ESTIMATION OF DEMOGRAPHY AND SEASONAL HABITAT USE PATTERNS OF ANATOLIAN MOUFLON (*Ovis gmelinii anatolica*) POPULATION IN KONYA BOZDAĞ PROTECTION AREA USING DISTANCE SAMPLING

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ABSTRACT

ESTIMATION OF DEMOGRAPHY AND SEASONAL HABITAT USE PATTERNS OF ANATOLIAN MOUFLON (*Ovis gmelinii anatolica*) POPULATION IN KONYA BOZDAĞ PROTECTION AREA USING DISTANCE SAMPLING

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The Anatolian mouflon (*Ovis gmelinii anatolica*) is an endemic ungulate subspecies and of IUCN Vulnerable status that inhabits Konya-Bozdag region located in Central Anatolia.

In this thesis, the demography and habitat use of the only natural population of Anatolian mouflon at Konya-Bozdağ Province is studied. Throughout the study, distance sampling techniques, specifically line transect sampling, are used to estimate density, size and growth rate of this population. Sex, age and count data are used to estimate relevant parameters. Changes in population structure and seasonal area use are monitored for two years.

Data is collected during repeated random line transects from May 2007 to July 2009. Line transect method is preferred since it requires less effort and is less expensive when compared to the complicated techniques that need animal marking or radio tagging.

In total, 78 transect lines were surveyed during the time which covers 3 lambing periods. In spite of the paratuberculosis epidemics in the fenced area which has affected the population adversely in the previous years, a rather stable population trend is observed.

The post-breeding population size in 2007, 2008 and 2009 were estimated to be 883±241, 939±136, 972±243 (average ± standard error), and the densities as 26.032, 27.227, and 28.186 individuals per sq km, respectively. Growth rate of population is found using the ratio of the population size estimates of consecutive years from 2007 to 2009, average 1.0495 ± 0.0203.

Habitat use patterns of the Anatolian mouflon throughout the study period are investigated according to seasons and sex groups. There is sexual segregation in the Anatolian mouflon population in Konya Bozdağ Province, with the females using the western part and the males using the eastern part of Bağderesi. Seasonal patterns affect on the area use of animals, group formation and compositions and the relationship between them are searched throughout the study. The movements of the individuals and groups followed seasonal patterns as centers of activities changed according to seasons.

Keywords: Anatolian mouflon, *Ovis gmelinii anatolica*, population demography, line transect sampling, seasonal area use.

ÖZ

KONYA BOZDAĞ ALANINDAKİ ANADOLU YABAN KOYUNU (*Ovis gmelinii anatolica*) TOPLUMUNUN EŞEY VE YAŞ GRUPLARINA GÖRE DEMOGRAFİK YAPISININ VE YAŞAYABİLİRLİK DEĞERLERİNİN BELİRLENMESİ

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Anadolu yaban koyunu (*Ovis gmelinii anatolica*) endemik ve IUCN kriterlerine gore hassas (vulnerable) statülü bir toynaklı alttürü olup Orta Anadolu'da, Konya-Bozdağ bölgesinde yaşamaktadır.

Bu çalışmada, Anadolu yaban koyununun tek doğal toplumu olan Konya Bozdağ Koruma alanındaki demografisi ve alan kullanımı incelenmiştir. Çalışma boyunca uzaktan örnekleme tekniklerinden özellikle çizgi transekti yöntemi, topluma ait yoğunluk, büyüklük ve büyüme hızını bulmak için kullanılmıştır. Bu değişkenlerin belirlenmesinde yaban koyununun cinsiyet, yaş ve sayım verisi kullanılmıştır. Anadolu yaban koyununun toplum yapılanmasındaki değişikliklerin ve mevsimsel alan kullanımının takibi 2 yıllık bir dönem boyunca gerçekleştirilmiştir.

Çalışmada kullanılan cinsiyet, yaş ve sayım verisi Mayıs 2007 ile Temmuz 2009 tarihleri arasında rastgele atılan çizgi transektleri ile toplanmıştır. Uzaktan örnekleme yönteminin seçilmesinin nedeni hayvanların işaretlenmesine ya da radyo verici ile takibine nazaran daha az çabaya ihtiyaç duyulan, daha az pahalı bir teknik olmasıdır.

3 kuzulama mevsimini kapsayan bu araştırma boyunca toplamda 78 transekt çizgisi tamamlanmıştır. Çalışma boyunca, toplumun üzerinde olumsuz etkilere sahip olduğu bilinen paratüberkuloz hastalığına rağmen sabit bir toplum değişimi eğilimi gözlenmiştir.

2007, 2008 ve 2009 yıllarına ait doğum sonrası sayımlarında sırası ile 883±241, 939±136, 972±243 (ortalama ± standart hata) sayıları ve kilometre karede 26,032; 27,227; 28,186 bireylik yoğunluk tahminleri elde edilmiştir. 2007 den 2009 a ardışık yılların toplum büyüklükleri tahminlerinin oranları kullanılarak bulunan ortalama toplum büyüme hızı 1,0495 ± 0,0203 olarak hesaplanmıştır.

Anadolu yaban koyununun çalışma boyunca alan kullanım şekilleri, mevsimlere ve cinsiyete bağlı olarak incelenmiştir. Konya Bozdağ alanında bulunan Anadolu yaban koyunu toplumunda eşeysel ayrılma olduğu ve dişilerin Bağderesi'nin batı bölgesini kullanırken erkeklerin doğu tarafını kullandığı tespit edilmiştir.

Bu çalışmada mevsimsel düzen ve değişikliklerin Anadolu yaban koyunu toplumunun alan kullanımı, grup yapılanması ve kompozisyonu ve birbirleri ile ilişkilerine olan etkisi araştırılmıştır. Birey ve grupların mevsimsel düzen ve değişiklikleri takip ettiği, aktivite merkezlerinin mevsimlere göre değişiklik gösterdiği bulunmuştur.

Anahtar kelimeler: Anadolu yaban koyunu, *Ovis gmelinii anatolica*, toplum demografisi, çizgi transect örneklemesi, mevsimsel alan kullanımı.

To My Dad

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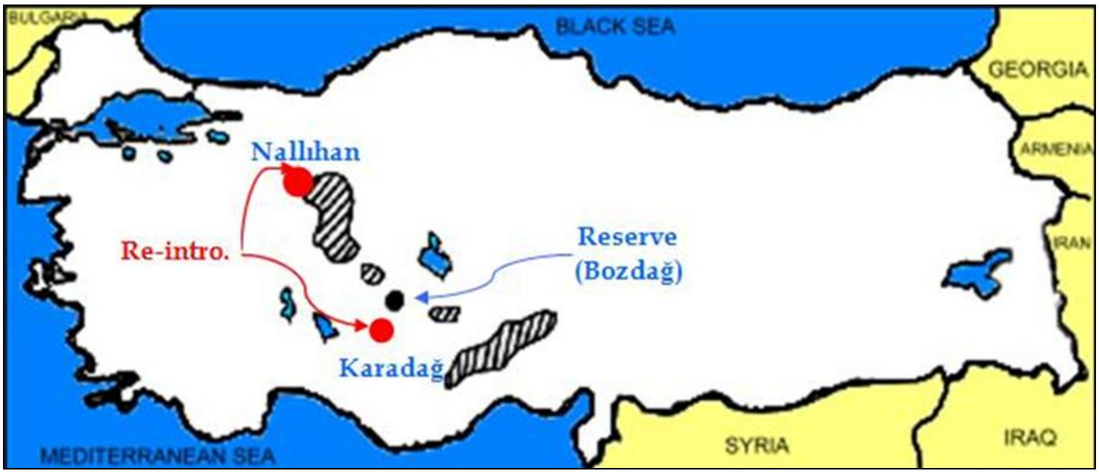
CHAPTER 1

INTRODUCTION

1.1 History and Distribution of the Species in Turkey

The Anatolian mouflon, *Ovis gmelinii anatolica,* is an endemic vulnerable subspecies in Turkey. The main Anatolian mouflon population is in Konya-Bozdağ where there has been a fenced, approximately 35 km^2 protected area since 1987. With the other two reintroduced (2004) and one introduced subpopulation (2006); there are three Anatolian mouflon populations in Turkey. The two reintroduced populations are at Nallıhan (Ankara) and Karadağ (Karaman): where the previous populations of Anatolian mouflon disappeared towards the beginning of the 1960s (Kayım, 2008) (Fig. 1). Furthermore, there is one small with 11 individuals in Hekimhan Yaban Hayvani Üretme Alani, Malatya. (Hekimhan Wildlife Reserve).

According to the survey results of Karaman National Parks and Nature Protection Department in December 2007 Karadağ population survived poorly due to high amounts of domestic stocks using the area and a high density of wolf population in the region. Therefore today the population size of Karaman subpopulation is estimated to be below 30. Wherever, the reintroduced Nallıhan population has been supported by additional translocations: a total of 68 marked animals (40 radio-collared and 28 ear-marked) were released to the area. As compared to 6 radio-collared released in Karadağ, Nallıhan subpopulation is monitored better than Karadağ population.



Known distribution, until 1960s (Turan, 1981)   Reintroduced populations

Current distribution

Figure 1. Current and past distribution of Anatolian mouflon.

The earliest studies about the conservation and status of Anatolian mouflon were conducted by Nihat Turan and Sabit Tarhan, Turkish National Parks and Game-Wildlife Department administrators, in 1960s. Except for the one at Konya – Bozdağ, with 35 to 50 individuals, the other small and isolated subpopulations of Anatolian mouflon in Central Anatolia at Nallıhan and Polatlı (Ankara), Sivrihisar (Eskişehir), Emirdağı (Afyon), and Ereğli, Karapınar (Konya) and Karadağ (Karaman) vanished out between 1945 and 1965 (Danford and Alston, 1877; Turan, 1984). The scope of this subspecies had been once covering nearly 50,000 km^2 in Central Anatolia (Arıhan 2000, Ozut 2004, Kayım 2008).

In 1966, a 440 km^2 protection area: namely Bozdağ Wildlife Development Area (WDA), located at the 50th km of Konya-Aksaray highway, was established by Ministry of Agriculture in order to protect the last endangered population in Konya-Bozdağ province (Arıhan 2000, Ozut 2004, Kayım 2008). The study area is the fenced a 35 km^2 portion of the Bozdağ Wildlife Development Area (WDA).

Due to a combination of over hunting, habitat fragmentation, habitat loss, increased human demand such as grazing the domestic livestock and land; the existence of the species ended at these places (Arıhan 2000, Ozut 2004). Also, poaching and diseases could be other possible reasons of extinction of these subspecies.

The other subspecies living in Turkey is *Ovis gmelini gmelinii*, Gmelin's mouflon (Armenian mouflon), which is cited as extended from the south of Mount Ağrı to the north of Mordağlar Mountains in Hakkari and from the east of Lake Van to Karadağ (south of Mount Ağrı, east of Lake Van and northern and eastern territories of Hakkari) (Kence and Tarhan, 1997; Arıhan, 2000, Albayrak *et al.*, 2007). The Gmelin's mouflon (*Ovis ammon gmelinii*) is stated as "the ancestral form of modern domestic sheep" (Williams *et al.*, 2006).

In order to conserve the eastern population of mouflon in Turkey, Van-Özalp Protection and Breeding Area (PBA) was established on a 150,000 ha area in 1971. However, due to the lack of organization in implementing the conservation plan, this protection remained just on paper and hence the area gained a so-called status (Kayım, 2008).

The information available about the life history of the Gmelin's mouflon species in Turkey is limited to their seasonal migrations, in which they move to Iran in autumn and migrate back to Turkey in spring (Kence and Tarhan, 1997 in Shackleton, 1997, p.134-138).

The Gmelin's mouflon is stated as agile at climbing steep mountain slopes preferring dry, open slopes in the mountain steppe zone. As the Anatolian mouflon, the number of Gmelin's mouflon decreased gradually as a result of as a result of habitat loss and poaching during the 20th century (Williams *et al.*, 2006).

Additionally, these mouflons are stated in IUCN red list page as "resident of the mountain foothills and rolling steppe of northwest and southwest of Iran"; moreover, there are few hundred of the animals left in southern Armenia and in the Nakhchyvan Autonomous Republic in Azerbaijan. The species is listed in the IUCN Red List as vulnerable (VU A2cde). Small amount of information is known of current distributions (IUCN red list page) and actions required to preserve mouflon habitat and increase protection of the animal (Williams *et al.*, 2006; Kayım, 2008).

The first datum about the Anatolian mouflon was first collected by Blyth in 1841. It was later identified by Valenciennes in 1856. The research carried out by Danford and Alston in 1877, was the only resource till the Turhan and Tarhan’s studies in 1960s. Although especially after 1987 the population biology, ecology, population viability and population genetics of *Ovis gmelinii anatolica* are studied, there is still not enough information and systematical data about the biology of the species and demography.

This study was initiated to provide a better understanding of the population’s current status. Assessment of demographic parameters both in this study and the followings will enable a proper population viability analysis and although the main population is in a closed area, will help to identify habitat preferences and selection criteria. After reaching all these information about the species, conservation actions, relocating the populations can be done significantly.

1.2 Taxonomic Scope

The taxonomy of the Anatolian mouflon is as well not explicit, as a member of genus *Ovis* (Linnaeus, 1758), which requires more taxonomic work in order to end the discussions about classification and more importantly to solve the conservation problems stemmed from uncertainty. There are a variety of taxon names that different authors used in genus Ovis (Hiendleder *et al*., 2002).

Not only are there problems on the taxonomy of the Anatolian mouflon, *Ovis gmelinii anatolica*, but as Lovari (2004) mentioned that it has changed a lot more than any other large vertebrates in literature (eg: *Ovis aries, Ovis ammon, Ovis musimon, Ovis orientalis, Ovis gmelini,* even *Aegoceros musimon*), there has also been a debate over the scientific name of European mouflon. For the Anatolian mouflon itself, the taxonomic history is quite similar: there are still different opinions on the scientific name of this species: *Ovis orientalis anatoliaca* or *Ovis gmelinii anatolica*.

According to the IUCN criteria (following *inter alia* Shackleton 1997) the domestic sheep and its wild ancestor the urial are called *Ovis aries* and *Ovis orientalis* respectively. The scientific name *Ovis orientalis* was used for both mouflon and urial, also after 1997, IUCN/SSC Caprinae Specialist Group classification. Whereas, as explained in Shackleton (1997) and in Status Survey and Conservation Action Plan for Caprinae (the subfamily containing Capra, Ovis and other ungulates), IUCN/SSC Caprinae specialist group (2000), because of the difference in the number of diploid chromosomes: 2n = 54 in mouflon, 2n = 58 in urial and 2n = 55, 2n = 56 chromosomes in hybrid populations (Valdez *et al.*, 1978), the mouflon and urial are different species. Moreover, the throat bibs which are present in urials but absent in mouflons and vary in the hybrid populations; the mouflon and urial considered to be different species (Arıhan 2000).

Although at the last, May 2000, Survey and Conservation Action Plan for Caprinae (the subfamily containing *Capra*, *Ovis* and other ungulates), IUCN/SSC Caprinae specialist group, it is concluded that mouflon and urial are different species, and mouflons are to be named *Ovis gmelinii* and urial to *Ovis vigneii*; formally the name *Ovis orientalis* is listed at the latest publications:

> "the WILD GOAT is going to be *Capra aegagrus*, the DOMESTIC goat stays with *C. hircus*, the ASIAN MOUFLON is *Ovis orientalis*, the EUROPEAN/MEDITERRANEAN etc. MOUFLONS must inexorably

make do with *O. aries* (in the company of domestic sheep)." (Lovari, 2004)

Gmelin was the first person who described *Ovis gmelinii* in 1774; and named as *Ovis orientalis*. The subspecies living in Turkey, Armenia and Iran was described by Blyth in 1841 as *Ovis orientalis gmelinii*. In 1856 Valenciennes described the other subspecies living in Central Anatolia *Ovis orientalis anatolica*. The other scientists studied the Anatolian moflon, *Ovis gmelinii anatolica*, Ellerman and Morrison-Scott (1966), Mursalıoğlu (1964) and Kaya (1990) recorded the Central Anatolian subspecies as *Ovis orientalis anatolica* Valenciennes 1856 as an endemic subspecies to Turkey. The Eastern Anatolian subspecies is recorded as *Ovis orientalis gmelinii.*

However, after the latest discussions on the taxonomy of these subspecies, one of the latest names *Ovis gmelinii anatolica* for the Anatolian mouflon and *Ovis gmelinii gmelinii* for the Gmelin's mouflon is chosen. Therefore, the latest accepted classification of Anatolian mouflon is as:

- Domain: *Eukaryota* (Whittaker & Margulis, 1978)
  - Kingdom: *Animalia* (L., 1758)
    - Phylum: *Chordata* (Bateson, 1885)
      - Subphylum: *Vertebrata* (Cuvier, 1812)
        - Class: *Mammalia* (L., 1758)
          - Subclass: *Theria* (Parker & Haswell, 1897)
            - Order: *Artiodactyla* (Owen, 1848)
              - Suborder: *Ruminantia* (Scopoli, 1777)
                - Family: *Bovidae* (Gray, 1821)
                  - Subfamily: *Caprinae* (Gray, 1821)
                    - Genus: *Ovis* (L., 1758)
                      - Species: *gmelinii* (Blyth, 1840)
                        - Subspecies: *anatolica* (Valenciennes, 1856)

One other discussion that the genus *Ovis* enjoys is the variety of the number of the species in the genus at different authors. While according to IUCN/SSC Caprinae Specialist Group, there are seven species of *Ovis*; Wilson & Reeder (2005) have classified five species in the genus.: *Ovis ammon* (L., 1758), *Ovis aries* (L., 1758), *Ovis canadensis* (Shaw, 1804), *Ovis dalli* (Nelson, 1884) and *Ovis nivicola* (Eschscholtz, 1829) are the 5 species classified in the latter. For the domestic sheep *Ovis aries* (L., 1758) is listed at both; whereas, in the former, IUCN/SSC Caprinae Specialist Group mouflons and urials are not placed at the same taxa, but to *Ovis gmelinii* and *Ovis vigneii* respectively (Table 1.1). Furthermore, in the Table 1.2 Red List of Threatened Species are listed with their current status.

Table 1.1 Classification of mouflons & urials

Species	Subspecies	Common Name
Ovis gmelinii		
	gmelinii (Blyth, 1841)	Gmelin’s (Armenian) mouflon
	anatolica (Valenciennes, 1856)	Anatolian mouflon
	laristanica (Nasonov, 1909)	Laristan mouflon
	ophion (Blyth, 1841)	Cyprian mouflon
	isphanica (Nasonov, 1910)	Esfahan mouflon
	musimon (Schreber, 1782)	European mouflon
Ovis vignei		
	arkal (Eversmann, 1850)	Transcaspian urial
	bocharensis (Nasonov, 1914)	Bukhara urial
	cycloceros (Hutton, 1842)	Afghan urial
	punjabiensis (Lydekker, 1913)	Punjab urial
	vignei (Blyth, 1841)	Ladakh urial *or* Shapu
	*blandfordi**	Blandford Urial

* Uncertain, can be an ecotype (Kayım, 2008)

Table 1.2 IUCN 2009. IUCN Red List of Threatened Species. Version 2009.1

Species	Status	Population trend
Ovis ammon (Argali)	Near Threatened ver 3.1	Decreasing
Ovis canadensis (Bighorn Sheep)	Least Concern ver 3.1	Stable
Ovis dalli (Thinhorn Sheep)	Least Concern ver 3.1	Stable
Ovis nivicola (Snow Sheep)	Least Concern ver 3.1	Unknown
Ovis orientalis (Urial)	Vulnerable A2cde ver 3.1	Decreasing

1.3 Description

The Anatolian mouflon species is a diurnal, herbivorous animal, feeding on grasses and shrubs, and also grains (Turan, 1984). The species inhabits moderately to very arid habitats, especially grasslands, but they also occur in agricultural fields and woodland areas (Valdez, 1982).

The appearance of Anatolian wild sheep is much different from domestic sheep. With their longer and slender bodies; longer hind-legs than forelegs; high shoulders and breasts they have an agile profile (Kayım, 2008).

The males and females show differences in phenotypes. The body length and breast height is typically larger in males than females. The males of wild sheep are called rams (Fig.2). Anatolian wild sheep rams' weight varies between 45 to 74 kg, and the females', so called ewes', 35 to 50 kg (Fig 3). The body length of O*vis gmelinii anatolica* changes from 105 to 140 cm. The breast height of rams varies between 80-90 cm, and ewes' varies between 80-85 cm. Their hind legs are longer, so they are very good runners. They prefer to live in the smoothly curved, open, and plane landscapes (Kaya, 1991).

Figure 2. Old and young rams of Anatolian mouflon (photograph by Aykut İnce).

Figure 3. Ewe and lamb of Anatolian mouflon (photograph by Aykut İnce).

Males are cited as having horns reaching up to 75 cm in total length (Arıhan, 2000). Horns of the males are thick, large, and stretch towards the sides and then loop towards the back of the animal. It is worth noting that during the several captures of the animals for reintroduction study, females that have small horns are detected.

Annual rings on the horns are indicators of age of rams. Age therefore can be determined by counting the annual rings in the horns of males. However, this method is not proper for the female Anatolian mouflon. The age determination of ewes can only be done from incisor teeth structure. Wherever, as handling of the animal is required to determine this it is not an efficient method. Also, as incisor teeth development stops after 3 years, only the individuals younger than 3 years old can be classified by this method. Therefore, an exact age determination after 3 years is not available for Anatolian mouflon ewes. The maximum life time for the species is suggested to be 15 to 18 years (Turan, 1984).

Fur color of Anatolian mouflon is tawny, and this tawny color is good for camouflaging, since background color of the habitat is mainly in this color. Coating shows seasonal variations. The summer coating is composed of short, thick, sparse, and light-colored hair, a kind of pale brown. Whereas, the hair of winter coating is long, thin, dense, and dark-colored; it is a kind of reddish brown (Figure 4). In May and June, they tend to shed their winter coats (Kaya, 1989). For males, the color of the hair begins to darken after 2 years for males. In some individuals a light saddle occurs after 3-4 years but (Kayım, 2008).

Figure 4. An example of the winter coating of the Anatolian mouflon big rams (photograph by Mazlum Demirbağ).

Males are predicted to reach sexual maturity after 2 years, whereas females are predicted after 1.5 years. Breeding takes place in November and December and high competition is seen between adult males. After gestation period of five months, 148 days, one or two lambs are born. As younger ewes are thought to be able to give birth to only one infant, older ewes can give twin births and very rarely three births are observed in the field. The lamb needs maternal care after parturition; thus, females care their offspring until December (Arıhan, 2000).

Anatolian mouflon shows a polygynous mating system; furthermore an equal sex ratio is monitored at birth (Kaya and Aksoylar 1992). There is a strong inter-male competition for females during the rutting season. The ewes generally prefer the older and having bigger horn rams.

1.4 Conservation Actions

The first conservation measure taken to protect Anatolian wild sheep has been the Land Hunting Law, prohibiting its hunting in 1937. In 1967, the first field survey was performed to obtain information about the distribution and numbers of Anatolian wild sheep by Directorate of Nature Protection and National Parks (DNP). This survey showed that wild sheep were left only in Bozdağ and population size was around 50 individuals. Therefore, it is revealed that only the Land Hunting Law (1937) stating that the Anatolian Mouflon was under protection and its hunting was prohibited was not effective for conservation (Turan, 1967, 1990). When the conservation actions started, there were not more but less 50 individuals, in 1967 in the Konya-Bozdağ area (Turan, 1967, 1990). Therefore in 1967, Ministry of Agriculture (which later separated into Ministry of Forestry and Ministry of Agriculture and now Ministry of Environment and Forestry) declared that the 42,000 ha area in Konya-Bozdağ be a Wildlife Protection Area and charged a warden for the protection of that area (Fig.5).

Figure 5. A view of Bozdağ Protection Area.

This action led to an increase in population size. However, this increase was lower than expected; because of this reason, a 3500 ha. of the protection area was fenced, and this fence was electrified in 1989 for protection. This area was cleared from wolves (*Canis lupus*). Water and food was provided inside the fence. These actions resulted to an increase in population size (Table 1.3) (Figure 6).

Table 1.3 Changes in population size of Anatolian wild sheep in Bozdağ Province.

Year	1967	1986	1987	1988	1999	2000	2001	2007
Estimated Population Size	35-50[1]	320[2]	382[2]	457[2]	530-703[3]	~1000[1]	~1200[1]	650[1]

1 [1] by DNP, [2] by Kaya, 1989, [3] by Arîhan, 2000

2 *1967 by Turan (1967); 1986-88 by Kaya (1989); 1999 by Arıhan (2000); 2000-1 by Turkish NPGWM

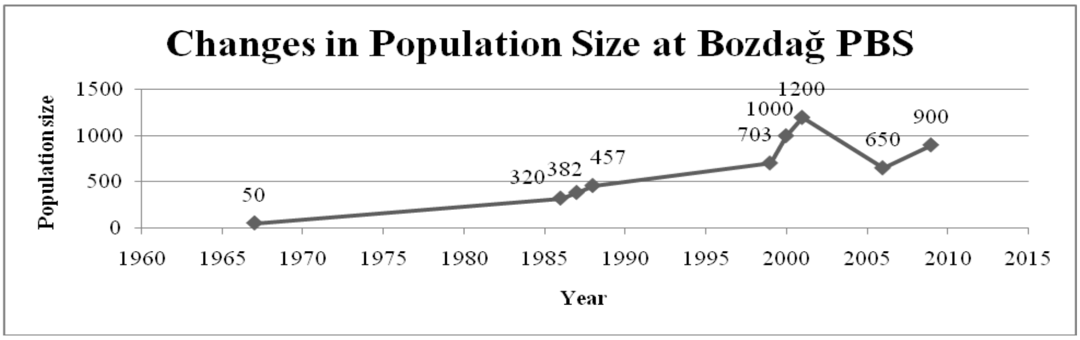


Figure 6. The change of the population size of Anatolian mouflon throughout the conservation actions in Bozdağ Protecton Area.

Throughout the years, the protection has been increased in the protection area by increasing the number of wardens and motorization by land vehicles. With the increase in the protection efforts, the population size of Anatolian mouflon in Konya-Bozdağ has increased exponentially (Figure 6).

In 2004, a reintroduction program was initiated by Turkish National Parks and Game-Wildlife Department administrators; mainly due to the increased density of the population within the fenced area. Nallıhan and Karadağ regions were chosen to be the reintroduction sites. These reintroductions took place through 2004 to 2007, and in total 120 individuals were released to Ankara-Nallıhan, and 60 individuals were released to Karaman-Karadağ in 2005. In addition to this number, in 2006, 14 individuals, and in 2007, 40 individuals were released to Nallıhan. Today the estimated size of Nallıhan population is 60-80 and less than 30 of Karadağ population.

While the population size estimates in Konya-Bozdağ in 2004 was around over 1400, the size decreased to around 700 in three years in the area. Around 200 much of this increase is due to translocations, but the main reason of the population decrease is paratuberculosis (*Mycobacterium avium*). Following a range of laboratory analyses on blood and fecal samples from the caught animals, it has been understood that the paratuberculosis (*Mycobacterium avium*) epidemics is very widespread in the population. Especially because of the deficiencies of organization in local administrations and lack of systematic reintroduction planning, the disease was deliberately introduced to the new areas. Understanding the possible consequences, National Parks authorities decide on establishing a new captive breeding area where only paratuberculosis negative animals will be used in the founding (Ozut, 2009).

1.5 Population Demography

Ecology subsumes the distribution and abundance studies of organisms mainly plants and animals and their interaction with environment. Understanding the animal abundance is vital for both to the ecological theory and practice of studies in terms of population biology (Krebs 1985; Souleâ 1986) and wildlife resource monitoring (Parmenter *et al*., 1989; Sinnary and Hebrand 1991; Conroy *et al.*, 1995; Cassey and Mcardle, 1999).

The estimates of the parameters as population density (D), population size (N) or rate of population change $\lambda_t = D_{t+1}/D_t = N_{t+1}/N_t$ are required in population studies. These parameters differ in time and over space, by species, sex and age (Buckland *et al.*, 2001). The essential features of a population that the ecologists are interested in are the population size or population density

From the game species, the wild ungulates have been a major focal point for the people who are interested in wildlife. Therefore there are quite a high number of studies available in the literature about the survey techniques (The Province of British Columbia, 1998).

A proper demographic data is very important in wildlife research. Demographic data essentially helps evaluation of population density, population status and trends. Understanding the population size of especially the ungulate population, will enable the wildlife managers and scientists to find answers to the issues of density-dependent regulation of populations, to find out the functional response of predators and to quantify impact on vegetation and finally manage wildlife resources. (Focardi *et al.*, 2005) Additional to the significant analytical approaches, demographic data is used in life-history knowledge.

The wildlife demographic parameters are mostly estimated from sex ratios, age structures, and count data; and these demographic parameters are commonly used in modeling population dynamics of wildlife species: productivity, survival, harvest rates, abundance, and rates of population change (Skalski and Ryding, 2005).

Ground-based surveys are frequently used to provide information on population sex and age structure, as well as for gathering information on population size, trends or distribution (The Province of British Columbia, 1998).

There are several quantitative methods of population assessment available, such as capture-mark-recapture (Pollock *et al.*, 1990), pellet counts (Putnam, 1984), distance sampling (Buckland *et al.*, 1993) and mark-resight of radio-tagged individuals (Minta and Mangel, 1989; Neal *et al.*, 1993) (in Focardi *et al.*, 2005).

During the estimation of demographic parameters, sex, age and count data are commonly used because, data collecting requires less effort when compared to more expensive, complicated, labor-intensive techniques that necessitate animal marking or radio tagging. Data use is widespread especially in wildlife managements and also is easier when dealing with statistics, than other field data. Hence, as the Hanson (1963) gives, the reasons that the sex and age-structure data used are data requirements were nominal, data were comparatively easy to collect, and the techniques were applicable over large geographic areas (Skalski and Ryding 2005).

Population abundance is the eventual summary of demographic events and the springboard to the future of the population. While the population trend is characterized by past abundance levels, population status is represented by the current abundance (Skalski and Ryding 2005).

One of the demographic parameters that we also try to obtain from our study population is the sex ratio. It is an important parameter, because it is often a sign of other demographic features of a population such as productivity and survival. Sex ratio is essential in understanding the present and future population status (Skalski and Ryding 2005).

Visual animal surveys provide the least obtrusive way of wild population census, indeed these techniques are economic. Since visual surveys of animals do not require handling or marking, hence the labor and equipment costs are minimized. Moreover, this method is preferred when studying endangered or threatened species (Skalski and Ryding 2005).

Seber's work (1973) is regarded as the standard reference for numerous techniques that use sex- and age-structure data to estimate abundance. Although the utility of Seber's work (1973) remains as a milestone, current procedures for demographic assessment might skip or omit certain steps of the initially established procedures (Skalski and Ryding 2005).

An additional approach to estimating wildlife abundance includes. The capture-recapture methods are frequently more labor-intensive , and more sensitive to failures of assumptions than distance sampling. nevertheless, they are valid to some species that are not suitable to distance sampling methods, and can give in estimates of survival and recruitment rates, which distance sampling cannot do. Capture–recapture methods can be useful for populations that aggregate at some location each year, whereas distance sampling methods are more efficient on dispersed populations. Consequently they are supposed to be seen as different tools for different purposes (Thomas *et al*., 2002).

1.5.1 Distance Sampling

It is essential to monitor wildlife populations for conservation management. There are numerous methodologies used for monitoring, which require large sample size for trusted approximation of abundance. However, since the species that need conservation are generally rare; not only it is not economical to collect large samples, but also it is elusive. Therefore, the alternative methods are commonly employed in wildlife monitoring (Focardi *et al.*, 2005).

Distance sampling is a widely-used set of closely associated methods for estimating the density and/or abundance of biological populations (Thomas *et al.*, 2002). In distance sampling, a uniform survey is accomplished in along a number of transects. With the increasing distance, the observations of animals become harder; for that reason the number of observations decreases with the increasing distance. The main point in distance sampling assessments is to define a detection function g(x) (Focardi *et al.* 2005). The main assumption in distance sampling is that g(0) = 1, all animals on the transect lines are detected (Buckland *et al.,* 2001).

There are a number of distance sampling methods; various types of which are extensions of quadrat sampling: strip transect sampling, line transect sampling, point transect sampling, trapping webs, cue counting, dung counts (Buckland *et al.,* 2001).

Distance sampling is an extension of quadrat-based sampling methods. Two types of quadrat sampling are strip transects, and point counts, in which numbers of objects in a circle about a point are counted.

Distance sampling broadens quadrat-based processes via relaxing the conjecture that all objects within the circle or strip are counted. The probability of observing an object within the strip can be estimated by measuring distances to the objects that are observed (Thomas *et al*., 2002).

1.5.1.1 Strip Transect Method

In strip transect surveys, the observer travels along a line, counting all objects within a predetermined distance of the line. Population density is then being predictable by dividing the whole count by the total area surveyed. A primary assumption of these methods is that all objects within the strip are counted. This assumption is hard to meet for many populations, and cannot be tested by the survey data. In addition, for scarce species, the methods are inefficient, for the reason that detections of objects beyond the strip border are ignored. If the width of the strip is made adequately minute that detection of any object within the surveyed area is roughly certain, then conceivably 50% or more of detections are outside the surveyed area and as a result are ignored (Thomas *et al*., 2002).

In strip transect method; the sampling units are long and narrow strips. The observer moves through the centerline of each strip and detects both sides of the midline equally, with the assumption that probability of detection is one. Hence, width of a transect is equal to upper shoulder of a detection function (Skalski and Ryding, 2005). Within the half-width of the strip transect all animals ought to have complete guarantee of detection. While the distance between the observer and the animal increases the sightability commonly declines (Skalski and Ryding, 2005). As stated by the major assumption, inside the fixed width of the transect, every animal has a detection probability of 1.0, all objects within the strip are counted (Buckland *et al.*, 2001).

In order to make this assumption certain in all habitats and environments, the strips might require to be chosen narrow. As a result, the strip transect method is capable of giving a good approximation as many objects are ignored since they are not in the strip (Buckland *et al.*, 2001).

The main problem in counting the individuals in strip transect, in which it is aimed to count all individuals, is underestimation. The double count possibility is less than missing the animals in the strips. So there is a negative bias on the estimations. The variability in census between transects are detected by "the variance formula from finite sampling theory"; however, if there is a systematic error from underestimating, this is not possible. As a result, abundance indices and minimal counts are used for strip transects (Skalski and Ryding, 2005). Also, as strip width and travel speed increases, abundance estimates become more prone to negative bias, sightability of all animals within the strip become harder.

The other assumptions in strip transects are: the animals stay immobile within the area of the strip transects avoiding double-count and the animals are restructured later than each strip transect survey (Skalski and Ryding, 2005).

1.5.1.2 Line Transect Method

In line-transect sampling, a number of straight lines is traversed by an observer (Thomas *et al*., 2002).

Line transects can be regarded as a simplification of strip transects. While in strip transect the entire strip is surveyed, in line transect only the line, a very narrow strip in the center is surveyed.

The line transect method is a functional alternative to mark recapture methods and asset to estimate the annual abundance. What makes line transect appealing is that this method can be used in wide areas without high efforts and without the requirement of animal handling. Therefore line transect method is preferred to study the animals those are rare and dangerous-to-handle. Line transect models also lack the equal detection assumption in mark recapture models, in which all marked individuals have the same probability of detection.

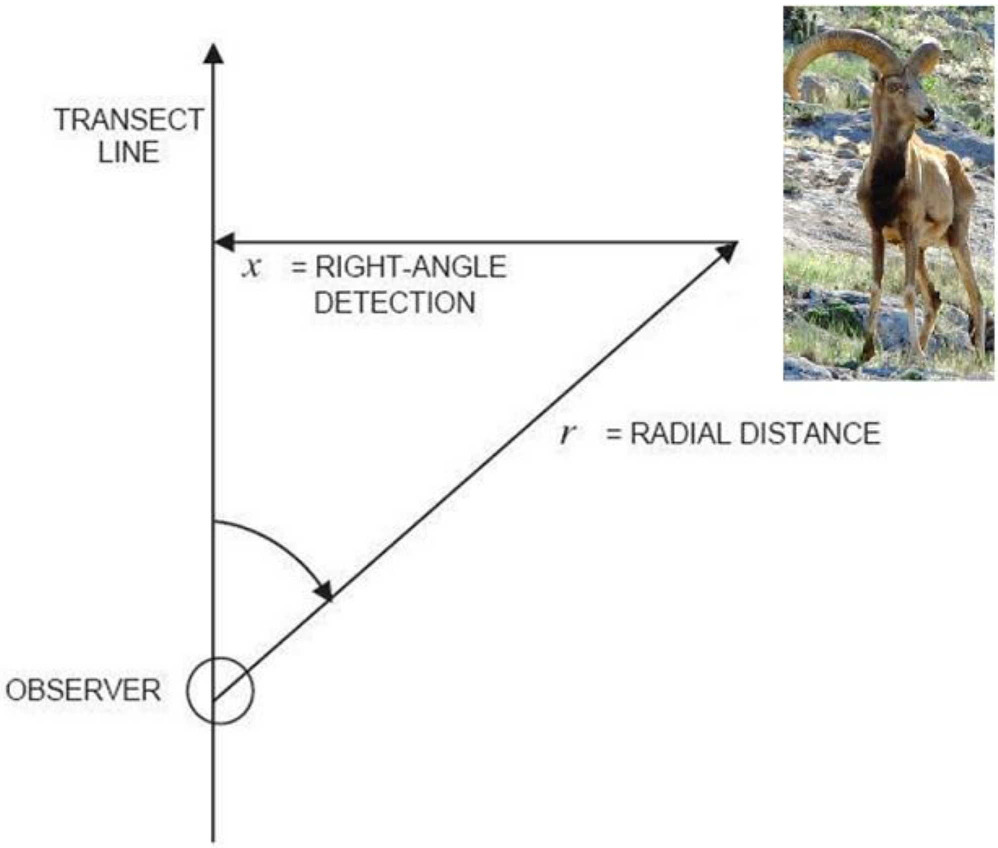


Figure 7. The basic measurements in line transect surveys. The sighting distance x is taken in the field; also the sighting angle θ is recorded in the field. The right distance of the animal from the observer is calculated from basic trigonometry.

In line transect surveys there are some basic measurements. The first of these measurements taken in the field is radial distance (sighting distance) r. In order to make the measurements correctly, special equipment is required like rangefinders or binoculars with special reticles that enable distance estimation. Also θ, the sighting angle is measured. This enables calculation of the right distance x. It is calculated as $x = r sin\theta$.

Similar to strip transect sampling; in line transect sampling the observations are made through moving along a line. The recordings of each observation are taken as distance from the line. While in strip transect detection of each individual in the defined width is a must, in line transect a proportion of individuals can be missed. Also, in line transect not only the individuals within a width are recorded but all detected individuals are recorded, regardless of their distance from the line (Buckland *et al.*, 2001).

1.6 Seasonal Area Use

Studying seasonal area use of a species falls within the scope of spatial ecology, which is the study of the interrelationship between organisms and their environment, especially the spatial nature of these interactions. In wildlife ecology studies, at population and individual level, home range and habitat selection are the two widely used concepts utilized to study the spatial ecology of a species. The use of the surrounding environment by the animals, their movements and spatial arrangements are directly linked to their population dynamics (Kernohan *et al.*, 2001).

It is essential to gain knowledge about threatened animals' ecology, like home range, habitat selection, and behavior in order to formulize management actions for their conservation. These kinds of data are especially important in reintroduction studies where they provide useful information in, for instance, selection of the suitable reintroduction sites, and determination of the size of protected area.

There are several approaches for estimating the home range of an animal. Among these methods are minimum convex polygon, cluster analysis, harmonic mean and kernel are the most widely used ones.

The organisms are thought to select from a given/existing conditions and resources and the collection of these constitute the habitat of that organism. This selection can vary among individuals, sexes, age classes and among seasons or other biologically meaningful parts of the year for the specific species (i.e. rutting and parturition seasons for mouflon). Hence, the study of habitat selection should take into account these factors to account for the existing variation.

1.6.1 Sexual segregation

In many ruminants, adult males and females show separations outside the rut from temperate and/or mountainous regions (Pfeffer, 1967; Geist, 1971; Clutton-Brock, Guinness & Albon, 1982; Bowyer, 1984; Alados, 1985; Shank, 1985; Putman, 1988; Beier & Mccullough, 1990; Miquelle, Peek & Van Ballenberghe, 1992; Frid, 1994; Gross, Alkon & Demment, 1995; Thirgood, 1996). There are some different explanations for the reasons of this sexual segregation and it remains as subject of vivid discussion.

The first hypothesis, namely the `sexual dimorphism-body size hypothesis' argues that males, when larger-bodied than females, should have greater metabolic requirements but also a greater capacity to convert fiber into energy since they have larger digestive tract. Furthermore, the scaling of incisor breadth to body size differs between the sexes. It causes males to prefer feeding on abundant, high-fibre forage. On the other hand, females should select low-fibre, high-quality forage. As a consequence, the two sexes would live separately during most of the year (Clutton-Brock *et al.*, 1982; Clutton-Brock, Iason and Guinness, 1987; Beier, 1987; Illius and Gordon, 1987).

The `reproductive-strategy hypothesis' emphasizes the role of natural selection. In polygynous herbivores, natural selection would support males that maximize body condition, in other words, their reproductive success. On the other hand, it would favor females that maximize security of their offspring, even when this entails sub-optimal foraging behavior. These different selective pressures cause adult males and females to prefer different habitats and live separately outside the rut (Jakimchuk, Ferguson and Sopuk, 1987; Festa Bianchet, 1988; Main and Coblentz, 1990).

Main *et al.* (1996) describes the `social factor hypothesis'. It refers to a heterogeneous and open set of ultimate and proximate reasons, for example, the need for males to develop fighting skills in contact with one another (Festa Bianchet, 1986; Verme, 1988). Lagory, Bagshaw & Brisbin (1991) discusses the spatial exclusion of one sex by the other.

1.7 Objectives of the Study

The aim of this study is to understand the demographic structure of the current Anatolian Mouflon population in Konya Bozdağ, to investigate group formation, group structure and to elucidate which parameters affect habitat use patterns. Additionally, gathering information on the effect of the demographic parameters on viability of the population is aimed.

CHAPTER 2

MATERIALS AND METHODS

2.1 Study Area

The study area is Bozdağ Wildlife Development Area (WDA) located at Konya, the 50th km of Konya-Aksaray highway. It covers the only remaining natural population of Anatolian mouflon, most of which is conserved in the Protection & Breeding Station (PBS).

As it is cited in Arıhan (2000), Sezen (2000), Özüt (2001) and Kayım (2008) the protection area totally covers 42,000 ha. Konya-Bozdağ province whereas covers, an approximate total of 3500 ha: the exact length of the fences is 28973.98 m and the area is 34410996.98 m^2.

Bozdağ is generally stony and rocky due to erosion by wind, thus the soil is generally seen only on the plane regions or the ground valleys and the geological structure of the study area consists of metamorphic rocks (Kaya, 1989).

2.1.1 Geographical scope

The elevation of this area ranges between 1000m to 1750m above sea level. The highest point is Hodulbaba Mountain. The area consists of a series of 1600m mountains which are high, smoothly curved, wide and plane hills fractured by typically thin and short valleys that lead to wider meadows (Fig. 8) (Ozut, 2001).

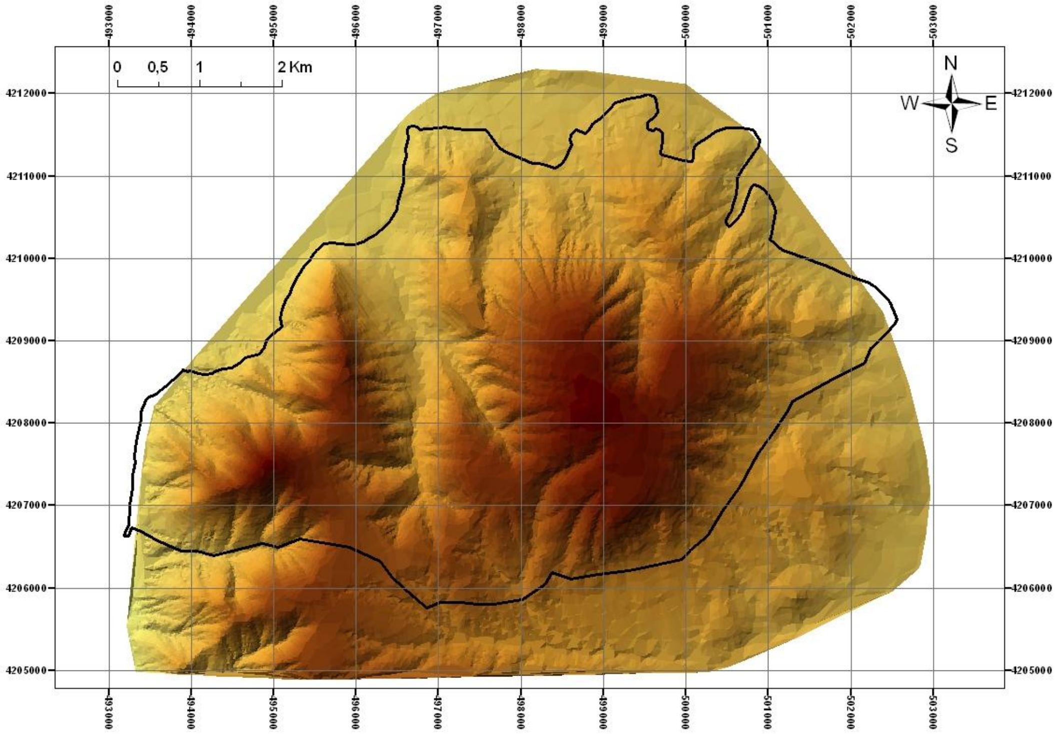


Figure 8. Topographic map of the fenced area, the black solid line indicates the fences.

2.1.2 Vegetation

The main vegetation of Bozdağ Wildlife Development Area (WDA) is steppe. Because of the natural history of the area with human impact, physiognomic and floristic composition, the altitude, the vegetation of the area can be considered as low mountain step.

There are about 350-400 species of plants in the area, but members of *Graminea* family dominates including *Festuca* spp., *Poa* spp., *Dactylis* spp., *Echinaria* spp., *Koeleria* spp., *Phleum* spp., *Stipa* spp., and *Bromus* spp. members of *Labiatae*, *Rosacea*, *Asteraceae*, and *Umbelliferae* families are also found in the area and consumed by mouflons (Dural, 1985; Kaya and Aksoylar, 1992; Arıhan, 2000). Trees are very rare but small trees, *Pistacia terebinthus* and *Rhus coriera*, are found in the area (Kayım, 2008).

There is also a natural population of Anatolian mouflon outside the fenced area with an approximate number of 100. Since animal farming with mainly sheep and goat is common in the villages around, the vegetation outside the fenced area confronts with heavy grazing. The most important shrubs and the small trees are destroyed to obtain fuel, which opened the way to erosion by wind (Turan, 1967). The erosion is stressed on steep slopes, uncovering the rocky layer beneath (Ozut, 2001).

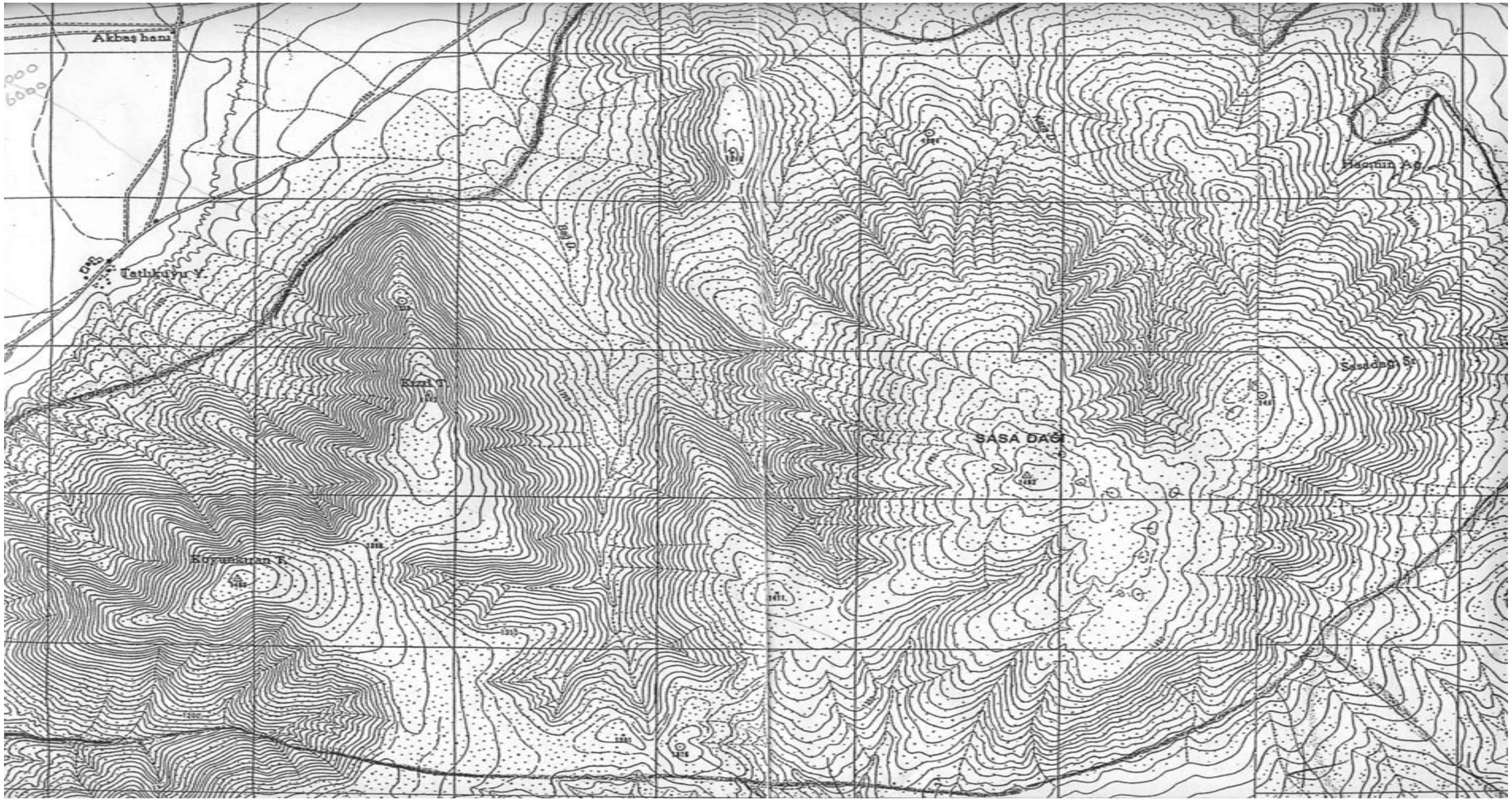


Figure 1. The 1/25000 scale map of Konya Bozdağ Province.

2.2 Study Period

The study covers 3 lambing periods. Line transects from May 2007 to July 2009 are surveyed.

Line transect survey timeline

2007	2008	2009
20.05.2007	13.01.2008	07.03.2009
26.06.2007	04.02.2008	08.03.2009
27.06.2007	31.03.2008	04.07.2009
11.11.2007	01.04.2008	05.07.2009
09.12.2007	27.04.2008	06.07.2009
	26.05.2008	
	16.07.2008	
	17.07.2008	
	31.10.2008	

Out of 8 observers worked in the field, 5 of them are permanent and the majority of the line transects are performed by them. In order to standardize differences in efforts of different observers, all the observers were trained to bring same kind of data before actual sampling.

2.2.1 Climate Variables

The most common characteristic of the Central Anatolia climate is its long sunny days in spring and summer, and the hard winters with precipitation. All the data are taken from Turkish State Meteorological Service.

Snow is the main precipitation type. The snow cover and the precipitation values are given in Tables 2.1, 2.2, 2.3 and 2.4. For the last three years the maximum temperature has been 39.8°C and lowest temperature -15.1°C, maximum number days with snow cover has been 10 days.

The data cover the whole study period, starting from May 2007 to March 2009. They were taken from the nearest 4 stations to the Konya-Bozdağ province, which are namely Aksaray, Konya, Konya-Bölge and Karapınar. In Table 2.1, daily average temperatures during the study period are listed. 17192 is the Aksaray station, 17244 is the Konya station, 17245 is the Konya Bölge station and 17902 is the Karapınar station.

Table 2.1 Daily average temperatures from 17192 (Aksaray), 17245 (Konya bölge), 17902 (Karapınar) stations.

Station no 17902 Daily Average Temp. (°C)				Station no 17192 Daily Average Temp. (°C)				Station no 17245 Daily Average Temp. (°C)			
Year	Month	Day	Average Temp.	Year	Month	Day	Average Temp.	Year	Month	Day	Average Temp.
2007	5	20	20.0	2007	5	20	23.3	2007	5	20	21.3
2007	6	26	24.3	2007	6	26	26.9	2007	6	26	27.5
2007	6	27	26.2	2007	6	27	27.7	2007	6	27	28.9
2007	11	11	3.9	2007	11	11	4.8	2007	11	11	7.3
2007	12	9	7.2	2007	12	9	8.2	2007	12	9	6.9
2008	1	13	-9.1	2008	1	13	-8.1	2008	1	13	-5.4
2008	2	4	-8.5	2008	2	4	-4.0	2008	2	4	-1.2
2008	3	31	4.2	2008	3	31	4.2	2008	3	31	3.6
2008	4	1	3.5	2008	4	1	3.9	2008	4	1	5.5
2008	4	27	15.3	2008	4	27	17.4	2008	4	27	15.8
2008	5	26	15.3	2008	5	26	16.6	2008	5	26	17.7
2008	7	16	26.0	2008	7	16	27.6	2008	7	16	27.5
2008	7	17	21.6	2008	7	17	22.0	2008	7	17	22.8
2008	10	31	11.7					2008	10	31	12.6
								2009	3	1	0.4
								2009	3	2	2.8

Table 2.2 Monthly maximum, minimum and average temperatures from 17245 (Konya Bölge) station.

Station no 17245 Monthly Max. Temperature (°C)			Station no 17245 Monthly Min. Temperature (°C)			Station no 17245 Monthly Average Temperature (°C)		
Year	Month	Maximum Temperature	Year	Month	Minimum Temperature	Year	Month	Average Temperature
2007	5	33.0	2007	5	6.4	2007	5	20.4
2007	6	37.2	2007	6	11.3	2007	6	23.2
2007	7	39.8	2007	7	14.8	2007	7	26.4
2007	8	38.9	2007	8	15.3	2007	8	26.4
2007	9	36.1	2007	9	8.9	2007	9	21.1
2007	10	27.5	2007	10	2.9	2007	10	14.6
2007	11	22.2	2007	11	-2.6	2007	11	7.6
2007	12	13.9	2007	12	-6.7	2007	12	1.8
2008	1	8.4	2008	1	-10.6	2008	1	-2.2
2008	2	12.2	2008	2	-13.0	2008	2	-1.2
2008	3	26.8	2008	3	-0.4	2008	3	10.8
2008	4	31.5	2008	4	1.9	2008	4	15.1
2008	5	31.5	2008	5	4.8	2008	5	16.5
2008	6	36.5	2008	6	11.4	2008	6	22.9
2008	7	38.5	2008	7	15.2	2008	7	25.3
2008	8	37.3	2008	8	15.9	2008	8	26.5
2008	9	34.3	2008	9	7.9	2008	9	20.6
2008	10	24.7	2008	10	4.5	2008	10	12.9
2008	11	19.4	2008	11	-1.4	2008	11	8.7
2008	12	18.5	2008	12	-13.6	2008	12	1.3
2009	1	16.5	2009	1	-15.1	2009	1	2.4
2009	2	15.0	2009	2	-5.9	2009	2	4.0

Table 2.3 Average relative humidity data from 17245 (Konya Bölge) and number of snowy days from 17192 (Aksaray), 17244 (Konya), 17245 (Konya Bölge) and 17902 (Karapınar) stations.

Station No	Year	Month	Average Relative Humidity (%)
17245	2007	5	42.1
17245	2007	6	40.8
17245	2007	7	29.0
17245	2007	8	35.2
17245	2007	9	35.1
17245	2007	10	53.5
17245	2007	11	71.9
17245	2007	12	79.3
17245	2008	1	73.5
17245	2008	2	73.4
17245	2008	3	49.7
17245	2008	4	44.9
17245	2008	5	47.6
17245	2008	6	37.7
17245	2008	7	32.6
17245	2008	8	32.6
17245	2008	9	48.0
17245	2008	10	66.0
17245	2008	11	74.0
17245	2008	12	82.6
17245	2009	1	77.9
17245	2009	2	74.8

Number of Snowy Days (Monthly)			
Station No	Year	Month	Number of Snowy Days
17192	2007	11	2
17192	2008	1	10
17192	2008	2	6
17192	2008	3	1
17192	2008	4	1
17192	2008	12	6
17244	2007	12	3
17244	2008	1	9
17244	2008	2	6
17244	2008	3	2
17244	2008	4	1
17244	2008	10	4
17244	2008	11	4
17244	2009	1	3
17902	2007	12	1
17902	2008	1	6
17902	2008	2	4
17902	2008	3	2
17902	2008	4	1
17902	2008	12	4
17902	2009	1	4

Table 2.4. Number of Days with Snow Cover from 17192 (Aksaray), 17244 (Konya), and 17902 (Karapınar) stations. Number of Stormy Days 17192 (Aksaray), and 17902 (Karapınar) stations.

Number of Days with Snow Cover (Monthly)			
Station No	Year	Month	Number of Days with Snow Cover
17192	2008	1	8
17192	2008	2	11
17192	2008	12	8
17244	2008	1	9
17244	2008	2	13
17244	2008	12	4
17244	2009	1	5
17902	2007	12	1
17902	2008	1	6
17902	2008	2	17
17902	2008	3	1
17902	2008	12	8
17902	2009	1	4

Number of Stormy Days (Monthly)			
Station No	Year	Month	Number of Stormy Days
17192	2007	6	1
17192	2007	9	1
17192	2007	11	2
17192	2008	3	2
17192	2008	4	2
17192	2008	10	1
17902	2007	7	1
17902	2008	3	1
17902	2008	4	1
17902	2008	6	1
17902	2009	1	2

2.3 Field Observations

As the objects of many distance sampling studies indicate, Anatolian mouflon occur in clusters. For that reason each observation is represented as a cluster. In the field data, the cluster size, the distance to the geometric center of the cluster, the angle to the point, time of day and the land cover that the cluster observed are recorded.

2.3.1 Transect Counts

There are 78 transects walked throughout the study. The transect lines are set either randomly or systematic randomly. In total random sampling, all the lines- all the directions, routes, starting points were chosen randomly. Wherever, in systematic random sampling, parallel lines with random starts are used: the starting point and direction of each transect line was chosen randomly, and the other lines are set parallel to that.

The area is divided into 1 km^2 squares, and the starting point and the direction is determined using a random number generator. The transect lines start from one fence and end at the other side of fence. Hand compass and binoculars with compass are used in order to walk through a defined direction.

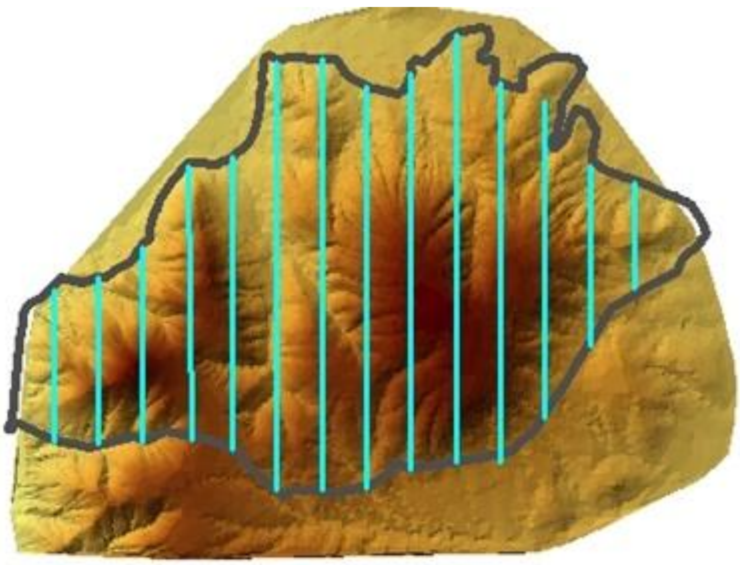


Figure 10. An example showing the stratified random sampling by transects lines (blue lines) within the study area (fences are shown with black border).

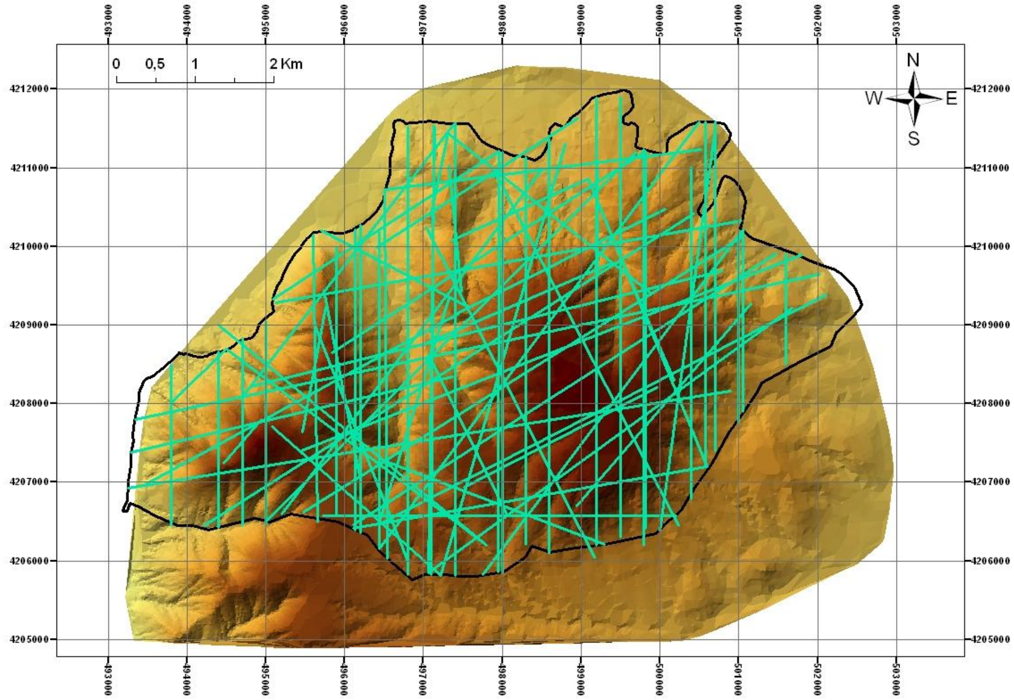


Figure 11. Projection of all transect lines (blue color) used to cover the study area during the study period

2.3.1.1 Line Transect Counts

In line transect sampling, the researcher mainly travels along a straight line and records the objects. The detection process largely depends on visual detection by the observer. The main measures are the number of animals observed and their distance and the angle to the transect line (Buckland *et al.*, 2002). The observers carry out a standardized survey along a series of lines or points, searching for objects of interest. The observer record the distance from the line to the object for every one of the objects noticed. It is required to detect all the objects that the observers pass, but a primary assumption of the basic methods is that all objects that are actually on the line are detected. Without needing to ask, it is expected that objects turn out to be harder to detect with increasing distance from the line, following on fewer detections with increasing distance. The main point to distance sampling analyses is to fit a detection function to the observed distances, and utilize this fitted function to estimate the proportion of objects fail to spotted in the survey. The interval estimate for the density and abundance of objects in the survey area are gathered from the detection function (Thomas *et al.,* 2002).

Line-transect methods provide a valuable alternative and a means of cross-validating mark-recapture methods. Contrasting to mark-recapture models, which in general assume homogeneous detection probabilities among individuals, line-transect methods relax the assumptions enabling heterogeneity between individual detections. Nevertheless, in order to avoid the assumption of randomly distributed animals in field, the transect lines are supposed to be randomly located. This requirement is in straight direct of the investigator.

2.3.1.1.1 Assumptions

Carrying out a line transect survey may result animals to move forward along the transect line. This either may cause counting the animals more than once or missing. In the forward, the density and abundance estimates are positively biased; where in the latter case underestimation of abundance and density is the result. Shorter, and more numerous transect lines can be a partial solution to such a movement (Skalski and Ryding, 2005). Moreover, other estimation techniques should be used if the over or underestimate conditions persist. For a greater precision and variance estimation, the number of transect lines should be favored as long as the stationarity of the detection is conserved.

The primary assumptions of the line transect method are:

- "The detection function g(0) is 1 on the line": all individuals on the line will be detected.
- The places of the animals do not affected by the observer: the animals either stayed at their initial location during the observation or randomly moved.
- The distance measurements are accurate.
- The detection of animal or animal groups is not dependent. (Focardi *et al.*, 2002)

The improper definition in the cluster size is a general problem in ungulate surveys. Also, the sightability of clusters should not change accordingly with clusters model.

2.3.1.1.2 Calculation

From a logistical viewpoint, the sighting angle (θ) and the radial or sighting distance (r) are the easiest to measure during a line-transect survey (Figure 7). The right-angle/ perpendicular distances x are calculated from the relationship:

$$x = r sin\theta.$$

The animal density D is estimated by using the formula:

$$D = \frac{n}{2wL\,\hat{P}_a}$$

where, the P_a is the probability of detection of a randomly chosen animal within the surveyed area and an estimate $\hat{P}_a$ is available. Moreover, when there are k lines of lengths $l_1, \ldots, l_k$ (with $\sum l_j = L$), defined according to randomized method; n animals are detected at perpendicular distances $x_1, \ldots, x_n$ .. There is also a truncation distance: the animals more than a defined distance w from the line are not recorded; therefore, the surveyed area is $a = 2wL$ in which n animals are detected.

In order to estimate P_a, a detection function $g(x)$, which is the probability that an object at distance x from the line is detected, is defined. As $0 \leq x \leq w$, and it is assumed that $g(0) = 1$; which means an animal on the line-transect is observed (it is certain). When the recorded perpendicular distances in a histogram are plotted, subsequently abstractly the issue is to identify a suitable model for $g(x)$ and to fit it to the perpendicular distance data.

When one animal in a cluster is detected, the whole cluster is assumed to be detected, and the distance to the center of the cluster is recorded. Probability of detection is generally a function of cluster size; as a result the sample of detected cluster sizes displays size bias. Larger groups are easier to detect, thus are over represented in the model.

There are several methods for estimating the mean of cluster size, $E(s)$, in the existence of size bias. Regression of $\log s$ on $g(x)$, the estimated probability of detection at distance x, ignoring the effect of cluster size, and after that predicting $log\ s$ when detection is certain, $g(x) = 1$, works well in practice.

In the line transect settings N objects are assumed to distribute through an area of size A according to some stochastic course of action; the density is on average calculated by $D = N/A$. Moreover, the lines are placed with randomized design; and a number of n objects are detected. The objects are not required to be randomly (i.e. Poisson) distributed in the field. It is critical that the lines are positioned randomly with respect to the distribution of objects (Thomas *et al.*, 2002).

Although the radial distances and the angles are recorded in the field, the observations are entered as perpendicular distances in DISTANCE. For this, the recorded angles are first converted to radians in order to make calculations in Microsoft Excel, and then the right distances are calculated according to the geometry of the right triangles.

2.4 Program Distance

DISTANCE is assessed to produce unbiased estimates of density despite possible sources of error from transect and population density estimation. The robustness of Distance to adjustments in the density, distribution, and detection of animals across sampling areas and transects are examined by populations simulations. In a consistent set of distance sampling data by random sampling of possible line transects, the estimates of density will be presented precisely and with accurate estimates of variance.

Distance sampling originates from standard closed or finite population sampling by total counts of randomly chosen primary sampling units: line transects (Seber, 1982). Total population size estimation is obtained from the multiplication of average density by the total area.

Even if the animals are not on the line, distance sampling methods permit for numerous of them remain undetected This is the main assumption of line transect method that is the animals on the line are detected with certainty, $g(0) = 1$. The detection of the animals is consequently a monotonically non-increasing function of distance. The number of animals within each transects estimated via Distance sampling methods instead of a total count as in strip transects.

It is assumed that the distribution of animals according to the transect is uniform. (Turnock and Quinn, 1991). As a result, it is critical to place the lines randomly with respect to the distribution of animals (Buckland *et al.*,1993). The density is projected on the basis of the theoretical shape of g(y) (Cassey *et al*., 1999).

Statistical software, such as DISTANCE Program (Buckland *et al*.. 1993, 2001) provides a well-situated, not bewildering set of options for modeling the detection function. Akaike Information Criterion (AIC) can help decide on an appropriate model that describes the detection process (Burnham and Anderson, 1998). Personal experience, yet, is valuable in selecting how to bin, pool, or truncate detection distances in the modeling process.

Detection distances are required to be pooled across replicate transect lines in most of the applications to get adequate sample sizes for modeling the detection course. Pooling is based on the assumption of a homogeneous detection process across the replicate transect lines. as the number of required transect lines increases concern over detection homogeneity become more important for a specified level of sampling precision. “Differences among survey crews, habitat, and animal behavior can all contribute to detection heterogeneity that may require stratification. Thus, field surveys should be designed from the start to account for potential blocking factors.” (DISTANCE manual, 2005)

2.4.1 Models and Calculations in Distance

Distance sampling data is modeled by using the Program DISTANCE. It makes probable to use different sub-sets of the data with different models. In order to analyze the data after data filtering, model definitions: the type of detection function model and the methods of estimating variance are determined. The properties of survey, data filter and model definitions shape the results of the analysis.

2.4.1.1 Akaike's Information Criterion

Akaike's Information Criterion (AIC) provides a quantitative method for model selection (Cassey *et al.*, 1999). Akaike's Information Criterion (AIC) is used in model selection by a function minimization (optimization) framework rather than a hypothesis testing framework. When detection function is estimated by stratum, AIC, AICc, BIC, and LogL like statistics are summed across the detection functions estimations. So that the models where detection function is estimated independently from stratum and those where it is pooled are compared easily.

2.4.1.2 Detection Function

The detectibility of the objects generally decreases as the distance from the centerline increases. Then, detection function with a 'shoulder' is the best shapes reflecting the reality. The detection function show variability according to taxa, habitats, sighting conditions, and other factors (HARRIS et al, 2002)

Size bias is one of the most general problem with the objects occur in clusters, like Anatolian mouflon. Bigger groups have higher probability of detection: larger clusters are more likely to be noticed further from the line than smaller clusters. Prediction of expected cluster size at zero distance using a regression of cluster size against probability of detection is one way to deal with this problem. While converting the estimated density of clusters into density of individuals, those expected cluster size is used.

The quantity of detection function at zero point is estimated by fitting an appropriate model to the perpendicular distances to represent their probability density function and evaluating this function at the origin . The preference of models is essentially limitless. Burnham *et al.* (1980) examined a wide range of estimators for density function at zero point: f(0) and derived a set of criteria that an estimator should satisfy (Ratti *et al.*, 1983).

Use of detection functions with a shoulder near the center-line, such as the Fourier series (Burnham *et al.* 1980) and the half-normal (Buckland *et al.*, 1993) is supported by the empirical data and simulation modeling.

Detection functions are modeled using the subsequent form:

$$g(y) \propto key(y)[1 + series(ys)]$$

where,

$g(y)$: detection function

$series(ys)$: series adjustment,

$key(y)$: key function

y: distance

ys: scaled distance

The function is scaled till $g(0)$ is 1.

Probability of detection at a given distance, y, is calculated as substitution of the parameter estimates into the formula.

$$g(y) = key(y)[1 + series(ys)]/key(0)[1 + series(0)]$$

There are four random key functions: uniform, half-normal, hazard-rate, and negative exponential, are provided in the DISTANCE (Laake *et al.*, 1994) . In order to develop the fit of the model to the distance data the key functions are adjusted by the flexible type of series expansions. Three series expansions, all of which having linear parameters, are: the cosine series, simple polynomials, and hermite polynomials. Any key function can be used with the different types of series expansion in DISTANCE (Cassey *et al.*, 1999).

There are both key function parameters and adjusted function parameters in the model designed in DISTANCE. The sequence of which parameter comes first in the stratum/model is key function parameters and adjustment function parameters respectively. The parameter indexes in the detection function part are used as starting values in "Density Estimates".

For line transects, effective strip width is calculated by numerical integration of

$$\mu = \int_0^w g(y)\,dy$$

where,

$g\ (y)$: probability of detection at distance y

w: truncation distance.

2.4.1.3 Stratification

Stratification is a practical way of dealing with heterogeneity in the survey data. It is also useful while improving precision and reducing bias (Buckland *et al.*, 1993). Stratification can be performed by environmental conditions, cluster size, geographic region, and time: seasonal period, observer, animal behavior, or many other factors. When stratum and global models give reasonable results the one with the lowest AIC is chosen. The key point here is the use of the same Data Filter in order to make comparisons in AICs.

When observers, methods and circumstances were the equivalent at all time points, investigation of the possibility of pooling the detection function over the time periods is suggested.

In order to estimate mean density over the whole study, post-stratification on the time period is made. And overall density is estimated as the mean in the post-strata. Whereas the problem arises while estimating variance: although they are not independent, each stratum in each year is treated as independent.

The level of resolution of estimate can be determined globally, by stratum and/or by sample. A combination of variance estimates for encounter rate, detection probability and expected cluster size is used at that level.

2.4.1.4 Analytic variance estimation

The empirical between-sample variation, Poisson or over-dispersed Poisson distribution can be specified for encounter rate variance calculations. The settings of encounter rate variance and degrees of freedom are done automatically by the software.

When using AIC to decide on alternative candidate models of the detection function, more than one model can be found to have analogous AIC scores, resulting happens, more reliable inferences on AIC-weighted average (Buckland *et al.*, 1997; Burnham and Anderson, 2002).

Sample definition enables specifying the data layer to be used in the estimation of the encounter rate variance. When it is assumed that encounter rate variance is zero in the model because of the sample size, only assumptions about the density or abundance of animals in the area actually sampled can be done and it would be a wise choice.

In order to make inferences about the whole area from one line, the distributions of observations are assumed as Poisson or over-dispersed Poisson distribution.

2.4.1.5 Adjustment Terms

Although automatic selection of adjustment terms is suggested to avoid, with automatic forward or sequential selection converged algorithm; the parameter estimates from the earlier fit are used for the starting values of the next model. Therefore, as long as the maximum number of adjustment terms is set to a low value use of automated selection is favored in the Distance user guide.

2.5 Seasonal Area Use

During the field studies besides the distance data, the locations, habitat and behavior data are collected. As the densities estimated, the habitat use pattern of the clusters of Anatolian mouflons is obtained. There are basic group types using different parts of the field.

As in many ruminants, adult males and females of this species tend to live separately outside the rut from temperate and/or mountainous regions (Cransac *et al.*, 1998). There are some different explanations for the reasons of this sexual segregation and it remains as a subject of vivid discussion. Sexual dimorphism-body size; reproductive-strategy and social factors are listed for the results of the source of such behavior and tendency.

In this study, relative density and densely used areas are aimed to be found and associated with the group compositions by using Home range approach. For home range calculations, the Animal Movements extension (Hooge *et al.*, 1999) of ArcView GIS® 3.1 (ESRI) is utilized. Fixed Kernel Method is preferred for statistical insight.

2.6 Equipment

The only equipments required for distance sampling field study comprised compass, GPS, data notebooks, binoculars, spotting scopes and two-way communication devices. Additionally the map of the study area facilitates data recording. For the distance estimation range finders give perfect outcome, optical and laser models are available with perfect resolutions. Wherever, "using trigonometry, distance can also be measured using a known height of the observers' eye above the ground and between the angle of declination between the object and either the horizon, a location at a known distance, or horizontal. This is the basis for measuring distance using binoculars with reticle marks." (Buckland *et al.*, 2001).

The radial distance data could be collected as distance intervals. Since one of the vital assumptions of distance sampling is inferring the accuracy of the distance measurements; in order to provide this we made pilot studies with our equipment

In order to define the distance intervals we made distance tests with the Bushnell (7x50 and 8x40) and Celestron (Oceana 7x50 WP-IF/RC Binocular). Assuming the height of the animal as 75 cm, the distance intervals from the reticles are determined. (Table 2.5)

Table 2.4 Distance measurements from reticles with Bushnell and Celestron.

Bushnell			
Reticle	**Height (m.)**	**Estimated Distance (m.)**	**Real Distance (m.)**
2,000	**0,75**	38	38
1,500	**0,75**	50	50
1,000	**0,75**	75	75
0,750	**0,75**	100	100
0,500	**0,75**	150	150
0,333	**0,75**	200-300	225
0,250	**0,75**	300-400	300
0,200	**0,75**	400-550	375
0,166	**0,75**	550-650	452
0,143	**0,75**	650-750	524
0,125	**0,75**	750-800	600
0,111	**0,75**	800-850	676
0,100	**0,75**	>850	750

Celestron		
distance (m)	**reticle**	**Height (m.)**
20	10,00	**0,75**
40	**5,00**	**0,75**
50	**4,00**	**0,75**
65	**3,00**	**0,75**
75	2,50	**0,75**
100	**2,00**	**0,75**
150	1,50	**0,75**
200	1,20	**0,75**
250-300	**1,00**	**0,75**
300-500	0,75	**0,75**
500-600	**0,50**	**0,75**
750	0,30	**0,75**

When distance date is collected in distance intervals it is called grouped data. While entering this group data into Distance, entrance of the mid points of the intervals is suggested. It is explained in the Distance User guide as when the intervals span 0-10m, 10-20m and 20-50m the bin would be entered as 5m, 15m and 35m respectively.

As the objects of many studies, Anatolian mouflon occur in clusters. For that reason each observation is represent a cluster. In the field data, the cluster size, the distance to the geometric center of the cluster, the angle to the point, time of day and the land cover that the cluster observed are recorded.

In the analysis of the clustered populations especially the estimation of "expected cluster size at zero distance" Distance provides decision for truncation for the data for estimation of cluster size separately of truncation for the detection function estimates.

Garmin E-Trex GPS devices were used for coordinate determination. Silva Ranger compasses were used for determining animal direction.

2.7 Maps

The variables used to quantify the habitat use of Anatolian mouflon were taken from various sources. Then, this information is digitized into a GIS platform (ArcGIS 9.2, ESRI) and the layers of habitat variables are created.

The topography of the area is taken from 1/25,000 scale military topographic maps (hereafter referred to as maps) from General Command of Mapping Turkey (Figure 9). The main variable digitized from the maps is the altitudinal isopleths, which had 10m altitudinal resolution. Through the digitization of the isopleths, slope and aspect maps of the area are created using ArcGIS tools.

2.7.1.1 Digitizing

"The topographic maps covering the study area were scanned and opened in ArcGIS 9.2 (ESRI). Using the geo-referencing tool, the images were converted into geo-referenced images according to the specific projection and datum that were used in the maps (Universal Transverse Mercator projection with European 1950 datum). For geo-referencing, five grid intersection points were used as control points and a mean residual error of less than 10 m were obtained in each map. Once geo-referenced, the altitudinal isopleths were all digitized as a line layer (altitude) by hand under around 1/10,000 scale in order to include the details in rugged terrain. The altitude layer (vector-line) was first converted to a triangulated irregular layer (TIN) using the 3D analyst of ArcGIS, and then this TIN layer was converted to a raster layer (tingrid), which formed the basis for creating the digital elevation model (DEM), elevation, aspect and slope habitat layers." (Ozut, 2009)

"to avoid an assumption of a random spatial pattern of individuals, line transects must be randomly located. A systematic pattern of transect placement risks correlation with a systematic pattern in animal abundance and an underestimation of sampling variance." (Skalski *et al.*, 2005).

CHAPTER 3

RESULTS

3.1 Demography

The female Anatolian mouflons are divided into three age-classes, which are lambs, 1 year-olds, and a composite age class of 2+ years-old individuals. The age classes are determined according to their body size. Whereas the males are divided to five age classes, as lambs, 1 year-old, 2-4 years-old, 5-7 years-old and a composite age class of 8+ years-old based on both the body size and the horn size (TURAN, 1982). (Figure 12, 13).

Figure 12 Anatolian mouflon rams within different age classes. Photograph by Aykut İnce.

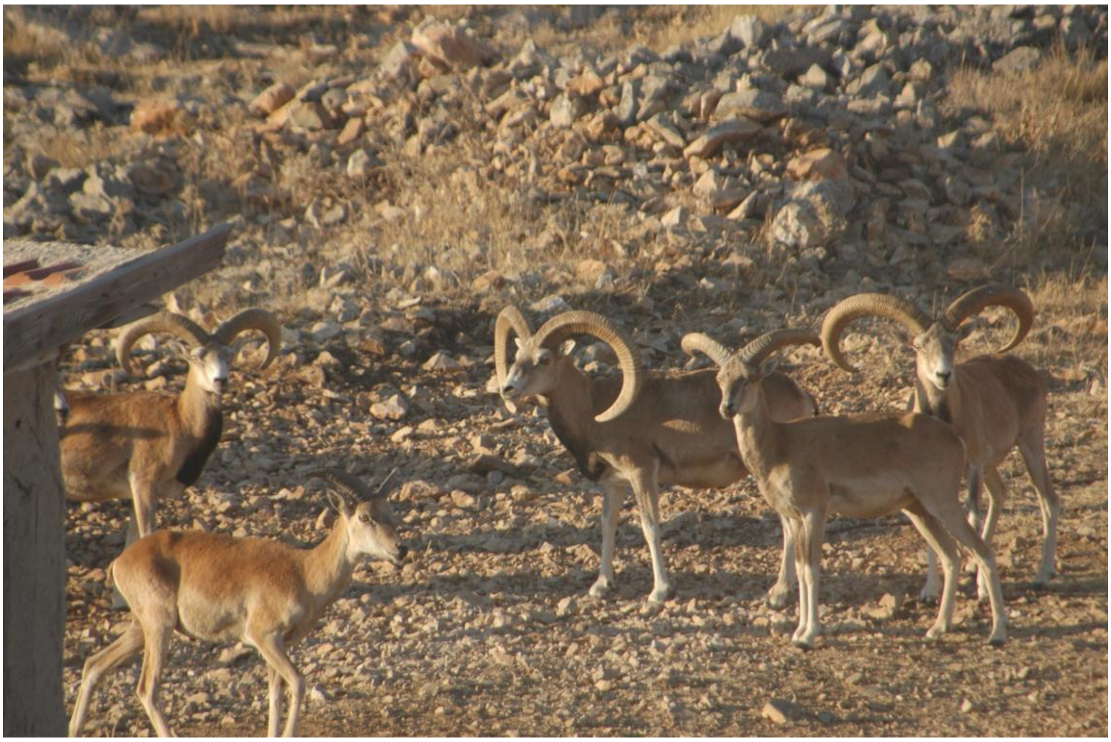


Figure 13 Anatolian mouflon rams representing the age classes 1, 2-4, 5-7 and 8+. Photograph by Deniz Özüt

The data obtained from line transects are run in Distance software (DISTANCE 5.0) designed for density estimates. Randomly located lines or randomly distributed parallel lines were used in distance surveys over the survey region.

In order to avoid biased abundance estimates and random number generator of RAMAS and MINITAB were used for selecting random lines, angles, and starting points. The survey was designed that all transects were assumed to have similar coverage probability.

3.1.1 Statistical analysis

We used the software Distance (Buckland *et al.*, 1993; Laake *et al.*, 1996) for the analysis. The Anatolian mouflon appears as clusters, therefore, the cluster size at zero distance was evaluated by regressions of the cluster size on detection probability to improve robustness.

The key functions, which are uniform, half-normal, hazard-rate, and negative exponential, the default function half normal provided in the DISTANCE were used. Cosine series are preferred to adjust the key function half normal. After the choice of Half-normal key function and cosine series expansion all the three selection methods, sequential, forward and all were applied in our model. The Aikake Information Criterion (AIC) was used for selection of the best-fitting model as Buckland (2002) suggested.

There is often more than one estimator available for a given demographic parameter and data type and choosing the most appropriate estimator will depend on which assumptions are valid for a particular data set and study objectives (Skalski and Ryding, 2005).

The seasonal variation in the population size obtained by pooling the density estimates is shown in Figure 13. Numbers of sex-age classes observed by using line transects surveys and the population size estimates were done with DISTANCE from the 665 groups observed in 78 line transects.

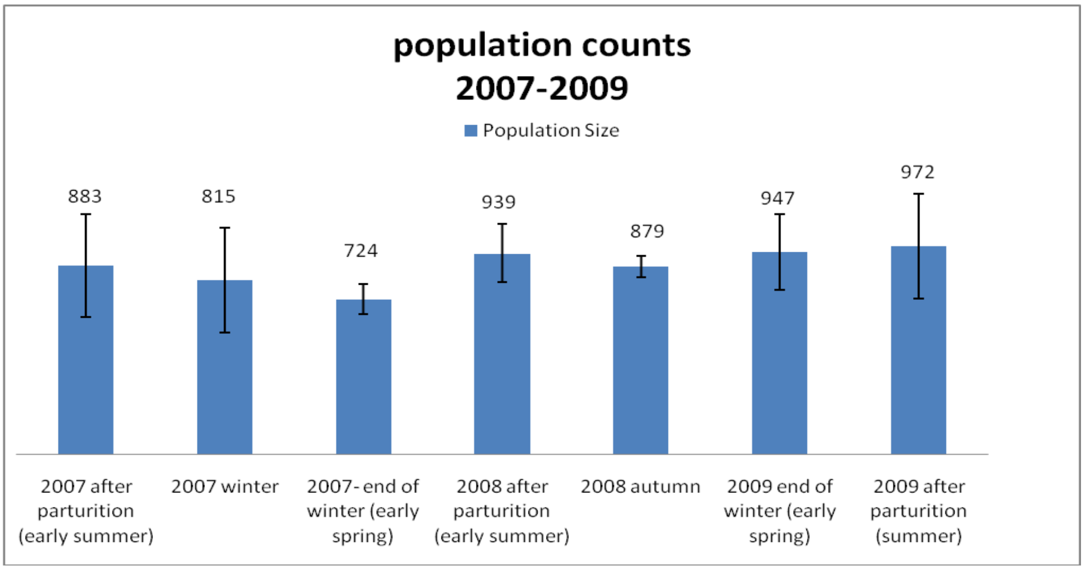


Figure 14. The population size estimates with standard deviations (indicated as scales) according to DISTANCE 5.0 during the study period.

The trend of the population during study period is found to be rather stable. The population is seemed to be recovered from the decreasing effects of paratuberculosis.

3.1.2 Viability Parameters

The locations and distances of animals as well as some other demographic parameters as the group size, group composition were recorded from the line transects. The sex ratio and the number of lambs per female were calculated for each transect line.

The important parameters such as fecundity, survival, and growth rates can be calculated from the data gathered from the line transects throughout the time.

The age structure of the Anatolian mouflon, the ratios of females to males and the density of the population in the fenced area, according to the post-parturition censuses are given in Table 3.1. The number of lambs per female can also be calculated over the years as follows;

for 2007 post-parturition this ratio is $\frac{\#lamb}{\#females} = \frac{121+125}{79+412} = 0{,}50 = 50\%$,

for 2008 post parturition $\frac{\#lamb}{\#females} = \frac{143+147}{100+238} = 0{,}86 = 86\%$,

and for 2009 post parturition it is $\frac{\#lamb}{\#females} = \frac{109+111}{49+282} = 0{,}66 = 66\%$.

The male per female is defied as the sex ratio, the change during the study period is obtained from the line transect calculations (Table 3.1).

Table 3.1 The age structure, the sex ratio, and the density of the Konya-Bozdağ Anatolian mouflon population during study period.

Period	Female Lamb	Female 1	Female 2+	Male Lamb	Male 1	Male 2-4	Male 5-7	Male 8+	Total	Sex Ratio (female/male)	Density (animal/km^2)
2007 post-parturition	121	79	412	125	39	48	27	33	883	3,34**	26,032
2008 post-parturition	143	100	238	147	68	84	57	102	939	1,09	27,227
2009 post-parturition	109	49	282	111	101	95	138	86	972	0,79	28,186

**Sex ratio deviated unusually from 1:1, since the aim was to estimate lamb/female ratio transects were not random.

The sex ratio of the population was estimated as 3.34 females to 1 male that may indicate an unusually higher survival rate of the females in 2007 post parturition period. On the other hand, the ratio of lambs/females was (0.50) in that period. This ratio was reported to be related to a reproductive strategy which involves the maternal effort in response to food sources and population density (Migli et. al., 2007). For the 2008 post parturition period, the sex ratio was estimated as 1.09 female to 1 male and the ratio of lambs/females was (0,86). The sex ratio of the population at 2009 post parturition period was estimated as 0.79 females to 1 male and the ratio of lambs/females was 0.66.

The change in the number of lambs throughout the year is calculated from the ratio of post-parturition lamb number to the pre parturition one. The average of estimates of lamb numbers is used for 2007 and 2008. For example, in 2007 census, only 40 out of 121 lambs (female only) were left after the parturition period. Therefore, 33 percent of the lambs passed to the other age class. Moreover, in 2008 census, 54 percent of the lambs remained in the population.

The growth rate is found from the ratio of the population size estimates of years, namely the ratio of 2009 to the ratio of 2008, 2008 to 2007 and calculated as 1.06 and 1,03 respectively with an average of 1,045±0,020.

The density of the ruminants is a very common concern in wildlife studies. Population Viability from the "Turkish Mouflon (*Ovis gmelinii anatolica*) in Central Anatolia under Scenarios of Harvesting for Trophy", presented 13.46 individuals per sq km for Bozdağ population and a total of 673 individuals per 50 sq km (5000 ha) (Sezen *et al.*, 2004). The densities of Anatolian mouflon during our study period were 26.03, 27.23, and 28.19 per square km according to post-parturition censuses of 2007, 2008, and 2009 respectively, which indicate approximately 900 individuals in 3500 ha. The maximum density of the mouflon population had reached to 1200 individuals per 3500 ha in year 2000; that is 34.78 individuals per sq km (Table 1.3). The mean density of mouflon (*Ovis aries*) in a confined Mediterranean area in Greece for example is found to be 22.1 individuals per sq km (Tsapartis *et al.*, 2008).

3.2 Group size and Composition

During the study period, 665 groups were observed in 78 line transect counts. Group sizes and compositions according to seasons which describe the structure of the population were summarized in Table 3.1.

3.2.1 Determination of group types

3.2.1.1 Female groups

The female groups are composed of adults, yearling females, and juveniles. The yearling males were included in the female group regardless of their numbers. If there were more than two adult males, the group is no longer considered as a female group but a mixed one. When the ratio of the adult males to the group size is less than 1/20, the group is considered as a female group.

The female groups according to seasons are analyzed using GraphPad Prism 5 software package (LaJolla, CA, USA). The group size range between 1 and 83 in 61 groups observed in spring, The female mouflons form groups changing in size 1-28 in summer, 2-25 in fall and 2-10 in winter.

Table 3.2 The minimum, maximum, and mean numbers of the female groups in different seasons

	SPRING	SUMMER	FALL	WINTER
Number of groups	61	202	8	5
Minimum	1	1	2	2
Maximum	83	28	25	10
Mean	9,967	3,703	6,875	5,2
Std. Deviation	14,07	3,858	7,492	3,347
Std. Error	1,802	0,2715	2,649	1,497
Lower limit of 95% CI of mean	6,363	3,168	0,6117	1,045
Upper limit of 95% CI of mean	13,57	4,238	13,14	9,355

ANOVA showed that the mean sizes of groups differ significantly ($P < 0.0001$). The Tukey's Multiple Comparison Test yielded significant difference between female group sizes, only in ‘spring vs. summer’ ($P<0.0001$). The other comparisons: ‘spring vs. fall’, ‘spring vs. winter’, ‘summer vs. fall’, ‘summer vs. winter’, and ‘fall vs. winter’ are not significantly different (Table 3.3).

Table 3.3 ANOVA Table of the female groups in different seasons

ANOVA Table	**SS**	**df**	**MS**
Treatment (between seasons)	1861	3	620,5*
Residual (within groups)	15320	272	56,31
Total	17180	275	

*P< 0.0001

3.2.1.2 Male groups

The male groups are composed of mainly adult and yearling males. If there are more than two adult females, the group is no longer considered as a male group but a mixed group with the exception that when the ratio of the adult males to the group size is less than 1/20, the group is considered as a female group.

The number and size of the male groups in different seasons are analyzed. The size of the male groups was between 1 and 60 individuals in 85 groups observed in spring. The rams form groups changing in size 1-29 in summer, 1-18 in fall, and 1-22 in winter.

Table 3.4 The minimum, maximum, and mean numbers of the male groups in different seasons

	SPRING	SUMMER	FALL	WINTER
Number of groups	85	157	21	43
Minimum	1	1	1	1
Maximum	60	29	18	22
Mean	6,918	2,408	3,571	4,442
Std. Deviation	10,9	3,395	4,261	5,216
Std. Error	1,182	0,2709	0,9299	0,7954
Lower limit of 95% CI of mean	4,567	1,872	1,632	2,837
Upper limit of 95% CI of mean	9,269	2,943	5,511	6,047

The means of groups appear to be significantly different (P < 0.0001) in ANOVA. Whereas, according to the Tukey's Multiple Comparison Test, from male group sizes, only 'spring vs. summer' seems to be different (P < 0.0001). The other comparisons: 'spring vs. fall', "spring vs. winter', 'summer vs. fall', 'summer vs. winter' and 'fall vs. winter' are not significantly different.

Table 3.5 ANOVA Table of the male groups in different seasons

ANOVA Table	**SS**	**Df**	**MS**
Treatment (between seasons)	1134	3	377,9*
Residual (within groups)	13280	302	43,99
Total	14420	305	

*P<0.0001

3.2.1.3 Mixed groups:

The mixed groups are composed of individuals from both sexes, where the ratio of the two sexes does not exceed 1/10.

The mixed groups according to seasons are analyzed. From the 47 groups observed in spring, the size of the groups changed from 2 to 104 (Table 3.6). The mixed groups changed in size as 2-28, 10-108, and 3-184 in summer, fall, and winter respectively.

Table 3.6 Mixed group formation according to seasons

	SPRING	SUMMER	FALL	WINTER
Number of values	47	13	4	13
Minimum	2	2	10	3
Maximum	104	28	108	184
Mean	22,81	8,077	43,5	35,31
Std. Deviation	27,3	7,1	44,2	50,05
Std. Error	3,982	1,969	22,1	13,88
Lower 95% of CI of mean	14,79	3,786	-26,83	5,064
Upper 95% of CI of mean	30,82	12,37	113,8	65,55

The means of number of individuals in mixed groups were not different ($P > 0.05$). The Tukey's Multiple Comparison Test did not show any significant seasonal difference (Table 3.7).

Table 3.7. ANOVA Table of the mixed groups in different seasons

ANOVA Table	SS	df	MS
Treatment (between seasons)	6527	3	2176*
Residual (within groups)	70810	73	969,9
Total	77330	76	

$P<0.0001$

In summary, the mean group size of females was larger than the mean of male group size in all seasons. The largest groups for both sexes were observed in spring. The sizes of mixed groups were much larger than the single sex groups, in all seasons and in pre-rut (Fall) and rut (Winter) periods, the mean mixed group sizes were very large.

Table 3.8 Summary of the group size and composition of Anatolian mouflon according to seasons.

N: number of groups observed

		female	**Male**	**Mixed**
Spring	**Average (mean)**	10	7	23
	Range	1-83	1-60	2-104
	N	61	85	47
Summer	**Average (mean)**	4	2	8
	Range	1-28	1-29	2-28
	N	202	157	13
Fall	**Average (mean)**	7	4	44
	Range	2-25	1-18	10-108
	N	8	21	4
Winter	**Average (mean)**	5	4	35
	Range	2-10	1-22	3-184
	N	5	43	13

When the lambs are excluded from the data, except from the male groups, the average group size (mean) of both females and males decreased (Table 3.9). Subsequent to analysis of data with exclusion of the lambs, the means of female and male groups are compared and again found significantly different ($P < 0.0001$. According to the Tukey's Multiple Comparison Test (α 0.05), while for female and male group sizes, only ‘spring vs summer’ comes to be significantly different ($P < 0.0001$). Additionally, for the mixed group no significance in means is calculated.

Table 3.9 Summary of the group size and composition of Anatolian mouflon when lambs are excluded according to seasons. N: number of groups observed

		Female	Male	Mix
Spring	**Average (mean)**	9	7	23
	Range	1-83	1-60	2-104
Summer	**Average (mean)**	2	2	8
	Range	1-15	1-29	2-21
Fall	**Average (mean)**	5	4	44
	Range	1-16	1-18	3-85
Winter	**Average (mean)**	4	4	35
	Range	1-8	1-22	2-154

3.3 Pattern of Seasonal Use of the Area

The seasons are defined as spring March to May, summer June to August, fall September to October, and winter November to February.

The group formations in different seasons were compared carrying out single classification of ANOVA and single (male – female) vs mixed groups were compared according to planned comparisons (Sokal and Rohlf, 1982).

3.3.1 Spring

Significant difference in means was found (P < 0.0001) when female, male, and mixed groups were compared based on the in spring observations.

The size changed from 1-83 in 61 female groups observed; 1-60 in 85 male groups, and 2-104 in 47 mixed groups. While group sizes in ‘female vs males’ comparison were not significantly different, ‘single vs mixed’ groups comparison were found to be significantly different (P < 0.05).

Table 3.10 Spring group formation according to sex

ANOVA Table	SS	Df	MS
Treatment (between seasons)	7926	2	3963*
Residual (within groups)	56150	190	295,5
Total	64070	192	

*P<0.0001

3.3.2 Summer

A significant difference in means is observed (P < 0.0001) from the comparison of female, male, and mixed groups formed in summer (Table 3.11).

In the observed 202 female groups the size changed from 1 to 28; in 157 male groups from 1 to 29 and in 13 mixed groups from 2 to 28.

Table 3.11 Summer group formation according to sex

ANOVA Table	**SS**	**Df**	**MS**
Treatment (between seasons)	454,4	2	227,2*
Residual (within groups)	5395	369	14,62
Total	5849	371	

*P<0.0001

All the differences in group comparisons, 'female vs males' 'single vs mixed', found to be highly significant. In all seasons the size of mixed groups were larger ($p<0.001$) than the single sex groups.

3.3.3 Fall

From the comparison of female, male and mixed groups formed in fall, a significant difference in means of group sizes is observed ($P < 0.05$) (Table 3.8). In the 8 female groups the size changed from 2 to 25; in 21 male groups from 1 to 18 and in 4 mixed groups from 10 to104.

Table 3.12. Fall group formation according to sex

ANOVA Table	SS	Df	MS
Treatment (between seasons)	5414	2	2707
Residual (within groups)	6617	30	220,6
Total	12030	32	

*P<0.0001

While group sizes in "female vs male" comparison were not significantly different, 'single vs mixed' groups were found to be significantly different ($P < 0.0001$). The sizes of mixed groups were larger ($P<0.001$) than the single sex groups in fall too.

3.3.4 Winter

Similarly, the comparison of female, male, and mixed groups formed in winter, a significant difference in means is observed ($P < 0.0001$) (Table 3.13). In 5 female groups observed in winter the size changed from 2 to 10; in 43 male groups from 1 to 22 and in 13 mixed groups from 3 to184.

Table 3.13 Winter group formation according to sex

ANOVA Table	SS	Df	MS
Treatment (between seasons)	9698	2	4849
Residual (within groups)	31250	58	538,7
Total	40940	60	

*P<0.0001

Planned comparisons were resulted in no significant difference between 'female vs male' group sizes; 'single vs mixed' groups were found to be different in size ($P < 0.0001$).

When the lambs are excluded from data for spring season, female vs. male is not found to be significantly different; whereas single sex vs. mixed groups show significance in spring and summer data. In fall and winter, 'male vs. mixed' group comparison show significant difference.

Our results are in line with the results of KAYA (1989) and ARIHAN (2000) and the personal comments of the researchers studied in the field, the isopleths obtained from the points of the clusters show that the females tend to use the areas to the west of Bağderesi, whereas, the males used the areas to the east of Bağderesi.

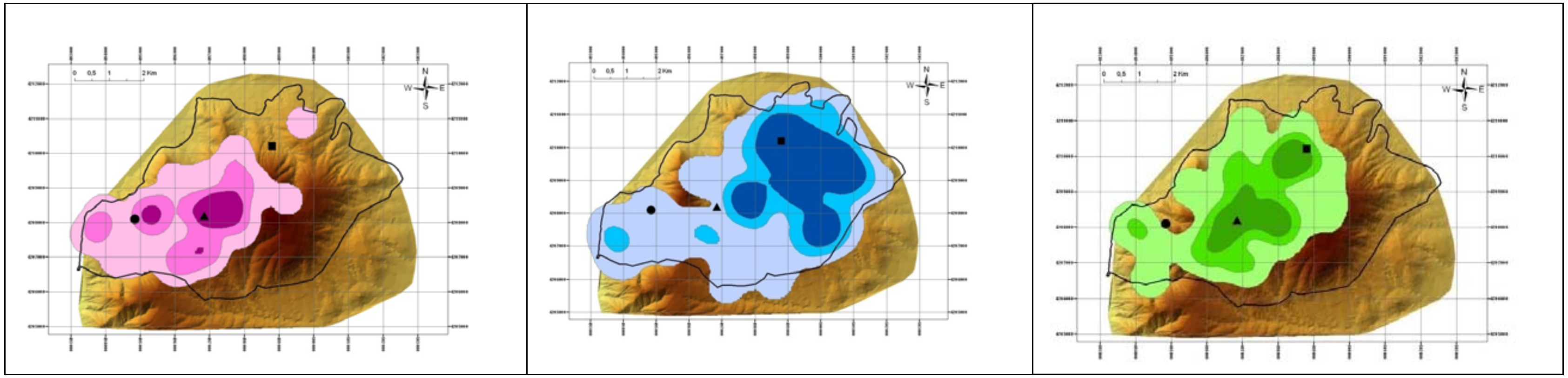


Figure 15 The isopleths of female, male, mixed groups in spring. Pink, blue and green colors represent the area use of female male and mixed groups respectively. The intensity of the colors indicates the amount of the use. The darkest areas are the activity centers. The shapes: ■,▲,● indicates Karanlıkdere catching station, Bağderesi catching station and Gölet catching station respectively. These stations are places where additional feeding is supplied especially in winter period.

From the isopleths, it can be concluded that males extend their area use substantially towards the female-dominated areas during spring.

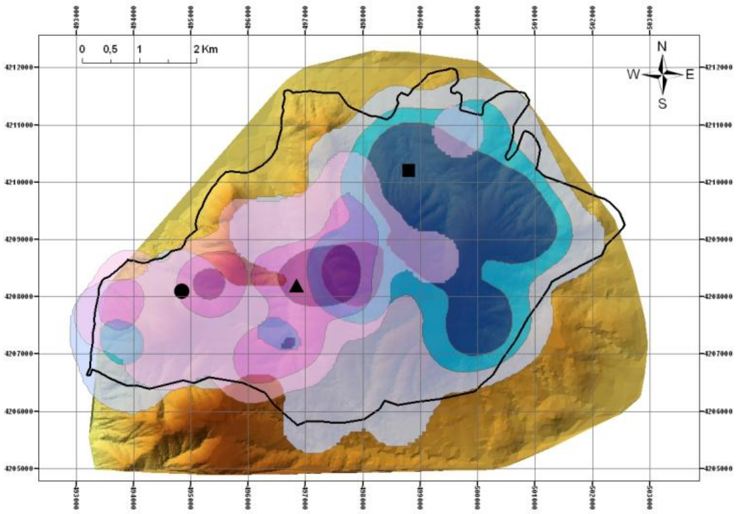


Figure 16 The result of Kernel analysis of female and male groups according to spring locations. The blue color represents the males and the pink color represents females. The activity centers are represented with dark color. The darker the color, the higher the rate of use of that area.

In Figure 15, 16, 17, 18 and 19 the isopleths from the spring points are drawn, showing a sexual segregation in the area use, especially when the activity centers are considered.

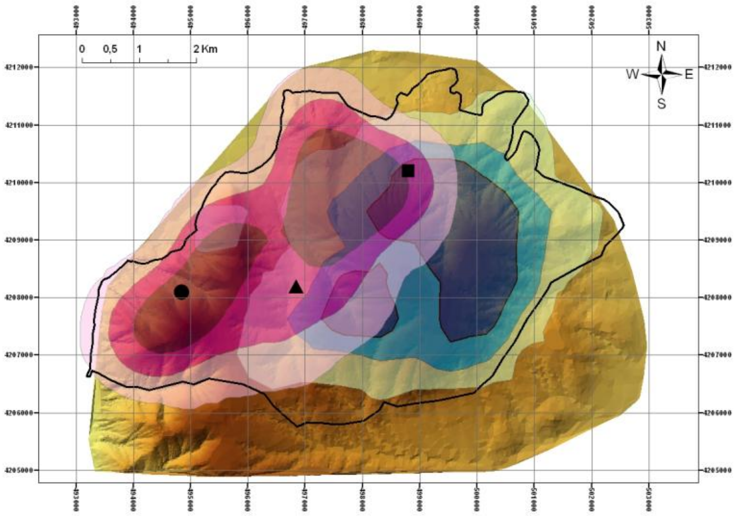


Figure 17 The result of Kernel analysis of female and male groups according to summer locations. The blue color represents the males and the pink color represents females. The activity centers are represented with dark color. The darker the color, the higher the rate of use of that area.

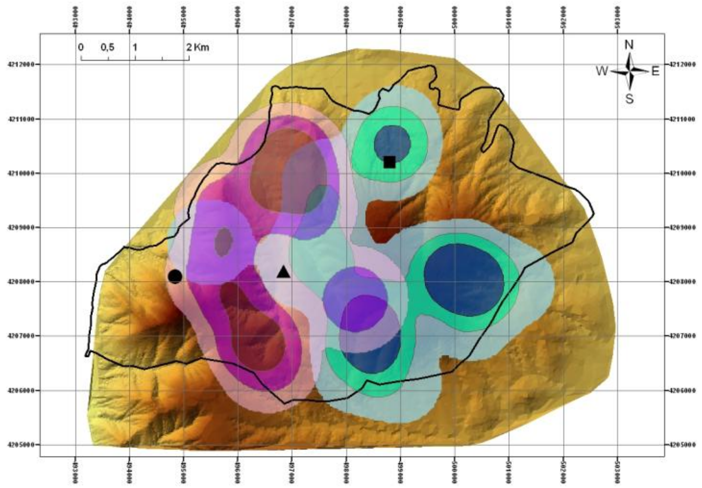


Figure 18 The result of Kernel analysis of female and male groups according to fall locations. The blue color represents the males and the pink color represents females. The activity centers are represented with dark color. As the color lighten, the probability of the groups/animals of being at that location increases.

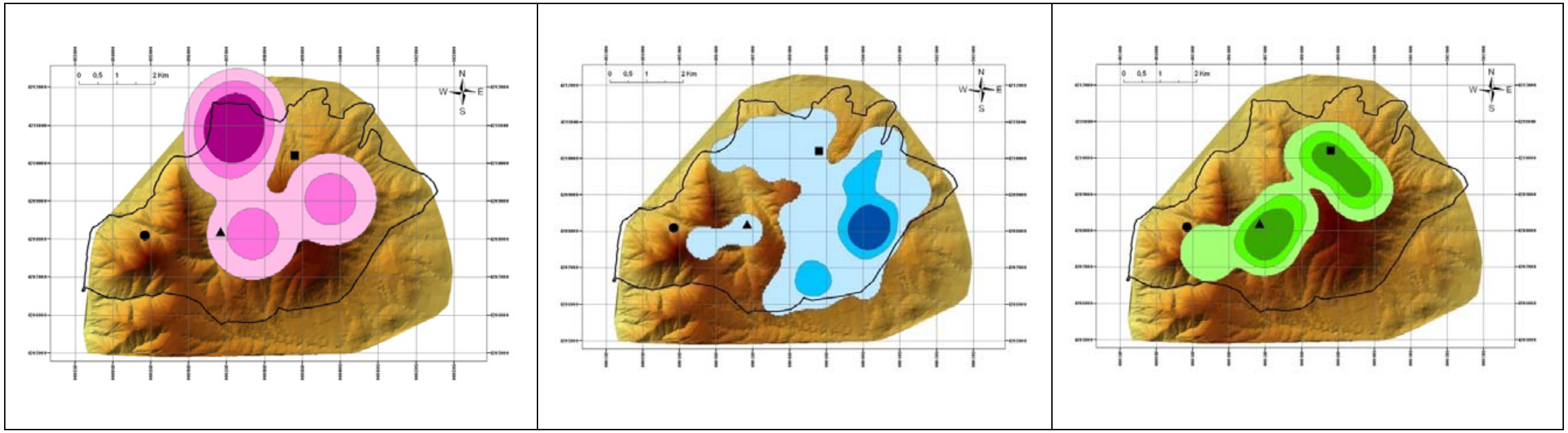
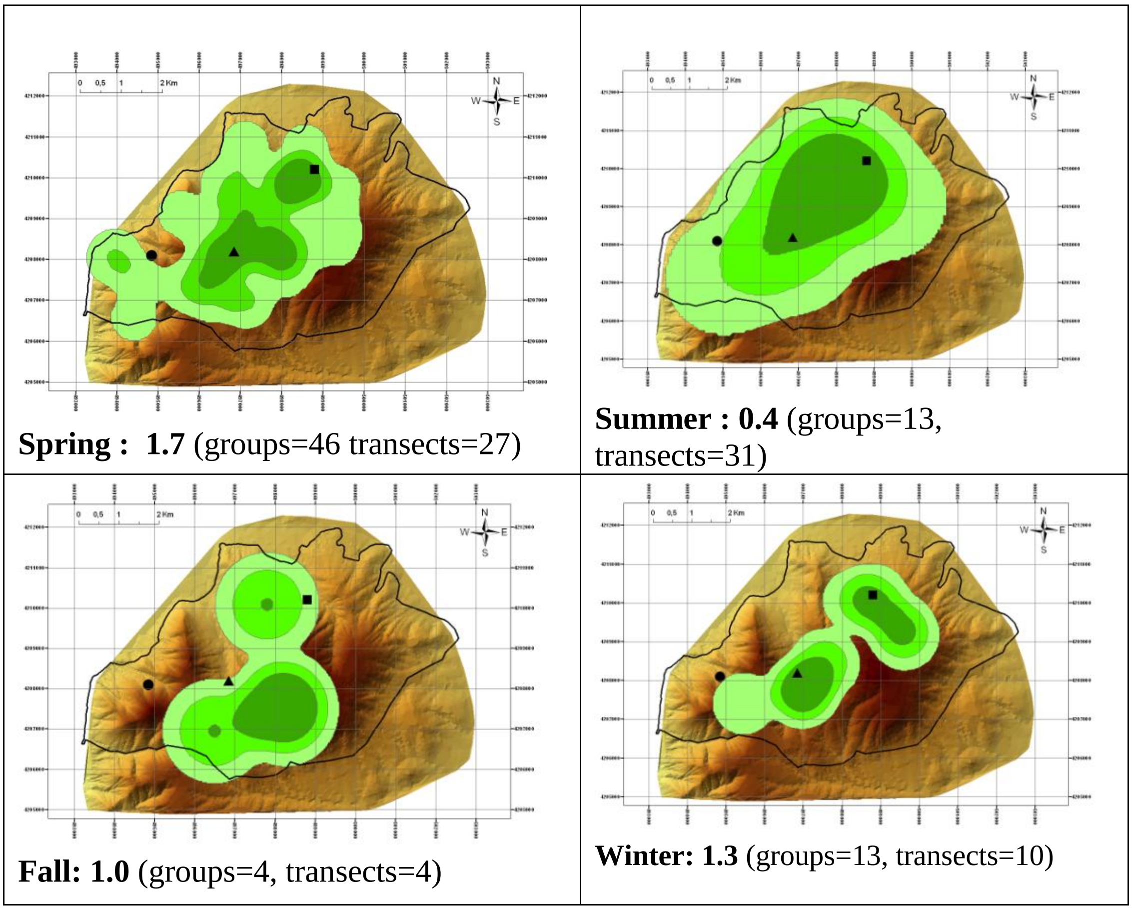


Figure 19 The isopleths of female, male mixed in winter. Pink, blue and green colors represent the area use of female male and mixed groups respectively. The intensity of the colors indicates the amount of the use. The darkest areas are the activity centers.

Interestingly, not males but females showed a shift in area use towards male-dominated areas during winter (rut).



Spring : 1.7 (groups=46 transects=27)

Summer : 0.4 (groups=13, transects=31)

Fall: 1.0 (groups=4, transects=4)

Winter: 1.3 (groups=13, transects=10)

Figure 20 Area use of mixed groups according to seasons. Average number of groups per transect in each season are given. The intensity of the colors indicates the amount of the use. The darkest areas are the activity centers

CHAPTER 4

DISCUSSION

4.1 Distance Sampling and Models

One of the main assumption of line transect is accurate measurement of distances of groups. While range finders are ideal for such accurate distance measurements, due to economical reasons, we used binoculars with reticles for distance measurements. Although binoculars with reticles enable distance measurements, from the trigonometric calculations with known (or assumed) length of the objects; as the distance from the objects increases, the error in the measurements occur. Overcoming this by the right truncation in the model to one degree is possible, but still, violation of that assumption cause high standard deviations as in our case.

When distance data is collected in distance intervals, it is called grouped data. While entering this group data into Distance, entrance of the mid points of the intervals is suggested. It is explained in the Distance User guide as when the intervals span 0-10m, 10-20m and 20-50m the bin would be entered as 5m, 15m and 35m respectively. Therefore the midpoints of the intervals determined in the test study are selected for radial distance.

Modeling our line transect data independently, we did not use post stratification. Post stratification is suggested in the Distance user guide when the study area is surveyed in multiple time periods, using a different transects in each time period. Post-stratification is useful when a combined estimate of the average density over all periods is aimed. According to seasonal changes and changes in the density of population throughout those time periods, and the shortage of the data, post stratification was not preferred.

Estimating density in some large study area (or stratum) using just a single transect (Buckland *et al.* 2001) is not a good way of estimation. But sometimes due to the practical reasons single transect data is used in analyzes. In such cases, using the empirical between-line variation in encounter rate is not possible in Distance.

When we aim to estimate the density and abundance of a biological population, Distance software enables design and analyzes distance sampling surveys. For a given demographic parameter and data type, there is often more than one estimator available. Choice of the most appropriate estimator will depend on which assumptions are valid for a particular data set and study objectives.

Although our data did not come from a single transect almost all surveys less than 4 transect lines gave the same error when using the empirical between-line variation in encounter rate (which is default). Once the encounter rate is chosen “empirically” when the sample size is small, that is there is single line transect data, the CDS-Convential Distance Sampling engine issues a warning. When the sample is composed of single entity, like single transect, the variance of the encounter rate for each sample is assumed to be Poisson.

The encounter rate is estimated by the resolution at which the estimate(s) are made: that is done by choosing SAMPLE, by STRATUM, or ALL data. When encounter rate is estimated by sample, the variability in encounter rate is to be explored by listing the encounter rate for each sample. The variance of the encounter rate for each sample is assumed to be Poisson because the sample is a single entity. Whereas, when encounter rate is estimated by stratum, the variability in encounter rate is to be explored by listing the encounter rate for each stratum. The variance of the encounter rate for each stratum is computed empirically for each stratum with more than one sample; otherwise, it is assumed to be Poisson.

Small sample size is one of the main grounds to the outfit of the model or the unexpected high or small numbers that Distance gives. The sample size would have to be increased greatly to obtain more precision in the estimates. In the gray partridge study of Ratti *et al*. (1983), it is concluded that "an increase from 40 to 160 observations (80-320 km of transects/survey) would have reduced the coefficient of variation from approximately 20 to 10%."

The population estimates by distance sampling had high error rates. This could be due violations of certain assumptions, such as accurate distance measurement and high rate of movement of mouflon relative to the observers.

Additional feeding in winter affects the group size and composition. Especially the sizes of mixed groups near those locations were observed to be large. As a result sizes of groups much larger than usual.

4.2 Density

From the table 1.3 and Figure 6 a dramatic increase in the size of the Anatolian mouflon population is observed especially after the fences. The results are absence of predators, poaching, domestic livestock (sheep) and decreased disturbance in the fenced area.

After the population viability analysis on Konya-Bozdağ Anatolian mouflon population (Sezen, 2000; Sezen *et al.*, 2004) it has been shown that re-introduction is vital in the conservation. Therefore, a reintroduction program was initiated in 2004 by Turkish National Parks and Game-Wildlife Department administrators. For the two sites: Karaman-Karadağ and Ankara-Sarıyar, chosen for the reintroduction, a total number of 200 individuals were translocated. The relocations cover the starting of the study period; that is, the translocation continued till autumn 2007. A significant decrease in the Anatolian mouflon population size is occurred according to a disease outbreak: paratuberculosis (*Mycobacterium avium*) epidemics occurrence in the fenced area.

While the estimates of population size in Konya-Bozdağ in 2004 was approximately 1200-1400, the size estimates in 2007 was around 700. Although the decrease in population size is incontestable, the number 1400 is a quite larger estimate for the 3500 ha Bozdağ Province. This much of higher estimate is a result of high amount of double counts, wrong application in the counting techniques, and tendency of the wardens to increase the number of individuals.

4.2.1 The age structure, the sex ratio

The sex ratio of the population was estimated to 1 male: 3.34 females, indicating an unusual higher survival rate of the females in 2007 post parturition period.

As the assumptions of line transect methods are considered, density estimation could be done from for 2007 post parturition period. Wherever, intended to count the new-borns and to find lamb per female, nonrandom line transects covering only the parts those female use were used in the first two transects (May 2007 and June 2007). Therefore, the data was improper for finding sex ratio. One other thing that should be noted is that the field experience affects the accuracy of the data. Especially determination of age class of one year olds and lambs becomes difficult with the increasing distance. For that reason, this much of deviation in the sex ratio may be a result of overestimation of the number of females in the beginning of the study.

4.3 Seasonal Area Use

When the group composition and habitat use of mouflon is studied in Bozdağ region it is clear that there is segregation between sexes. Not only in Anatolian mouflon but in many ruminants, adult males and females show separations outside the rut from temperate and/or mountainous regions (Cransac *et al.*, 1998).

The very same species in continental France, "mouflon sheep (*Ovis gmelini*)" show a similar pattern. There is segregation outside the rut, both between the sexes, and between the different hierarchies of rams (Cransac *et al.*, 1998). Moreover, it is shown that the ewes, young rams, and old rams displayed a quantity of differences in patterns of habitat use in different seasons: as, the mid-rutting and lambing seasons.

We divide the period as seasons: winter, spring, summer and autumn. From the collected points, using the home range approach (using Kernel statistics) we come up with the results shown in Figure 15-20.

The analysis of group composition revealed segregation between the activity centers of females and males. While the males use the eastern part of the region; the activity centers of the females are north western parts of the area. The center of activity of males and females are mostly separate throughout the year, while there is continuous overlap in general area use.

The studies of interactions and proximity between individuals within groups, Cransac's study it is stated that segregation between age-sex classes has a strong social basis in mouflon sheep. (Cransac *et al.*, 1998).

One thing that should be considered both for population size/growth and habitat use of Anatolian mouflon is the supplementary feeding in the Bozdağ area. Although in past the supplementary food supplied only in harsh winters, especially after the reintroduction and the becoming aware of the presence of paratuberculosis in the fenced area, it was observed that the managers and the wardens has a tendency to put additional food near the catching stations. The warnings about the risk of increase of the spread of the epidemic by bringing that much of animals together: increasing the density of individuals to only those three locations did not work. Therefore, the additional food was available for the whole study period. As the transects coincide with these places, they are observed to be used by large groups (2 largest mixed groups: group size 184 and 108), especially in food shortage periods (winter).

Thus, as the area is fenced (no migration, or movement outside the fenced area is available) and additional foods are put in the some regions (Catching stations: Karanlıkdere, Gölet and Bağderesi), the conclusions on the habitat use of Anatolian mouflon (*Ovis gmelinii anatolica*) in Konya Bozdağ Province is risky. Still from the data we collected for three lambing periods, we come up with the conclusion that, there is at least segregation between sexes in Bozdağ protection area.

While no activity centers of the single sex group intersect the additional feeding places, especially in the winter period; the locations of mixed groups and the locations of those catching stations coincides. But this coincidence does not fallow a seasonal pattern. Especially, the additional feeding in Gölet station is not effective on the area use of female, male and mixed groups. Karanlıkdere and Bağderesi station wherever are in the activity centers of mixed groups in spring, summer and winter. Wherever, the presence of additional feeding in Bağderesi station may be the result of 95% isopleths in male groups shown in Figure 19. Except this the additional feeding stations seems not to have an effect on the habitat use of male and female groups.

Sampling efforts were lower in Fall and Winter compared to Summer and Spring. This was mainly due to increased effort in pre- and post-breeding seasons to quantify the population size change.

Area use by sex groups according to season were quantified using a home-range approach. Validity of this approach is questionable. However, the statistical property of kernel home-ranges (utilization distribution) is quite appropriate for substituting the sex groups with individuals.

Use of random and stratified random sampling enabled to quantify the area use and statistical estimates of density.

CHAPTER 5

CONCLUSION

As Naderi *et al.* (2008) indicated Eastern Anatolia is one of the domestication centers of goats. The mouflon subspecies found in Anatolia (*Ovis gmelinii anatolica* and *Ovis gmelinii gmelinii*) are the most possible ancestors of domestic sheep (Hiendleder *et al.*, 2002). Anatolian mouflon is worthy of strong effort in research and conservation for it is an endangered species, the only large herbivore living in low altitude of Anatolian steppes and it is also the ancestor of such economically important species.

From the laboratory analyses on blood and fecal samples of the caught animals in Konya Bozdağ, the presence of paratuberculosis epidemic is defined in the population. For the new captive breeding area and reintroductions paratuberculosis negative animals should be used in order to prevent the spread.

The trend of the population during study period is found to be rather stable. The population seemed to recover from the decreasing effects of paratuberculosis.

The location data of groups can be used in explaining the area use patterns through habitat selection analyses. The center of activity of males and females are mostly separate throughout the year: sexual segregation, while there is continuous overlap in general area use. Supporting the previous studies (Arıhan, 2000), females used the areas to the west of Bağderesi, and males used the areas to the east of Bağderesi dominantly where two areas seem to differ in ruggedness and altitude

It is appealing that not males but females showed a shift in area use towards male-dominated areas during winter (rut); and males extend their area use substantially towards the female dominated areas during spring.

Sexual segregation, typical of the ruminant species, was maintained in of Anatolian mouflon especially during the summer period. Moreover, female and male groups tended to use diverse and distant parts within the study area, despite the small size of area.

Average group sizes of females were larger than males in all seasons, most probably due to the associated juveniles and yearlings. The average group sizes of mixed groups were much higher in all seasons than the single-sex groups.

Average number of mixed groups observed per season was lowest in summer. In fall and winter, it increased as expected due to the mix of sexes in rut. This value was highest in spring, most probably due to increased area use of males in spring.

For the next studies, the population trend should be monitored using appropriate methods. The possible effects of the paratuberculosis epidemics in the fenced area should be monitored by answering the basic questions about the reaction of population and individuals, the speed of the spread of epidemic, and the resistance.

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Table. The binocular test for the accuracy of the distance estimation and a comparison with real distances.

No	Azm	Reticle	Height (m.)	Real Distance (±5m.)	Estimated Distance (m.)	Yorum	Reticle	Class Cutpoints
1	OZUT	2,000	**0,75**	30	38		**2**	**20 – 40**
1	OZDIREK	2,000	**0,75**	30	38			
1	KAYIM	2,000	**0,75**	30	38			
2	OZUT	1,500	**0,75**	50	50		**1,5**	**40 – 60**
2	OZDIREK	1,500	**0,75**	50	50			
2	KAYIM	1,500	**0,75**	50	50			
3	OZUT	1,000	**0,75**	70	75		**1**	**60 – 80**
3	OZDIREK	1,000	**0,75**	70	75			
3	KAYIM	1,000	**0,75**	70	75			
4	OZUT	0,500	**0,75**	100	150	Here, the reason why all 100s are noted as 150 is the sclae of the reticles in the binocular. That is after 1 reticle directly vomes ½. Addition of the medium values is while scaling is required.	**3/4**	**80 – 130**
4	OZDIREK	0,500	**0,75**	100	150			
4	KAYIM	0,500	**0,75**	100	150			

Table cont. The binocular test for the accuracy of the distance estimation and a comparison with real distances.

5	OZUT	0,500	**0,75**	150	150		**1/2**	**130 – 250**
5	OZDIREK	0,500	**0,75**	150	150			
5	KAYIM	0,500	**0,75**	150	150			
6	OZUT	0,500	**0,75**	200	150			
6	OZDIREK	0,500	**0,75**	200	150			
6	KAYIM	0,333	**0,75**	200	225			
7	OZUT	0,250	**0,75**	300	300		**1/3 - 1/4**	**250 – 450**
7	OZDIREK	0,333	**0,75**	300	225			
7	KAYIM	0,250	**0,75**	300	300			
8	OZUT	0,250	**0,75**	400	300			
8	OZDIREK	0,250	**0,75**	400	300			
8	KAYIM	0,250	**0,75**	400	300			
9	OZUT		**0,75**	500		Added to scale	**1/5 - 1/6**	**450 – 650**
9	OZDIREK		**0,75**	500				
9	KAYIM		**0,75**	500				
10	OZUT	0,166		600	452			
10	OZDIREK	0,200		600	375			
10	KAYIM	0,166		600	452			
11	OZUT	0,125	**0,75**	670	600		**1/7 - 1/8**	**650 – 750**
11	OZDIREK	0,143	**0,75**	670	524			
11	KAYIM	0,143	**0,75**	670	524			
							1/9 - 1/10	**750 – 850**

APPENDIX B

Table. The Line transect summary. The observer, date starting and finishing points, direction, group number and composition and the length of transects are listed.

OBJECT ID	OBSERVER	Date	x_start	y_start	x_finish	y_finish	direction	Group number	Total Animal	male	female	lamb	duration	SHAPE_Length
1	OZUT-LUTFIYE	20.05.2007	493290	4207380	497369	4208340	75	18	77	15	42	20	8,55	4191,5964092
2	LUTFIYE	26.06.2007	496194	4207090	495720	4209380	349	8	23	2	16	5	5,55	2394,6840255
3	LUTFIYE	26.06.2007	495762	4209230	495466	4207640	190	12	23	1	16	6	3,52	1612,7807189
4	LUTFIYE	26.06.2007	494944	4207800	494461	4207240	221	16	45	2	23	20	1,34	735,7411194
5	LUTFIYE	27.06.2007	498059	4206590	497069	4208630	334	7	11	8	3	0	7,30	2264,8326726
6	LUTFIYE	27.06.2007	497478	4209430	497328	4211040	354	15	44	2	27	15	3,55	1608,0110015
7	LUTFIYE	11.11.2007	499900	4209400	497310	4211450	308	8	43	24	15	4	4,21	3300,6391444
8	LUTFIYE	11.11.2007	497310	4211450	497100	4210410	188	1	10	1	7	2	1,00	1057,0679945
9	OZUT	09.12.2007	501800	4209900	495450	4207400	248	14	165	61	73	31	7,44	6824,4057044
10	LUTFIYE	09.12.2007	501158	4209270	498950	4206700	220	16	59	59	0	0	9,00	3389,7556337
11	OZUT	13.01.2008	500000	4206300	500700	4211500	8	6	18	18	0	0	3,19	5167,6292113
12	OZUT	13.01.2008	498960	4211630	496404	4209990	238	5	6	4	1	1	3,37	3039,5993782
13	LUTFIYE	13.01.2008	499300	4206220	496555	4207260	290	6	131	43	77	11	7,15	2936,1193952
14	OZUT	04.02.2008	499544	4209770	500187	4208310	155	2	43	43	0	0	2,00	1595,3201205
15	OZUT	04.02.2008	499962	4208200	497514	4206930	243	2	8	7	1	0	3,00	2758,2862536
16	LUTFIYE	04.02.2008	499400	4209800	496972	4208750	246	3	193	61	102	30	6,03	2646,9041428
17	OZUT	31.03.2008	502113	4209390	496424	4206460	242	3	7	7	0	0	4,44	6399,1888708
18	OZUT	31.03.2008	496424	4206460	497321	4209340	17	3	59	7	30	22	3,44	3016,6685631
19	LUTFIYE	31.03.2008	494400	4209000	497800	4206200	120	1	18	3	12	3	4,00	4404,5420822
20	LUTFIYE	31.03.2008	497800	4206200	494500	4208700	300	4	15	1	14	0	3,30	4140,0486266
21	LUTFIYE	31.03.2008	494500	4208700	493810	4208020	225	4	88	25	51	12	2,10	966,6569777
22	OZUT	01.04.2008	501044	4210130	495471	4206620	242	11	140	76	64	0	6,34	6585,4787654
23	LUTFIYE	01.04.2008	495700	4210200	496386	4209790	118	5	159	47	87	25	7,30	2105,6857674
24	MUSTAFA	27.04.2008	500800	4209700	494805	4208220	262	12	45	25	16	4	6,09	6175,9438998
25	LUTFIYE EMRE	27.04.2008	498800	4211300	497224	4205820	197	16	61	36	22	3	8,35	5700,1975160

Table cont. The Line transect summary. The observer, date starting and finishing points, direction, group number and composition and the length of transects are listed.

26	LUTFIYE EMRE	27.04.2008	497225	4205820	495073	4207710	311	9	51	6	45	0	3,26	2864,7847090
27	OZUT	26.05.2008	499697	4211200	495000	4206500	222	29	135	45	51	39	7,47	6643,9750291
28	LUTFİYE	26.05.2008	500244	4206450	497920	4210940	335	16	81	57	17	7	7,34	5051,3573495
29	MUST.EMRE.MERT	16.07.2008	493466	4206980	497449	4209150	61	19	91	0	48	43	10,41	4538,1605688
30	MUST.EMRE.MERT	17.07.2008	497428	4209160	500072	4210480	62	15	50	26	12	12	5,12	2956,9764477
31	MUSTAFA MERT	31.10.2008	496800	4206000	495613	4209030	335	6	68	27	24	17	5,42	3254,2080237
32	OZUT	31.10.2008	500600	4207200	499095	4210860	335	9	13	13	0	0	5,10	3958,2770322
33	OZUT	31.10.2008	499095	4210860	497361	4210080	245	4	42	11	19	12	2,30	1903,0006336
34	LUTFIYE EMRE	31.10.2008	499175	4206040	496802	4210080	335	14	181	89	60	32	8,00	4707,9337757
35	MUSTAFA	07.03.2009	498300	4206210	498301	4211130	3	3	148	67	81	0	3,31	4926,0003647
36	EMRE	07.03.2009	497100	4205830	497132	4211540	3	3	9	3	6	0	4,02	5714,0888845
37	OZUT	07.03.2009	499500	4206310	499500	4211910	0	7	137	47	95	0	3,55	5599,9984112
38	MERT	07.03.2009	494700	4208830	494700	4206450	180	2	95	2	93	0	3,55	2381,0006711
39	MENGULLU	07.03.2009	495900	4209990	495900	4206590	3	2	143	44	99	0	2,21	3400,0002827
40	LUTFIYE SEMRA	07.03.2009	500700	4207400	500701	4211590	3	4	55	51	4	0	4,16	4192,9982925
41	LUTFIYE	08.03.2009	499200	4211900	499200	4206200	3	5	99	93	6	0	4,48	5699,9991728
42	LUTFIYE	08.03.2009	499800	4206200	499801	4211240	183	5	49	49	0	0	3,32	5039,9989023
43	MERT	08.03.2009	496800	4211520	496800	4205830	183	5	127	27	100	0	4,12	5694,7744531
44	MERT	08.03.2009	497400	4205810	497400	4211580	3	10	151	55	96	0	4,25	5760,9984732
45	SEMRA	08.03.2009	493800	4208490	493800	4206460	183	2	13	12	1	0	1,29	2031,0003339
46	SEMRA	08.03.2009	494400	4206430	494402	4208660	3	2	87	46	41	0	2,17	2235,9992972
47	SEMRA	08.03.2009	495000	4209050	495000	4206470	183	1	14	14	0	0	2,50	2582,0010378
48	EMRE	08.03.2009	495600	4210150	495657	4206500	180	1	4	4	0	0	2,45	3649,4438386
49	EMRE	08.03.2009	496200	4206360	496200	4210270	3	3	50	12	38	0	2,54	3914,0018689
50	MENGULLU	08.03.2009	500400	4211010	500400	4206790	183	7	93	93	0	0	2,52	4220,9983862
51	MENGULLU	08.03.2009	501000	4207750	501000	4210150	3	1	4	4	0	0	1,00	2400,0019800
52	MENGULLU	08.03.2009	501600	4209920	501600	4208500	183	0	0	0	0	0	1,00	1415,0002991
53	MUSTAFA	08.03.2009	498000	4211200	498000	4205850	180	2	54	17	37	0	3,20	5356,0012095
54	MUSTAFA	08.03.2009	498600	4206100	498600	4211380	3	0	0	0	0	0	2,46	5276,9994437
55	EMRE	04.07.2009	497752	4205820	501062	4210220	37	8	14	14	0	0	3,00	5499,6153342
56	EMRE	04.07.2009	501057	4210200	501057	4207900	180	1	2	2	0	0	2,00	2299,9988901

Table cont. The Line transect summary. The observer, date starting and finishing points, direction, group number and composition and the length of transects are listed.

57	EMRE	04.07.2009	500211	4206570	495730	4206570	270	0	0	0	0	0	2,00	4481,0003664
58	MUSTAFA	04.07.2009	495207	4206600	498485	4210950	217	12	31	1	19	11	7,18	5448,4115605
59	MUSTAFA	04.07.2009	499209	4211030	499205	4209680	180	11	18	14	3	1	2,16	1350,0068942
60	LUTFIYE SONER	04.07.2009	497389	421565	494732	4208110	217	20	76	10	42	24	7,25	4356,1386542
61	MERT	04.07.2009	496435	4210180	496435	4206160	183	7	51	4	29	18	5,07	4022,0003631
62	MERT	04.07.2009	496435	4206160	500500	4211590	37	10	31	25	4	2	5,25	6784,6031044
63	MUSTAFA	05.07.2009	499816	4206410	499822	4211220	183	17	29	29	0	0	4,53	4801,0042244
64	MUSTAFA	05.07.2009	499822	4211220	495835	4208650	237	25	95	18	48	29	5,50	4739,1991965
65	EMRE	05.07.2009	496131	4210220	496131	4206400	180	7	23	0	12	11	4,15	3816,9999660
66	EMRE	05.07.2009	496112	4206460	501480	4209910	57	22	68	44	13	11	4,42	6378,3586646
67	MERT	05.07.2009	500428	4210420	494216	4206450	237	21	108	66	24	18	10,30	7370,6195508
68	SONER	05.07.2009	497145	4211520	497069	4205840	183	10	60	6	33	21	5,20	5677,5088349
69	SONER	05.07.2009	497069	4205840	501686	4209220	57	12	30	30	0	0	3,53	5719,6203652
70	LUTFIYE	05.07.2009	497946	4205870	497965	4211220	3	17	60	23	25	12	6,20	5349,0337412
71	LUTFIYE	05.07.2009	497965	4211220	495091	4209340	237	8	26	0	15	11	3,17	3433,7338305
72	MUSTAFA	06.07.2009	493253	4206920	500895	4208160	80	26	54	27	18	9	8,42	7742,1083915
73	LUTFIYE	06.07.2009	495128	4209290	501036	4210330	80	23	101	42	40	19	7,00	5999,1865219
74	MERT	06.07.2009	496109	4206420	500587	4207200	80	4	7	7	0	0	3,38	4546,6301722
75	MERT	06.07.2009	500580	4207210	500580	4211590	3	7	21	21	0	0	3,47	4378,9995895
76	SONER	06.07.2009	496543	4206030	496512	4210720	3	4	13	0	7	6	2,40	4691,1020603
77	SONER	06.07.2009	496514	4210720	500518	4211240	80	1	1	1	0	0	2,00	4036,8568277
78	EMRE	06.07.2009	493338	4207800	502027	4209650	80	8	28	10	12	6	7,12	8885,0129120
								665						

Table . The model selection in DISTANCE. According to each model the densities and the population size are listed.

	Estimate		Detection function-adjustment function			Cluster size		Variance			
Date	**Global**	**Sample**	**Sequential**	**All**	**Forward**	**Size bias**	**Mean**	**Emprical**	**Poisson**	**Density**	**Population size**
20.05.2007	+	/+	+	/+	/+		+		+	37,478	1293
26.06.2007	+		+	/+	/+		+	+	+	13,238	457
27.06.2007	+		+	/+	/+		+		+	27,379	945
27.06.2007	+		+				+	/+	+	26,034	898
11.11.2007	+		+			+	/+	+	/+	15,241	526
09.12.2007	+	/+	+	/+			+		+	44,483	1535
13.01.2008	+		+			+		+		20,776	717
04.02.2008	+		+			+		+	/+	14,292	493
04.02.2008	+			+		+		+	/+	21,573	744
31.03.2008	+		+	/+	/+		+	+	/+	19,472	672
01.04.2008	+	+		+			+		+	25,053	864
27.04.2008	+	+	+				+	+	/+	18,472	637
27.04.2008	+		+				+	+	/+	19,571	675
27.04.2008	+	+		+	+		+	+	/+	23,386	807

Table cont. The model selection in DISTANCE. According to each model the densities and the population size are listed.

27.04.2008	+			+	+		+	+	/+	24,481	845
April 2008	+		+	/+	/+		+	+		24,841	854
26.05.2008	+	+	+				+		+	39,027	1346
16.07.2008	+		+	/+	/+	+			+	27,227	939
31.10.2008	+		+				+	+		25,472	879
07.03.2009	+	+	+				+	+		37,677	1300
08.03.2009	+		+	/+	/+		+	+		27,450	947
March 2009	+	/+	+	/+	/+		+	+		31,383	1081
04.07.2009	+		+				+	+		13,685	472
05.07.2009	+		+				+	+		28,423	981
05.07.2009	+			+	/+		+	+		28,186	972
06.07.2009	+		+	/+	/+		+	+		12,284	454
July 2009	+		+				+	+		18,702	645
July 2009	+			+	+		+	+		17,685	610
July 2009		+	+				+	+		31,423	1084
July 2009		+		+			+	+		32,282	1114
July 2009		+			+		+	+		32,665	1127

Table. The age structure table from the population size estimates according to Distance 5.0 for the study period.

Period	Date	Female Lamb	Female 1	Female 2+	Male Lamb	Male 1	Male 2-4	Male 5-7	Male 8+	Total	Pop. Size
2007 post-parturition	20.05.2007	168	134	571	168	101	84	0	67	1293	**883**
	26.06.2007	80	20	256	75	15	10	0	0	457	
	27.06.2007	114	82	408	131	0	49	82	33	898	
2007 winter	11.11.2007	30	10	208	30	30	179	40	0	526	**815**
	09.12.2007	110	116	384	103	116	199	281	226	1535	
	13.01.2008	27	132	223	27	77	64	109	45	704	
	04.02.2008	30	99	109	30	57	40	79	48	493	
2007 pre-parturition	31.03.2008	68	54	331	65	83	36	18	18	672	**724**
	01.04.2008	35	121	315	38	130	75	124	26	864	
	27.04.2008	16	69	268	12	77	105	32	57	637	
2008 post-parturition	16.07.2008	217	165	330	227	0	0	0	0	939	**939**
	17.07.2008	113	75	150	113	38	169	75	207	939	
2008 winter	31.10.2008	90	84	214	87	87	130	104	84	879	**879**
2009 pre-parturition	08.03.2009	0	161	244	0	92	128	181	141	947	**947**
2009 post-parturition	04.07.2009	59	44	161	59	53	36	30	30	472	**972**
	05.07.2009	109	49	282	111	101	95	138	86	972	
	06.07.2009	28	15	92	28	51	31	33	35	313	