AN INVENTORY OF MEDIUM AND LARGE MAMMAL FAUNA IN PINE FORESTS OF BEYPAZARI THROUGH CAMERA TRAPPING

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AN INVENTORY OF MEDIUM AND LARGE MAMMAL FAUNA IN PINE FORESTS OF BEYPAZARI THROUGH CAMERA TRAPPING

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ABSTRACT

AN INVENTORY OF MEDIUM AND LARGE MAMMAL FAUNA IN PINE FORESTS OF BEYPAZARI THROUGH CAMERA TRAPPING

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Information about large mammals in Turkey usually does not go further than species lists or annual counts of particular species such as the wild goat. Camera trapping is a very useful technique to overcome this deficiency by gathering information about species presence, numbers, habitat use and behavior. Hence, a one year long camera trap study was conducted to demonstrate the diversity, activity, distribution patterns, habitat preferences and interspecific interactions of medium and large mammals in a 148 km2 large pine woodland near Ankara. Brown bear (*Ursus arctos*), wolf (*Canis lupus*), Eurasian lynx (*Lynx lynx*), golden jackal (*Canis aureus*), jungle cat (*Felis chaus*), red fox (*Vulpes vulpes*), Eurasian badger (*Meles meles*), stone marten (*Martes foina*), red deer (*Cervus elaphus*), wild boar (*Sus scrofa*), brown hare (*Lepus europaeus*), Caucasian squirrel (*Sciurus anomalus*) and southern white-breasted hedgehog (*Erinaceus concolor*) were the 13 mammal species captured during the study.

Spatial segregation was observed among canid species indicating intraguild competition and competitive exclusion. Prey-predator interactions were documented at both spatial and temporal scales between wolves, deer and wild boars. Red deer showed seasonal and sex differences in activity patterns that appeared to be influenced by wolf predation risk.

The presence of two felids unknown to the local people were revealed by camera trapping, showing the utility of this technique for such secretive and rare species. However, the low encounter rates for particular species such as lynx, brown bear and jungle cat indicated the importance of the length of study.

Based on various evidence, resident adult population sizes were estimated for wolf (2-5), Eurasian lynx (2-4), brown bear (0-2) and jungle cat (2-3). The study showed that lynx can exist in high densities in a relatively small area when prey species are abundant.

This study area hosted a rich mammal fauna in spite of human activities such as livestock grazing, logging and hunting. A relatively intact ecosystem, high altitudinal and habitat diversity, and a positive attitude of local people are believed to be the reasons of this observed high diversity.

Keywords: Camera trap, spatial distribution, activity patterns, Ankara, *Cervus elaphus*, *Canis lupus*, *Lynx lynx*

ÖZ

BEYPAZARI ORMANLARINDAKİ ORTA VE BÜYÜK BOY MEMELİ FAUNASININ FOTOKAPANLAMA YÖNTEMİYLE ENVANTERİ

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Türkiye'de büyük memeliler hakkındaki bilgi çoğu zaman basit tür listeleri ya da yaban keçisi gibi belirli türler için yapılan yıllık envanter verilerinden öteye gitmemektedir. Fotokapan yöntemi türler hakkında varlık-yokluk, sayı, habitat kullanımı ve davranış özellikleri gibi bilgiler sağlayarak bu bilgi yetersizliğini giderebilmektedir. Bu amaçla, Ankara yakınındaki 148 km2 büyüklüğündeki bir orman alanında, orta ve büyük boy memelilerin tür çeşitliliği, aktivite ve yayılış özellikleri ve türler arasındaki ilişkileri ortaya koymak amacıyla bir yıl süresince fotokapan çalışması gerçekleştirilmiştir. Çalışma süresince fotoğraflanan 13 tür, bozayı (*Ursus arctos*), kurt (*Canis lupus*), vaşak (*Lynx lynx*), çakal (*Canis aureus*), saz kedisi (*Felis chaus*), kızıl tilki (*Vulpes vulpes*), porsuk (*Meles meles*), sansar (*Martes foina*), kızıl geyik (*Cervus elaphus*), yaban domuzu (*Sus scrofa*), tavşan (*Lepus europaeus*), sincap (*Sciurus anomalus*) ve kirpi (*Erinaceus concolor*) olmuştur.

Ekolojik grup içi rekabet ve rekabete dayalı dışlama belirtisi olarak üç köpekgil arasında mekan temelinde ayrışma ile alandaki başlıca avcı ve avları olan kurt, geyik ve yaban domuzu arasında zamansal ve mekansal ilgileşimler gözlenmiştir. Dişi ve erkek geyikler arasındaki dönemsel aktivite farkının etkenlerinden birinin kurt baskısı olduğu görülmüştür.

Yerel halk tarafından varlığı bilinmeyen iki kedigil türünün saptanması, fotokapan yönteminin gizli ve nadir türlerin varlığını ortaya koymadaki başarısını desteklemiştir. Ancak, bozayı, vaşak ve saz kedisi gibi düşük foto kayıt oranına sahip türler çalışma periyodu uzunluğunun önemini ortaya koymuştur.

Fotokapan çalışması sonuçları ve çeşitli diğer kanıtlara dayanarak kurt (2-4), vaşak (2-4), saz kedisi (2-3) ve bozayı (0-2) için yerleşik yetişkin birey sayıları hesaplanmıştır. Bu çalışma, bir alanda av populasyonlarının yüksek sayılarda bulunması halinde vaşakların da yüksek sayılarda bulunabilecekleri tezini desteklemiştir.

Çalışma alanı, evcil hayvan otlatma, ormancılık ve avcılık gibi faaliyetlere rağmen zengin bir memeli faunasına sahiptir. Göreceli olarak zarar görmemiş ekosistemi, habitat ve yükselti çeşitliliği ve insanların olumlu tutumunun gözlenen bu yüksek çeşitliliğe neden olduğu düşünülmüştür.

Anahtar Kelimeler: Fotokapan, yayılış, aktivite, Ankara, *Cervus elaphus*, *Canis lupus*, *Lynx lynx*

To Grandma and My Family..

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CHAPTER 1

INTRODUCTION

Biodiversity conservation is generally linked with conservation of megafauna as flagship characters. Protecting these species would in turn result in conservation of a wider biodiversity as well (Walpole and Leader-Williams, 2002). Turkey has many species of large mammals that are globally at risk, locally endangered or in a decreasing trend (National Strategy and Action Plan for Biodiversity in Turkey, 2001). However, there is a lack of information on population status, distribution and ecology of most species which can constitute a base for conservation and management actions. Little or no surveys are done to understand the population status of many large herbivore and carnivore species. The regular inventories for several game species such as wild goat (*Capra aegagrus*), chamois (*Rupicapra rupicapra*), red (*Cervus elaphus*) and roe deer (*Capreolus capreolus*) and wild boar (*Sus scrofa*), for example, are generally biased or inefficient.

The elements of mega- and mesocarnivore fauna in Turkey are, brown bear (*Ursus arctos*), leopard (*Panthera pardus*), wolf (*Canis lupus*), striped hyena (*Hyaena hyaena*), Eurasian lynx (*Lynx lynx*), golden jackal (*Canis aureus*), caracal (*Caracal caracal*), jungle cat (*Felis chaus*), red fox (*Vulpes vulpes*), Eurasian badger (*Meles meles*), Eurasian otter (*Lutra lurta*), wild cat (*F. silvestris*), pine and stone martens (*Martes martes* and *M.foina*), European polecat (*Mustela putorius*), marbled polecat (*Vormela peregusna*), Egyptian mongoose (*Herpestes ichneumon*) and least weasel (*Mustela nivalis*). The herbivore fauna is composed of red deer, fallow deer (*Dama dama*), wild boar, wild goat, wild sheep (*Ovis gmelinii*), chamois, roe deer, mountain gazelle

(*Gazella gazella*), goitered gazelle (*Gazella subgutturosa*), brown hare (*Lepus europaeus*) and a hystricid, the Indian crested porcupine (*Hystrix indica*).

In spite of the high mammal diversity, only a few species were the subject of scientific research in the recent past (Oğurlu, 1997; Birand, 1999; Arıhan, 2000; Pamukoğlu, 2000; Can, 2001; Özüt, 2001; Soyumert, 2004; Tuğ, 2005; Ambarlı, 2006; Can, 2008; Özdirek, 2009; Özüt, 2009; İlemin, 2009; Çobanoğlu, 2010; Durmuş, 2010; Ambarlı et al., 2010; Ertürk, 2010). Researchers focused on different topics, such as spatial use patterns of a radio-collared red deer (Oğurlu, 1997); diet of caracal, jackal and fox in Düzlerçamı (Birand, 1999); habitat use of Anatolian wild sheep (*O. g. anatolica*) in Konya (Arıhan, 2000); diet of badger in western Turkey (Pamukoğlu, 2000); status of wolf, brown bear and Eurasian lynx in Turkey (Can 2001); conservation genetics of Anatolian wild sheep (Özüt 2001); habitat preferences of badger and fox in Antalya (Soyumert, 2004); human-wolf conflict in Konya (Tuğ, 2005); human-brown bear conflict in Artvin (Ambarlı, 2006); camera trapping of large mammal fauna of Yenice (Can, 2008); habitat preferences and demography of Anatolian wild sheep in Konya (Özdirek, 2009); spatial ecology and adaptation of a re-introduced Anatolian wild sheep in Ankara (Özüt, 2009); meso and macro mammal fauna and their distribution with respect to vegetation types in Datça-Bozburun Peninsula (İlemin, 2009); population viability analysis of a reintroduced goitered gazelle population in Urfa (Çobanoğlu, 2010); home range size and habitat preferences of reintroduced population of goitered gazelles in Urfa (Durmuş, 2010); status of Eurasian lynx in Artvin and Ankara (Ambarlı et al., 2010); and GIS based habitat suitability analysis of wolf and modeling its distribution in Bartın (Ertürk, 2010).

In this study camera trapping technique was used to reveal species richness, diversity and community structure, daily activity patterns, habitat selection and distribution of species, behavioral patterns such as predation and competition in a fragmented pine woodland near Ankara.

1.1. Camera Trapping and Species Inventories

Wildlife presence and activity are difficult to document directly in the field. The monitoring and management of large cryptic species that live in forested habitats is very time consuming and costly (Carbone et al. 2001). Especially, carnivore species are very difficult to trap, handle and observe (Bull et al. 1992; Mace et al. 1994). However, the use of camera traps makes efficient and long term surveillance of study areas possible.

Its advantages and benefits make camera trapping a popular method that is used more and more frequently in conservation and wildlife management (Carbone et al. 2001). Camera trapping studies and publications experienced 50% annual growth for the last decade with a cumulative number of more than 100 published papers (Rowcliffe and Carbone, 2008). Though it is becoming a common tool for wildlife ecology and conservation nowadays, camera trapping has been practiced since the beginning of 20th century (Rowcliffe and Carbone, 2008).

The camera technology is used to capture unbiased pictures of animals and their environmental dynamics (Kays et al., 2009). Other techniques such as radio-tracking or tagging are generally biased and difficult, need a lot of pre- and post-capture labor and surveying for long periods and on large areas (Kays et al., 2009). Camera trapping, on the other hand, is noninvasive and with low labor costs, exerts minimal environmental disturbance, and is resistant to a wide range of climatic conditions; therefore, it can be used to obtain information about highly elusive species day and night in extreme conditions where other techniques can be ineffective (Rowcliffe et al., 2008). Camera traps offer “robust data” analogous to museum specimens with exact date, hour and species, and can record animal behavior which may provide important answers for scientific questions as well as all kinds of pictures which are themselves a source of education and promotion (Kays et al., 2009).

When distributed over a network of stations, camera traps can collect data on animal populations of medium and large sized animals. The use of this tool can range from species inventories abundance estimation, conservation assessments and population dynamics (reviews in Rowcliffe and Carbone, 2008) to nest predation, frugivory and seed dispersal studies (reviews in Giman et al., 2007) and species activity patterns (Gomez et al., 2005; Azlan & Lading, 2006; Kays et al., 2009).

Silveria et al. (2003) concluded that “despite the high initial costs for camera-trapping, this method is the most appropriate for mammal inventory in all environmental conditions, allowing a rapid assessment of wildlife conservation status”. Camera trapping was used in many mammal inventories as a method throughout the world (Maffei et al., 2002; Silveira et al., 2003; Trolle, 2003; Srbek-Araujo & Garcia, 2005; Azlan & Lading, 2006; Giman et al., 2007; Linehan et al., 2008; Stein et al., 2008; Tobler et al., 2008; Kays et al., 2009). Species accumulation curves and diversity estimators are generally used to evaluate completeness of an inventory which is especially important when comparing species diversity in other words community structure between sites and monitoring species composition over time (Tobler et al., 2008).

1.2. Community Structure

A community is an association of interacting species inhabiting some defined area. Community structure includes attributes such as the number of species, relative abundance of species, and the kinds of species comprising a community (Molles, 2005). Animal distributions and interspecific interactions are highly influenced by physical structure of the environment, which is generally shaped by plant communities and distribution patterns (Tews et al., 2004). The habitat heterogeneity hypothesis states that species diversity increases by increased habitat complexity, which serves as a source of more niches and diverse ways of exploiting the environmental resources (Tews et al., 2004). Bird species diversity in forests is a good example that shows how physical structure of a plant community may be more important than the plant species composition (MacArthur & MacArthur, 1961; Molles, 2005).

Communities are also more structured and increased in species diversity as a result of resource partitioning based on competitive exclusion (Begon et al., 1996). Competition between species may take place over one or more dimensions of the ecological niche. In theory, the more specialized species are, the less their niches will overlap (Leveque and Mounolou, 2003).

1.3. Competition between carnivores

Fundamental niche of a species is narrowed to a restricted sets of conditions by certain interactions such as competition; these restricted sets of conditions are defined as the realized niche (Molles, 2005). Various forms of interspecific interactions are shaped by the carnivore guild composition and realized niches of species. Utilization of similar resources, such as similar-sized prey, may lead to competition (Homala, 2009).

Generalist life history of mesopredators forces them to share a wide variety of habitats and a wide range of resources (Homala, 2009). They typically have omnivorous diets consisting of available prey species, carrion, invertebrates and many types of plants (Disney, 2005). These species will compete for resources especially in less productive environments or in high density populations through what is termed as intraguild competition (IGC). IGC can take the form of exploitative competition or interference competition. Exploitative competition occurs when species indirectly compete for a limited resource. In such cases a food item, territory or suitable nest site is utilized by one individual and cannot be utilized by another one at the same time. In interference competition, however, two individuals compete directly for a valuable resource such as food which in turn can result in death of the one of the competitors (Linnell and Strand, 2000; Hunter, 2008).

Competition and predation are two discrete evaluated mechanisms of traditional food web dynamics, where the former one operates at the same trophic level and the latter at different levels. However, in many ecological systems as an extreme case of interference competition, species at the same trophic level may act as both predator and prey which is termed as intraguild predation (IGP) (Polis et al., 1989; Fedriani, 2000). IGP is thought to have a reasonable impact shaping the niche allocation between competing species (Polis et al., 1989; Nelson, 2005) and may result in reduced densities of subordinate species (Fedriani, 2000). In order to mitigate these pressures, mesocarnivores should adopt strategies to minimize the risks posed by agonistic interactions with heterospecifics (Linnell and Strand 2000; Hunter, 2008). Behavioral factors, leading to differential use of space can facilitate predator coexistence (Karanth and Sunquist, 2000). As being widespread among North American canids, IGP influences spatial use of habitat by certain species (reviews in Nelson, 2005). Spatial and temporal avoidance by two or three guild members has been well documented and has been the primary focus of much of the research on carnivore coexistence (reviews in Hunter, 2008). In the absence of refugia, superior competitors could have a substantial negative effect on populations. This theory is described by the Lotka-Volterra model: the presence of competition can lead to exclusion of one species by the other if the effects of the competitive species on each other are not balanced or they do not have competition refuges (Nelson, 2005).

1.4. Habitat selection, spatial distribution

Species are not distributed homogeneously in their environment and they tend to aggregate in some parts of their distribution while avoiding other parts. When animals are selecting their habitats they have to simultaneously consider many factors. They need to feed, find mates, and avoid extreme weather while also avoiding predation, often from multiple predators, and accidents (Ratikainen, 2005). These needs are often satisfied to varying degrees in different habitats, and habitat selection is thus often a trade-off between the costs and benefits for a given habitat (Ratikainen, 2005). Instead of animals selecting ancestral habitats based on psychological instinct, it is believed that animals will, in actual fact, choose features or a combination of features that will indirectly enhance their fitness (Broekhuis, 2007). Often, chosen habitats are not homogenous in nature but are a collection of a variety of patches, since different activities such as feeding, drinking and resting, can essentially be carried out in different environments (Broekhuis, 2007). Even when an optimal habitat is present it does not necessarily mean that it is readily available as access can be restricted by inter- and intraspecific competition, predation, disturbances or disease. The habitat that is ultimately used is the result of a complex process with various trade-offs that balance costs and benefits (Broekhuis, 2007).

Understanding the spatial structure of a population (i.e., where, when and why individuals are present in some locations and absent in others) provides insights into population characteristics and ecological and evolutionary processes such as resource distribution, scale-dependent habitat associations, population density, and social organization and mating (Hearn, 2007). Among several procedures of understanding the selection of habitats by species, the most widespread used one is “focal-animal approach” in which the number of occurrences of a species in a certain habitat reflects its preference by that particular species. Selection is said to have occurred when the use of a particular habitat is disproportionate to its relative availability (Sinclair et al., 2006).

Habitat productivity and resource utilization is one of the basic determinants of habitat selection but also plays a major role on home range size of many species. “The extent of an area with a defined probability of occurrence of an animal during a specified time period" is termed as home range by Kernohan et al. (2001). Home range size of a species is said to be negatively correlated with food/prey density (Herfindal et al., 2005). The size of the home range is also related to the combination of other parameters such as age, population density, predation and human disturbance (reviews in Luccarini et al., 2006).

1.5. Herbivore-Carnivore Relations

An animal may experience trade-offs between the costs and benefits for a given habitat, differently over time depending on current changes in the risk of being predated, resulting in variable habitat selection depending on short-term (daily) variation in factors such as activity, time of day, weather; medium-term (seasonal) variation in fat reserves; and also long term (annual, decadal) variation in population size of the predator (Ratikainen, 2005). Large herbivores influence ecosystems in terms of shaping the plant community structure, plant and animal species diversity, organic and inorganic nutrient cycles, fire regimes, hydrology and soil erosion (reviews in Becker, 2008). Large predators on the other hand, control prey populations, therefore affecting ecosystem cycles and structure indirectly. Understanding the prey and predator interactions and population dynamics, is therefore, crucial for planning conservation and management actions for species and their interaction mechanisms (Becker, 2008).

A common trade-off facing animals when choosing habitat is the one between foraging and avoiding predation. Behavioral responses used to minimize exposure to predation risk include changes in group size, increased vigilance levels, and habitat shifts (Liley, 2007). At relatively broad scales, prey often alter their use of habitats in response to predation risk, trading security for a reduction in forage quality, quantity, or both (Winnie Jr and Creel, 2007). When foraging in this landscape, prey will often shift their use from riskier to safer areas to reduce their predation risk (Hernandez and Laudre, 2005). When the most profitable feeding patch incurs the least risk, this patch should be favored over all other patches (Nonacs and Dill, 1990).

The most important key to avoid predation is often regarded as being cover. However, what is considered a good anti-predator tactic may vary depending on the hunting strategy of the various predator species (Ratikainen, 2005). Prey species exert different anti-predator strategies depending on the predator species. Mule and black-tailed deer avoid productive foraging areas away from hiding and escape cover, although response distances vary as functions of geographic location, habitat type, season, sex, age, and other factors (Kie, 1999). African antelope species, however, avoid dense cover in which predators can hide (Underwood, 1982). These behavioral responses could reduce the probability of being killed by a predator, but may come with associated fitness costs: it is likely that habitat selection, foraging, grouping and other aspects of behavior more closely approach the optimum when they are not constrained by predation risk (Liley, 2007).

CHAPTER 2

MATERIALS and METHODS

2.0. Aims and scope of this study

This study aims to document and evaluate patterns of occurrence of wildlife at a wooded area near Ankara using camera traps. The focus is on large and medium carnivores and their large herbivore prey.

2.1. Study Area

The study was conducted in a nearly 148 km^2 area on Depel Mountain (40°12' N, 31°44' E) and surrounding hills that constitute a natural border between Ankara and Bolu provinces in north-western Turkey. The study area is located in the transition zone between Xero-Euxine (dry western blacksea) and Irano-Turanian (central Anatolian) floristic zones and also influenced by the Mediterranean floristic zone (western Aegean) which reaches to this region by the aid of Sakarya River catchment (Aksoy, 2009). The area represents a diversity of geomorphologic formations with high elevation hills and valley depressions. At the barren sides of the hills sedimentary soil generally eroded forming colluvial accumulations whereas valley bottoms and waterbeds bear alluvial accumulations (Aksoy, 2009). Annual mean temperature is 10.36 ± 1.63 degrees Celsius, minimum temperature is -7.10 degrees Celsius in January and maximum temperature is 30.7 degrees Celsius in July (Worldclim-Global climate data, 1950-2000). Mean annual precipitation is 41.4 ± 4.4 mm^3 with highest precipitation in December (65.05 ± 6.4 kg/m2) and lowest in August (16.05 ± 1.7 kg/m2) (Worldclim-Global climate data, 1950-2000).

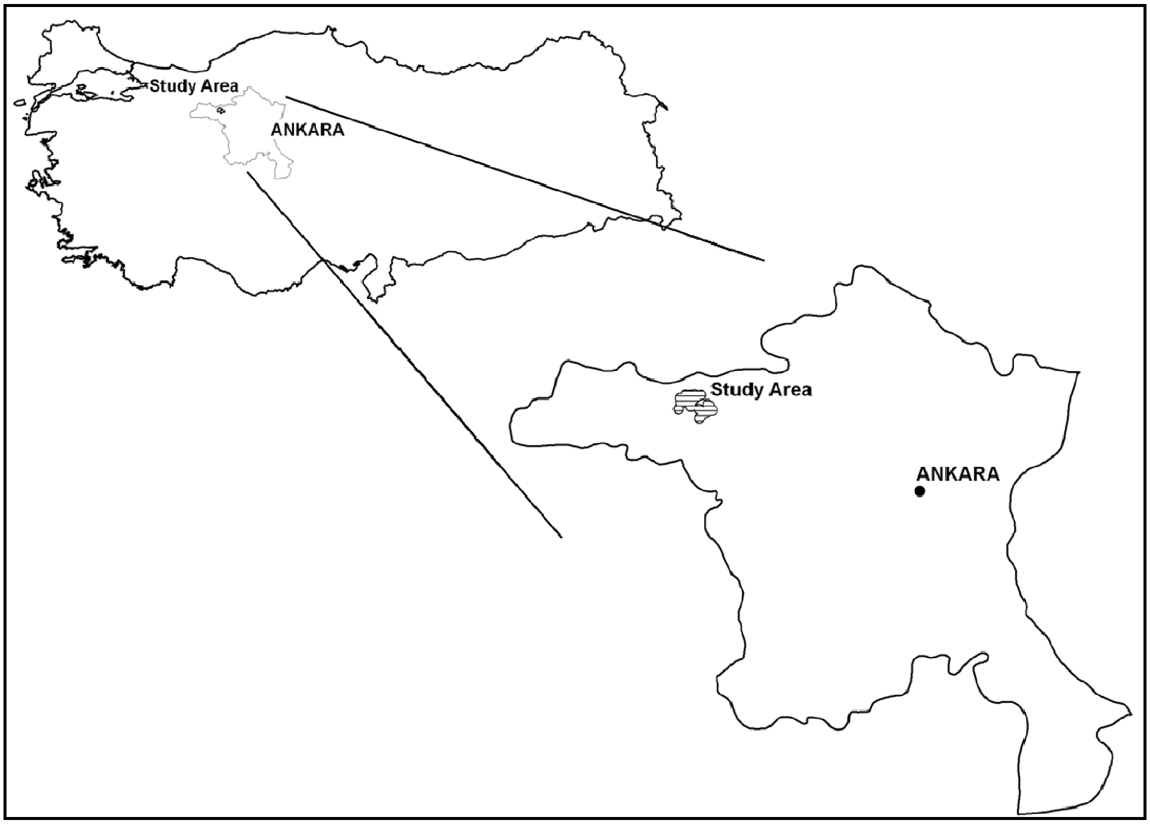

Figure 2-1. The location of study area in Ankara and Turkey.

Vegetation composition and structure depend on the altitude and historical human use. The lower parts (500 to 1000 meters) are covered by Turkish Pine (*Pinus brutia*) and other typically Mediterranean plants such as *Paliurus spina-christi*, *Pistacia atlantica* and *Cistus laurifolius*, as well as some cropland and orchards. Above this belt, temperate coniferous forest composed of Black Pine (*P. nigra*), junipers (*Juniperus excelsa* and *J. oxycedrus*) and with an understory of oak-dominated scrub (*Quercus pubescens*, *Pyrus elaeagnifolia*, *Crataegus spp.*) reaches up to 1650 meters. Above this altitude, there are grass dominated highland pastures, which might have been also covered with trees in the distant past. Bird fauna includes Golden Eagle (*Aquila chrysaetos*), White-tailed Eagle (*Haliaeetus albicilla*), Cinereous Vulture (*Aegypius monachus*), Bearded Vulture

(*Gypaetus barbatus*), Common Raven (*Corvus corax*), several trush species (*Turdus* spp.), and other songbirds.

Figure 2-2. Scenes from study area.

During the camera trap placement, six shepherds from 6 villages (Sekli, Hırkatepe, Gökçeöz, Köst, Sarıağıl and Kuyucak) that utilize various habitats inside the study area were interviewed to get insights about the existing mammal fauna. *Canis lupus*, *Vulpes vulpes*, *Meles meles*, *Martes foina*, *Cervus elaphus*, *Sus scrofa*, *Lepus europaeus* were the most frequently mentioned mammals to occur in the area. Three shepherds mentioned the presence of *Ursus arctos* and *Canis aureus.* No felid species was mentioned although asked.

2.1.1. Human activities

There are 7 villages inside and at the periphery of the study area with a low density human population; people mostly emigrated to towns of Ankara and Bolu. As the population declined in the surrounding villages, human use of the study area has also decreased. Historically the mountain was used for grazing large numbers of Angora goats and sheep as evidenced by anecdotal information (A. Yıldırım, pers.comm.; http://www.gazigunduzalp.com), presence of flora elements typical of overgrazing (e.g. spiny and poisonus species), and signs of abandoned sheepfolds. Currently, there are roughly 2000 sheep and 1300 goats utilizing the study site as summer pasture. In colder seasons only the lowlands are used for grazing while higher ground use begins in June and lasts until late November.

Most land falls under the jurisdiction of Beypazarı Forestry District and is managed for timber production and soil protection. From May 2009 until the end of October 2009, the study area experienced forestry activity, especially on the northern side of Depel Mountain. Not only the noise caused by the chainsaws, but also the vehicle traffic and presence of 11 forestry workers and their families for 7 months at the logging site, created significant disturbance. Forestry activities are planned to continue for the next two years.

Hunting is another factor that creates disturbance especially in late autumn and throughout the winter season. The area is mostly used for hare and partridge shooting. Also, up to 5 red deer stags are hunted for trophy in the rutting season (October and November); some red deer poaching is also suspected. A one year hunting ban was proposed in the second half of the camera trapping period for the 2009-2010 hunting season, which was accepted by the Central Game Commission.

2.2. Camera trapping survey design

The camera trapping survey was conducted between December 2008 and December 2009 for a one year period. Camera stations were located to maximize the number of medium and large sized mammal captures while covering as large an area as possible to maximize the number of individuals photographed (e.g. Silver 2004). Therefore, a 148 km^2 area was covered by 30 camera trap stations that were placed at 1 to 2 kilometers intervals (Figure 2-3). No camera traps were placed near villages or in intensively used croplands/orchards. Trapping sites were on animal trails leading to forest or forest openings, on dirt roads, ridges, passages and trail junctions which were selected after track surveys. Most camera traps stayed where they were first placed throughout the whole year. Some had to be moved once or twice to new locations within the same grid or into alternative grids because of seasonal movements of livestock flocks, extreme weather conditions (very deep snow cover at higher altitudes) or natural disturbances such as fluctuating water levels at the Aladağ River in spring. This led to a few stations at close distances.

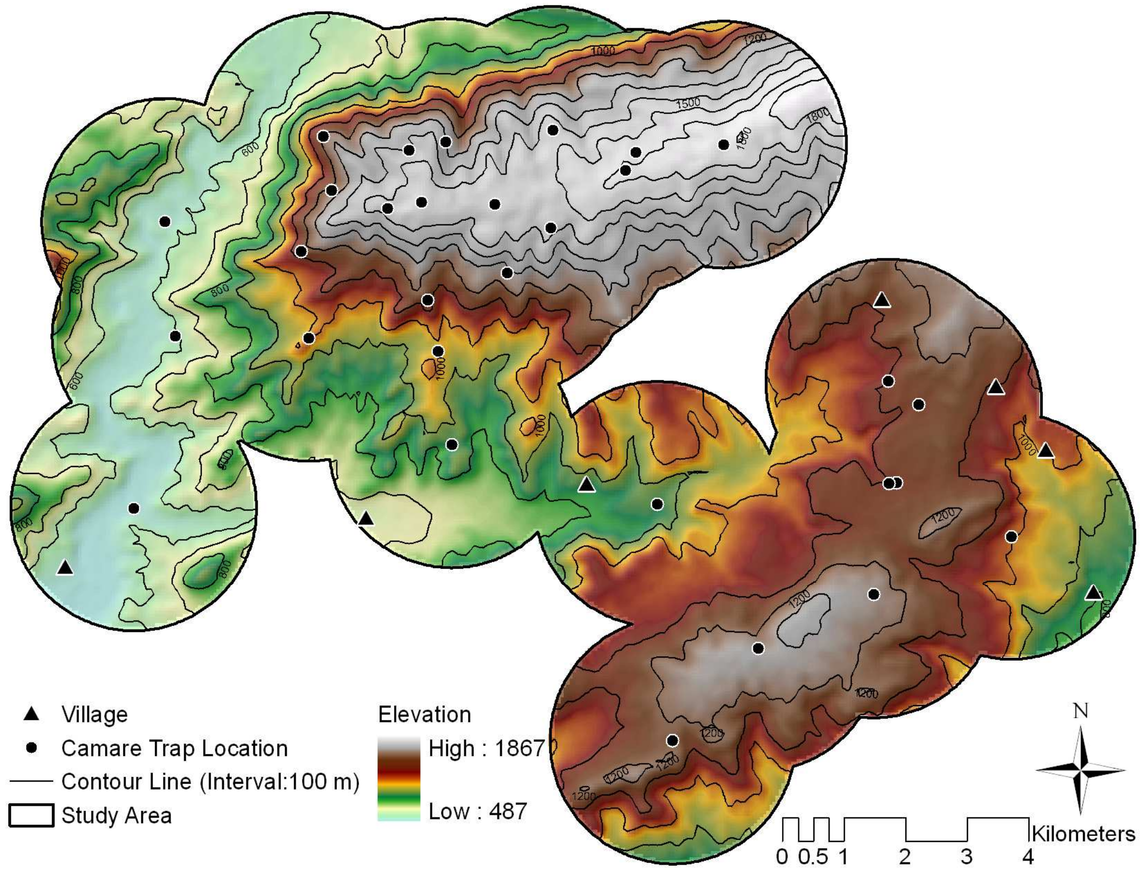

Figure 2-3. Camera trap distribution in the study area. The two main blocks (Depel Mountain at north and Elmabel Ridge at south-east) of study area were separated by Sekli Valley. Aladağ River Valley is the western border of the study area.

The study area is composed of two main habitat blocks that are separated by villages, agricultural fields and orchards. The Depel Mountain, the bigger block, had 21 camera trap stations while the smaller Elmabel Ridge and surroundings, where human disturbance was higher, had 9 camera trap stations (Figure 2-3).

Figure 2-4. A picture of DeerCam DC300 camera trap. The muddy appearance was result of wild boar rubbing.

Twenty five DeerCam DC300 (DeerCam, Pak Falls, USA) brand camera traps were used in the trapping survey. Placement began with the stations at the most remote parts of the study area (highly elevated points) to make best of the approaching winter. In total, camera trapping was done in thirty trap stations. All trap locations were recorded by GPS (Magellan Explorist 400, CA).

Camera traps were installed on tree trunks with the infrared sensor at 30-40 cm height from ground (Kelly & Holub, 2008) (Figure 2-5). Each station had a single device generally facing northerly directions in order to prevent false triggers due to direct sunlight. The time delay was set to 2 minutes and ran continuously day and night. They were locked to the trees by the aid of steel cables and pad-locks. No camera trap security shells were used. Only one camera trap was stolen by hunters who apparently used wire cutters. Rechargeable 9V batteries were used for the first 3 months of the survey for camera sensors; then they were replaced by alkaline batteries due to short battery life. Rechargeable AA batteries were used for cameras themselves with a long lasting capacity. We began with 400 ASA film rolls but then shifted to 200 ASA rolls because of high grainy photos of the former type.

Figure 2-5. Camera trap installation and some camera trap stations from the study area

The survey area was visited 30 times during the year (in average, once in 12 days) and each trap location was visited twice a month on average (not all camera traps were visited in each field trip). Alkaline 9V batteries were replaced every 2 months whereas AA batteries of the cameras were replaced at every visit. Following film and battery replacement, a test picture was taken to be sure that the device is working properly and facing the trail or target site at the right angles. Film rolls with more than 20 pictures were replaced with new ones; the films were processed and digital copies of pictures written on CDs after each field trip.

2.3. Data analysis

2.3.1. Assumptions and definitions

- An “event” is defined as a picture or pictures of the same individual or group taken once or consecutively within 20 minutes.
- Total days of camera trapping was calculated by the sum of each period starting from film installation till to the last photo taken until the film was replaced with a new one for each camera trap. If the batteries were exhausted before a film roll was under 20 captures, trap-days stopped at the day of last capture and started with the new battery installation again. Therefore, it is a conservative calculation because it does not include the working days after the last capture till to the day when the batteries fully exhausted.

2.3.2. Species detection and trapping success

All results of the camera trapping survey were written on an Excel form that show the camera trap ID, the date of the event, the time of the event, scientific name, sex of the individual if it is possible to identify, group size and any further notes. The total event values were used to construct “events per species”, “percent events by species”, “species accumulation rate” and “the trap-day of first capture for each species” graphs.

Camera trap stations were classified into seven groups considering the habitat type, aspect and human disturbance. The Elmabel Ridge is the first group where grazing is done most of the year. There is always a livestock and LGD disturbance in this site.

2.3.3. Cluster analysis of trap stations in accordance with mammal communities and species richness

PC-ORD software (McCune and Mefford 1999) was used to classify the thirty camera trap stations in accordance with their mammal communities. Detrended Correspondence Analysis (DCA), Hierarchical Cluster Analysis (HCA), and Two-way Indicator Species Analysis (TWINSPAN) were calculated to obtain the best classification of trap stations. The biodiversity indices of each class were calculated by Shannon's and Simpson's diversity indices. In addition, total biodiversity indices and biodiversity indices for each cluster were calculated by PAST software (Hammer and Harper, 2005).

Shannon's diversity index (Krebs, 1999) was calculated as;

$$H' = -\sum_{i=1}^{s} p_i \log p_i$$

Where

H' =Index of species diversity

S = Number of species

p_i = Proportion of total sample belonging to ith species

Simpson's diversity index (Krebs, 1999) was calculated as;

$$\tilde{D} = 1 - D = 1 - \sum_{i=1}^{S} p_i^2,$$

Where

$(1-D)$ = Simpson's index of diversity

p_i = Proportion of species i in the community

Tobler et al. (2008) evaluated the performance of different species richness estimators and found the Jackknife estimators generally to perform best increased trapping effort. Hence, Jackknife species richness estimators, Jack 1 and Jack 2, were calculated to estimate total species richness.

Jack 1 was calculated as:

$$S_{jack1} = S_{obs} + Q_1\left(\frac{m-1}{m}\right)$$

and Jack 2 was calculated as:

$$S_{jack2} = S_{obs} + \left[\frac{Q_1(2m-3)}{m} - \frac{Q_2(m-2)^2}{m(m-1)}\right]$$

2.3.4. Species activity patterns and correlations

Each species' data written on another Excel sheet to construct the daily activity patterns for that particular species. The day hours are divided into six categories with 4 hour-long intervals as in other studies (Kostyria et al. 2003; Mengüllüoğlu & Bilgin 2008, 2010). The total number of events that lie inside a particular time interval was assumed to reflect the activity pattern of a species in that interval. Only comparisons shown to be significant by Chi-square testing are graphed with standard error bars. Annual activity patterns for Eurasian badger and red deer were also constructed. These species show major differences in activity patterns throughout the year especially in seasons such as winter vs. other seasons for the badger, which shows hibernation like behavior in winter, and rutting versus winter and summer seasons for red deer females and males, respectively.

Species with very low event numbers (hedgehog, jungle cat, and brown bear) were not included in activity pattern analysis.

The prey and predator, competitor, and intra-guild species' activity patterns were also compared to infer any probable relation of activity behavior between these pairs of species.

2.3.5. Spatial distribution patterns and land use

Arcmap software (ESRI, Redlands, California, 2005) was used to construct spatial distribution maps of thirteen species. The species detection rates were used to plot the species presence in a certain trap station and surrounding area. The detection rates were reflected by five different circle sizes on the graph. The five detection rate range classes were 0.01-0.99, 1.00-4.99, 5.00-9.99, 10.00-14.99 and 15.00 and more events per 100 trap days. No circle was plotted for trap stations where the species was not encountered. The three species with single site detection, bear, jungle cat and hedgehog were plotted on the same map.

2.3.6. Altitudinal distribution patterns

Altitudinal distribution map of the species was constructed by classifying the camera traps into five 250 meters altitude intervals, starting with 500 meters and reaching 1750 meters. Although the distribution of the camera trap stations was more or less equally divided into seven main classes in terms of habitat and human influence, the altitudinal distribution classes of the traps were proportional with the surface percentage of each elevation class (ranging between 500-1750 meters by 250 meters intervals) and not equally numbered. Hence, the raw event data was not used directly but detection rates were used to construct maps and graphs for this section.

2.3.7. Individual identification and population estimates

Camera trapping method is very useful to identify individual animals especially with spotted or striped coat patterns. Several cat species can be identified by this method: Examples are Eurasian lynx in Macedonia (Melovski et al. 2008), Bobcat (*Lynx rufus*) in Texas (Heilbrun et al. 2003), Ocelot (*Leopardus pardalis*) in Pantanal (Trolle & Kery, 2003), Cheetah (*Acinoyx jubatus*) in the Serengeti (Kelly, 2001), Snow Leopard (*Uncia uncia*) in central Asia (Jackson et al. 2005), Tiger in India (Karanth 1995) and Jaguar in Central America (Silver et al. 2004). This method was used to individually identify Eurasian lynxes that were captured during the camera trap survey. Conservative population estimates were also made for certain species, such as Wolf, Brown Bear and Jungle Cat (*Felis chaus*).

2.3.8. The influence of livestock grazing to wildlife

The study area is used by several sheep and goat flocks that utilize certain parts in different seasons of the year. It was questioned that if the presence of these flocks interferes with wild populations of herbivores and/or carnivores and in what respects. The questions were, if there is any competition between wild and domestic herbivores in utilizing the highland grasslands, predation by Livestock Guarding Dogs (LGD) on wild herbivores, predation by wolves or other carnivores on domestic livestock.

CHAPTER 3

RESULTS

3.1. Species detection and trapping success

In 3699 trap nights a total of 1108 wildlife photographs were taken by the cameras and analyzed in this study. Each of those 1108 pictures was processed and grouped into individual events. As a result, 1020 wildlife events remained after filtering. 13 species of wild mammals were captured throughout the study (Figure 3-1). The list of these species is given in Table 3-1 together with the species lists which were gathered by literature research and interview results. Most of the species that are given in the literature were obtained from Turan' (1984) with only one exception, marbled polecat (*Vormela peregusna*). This species' distribution was not covering the study area in the publication; however, there are recent records (Deniz Özüt pers.comm.; TRAMEM) both from north and south at very close distance to the study area.

Figure 3-1. Examples of camera trap captures for the 13 mammal species: bear (1), fox (2), deer stag (3), wild boar (4), lynx (5), jackal (6), hare (7), wolves (8), marten (9), hedgehog (10), badger (11), squirrel (12), jungle cat (13).

Higher taxon	Scientific name	Literature	Interview	Camera Trapping
ERINACEOMORPHA				
Erinaceidae	*Erinaceus concolor*	√	√	√
LAGOMORPHA				
Leporidae	*Lepus europaeus*	√	√	√
RODENTIA				
Sciuridae	*Sciurus anomalus*	√	√	√
CARNIVORA				
Ursidae	*Ursus arctos*	√	√	√
Mustelidae	*Martes foina*	√	√	√
	Mustela nivalis	√	√	X
	Vormela peregusna	√	X	X
	Meles meles	√	√	√
	Lutra lutra	√	X	X
Felidae	*Felis sylvestris*	√	X	X
	Felis chaus	√	X	√
	Lynx lynx	√	X	√
	Panthera pardus	√	X	X
Canidae	*Vulpes vulpes*	√	√	√
	Canis aureus	√	√	√
	Canis lupus	√	√	√
ARTIODACTYLA				
Suidae	*Sus scrofa*	√	√	√
Cervidae	*Cervus elaphus*	√	√	√
Ovidae	*Ovis gmelinii*	√	X	X
Total		**19**	**12**	**13**

Table 3-1. The comparison of mammal fauna of the study area that was given in the literature, obtained by camera trapping and interview results

There are nineteen species of meso and macro mammal fauna that had records from recent past. Besides the camera trapped species, Anatolian Mouflon, *Ovis gmelinii anatolica*, and Anatolian Leopard, *Panthera pardus tulliana,* were the important elements of macro-fauna until recent past (Turan 1984). The last kill record of leopard was exactly from the study area back in 17 January 1974. Anatolian mouflon was locally extirpated in late fifties but was reintroduced to the area (15 km.s to south) in 2004, and is now represented by nearly 80 free roaming and fewer captive individuals.

Eleven species that were documented by camera trapping had been mentioned by the shepherds before the survey had begun, except for the two felid species, *Lynx lynx* and *Felis chaus*. On the other hand, there was a species, *Mustela nivalis,* which was mentioned but could not be captured by the camera traps.

The lynx pictures were the first camera trap records for Turkey together with other pictures captured in another project study that was conducted in synchrony by our lab group in Artvin (Ambarlı et al. 2010). Although previously mentioned by Turan (1984), there was no recent evidence for the existence of Jungle Cat from the area until a car accident in the 2007 winter near Beypazarı town (http://www.balikcidogan.com/vasak.htm).

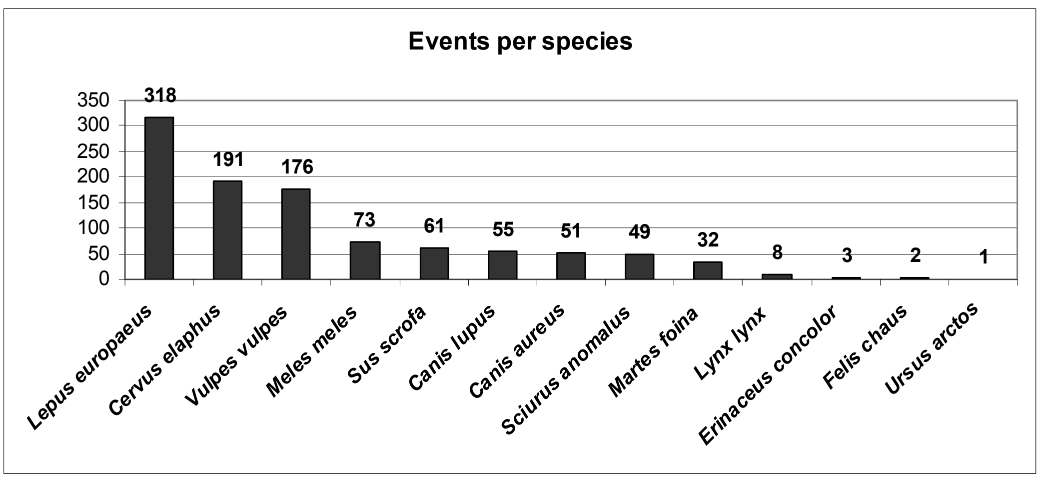

Figure 3-2. Captured events per mammal species

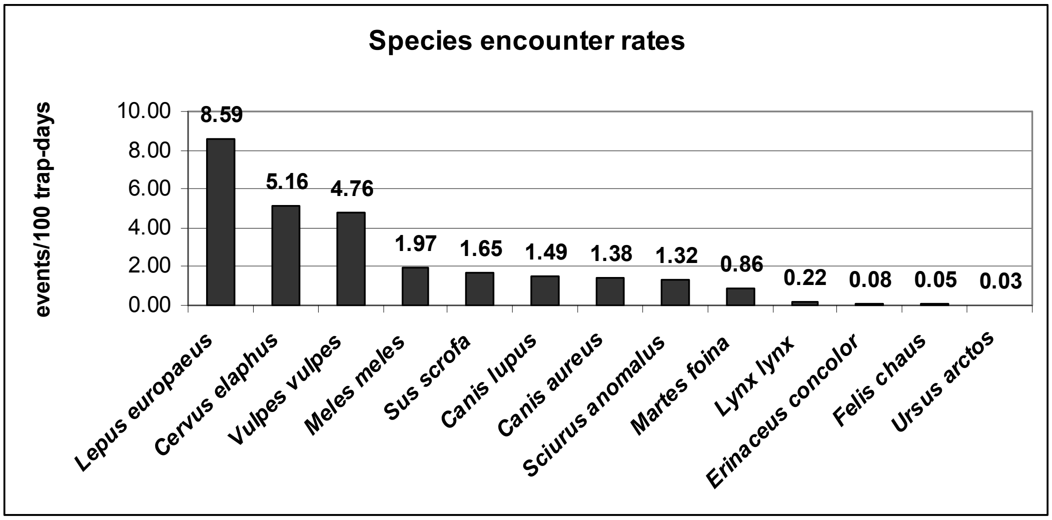

Figure 3-3. Event numbers per 100 camera trap-days for each species

Events per species and species detection rates are represented in Figures 3-2 and 3-3. Brown hare had the highest event numbers, followed by red deer and red fox. These three species formed 68% of all events. Lynx, hedgehog, jungle cat and bear events each made up less than 1% and in total constituted only 1.4% of all events (Figure 3-4).

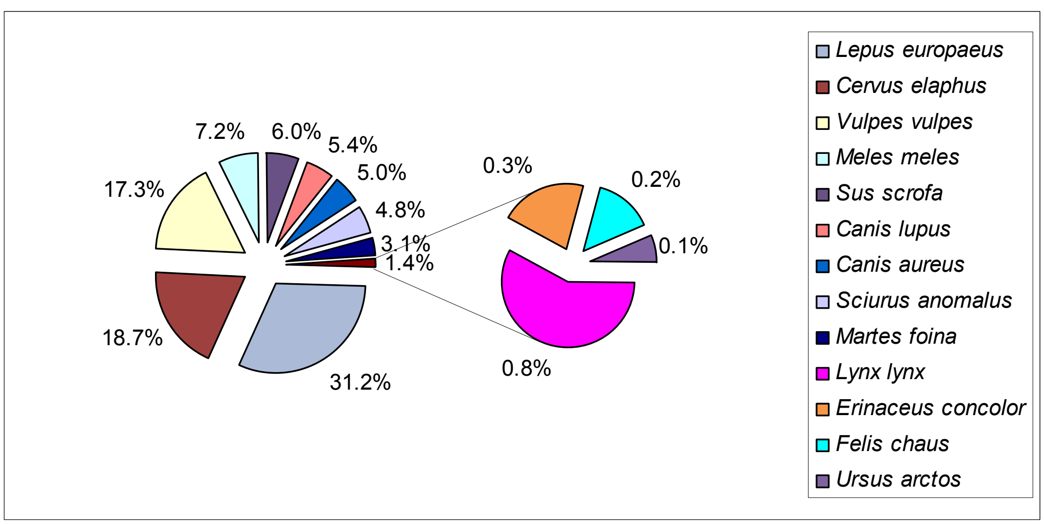

Figure 3-4. Capture percentages for each species

There were also non-target captures which were mainly composed of livestock photos followed by LGD and feral dogs, feral cats, birds, mice and people other than false triggers caused by sun, especially in hot weather. 282 capture events belonged to non-target organisms, 87 to false triggers, and 165 to unknown species which triggered the cameras but not registered in the pictures because of fast movement. In total, with 1020 wildlife events and 536 other events, 1556 capture events were gathered by this camera trap survey. Hence, 65.5% of total capture events (1020 out of 1556) were used for further analysis.

3.1.1. Days until first encounter and species accumulation rates

The trap-day of the first encounter for each species varied between species in negative correlation (linear correlation = -0.59) with the species event numbers (Figure 3-5). As seen in Figure 3-2, species with small number of events were photographed later during the trap survey. Especially, brown bear which is the species with only 1 picture was the last species to be captured.

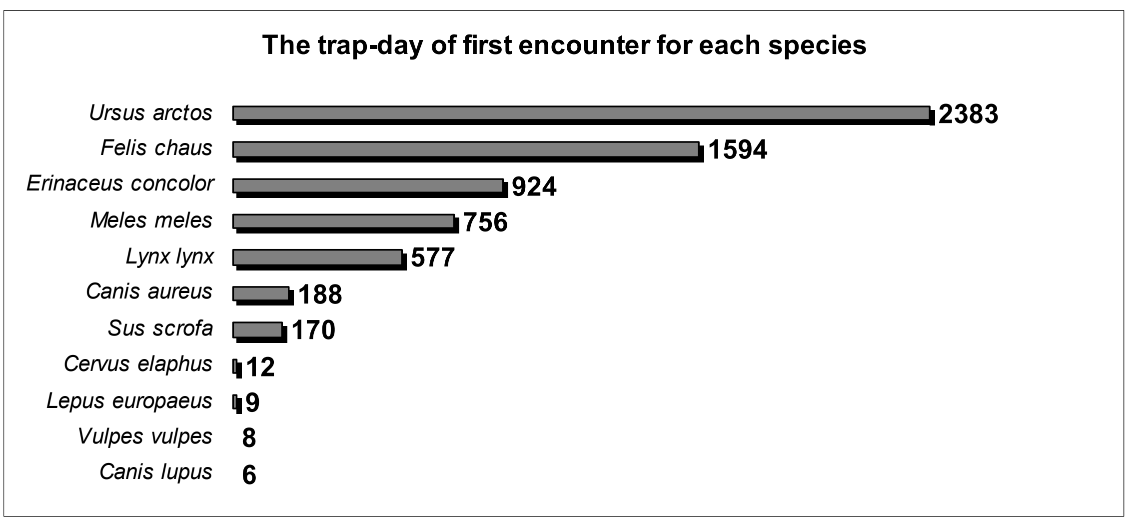

Figure 3-5. Trap-days until first encounter for each species

Hedgehog and marten were not included in this graph due to break down of the camera trap by the elevated water level of Aladağ River after a heavy rainfall, where this two species were first encountered in the pictures. A high percent of the film was erased by the river water and the remaining pictures were damaged enabling only species recognition but not reading the date and hour of the captures (Figure 3-6).

Figure 3-6. The camera trap that was flooded by raised river water

3.1.2. Mammal communities and diversity indices

Among DCA, HCA and TWINSPAN, the latter method was considered to best reflect the community types and the relations among trap stations. The two camera traps were not included in these analyses due to short working period. TWINSPAN classified 28 camera trap statitons into six main groups (Appendix A). Group A was composed of trap stations which were mainly located in humid valleys and riverine habitats. Group B was made up of trap stations at middle elevations where pine woodlands with openings of abandoned agricultural fields and grasslands which were previously or currently grazed. The cameras of the group C (two cameras) were placed on earth roads. Group D was composed of similar community but different altitudinal and habitat elements. Group E was composed of high altitude grassland community elements. The camera stations of group F were seldom visited by several species. The diversity indices of different community types are shown in Table 3-1. The overall diversity indices for the whole study area were 1.97 (Shannon's H') and 0.82 (Simpson's 1-D).

	Community Groups					
	A	B	C	D	E	F
Shannon_H	2.07	1.55	1.76	1.49	1.09	1.76
Simpson_1-D	0.86	0.73	0.81	0.75	0.62	0.80
Species richness	10	10	7	5	4	7

Table 3-2. Shannon and Simpson's diversity indices for 7 camera trap groups and the species richness values.

Jackknife 1 and Jackknife 2 richness estimators were calculated as 15.9 and 18.7 total species, respectively.

3.2. Species activity patterns and correlations

The daily activity levels of nine species are constructed and some species' activity patterns are shown in the same graphs for easy comparison. General activity levels of wolf and fox were similar in many periods but differed in some (Figure 3-7). Wolves were active in morning and night hours, also showing some extent of activity during day hours.

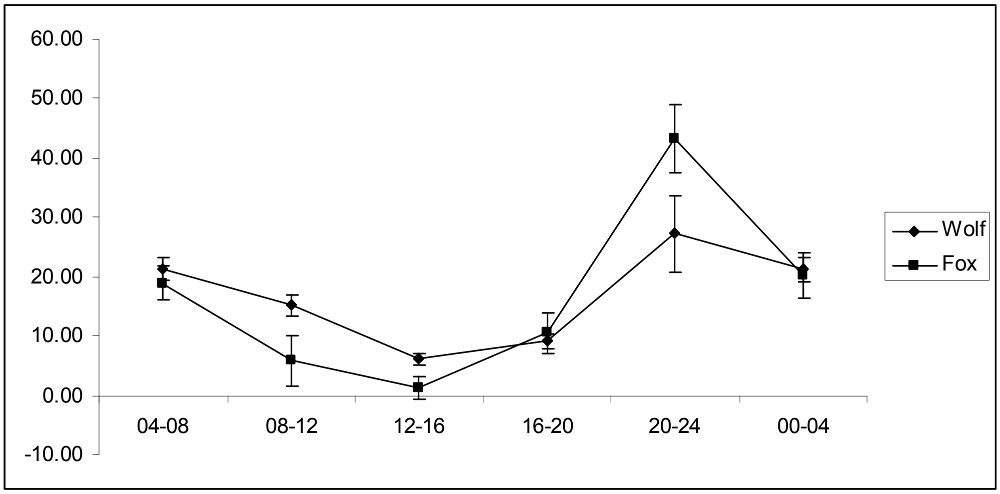

Figure 3-7. Daily activity levels of wolf and fox

Comparison of activity levels for camera trap locations where jackal and fox co-occur is represented in Figure 3-8. Foxes were most active during 20:00-24:00 while jackals were most active in 00:00-04:00 time interval. No activity was observed for foxes in 08:00-12:00 and 16:00-20:00 time intervals compare to Figure 3-7.

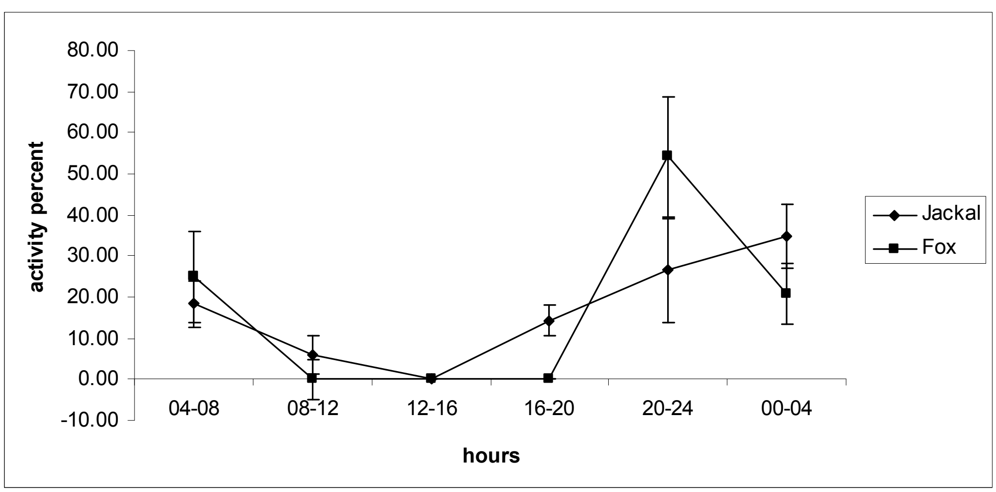

Figure 3-8. Daily activity levels of jackal and fox in valleys where they coexist

Lynx showed a major surge in activity level especially in the 00:00-04:00 time interval. All pictures were taken at midnight and one at dawn; the capture times ranged from 23:58 to 04:50 (Figure 3-9). Brown hare, the species with the highest number of events, was mainly active in the night hours, 20:00-04:00, and showed comparatively low activity during daytime (Figure 3-9).

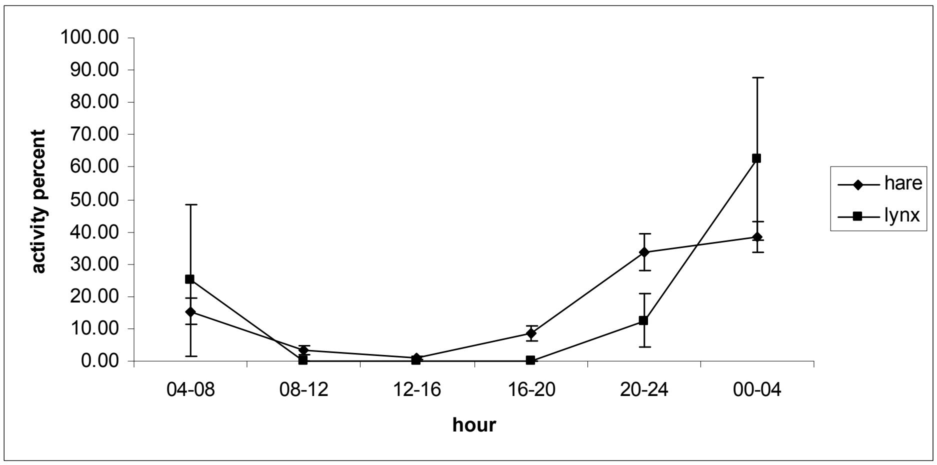

Figure 3-9. Daily activity levels of hare and lynx

Badgers and martens showed very similar activity patterns being both very active in the night hours (especially around midnight) (Figure 3-10).

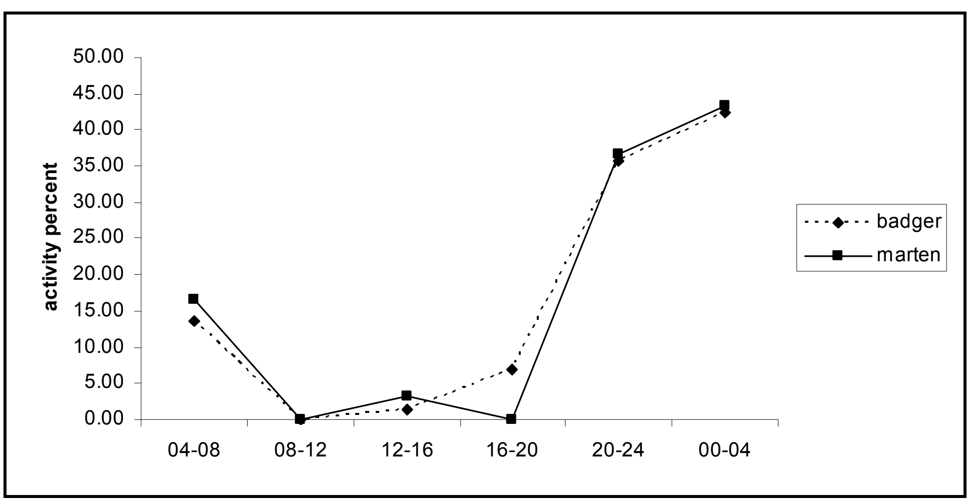

Figure 3-10. Daily activity levels of badger and marten

Wild boars also showed an almost complete nocturnal activity pattern, starting to be active in the early evening hours just until after twilight. Most of the events ranged within this dark time interval (Figure 3-11). Overall, when both sexes and all seasons were included, red deer showed a higher activity level in very early morning hours but also showed a stable level of activity in evening and night hours (Figure 3-11).

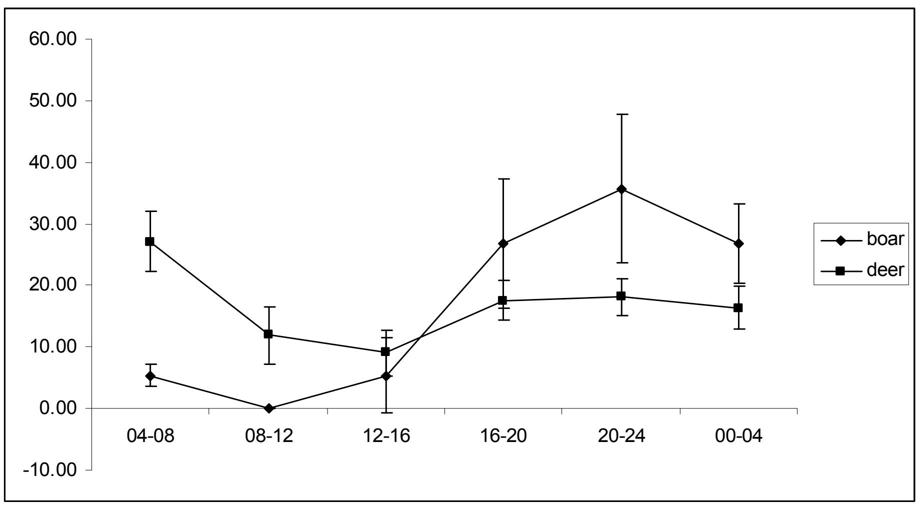

Figure 3-11. Daily activity levels of wild boar and red deer

3.2.1. Seasonal differences in activity patterns of badger, red deer and wolf

Badgers displayed reduced activity levels in March and during autumn months, but it was mainly active in the other spring and all summer months. There was no trap record of this species during winter months (Figure 3-12).

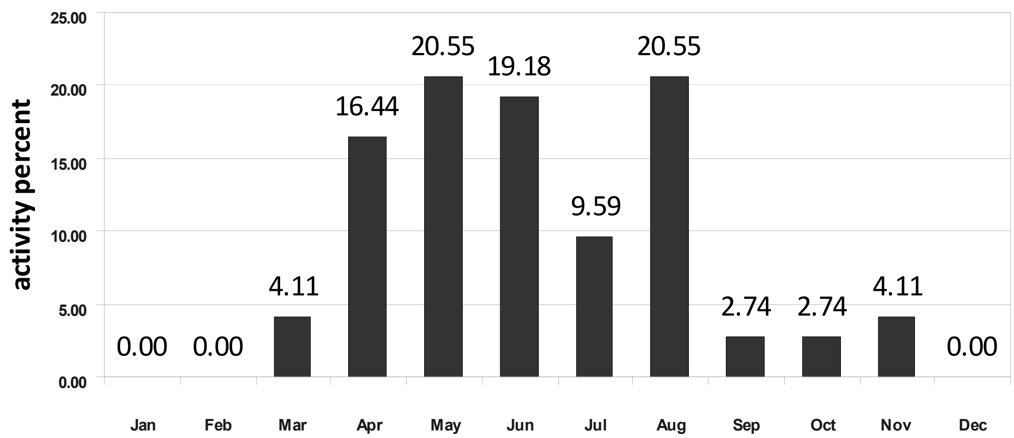

Figure 3-12. Seasonal differences in activity patterns of badger

As a major prey species of wolves in the study area, red deer activity levels were plotted in the same graphs together with wolves' to demonstrate or infer some activity correlation between these two species (Figures 3-13, 3-14 and 3-17).

During the winter, hinds were mainly captured in the day hours peaking in the late afternoon. There were comparatively less captures in the dark hours of the day (Figure 3-13). Stag activity peaked both in very early morning and late afternoon hours but decreased through midnight. Wolf activity peaked at 20:00-24:00 time interval (40%) but also reached moderate levels at early morning, evening and midnight hours. There was no significant activity difference (chi square=4.83, p=0.44) between two sexes in winter.

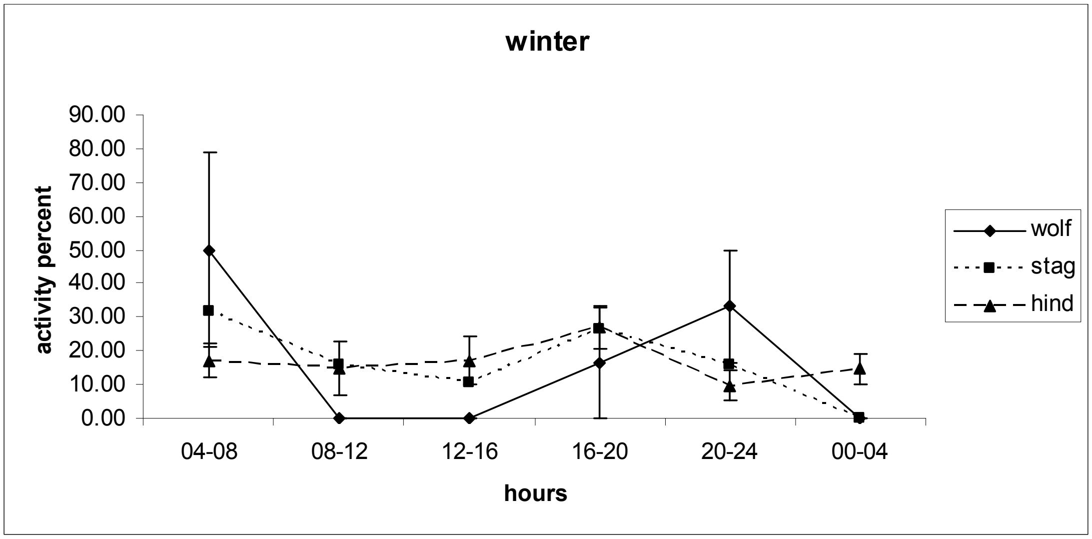

Figure 3-13. Daily activity levels of stags, hinds and wolves in winter

In summer, which here includes the days between March 21st and August 31st, hind and stag activity levels peaked in the dawn hours; hinds also showed some activity in early hours of 08:00-12:00 time interval (Figure 3-14). Stags tended to be inactive in hotter hours of the day and increased their activity through the night. Hinds increased activity at dusk but then decreased activity throughout the night when wolves were very active and searching for prey (Figure 3-15). Wolf activity coincided with deer activity in the morning and evening hours. The difference in activity levels of two sexes was highly significant (chi square=12.9, p= 0.025).

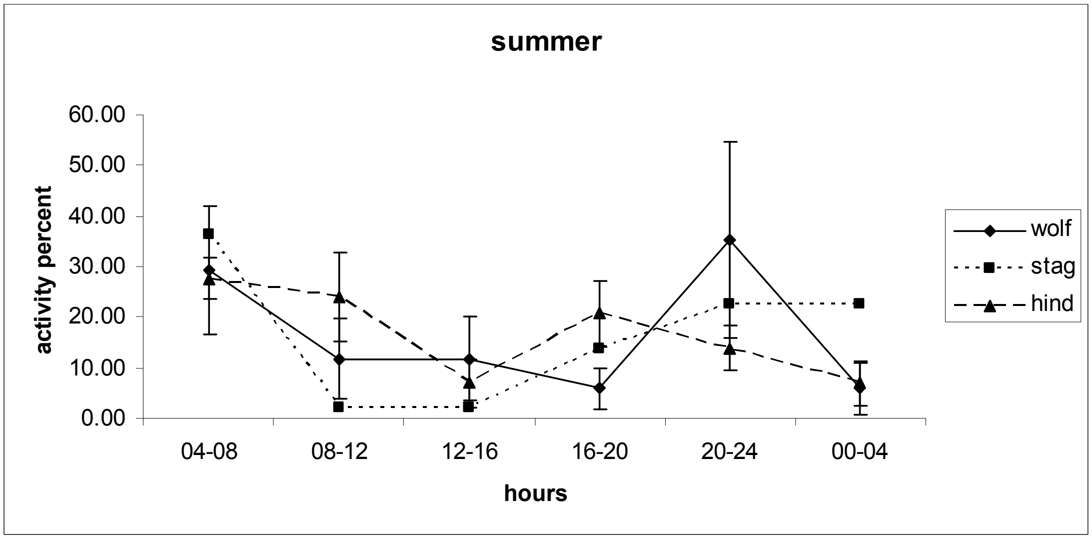

Figure 3-14. Daily activity levels of stags, hinds and wolves in summer

Figure 3-15. In a light influenced camera trap picture, suckling alpha female wolf carrying a deer calf head after a hunt.

In the rutting season (September 1st-November 15th) the two sexes showed significantly very different (chi square=25.4, p=0.00) activity patterns from each other. Hinds were active beginning with dawn till early evening hours, decreasing the activity through the night. Stags, in rutting season tended to be less active in day hours increasing their activity significantly (~60%) through midnight hours. Wolf' activity also peaked in the midnight hours (Figure 3-16).

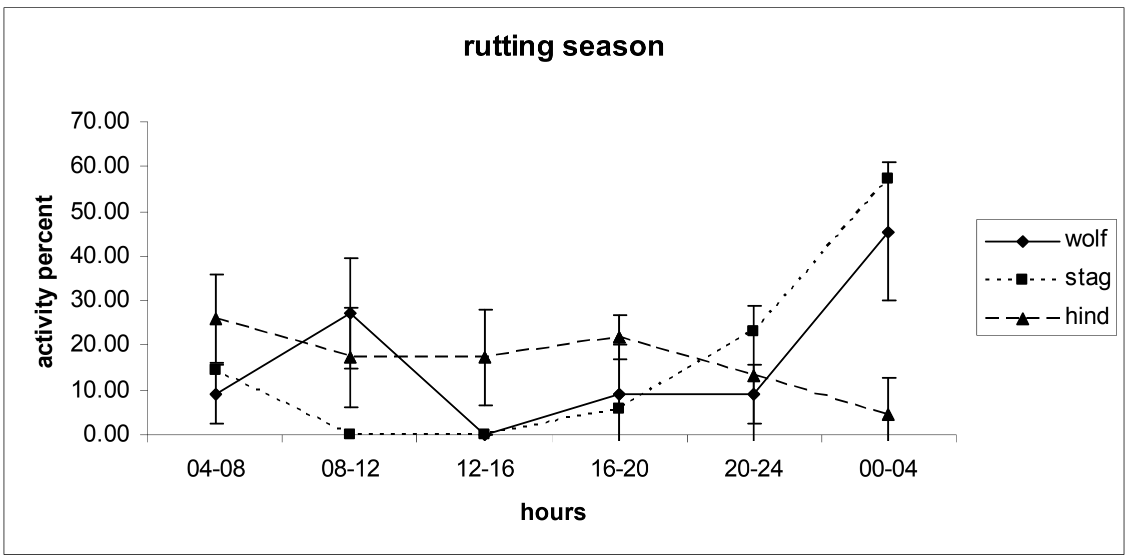

Figure 3-16. Daily activity levels of stags, hinds and wolves in rutting season

3.3. Spatial distribution patterns and habitat use

Golden jackal was one of the study species which was distributed in valley systems of the study area (Figure 3-17). The highest detection rate, reflecting the abundance of this species was at the lowest elevations of the study area in Aladağ River basin. Another relatively high density site was at the upper elevations of Sekli Valley. These high density sites were all humid areas at close distance to permanent water sources and riparian vegetation. Jackals were captured at lower rates at other sites of the study area.

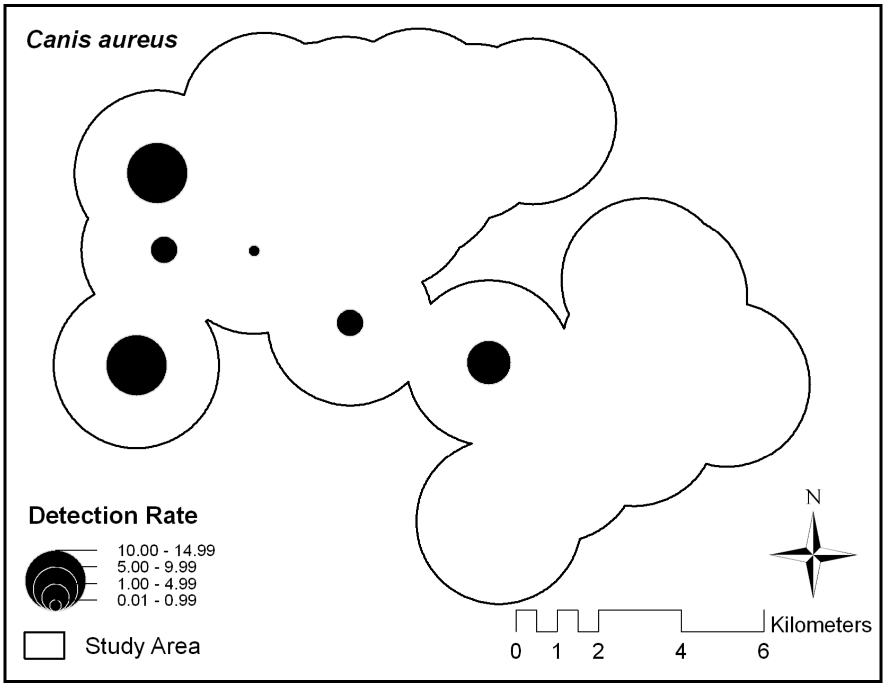

Figure 3-17. Jackal distribution was throughout the valley systems

Red deer was a common species of the study area. The main population and a higher density of deer were captured at the trap stations on Depel Mountain part of the study area (Figure 3-18). The capture sites with highest density were highland grazing grounds and surrounding pine woodlands. Although, Elmabel part had some deer events the deer population here was not stable and used this area only in certain seasons. Smaller circles represent some passage sites that are not used throughout the year.

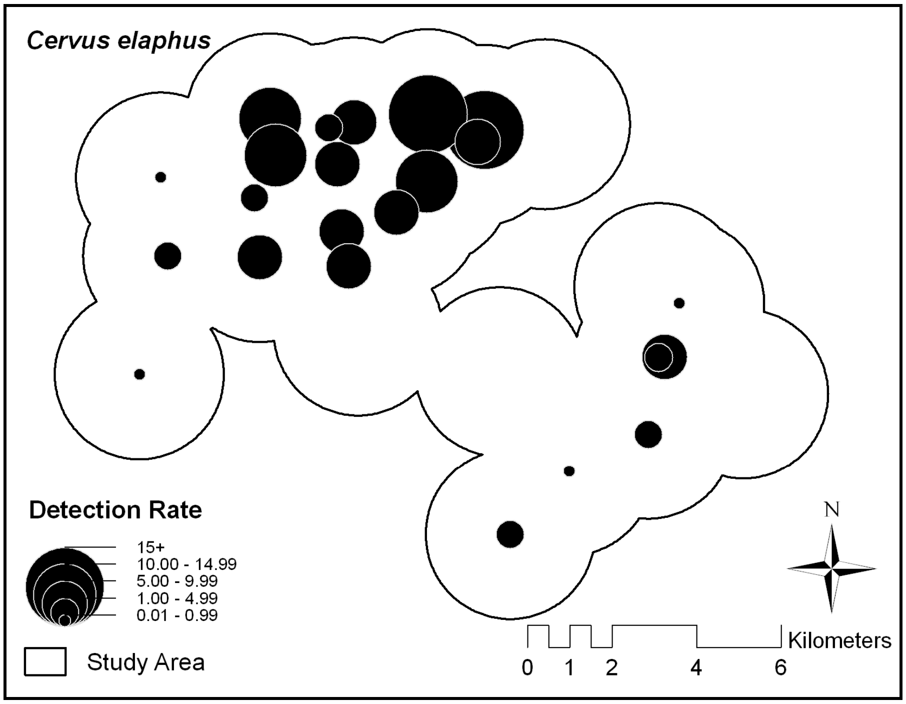

Figure 3-18. The main deer population was distributed along Depel Mountain

Wolf distribution coincided mainly with red deer and livestock distribution in the study area (Figures 3-18 and 3-19). Highest wolf capture densities were in Depel Mountain where the healthy deer population and livestock co-occur in half of the year. Wolves were patrolling the main trails in this part more frequently. The only wolf detection site in Elmabel ridge was also an earth road which was used by the species regularly.

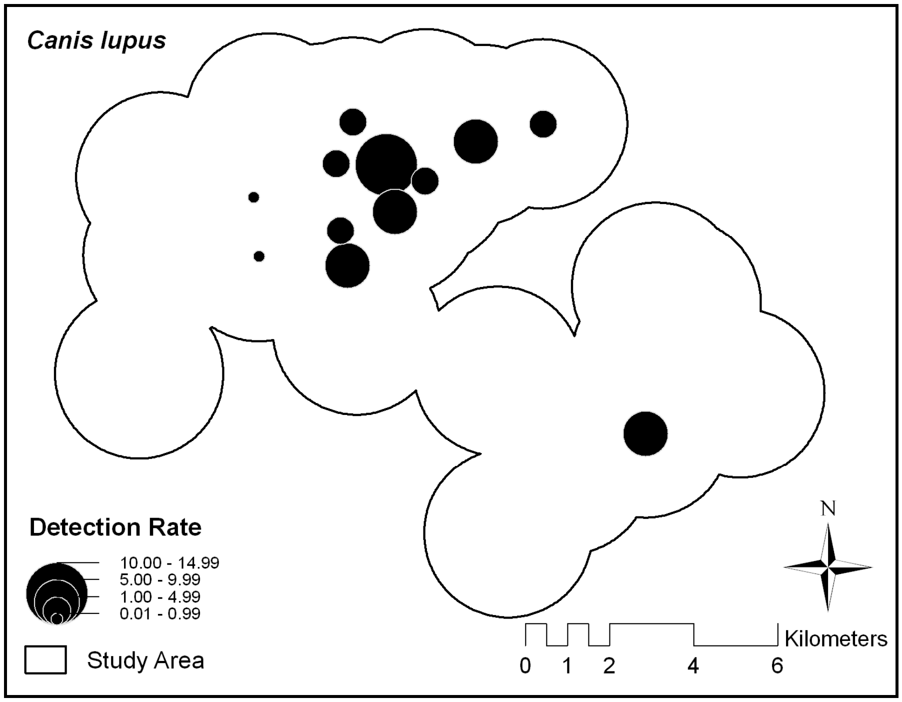

Figure 3-19. Wolves were common in Depel Mountain where livestock and high density of deer occur together

As the highest abundant species of this study, brown hare was also one of the most widespread species of the study area (Figure 3-20). This species was abundant at many sites of the study area. However, the highest density sites were open grazing grounds at middle and high altitudes.

Lynx was only detected in Depel Mountain part of the study area where both hare and deer were present in high numbers (Figure 3-21). This species did not use lower elevations and/or areas with human activity. The rightmost circle was one of the trap sites where lynx was captured before livestock were brought to the site. After their movement lynx was not encountered any more at this station for the next three months till the end of the study period.

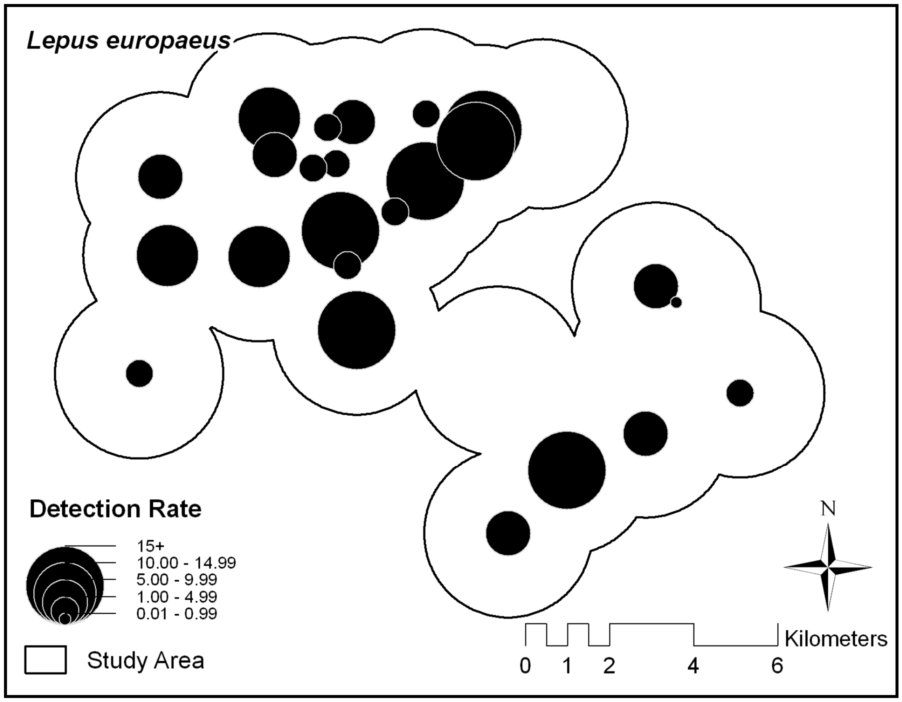

Figure 3-20. Hares were very common throughout the study area

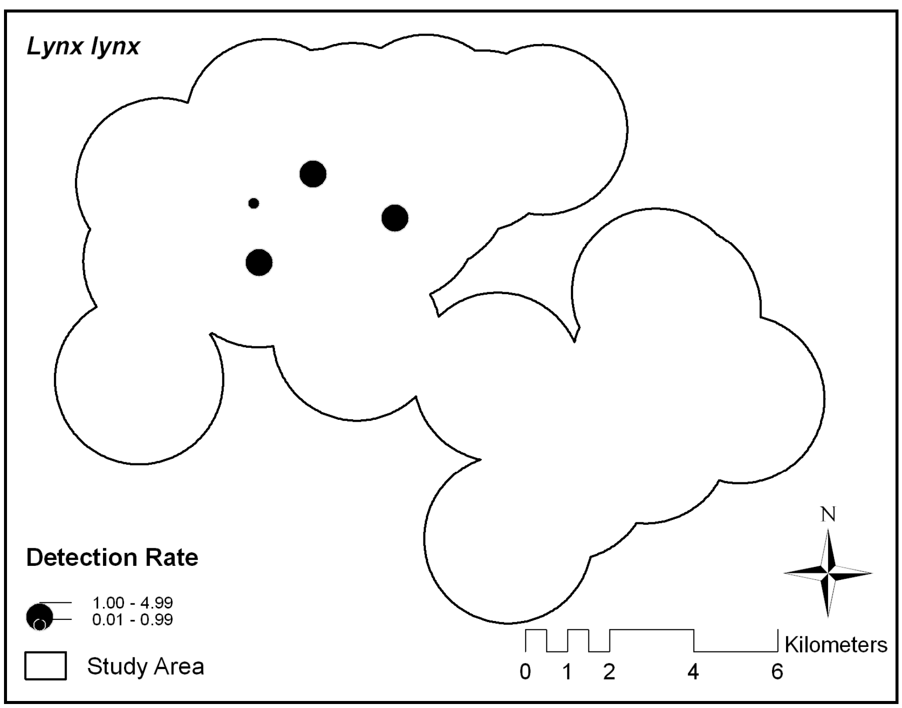

Figure 3-21. Lynx were distributed only in Depel Mountain with high densities of hare and deer and little human disturbance.

Stone marten was mainly captured at trap stations in humid valleys of both low and high elevations (Figure 3-22). This species was not captured in open areas but rather in densely vegetated, especially higher woodland. The valley bottoms and the small valleys in the foothills were the capture sites of this species.

Eurasian badger seemed to be influenced by altitude and distributed throughout the study area accordingly. Highest capture sites were in valleys and middle elevations at both Depel Mountain and Elmabel Ridge parts (Figure 3-23).

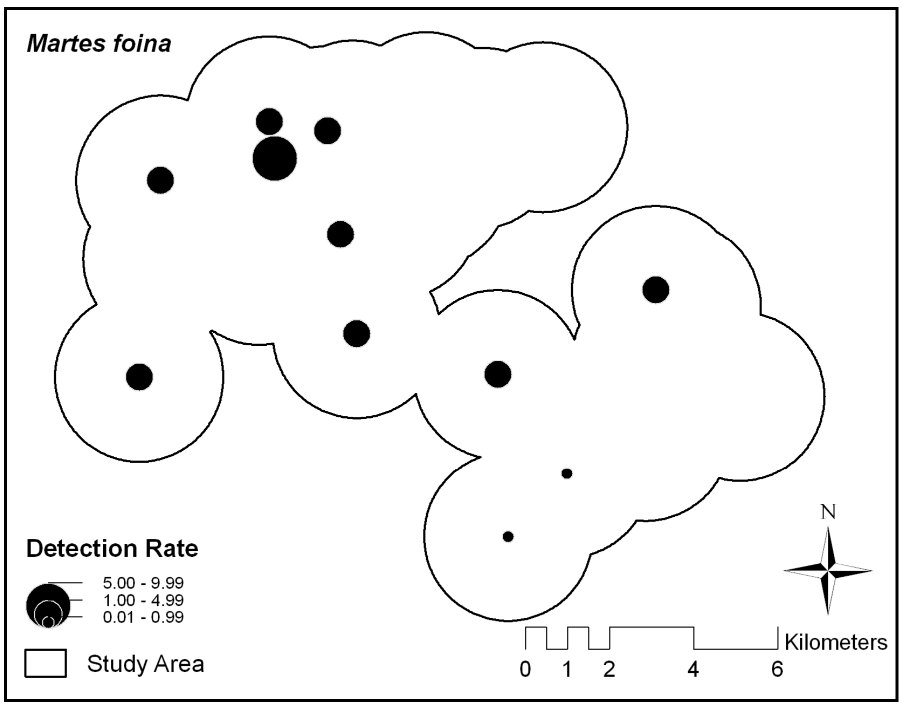

Figure 3-22. Stone marten were generally captured in valleys and around riparian vegetation on small mountain drainages.

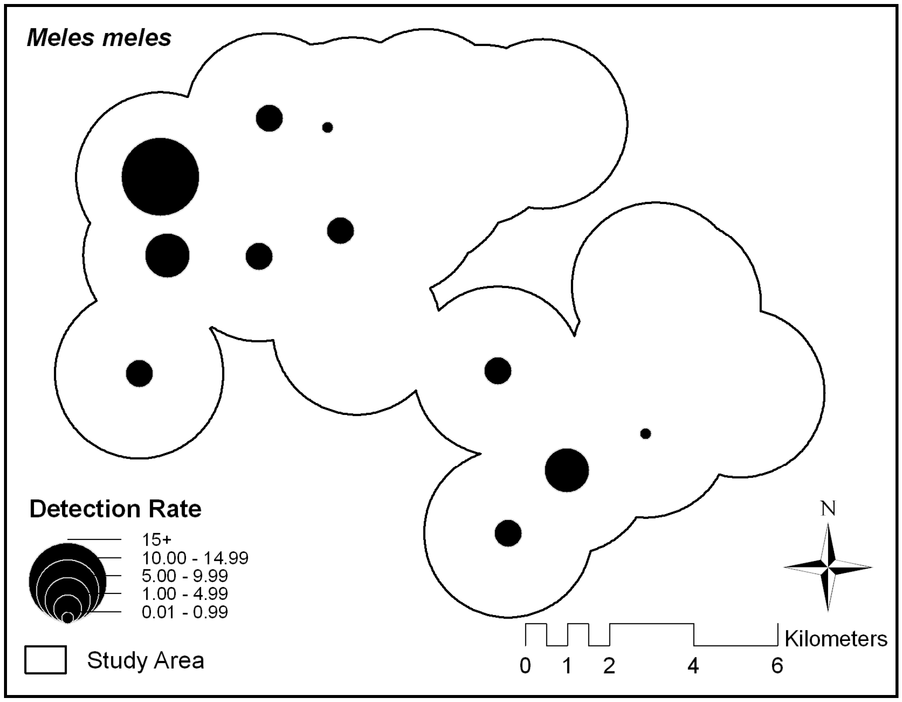

Figure 3-23. Badgers were common in valleys and also captured in middle altitude forests.

The Caucasian squirrel distribution was much correlated with human influenced land distribution in the study area (Figure 3-24). Most of the capture events came from stations near orchards and villages where a high density of walnut trees are present.

Wild boars were more abundant in the Aladağ River basin and in the surroundings of Elmabel Ridge (Figure 3-25). In Depel part of the study area male boars were distributed mainly at higher elevations while female and young were in valleys. At Elmabel Ridge and surroundings both sexes were distributed at middle elevations because of the relatively flat topography.

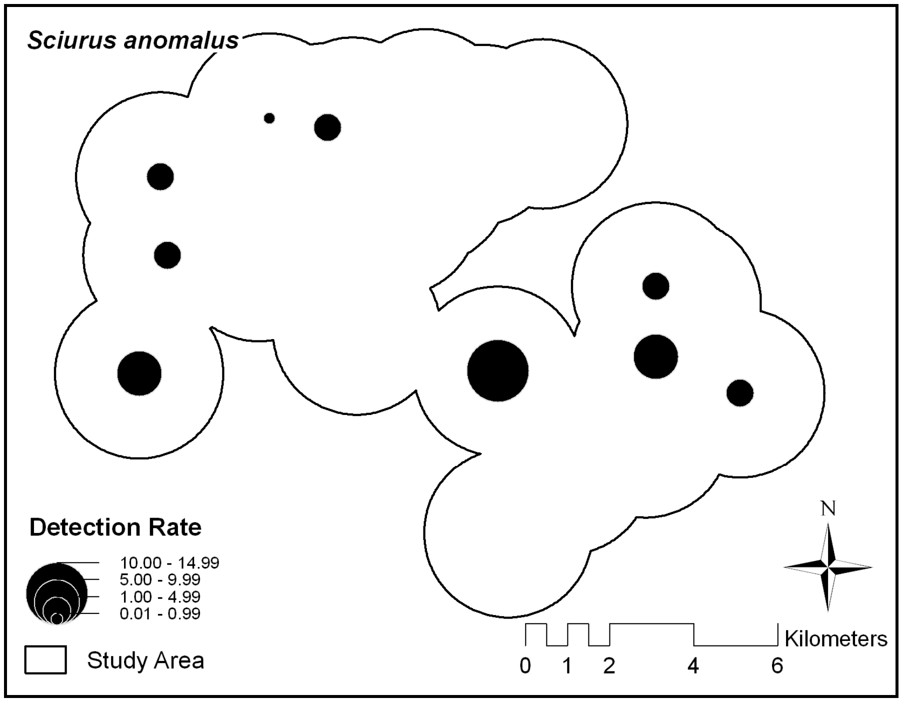

Figure 3-24. Squirrels were captured in valleys and near orchards where walnut trees were common. Some were captured in high altitude black pine forest.

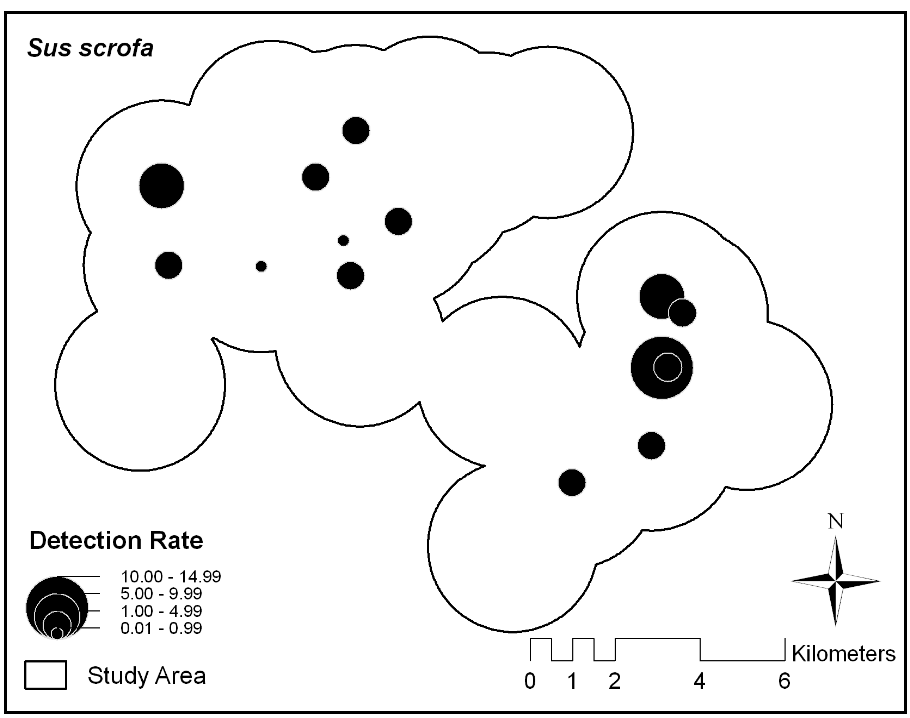

Figure 3-25. Higher densities of boars were captured near croplands and in valleys.

Red fox was the most widespread mammal and carnivore in the study area (Figure 3-26). Foxes were mainly encountered at camera trap sites of middle elevations in both Depel Mountain and Elmabel Ridge. Forest openings, agricultural fields, and the transition zone of Mediterranean *Pinus brutia* and higher *P. nigra* woodland were the main red fox habitats. Higher elevations above tree zone at Depel Mountain were also used especially in seasons without snow cover. The lowest density and least used habitats in the study area were mainly valleys.

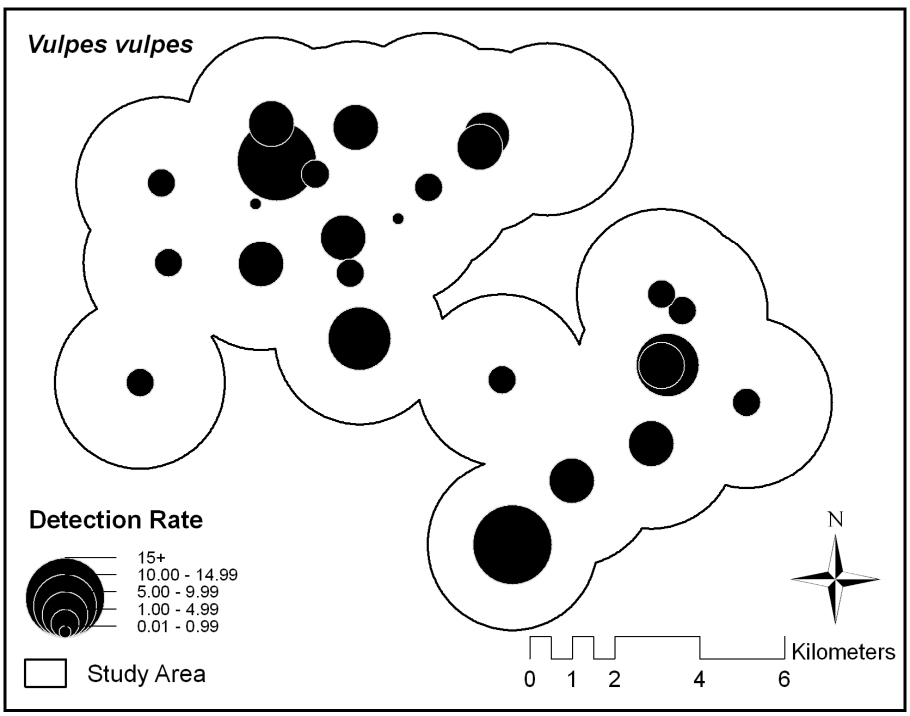

Figure 3-26. Fox was the most wide spread captured species but was captured in lower rates where wolf and jackal capture rates were high.

The only permanent flowing big water body which is surrounded by dense riparian vegetation was the Aladağ River. Hence, jungle cat captures were only restricted to this valley. Hedgehog was also captured at camera trap station in the junction of Sekli and Aladağ Valleys near fields and orchards. Based on other observations, brown bear was found to be distributed at higher and middle elevations of Depel Mountain; villagers claimed bears also used the low elevation orchards in Aladağ Valley. Bear sign was found in the beginning of the study above the pine woodland zone where grasslands and scattered thorn apple (*Crataegus* spp.) trees occur. In the previous year, bear tracks were also found on earth roads at the elevation where this species was later captured by a camera trap (Figure 3-27).

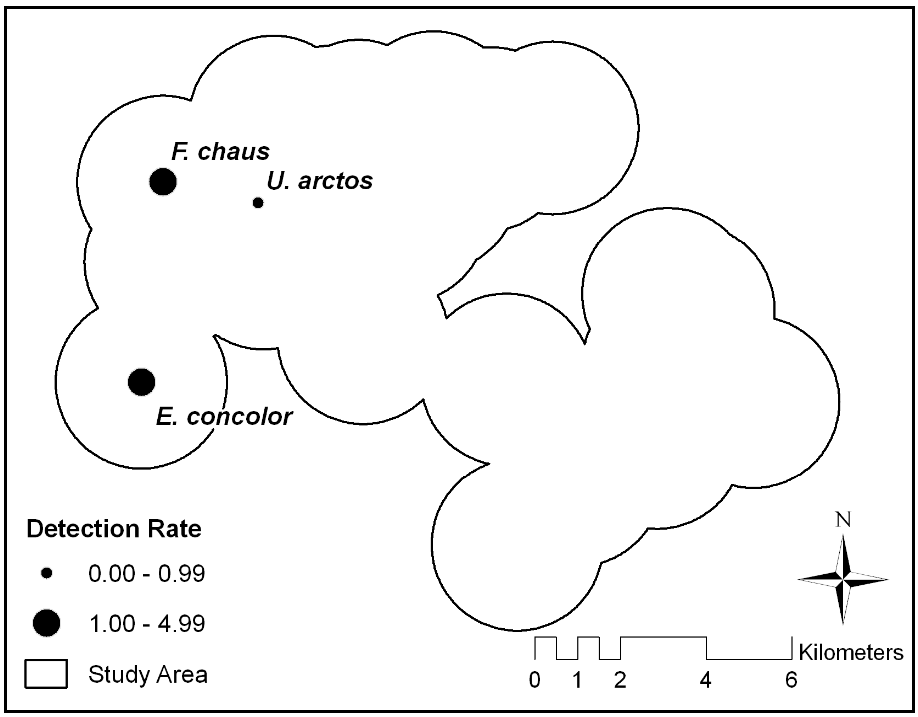

Figure 3-27. Jungle cat and hedgehog, and brown bear were each captured only once in Aladağ Valley and at middle altitude woodland, respectively.

3.4. Altitudinal distribution patterns

Figure 3-28 demonstrates the species event ratios at different altitudinal belts. Except for red fox and Brown Hare all species showed some kind of higher preference towards particular height interval/s. Jungle cat and hedgehog were only confined to lowest elevations. The capture events of these species came from trap stations that were at 549 and 519 meters altitude respectively. Stone marten and Eurasian badger showed similar altitudinal distribution patterns, likewise in daily activity patterns. Most of the capture events of these two species came from the trap stations at altitudes between 500 and 1000 meters.

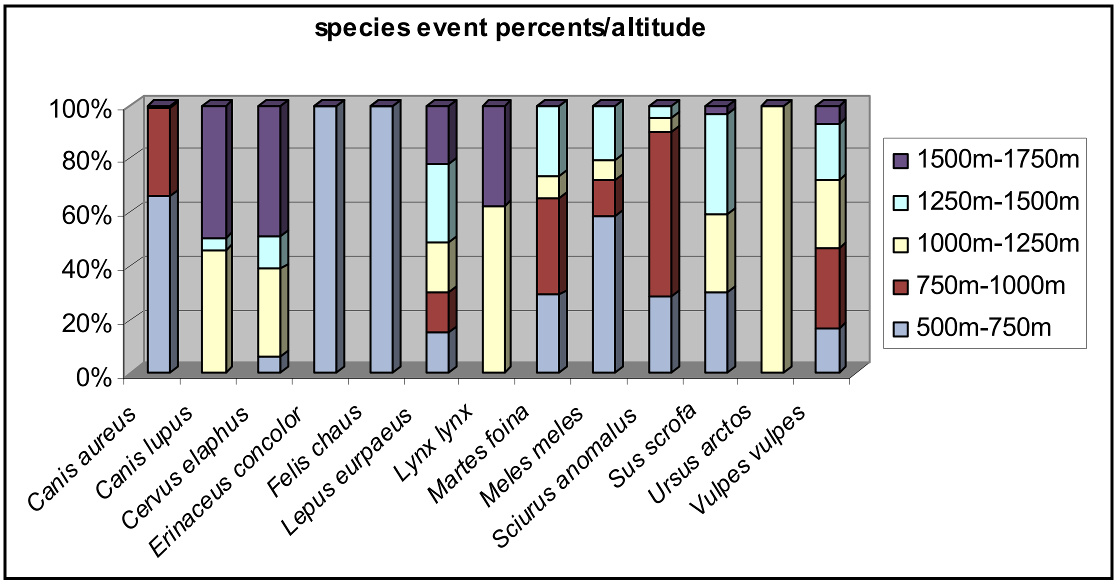

Figure 3-28. Species event distribution with respect to altitude.

Jackal events were mainly from valley bottoms with a high capture density (7.84 events/100 trap-days). Only two capture events of jackals were in the 1000-1250 m belt from a single camera-trap station that was at 1005 meters altitude (Figure 3-29). Foxes were common at almost all intervals. The lowest event densities were at the 500-750 and 1500-1750 m belts for this species and it was highest in the 750-1000 m belt. Wolf events were concentrated at two altitudinal belts above 1000 meters. Not a single event of a wolf was captured below this altitude (Figure 3-29).

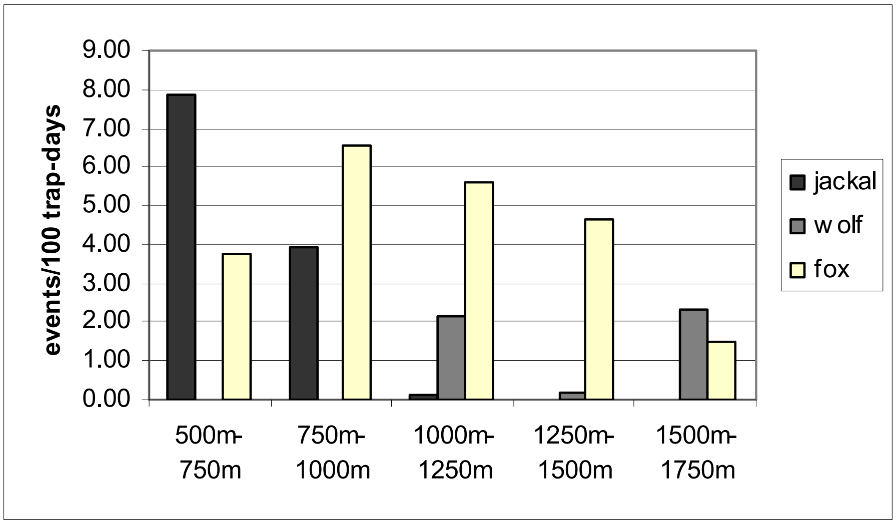

Figure 3-29. Altitudinal distribution patterns of jackal wolf and fox.

Wild boars have almost the same detection rate at the three altitudinal belts they were detected (Figure 3-30). There were no captures from the 750-1000 m belt and only one capture from the highest belt. Red deer were abundant at especially two altitudinal belts, 1000-1250 and 1500-1750 meters. Some deer (females and immature males) were also captured at very low altitudes. Brown hares were commonly captured at all altitudinal levels but overall were highest at the 1250-1500 m (Figure 3-30).

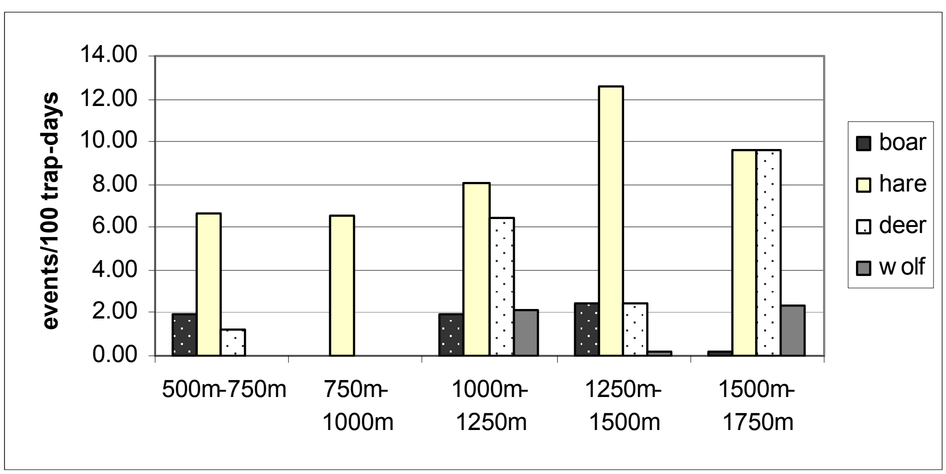

Figure 3-30. Altitudinal distribution patterns of wild boar, hare, deer and wolf

Only in the larger Depel part of the study area lynx and hare occur together. Therefore hare events from Elmabel Ridge were not included in the lynx-hare comparison graph (Figure 3-31). At this site, hare were distributed and captured at all altitudinal belts but mainly at the camera trap stations installed at 1000-1250 and 1500-1750 meters. All of the lynx capture events were also from these two height intervals – seven from the 1000-1250 m belt and one from highest belt. Distribution patterns of these two species were highly correlated (r=0.83).

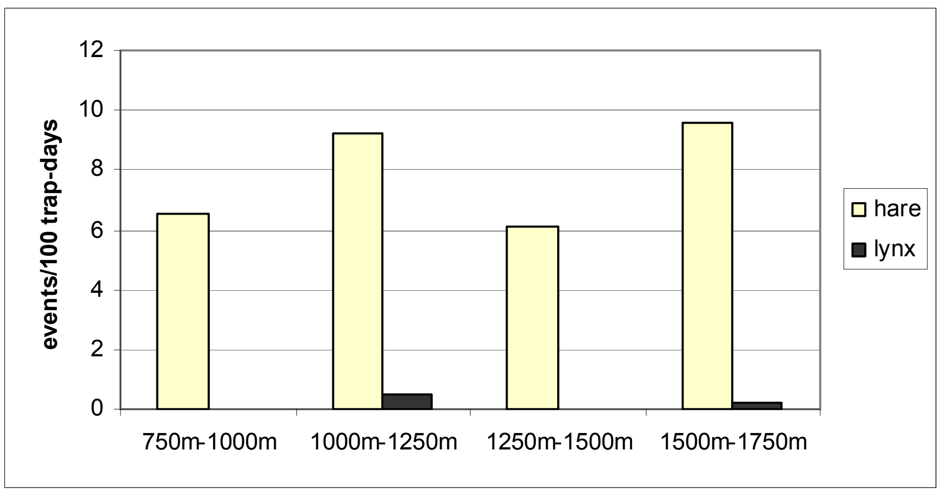

Figure 3-31. Altitudinal distribution patterns of hare, and lynx

3.5. Individual identification and population estimates

Conservative population estimates were made for certain territorial species, namely brown bear, wolf, lynx, and jungle cat.

Species	Minimum individuals recorded	Estimated resident population
Brown Bear	2	0-2
Wolf	7	2-5
Lynx	4	2-4
Jungle Cat	2	2-3

Table 3-3. Minimum individuals identified from photos during the study and estimated resident adult populations of bear, wolf, lynx and jungle cat within the study area

3.5.2. Population estimates for bears and wolves

Camera trapping revealed only one picture of a subadult or young adult bear (Figure 3-32). During an interview with a shepherd, it was also mentioned that a female bear with cubs were seen in the study area in the same season as this study. Therefore, the number of bear individuals should have been at least 2 inside the survey area, an adult female, and the photographed individual. There is also the possibility of presence of additional individual/s if the cub(s) survived.

Figure 3-32. The only camera trap picture of brown bear

Identification of individual wolves is a very difficult skill that needs long observation and monitoring of individuals. There were fifty-five capture events of adult and cub wolves in total in the whole study area. Therefore, population number estimates of wolves were made by only including the easily identified individuals of Elmabel ridge and the pack of Depel Mountain. This pack was conservatively counted as two adults and three cubs to prevent overestimation of adults. The resident pack of the Depel Mountain territory was estimated as two adults, the alpha pair (Figure 3-33) and their three cubs that were born and grew up during the trap survey period. It is probable that this pack might have one or two additional non-breeding adults. The three cubs were repeatedly captured from when they were two or three months old till the last picture on November 10th when they were captured in a single picture event as 7 months old juveniles (Figure 3-33). The two individuals from the Elmabel ridge were identified from capture events that occurred in the same month within a fifteen days time span and at the same trap station. Both individuals were captured from their right sides (Figure 3-33).

Figure 3-33. The supposedly alpha male in different seasons was recognized from white patch on left hind foot (1, 2), the suckling alpha female (3), the three cubs at 2-3 months of age (4, 5), and the three juveniles at seven-eight month of age (6) were captured in Depel Mountain. The two individual wolves (7,8) were captured on Elmabel Ridge.

3.5.2. Individual identification of Eurasian lynx and jungle cats

When the study was terminated at the end of November 2009, eight Eurasian lynx events were captured at four camera trap stations. Several individuals could be identified from both sides. However, it was not clear if they represented only three individuals or more. To further monitor lynx, some camera traps were not pulled from the study area after the study ended. In 2010 an additional three lynx capture events provided 3 more pictures of an individual which provided strong evidence for the presence of up to four individuals of lynx inside the survey area (Figure 3-34).

Two captures of jungle cats in one month at the same camera trap station revealed two different individuals which were identified from their tail tips and ear coloration (Figure 3-35).

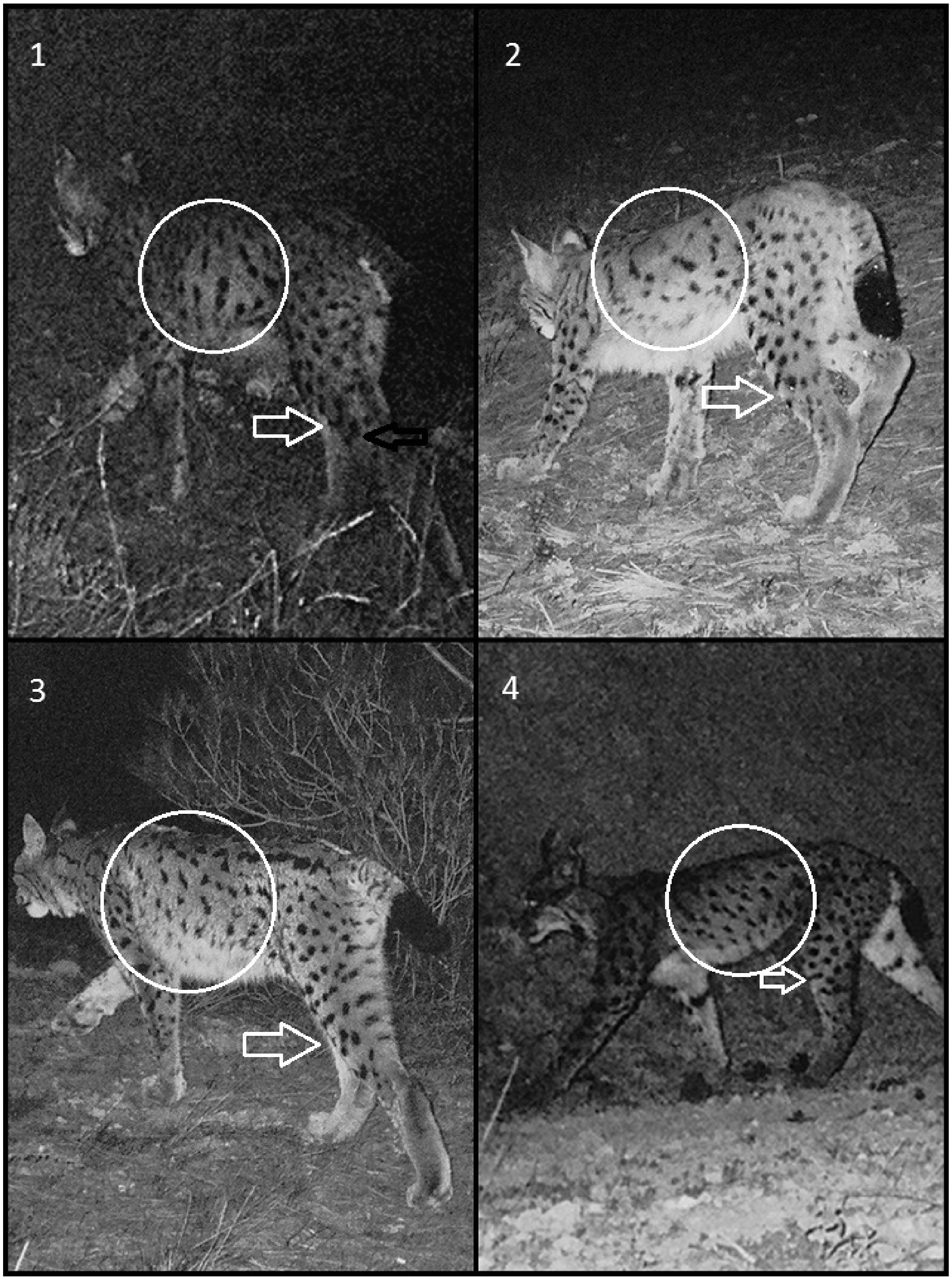

Figure 3-34. The four individual lynxes identified from left pelt sides. Numbers 2 and 3 are different from others by their vertical (2) and horizontal (3) stripy spots within the white circles. 1 and 4 are distinguished by both spots in circles and by patterns shown by arrows. Number 4 has more spots inside the circled area and 1 has two horizontal stripes on the leg.

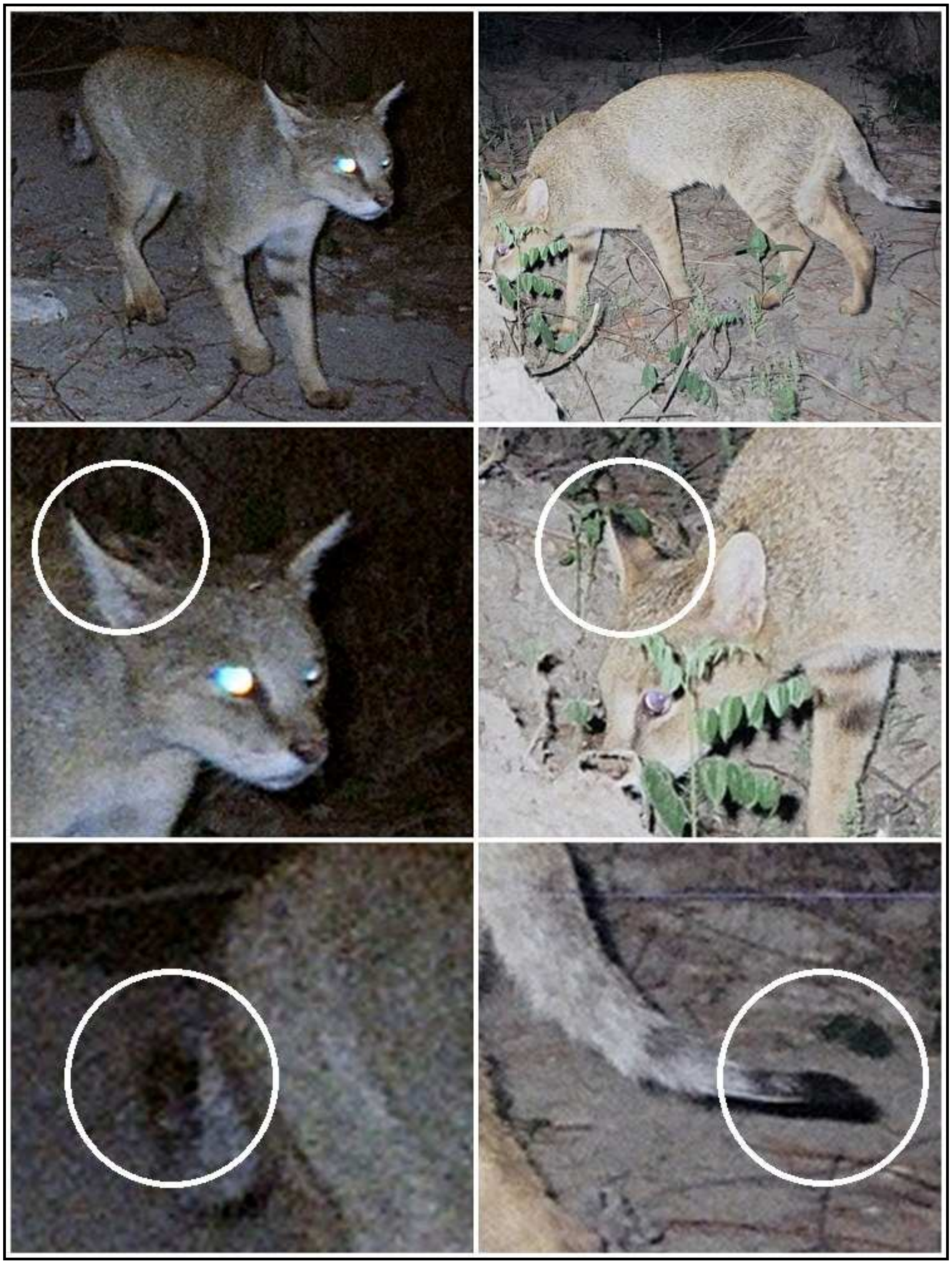

Figure 3-35. The two individual jungle cats distinguished by both ear coloring and tips of the tails, first one has a thicker tail tip than the second individual's.

3.6. The influence of livestock grazing to wildlife

3.6.1. The use of grasslands by livestock and deer

The grasslands were used by both livestock and deer especially in late spring and summer season. In that period, livestock were mainly active from the morning hours till the late afternoon. However, most of the activity was registered between 08:00 and 16:00 where deer in winter and spring showed a reasonable activity level before livestock arrival (Figure 3-13). Hence, deer grazing activity shifted from daylight hours towards dawn, dusk and night hours (Figure 3-36).

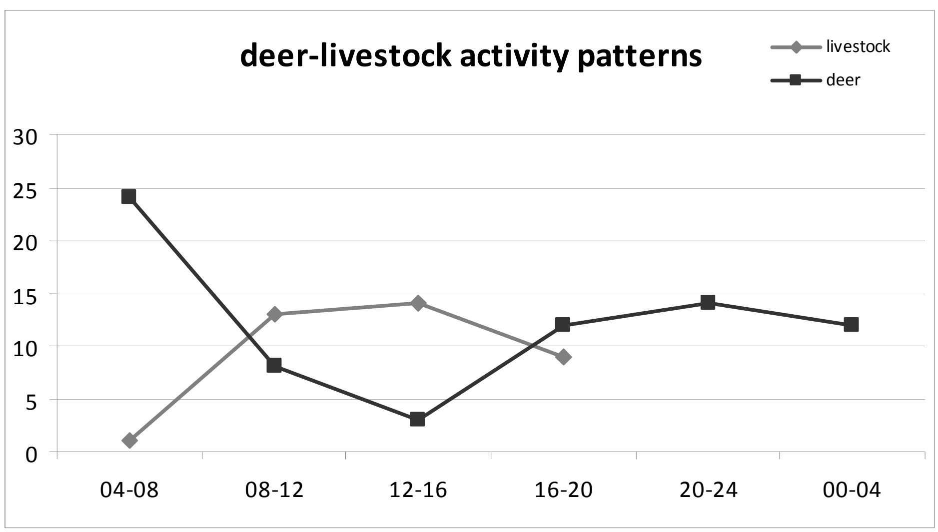

Figure 3-36. Deer and livestock daily activity patterns

Some areas of high disturbance (near the sheepfolds) were utilized by deer until livestock migrated to the higher land in late spring. These areas were no more visited by deer in this season. Kangal and Akbash are the two most common Turkish breeds used as LGD (Tuğ 2005). The negative effect of LGD on deer calf mortality rates in the birth season, when the livestock come up to highlands, was admitted by the shepherds. Groups of LGDs chased deer calves until they were caught and killed (pers.comm. with shepherds). Mature deer were not at the target of LGDs and generally adult deer were not killed by them.

Wild boars were also chased by LGDs when encountered. In some cases dogs were seriously wounded during these battles.

3.6.2. Depredation on livestock

Wolves also prey upon livestock which decreases the predation pressure on deer and wild boar populations. It was observed that flocks with lower number of LGDs were most affected by wolf depredation. Wolf distribution was mainly concentrated in Depel Mountain where livestock and high density of deer co-occured, and the higher encounter rates of wolf and livestock coincided in Elmabel Ridge (Figures 3-37, 3-18, 3-19).

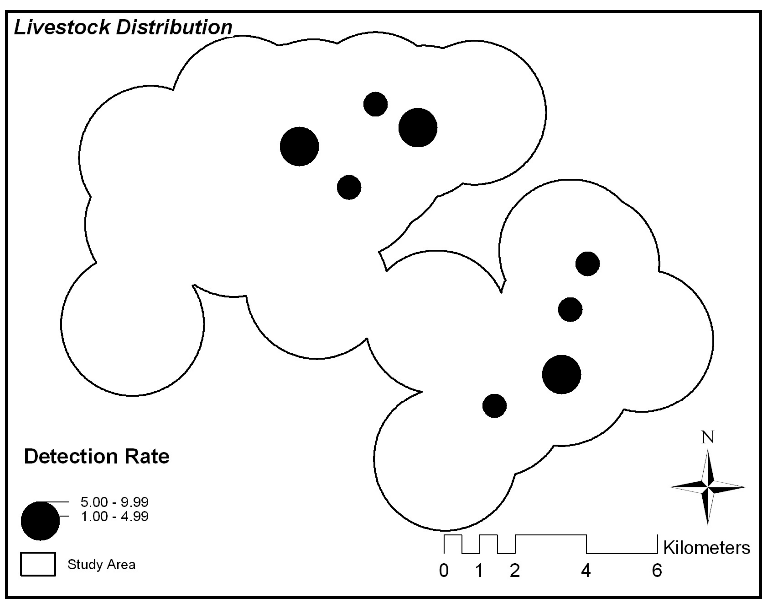

Figure 3-37. Livestock distribution map (May-October)

Wolf depredation was also proven by camera trapping where nearly 800 Angora goats were grazed in the company of 2 adult and 2 juvenile Akbash sheep dogs (Figure 3-38). This flock was said to have lost more than 50 goats to depredation annually (pers comm.). The shepherds of flocks with higher number of adult LGDs suffered little or no depredation.

Figure 3-38. Alpha female wolf, carrying an Angora goat kid kill at Depel Mountain.

Occasionally, brown bear is also said to depredate livestock (as reported by two shepherds from Köst and Hırkatepe) but this is negligible when compared to wolf depredation. There was no other known carnivore depredation on livestock.

CHAPTER 4

DISCUSSION

4.1. Species detection and trapping success

The camera trap survey, in 3699 trap-days, revealed the presence of a healthy meso- and macro-mammal fauna. The 13 captured species included carnivores such as brown bear, wolf, Eurasian lynx, golden jackal, jungle cat, Eurasian badger, red fox and stone marten, herbivores such as red deer, wild boar, brown hare, an insectivore, southern white-breasted hedgehog and a rodent, the Caucasian squirrel.

When literature information, interviews with shepherds and the camera trapping survey were considered jointly, there were some species that could not be captured by the camera traps. These species are Eurasian otter, weasel, marbled polecat, wild cat, Anatolian leopard and Anatolian mouflon. The first three species are known to exist in the study area both from recent records and from interviews with locals. Otters are common in Sarıyar Dam which is fed by the incoming waters of Aladağ and Kirmir rivers. Aladağ River is the main and the only permanent flowing big water body crossing the study area. Hence, otters are expected to be residents of the study area along this river. Weasels were reported to exist near human settlements where they could find sufficient small prey to meet needs of reasonable population densities. Marbled polecats also have recent records from nearby sites. The reasons for these three species not being captured by camera traps could be as follows:

Weasel:

1. No camera trap was installed in close proximity to human settlements where the species is thought to be more common
2. Weasel is a very agile and small species that camera traps could not have been able to detect
3. The height of the camera trap sensors from the ground (ranging between 20-40 cm) was perhaps too high for this species so as not to detect during some encounters

Marbled Polecat:

1. Home range of Marbled Polecats is generally very small. Gorsuch and Lariviere (2005) repored the home range size of this species as 0.5-0.6 square kms. No camera trap was installed near a known Marbled Polecat den.
2. The height of the camera trap sensors from the ground (ranging between 20-40 cm) was perhaps too high for this species so as not to detect during some encounters.

Eurasian Otter:

1. Otters are confined to wetland habitats where in the study area only one camera trap station was present. Hence, the probability of capturing an otter was very low compared to all other mammal species.

The encounters of many feral cats but not of any wild cat in suitable wild cat habitat, indicates the absence of this species in the study area. Leopard is another species that was not present at the study site, at least during the study period. The situation of Anatolian mouflon is very different from other species. It has not yet reached a healthy population size and is only restricted to the reintroduction site further southwest. Therefore, this species is not present inside or near the study area where there are also suitable habitat.

The jungle cat and lynx were the two species that were not mentioned in the interviews with the shepherds, but captured by the camera traps. It was the first camera trapping event of a jungle cat in Turkey in a place other than Adana where the species has a high density population. In the recent past, Turkey experienced a huge loss of wetlands to drainage, especially in inner Anatolia (Erdem, 2004). As a wetland specialist, the jungle cat also lost most of its habitat and range in this region. Hence, the camera trap pictures of the species here are very important and encouraging in an inner Anatolian province. Eurasian lynx is one of the least known mammal species of Turkey. Therefore, pictures obtained through camera trapping are valuable for understanding its ecology and for its conservation in Turkey. Reasons for unawareness of shepherds about these two species are thought to be their elusive and largely nocturnal behavior and their low population densities.

The most common species of the trap survey was the brown hare that had a detection rate of 8.59 per 100 trap-days. This was followed by red deer with a rate of 5.16 per 100 trap days. These high rates indicate the quality of the habitat and the species' high productivity as the major grazers of the area. North-western Ankara, northern Eskişehir (Sündiken Mountains) and some districts of Bolu province have the highest density red deer populations throughout Turkey (Mengüllüoğlu and Bilgin, unpublished). The main reason is that the residents of this geographical triangle are usually against deer hunting due to semi-religious beliefs, such as that shooting deer brings bad luck to whoever hunts them. Therefore, that large region covered by pine and oak woodlands, croplands and orchards, is a refuge to the remaining healthy and interconnected Red Deer metapopulation in Turkey.

Red fox had 4.76 capture events per 100 trap-days which was higer compared to the other camera trap studies made in Turkey. Can's (2008) camera trap survey in Yenice Forest revealed a detection rate of 2.83 events/100 camera trap days (CTD), İlemin's study (2009) 2.65 events/100 CTD, and another survey in Dilek Peninsula National Park 2.95 events/100 CTD (Mengüllüoğlu and Bilgin, unpublished data). The higher detection rate of red fox in this study may be due to higher densities of rodents and brown hares and the presence of wolves as a source of scavenging opportunity for foxes.

Eurasian badger was the fourth most frequently captured species with 1.97 events/100 CTD rate. This rate was higher than rates for other species such as wild boar, jackal and marten. Can (2008) and İlemin (2009) obtained 0.33 and 0.51 events/100 CTD respectively for badger. The high habitat heterogeneity provided by a mosaic of pine woodlands, agricultural fields and orchards, riparian habitats, secondary steppe and forest openings is thought to be the reason for the high rate of badger capture, i.e. higher badger abundance. This diversity of habitats apparently provides a wide variety of invertebrate and small vertebrate species, wild and cultivated fruits that badgers feed on (Fedriani et al., 1999; Balestrieri et al., 2004).

Interestingly, the wild boar detection rate (1.65 events/100 CTD) was considerably lower in the study area when compared to studies in other regions of Turkey. The wild boar detection rate in Yenice Forests (Can, 2008), a broadleaved woodland more to north of this study area, was 12.66 events/ 100 CTD. In a camera trap survey at Akyatan Wildlife Development Reserve (Akyatan WDR) on the Mediterranean coast of Turkey, 54.55 wild boar events were recorded per 100 CTD (Demir et al., in press) which was an extraordinarily high rate. In south-western Turkey 8.41 events/100 CTD were recorded in the Datça-Bozburun Peninsula (İlemin, 2009), and 20.43 events/100 CTD in Dilek Peninsula National Park (Mengüllüoğlu and Bilgin, unpublished data). Although Akyatan and Dilek Peninsula NP are two well protected wildlife refuges with no big predators, the rates are also significantly higher in Datça-Bozburun Peninsula and Yenice Forests. One reason for this lower detection rate, or wild boar abundance, is thought to be the presence of an almost intact carnivore fauna, especially wolves (Kanzaki & Perzanowski 1997) and jackals, at the study site. Both jackals (Lanszki et al., 2006) and wolves can prey upon piglets, and wolves also on juvenile and adult boars (Jedrzejewski et al., 2002). Other reasons could be the less humid character of the study area, providing wild boars with reduced food resources, and the hunts organized at the lower elevations nearby.

The wolf detection rate was 1.49 events/100 CTD. In a similar survey effort (4188 CTD) Khorozyan et al. (2008) obtained a rate of 0.93 wolf events/100 CTD in Armenia. The wolf detection rate in Yenice Forests was even lower, 0.75 events/100 CTD (Can, 2008). Both survey sites in Yenice and Armenia were protected areas and no livestock grazing was allowed or present (Can, 2008; Khorozyan, 2008). Thus, the higher rate of wolf capture events in the study area is most probably due to the presence of livestock herds, which appear to make up a reasonable part of the wolf diet in the area, along with the wild herbivores.

In spite of being the seventh most frequently captured species (1.38 events/100 CTD), golden jackal was captured fairly commonly in camera traps placed at valleys (even more frequently than the red fox).

Squirrel, marten and hedgehog detection rates were 1.32, 0.86 and 0.08 events/100 CTD respectively. However, the detection rates of these three species should not be correlated with the abundances of these species in the study area due to various reasons. Despite, being one of the most common species in the study area, squirrel detection rate was very low most probably because of the fast movement, small size and arboreal habits of this species. Similar assumptions are also true for martens to some extent. Smaller species are shown to be more often missed by the camera traps because of their relative small size and speed (Tobler et al., 2008). The same reasoning is also valid for hedgehogs. Therefore the encounter rates of these species do not account for their abundances.

As a habitat specialist, the jungle cat was encountered in the pictures only twice. Jungle cat habitat is restricted only to a small percent of the study area where Aladağ River runs along. The detection rate of this species, therefore, remained very low at 0.05 events/100 CTD.

Brown Bear was unexpectedly the last and least captured species despite previous signs of bear presence in the form of tracks and scat at different elevations (Mengüllüoğlu and Bilgin, 2009). Logging activities during the study are thought to be the reason for rare visits or total avoidance by the one or two bears normally seen in the study area.

When number of trap-days until the first encounter are considered for each species, wolf (6th trap day), red fox (8th trap day), brown hare (9th TD) and red deer (12th TD) are the first four species that were immediately captured at the very beginning of the camera trap placement period. The first six species that were captured were also the six species with the highest encounter rates throughout the survey period. The only exception in this order was Eurasian badger. Since the trap survey was begun in December 2008 which was the first month of the winter, badgers were inactive for following two months. Hence, this species was captured for the first time on 756th TD of the survey even after first lynx encounter (577th TD). The reasons for wolf to be captured 1st at the 6th camera trap-day are thought to be the wide territory and long daily distance covering behavior of this species, and that camera trap placement began with mountain tops where this species was more abundant. As the least frequently captured, and most probably least abundant species, brown bear was also the last captured species on the 2383rd trap day of the survey, even later than the jungle cat, which was encountered on the 1594th trap day of the survey.

The study area has high mammal diversity (Shannon's H'=1.97, Simpson's 1-D=0.82) when compared to other mammal habitats in Turkey. In a low disturbance temperate deciduous forest, Can (2008) found lower mammal diversity (Shannon's H'=1.27, Simpson's 1/D=2.55). However, Can did not include the mammals other than his study target species in this calculation. Mammal diversities at Akyatan WDR (Shannon's H'=1.10, Simpson's 1-D=0.60) which is a afforested area surrounded with wetlands and agricultural fields, and at Dilek PNP (Shannon's H'=0.86, Simpson's 1-D=0.38) which is a mixed Mediterranean scrubland and *Pinus brutia* woodland area, were even lower than the study area. The reason for such a high diversity could be a result of high habitat diversity in the study area. Especially a Mediterranean microclimate and associated vegetation in this inner Anatolian region should account for diversity of higher fauna elements. Another factor is the very high altitudinal gradient (500 to 1850 m) in a relatively small area where a diverse array of vegetation types occur.

PC-Ord software was used to classify the camera trap stations with respect to their mammal communities. Among three different approaches TWINSPAN analysis gave the best result, matching the communities with similar properties and classified these communities into the same groups. Among the six classes, the group of traps in valleys and riverine habitats had the highest diversity indices. The mammal community in this group is composed of 10 mammal species, 5 of which were carnivores with a wide diet breadth. Jackal, jungle cat, badger, fox and marten mainly feed on small mammals, birds, insects and wild berries which are concentrated in such habitats. The camera traps of this group were distributed in the range of 500-1150 meters altitude. The second group (Group B) had the same number of species. The camera traps here were distributed mainly in the range of 1000-1300 meters altitude. The main vegetation cover at these altitudes was black and Turkish pine woodland with some grassland openings. However, the diversity indices here were even lower than those of community groups with seven species (Groups C & F) due to low evenness. Detection rates for each species in groups C and F were more evenly matched. The camera traps of Group C were on earth roads. The species captured in these camera traps were mainly transient and/or seeking for grazing ground or prey. Therefore, the species with relatively small territory requirements were not captured. Group E reflected the highland communities mainly above 1500 m altitude. Here four mammal species were captured, two of which were the main grazers of the area, red deer and brown hare, and two were predators, wolf and red fox. Because this area was a good grazing ground for deer and hare, wolves were frequently patrolling this area in search of prey. Group F was composed of camera traps which were seldom visited by several species. Two of these cameras were on ridge trails and one on a trail leading to a water source. Lynx and bear were two components of these communities together with fox, hare, wild boar and deer.

The only camera trap, in other words, community group which was not similar in habitat type and vegetation coverage was Group D. The two camera traps in this group were in opposite aspects of the Depel Mountain but shared the same five commonly detected species, wolf, deer, wild boar, fox and hare.

As mentioned in the results the literature research revealed 19 species of mammals in the study area. Jackknife 1 and Jackknife 2 species richness estimators estimated the species number as 15.9 and 18.7 respectively. Jackknife 1 seemed to cover 83% of the species while Jackknife 2 covered 98% of the researched local species number. In this study Jackknife 2 performed better than Jackknife 1.

4.2. Species activity patterns and correlations

Wolves showed activity at almost all time periods of the day but especially during early morning hours and night hours. Can (2008) also found daylight activity to some extent for wolf in a low human disturbance area. However, in this study, camera trap records revealed nearly 25% daylight activity in total for wolves. This result was unexpected for an area with moderate human disturbance, including livestock grazing, logging and hunting activities. The reason for this higher daylight activity is thought to be the positive attitude of local people towards wildlife and the raising of three cub wolves, which should have been demanding lots of food.

Foxes showed 43% activity level at 20:00-24:00 time period when all fox records are considered. This species was largely nocturnal and had only small percent of daylight pictures in the very early morning hours. İlemin (2009) and Can (2008) also found similar patterns in fox daily activity levels, peaking at early night but mostly inactive during daylight. Foxes showed even more nocturnal behavior in valleys where they coexist with jackals. Jackal activity peaked at midnight hours (00:00-04:00). Here fox activity exceeded jackal activity before and after this peak: first during 04:00-08:00 and second during 20:00-24:00. Jackal encounter rate was much higher than fox encounter rate at these trap stations, probably as a result of interspecific competition. Scheinin (2005) proved fox wariness and avoidance of sites where jackals occured.

Brown hares were mainly nocturnal and had only small number of captures during daytime. The activity level peaked at midnight hours where the lynx activity also peaked. This probably shows correlated behavior of this predator to its main prey species in the area. Lynx, however, shows more daytime activity where it is non-disturbed and selects roe deer as the primary prey species where it exists (Schmidt, 1999).

Badgers and martens were almost completely nocturnal. In a study in eastern Poland, Kowalczyk et al. (2003) found average hours for badger emergence from and return to a sett as 19:00 and 03:42 respectively. Only in one camera trap station badgers showed some activity in daylight hours. No human disturbance at this site is thought to be the reason for the daylight activity. The annual activity of badgers was also represented by the camera trap pictures. Badgers showed high activity especially after hibernation ended and throughout the summer. Detection rates declined in autumn but no explanation can be given for this observation. There was no capture of the species in winter months due to hibernation as in many places with a similar climatic zone (Kowalczyk et al., 2003).

Wild boars were also nocturnal showing nearly 90% activity level from dusk till dawn. Their activity peaked at the 20:00-24:00 time period. The only daylight pictures in the 12:00-16:00 period were caused by a single boar group, resting and foraging nearby a trap station throughout an afternoon but were captured as several discrete events. Hunting pressure at this site most probably accounts for the complete nocturnal behavior observed. Wild boars in other parts of Turkey show daylight activity where there is no hunting, such as in Akyatan WDR and Dilek Peninsula NP (Mengüllüoğlu and Bilgin, unpublished data).

When the whole year was considered, red deer were found to be actively grazing mostly at dawn and sunrise but showing considerable activity throughout the day and night. Red deer was the species with the most altered activity behavior throughout the year and between the two sexes. In winter months, there was no significant activity difference between sexes. Both were active throughout the day hours. Stag activity peaked at dawn and hind activity peaked at dusk. Though the stag nighttime activity was higher in other seasons, it decreased in winter most probably due to higher predation risk in snow and to conserve energy in winter (Winnie and Creel, 2007: Gula, 2004). However, in summer and in the rutting season these two sexes showed significant differences in activity. In summer, stags showed 36.3% activity at dawn, sunrise and throughout the night hours, but nearly no activity during the day, most probably to avoid overheating. Hinds also showed major activity at sunrise but there was also nearly 20% activity in the morning hours. Although hinds showed some activity at dusk, their nocturnal activity decreased which could be related with higher wolf activity at night and vulnerability of fawns to wolf predation (Figure 3-15). The high activity level of stags and lower activity levels of hinds especially at night during rutting season are thought to be related with mating behavior. Most of the stags were roaring and searching for hinds through the night while hinds were inactive and probably aggregated in groups in certain high quality mating areas with dominant stags (Carranza and Valencia, 1999).

4.3. Spatial distribution patterns

As in other jackal habitats in Europe (Giannatos et al., 2005) jackals in the study area were distributed in valleys and near wet areas of streams and Aladağ River below 1000 meters but mainly at the 500-750 m belt. This species was highly associated with water courses, especially in the western part of the study area.

Though it is widespread in the study area, red deer was mainly found in Depel Mountain part of the study area above 1000 meters altitude and mostly captured in trails leading to forest openings and at higher elevation grasslands. The distribution of red deer in the area was highly associated with valuable grazing ground. Uplands were used mainly in winter while in summer intermediate elevations were preferred. However this species was also captured in valley bottoms near fields and orchards and at passages between two parts of the study area, especially during mating and winter seasons. Altitude at the Elmabel Ridge ranges between 1100 and 1300 meters, and as it is not covered by heavy snow in winter, deer seem to prefer this ridge then. Similar habitat use patterns were observed also in red deer habitats in Europe (Luccarini et al., 2006; Pepin et al., 2008; Zweifel-Schielly et al., 2009).

Wolf distribution largely coincided with both deer and livestock presence in the study area. Depel Mountain part was regularly patrolled and used as main territory by a wolf pack. Wolves were mainly photographed along earth roads, main trails and trails above the tree zone where red deer and livestock graze. The altitudinal distribution was also similar with deer and livestock as main prey items. At Elmabel Ridge wolves were only recorded at a station on an earth road which was regularly visited by at least two individuals.

Brown hare was widely distributed and captured at almost all camera trap stations except for one camera trap under a stone bridge. The highest densities of hares were at forest openings, uplands above tree zone and secondary steppe surrounded by pine woodlands in both Depel Mountain and Elmabel Ridge. This species was the widest ranging herbivore of the area.

Lynx was restricted to pine woodlands of Depel Mountain with some openings. The habitat preference of this species was correlated with both hare and deer presence. Other habitats at lower altitudes and the human disturbed areas were avoided by this species. Similar patterns were also found for lynx by Basille (2006) in a human dominated landscape.

Stone marten preferred valleys, water courses with riparian vegetation and humid slopes with dense vegetation in the study area. Dry or sparsely vegetated areas were not preferred. In a study on radio-collared martens in a fragmented landscape, Rondinini and Boitani (2002) also found similar habitat preferences for this species.

Eurasian badger was found mainly in middle elevations and lower altitude valleys. As its main food resources (i.e. invertebrates, small vertebrates and wild berries [Balestrieri et al., 2004]) were concentrated at these habitat types, this restricts badgers to the lower lands.

Wild boar distribution was correlated with available food resource and risk of predation. The main wolf territory in Depel Mountain was used to a lower extent and mainly by male boars. Female boars generally used valleys where water courses, agricultural field and orchards occur. Highest density wild boar sites were in the surroundings of Elmabel Ridge where wider agricultural croplands occur. Here wild boars used both cropland and walnut groves as food resource when available. Similar habitat use patterns were found also in Italy by Boitani et al. (1994).

Red fox was a generalist carnivore and distributed throughout the study area. However, its density was lower in high density jackal and wolf sites compared to other sites. This is thought to be the result of intraguild avoidance behavior of this species (Scheinin et al., 2005, Giannatos et al., 2005)

As a habitat specialist jungle cat was captured only in a station placed in the riparian vegetation of Aladağ River. This species was not photographed in any other trap stations in the valleys. Hence, in the study area it is believed to be restricted to the Aladağ River course.

Although, its presence and habitat used in a wider area, brown bear was only captured at a trap station at a middle elevation pine woodland. This species is known to use valleys in spring and summer as orchards and croplands present good food resource (pers. comm. with locals). On the other hand, thorn apple and other wild fruits at higher elevations were consumed in autumn before hibernation as revealed by scat contents.

4.4. Altitudinal distribution patterns

When the three canid species are considered, foxes were encountered at all altitudinal levels; however, they showed lower encounter rates in the presence of larger predators apparently to reduce the risk to be killed. In valley bottoms golden jackals were very common. Here, the fox detection rate was half of the jackal detection rate, most probably due to interference competition between these two species (Scheinin et al., 2005, Giannatos et al., 2005). No fox picture was captured in Akyatan WDR where jackal detection rate was very high (55.56 events/100 CTD) and jackals formed big family groups (Mengülloğlu and Bilgin, unpublished data). Foxes responded with almost twofold increase in detection rate to a decline in jackal detection rate at the 750-1000 m belt. Jackals themselves were completely excluded from wolf habitat from 1000 m upwards. Giannatos (2005) also found similar altitudinal distribution patterns in Greece and interpreted that a result of competitive exclusion. Foxes were relatively rare also at the 1500-1750 belt where little or no woody plant cover was present, but wolves were frequently captured at this altitude. A higher risk of detection by wolves due to lack of plant cover as hiding refuges would account for the rarity.

Wolves were captured mostly at the 1000-1250 and 1500-1750 m belts which were also the altitudes where red deer showed the highest encounter rates. In summer livestock also used these altitudes. Brown hare detection rate was also high at these altitudes. Wild boars that were captured above 1000 meters where also wolves occur were mainly males, which are relatively safe from predation due to their large size and formidable defenses. Only one group of females with juveniles was captured in wolf habitat. Other females or female groups were captured below 1000 meters where they found more food and where wolves apparently did not visit. Wolves are thought to prefer habitas where their main prey occur while female wild boars with young probably seek habitats with the lowest predation risk. Lower altitudes present more and easy food while decreasing the predation risk by wolves which are replaced by jackals here that are easier to cope with.

Lynx detection rates at different altitudinal belts (1000-1250, 1500-1750 meters) were highly correlated (r=0.83) with hare detection rates above 1000 meters where the two species coexist (Depel Mountain part). These were also the two altitude belts where detection rates for red deer were the highest. Although the main prey of lynx here is thought to be brown hare, deer fawns chould also be taken as prey in some instances by lynx as in other regions (Okarma et al., 1997; Schmidt, 2004).

4.5. Individual identification and population estimates

Ambarlı (2005) estimated the bear density in Yusufeli as 11-27 adult individuals per 100 km^2, in another study Can (2008) estimated the population density as 4 adult individuals per 40 km^2 in Yenice Forests, which makes 10 individuals per 100 km^2. The low density in this study area may be attributed to the habitat type and absence of good food resources for bear. The both study sites in Yusufeli and Yenice offer more edible plant material for bear as a source of food.

The wolf pack that roams Depel Mountain part was known to be made up of at least five individuals, two alphas and their three dependent young. Around the time cubs were born another juvenile, most probably the young of the previous year, was also captured here but not included in the estimate because it was not captured later. The Elmabel Ridge is isolated from Depel part by deep valleys and villages. Although red deer are known to cross the valleys between these two higher elevations, this mostly occurs when deer come down to drink water, graze on agricultural crops or search for mates in the rutting season. The wolf pack of Depel part, therefore, is assumed to use the Depel territory and the big patch of black pine forest outside the study area to the north-east. At least two different individuals captured on the Elmabel Ridge are thought to be members of another pack that roam this ridge and surroundings where it is also a livestock grazing area. In total, five individuals from Depel and two individuals from Elmabel Ridge make a conservative estimate of seven wolves using the study area as part of their territories.

The capture events revealed 4 individuals of lynx which used at least a part of the study area during the whole or part of the year either temporarily or permanently. Lynxes were captured only in Depel Mountain part of the study area. The habitat assumed to be suitable for lynx in Depel Mountain was relatively small for four lynx individuals when compared with other lynx habitats in Europe. The available habitat here is not larger than 100 square kilometers, which is smaller than any adult female lynx home range size in Europe (Herfindal et al., 2004). Moreover, the four individuals were captured in very closely located camera traps,within a polygon of 16 square kilometers. Herfindal et al. (2004) showed that lynx home ranges are be negatively correlated with prey density, which may also account for the situation in Depel Mountain where high density brown hare and red deer populations are present. However, at any time no more than two identifiable individuals were recorded within a month, therefore a high turnover of territory ownership where one lynx replaced another during the study period is also possible. This indicates an estimated resident lynx population of 2-4 individuals in the study area.

CHAPTER 5

CONCLUSIONS

This study used camera trapping as an inventory tool for understanding the species composition and diversity in a fragmented pine woodland with intermediate human disturbance, and provided valuable inferences about activity patterns, habitat selection, altitudinal and spatial distribution patterns, competitive and predatory interactions of large and medium sized mammal species.

Brown bear, wolf, Eurasian lynx, golden jackal, jungle cat, red fox, Eurasian badger, stone marten, red deer, wild boar, brown hare, Caucasian squirrel and southern white-breasted hedgehog were the 13 mammal species that were captured in the study.

The study provided valuable information especially on secretive and rare species like the Eurasian lynx. For example, it indicated that this species can exist in high densities in a relatively small area when prey species are abundant.

The study area is one of few areas in Turkey where three species of canids are still able to co-occur in healthy populations. Spatial segregation was observed between species as evidence of intraguild competition and competitive exclusion.

Prey-predator interactions were well documented at both spatial and temporal scales between wolves, deer and wild boar. Prey species used different tactics to avoid encounters with the predator. Wild boars used altitude and deer used time as a refuge to avoid wolves.

Being a year round survey, this study provided information about seasonal and daily activity patterns of species. Seasonal activity patterns of wolves and the both sexes of red deer demonstrated the high activity difference between seasons. This was also the first study representing the hibernation period and annual activity patterns of Eurasian badger in central Turkey.

The low encounter rates of particular species such as Eurasian lynx, brown bear and jungle cat, indicates the importance of the length of study. High effort should be spent in terms of trapping days to encounter low density species.

Population size estimates in camera trap studies can be made for certain species such as made for Eurasian lynx, brown bear, wolf and jungle cat in this study.

This study has revealed a high mammal diversity in spite of human activities such as livestock grazing, logging and hunting. Along with the mammal fauna, a high diversity of raptors and other bird species indicates the intactness of the ecosystem here. Such studies can demonstrate the nature of human-wildlife interactions besides the diversity and ecology of the wildlife and can form a good baseline for conservation and management efforts.

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Appendix A

TWINSPAN CLUSTERING DATA

		GROUPS																											
		A								B								C		D		E					F		
	STATION->	2	25	27	28	29	16	18	22	4	5	6	26	19	20	23	24	1	9	10	15	30	7	11	13	8	21	17	12
1	C aureus			4	2	4			3				2			2													
4	*E concolor*			2																									
5	*F chaus*					2																							
8	*M foina*			2		3	3		2	2	1	2		2	2	1													
9	*M meles*			2	4	5	1		2	4	2	3	2	2				1											
10	*S anomalus*	1	3	4	2	2	2	2	4					1															
11	*S scrofa*		4		2	3		3		4		2	1				2	2	2	3	1							2	1
13	*V vulpes*	1	3	3	2	3		1	2	4	5	4	4	3	3	4	4	3	1	2	3		1		2	2	2	2	1
2	*C elaphus*		2	1	2	1	2			1	3	5	5	4	2		3	2	3	4	3	5	2	3	2	4	2	1	
3	*C lupus*											3	2					3	3	5	1			2	2	2	1		
6	*L europaeus*	2		2	5	4	3	3		5	4	5	5	4	2	4		3	2	3	3	2	2	2	4	5		1	1
7	*L lynx*												2						2								1		1
12	*U arctos*																										1		