re-introduction is used for covering both terms. The aim of re-introductions is establishment of self-sustaining viable populations in an area that previously inhabited by re-introduced animal. Success of re-introduction programs strictly depends on its design; the number, sex and composition of released animals, the knowledge of social structure of species and choice of re-introduction site and time should be evaluated carefully (Akçakaya et al, 1999).

According to IUCN Guidelines for Re-introductions prepared by IUCN Species Survival Commission's Re-introduction Specialist Group, there are some necessities before and after the re-introduction. Before the re-introduction, a taxonomic evaluation of re-introduced individuals should be made and they are chosen from the same taxon. If a remnant population survives, it would be investigated for determining important requirements of animals. If species is extirpated in the wild, close species could be searched. In order to gain insights about the fate of re-introduction, population and habitat variables should be modelled by using population viability analysis. Re-introductions of similar species should be searched for gaining experience and insight. Re-introduction site should be within the former range of the animal and should satisfy habitat requirements of the species. In addition, re-introduction site should be adjusted as reducing potential disturbances on the animals. Security of re-introduced population should be assessed by searching the reasons of extinction, and negotiated with local people. If there is a failure risk, the site should be abandoned and alternative sites should be considered. The health and survival of the re-introduced population should be monitored and genetic screening should be made. Post release monitoring of animals is quite important for intervening process when necessary. Population parameters of the population, fecundity, survival and death rate should be searched. These points are some of the important entries in the IUCN Guidelines for Re-introductions. This guideline should be followed for better re-introduction programs (IUCN, 1998).

Captive populations are the source of re-introduction programs. The main goal of captive breeding is maintaining genetic diversity and viability of captive populations. Genetic processes in captivity deeply affect the success of re-introductions. Genetic deterioration of captive populations could be the result of inbreeding depression, loss of genetic diversity, accumulation of new deleterious mutations, adaptation to captivity in genetic level, and relaxation of natural selection. Many captive populations are small in population size and suffer from inbreeding. Also, “bottleneck” at the foundation stage causes the loss of genetic diversity if founder population is small. These problems can be overcome by an effective genetic management. Maximizing both the ratio of effective population size and population size, and minimizing kinship among the individuals in the captive population can be solution. However, it is very hard to put them into practice, and they are not realized in most of the captive breeding programs. The other problem related to small founder population is the accumulation of new deleterious mutations and increasing the frequency of deleterious alleles that founder individuals are already have. Detecting and removing affected individuals is the only solution. However, the elimination of deleterious alleles is more difficult if they are recessive and carried by heterozygote individuals. Animals translocated from wild to captivity have subjected to new environmental conditions, and the population tend to adapt to new conditions due to the change in selection pressure. New conditions may change the courtship, mating, breeding, predator avoidance and prey capture behaviour of captive animals. To prevent the change in selection pressure in captivity, the environment should be kept as close as in wild conditions (Frankham et al., 2004).

Loss of genetic diversity is more problematic for small captive populations and adaptation to captivity for large captive populations. An alternative captive breeding management has been developed for solving the conflict of single large or several small (SLOSS). Fragmented and partially isolated several small sub-populations with exchanges of individuals between them can prevent the loss of genetic diversity and adaptation to captivity (Frankham et al., 2004).

1.9 Home Range

Kernohan et al. (2001) defines the home range as "the extent of an area with a defined probability of occurrence of an animal during a specified time period". Habitat selection and home range size of a re-introduced threatened species are among the most important information for conservation biologists, managers and administrators when choosing re-introduction site and determining the size of the conserved area (Özüt, 2009). Besides, Kernohan et al. (2001) state that, seasonal and sexual variations in animal behaviour may lead to changes in home range size and habitat selection and they are significant for conservation actions. The factors affecting home range accuracy can be listed as;

1- The time interval between successive locations (Swihart and Slade 1985),
2- The number of observations (Seaman et al., 1999),
3- The data collection technique (Adams and Davis 1967).

Time interval and sample size are dependent on each other. Increasing time interval decreases the sample size but the data show autocorrelation in the opposite case. There is always a trade-off between sample size and time interval between consecutive locations (Hansteen et al., 1997). Seaman et al. (1999) showed that sample size required for home range estimation is different in various home range estimators with different bandwidth selection techniques. For instance, fixed kernel is required for sample size of over 50 with least square cross validation technique, and adaptive kernel works fine in smaller sample sizes (<50).

The most widely used data collection method is radiotelemetry. In this technique, a transmitter is placed on the animal, and gives the signal with a previously determined radio frequency. Triangulation method is used for obtaining the location of an animal if direct observation is difficult. This method requires at least three people that encircled the animal. They measure the direction of signal and three directions crossed for finding the location of animal. Most of the time it does not give a single point datum, rather it gives an area. However, if the study area is suitable for direct observation by following the signals, the collected data are more reliable and home range estimate is more accurate. This method is called “homing”. The main disadvantages of these techniques are labour intensive and time consuming (Mech, 1983 cited in Mech and Barber, 2002). On the other hand, time and labour efficient “GPS telemetry” is one of the newest techniques for monitoring animal populations in the wild. It can give the researcher more reliable and abundant data. Also, time of day is not important to take a GPS fix, in VHF telemetry, daylight is necessary for people to work. Major drawback of the GPS telemetry is high cost of the GPS collars.

Home range of an animal can be estimated by using many techniques like kernel density estimations, minimum convex polygon, and cluster analyses. Minimum convex polygon is the most widely used method since it is one of the first developed techniques. Seven crucial criteria are used for assessing robustness of the home range estimator. These criteria and the scores of 12 estimators are shown in table 7. Each estimator has a score of 0 or 1 for each criterion, and total maximum score is 7. The use of kernel approach is suggested because of its superiority in many criteria to the other methods (Kernohan et al., 2001).

Some estimators do not estimate a realistic home range with small sample sizes like minimum convex polygon, concave polygon and grid cell count (Doncaster and Mcdonald, 1991). Autocorrelation means successive relocations are not independent. This is the case for the datasets with lower time intervals between consecutive locations. If an estimator not sensitive to autocorrelation in data is more robust than autocorrelation sensitive estimators (Kernohan et al., 2001). Utilization of the distribution calculation makes an estimator better, since if an estimator can calculate the utilization distribution, it calculates the occurrence probability of an animal at one location by using relative frequency of all occurrences (Millspaugh et al., 2000). Nonparametric estimators are free of underlying statistical distribution of the data and it is good for home range evaluation (Kernohan et al., 2001). An animal can use more than one area and estimators’ ability to calculate multiple centres of activity reflects the spatially heterogeneous structure of home range

(Hodder et al., 1998; Kernohan et al., 2001). Effect of outliers on home range estimation is so immense that outlier sensitivity makes an estimator less reliable (Ackerman et al., 1990). The last criterion, comparability is not very crucial criterion than the other criteria, but it is a good property for an estimator (Kernohan et al., 2001).

Table 7. Evaluation of 12 home range estimators[a] relative to 7 criteria (Kernohan et al., 2001)

[a]Each criterion could receive one (1) point, and score represents the sum of those points.
[b]Calculated home range extent often stabilizes with ≤ 50 location points.
[c]Estimator is less sensitive to autocorrelated data.
[d]UD: Utilization Distribution - Estimator calculates home range boundary based on the complete utilization distribution.
[e]Estimator is nonparametric.
[f]Estimator calculates multiple centers of activity.
[g]Estimator is less sensitive to outliers.
[h]Estimator is comparable to other estimators when using the same dataset.

Home Range Estimator	Sample Size[b]	Auto-correlation[c]	UD[d]	Non-parametric[e]	Center of activity[f]	Outliers[g]	Com-parability[h]	Score
Minimum convex polygon	0	1	0	1	0	0	1	3
Peeled polygon	1	1	0	1	0	0	1	4
Concave polygon	0	1	0	1	0	0	1	3
Cluster analysis	1	1	0	1	1	0	1	5
Grid cell count	0	1	0	1	1	0	1	4
Jennrich-Turner	0	0	1	0	0	0	1	2
Weighted bivariate normal	0	0	1	0	0	0	1	2
Dunn estimator	0	0	1	0	0	0	1	2
Fourier series smoothing	0	0	1	1	1	1	0	4
Harmonic mean	0	0	1	1	1	1	0	4
Fixed kernel	1	1	1	1	1	1	0	6
Adaptive kernel	1	1	1	1	1	1	0	6

The bandwidth value also named as smoothing parameter is very important parameter of the kernel density estimation and it determines the smoothing amount applied to the input data by controlling width of individual kernels. Small bandwidth means less smoothing and the output is composed of many local peaks and valleys. Large bandwidth increase the smoothing of data and local peaks and valleys disappear and the output shape looks like a smoothed single surface (Kernohan et al., 2001).

There are many bandwidth selection methods, most frequently used ones in ecological studies are the reference bandwidth (h_{ref}), and least squares cross validation (h_{lscv}) (Seaman and Powell, 1996; Seaman et al., 1999; Millspaugh et al., 2006). In literature, generally h_{lscv} is recommended (Seaman et al., 1999) but there is no best smoothing parameter; it may vary with the aims of the study, number of observations, and space use patterns of the study species (Worton, 1995; Gitzen and Millspaugh, 2003; Gitzen et al., 2006). Both methods calculate the smoothing parameter differently in an automated way. h_{ref} takes into account the variation of x and y coordinates, and h_{lscv} estimates bandwidth in a way that minimizing the difference between true and estimated distributions (Worton, 1995). h_{ref} is more suitable for unimodal distributions, whereas h_{lscv} for bimodal and multimodal distributions. h_{lscv} method is used more commonly than h_{ref} and selects smaller bandwidth values. Home range of an animal is composed of fragments in h_{lscv} (Gitzen and Millspaugh, 2003). In addition to two mentioned common methods, the plug-in approach may also be useful technique in case of high sample sizes like GPS telemetry studies (Amstrup et al., 2004). Gitzen et al. (2006) also recommend the use of plug-in techniques in studies with large datasets. They show the failure of h_{lscv} technique in multimodal distributions when sample size is higher than 150. Plug-in methods estimate the ideal bandwidth by using additional bandwidths related to ideal one (Park and Marron, 1990 cited in Bowman and Azzallini, 1997, pp34).

There are two types of kernel methods differing in bandwidth selection (smoothing parameter, h) method; adaptive kernel and fixed kernel. Bandwidth is defined as an expression of the variances of the x and y coordinates around a given point (Rodgers and Carr, 1998). Fixed kernel method use the same bandwidth value for each observation but adaptive kernel select different bandwidths for each observation (Kernohan et al., 2001). Seaman et al. (1999) compared fixed and adaptive kernel estimators and stated that the fixed kernel is superior estimator than the adaptive kernel. Better accuracy and precision of the home range estimates is obtained by using fixed kernel and has lower bias than the adaptive kernel approach. Seaman and Powell (1996) showed the lower percent bias of the fixed kernel method compared to the adaptive kernel method. They found 5.5% percent bias for the fixed kernel method and 36.6% for the adaptive kernel method for the same input data.

The other special type of kernel density estimation of home range is Brownian bridge home range kernel density estimation. Brownian motion can be defined as two dimensional random walk in an area (Bullard, 1991). In order to model utilization distribution of an animal in a specified time period, the knowledge of location data and movement patterns of animal are important. Continuous observation of animal is impossible and so the data are not continuous. However, missing points along a path of the animal are estimated by using available locations on the path and the process is called a Brownian bridge (Horne et al., 2007). Brownian bridge approach for estimating home range probability density function is first proposed by Bullard (1991). Bullard defines the major weaknesses of home range estimations as lack of considering temporal nature of locations. Brownian bridge approach of home range estimation takes into account the starting and ending points, time interval and distance between consecutive locations, speed of animal, and inaccuracy of the relocations (Horne et al., 2007). The difference created by movement pattern consideration is clearly seen between the fixed kernel and Brownian bridge home ranges in figure 11.

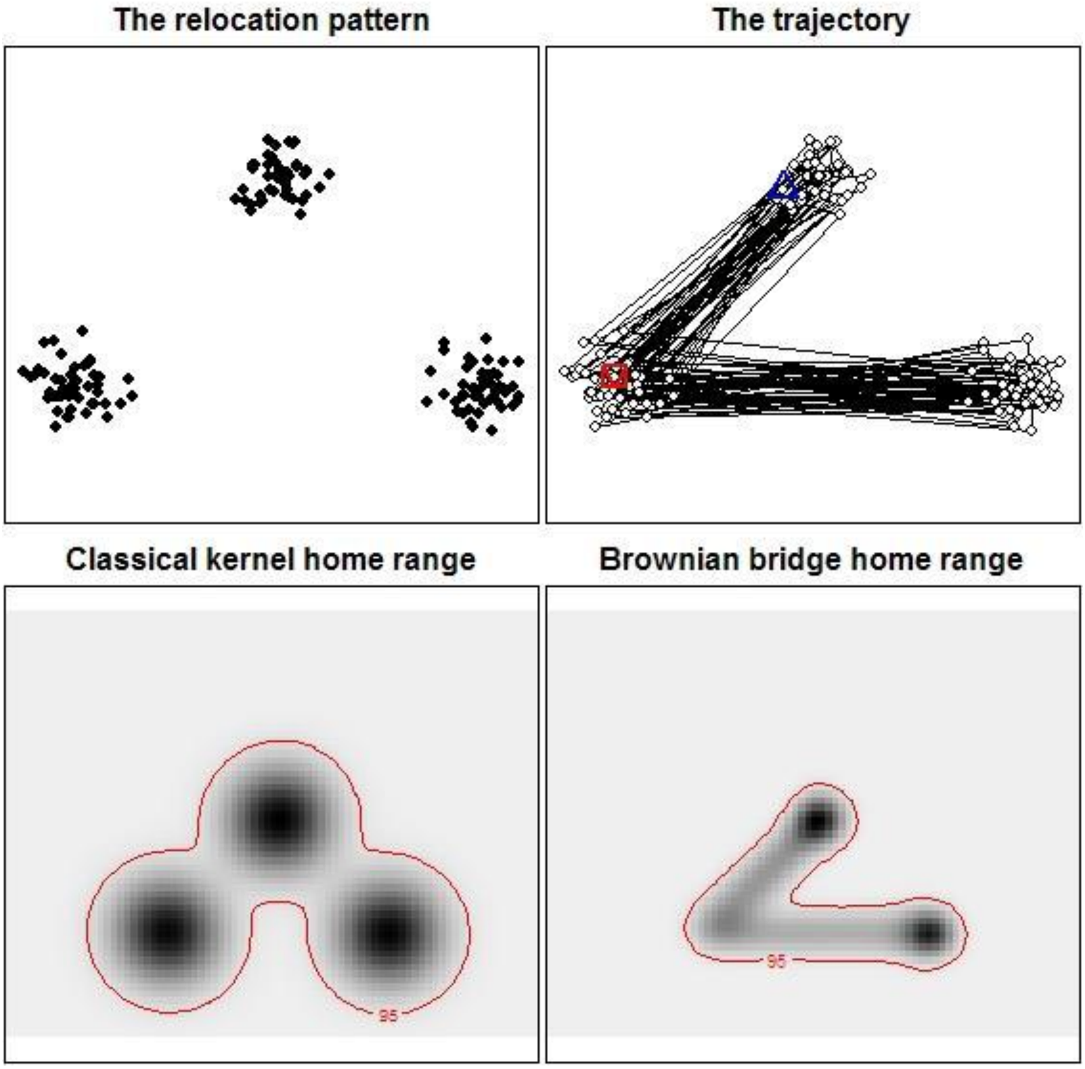


Figure 11. The difference between classical kernel home range and Brownian bridge home range (figure is taken from the kernel Brownian bridge example of the software R)

1.10 Habitat Selection

Habitat is defined as any part of the biosphere where a particular species can live either temporarily or permanently (Krebs, 2001). Habitat selection is related to various environmental variables, ecological processes, resource availability and distribution and it can change with sex, age, season and behaviour of species. For example, bighorn sheep (*Ovis canadensis*) prefers to live in steep slopes because of lower risks of predation (Lawson and Johnson, 1982 cited in Buskirk and Millspaugh, 2006), goitered gazelle migrate to southern central Asia in winter times since deep snow cover and frozen soil “dzhut” prevent grazing (Antipin, 1941; Heptner et al., 1988; Zhevnerov, 1984 all cited in Kingswood & Blank, 1996) and pregnant female goitered gazelles move to shrubby and stony places for parturition (Baskin and Danell, 2003). Habitat is composed of resources and habitat selection term is strictly related to resource selection. Resource is defined as a habitat component that its presence has positive effect on fitness of animal (Buskirk and Millspaugh, 2003). There is a hierarchy in habitat selection and Manly (2002) defines the orders of selection that were first described by Johnson (1980) as follows;

“Resource selection occurs in a hierarchical fashion from the geographic range of a species, to individual home range within a geographic range, to use of general features (habitats) within the home range, to the selection of particular elements (food items) within the general features (or feeding site).”

Resources are distributed in a habitat heterogeneously most of the time and comparisons of available, used and unused resource units are the key components of the resource selection studies. Disproportion of used and available resources indicates the selection of one or more habitat variables (Johnson, 1980). There are common assumptions in resource selection studies of radio-marked animals (Manly et al., 2002). They are;

1- Radio-marked individuals are randomly selected,
2- Location data of radio-marked individuals are independent in time,
3- Resource use of one radio-marked animal is independent of other radio-marked animals,
4- Availability of resources does not change throughout the study,
5- Used resources are classified correctly.

Thomas and Taylor (1990) suggested three types study designs for resource selection studies namely design I, design II, and design III with respect to the individual or population level of use and availability data. Ericson et al. (2001) and Manly (2002) summarize them as follows;

Design I;

- individual animals are not identified,
- used, unused and available resource units are sampled in study area at population level,
- sampling unit is animal locations,
- suitable statistics; χ^2 analysis (Neu et al., 1974), logistic regression (Manly et al., 2002), log-linear modelling (Heisey, 1985), and discrete choice modelling (Cooper and Millspaugh, 1999).

Design II;

- individual animals are identified,
- used resource units are measured for each marked animal,
- available resource units are measured at population level,
- sampling unit is individual animals,
- suitable statistics; Friedman's test (Friedman, 1937 cited in Manly et al., 2002), Johnson's method (Johnson, 1980), compositional analysis (Aebischer et al., 1993), logistic regression (Smith et al., 1982), log-linear modelling (Heisey, 1985), and discrete choice modelling (Cooper and Millspaugh, 1999).

Design III;

- individual animals are identified,
- at least two sets of used resource units (available, used and unused) are sampled for each marked animal.
- sampling unit is individual animals,
- suitable statistics; Friedman's test (Friedman, 1937), Johnson's method (Johnson, 1980), compositional analysis (Aebischer et al., 1993), logistic

regression (Smith et al., 1982), log-linear modelling (Heisey, 1985), and discrete choice modelling (Cooper and Millspaugh, 1999).

In addition to these designs, Ericson et al. (2001) introduced the design IV that is defined for individual and availability for each point of use. Thus, use and availability are paired for each animal location.

Calenge et al. (2005) proposed K-select analysis for analyses of habitat selection especially in radio-tracking studies. It is a recent technique that allows multivariate habitat selection analysis. Development of the GIS technology makes it possible to obtain many habitat variable layers easily and so multivariate analysis of habitat selection is increasingly preferred. K-select is an exploratory method that is useful for making inference about resource selection. The theory underlying the K-select analysis is Hutchinson's (1957) concept of ecological niche. Niche is defined as the range of biotic and abiotic environmental conditions that an organism can live in and Hutchinson defines niche as "n-dimensional hypervolume" that each n represents an environmental variable. Also, K-select is sensitive to autocorrelation (Calenge et al., 2005).

K-select is based on eigenanalyses, extension of principal component analysis, and eigenanalyses of marginality values of environmental variables indicate the strength of selection. Marginality concept relies on the difference between average resource availability and average use of a species on the area. Average use of a species on the area is accepted as optimum environment for the species. The vector between optimum (average use) point and average available point is called "marginality vector" (Hirzel et al., 2002). The magnitude of marginality vectors shows the strength of selection. Significance of habitat selection is evaluated by randomization test. The test compares observed marginality to marginality of random habitat use obtained by the results of K-select analysis of random datasets. Bonferroni correction is used to evaluate multiple comparisons of variables for each animal. On the other hand, Bland and Altman (1995) showed that comparison of large number of tests does not give significant results.

1.11 The Use of GIS in Ecology

GIS have been a useful tool in ecological studies in recent years. A GIS is defined as any manual or computer-based set of procedures to store and manipulate geographically referenced data (spatial data) (Aronoff, 1989). Spatial data in GIS can be point data (e.g. animal location), line data (e.g. roads, rivers) and polygon data (e.g. lakes, forests, settlements). It is used for locating, manipulating and analyzing data of interest. GIS provides a complementary view of interrelations between spatial information and various natural or human-made geographic features (Bonham-Carter, 1994). By using GIS, a wildlife researcher can obtain various types of information about study animal and habitat relationships. For each point data of the animal, elevation, slope, aspect of the location, type of the habitat can be determined. Also, much other information can be obtained like distance to roads, settlements, water sources, plantation and industrial enterprises. Therefore, it is particularly a valuable tool for habitat and resource selection studies. In addition, suitable places for re-introductions can be modelled by using GIS. Moreover, habitat changes can be evaluated with the use of GIS (Koeln et al., 1994).

1.12 The Aims of The Present Study

Goitered gazelle is one of the endangered mammal species of Turkey, so any study focused on the species is valuable for conservation. For an effective conservation action, the knowledge of genetics and biology of the species are very important. This study is one of the first attempts to understand the ecology of the Goitered gazelle in Turkey. The thesis covers the issues of seasonal home range and individual level seasonal habitat selection of female goitered gazelle, and making inferences about the adaptation periods of releases goitered gazelle. The results show the important environmental variables for gazelles and the findings of this study will help the establishment of informed conservation efforts.

CHAPTER 2

Material and Methods

2.1 Study Area:

This study has been performed in Şanlıurfa, southeast part of Turkey (Figure 12). The area is approximately 105 km^2 and includes central and west parts of the Kızılkuyu Wildlife Development Area (release site) (285 km^2) (Figure 13). Release site is 15 km away from Şanlıurfa city centre in the southwest direction. Study area is created by using all the location data of goitered gazelles for one-year period. Records of gazelles are placed on the map and outliers of the data were used for determination of study area border.

There are nearly 70 gazelles in fenced area (0, 13 km^2), shown in yellow in figure 13, and gazelles were caught and released from there. The place is also considered as an acclimatization area. Fenced area contains a water source and a trap. Food support is provided for the captive animals. An additional area (0, 1 km^2) was fenced adjacent to the former area in late July 2009, but they are isolated. National Parks administrators have considered that gazelles grazing periodically within these areas.

The study area is composed of smooth hilly plains. There are not much steep, rocky land forms (Figure 8). Maximum altitude is 745 m and minimum is 480 m. Arid, semi-desert climate is dominated; summers are very hot and dry, winters, autumns and springs are mild and occasionally wet. End of May and early September can be considered as summer months. Table 8 shows the monthly mean temperatures and precipitation in Şanlıurfa.

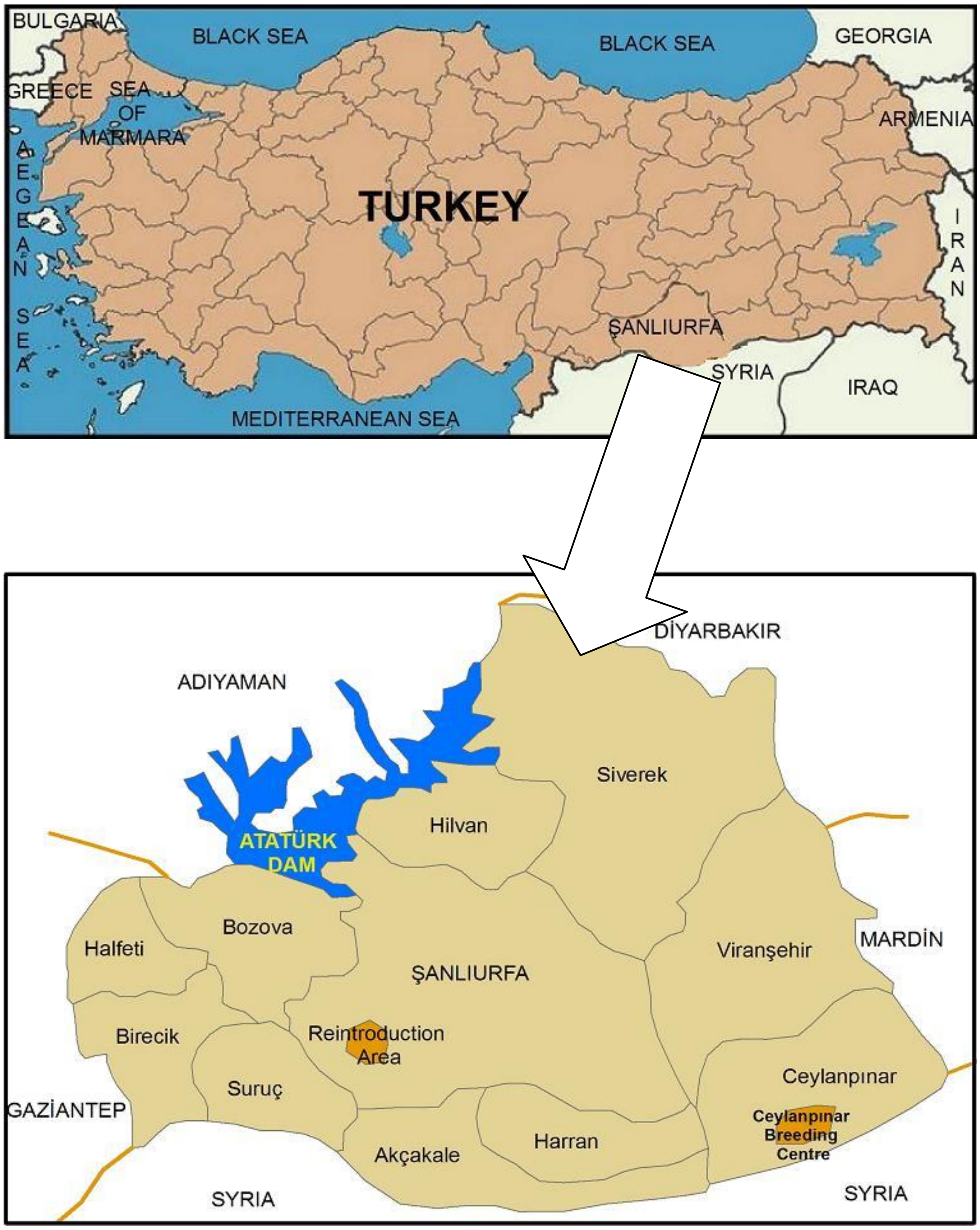


Figure 12. The location of Şanlıurfa on the map of Turkey and the locations of the study area and breeding centre

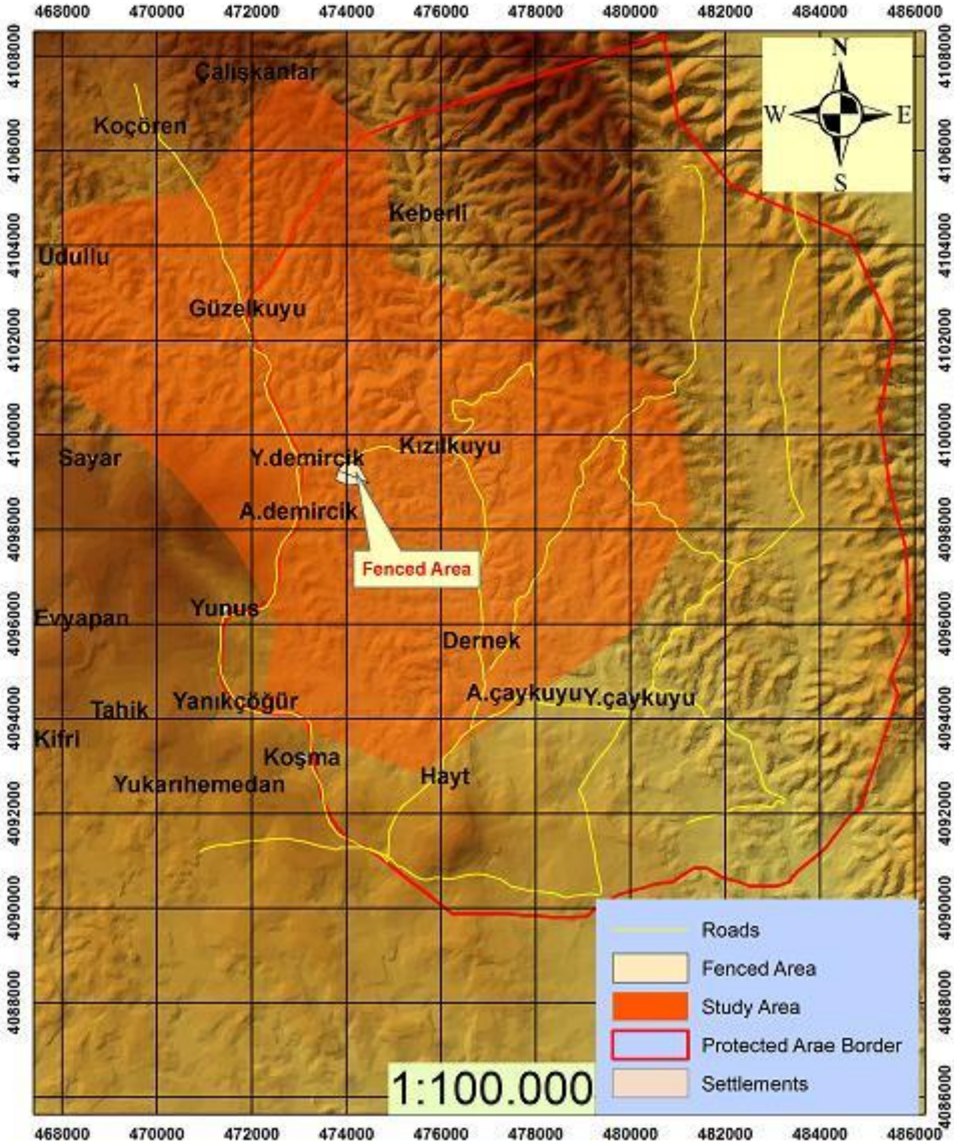


Figure 13. Study Area (release site)

Table 8. Mean monthly temperatures and rainfalls of Şanlıurfa (1975 – 2008) (DMİGM, 2008)

* Average Temperature

** Average Precipitation

	Dec.	Jan.	Feb.	Mar.	Apr.	May
T* (°C)	7.4	5.8	6.8	10.8	16.2	22.2
Precipitation ** (kg/m^2)	74.2	74.9	76.1	63.6	43.1	27.5
	June	July	Aug.	Sep.	Oct.	Nov.
T (°C)	28.1	31.9	31.1	26.8	20.1	12.5
Precipitation (kg/m^2)	3.7	0.8	1.0	3.3	27.4	49.5

Vegetation type of the study area is steppe (Figure 9). Spring and autumn are the rainiest times of the year and vegetation cover and food availability for goitered gazelles are the best in these periods. Water is scarce in the area. There had been one artificial water source in the area built by General Directorate of Nature Protection and National Parks at the end of July 2009, seven additional artificial water sources were built at the same time (Figure 14). The old water source was kept inside the additional fenced area.

Human population in villages is low, but they have high numbers of domestic livestock. Also, their agricultural activities create additional disturbances for gazelles. Human - gazelle conflicts are low today because of small gazelle population, but it would probably be more problematic in future with the possible increasing number of gazelles.

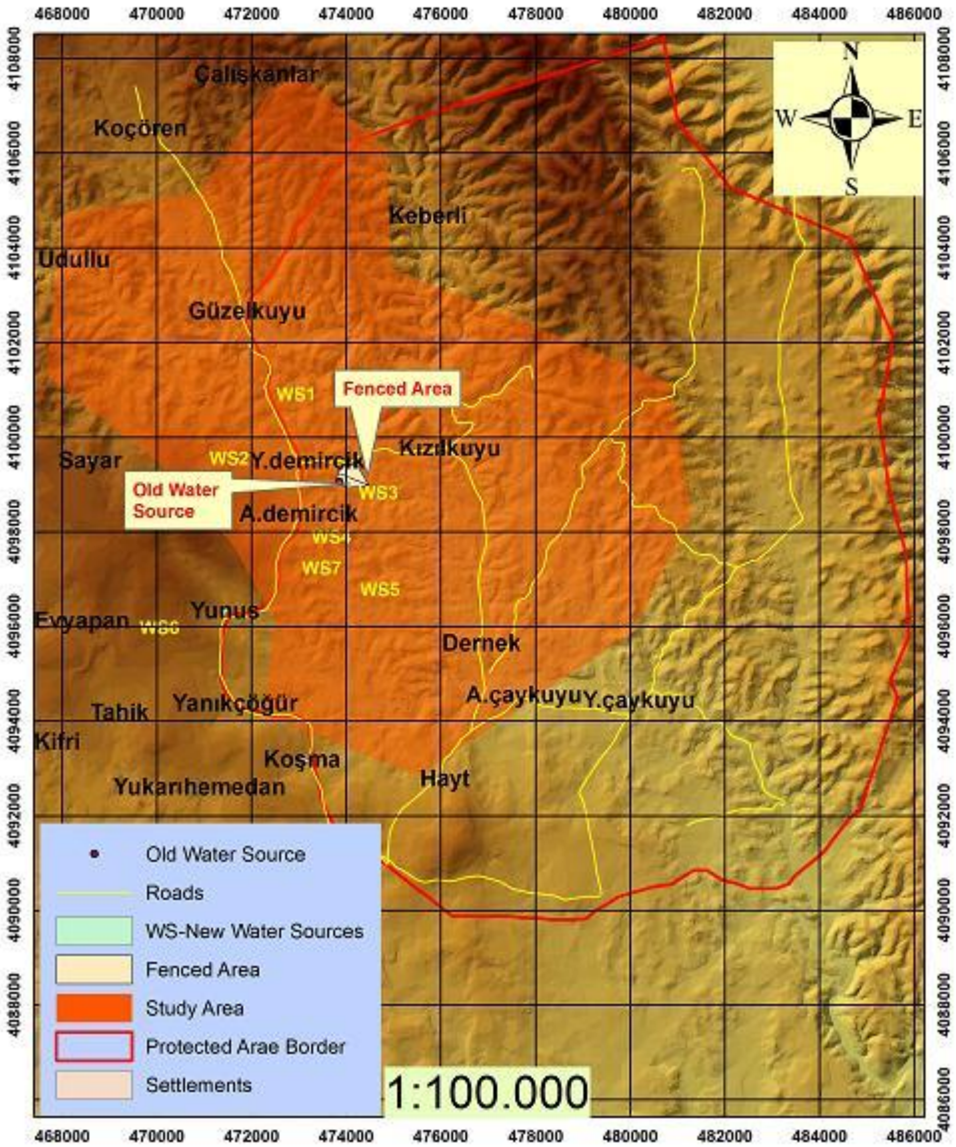


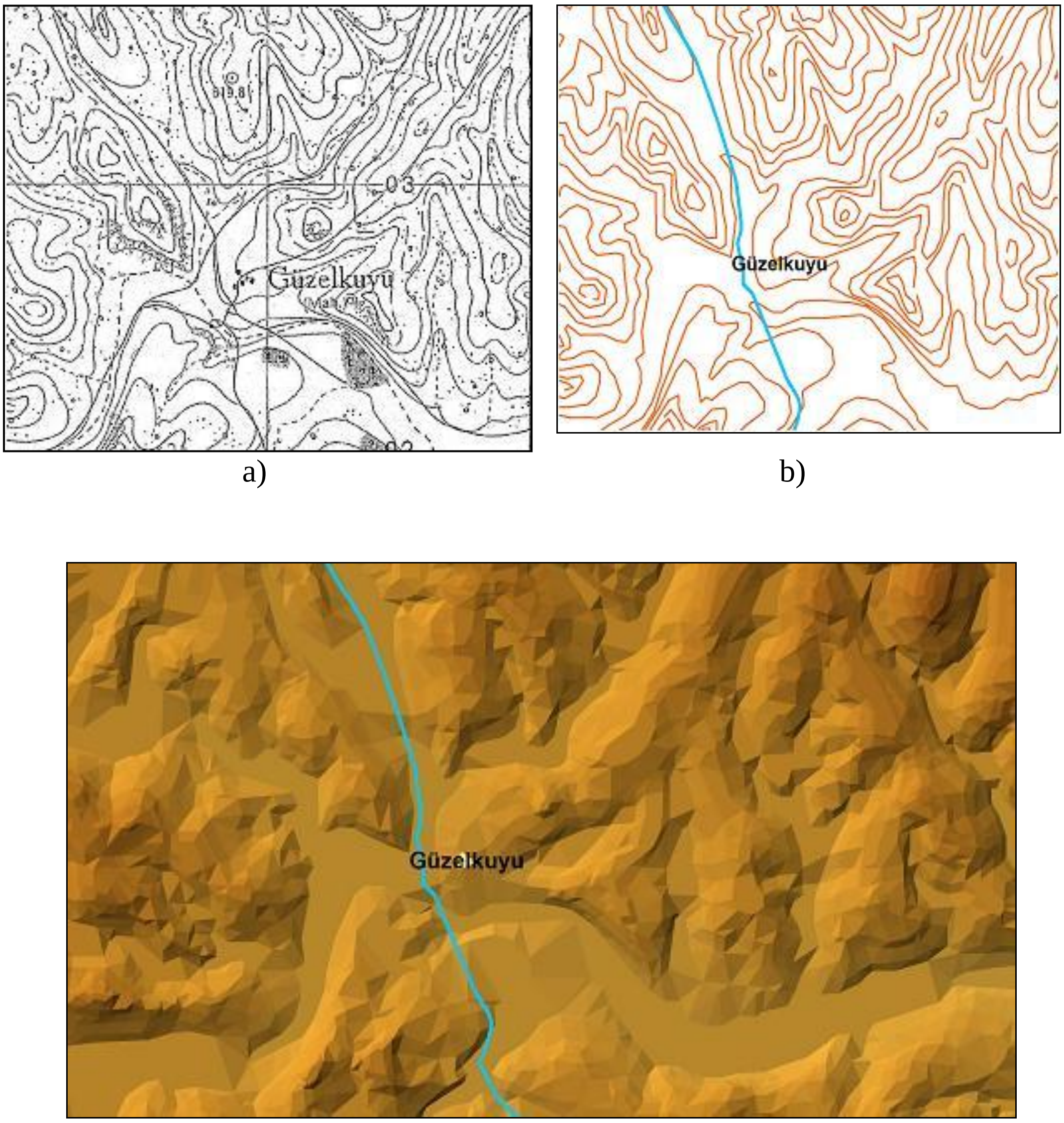
Figure 14. Water Sources

There are some other wild species in the area. Some of them were directly observed and identified such as fox (*Vulpes vulpes*), european hare (*Lepus europeaus*), pin-tailled sandgrouse (*Pterocles alchata*), cream-coloured courser (*Cursorius cursor*), see-see partridge (*Ammoperdix griseogularis*), great bustard (*Otis Tarda*), nothern lapwing (*Vanellus vanellus*), Black kite (*Milvus migrans*), lesser grey shrike (*Lanius minor*), Finsch's Wheatear (*Oenanthe finschii*) and Skylark (*Alauda arvensis*).

2.2 Preparation for the Study

The study area was digitized by using a template elevation map. This digitized map is the key component of the study; all habitat selection and home range analysis rely on it. The software ArcGIS Desktop 9.2 was used for this purpose (ESRI, 2005). The scale of original elevation maps is 1:25 000. In order to obtain a digitized map, original elevation map was georeferenced with the help of georeferencing tools of ArcGIS (ESRI, 2006) by using ground control points, and then necessary vector files were created. Georeferencing was made according to Universal Transverse Mercator projection and European 1950 datum. Eventually, the elevation contours on the scanned original map were traversed and a digitized elevation map was obtained (Figure 15). In addition to elevation contours, the roads and villages were also digitized.

Raster (Figure 15a) and vector (Figure 15b-c) datasets were used in the process. They are GIS terms that a raster means “a spatial data model that defines space as an array of equally sized cells arranged in rows and columns, and composed of single or multiple bands” like air photos and satellite images and a vector is “a coordinate-based data model that represents geographic features as points, lines, and polygons” (ESRI, 2006). Triangulated Irregular Network (TIN) is an example of vector data format that can be useful for the representation of the elevation contours (Figure 15c) (Bonham – Carter, 1994).



a) b)

c)

Figure 15. a) Original scanned elevation map, b) digitized elevation contours, c) A TIN file converted from digitized elevation contours

2.3 Trapping Gazelles

In November 2008, 15 goitered gazelles were caught and released. Ten of them were female, and the rest were male. In order to catch animals, food was put in the trap (Figure 16) within the fenced area, and waited for entering animals to the trap. Closure mechanism of the trap door is outside the fenced area and a person waited for entrance of animals to close the trap door. The trap has a corridor that is narrower to the end. This corridor is composed of chambers with sliding doors and the last chamber is big enough for entering only one gazelle and it can be moved. Trapped gazelles were forced to enter this chambered corridor and after one gazelle enter the last chamber, its door was closed.

Figure 16. Trap in the fenced area

Gazelle was caught from its legs and immediately its eyes were closed with a rag to calm down the animal, to minimize the visual stimuli, and to protect the eye from dust and any particle that can damage the eye. Some morphologic measurements are done and tissue samples were taken for genetic analyses. Animals were also marked with ear tags and identification collars (Figure 17).

a)

b)

c)

d)

Figure 17. Some tasks performed during catching

a) The animal is weighed by a weighbridge, b) The animal is removed from the cage, c) Measurements are being taken from the animal, d) The animal is released after measurements taken

Seven of the female gazelles were collared with GPS collars due to limited budget. After finishing these tasks, gazelles were released. GPS collared gazelles are named as A, B, C, D, E, F, and G in analyses.

Figure 18. Three of the released GPS collared gazelles (long after release)

2.4 GPS Collars and Equipments

Eight G2110B model GPS collars (Advanced Telemetry Systems, Minnesota, USA) were bought for this study. The frequencies were between 150.000 MHz to 151.000 MHz. One of them was broken at the beginning of the study and it was not used. The weight of the collars is 350 gr. and their weight is average 2.5 % of the collared animals (n=7. 13 – 17 kg). They have drop-off mechanism. Drop-off time is user-programmable it is adjusted for 380 days (Late November 2008 – Early December 2009). All the data are stored on board. Some of the data that collar records are location of animal, date and time of the location, ambient temperature, altitude, and Positional Dilution of Precision (PDOP). In addition, the collar gives out some different signal patterns including mortality, low battery and release signals. VHF signal schedule can also be programmed. VHF signal was on Thursday, Saturday and Sunday of every two weeks. In those days, the signal was given out and it was detected by a receiver. Thus, both the condition of the animal and collar could be evaluated.

Figure 19. GPS collar used in the project

Two GPS fix recording schedules were adjusted as primary and auxiliary GPS fix schedules. Primary schedule is one GPS fix in every five hours for all days, and auxiliary schedule is 1 GPS fix in every hour for every Wednesday. 5 hours time interval was selected for taking GPS fixes in different times of the day. Generally, there are 4 location data for every day. In a time interval which is dividing 24 like 2, 3,4,6,8, and 12, GPS fixes would belong to the same hours of the day throughout the study. The choice of five hours time interval is both suitable for the one year battery life and differently timed GPS fixes.

The equipments used in this study are GPS collars, a radio receiver (Wildlife Materials Inc., USA), an antenna and its cable, binoculars, spotting scopes, two-way radio, Garmin E-Trex GPS devices and Silva Ranger compasses. GPS collared animals are found by using homing method in VHF-on days. A radio receiver, an antenna and its cable are necessary equipments for homing. All the gazelles detected in the field were recorded in addition to GPS collared animals. In order to find the location of the animals, observer location, direction of the animal groups and sighting distance are required. GPS is necessary for the observer location and compass for direction of animal groups. Sighting distance was measured from reticulated binoculars and reticules on the compass. Binoculars and spotting scopes were used for detecting groups and determining their composition.

2.5 Data and Some Notes on Study

After collaring animals in November 2008 field studies has been held on as possible as regularly; once in every two weeks in VHF-on days. 33 field studies were performed during the one-year study period and over 1700 location data were recorded in addition to data recorded on GPS collars. The number of pooled location data of GPS collars is over 13.500. Table 9 shows some information of GPS collared animals. Test studies of the GPS collars showed that GPS fixes on the collars were precise but inaccurate. Standard errors of the GPS fixes were found by test fixes (Table 10). They were located on some places where location information is known and compared with the location data on the collars. Then, all the data on the collar were corrected by using standard error of the collars.

Table 9. Data summary of GPS collared animals

Animal	Collaring Time	Drop-off Time	Drop-off Reason	Number of Data Collected
A	November 2008	May 2009	Death	1197
B	November 2008	December 2009	Programmed Drop	2814
C	November 2008	December 2009	Programmed Drop	2799
D	November 2008	September 2009	Death	2042
E	November 2008	February 2009	Death	623
F	November 2008	December 2009	Programmed Drop	2808
G	November 2008	December 2009	Programmed Drop	1595

Table 10. Average errors of GPS collar locations

Animal	Average Error of The X Coordinate	Standard Deviation of The Mean X	Average Error of The Y Coordinate	Standard Deviation of The Mean X	Number of Sample
A	35.956	5.253	100.73	5.939	70
B	26.478	3.033	105.74	3.233	64
C	25.362	3.343	107.78	3.444	59
D	36.701	6.935	97.761	5.332	55
E	33.98	4.176	99.889	3.67	67
F	22.422	4.198	105.02	3.856	77
G	32.319	4.59	100.821	4.146	54

Some of the data are excluded from analysis due to the high values of PDOP. The precision of the GPS fixes is related to satellite geometry. Dilution of precision (DOP) value indicates the goodness of the satellite geometry. PDOP is a measure of overall uncertainty in a GPS location. Since PDOP less than 4 gives the highest accuracy (Moen et al., 1997). GPS fixes having PDOP values are higher than 4 are excluded from analyses.

The data recorded between the dates 27 November 2008 (first fixes) and 14 January 2009 are also excluded from the analyses since this period is considered as acclimatization period of the gazelles. Abbreviations are used for representing seasons in the thesis as M1, M, C, W, S, S1, S2, and A for the first mating season, second mating season, calving season, winter, spring, two summer periods, and autumn respectively. Summer season is divided into two as S1 and S2 because of the changing water resource availability at the end of the July mentioned in part 2.1. Summer season is also extended from 15 May to 15 September due to the climatic condition of the area. Mating and calving season dates are determined by using group composition changes data and field observations. Mating season is considered between the dates 15 November and 15 January. Two mating season home range are estimated for 2009. One covers the dates from 15 November 2009 to 9 December 2009. The final dates are the ones GPS fixes recorded on collars. The other mating season covers the dates from 15 December 2008 to 15 January 2009. Calving season lasts from 15 April to 15 June.

Table 11. Time periods for home range and habitat selection calculations

*M1 – Mating1 2009 (15.12.2008 – 15.01.2009), W– Winter 2009, S – Spring 2009, S1 – Summer1 2009 (15.05.2009 – 31.07.2009), S2 – Summer2 2009 (01.08.2009 – 15.09.2009), A – Autumn 2009, M – Mating 2009 (15.11.2009 – 09.12.200), C – Calving 2009 (15.04.2009 – 15.06.2009)

** Only home range

+ Data available

- Data not available

Animal Codes	M1**	W	S	C	S1	S2	A	M
A	+	+	+	+	-	-	-	-
B	+	+	+	+	+	+	+	+
C	+	+	+	+	+	+	+	+
D	+	+	+	+	+	+	-	-
E	+	+	-	-	-	-	-	-
F	+	+	+	+	+	+	+	+
G	+	+	+	+	+	+	+	-

2.6 Home Range

In this study, kernel Brownian bridge approach (kernelbb) is used for estimating seasonal home range sizes of seven GPS collared female goitered gazelles because of its ability to evaluate temporal nature of locations. It is problem for many estimators since autocorrelation violates the assumption of independency of locations. Also, kernelbb assesses the speed of the animal, time interval between successive fixes, the distance between consecutive points and inaccuracy of location (Horne et al., 2007). Kernelbb uses plug-in bandwidth selection method to estimate the smoothing parameter. Plug-in technique of smoothing parameter estimation is recommended for large datasets like GPS telemetry studies (Amstrup et al., 2004; Gitzen et al., 2006) It needs average inaccuracy of points for estimation ideal smoothing parameter and it is selected as 8 since the collars have GPS and GPS devices give locations generally with 7-8 m accuracy. A package of software R (R Development Core Team, 2009), adehabitat (Calenge, 2006) is used for the kernelbb home range estimation. Home range polygons are exported to ArcGIS Desktop 9.2 (ESRI, 2006) to obtain better illustrations. Density isopleths of utilization distribution are used for the representation of the home range in kernel density estimations. The choice of utilization distribution contours determines the shape and coverage of home range. In literature, 95% density isopleths is commonly used. However, Börger et al. (2006) compare the accuracy of different home range density isopleths and find the highest accuracy between 50-90% isoplets. As a result they propose the use of 90% density isopleths as upper limit of accurate home range estimation. Seaman et al. (1999) recommend this limit as 80%. However, all the simulations compare the fixed and adaptive kernel with h_{lscv} and h_{ref} in Seaman's study (1999), minimum complex polygon, bivariate ellipse, adaptive and fixed kernel with h_{lscv} and h_{ref} in Börger's study (2006). There is no comparative study including kernel Brownian bridge home range estimation with plug-in techniques. Therefore, in order to both not missing the biological importance and avoid overestimation and inaccuracy, 90% density contours is selected in this study.

Table 12. Number of data used in home range analyses

*Data not available

	M1	W	S	C	S1	S2	A	M
A	132	297	325	128	*	*	*	*
B	140	319	314	256	323	193	320	105
C	133	304	321	240	303	190	352	108
D	142	326	320	260	341	163	*	*
E	134	286	*	*	*	*	*	*
F	139	312	319	267	338	193	317	110
G	140	309	316	243	312	194	172	*

2.7 Habitat Selection

Seven habitat variable layers were prepared for the study area in order to assess the habitat selection. The analyses were performed for the seven female GPS – collared goitered gazelles by using "adehabitat" package (Calenge, 2006) of software R (R Development Core Team, 2009). K-select analysis is used for evaluating habitat selection of the gazelles.

All layers, slope, aspect, elevation, distance to settlements, distance to roads and distance to water sources were created in 50x50 m^2 pixels by using Spatial Analyst tool of ArcGIS. The template map for habitat variable layers is digitized elevation map of the study area. The created layers were clipped to fit the study area by using an ArcMap Extension, Hawth's Analysis Tools version 3.27 (Hawthorne, 2006) (Figure 20-26) to perform habitat selection analyses. Clipped layers were converted to ASCII format and imported to R. Five aspect classes were created as flat, north, east, south, and west. The elevation range is between 479 – 726 m and slope range is between 0 – 51 degrees. Euclidian distance tool of Spatial Analyst was also used to create the distance to water sources, distance to settlements and distance to roads layers. Two distance to water sources layers were created for the time between January 2009 - August 2009 dwold), and August 2009 February 2010 (dwnew) due to the change in availability of water. The old water source was enclosed in additional fenced area and 7 additional water ponds were built in the area at the end of July 2009. The maximum values are 4966 m for distance to settlements layer, 6800 m for the distance to new water sources layer, 8646 m for the distance to old water source layer, and 4238 m for the distance to roads layer.

K-select analysis is a useful technique for exploring habitat selection of animals in a multivariate way. The study is a design III study, since each relocation is considered as used for individual animals and home ranges as available for each individual for each season. In other words, the use and availability are defined for each individual. K-select analysis gives results as marginality vectors and larger marginality indicates the strength of the selection (Calenge, 2006).

K-select method assumes the independency of relocations and because of this reason the data have been simplified according to Schoener's (1981) index, and Swihart and Slade (1985) index. Significant deviations from both indices index indicate the strong autocorrelation. Expected value is around 2.0 for Schoener's index and < 0.6 for Swihart and Slade index. Random deletions of locations are recommended for autocorrelation (Ackerman et al., 1990). The autocorrelation of data has been tested by using ArcView GIS 3.3 Home Range Extension (ESRI, 2002) and necessary simplifications are performed in MINITAB 13.

Only mating period is considered in order to evaluate the mating period preferences because the animals have been probably were still in acclimatization in mating1 period.

Table 13. Number of data used in habitat selection analyses

* Data not available

	W	S	C	S1	S2	A	M
A	260	280	100	*	*	*	*
B	260	280	220	290	160	290	85
C	260	280	220	270	160	320	85
D	260	280	220	290	130	*	*
E	250	*	*	*	*	*	*
F	260	270	220	300	160	290	85
G	260	280	220	270	160	140	0

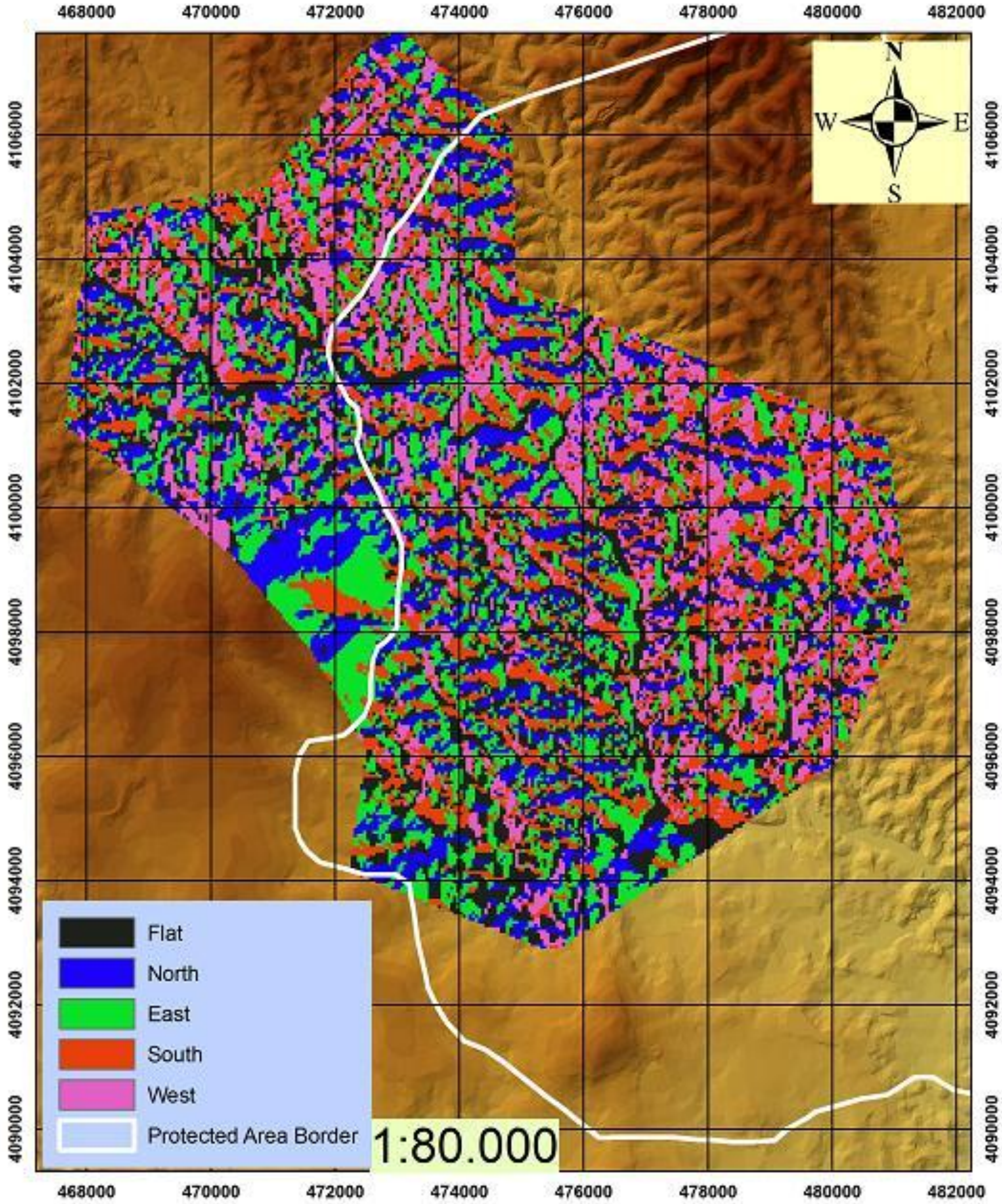


Figure 20. Aspect layer

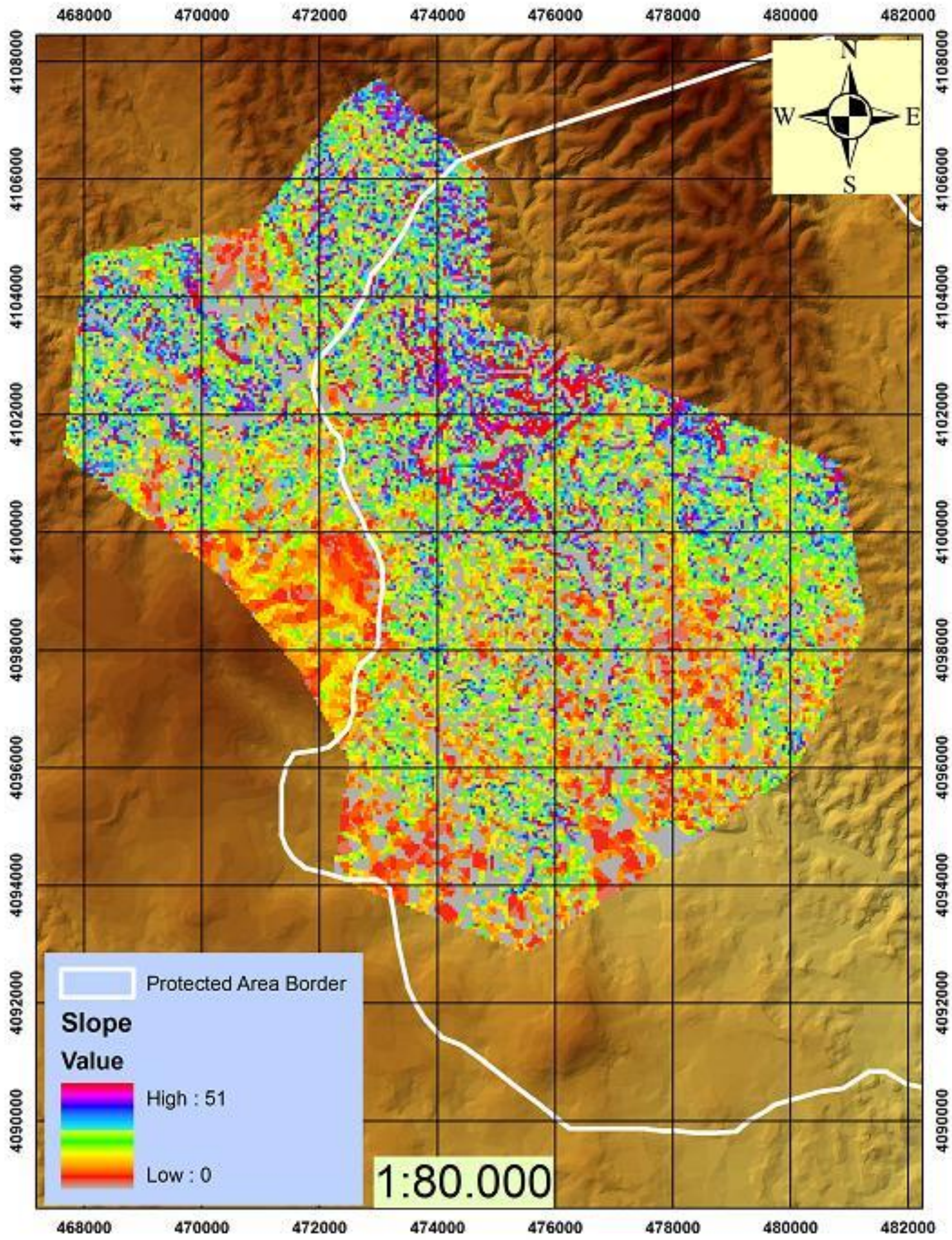


Figure 21. Slope layer

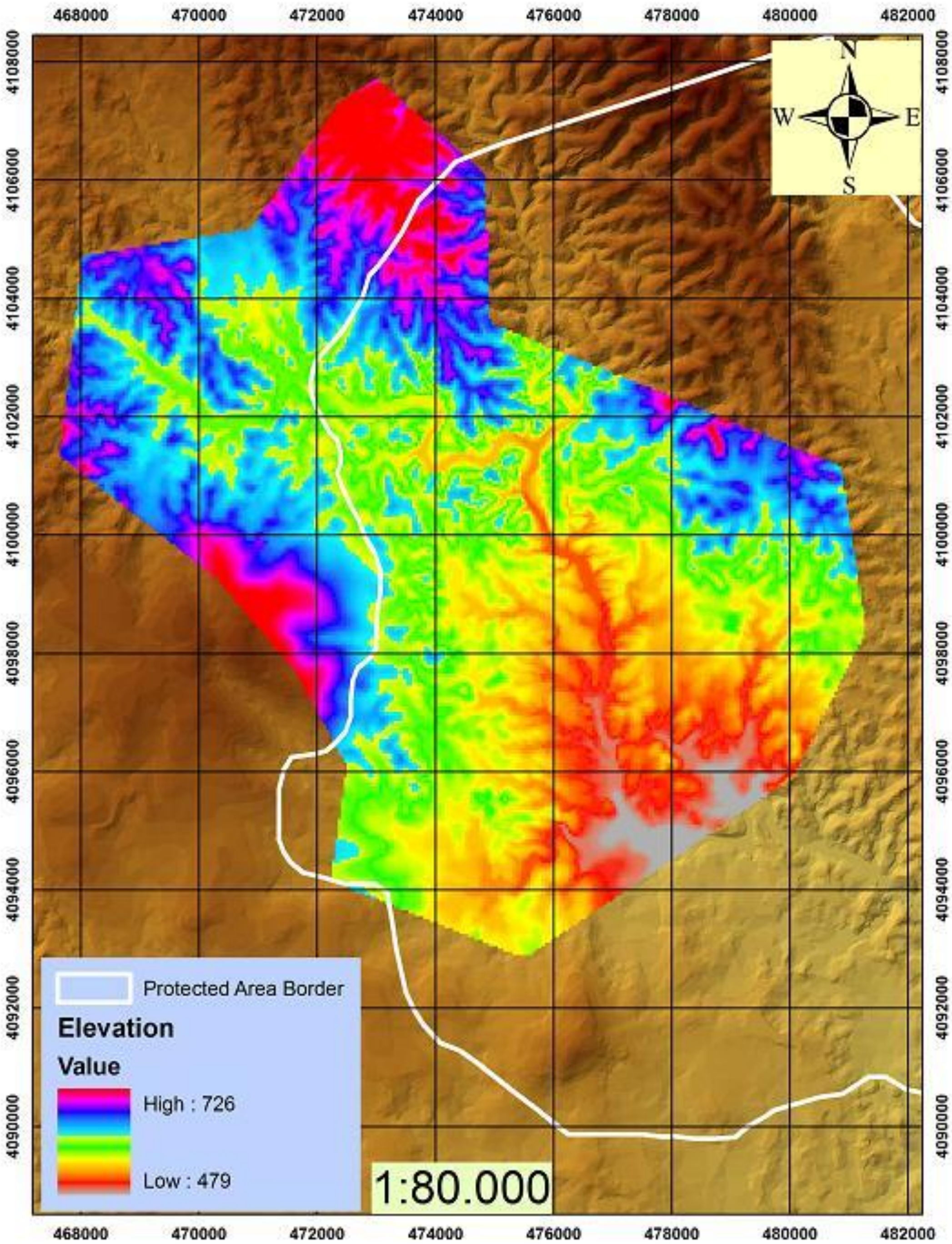


Figure 22. Elevation layer

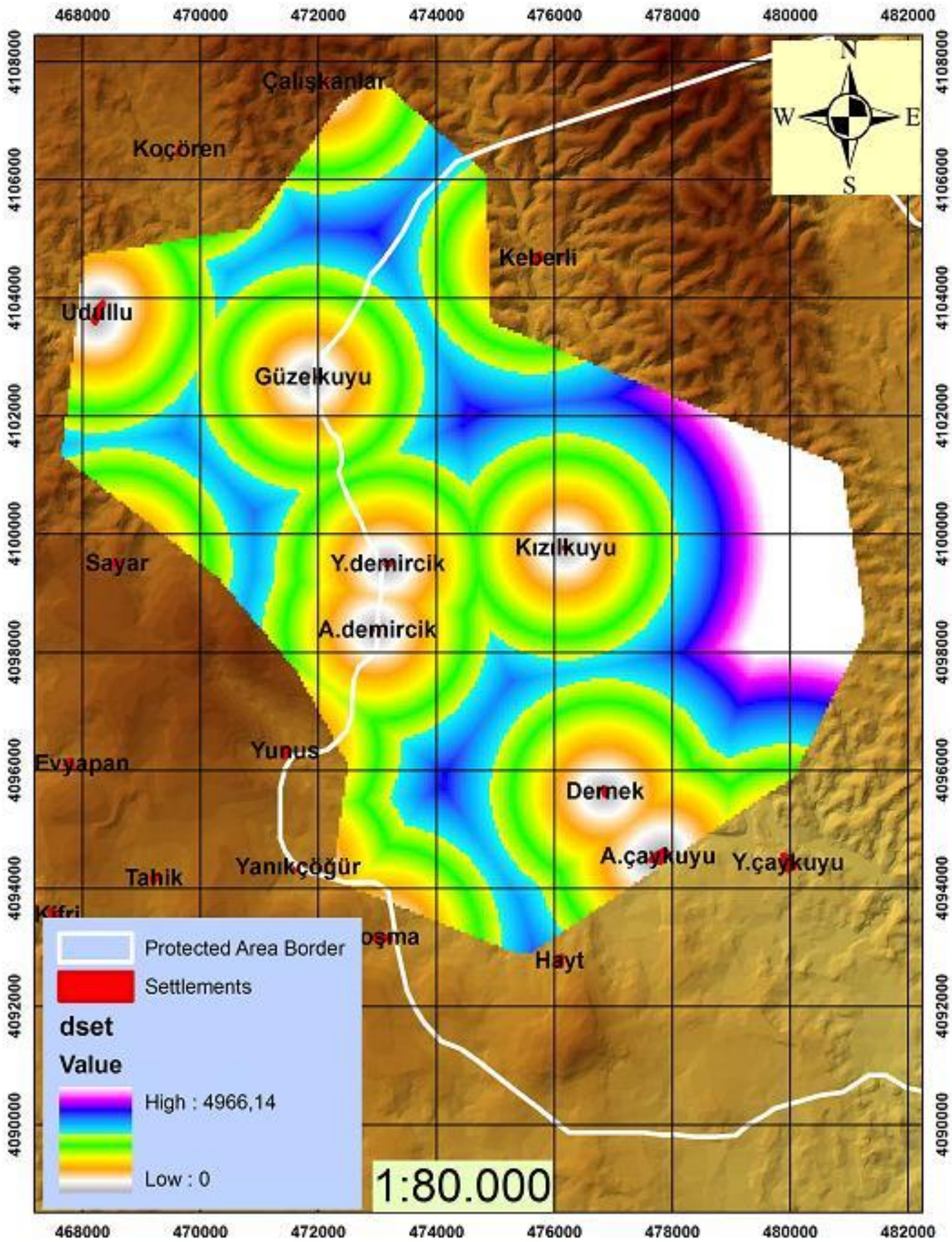


Figure 23. Distance to settlements layer

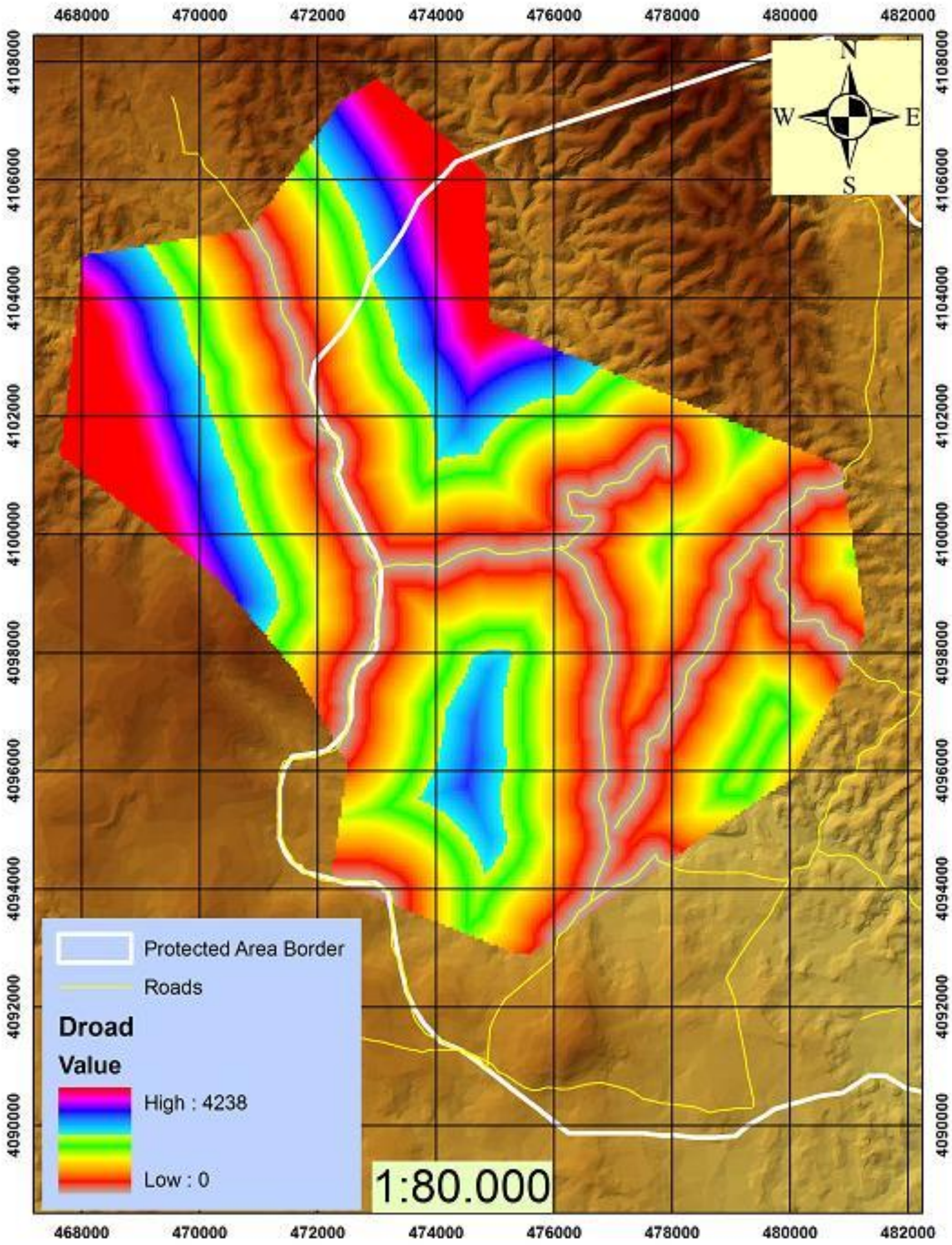


Figure 24. Distance to roads layer

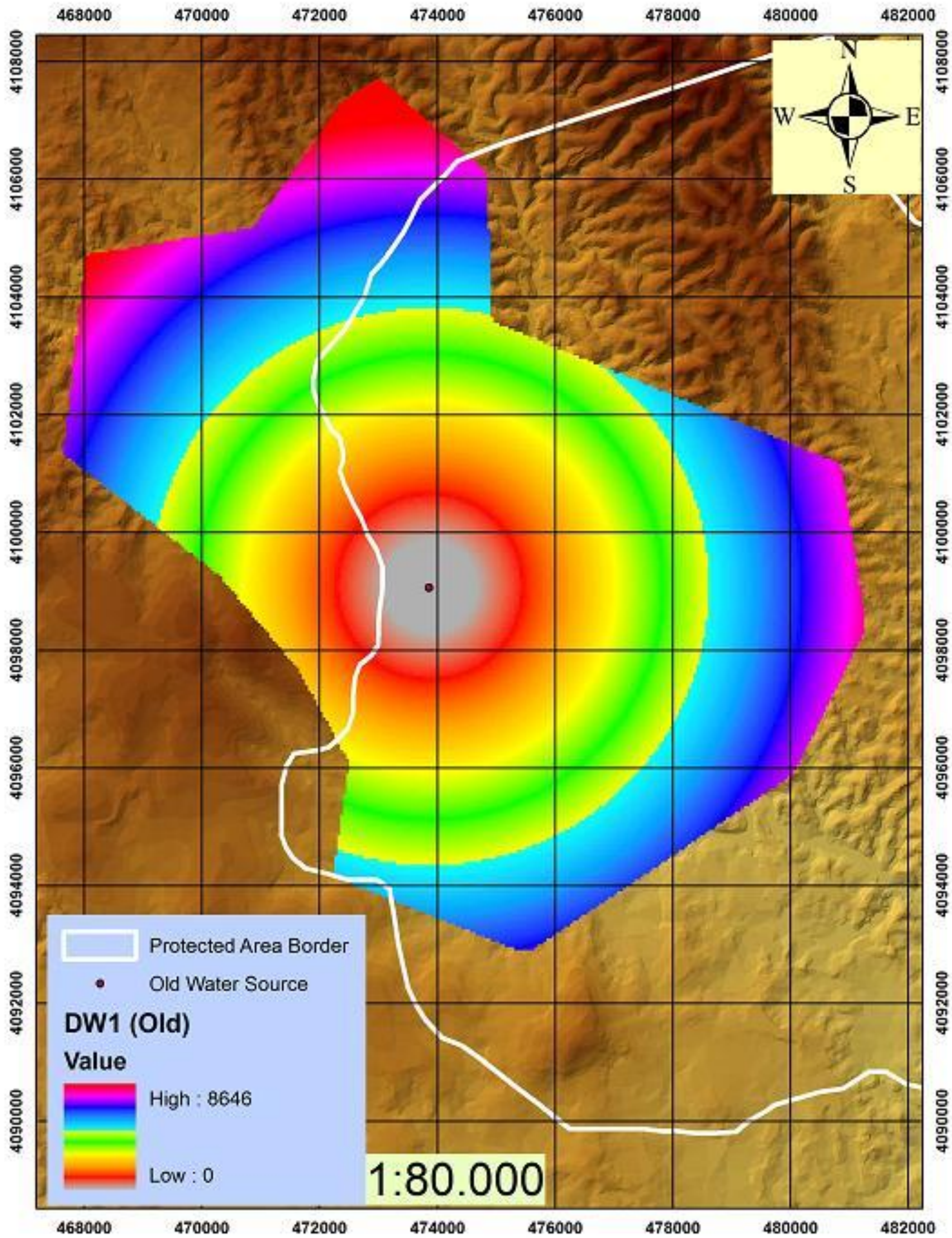


Figure 25. Distance to old water sources layer

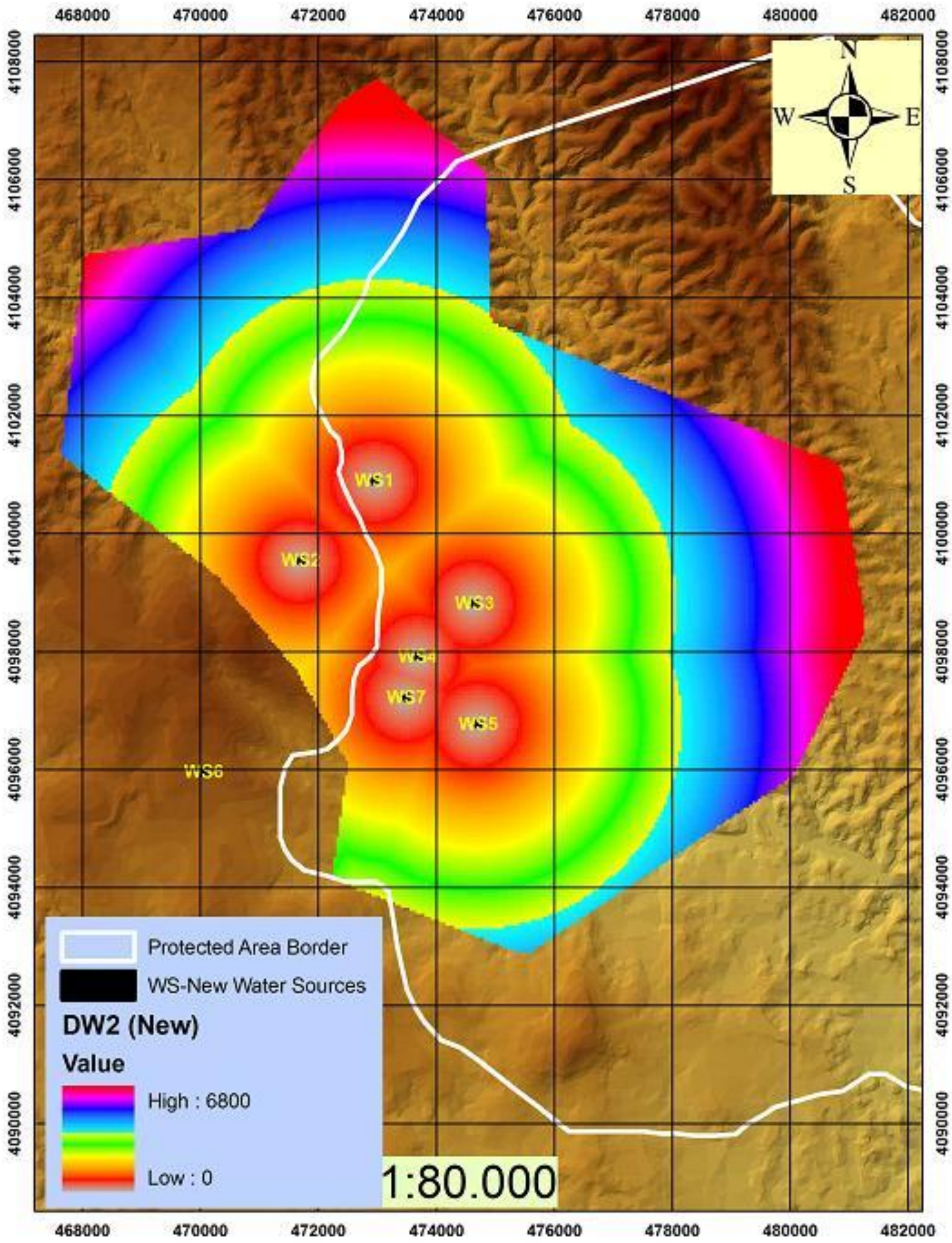


Figure 26. Distance to new water sources layer

CHAPTER 3

Results

3.1 Home Range

Seasonal home range sizes of GPS collared female goitered gazelles are estimated by using kernel Brownian bridge approach. The results of analyses and seasonal home range averages are presented in table 14. The calculations are made by using 90 % density isopleths of utilization distribution contours. In order to clarify general space use of gazelles for one year period, all home ranges are shown in a single map (figure 24). Seasonal home ranges of each individual are sorted in the figures 25 – 31. Some of the home ranges cover the fenced area and size of fenced area are extracted from home range size.

Home range sizes of seasons are compared by using one-way ANOVA to evaluate their differences. The significant differences are found between summer1 and summer2 ($p = 0.014$), summer2 and autumn ($p = 0.004$), mating1 and winter ($p = 0.000$), spring and calving ($p = 0.019$), calving and summer1 ($p = 0.005$), and autumn and mating ($p = 0.002$) periods. Home range sizes have shown a fluctuated pattern except summer2 to autumn and autumn to mating passes (Table 14). There are some strange increases and decreases in home range sizes deviated from general tendency like spring to calving and summer1 to summer2 increase in home range sizes of gazelle D. The other point is to note that the home range sizes of gazelle A are considerably smaller than that of the other gazelles. Yearly average of all collared gazelles excluding extreme values is 2.93 ± 1.92 km^2.

Moreover, post-release monitoring was carried out effectively; a total of 33 field surveys were performed for more than a year. Monitoring is the only way for evaluating the success of re-introduction/supplementation and taking appropriate management policies.

All the individuals have remained almost in the same area during the study period. They have formed two groups that one is composed of five individuals (B, C, D, E, and F – group 1) and the other is composed of two individuals (A, G – group 2). The individuals of the first group were observed together almost all the field studies (figure 24). Home range analyses also verify the field observations, their home ranges overlap for the same time periods. Their own home ranges also overlap with each other at different seasons. Individuals of group 2 were observed together in the first few months, afterwards individual G had expanded its range. However, home range analyses show a different case, overlap of their mating1 home ranges is very small. The size of the overlapped home range areas has increased later. Because of the death of gazelle A in calving season, group 2 definition will not be used for seasons following calving season.

Table 14. Seasonal home range sizes of GPS collared female gazelles

* Extreme values excluded from the season averages

Season / Ind.	M1 (km^2)	W (km^2)	S (km^2)	C (km^2)	S1 (km^2)	S2 (km^2)	A (km^2)	M (km^2)	Av. (km^2)	St. Dev.
A	1.33	1.18*	0.6*	0.22*	-	-	-	-	0.83	0.52
B	2.2	3.57	5.02	2.4	3.87	1.98	2.79	0.96	2.85	1.27
C	2.36	3.69	5.09	1.4	6.58	2.27	3.28	1.21	3.24	1.85
D	1.76	4.49	2.74	6.64*	5.24	8.86*	-	-	4.96	2.59
E	2.3	3.12	-	-	-	-	-	-	2.71	0.58
F	1.67	3.43	4.89	1.38	3.28	2.32	3.65	1.93	2.82	1.19
G	2.85	3.37	2.08	1.46	3.78	2.45	3.78	-	2.82	0.88
Av.	2.07	3.61	3.96	1.66	4.55	2.26	3.38	1.37		
St. Dev.	0.51	0.47	1.44	0.50	1.35	0.20	0.44	0.50		

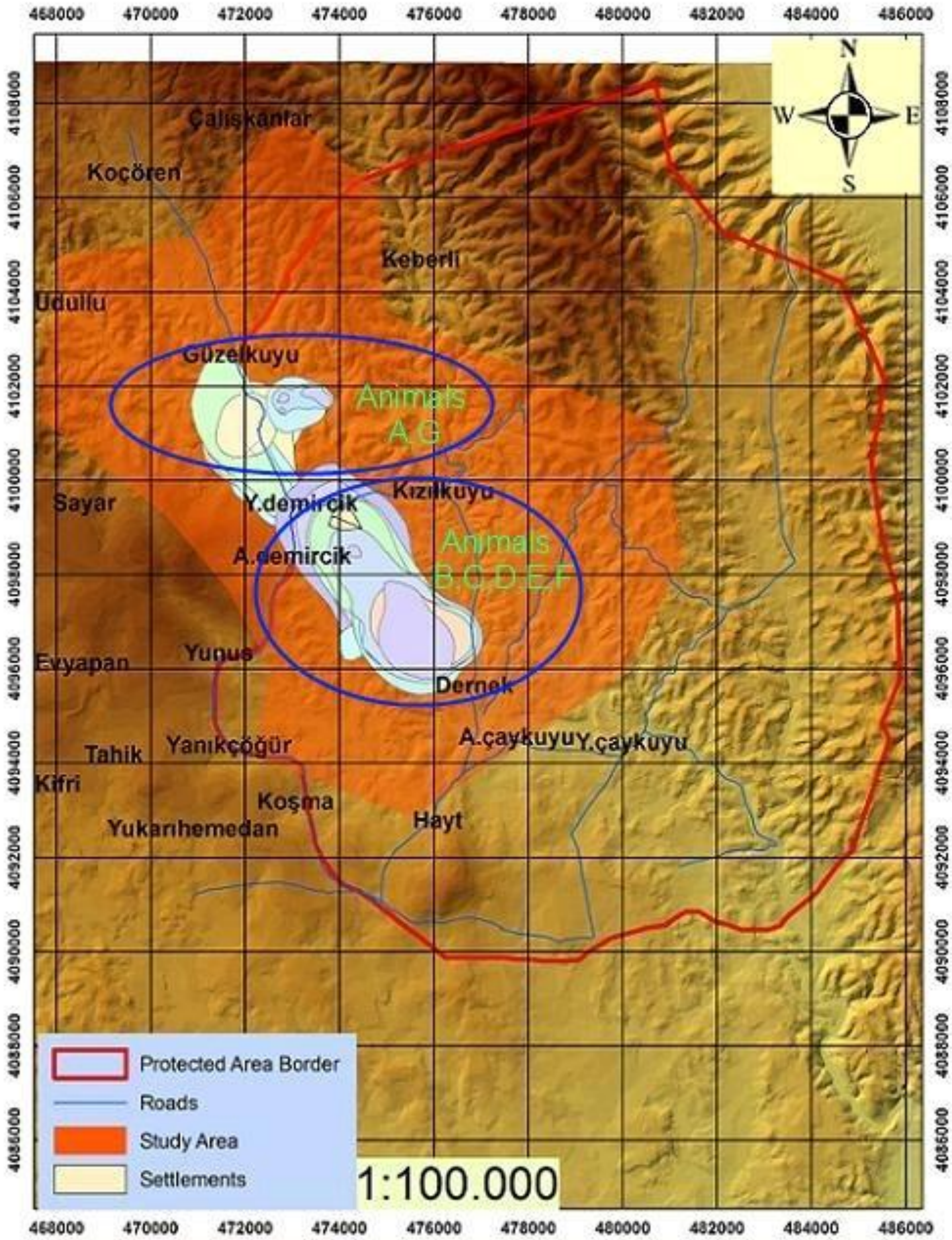


Figure 27. All home range polygons of every individual for one year period

Box 4. ANOVA results of home range comparisons of sequential seasons

Winter - Spring

Source	DF	SS	MS	F	P
Season	1	0.34	0.34	0.32	0.583
Error	9	9.40	1.04		
Total	10	9.74			

Spring - Summer1

Source	DF	SS	MS	F	P
Season	1	0.86	0.86	0.44	0.525
Error	8	15.55	1.94		
Total	9	16.41			

Summer1 - Summer2

Source	DF	SS	MS	F	P
Season	1	11.70	11.70	11.10	0.013
Error	7	7.38	1.05		
Total	8	19.09			

Summer2 - Autumn

Source	DF	SS	MS	F	P
Season	1	2.509	2.509	21.23	0.004
Error	6	0.709	0.118		
Total	7	3.21			

Autumn - Winter

Source	DF	SS	MS	F	P
Season	1	0.134	0.134	0.63	0.450
Error	8	1.703	0.213		
Total	9	1.838			

Box 5. ANOVA comparing the home range at calving and mating seasons with that of other seasons

Mating1 - Winter

Source	DF	SS	MS	F	P
Season	1	7.707	7.707	31.65	0.000
Error	11	2.678	0.243		
Total	12	10.386			

Spring - Calving

Source	DF	SS	MS	F	P
Season	1	11.80	11.80	9.15	0.019
Error	7	9.02	1.29		
Total	8	20.82			

Calving - Summer1

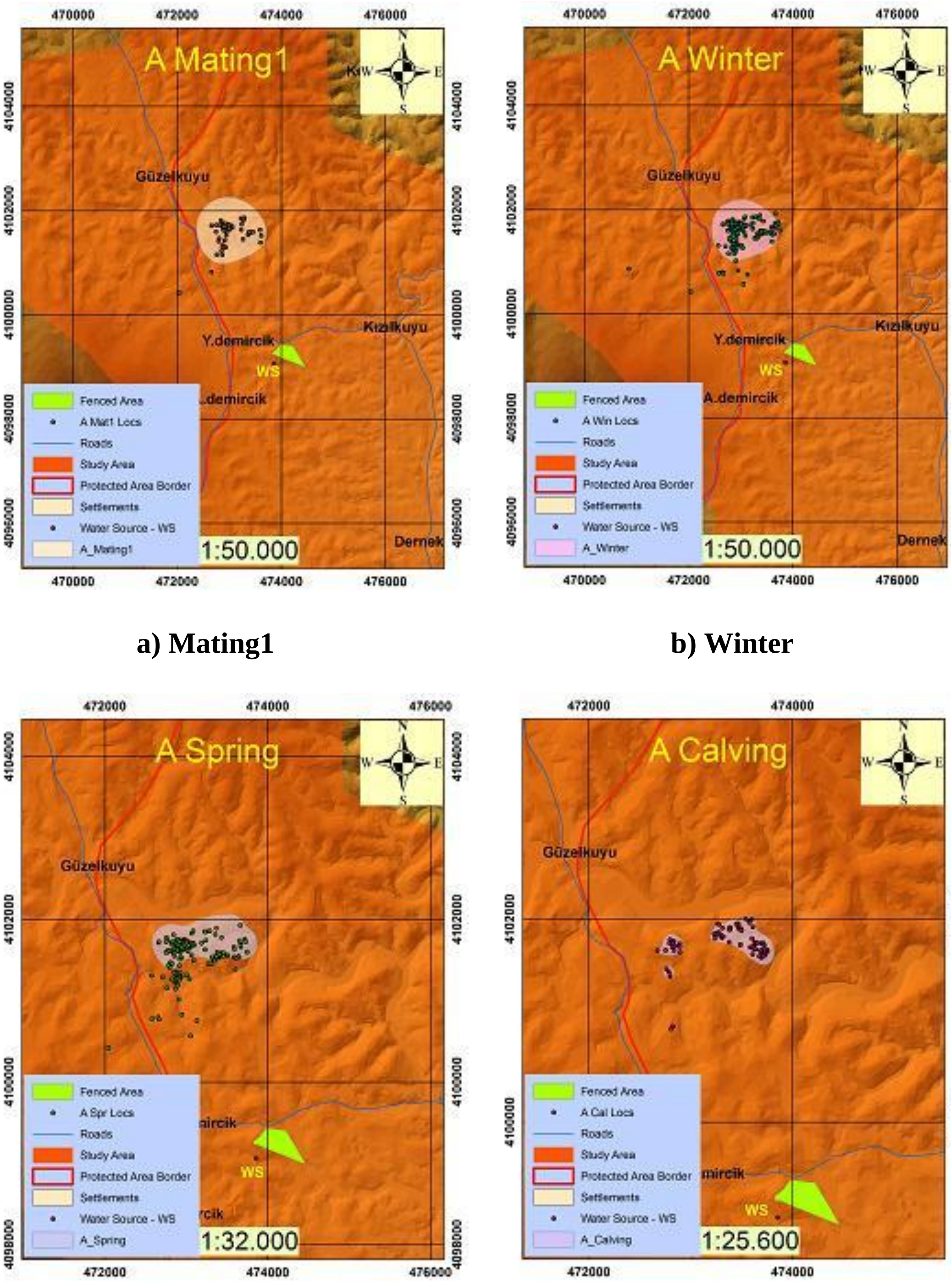
Source	DF	SS	MS	F	P
Season	1	18.56	18.56	16.24	0.005
Error	7	8.00	1.14		
Total	8	26.5			

Autumn - Mating

Source	DF	SS	MS	F	P
Season	1	6.914	6.914	31.48	0.002
Error	5	1.098	0.220		
Total	6	8.013			

3.1.1 Individual A:

Seasonal home ranges of individual A are shown in following maps.



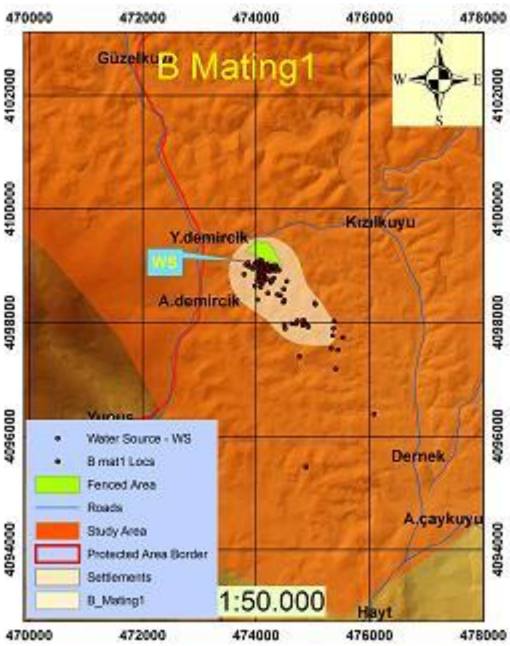
a) Mating1 b) Winter

c) Spring d) Calving

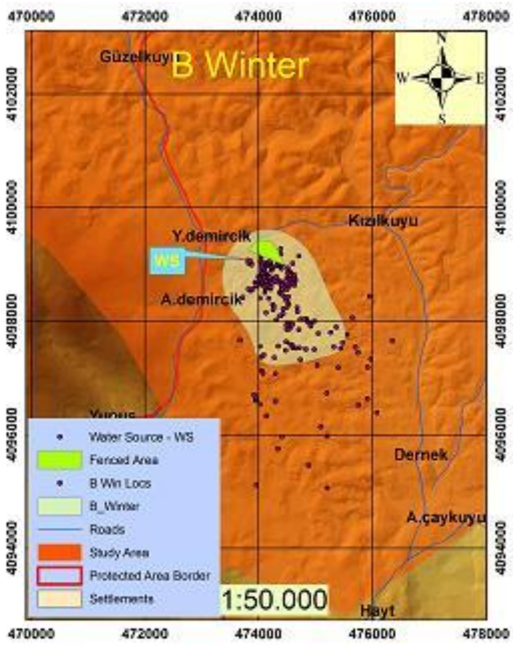
Figure 28. Seasonal home ranges of individual A

3.1.2 Individual B:

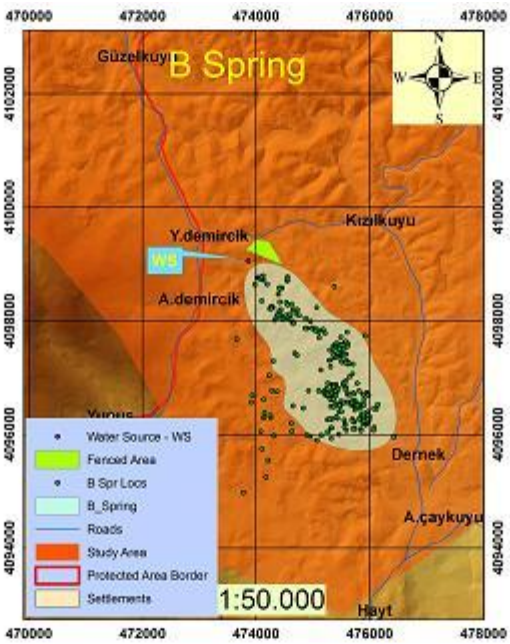
Seasonal home ranges of individual B are shown in following maps.



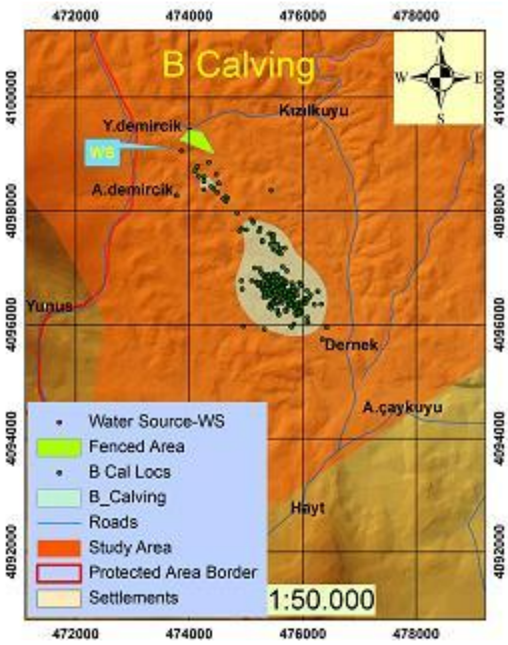
a) Mating1



b) Winter

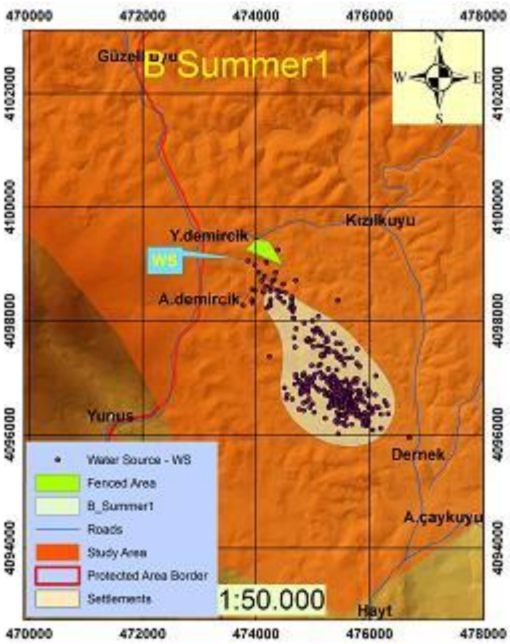


c) Spring

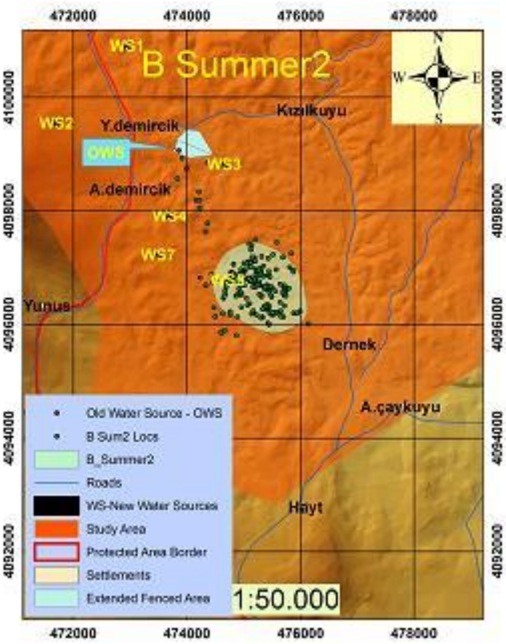


d) Calving

Figure 29. Seasonal home ranges of individual B

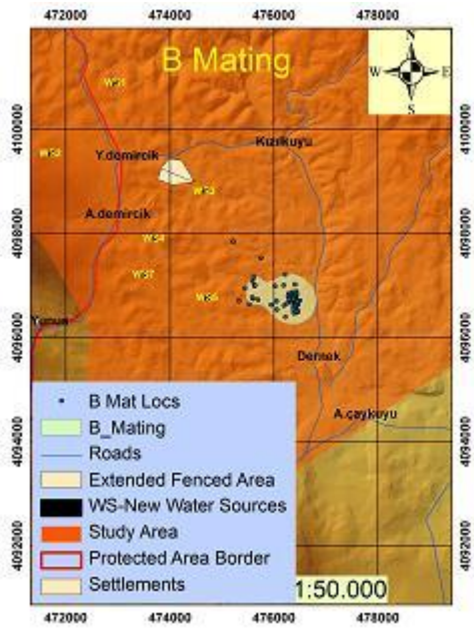


e) Summer1



f) Summer2

g) Autumn

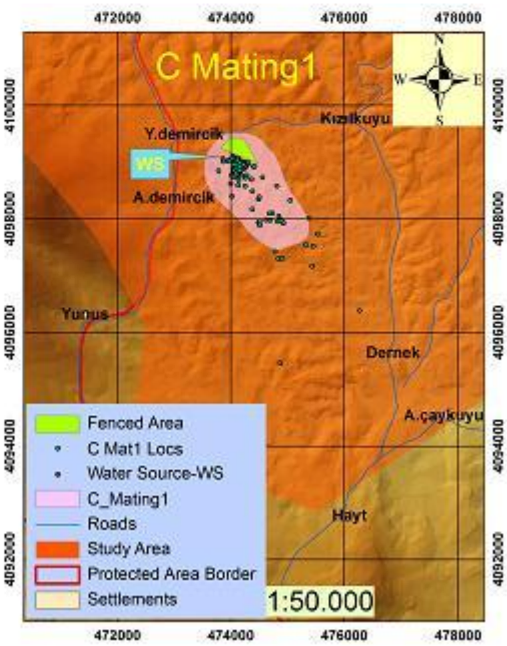


h) Mating

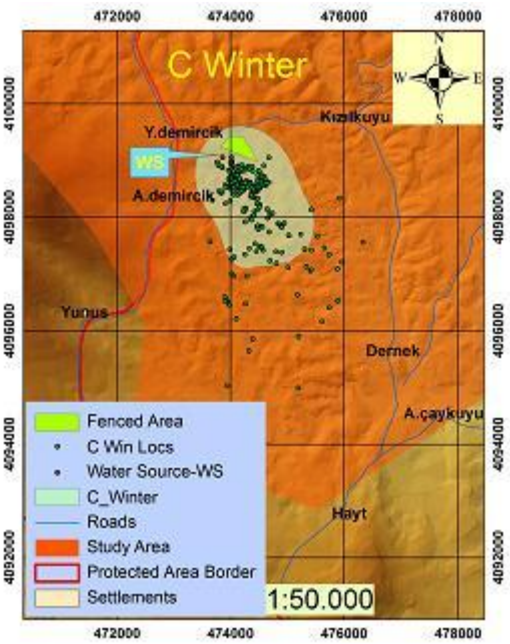
Figure 29. **(cont.)**

3.1.3 Individual C:

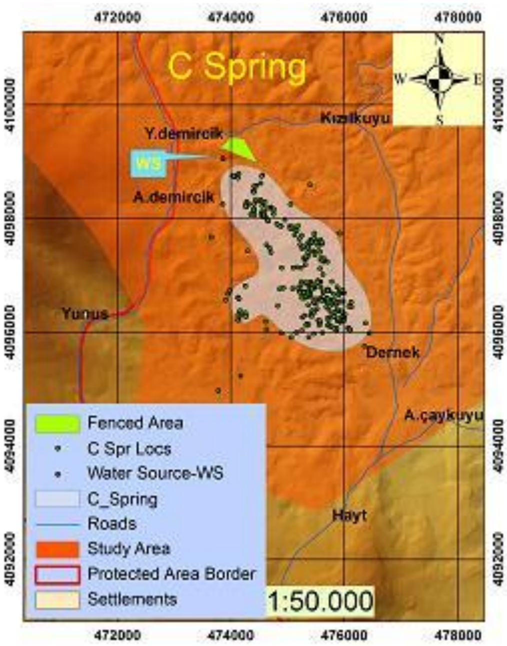
Seasonal home ranges of individual C are shown in following maps.



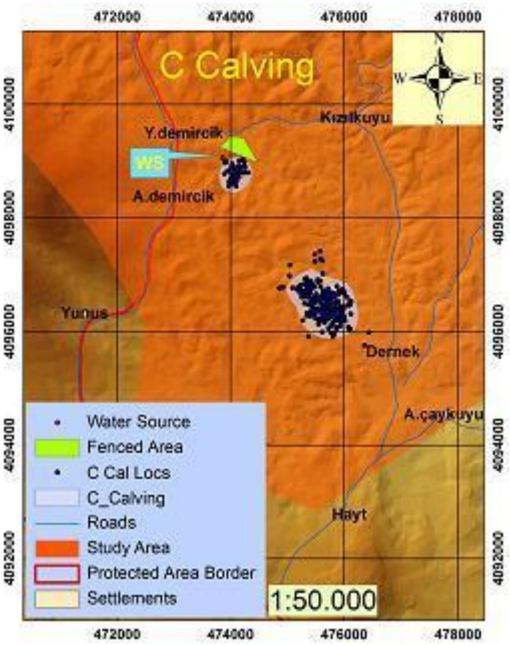
a) Mating1



b) Winter

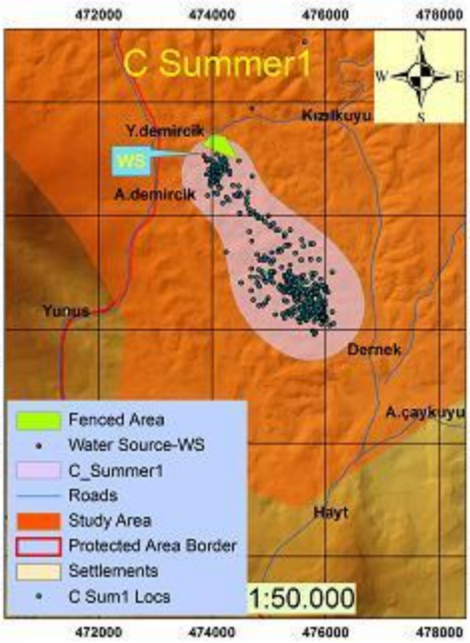


c) Spring

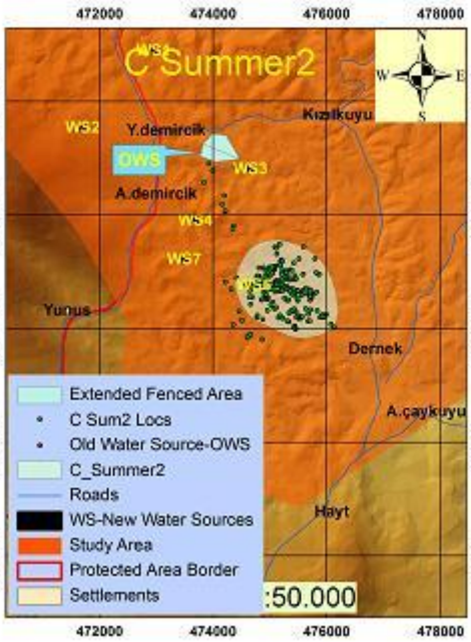


d) Calving

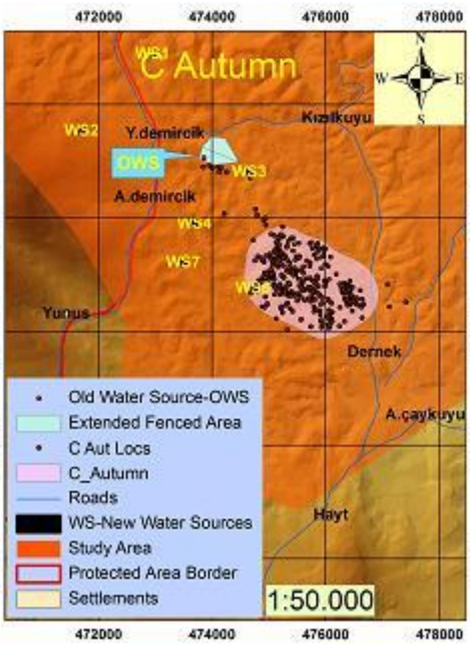
Figure 30. Seasonal home ranges of individual C



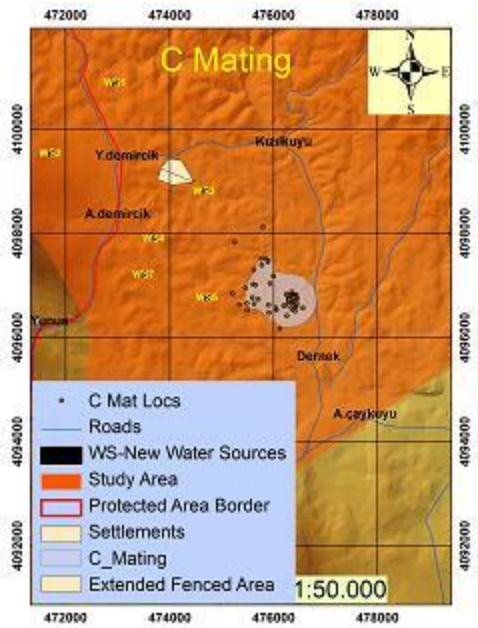
e) Summer1



f) Summer2



g) Autumn

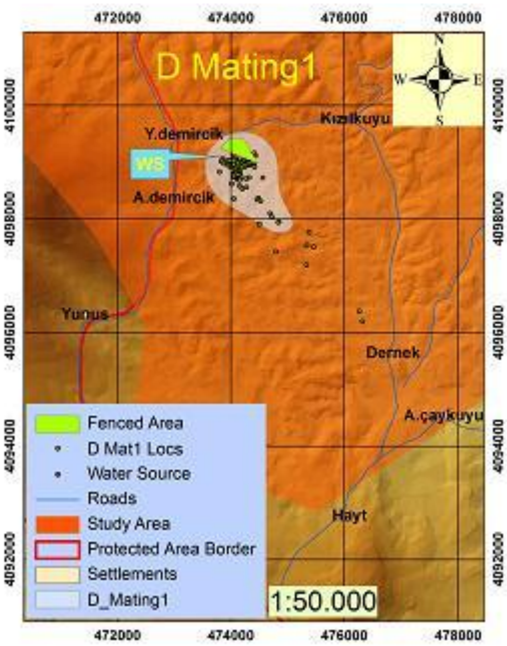


h) Mating

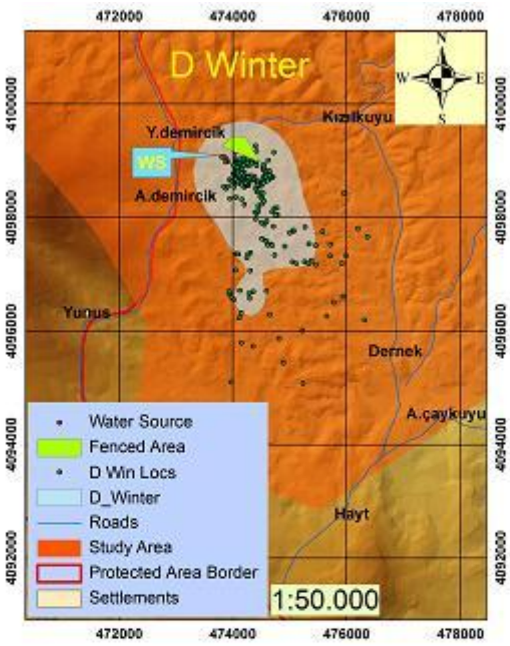
Figure 30. (cont.)

3.1.4 Individual D:

Seasonal home ranges of individual D are shown in following maps.

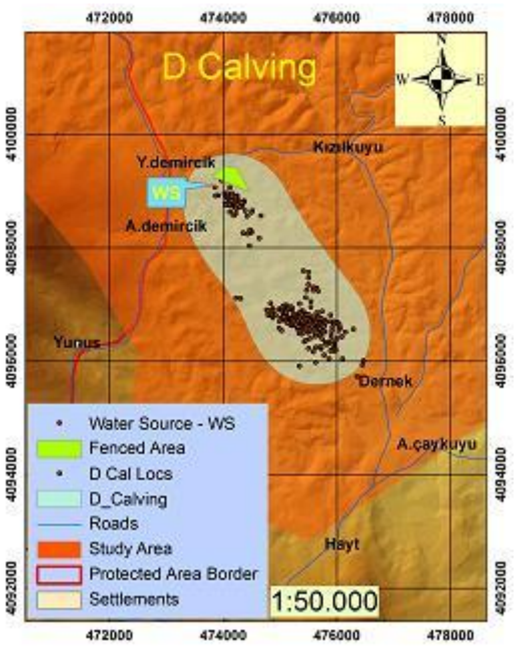


a) Mating1



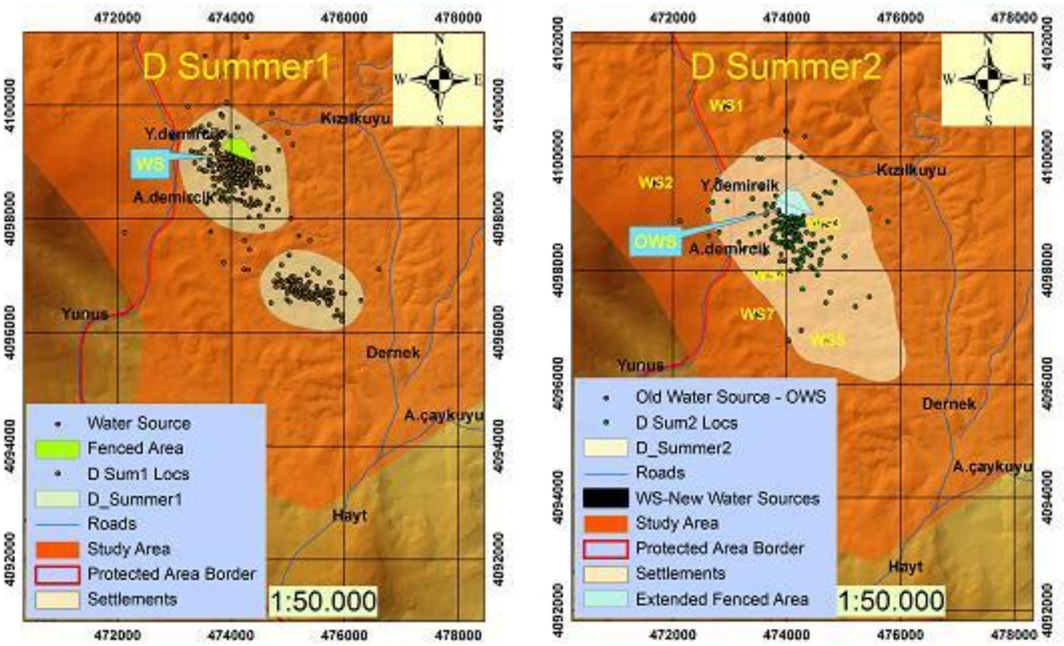
b) Winter

c) Spring



d) Calving

Figure 31. Seasonal home ranges of individual D

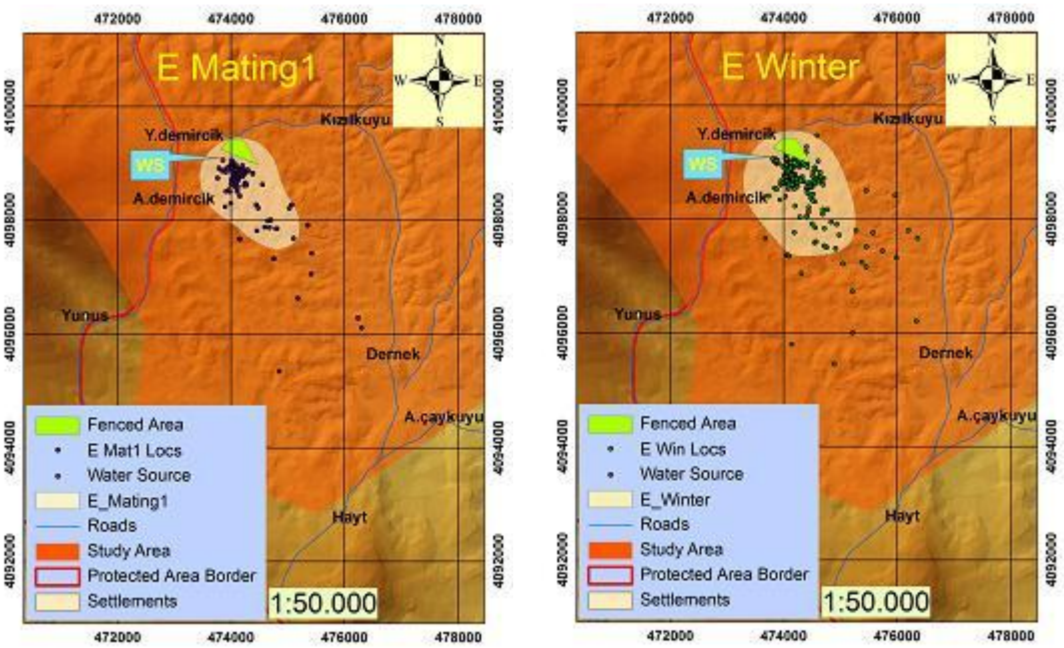


e) Summer1 f) Summer2

Figure 31. (cont.)

3.1.5 Individual E:

Seasonal home ranges of individual E are shown in following maps.

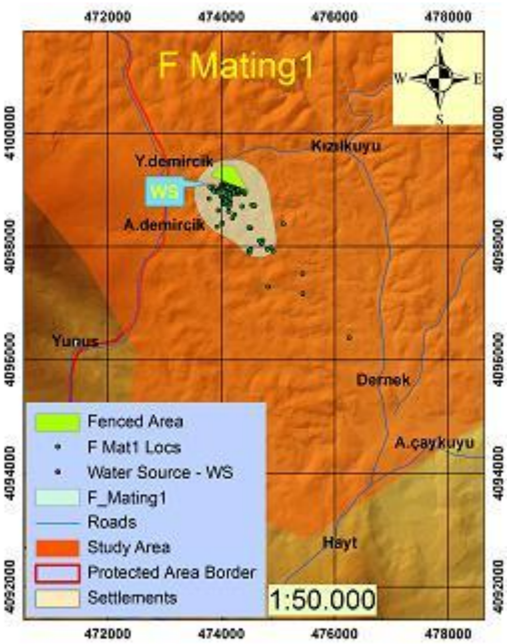


a) Mating1 b) Winter

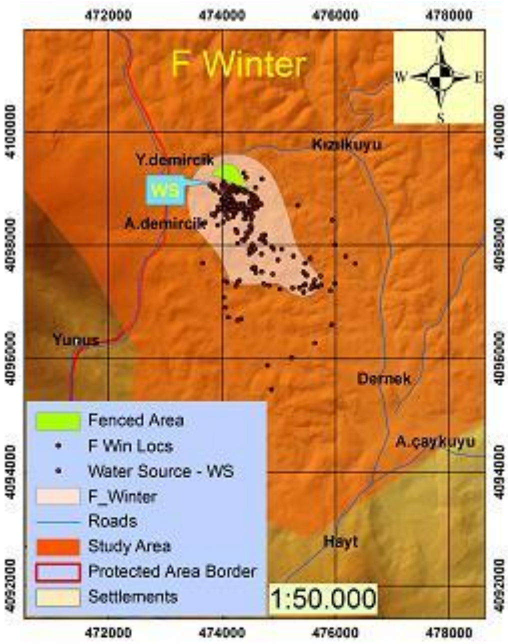
Figure 32. Seasonal home ranges of individual E

3.1.6 Individual F:

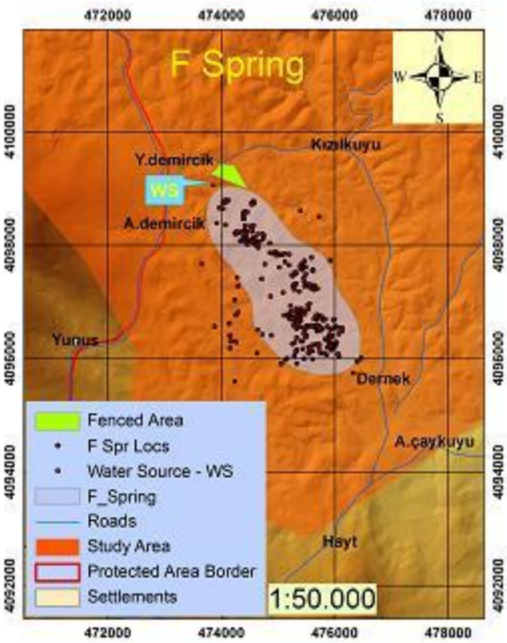
Seasonal home ranges of individual F are shown in following maps.



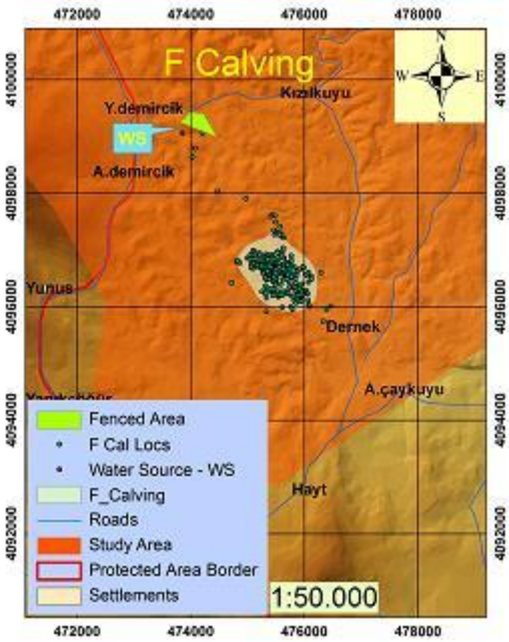
a) Mating1



b) Winter

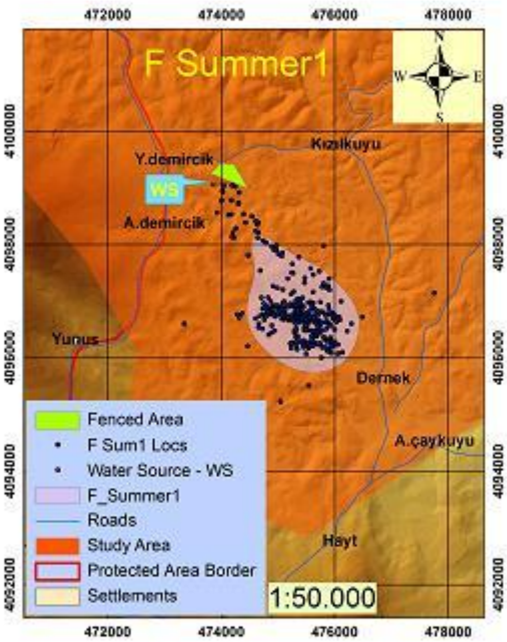


c) Spring

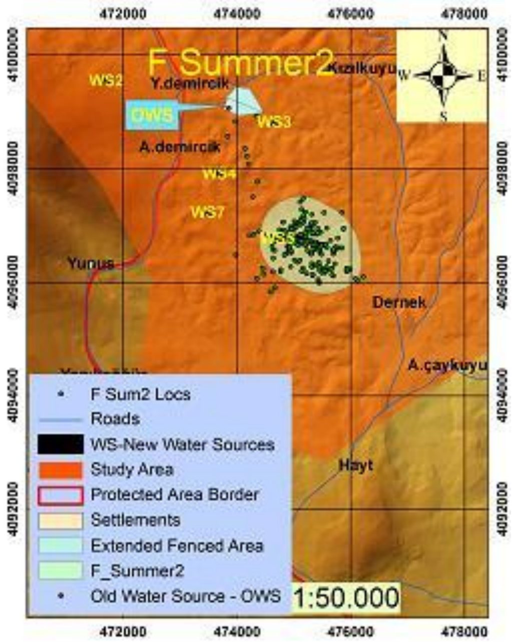


d) Calving

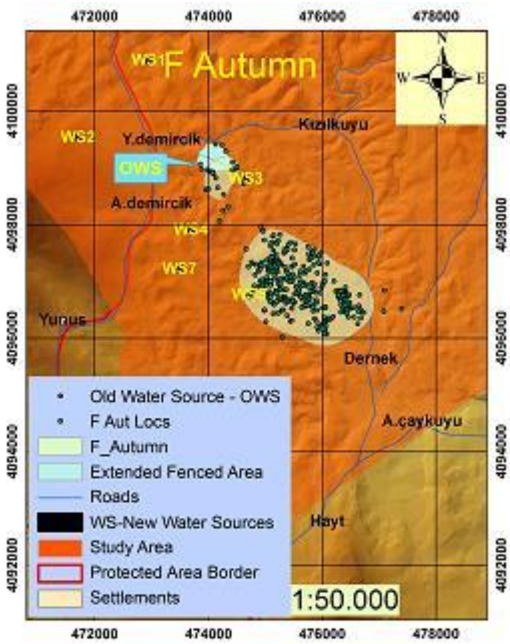
Figure 33. Seasonal home ranges of individual F



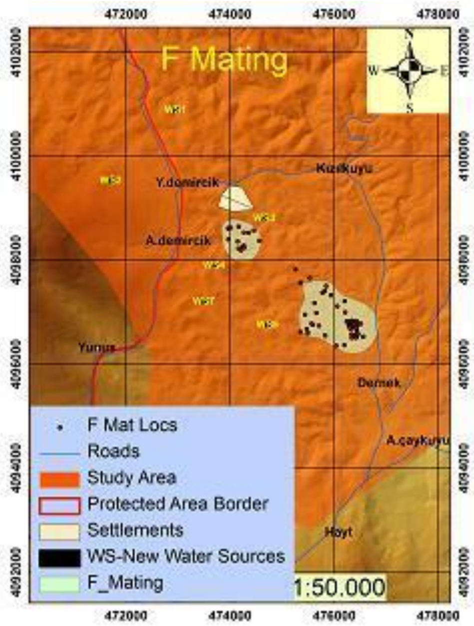
e) Summer1



f) Summer2



g) Autumn

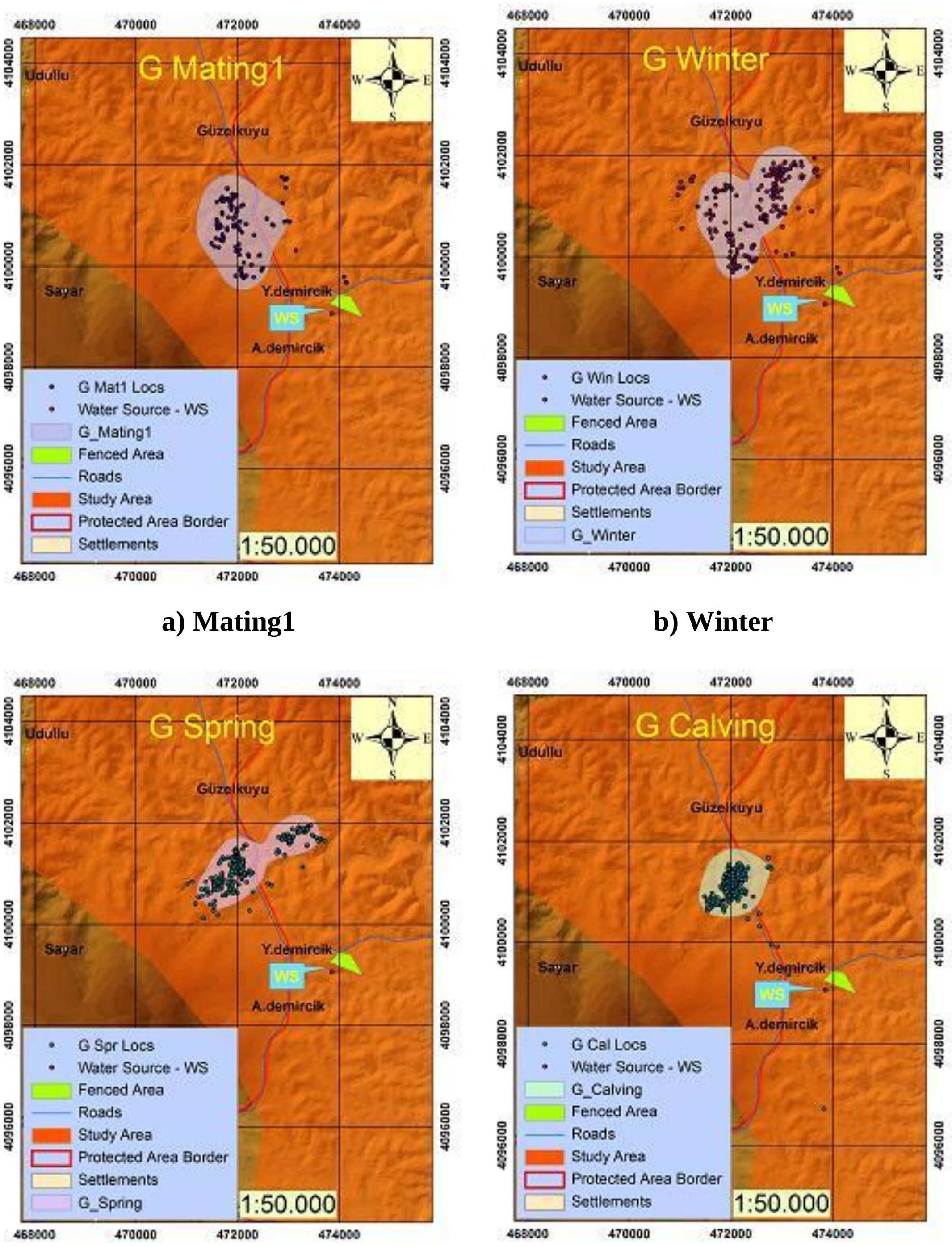


h) Mating

Figure 33. (cont.)

3.1.7 Individual G:

Seasonal home ranges of individual G are shown in following maps.



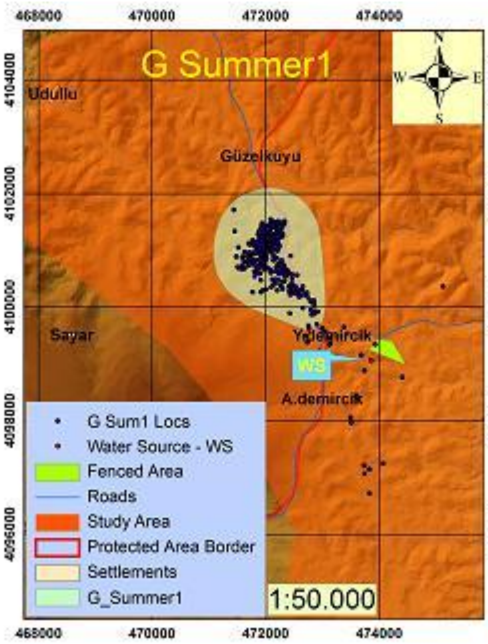
a) Mating1

b) Winter

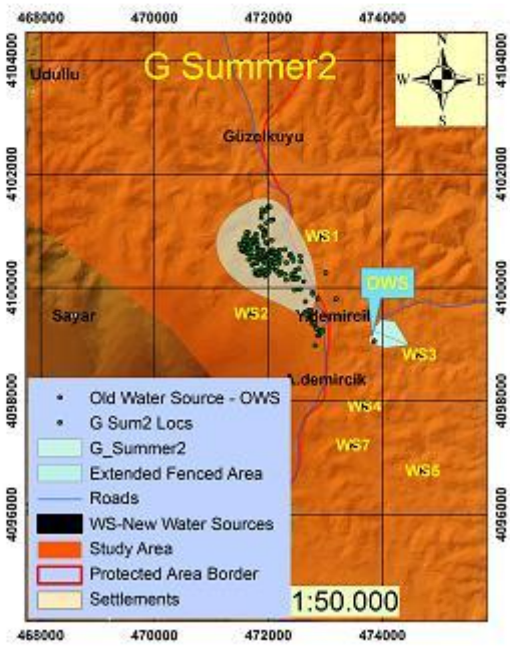
c) Spring

d) Calving

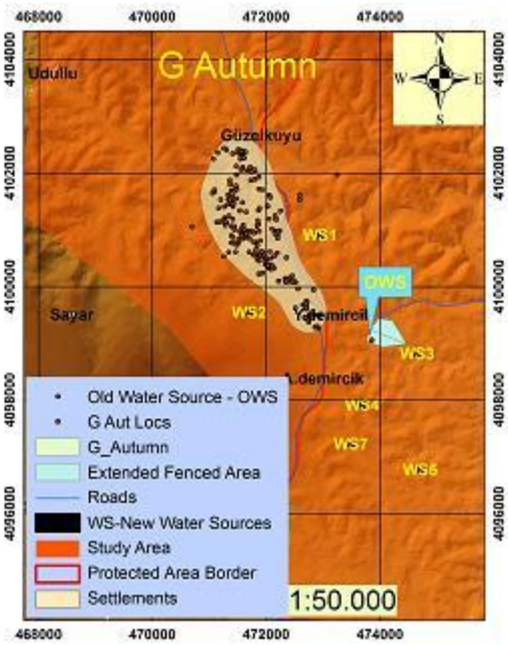
Figure 34. Seasonal home ranges of individual G



e) Summer1



f) Summer2



g) Autumn

Figure 34. (cont.)

3.2 Habitat Selection

K-select is an exploratory method that used for the multivariate analyses of habitat selection. Seven habitat variable layers were created as aspect, slope, elevation, distance to settlements, distance to water sources, and distance to roads. Seasonal habitat selection of GPS collared female goitered gazelles are inferred within their home ranges. Both use and availability are defined for each individual and relocations and home ranges represent respectively use and availability. K-select analysis presents the results as marginality vectors that their lengths indicate the strength of selection. The weights of variable selections by animals create factorial axes that represent the selected habitat types. The interpretation of selected habitats is made by considering length and direction of marginality vectors of habitat variables. First two factorial axes explain most of the marginality. Marginality vectors of the variable loadings (environmental variables) and individuals are interpreted together to evaluate habitat selection of individuals. Marginality vectors of individuals are recentered on the plane first two factorial axes. Length and closeness of marginality vectors to axes indicate the selected habitat variables. Eigenanalyses compare the observed habitat use and random habitat use for many times to evaluate the significance of selection (Calenge et al., 2005). However, some results did not reveal significant differences because of the conservative nature of Bonferroni test with high numbers of tests performed (Bland and Altman, 1995). Therefore, 10% significance level is used in tests.

In the results, sl, elv, dset, drd, dw1, and dw2 abbreviations are used to represent slope, elevation, distance to settlements, distance to roads, distance to old water source (from 15th January 2009 to 31st July 2009), and distance to new water sources (from 1st August 2009 to 9th December 2009) respectively.

The analyses based on 1000 randomization steps were performed for all seasons defined in part 2.5 except mating1 season. It was not analysed since the acclimatization period of gazelles could still affect the habitat selection of animals and to assess the mating season selection, instead the data collected on collars at the end of the study period coinciding with the mating season were used.

The results of analyses indicate the seasonal differences in habitat selection of collared goitered gazelles within their seasonal home ranges. They also show individual variations within the seasons. Interpretations of the results allow inferring the tendencies of collared goitered gazelles about habitat selection. The aspect preference of gazelles was east, west, and south for a year. East aspect was selected for spring and summer periods, and west and south for autumn and winter. Flat and north aspects were avoided throughout the year. Low elevation was selected weakly in winter and there is no selection or avoidance for other seasons of the year. Slope areas of home ranges were selected weakly in winter, calving, and summer. There is a similar pattern of selection in distance to settlements and roads variables. The gazelles were close to both in winter and spring season, and apart from them for summer and autumn. The area nearby water sources within their home ranges were preferred for the summer and winter season, and there was no selection or avoidance for rest of the year (Table 15).

Table 15. Summary of seasonal habitat selection of female GPS collared gazelles

Season / Variable	W	S	C	S1	S2	A	M
Slope	+	0	+	+	+	0	-
North	-	-	-	-	-	-	-
East	-	+	+	+	+	0	-
South	+	+	0	0	-	-	-
West	+	0	+	0	-	+	+
Flat	-	-	-	-	-	-	-
Elevation	-	0	0	0	0	0	-
Near settlements	+	+	0	0	0	0	+
Near roads	+	+	0	0	0	0	+
Near old water source	+	0	0	+	0	*	*
Near new water sources	*	*	*	*	+	0	-

3.2.1 Winter

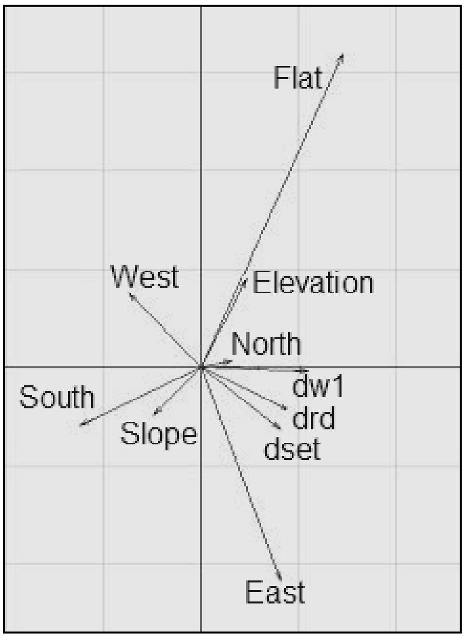
The first factorial axis eigenvalue of average marginality is larger than the expected random habitat use value ($\lambda_1 = 0.582$, $p < 0.001$) (Table 15). The habitat selection of individuals is not significant except gazelle D, E, and F (Table 16), but because Bonferroni test is conservative and exploratory nature of K-select method, general tendency is explained for winter and other seasons. The first factorial axis can be characterized by the opposition of two habitat types that one, positive side of the x-axis, is flat areas with high elevations, distant to water source, roads, and settlements, and the other, negative side of the x-axis, is slope areas south and west aspects with low elevations that near water source, roads, and settlements which was selected by group 1. The positive side of the second factorial axis was preferred by group 2 and represents the habitat having the properties of flat and west aspects with high elevations close to roads and settlements, and the other side represents low elevation slope areas of east aspects that are far from settlements and roads. It can be said that collared gazelles have selected to slope areas of west and south aspects which is close to settlements, roads, and water source. Also, all individuals avoided from the east and north aspects.

Table 16. Eigenvalues of factorial axes for winter season

Number of factorial axis	1	2	3	4	5	6	7
Eigenvalue	0.582	0.092	0.029	0.014	0.003	0.001	0.001

Table17. Summary of winter season habitat selection of individuals (positive values indicate selection and negatives avoidance)

Gazelle	A	B	C	D	E	F	G
Tests of The Marginality (Bonferroni α-level = 0.1 / 7 = 0.014)							
Marginality	0.484	0.638	0.785	1.234	0.838	0.921	0.169
Pvalue	0.247	0.079	0.025	0.001	0.006	0.002	0.830
Selection of habitat variables by each animal; mean used-mean available (Bonferroni α-level = 0.1 / 7x10 = 0.0014)							
Slope	0.111	0.114	0.259	0.186	0.251	0.247	-0.220
North	0.038	-0.183	-0.198	-0.044	-0.458	0.048	-0.119
East	-0.741	-0.394	-0.315	-0.321	-0.451	-0.485	-0.351
South	-0.279	0.614	0.457	0.475	1.097	0.346	0.129
West	0.355	0.341	0.499	0.221	0.254	0.418	-0.089
Flat	1.034	-0.647	-0.695	-0.623	-0.704	-0.638	0.715
Elevation	0.380	-0.254	-0.246	-0.274	-0.100	-0.196	0.024
Dset	-0.168	-0.278	-0.312	-0.481	-0.347	-0.414	-0.150
Drd	-0.145	-0.321	-0.382	-0.588	-0.257	-0.452	0.002
dw1	0.004	-0.428	-0.479	-0.647	-0.373	-0.538	0.045



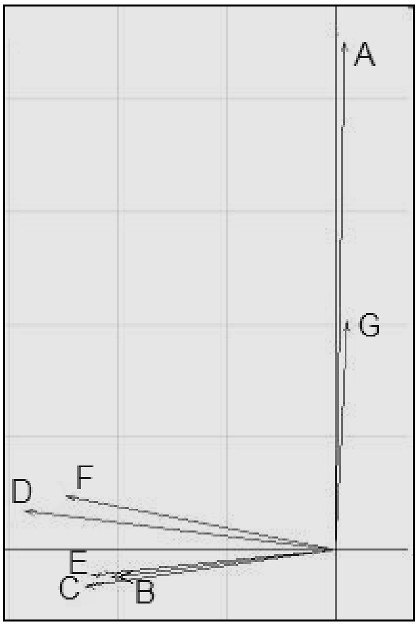


Figure 35. Marginality vectors of variable loadings and individuals on the first two factorial axes for winter

3.2.2 Spring

The eigenvalue of first factorial axis average marginality is larger than that of the expected random habitat use (λ_1 = 0.235, p < 0.001) (Table 17). All individuals show significant selection in spring (Table 18). Marginality vectors of individuals show that three different habitat types are selected by six individuals (Figure 33). Selection of gazelle A is the strongest that the most of the marginality of first factorial axis is explained by its selection. The selected side of the first factorial axis has the habitat characteristics of south and east aspects with high elevations. The selection of group1 and animal G are explained by both first and second factorial axis that gazelle G selected the areas of flat and east aspects with high elevations and group 1 selected the habitat characterized by south and east aspects distant to water source. It could be said that collared gazelles have tendency to select east and south aspects close to roads. North and flat aspects were avoided.

Table 18. Eigenvalues of axes for spring season

Number of factorial axis	1	2	3	4	5	6
Eigenvalue	0.235	0.111	0.040	0.004	0.003	0.001

Table19. Summary of spring season habitat selection of individuals (positive values indicate selection and negatives avoidance)

Gazelle	A	B	C	D	F	G
Tests of The Marginality (Bonferroni α-level = 0.1 / 6 = 0.017)						
Marginality	1.165	0.150	0.171	0.327	0.178	0.323
Pvalue	0.001	0.013	0.008	0.001	0.006	0.001
Selection of habitat variables by each animal; mean used-mean available (Bonferroni α-level = 0.05 / 6x10 = 0.0017)						
Slope	0.018	0.083	0.037	0.176	0.063	-0.148
North	-0.554	-0.396	-0.310	-0.364	-0.420	-0.265
East	0.331	0.318	0.300	0.451	0.216	0.533
South	1.101	0.219	0.063	0.182	0.330	-0.004
West	-0.429	0.175	0.238	0.156	0.175	-0.567
Flat	-0.889	-0.415	-0.386	-0.692	-0.397	1.084
Elevation	0.782	-0.032	-0.080	-0.077	-0.081	0.230
Dset	-0.171	-0.092	-0.176	-0.143	-0.057	-0.067
Drd	-0.178	-0.130	-0.177	-0.118	-0.107	-0.087
dw1	0.010	0.142	0.177	0.355	0.220	0.015

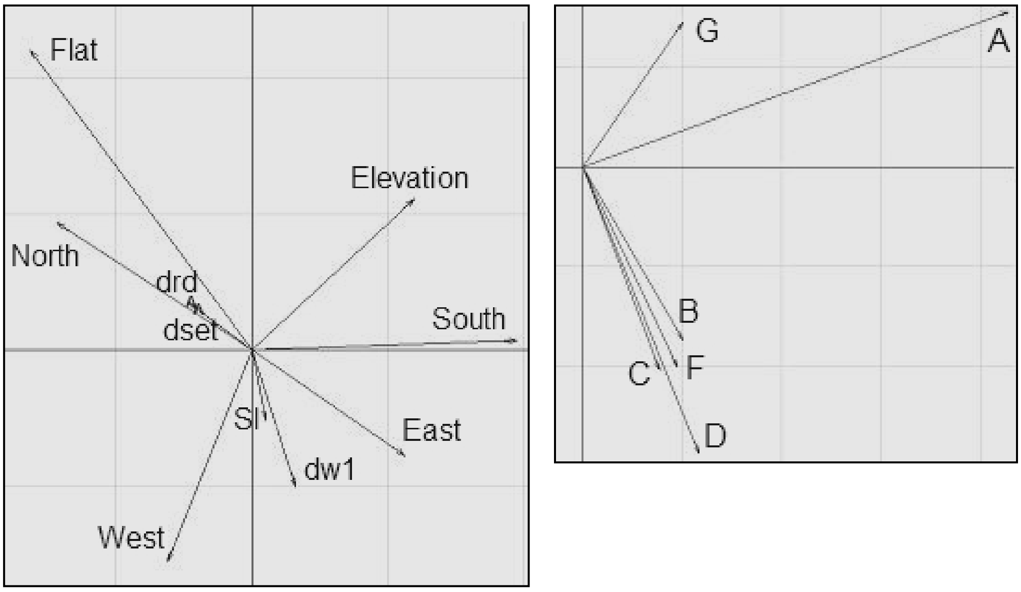


Figure 36. Marginality vectors of variable loadings and individuals on the first two factorial axes for spring

3.2.3 Calving

The eigenvalue of the first factorial axis average marginality (0.166) is larger than that of the random habitat use expectation ($p<0.0001$) (Table 19). Only gazelle A selected some habitat variables significantly, others showed weaker habitat selection (Table 20). The selection of gazelle A is explained by variable loadings of the first factorial axis and selection of group 1 is explained by both axes. South and east aspects with high elevations were selected by gazelle A and slope areas of west and east aspects apart from water source were selected by group1. It could be said that slope areas of east and west aspects were preferred by gazelles, and general tendency to avoid north and flat aspects are remarkable.

Table 20. Eigenvalues of axes for calving season

Number of factorial axis	1	2	3	4	5
Eigenvalue	0.166	0.056	0.024	0.017	0.010

Table21. Summary of calving season habitat selection of individuals (positive values indicate selection and negatives avoidance)

Gazelle	A	B	C	D	F	G
Tests of The Marginality (Bonferroni α-level = 0.1 / 6 = 0.017)						
Marginality	1.503	0.128	0.197	0.135	0.117	0.155
Pvalue	0.001	0.341	0.146	0.305	0.359	0.252
Selection of habitat variables by each animal; mean used-mean available (Bonferroni α-level = 0.05 / 6x10 = 0.0017)						
Slope	0.059	0.175	0.133	0.074	0.151	-0.174
North	-0.645	-0.153	-0.456	-0.204	-0.332	-0.216
East	0.533	0.023	0.220	0.137	0.348	0.358
South	1.492	-0.095	0.129	0.162	-0.006	-0.013
West	-0.733	0.431	0.317	0.192	0.184	-0.182
Flat	-2.016	-0.330	-0.209	-0.659	-0.229	0.297
Elevation	0.606	0.092	0.040	-0.039	0.159	0.242
Dset	-0.020	-0.164	0.005	-0.184	0.009	-0.093
Drd	0.006	-0.036	0.111	-0.147	0.037	-0.065
dw1	-0.001	0.087	0.266	0.102	-0.031	0.009

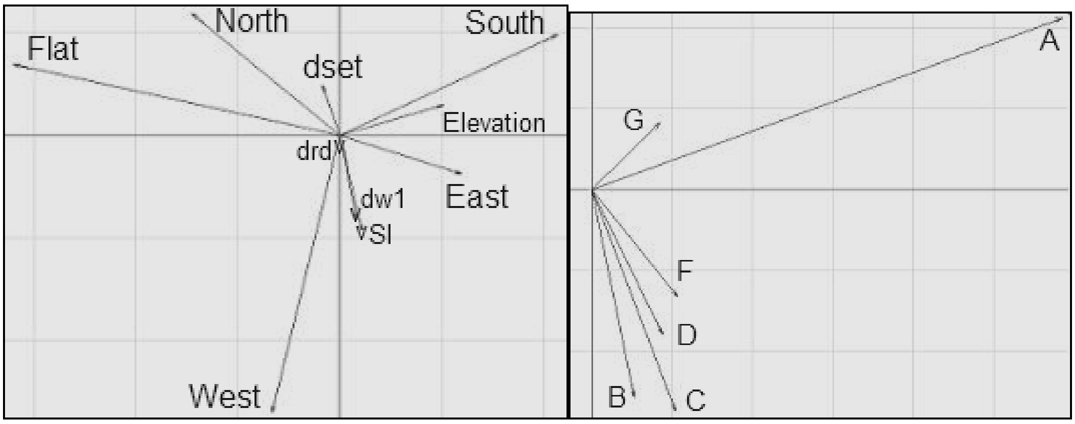


Figure 37. Marginality vectors of variable loadings and individuals on the first two factorial axes for calving season

3.2.4 Summer1

The first eigenvalue of average marginality is larger than the value from the expected random habitat use value (λ_1 = 0.144, p < 0.001) (Table 21). Habitat selections of gazelle D, F, and G are significant (Table 22). Three types of habitats were selected, the first one was preferred by gazelle B, C, and F, negative side of the first factorial axis, and characterised by slope areas of east far from water source, the second one reflects the preference of gazelle D, mostly explained by negative side of the second factorial axis, and slope areas of south aspects apart from roads, and settlements close to water source define the habitat, and the last one was the selection of gazelle G, positive side of the second factorial axis and east and flat aspects are the properties of the selected habitat. General tendency of gazelles is explained by the slope areas of east aspects and avoidance from north and flat aspects.

Table 22. Eigenvalues of axes for summer1 period

Number of factorial axis	1	2	3	4	5
Eigenvalue	0.144	0.085	0.048	0.013	0.005

Table 23. Summary of summer1 habitat selection of individuals (positive values indicate selection and negatives avoidance)

Gazelle	**B**	**C**	**D**	**F**	**G**
Tests of The Marginality (Bonferroni α-level = 0.1 / 5 = 0.02					
Marginality	0.217	0.196	0.329	0.367	0.372
pvalue	0.005	0.009	0.001	0.001	0.001
Selection of habitat variables by each animal; mean used-mean available (Bonferroni α-level = 0.1 / 5x10 = 0.002					
Slope	0.232	0.159	0.234	0.295	-0.221
North	-0.209	-0.376	-0.110	-0.310	-0.171
East	0.592	0.278	0.036	0.958	0.233
South	-0.150	0.273	0.275	0.042	-0.270
West	0.092	0.044	-0.011	-0.315	-0.308
Flat	-0.521	-0.263	-0.448	-0.569	1.548
Elevation	-0.053	-0.102	0.033	-0.004	0.120
dset	-0.062	-0.105	-0.197	-0.060	-0.067
drd	-0.096	-0.060	-0.129	-0.065	-0.205
dw1	0.191	0.259	-0.424	0.126	0.092

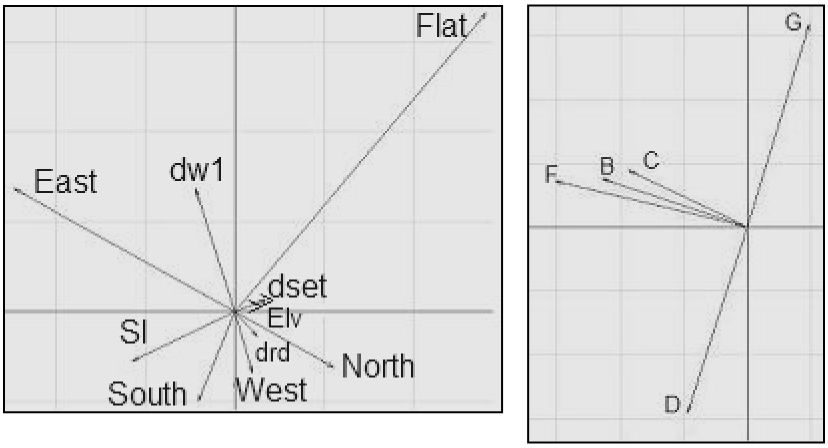


Figure 38. Marginality vectors of variable loadings and individuals on the first two factorial axes for summer1 period

3.3.5 Summer2

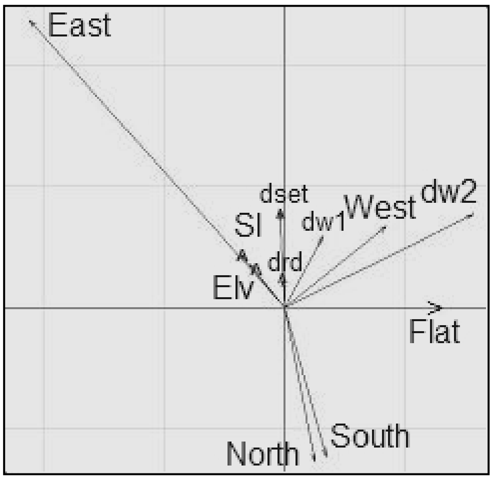
The first eigenvalue of average marginality (0.173) is larger than that of the expected random habitat use value ($p < 0.001$) (Table 23). Habitat selections of all gazelles are significant except gazelle B (Table 24). Old water source is also included in the analysis to see the effects of old habits. Three types of habitat selection are seen as in summer1 period for the same individuals. The first one is mainly explained by negative side of the second factorial axis and selection of slope areas of east aspects near the new water source by gazelle B, C, and F is clear. The second one, selection of gazelle D, is the south aspects near to both old and new water sources, roads and settlements. The last one is the selection of gazelle G, and characterised by the slope areas of east aspects apart from both old and new water sources. General selection can be considered as slope areas of east aspects near the new water sources and flat, north and west aspects were avoided. Slope areas of east aspects were selected for both summer1 and summer2 seasons, and all aspects except east were avoided.

Table 24. Eigenvalues of axes for summer2 period

Number of factorial axis	1	2	3	4	5
Eigenvalue	0.173	0.116	0.033	0.003	0.001

Table25. Summary of summer2 period habitat selection of individuals (positive values indicate selection and negatives avoidance)

Gazelle	B	C	D	F	G
Tests of The Marginality (Bonferroni α-level = 0.1 / 5 = 0.02)					
Marginality	0.205	0.314	0.404	0.296	0.423
pvalue	0.038	0.003	0.001	0.002	0.001
Selection of habitat variables by each animal; mean used-mean available (Bonferroni α-level = 0.1 / 5x11 = 0.0018)					
Slope	0.156	0.142	0.098	0.024	0.189
North	-0.225	-0.120	-0.041	-0.020	-0.540
East	0.571	0.727	-0.107	0.707	0.599
South	0.015	-0.267	0.192	-0.210	-0.357
West	-0.128	-0.175	-0.005	-0.274	0.438
Flat	-0.405	-0.216	-0.129	-0.403	0.144
Elevation	0.088	0.106	-0.133	0.123	0.018
dset	0.050	0.085	-0.281	0.092	0.156
drd	0.008	0.041	-0.156	0.042	-0.002
dw1	-0.027	-0.009	-0.321	-0.030	0.102
dw2	-0.271	-0.367	-0.397	-0.358	0.357



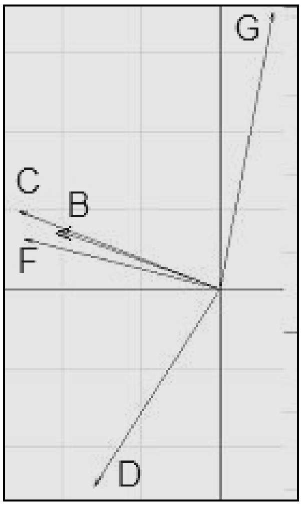


Figure 39. Marginality vectors of variable loadings and individuals on the first two factorial axes for summer2 period

3.3.6 Autumn

Average marginality of the first factorial axis is larger than the one from expected random habitat use value ($\lambda_1 = 0.279$, $p < 0.001$) (Table 24). Habitat selections of all gazelles are significant (Table 25). Two types of habitats are selected in this season by five collared gazelles. The first habitat was preferred by gazelle G characterised by slope areas of west far from water sources. The second is the preference of group1 (gazelle B, C, and F) and mainly aspect west defines the habitat. General tendency of habitat selection by gazelles is explained by the areas of west aspects and all avoided flat, north, and south aspects.

Table 26. Eigenvalues of axes for autumn season

Number of factorial axis	1	2	3	4
Eigenvalue	0.279	0.027	0.011	0.001

Table27. Summary of autumn season habitat selection of individuals (positive values indicate selection and negatives avoidance)

Gazelle	B	C	F	G
Tests of The Marginality (Bonferroni α-level = 0.1 / 4 = 0.025)				
Marginality	0.236	0.393	0.314	0.321
pvalue	0.002	0.001	0.001	0.001
Selection of habitat variables by each animal; mean used-mean available (Bonferroni α-level = 0.1 / 4x10 = 0.0025)				
Slope	-0.084	-0.151	0.062	0.214
North	-0.270	-0.354	-0.424	-0.443
East	0.033	-0.067	0.005	-0.076
South	-0.268	-0.329	-0.216	-0.003
West	0.917	1.239	1.071	0.909
Flat	-0.475	-0.466	-0.359	-0.417
Elevation	-0.008	-0.053	-0.029	0.083
dset	0.087	0.005	0.129	-0.085
drd	0.022	-0.058	0.060	0.030
dw2	-0.108	-0.038	-0.078	0.198

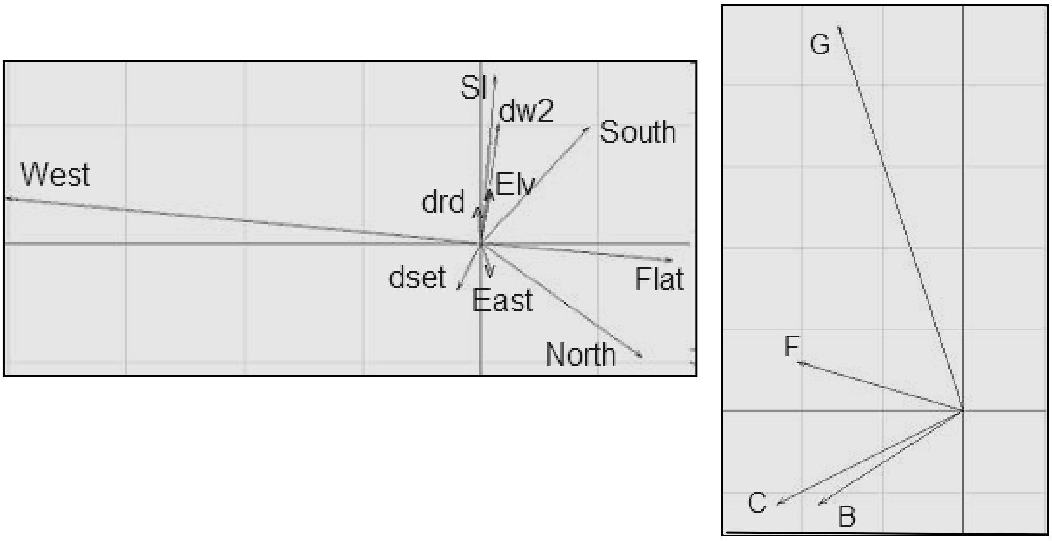


Figure 40. Marginality vectors of variable loadings and individuals on the first two factorial axes for autumn

3.3.7 Mating

Average marginality eigenvalue of the first factorial axis is larger than the one of the expected random habitat use value ($\lambda_1 = 0.998$, $p < 0.001$) (Table 26). Habitat selections of all gazelles are significant (Table 27). There are small differences in their habitat selections, but generally prefer the similar habitats. All selected the west aspects with low elevations and low slopes far from water sources and close to settlements and roads. All aspects except the west were avoided by all gazelles.

Table 28. Eigenvalues of axes for mating season

Number of factorial axis	1	2	3
Eigenvalue	0.998	0.039	0.009

Table29. Summary of mating season habitat selection of individuals (positive values indicate selection and negatives avoidance)

Gazelle	B	C	F
Tests of The Marginality (Bonferroni α-level = 0.1 / 3 = 0.033)			
Marginality	0.958	1.189	1.000
pvalue	0.001	0.001	0.002
Selection of habitat variables by each animal; mean used-mean available (Bonferroni α-level = 0.1 / 3x10 = 0.0033)			
Slope	-0.181	-0.216	-0.123
North	-0.371	-0.354	-0.140
East	-0.643	-0.390	-0.408
South	-0.281	-0.654	-0.521
West	1.818	1.958	1.480
Flat	-0.683	-0.064	-0.380
Elevation	-0.154	-0.209	-0.416
dset	-0.248	-0.310	-0.253
drd	-0.209	-0.264	-0.274
dw2	0.139	0.176	0.384

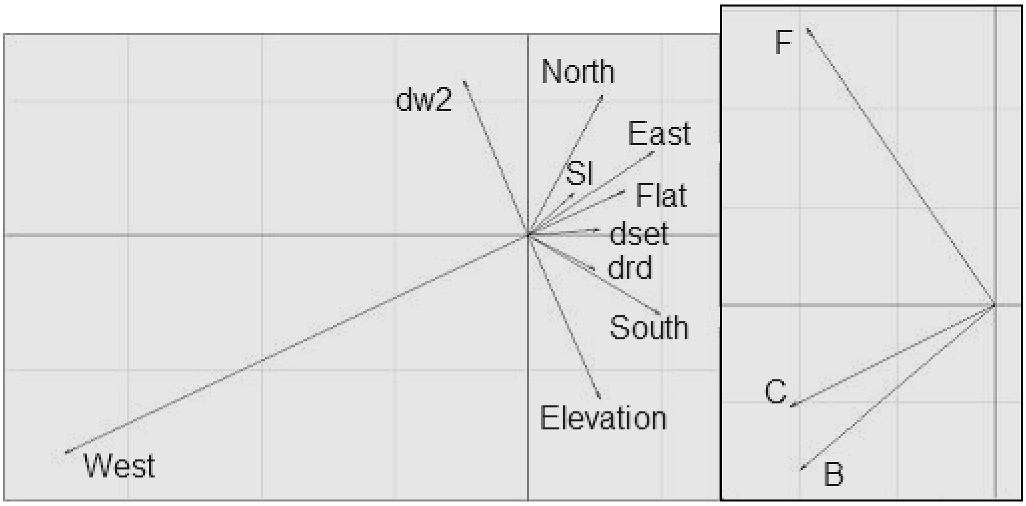


Figure 41. Marginality vectors of variable loadings and individuals on the first two factorial axes for mating season

CHAPTER 4

Discussion

4.1 Overview of the Study

This study was started with difficulties related to custom procedures. Even though the collars were at the customs in July 2008, we were not able to receive them until September 2008. After that time, gazelles were thought to be collared and released in October but it could not be realized due to the lack of preparations for trapping in Şanlıurfa. Prolonged preparations caused to the first wrong step and gazelles were trapped in mating season, November 2008. After the release, they were monitored periodically at least two times a month.

Even all the directories in the IUCN guidelines for re-introductions were not followed, there were some suitable steps. The release site, Kızılkuyu Wildlife Development Area, covers the historical range of the species. However, the area can be considered as unsuitable for gazelles since human activity is high in the area and especially high number of domestic livestock and intensive farming create disturbances for gazelles. In addition, the legislative measurements were taken for wildlife in the area as prohibition of hunting and live catching of calves, but its efficiency in practice is questionable. Agreements of the local people were obtained and one person was employed as a ranger in almost every village on the release site. Moreover, post-release monitoring was carried out effectively; a total of 33 field surveys were performed for more than a year. Monitoring is the only way for evaluating the success of re-introduction/supplementation and taking appropriate management policies (Mesochina et al., 2003). On the other hand, genetic analyses were not performed for taxonomic identification of gazelles before the release. According to IUCN re-introductions guideline, they should be in the same taxon (IUCN, 1998). When considering the neighbouring countries where goitered gazelles are found, Syria (Kingswood et al., 2001b) and Iraq (Al-Robaae and Kingswood, 2001), there is the possibility of them being hybrid forms of *G. s. subgutturosa* and *G. s. marica*.

Three of the GPS collared gazelles dead during the study. The causes of deaths are not clear. However, animal E was possibly poached, since a shepherd had found the collar on the field on February 2009. He said there was no gazelle carcass, it was just standing on the ground, and there was not any blood stain and any damage on the collar. Therefore, it was possibly removed from animal's neck carefully by poachers and protected from blood stain by covering it with a plastic bag or something else.

The carcass of the animal A was found on May 2009. It was possibly be predated by a carnivore species wolf or dog. Its abdomen was ripped. The animal had been looked like unhealthy and its one leg has limped in the last field survey before the survey that carcass of the animal was found. The weakness of the animal could make it an easy prey for carnivores or maybe dead from illness, and then its abdomen ripped by scavengers. The unhealthy look of the animal could be the result of existence of sewage water passing nearby the area she was found.

The animal D was dead possibly because of by thirst. Its carcass was found at September 2009. It looked like to the carcass of the animal A, its abdomen was also ripped. The animal could also be an easy prey for carnivores because of thirst related weakness, or maybe died of dehydration and its abdomen was ripped by scavengers. September is still very hot and water scarcity is one of the major problems for gazelles. It is known that artificial water ponds were not filled with water regularly at that month. We saw empty water ponds and also local people said that the ponds were not filled. The previous water source was included in additional fenced area and we saw the gazelle A just beside water source close part of the fence in early September field survey. Therefore, the reason of death is most probably related to dehydration.

The mating period of the goitered gazelle population in the Şanlıurfa is between mid November and mid January based on field observations and group composition changes (Çobanoğlu, 2010). However, the courtship behaviour have been observed even in February; but copulation in this month can not be resulted in pregnancy since, parturition lasts from late April to early July, and gestation period is 5-6 months. These observations are consistent with the Iran and Central Asia populations (Zhevnerov, 1984 cited in Martin 2000; Perelodova et al., 1998; Sempere et al., 2001).

4.2 Home Range

Home range analyses show that there are some patterns between season transitions. Some of the home range differences are statistically significant that are between summer1 and summer2 ($p = 0.014$), summer2 and autumn ($p = 0.004$), mating1 and winter ($p = 0.000$), spring and calving ($p = 0.019$), calving and summer1 ($p = 0.005$), and autumn and mating ($p = 0.002$) period home ranges. Average summer1 home range size (4.55 ± 1.55 km^2) is the highest and average calving (1.66 ± 0.50 km^2) and mating (1.37 ± 0.50 km^2) home ranges are the lowest ones.

Home range sizes of gazelles can be affected by many factors like availability and distribution of resources and behaviour of species. Gazelles may be sedentary and nomadic, and some species perform seasonal migrations (Martin, 2000). Home ranges of sedentary gazelles like Arabian sand gazelles in Saudi Arabia (Habibi at el. 1993, cited in Martin, 2000) and goitered gazelles in Turkey are small. Home ranges of gazelles showing restricted seasonal movements are also small like lower elevation and higher elevation seasonal movements of *Gazella gazella* in Israel (Baharav, 1983, cited in Martin, 2000). Yearly average home range of goitered gazelle in Şanlıurfa (2.93 ± 1.92 km^2), is generally consistent with other sedentary gazelle species. Home range size of one of *Gazella dorcas* population enclosured in

6 km^2 area in Israel is 1-2 km^2 and one of *G. gazella* population enclosured in 550 km^2 area is 2 km^2 in Israel (Baharav, 1982, 1983, all cited in Martin, 2000). Northern Israel population of *G. gazella* has a home range of 0.2 – 2 km^2 (Mendelssohn et al., 1995). Re-introduced *G. gazella* population in Saudi Arabia has a home range of approximately 1 km^2 (Dunham, 1998a). Nomadic gazelles use larger areas like one of *G. dorcas* population in Israel has 25 km^2 home range (Baharav, 1982 cited in Martin, 2000) and home ranges of Kazakhstan and Tajikistan *G. subgutturosa* populations performing seasonal migrations are 184 km^2 and 1000 km^2 respectively (Zhevnerov, 1984, cited in Martin, 2000).

Mating1 period is coincided with the time periods covering the release times. Therefore, the acclimatization period of released gazelles to the wild might not reflect the natural behaviour of goitered gazelle. Consideration of the acclimatization period as between the dates 27 November 2008 and 15 December 2008 may not be correct, and it might be longer than that. However, the date of the first records of the collared gazelles with the wild individuals is at 18 December 2008.

Other significant difference found, between the home ranges at autumn and mating, periods can be explained by mating behaviour of the gazelles during which, female gazelles form large groups in a small area and older males reveal courtship behaviours to make their harems. Gathering behaviour of females can be the reason of the decrease in home range sizes. Similar field observations are made in *G. gazella* population in Saudi Arabia; males restrict the distance of the movement of chosen females (Dunham, 1998a).

One of the striking differences is between the home range sizes of spring season and calving period. Home range sizes of all gazelles, except the gazelle D, are smaller in calving period. Individual A has the minimum and D has the maximum values of spring home ranges. Calving home range size of gazelle A is too small that the reason may be explained by its health condition or failure in adaptation to the wild. It died at the end of May and it looked unhealthy and one of his legs was limped in

April and May field surveys. The reason of unhealthy look might be related to waste water coming from industrial enterprises and passing near its home range. Therefore, the small home range size may not reflect the natural preference of the individual, and it might be obliged to stay in such a small area due to weakness. The other home ranges are close to each other. When passing to parturition period, reducing home range size is expected due to the calving behaviours of pregnant female gazelles. The calves are hidden by their mothers among rocks and grasses for a few weeks and regularly nursed by their mothers. Nursing behaviour of female gazelles forces them dependent to the area where their calves hidden. All the released gazelles were detected as pregnant in calving season, but only twins of animal G were alive.

One of the other conspicuous differences between home range sizes is seen between calving and summer1 periods. Approximately average summer1 home range sizes are two times larger than that of the calving. The increase can be related to decrease in availability of food and water resources and with increasing mobility and strength of the calves. The same argument is also considered for spring to summer1 transition. In order to understand the water need of gazelles, making comparisons between the summer1 and summer2 period home ranges of individuals would be meaningful.

In 1st August 2008, seven artificial water sources were built in the area, so summer season is divided into two at this date. There was only one water source in the area in summer1 period. On the other hand, there were seven in the summer2 period. Also old water source was included in fenced area. Home range sizes of the gazelles, except gazelle D, had decreased with the increasing water sources. The group 1 gazelles had narrowed down their home ranges through the one new water source (WS5) and decrease in the gazelle G home range towards the area between two new water sources (WS1, WS2). The effect of water availability on home range size can be understood by looking at three conspicuous points; (1) the decrease in home range size with increasing water sources, (2) home range shape in summer1 season, extended to water source, and (3) movement patterns of the individuals in summer1 season, through the water source. In the opposite case, increase in home range size with increasing water source is seen for gazelle D. Increase in the summer2 home range size of gazelle D can be explained by the searching for new water sources. It is most probably true that, water is more important to gazelle D than the others. All home range polygons of individual D, especially summer1, indicate its higher tendency to stay close to water source than the other group 1 individuals. The other individuals possibly went to water source for short time periods, drink and returned to their living site. The differences between sizes and shapes of summer2 and summer1 periods indicate that, group 1 had stopped to go to the old water source since one of the new water sources was built in their home range (WS5). Then, why the individual D did not stay on near new water sources as the other group1 individuals? The answer could be the lack of resistance of gazelle D to thirst. Field surveys and conversations with local people indicated the negligence of filling water sources. It is possible that occasional filling of water sources were satisfactory for the group 1 gazelles other than gazelle D. Therefore, gazelle D had possibly been suffered from thirst. It can also be thought that, more mobile individuals have more chance to find water. However, water is scarce in the area and efforts of finding water would not be successful.

An increasing trend in home range sizes is seen from passing summer2 to autumn when table 14 is examined. Availability of food and water resources is distributed more homogenously in the area as a result of occasional rainfalls, and may lead to decrease in site fidelity.

The other comparisons were non-significant that indicate there is no pattern between the winter and spring and autumn and winter.

The other remarkable point in table 14 is continuous decrease in home range sizes of gazelle A. It can also be seen in home range map figures (figure 25 a – d). It had selected the most remote area to live after release than other individuals. Gazelles were dispersed desperately in the area at the release time. The direction of the first movements and covered distance may affect the living site selection of gazelles.

Gazelle G had also selected the area near gazelle A, but it is more mobile than gazelle A. For instance, it had crossed the roads many times, but gazelle A were able to cross only a few times. Individual A may be shyer than gazelle G and this might have prevented her exploring the environment. Gazelle G might avoid the waste water passing near the Güzelkuyu village (the village is shown in home range figures of gazelle A and G) by searching for resources more efficiently than gazelle A and individual A might be obliged to use waste water. It also looked unhealthy in the spring and calving season field surveys. It can be also said that individual A has not adapted to the wild. She has never observed with wild individuals.

Gazelle E died just beginning of the study in February 2009 most probably because of illegal hunting. Collar was found by a shepherd and he said it was just standing on the ground; it was clean and no blood stain and any damage on it. Therefore, it was possibly poached and the collar was removed from animal’s neck by hunters.

Gazelle D differs from all the other gazelles by its large home range sizes in calving, summer1, and summer2 periods, the warmest times of the year in the area. The most possible explanation of this difference may be the search for water and it may be the least resistant individual to thirst as explained before.

All surviving released animals, gazelle B, C, F, and G, are similar in seasonal home range patterns when looking at their changes in home range sizes. It can be said that they are more successful individuals than the dead ones except gazelle E. They may be less shy than gazelle A, and more resistant to dehydration than gazelle D.

It was observed that released gazelles had interacted with wild gazelles in the area since mid December 2008. The group1, especially three of them gazelle B, C, and F had stayed together for the study period. Their direction of release movements may be coincided and this could be the reason of their closeness. The other possibility is that they may be relative individuals.

To summarize the seasonal home range size of gazelles, it can be inferred that their home range size is largest in summer season especially water is scarce in the area, and other seasons there is no big differences between them. If water is not scarce in the area (summer2 period), home range sizes would not vary between seasons. Therefore, it can be stated that water is one of the key resource for gazelles in summer season.

The field observations, all the recorded location data, and the home ranges of gazelle G show that gazelles have used densely to the central, southwest and northwest part of the protected area and also outside of the area in northwest direction. The other parts of the area have also used by gazelles, but amount of use is very low. These findings indicate the necessity of rearrangement of the Kızılkuyu Wildlife Protection Area border, it should include the areas that intensively used by gazelles.

4.3 Habitat Selection

The results of analyses indicate the habitat selection of gazelles varies in some aspects in different seasons. There are some shared selections of habitat variables in some seasons. However, there are also individual differences in the same season. Availability is defined for each individual as home range and each single location is considered as used. Thus, availability is not the same for all individuals because of home range level definition. The differences between used and available resource units indicate the strength of selection, if there is. There are significant selections for all seasons for used parameters. However, seasonal habitat selection is not significant for all individuals.

Vegetation may be the major determinant of the habitat selection of gazelles. Its abundance and quality can be affected by spatial variables like, slope, aspect, elevation, soil characteristics, and solar radiation. Mutanga et al. (2004) showed the effects of slope, altitude, and aspect on grass quality. One major drawback of the habitat selection analyses is the lack of vegetation layer. The effects of quality and quantity of vegetation on spatial distribution of goitered gazelles are shown in Bamoo national Park, Iran (Nowzari et al., 2007).

In addition to distribution of quality and quantity of vegetation in the area, competition with domestic livestock can be another factor influencing spatial distribution of the gazelles. Cunningham (2009) shows the competition between *G. s. marica* and domestic livestock. The competition is also reported for G. gazella and domestic livestock in Saudi Arabia (Attum, 2007). Gazelles may prefer the areas where less intensely used by domestic livestock.

Free roaming dogs in the area may have influence on space use of animals and their survival. The dogs also disturb goitered gazelles in Iran and they can leave their habitat because of dogs (Farhadinia, 2009). In the field surveys, it is observed that gazelles chased by dogs. They are also potential threat for especially calves. Manor and Saltz (2003), and Gingold et al. (2009) show the negative effects of dogs on calf survival of *G. gazella* in Israel. *G. gazella* population in Saudi Arabia has also suffered from dogs (Dunham, 2001, cited in Attum, 2007)

Smooth slope areas were selected by collared gazelles in winter, calving, and summer seasons but avoided in mating season. High slope areas were not chosen by gazelles during the study period as in *G. subgutturosa* population Iran (Farhadinia et al., 2009). The choice of smooth slope areas in summer periods may be related to be protection from intensive sunshine. Flat areas are subjected to more solar radiation than slope areas. Also, flat areas are in sight, so there are not good places for hiding calves in calving season and live catching of calves in hilly terrains is difficult since hardiness of the vehicle and human movements. Therefore, slope area selection of female gazelles is meaningful in this period.

Aspect selection of animal can be related to many other variables. For instance, a cold adapted species in northern hemisphere can select the south aspects because of using sunshine effectively, or an aspect can contain some other resources like water or food source that their selection can be seen as selection of this aspect. The gazelles selected to east aspects in spring, calving, and summer periods; west aspects in autumn, winter, and mating seasons and south aspects in winter and spring seasons. North and flat aspects were avoided for all seasons. General aspect selection of goitered gazelles was in east and west aspects throughout the year. South aspect selection is reasonable in colder seasons because of efficient use of sunlight. East and west selection of gazelles may be related to the increasing field of vision. The mountain range in the area is in north-south direction, and even the availability of aspect classes is close to each other, vision on the north and south aspects is restricted.

The general avoidance from flat aspects may be the result of avoiding being an easy prey for poachers because of their easy detection on open habitats. Also, their occurrence on near hilly areas may be related to the easier escape from poachers. The trade-off between optimum forage and visual detection by predators is common in large herbivores (Illius and Fitzgibbon, 1994 cited in Skarpe and Hester, 2008). A study focused on the habitat selection of goitered gazelles in Iran shows that they prefer to live in hilly terrains near flat areas (Farhadinia et al., 2009). Moreover, increase in poaching risk in open habitats is shown in *G. gazella* in Saudi Arabia (Attum, 2007). However, the rates of encountering with predators are affected by topographic variables such as slope and elevation (Dehn, 1990; Hebblewhite et al., 2005). Hilly areas restrict their eyesight and encountering with predators mostly result in death (Farhadinia et al., 2009). The findings of this study are similar in that of Iran in case of near hilly terrain selection. The avoidance of the open plain habitats far from hilly landscape by gazelles may be the result of poaching pressure on them. In addition, it is possible that the population size of natural predators of gazelles in those hilly areas is low and hence the rate to encounter with the predators in hilly terrains may be low.

Elevation seems to be the least important environmental variable for female goitered gazelles. It was neither selected nor avoided in any season, except the avoidance of elevation in mating season. Collared gazelles have never been found on the northern mountainous terrains like in Iranian goitered gazelles (Farhadinia et al., 2009).

None of the seasons they selected to be apart from settlements and roads. This may be the result of their tameness. Agricultural activity and animal husbandry are intense in the area and they possibly accustomed to human and man-made structures for years. Therefore, the results are reasonable.

Water source was not selected generally by gazelles, but home range interpretations present the water source as a key habitat variable in the area. The reason of this contradiction is exactly related to availability definition of habitat selection analyses. Availability is defined for home ranges and water sources were selected strongly or slightly by gazelles whose home range includes one of the water sources in seasons followed the summer2 period. Furthermore, movements of gazelles, shape of their home ranges, and changes of their home range sizes possibly as a response to change in water availability in summer1 and summer2 periods indicate the importance of water sources for gazelles. In addition, their home ranges are not far from water sources in any season similar to the findings of Farahmand (2002) cited in Farhadinia (2009). He shows that roaming distance of goitered gazelles from water sources does not exceed the 5 km in Qazy National Park in Iran. It is reported that water is crucial for the thermoregulation in *Gazella dorcas dorcas* (Ghobrial, 1970). The availability of water also affects the types of food they eat, if water is scarce in the area, they eat the foods with high water content (Ghobrial, 1974, cited in Dunham, 1998b). This may also be true for goitered gazelles in Şanlıurfa.

Finally, it is important to note that if the sample size would be higher and study period would be longer, the results might be different in some aspects.

CHAPTER 5

Conclusion

This is one of the first studies that focuses on the ecology of the goitered gazelles in Turkey. This type of information about the species is crucial in order to take appropriate conservation measurements. This study is focused on the seasonal home range and habitat selection of female goitered gazelles.

This study shows that some of the areas within the protection area are not used and some of the areas outside the protection area are heavily used by gazelles. The border should be re-arranged and, important areas should be determined with modelling for both reshaping the area and allocation of suitable site for potential forthcoming supplementations.

In order to improve the conservation of gazelles, stricter measurements should be taken. The most urgent problem that must be solved is preventing live catching of calves. The other major problem is poaching. Even though the rate of live catching of calves and poaching is small; these two threats deeply affect the population structure, especially the concern is an endangered small population. The other problem is intensive agricultural activities. The study area contains many farmlands and increasing agricultural activities decrease the size of suitable habitats for gazelles. The other human-caused disturbance is the existence of large number of livestock in the area. They probably compete with the gazelles for food and water resources. The important areas for gazelles should be restricted or banned for domestic livestock grazing. In addition, public awareness about gazelle conservation should be increased by educative activities. For the future, the population should be supplemented with additional releases.

This study is an attempt to infer seasonal home range sizes and habitat selection of female goitered gazelles with the realization of the small number of individuals monitored and the shortness of the study period.

Larger number of individuals should be identified and monitored more frequently for longer times in order to make inferences about the whole population. Also, captive habits of the animals may affect their movements and behaviours in the wild. Yet the information gathered during this study is valuable for guiding future research.

References

Abdusalyamov, I.A., 2001. Tajikistan, In: Mallon, D.P. and Kingswood, S.C. (eds.), *Antelopes. Part 4: North Africa, the Middle East and Asia, Global Survey and Regional Action Plans*. IUCN/SSC Antelope Specialist Group, IUCN, Gland and Cambridge. pp, 148 - 149.

Ackerman, B.B., Leban, A. F., Garton, E.O., and Samuel, M.D., 1990. User's manual for program home range, Second edition, Technical Report 15, Forestry, Wildlife and Range Experiment Station, University of Idaho, Moscow, Idaho, USA.

Adams, L. and Davis, S. D., 1967. The internal anatomy of home range. *Journal of Mammalogy*, 48, pp. 529-536.

Aebischer, N.J., Robertson, P.A., and Kenward, R.E., 1993. Compositional analysis of habitat use from animal radio–tracking data. *Ecology*, 74, pp. 1313-1325.

Akçakaya, H. R., Burgman, M. A., and Ginzburg, L. A., 1999. *Applied Population Ecology: Using RAMAS Ecolab*. 2nd ed., Applied Biomathematics, Setauket, New York. 285 pages.

Al-Hamar, Y., and Almutai, A., 2001. Qatar, In: Mallon, D.P. and Kingswood, S.C. (eds.), *Antelopes. Part 4: North Africa, the Middle East and Asia, Global Survey and Regional Action Plans*. IUCN/SSC Antelope Specialist Group, IUCN, Gland and Cambridge. pp. 82 - 83.

Al-Robaae, K., and Kingswood, S.C., 2001. Iraq, In: Mallon, D.P. and Kingswood, S.C. (eds.), *Antelopes. Part 4: North Africa, the Middle East and Asia, Global Survey and Regional Action Plans*. IUCN/SSC Antelope Specialist Group, IUCN, Gland and Cambridge, pp. 88 - 92.

Amstrup, S.C., McDonald, T. L., and Durner, G.M., 2004. Using satellite radiotelemetry data to delineate and manage wildlife populations. *Wildlife Society Bulletin*, 32, pp. 661-679.

Aronoff, S., 1989. *Geographic Information Systems: A Management Perspective*, WDL Publications, Canada, 294 pages.

Attum, O., 2007. Can landscape use be among the factors that potentially make some ungulates species more difficult to conserve?, *Journal of Arid Environments*, 69, pp. 410–419.

Baskin, L., and Danell, K., 2003. *Ecology of ungulates: a handbook of species in Eastern Europe and Northern and Central Asia*. Heidelberg: Springer. 434 pages.

BCEAW (Breeding Centre for Endangered Arabian Wildlife), date unknown, Ungulates, Sand Gazelle,
Available at: http://www.breedingcentresharjah.com/about_us.html
[Accessed 27 December 2009].

Bekenov, A.B., Blank, D.A., Grachev Y.A., and Plakhov, K.N., 2001. Kazakhstan, In: Mallon, D.P. and Kingswood, S.C. (eds.), *Antelopes. Part 4: North Africa, the Middle East and Asia, Global Survey and Regional Action Plans*. IUCN/SSC Antelope Specialist Group, IUCN, Gland and Cambridge. pp, 134 – 140.

Bland, J.M., Altman, D.G., 1995. Multiple significance tests: the Bonferroni method. *Br. Med. J*, 310, pp.170.

Bonham-Carter, G., 1995. *Geographic Information Systems For Geoscientists: Modelling With Gis*. Second Edition, Ontario, Canada, 398 pages.

Bowman, A.W., and Azzallini, A., 1997. Applied smoothing techniques for data analysis: the kernel approach with S-Plus Illustrations, Clarendon Press. 193 pages.

Börger, L., Franconi, N., Ferreti, F., Meschi, F., de Michelle, G., Gantz, A., and Coulson, T., 2006. An integrated approach to identify spatiotemporal and individual-level determinants of animal home range size. *The American Naturalist*, 168(4), pp. 471-485.

Bullard, F., 1991. Estimating the home range of an animal: a Brownian bridge approach. Ms Thesis, University of North Carolina, Chapel Hill, North Carolina, USA.

Burmester, A.C., 2005. Socio-Economic Situation and Land Use Conflicts in Shirvan National Park Region, Azerbaijan, 167 pages.

Buskirk, S.W., and Millspaugh, J.J, 2006. Defining availability and selecting a currency of use: key steps in modelling resource selection. *Journal of Wildlife Management*, 70, pp. 358-366.

Calenge, C., Dufour, A.B., and Maillard, D., 2005. K-select analysis: a new method to analyse habitat selection in radio-tracking studies. *Ecological Modelling*, 186, pp. 143-53.

Calenge, C., 2006. The package adehabitat for the R software: a tool for the analysis of space and habitat use by animals. *Ecological Modelling*, 197, pp. 516-519.

Campos-Arceiz, A., Takatsukı, S., and Lhagvasuren, B., 2004. Food overlap between Mongolian gazelles and livestock in Omnogobi, southern Mongolia. *Ecological Research*, 19, pp. 455–460.

Clark, E.L., Munkhbat, J., Dulamtseren, S., Baillie, J.E.M., Batsaikhan, N., King, S. R.B., Samiya, R. and Stubbe, M. (compilers and editors), 2006. *Summary Conservation Action Plans for Mongolian Mammals. Regional Red List Series Vol. 2*, Zoological Society of London, London. 96 pages.

Cooper, A.B., and Milspaugh, J.J., 1999. The application of discrete choice models to wildlife resource selection studies. *Ecology*, 80, pp. 566-575.

Council of Europe, 1979. The Convention on the Conservation of European Wildlife and Natural Habitats.

Cunningham, P.L., 2009. Observations of the seasonal dietary preference of *Gazella subgutturosa marica* Thomas, 1897(Cetartiodactyla: Bovidae) along foraging trails of central Saudi Arabia. *Journal of Theratened Taxa*, 1(9), pp. 445-449.

Czudek, R., 2006. Wildlife issues and development prospects in West and Central Asia, Thematic study for the Forestry Outlook Study for Africa. The wildlife management working papers of Food and Agriculture Organization. 65 pages.

Çobanoğlu, A.E., 2010. Identification Of Demographic Structure And Population Viability Analysis Of *Gazella subgutturosa* In Şanlıurfa. Ms Thesis, Middle East Technical University, Ankara, Turkey.

Daszak, P., Berger, L., Cunningham, A.A., Alex, D., Hyatt, D., Green, E., and Speare, R., 1999. Emerging infectious diseases and amphibian population declines. *Emerging Infectious Diseases*, 5(6), pp. 735-748.

Dehn, M.M., 1990. Vigilance for predators: detection and dilution effects. *Behav. Ecol. Sociobiol.*, 26: 337-342.

DMGİM (Devlet Meteoroloji İşleri Genel Müdürlüğü), 2008. (Updated 2008), available at:
http://www.dmi.gov.tr/veridegerlendirme/ilveilceleristatistik.aspx?m=SANLIURFA [Assessed 28 December 2009].

Doncaster, C.P., Macdonald, D.W.,1991. Drifting territoriality in the Red Fox *Vulpes vulpes. Journal of Animal Ecology*, 60(2), pp. 423-439. *The Journal of Zoology*, 245, pp. 371-384.

Dunham, K.M., 1998a. Spatial organization of mountain gazelles *Gazella gazella* reintroduced to central Arabia. *The Journal of Zoology*, 245, pp. 371-384.

Dunham, K.M., 1998b. Use of artificial water supplies by captive-born mountain gazelles (*Gazella gazella*) released in central Arabia. *The Journal of Zoology*, 246, pp. 449-454.

Dunham, K.M., Williamson, D.T., and Joubert, E., 2001. Saudi Arabia, In: Mallon, D.P. and Kingswood, S.C. (eds.), *Antelopes. Part 4: North Africa, the Middle East and Asia, Global Survey and Regional Action Plans*. IUCN/SSC Antelope Specialist Group, IUCN, Gland and Cambridge, pp. 55 - 62.

El-Keblawy, A., Ksiksi, T., and El Alqamy, H., 2009. Camel grazing affects species diversity and community structure in the deserts of the UAE. *Journal of Arid Environments*, 73(3), pp. 347-354.

EPAA (Environment and Protected Areas Authority), 2003. Fourth International Conservation Workshop for the Threatened Fauna of Arabia. BCEAW/EPAA, Sharjah, UAE. 141 pages.

Erickson, W.P., McDonald, T.L., Gerow, K.G., Howlin, S., and Kern, J.W., 2001. *Statistical issues in resource selection studies with radio-marked animals In: Radio Tracking and Animal Populations.* (eds. by Millspaugh JJ & Marzluff JM), Academic Press, London. pp. 211-241.

ESRI, 2005. ArcGIS 9.2. The Geographic Information Systems for Everyone, Environmental Systems Research Institute Inc, Redlands, CA.

ESRI, 2006. (updated Oct 31, 2006), GIS Dictionary, available at: http://support.esri.com/index.cfm?fa=knowledgebase.gisDictionary.gateway [Assessed 28 December 2009].

Farhadinia, M.S., Esfandabad, B.S., Karami, M., Zavarei, F.H., Absalan, H., and Nezami, B., 2009. Goitered Gazelle *Gazella subgutturosa* Guldenstaedt, 1780: its habitat preference and conservation needs in Miandasht Wildlife Refuge, northeastern Iran. *Zoology in the Middle East*, 46, pp. 9-18.

Frankham, R., Ballou, J.D., and Briscoe, D.A., 2004. *A primer of conservation genetics*. University Press, Cambridge, 617 pages.

Ghobrial, L.I., 1970. The Water Relations of the Desert Antelope *Gazella dorcas dorcas*. *Physiological Zoology*, 43(4), pp. 249-256.

Gingold, G., Yom-Tov, Y., Kronfeld-Schor, N., and Geffen, E., 2009. Effect of guard dogs on the behavior and reproduction of gazelles in cattle enclosures on the Golan Heights. *Animal Conservation*, 12, pp. 155-162.

Gitzen, R.A., and Millspaugh, J.J., 2003. Comparison of least-squares cross-validation bandwidth options for kernel home-range estimation. *Wildlife Society Bulletin*, 31, pp. 823-831.

Gitzen, R.A., Millspaugh, J.J., and Kernohan, B.J., 2006. Bandwidth selection for fixed-kernel analysis of animal utilization distributions. *The Journal of Wildlife Management*, 70(5), pp. 1334-1344.

Gorelov, Y.K., 2001. Turkmenistan, In: Mallon, D.P. and Kingswood, S.C. (eds.), *Antelopes. Part 4: North Africa, the Middle East and Asia, Global Survey and Regional Action Plans*. IUCN/SSC Antelope Specialist Group, IUCN, Gland and Cambridge, pp. 150-154.

Groves, C.P., 1985. An introduction to the gazelles. *Chinkara* 1, pp. 4–16.

Habibi, K., 2001. Pakistan, In: Mallon, D.P. and Kingswood, S.C. (eds.), *Antelopes. Part 4: North Africa, the Middle East and Asia, Global Survey and Regional Action Plans*. IUCN/SSC Antelope Specialist Group, IUCN, Gland and Cambridge, pp. 122-128.

Hammond, R.L., Macasero, W., Flores, B., Mohammed, O.B., Wacher, T. and Bruford, M.W., 2001. Phylogenetic reanalysis of the Saudi Gazelle and its implications for conservation. *Conservation Biology*, 15(4), pp. 1123-1133.

Hansteen, T.L., Andreassen, H.P. and Ims, R.A., 1997. Effects of spatiotemporal scale on autocorrelation and home range estimators. *Journal of Wildlife Management*, 61, pp. 280-290.

Haque, M.N., and Smith, T.R., 1996. Reintroduction of Arabian sand gazelle *Gazella subgutturosa marica* in Saudi Arabia. *Biological Conservation*, 76(2), pp. 203-207.

Hawthorne, L.B., 2006. Hawth's Analysis Tool Version 3,27.

Hebblewhite, M., Merrill E.H., and McDonald, T. L., 2005. Spatial decomposition of predation risk using resource selection functions: an example in a wolf/elk predator/prey system. *Oikos*, 111, pp. 101-111.

Heisey, D.M., 1985. Analyzing selection experiments with log-linear models. *Ecology*, 66, pp. 1744-1748.

Hemami, M.R., and Groves, C.P. 2001. Iran, In: Mallon, D.P. and Kingswood, S.C. (eds.), *Antelopes. Part 4: North Africa, the Middle East and Asia, Global Survey and Regional Action Plans*. IUCN/SSC Antelope Specialist Group, IUCN, Gland and Cambridge, pp. 114-118.

Hirzel, A.H., Hausser, J., Chessel, D. and Perrin N., 2002. Ecological-niche factor analysis: How to compute habitat-suitability maps without absence data?, *Ecology*, 83, pp. 2027-2036.

Hodder, K. H., Kenward, H.E., Walls, S.S., and Clarke, R.T, 1998. Estimating core ranges: a comparison of techniques using the common buzzard (*Buteo buteo*). *Journal of Raptor Research*, 32, pp. 82-89.

Horne, J.S., Garton, E.O., Krone, S. M., and Lewis, J.S., 2007. Analyzing animal home ranges using Brownian bridges. *Ecology*, 88, pp. 2354–2363.

Hutchinson, G.E., 1957. Population studies - animal ecology and demography - concluding remarks. Cold Spring Harbor Symposia on Quantitative Biology, 22, pp. 415-27.

ICARRD (The International Conference on Agrarian Reform and Rural Development) Porto Alegre, Brazil, 7-10 March, 2006. A Case Study On Rangeland Rehabilitation and Establishment of a Wildlife Resource in sustainable rangeland management in Al Badia Region and the outcome of a video conference held on 2nd February 2006 to discuss the case study and the main issues on Syrian Agrarian Reform and Rural Development, 4 pages.

Insall, D., 2001. Oman, In: Mallon, D.P. and Kingswood, S.C. (eds.), *Antelopes. Part 4: North Africa, the Middle East and Asia, Global Survey and Regional Action Plans*. IUCN/SSC Antelope Specialist Group, IUCN, Gland and Cambridge, pp. 69 -73.

IUCN, 1998. Guidelines for Reintroduction, prepared by the IUCN/SSC Reintroduction Specialist Group, IUCN, Gland, Switzerland, and Cambridge, UK., 10 pages.

IUCN Standards and Petitions Working Group. 2008. Guidelines for Using the IUCN Red List Categories and Criteria. Version 7.0. Prepared by the Standards and Petitions, Working Group of the IUCN SSC Biodiversity Assessments Sub-Committee in August 2008.
Downloadable from
http://intranet.iucn.org/webfiles/doc/SSC/RedList/RedListGuidelines.pdf.

IUCN SSC Antelope Specialist Group 2009. *Gazella subgutturosa ssp. marica*. In: IUCN 2009. IUCN Red List of Threatened Species. Version 2009.2. <www.iucnredlist.org>. Downloaded on 03 January 2010.

Jiang, Z., and Sung W., 2001. China, In: Mallon, D.P. and Kingswood, S.C. (eds.), *Antelopes. Part 4: North Africa, the Middle East and Asia, Global Survey and Regional Action Plans*. IUCN/SSC Antelope Specialist Group, IUCN, Gland and Cambridge, pp. 168 - 177.

Johnson, D.H. ,1980. The comparison of usage and availability measurements for evaluating resource preference. *Ecology*, 61, pp.65-71.

Kernohan, B.J., Gitzen, R.A. and Millspaugh, J.J., 2001. *Analysis of animal space use and movements, In: Radio Tracking and Animal Populations.* (eds. by Millspaugh JJ & Marzluff JM). Academic Press, New York, USA. pp. 126-164.

Kingswood, S.C. and Blank, D.A., 1996. *Gazella subgutturosa*. *Mammalian Species* 518, pp.1–10.

Kingswood, S.C., Cowan, P.J., and Clayton, D.A., 2001a. Kuwait, In: Mallon, D.P. and Kingswood, S.C. (eds.), *Antelopes. Part 4: North Africa, the Middle East and Asia*, *Global Survey and Regional Action Plans*. IUCN/SSC Antelope Specialist Group, IUCN, Gland and Cambridge, pp. 84 - 87.

Kingswood, S.C., Wardeh, M.F., and Williamson, D.T., 2001b. Syria, In: Mallon, D.P. and Kingswood, S.C. (eds.), *Antelopes. Part 4: North Africa, the Middle East and Asia, Global Survey and Regional Action Plans.* IUCN/SSC Antelope Specialist Group, IUCN, Gland and Cambridge, pp. 84 - 87.

Kiwan, K., Boef, J., and Boudari, A., 2001. Jordan, In: Mallon, D.P. and Kingswood, S.C. (eds.), *Antelopes. Part 4: North Africa, the Middle East and Asia, Global Survey and Regional Action Plans.* IUCN/SSC Antelope Specialist Group, IUCN, Gland and Cambridge, pp. 102 - 106.

Koeln, G.T., Cowardin, L.M., and Strong, L.L., 1994. *Geographic Information Systems, In:Research and Management Techniques for Wildlife and Habitats*. Fifth edition, (eds. by Bookhout, T.A.), The Wildlife Society, Bethesda, Md, pp.540-567.

Krebs, C.J., 2001. Ecology: The Experimental Analysis of Distribution and Abundance. San Francisco: Addison Wesley Longman, Inc., 695 pages.

Lhagvasuren, B., Dulamtseren, S., and Amgalan, L., 2001. Mongolia, In: Mallon, D.P. and Kingswood, S.C. (eds.), *Antelopes. Part 4: North Africa, the Middle East and Asia, Global Survey and Regional Action Plans*. IUCN/SSC Antelope Specialist Group, IUCN, Gland and Cambridge, pp. 159 - 168.

Mallon, D.P., 2008. *Gazella subgutturosa*. In: IUCN 2009. IUCN Red List of Threatened Species. Version 2009.2. <www.iucnredlist.org>. Downloaded on 11 November 2009.

Mallon, D.P. and Al-Safadi, M., 2001. Yemen. In: Mallon, D.P. and Kingswood, S.C. (eds.), *Antelopes. Part 4: North Africa, the Middle East and Asia, Global Survey and Regional Action Plans*. IUCN/SSC Antelope Specialist Group, IUCN, Gland and Cambridge, pp. 63-68.

Mallon, D.P. and Kingswood, S.C., (compilers). 2001. *Antelopes. Part 4: North Africa, the Middle East, and Asia. Global Survey and Regional Action Plans.* SSC Antelope Specialist Group.IUCN, Gland and Cambridge viii + 260pp.

Manly, B.F.J., McDonald, L.L., Thomas, D.L., McDonald, T.L., and Erickson, W.P., 2002. *Resource Selection by Animals*. Second Edition, Kluwer Academics, Dordrecht, The Netherlands, 221 pages.

Manor, R., and Saltz, D., 2003. The impact of free-roaming dogs on gazelle kid/female ratio in a fragmented area. *Biological Conservation*, 119, pp. 231–236.

Marmazinskaya, N.V., and Mardanov, B.K., 2001. Uzbekistan. In: Mallon, D.P. and Kingswood, S.C. (eds.), *Antelopes. Part 4: North Africa, the Middle East and Asia, Global Survey and Regional Action Plans*. IUCN/SSC Antelope Specialist Group, IUCN, Gland and Cambridge, pp. 141-145.

Martin, L., 2000. Gazelle (Gazella spp.) behavioural ecology: predicting animal behaviour for prehistoric environments in south-west Asia. *Journal of Zoology*, 250, pp. 13-30.

Massolo, A., Spalton, A., and Al-Lamk, F., 2008. Notes on the status and conservation of the reem gazelle *gazella subgutturosa marica* in the Sultanate of Oman. *Italian Journal of Zoology*, pp. 1–5.

Mech, L.D., and Barber, S.M., 2002. A critique of wildlife radio-tracking and its use in national parks a report to the U.S. National Park Service, 80 pages.

Mendelssohn, H., Yom-Tov, Y., and Groves, C.P., 1995. *Gazella gazella*. *Mammalian Species*, 490, pp.1-7.

Mésochina, P., Bedin, E., and Ostrowski, S., 2003. Reintroducing antelopes into arid areas: lessons learnt from the oryx in Saudi Arabia, *C. R. Biologies*, 326, pp. 158–165.

Millspaugh, J.J., Brundige, G.C., Gitzen, R. A., and Raedeke, K.J., 2000. Elk and hunter space-use sharing in South Dakota. *The Journal of Wildlife Management*, 64(4), pp. 994-1003.

Millspaugh, J.J., Nielson, R.M., McDonald, L., Marzluff, J.M., Gitzen, R.A., Rittenhouse, C.D., Hubbard, M.W., and Sheriff, S.L., 2006. Analysis of resource selection using utilization distributions. *Journal of Wildlife Management*, 70, pp. 384-395.

MINITAB, 2000. *MINITAB Release 13 Statistical Software*. State College, PA: MINITAB Inc.

MoAIL (Ministry of Agriculture, Irrigation and Livestock), 2009. Afghanistan's Fourth National Report to the Convention on Biological Diversity, 110 pages.

MoE (Jordanian Ministry of Environment), 2009. Fourth National Report On Implementation Of The Convention On Biological Diversity, Amman, 105 pages.

Mohamed, S.A. and Al Dosari, M.A., 2001. Bahrain, In: Mallon, D.P. and Kingswood, S.C. (eds.), *Antelopes. Part 4: North Africa, the Middle East and Asia, Global Survey and Regional Action Plans*. IUCN/SSC Antelope Specialist Group, IUCN, Gland and Cambridge, pp. 79 - 81.

Moen, R., Pastor, J., and Cohen Y., 1997. Accuracy of GPS telemetry collar locations with differential correction. *The Journal of Wildlife Management*, 61(2), pp. 530-539.

MoNP (Ministry Of Nature Protection Of Turkmenistan), 2002. Biodiversity Strategy and Action Plan for Turkmenistan, Ashgabat, 105 pages.

Moulton, M.P. and Sanderson, J., 1999. *Wildlife issues in a changing world*. 2nd ed., pp 101-102, CRC Press LLC, 500 pages.

Mutanga, O., Prins, H.H.T., Skidmore, A.K., Van Wieren S., Huizing, H., Herman, R.N., Peel, M., and Biggs, H., 2004. Explaining grass-nutrient patterns in a savanna rangeland of southern Africa. *Journal of Biogeography*, 31, pp. 819–829.

NBSAP (National Biodiversity and Action Plan), 2005. Georgia, Tbilisi, 106 pages.

NCWCD (National Commission for Wildlife Conservation and Development), 2005. The National Strategy For Conservation Of Biodiversity In The Kingdom Of Saudi Arabia, 94 pages.

Neu, C.W., Byers, C.R. and Peek, J.M., 1974. Technique for analysis of utilization - availability data. *Journal of Wildlife Management*, 38, pp. 541-545.

Nowzari, H., Behrouzi Rad, B., Hemami, M.R., 2007. Habitat use by Persian gazelle (*Gazella subgutturosa subgutturosa*) in Bamoo National park during autumn and winter, *Acta Zoologica Mexicana*, 23, pp. 109–121.

Ölçer, S.Y., 2001. Turkey, In: Mallon, D.P. and Kingswood, S.C. (eds.), *Antelopes. Part 4: North Africa, the Middle East and Asia, Global Survey and Regional Action Plans, IUCN/SSC Antelope Specialist Group*. IUCN, Gland and Cambridge, pp. 112 -113.

Özüt, D., 2009. Evaluation of the adaptation process of a reintroduced Anatolian Mouflon (*Ovis Gmelinii Anatolica*) population through studying its demography and spatial ecology. PhD Thesis, Middle East Technical University, Ankara, Turkey.

PCMREW (Public Commission for the Protection of Marine Resources, Environment and Wildlife), 2006. Bahrain First National Report to the Convention on Biological Diversity, Kingdom of Bahrain, 102 pages.

Pereladova, O. B., Bahloul, K., Sempere, A. J., Soldatova N. V., Schadilov, U. M., and Prisiadznuk, V. E., 1998. Influence of environmental factors on a population of goitred gazelles (*Gazella subgutturosa subgutturosa* Guldenstaedt, 1780) in semi-wild conditions in an arid environment: a preliminary study. *Journal of Arid Environments*, 39, pp. 577-591.

Pollock, C.G., 2001. Silent Spring Revisited: A 21st-Century Look at the Effect of Pesticides on Wildlife, Journal of Avian Medicine and Surgery, 15(1), pp. 50-53.

R Development Core Team, 2009. R: A Language and Environment for Statistical Computing, Austria: R Foundation for Statistical Computing.

Robinson, S., and Milner-Gulland, 2003. E.J., Political change and factors limiting numbers of wild and domestic ungulates in Kazakhstan. *Human Ecology*, 31(1), pp. 87-110.

Rogers, A.R., and Carr A.P., 1998. HRE: the home range extension for ArcView user's manual. Centre for Northern Forest Ecosystem Research, Ontario Ministry of Natural Resources, Canada.

Samour, J.H., 2001. United Arab Emirates, In: Mallon, D.P. and Kingswood, S.C. (eds.), *Antelopes. Part 4: North Africa, the Middle East and Asia, Global Survey and Regional Action Plans*. IUCN/SSC Antelope Specialist Group, IUCN, Gland and Cambridge, pp. 74 -78.

Skarpe, C. and Hester A.J., 2008, Plant Traits, Browsing and Gazing Herbivores, and Vegetation Dynamics, In: Gordon I.J. and Prins, H.H.T. (eds.), *The Ecology of Browsing and Grazing*. Springer, Berlin, pp. 217–261.

SCENR (Supreme Council for Environment and Natural Reserves), 2004. National Biodiversity and Action Plan, State of Qatar, 72 pages.

SCENR (Supreme Council for Environment and Natural Reserves), 2007. Protected Area Action Plan 2008-2013, State of Qatar, Doha, 25 pages.

Schoener, T.W., 1981. An empirically based estimate of home range, Theoretical Population Biology, 20, pp. 281-325.

Seaman, D.E., Millspaugh, J.J., Kernohan, B.J., Brundige,, G.C., Raedeke K.J. and Gitzen R.A., 1999. Effects of sample size on kernel home range estimates. *Journal of Wildlife Management*, 63, pp. 739-47.

Seaman, D. E., and Powell R.A., 1996. An evaluation of the accuracy of kernel density estimators for home range analysis. *Ecology*, 77, pp. 2075-2085.

Sempe ´re, A.J., Brown, N., Pereladova, O. B., Bahloul, K., Lacroix, A., and Soldatova, N., 2001. Comparative Analysis of Reproductive Cycles in Female Persian Gazelle (*Gazella subgutturosa subgutturosa*) (Central Asia) and Sand Gazelle (*Gazella subgutturosa marica*) (Arabian Peninsula). *General and Comparative Endocrinology*, 121, pp. 57–65.

Shavgulidze, I., 2001. Georgia, In: Mallon, D.P. and Kingswood, S.C. (eds.), *Antelopes. Part 4: North Africa, the Middle East and Asia, Global Survey and Regional Action Plans*. IUCN/SSC Antelope Specialist Group, IUCN, Gland and Cambridge, pp. 132 - 133.

Sheikh, K.M., and Molur, S., 2004. (Eds.) Status and Red List of Pakistan's Mammals Based on the Conservation Assessment and Management Plan, IUCN, Pakistan, 312 pages.

Shchadilov, M., and Hadjiev E.M., 2001. Azerbaijan, In: Mallon, D.P. and Kingswood, S.C. (eds.), *Antelopes. Part 4: North Africa, the Middle East and Asia, Global Survey and Regional Action Plans.* IUCN/SSC Antelope Specialist Group, IUCN, Gland and Cambridge, pp. 129 - 131.

Smith, L., Hupp, J.W., and Ratti, J.T., 1982. Habitat use and home range of gray partridge in southern Dakota. *Journal of Wildlife Management*, 48, pp. 580-587.

Swihart, R. K., and Slade, N. A., 1985. Testing for independence of observations in animal movement. *Ecology*, 66, pp. 1176-1184.

TERC (Terrestrial Environmental Research Center), 2005. A Proposal to Establish The Umm Al-Zummoul National Park, Document ref. no: 03-31-0002/WSM/TP.

TİGEM (Tarım İşletmeleri Genel Müdürlüğü), 2009. Ceylanpınar T.İ.M., Ceylan Yetiştiriciliği, (Updated 2009) Available at: http://www.tigem.gov.tr/icerik.asp?is=160q11554q10q1hdq10q1133q10q1153 [Accessed 23 December 2009].

Thomas, D.L., and Taylor, E. J., 1990. Study designs and tests for comparing resource use and availability. *Journal of Wildlife Management*, 54, pp. 322-330.

Thomas,D.L., and Taylor, E.J., 2006. Study designs and tests for comparing resource use and availability II. *Journal of Wildlife Management*, 70, pp. 324-36.

Turan N., 1977. Ceylan (*Gazella subgutturosa*) Neslinin Korunması ve Geliştirilmesine Dair Rapor. Ministry of Forestry, Ankara.

Turan N., 1984. *Türkiye'nin Av ve Yaban Hayvanları – Memeliler*, Ar Yayınevi, Ankara, 179 pages.

TÜBİTAK (The Scientific and Technological Research Council of Turkey), 2006. Project Name: Ceylanların (*Gazella subgutturosa)* Bazı Genetik ve Ekolojik Özelliklerinin Belirlenmesi Üzerine Bir Araştırma.

Toktosunov, A.T., and Mallon D.P., 2001. Kyrgyzstan, In: Mallon, D.P. and Kingswood, S.C. (eds.), *Antelopes. Part 4: North Africa, the Middle East and Asia, Global Survey and Regional Action Plans*. IUCN/SSC Antelope Specialist Group, IUCN, Gland and Cambridge, pp. 146 - 147.

United Nations Environment Programme (UNEP), 2002. The Convention on the Conservation of Migratory Species of Wild Animals.

Worton, B.J., 1995. Using Monte Carlo simulation to evaluate kernel-based home range estimators. *Journal of Wildlife Management*, 59, pp. 794–800.

Zachos, F.E., Karami, M., Günther B.H., Eckert, I., and Kirschning J., 2009. First genetic analysis of a free-living population of the threatened goitered gazelle (*Gazella subgutturosa*). *Mammalian Biology,* doi:10.1016/j.mambio.2009.01.001

Zazanashvili, N., Sanadiradze, G., and Kandaurov A., 2006. An Ecoregional Conservation Plan For The Caucasus, 220 pages.