Turkish Journal of Forestry | Türkiye Ormancılık Dergisi
2018, 19(1): 57-62 | Research article (Araştırma makalesi)

Investigation of fallow deer (*Cervus dama* L.) population densities by camera trap method in Antalya Düzlerçamı Eşenadası Breeding Station

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Abstract: In Turkey, it has been aimed to take a number of measures to protect and breed fallow deer, which is under danger of reduction of population, even extinction. One of these measures is Antalya Düzlerçamı Eşenadası Fallow Deer Breeding Station (EFDBS). Fallow deer is protected in this area, where measures and improvements are taken to the maximum for breeding fallow deer in its natural environment. 55 out of 170 mammal species are critically endangered in Turkey, and one of these is fallow deer (*Cervus dama* L.). This study aims to investigate the population densities of individuals spread in the EFDBS at Antalya Düzlerçamı Wildlife Development Area with 521 ha of land using the method of camera traps. Density calculations were made using the method of individual identification based on spot distribution and antler structure of individuals. The information provided by the Jackknife Model was used to determine population densities. "CAPTURE" software was used for the analysis of the data. Based on the obtained results, maximum of 120, minimum of 96 and average of 105 fallow deer individuals were found. According to these results, fallow deer population density was 20.1/km^2 in the study area.
Keyword: Fallow deer (*Cervus dama*), Camera trap, Capture-recapture, Wildlife inventory

Antalya Düzlerçamı Eşenadası Alageyik Üretim İstasyonu'nda fotokapan yöntemiyle alageyik (*Cervus dama* L.) popülasyon yoğunluklarının araştırılması

Özet: Ülkemizde, nesli bu denli azalma hatta yok olma seviyesine gerileyen alageyik için bir takım koruma ve üretme tedbirleri alınmak istenmiştir. Bunlardan bir tanesi, Antalya Düzlerçamı Yaban Hayatı Geliştirme Sahasında kurulan Eşenadası Alageyik Üretme İstasyonu'dur. Alageyikler bu alanda koruma altında olup, doğal ortamında üremesine yönelik maksimum önlemlerin ve iyileştirmelerin yapıldığı bir alandır. Ülkemizde yaşadığı saptanan 170 memeli türden 55'inin nesli önemli ölçüde tükenme tehdidi altında olup, bunların en önemlilerinden bir tanesi alageyik (*Cervus dama* L.)'dir. Bu araştırmada, fotokapan yöntemi ile 521 ha alana sahip Antalya Düzlerçamı Yaban Hayatı Geliştirme Sahasında bulunan Eşenadası Alageyik Üretme İstasyonu içerisinde yayılış gösteren bireylerin popülasyon yoğunluklarının araştırılması hedeflenmiştir. Yoğunluk hesaplamaları, bireylerin benek dizilişinden ve boynuz yapısından birey tespiti yöntemi kullanılarak yapılmıştır. Verilerin analizi için "Capture" bilgisayar programından faydalanılmıştır. Populasyon yoğunluğunun belirlenmesi için Jackknife Model verileri dikkate alınmıştır. Elde edilen sonuçlara göre maksimum 120 birey, minimum 96 ve ortalama 105 Alageyik tespit edilmiştir. Elde edilen bu sonuçlara göre çalışma alanında alageyik populasyon yoğunluğu 20,1/km^2 dir.
Anahtar kelimeler: Alageyik (*Cervus dama)*, Fotokapan, Capture-recapture, Yaban hayati envanteri

1. Introduction

It is known that fallow deer population is 8.000 in Germany, 62.000 in the United Kingdom, 18.000 in Hungary, 12.500 in Romany, 11.600 in France and 250,000 in total in Europe, between 15,000 and 35,000 in New Zealand and 28,350 in Canada, while it is about 450,000 in the world (Heidemann, 1976; Ueckermann and Hansen, 1994; Kaçar, 2002). Despite the fact that the native land is Turkey, the last natural fallow deer population in the world is known to be Antalya-Düzlerçami. The fallow deer is categorized as LC (Least Concern) in the world, as it is spread around the world, and the species is not under the threat of extinction in the near future (IUCN, 2016). However, in Turkey in the last century, it has been seen that fallow deer populations are increasingly in danger of reduction or even extinction especially due to illegal hunting, increase in urbanization parallel to the human population, dense forestry, and agriculture activities, grazing of domestic animals such as goats and sheep, and deterioration of endangered environments of human pressures in fallow deer fields (Heidemann, 1976; Saribaşak et al., 2005; Chapman and Chapman, 1997). Although it is not categorized in any way in terms of our country, taking into account that the species is the most endangered mammal species, it would be a correct approach to treat it as a CR (Critically Endangered) status (Sevgi et al., 2013).

In the scientific research, inventory method with camera-trap gives more positive results in speckled species such as fallow deer. Trolle and Kerry (2003), Connolly (2007), Meek et al. (2012) and Keuling et al. (2012) reported that camera-traps were produced primarily to monitor wildlife populations and Mengüloğlu (2010) reported that camera-trapping is particularly useful for

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✓ **Received** (Geliş tarihi): 20.09.2017, **Accepted** (Kabul tarihi): 20.12.2017

Citation (Atıf)**:** Ünal, Y., Çulhacı, H., 2018. Investigation of fallow deer (*Cervus dama* L.) population densities by camera trap method in Antalya Düzlerçamı Eşenadası Breeding Station. Turkish Journal of Forestry, 19(1): 57-62.
DOI: 10.18182/tjf.339042

identifying striped or spotted species on an individual basis. The method of camera trapping is especially beneficial in identifying wild mammals, as well as determining activity patterns (Soyumert, 2010; Foster and Harmsen, 2012; Can, 2008; Griffiths and Schaik, 1993). Both random-opportunist and systematic methods are used in wildlife studies to collect information regarding wild animal populations with camera trap method. Method of systematic is the work done by establishing certain distance between each camera trap (Harmsen et al., 2011).

The capture-recapture method is a frequently used method in determining population sizes and densities by using biological parameters of populations (Chao et al., 2001; Karanth and Nichols, 1998; Marker et al., 2008; Wang and Macdonald, 2009). This method provides reliable scientific and comprehensive results in studies on enclosed wild animal populations (Chao, 2001). The software Capture is frequently used to estimate the maximum, minimum and average population sizes of fallow deer (Rexstad and Burnham, 1991; Silver et al., 2004). This program is often used in predicting the population size, starting from the frequency of capture and recapture of camera traps in study areas. This method reveals the minimum, maximum and average sizes of the population by allowing comparison of different statistical methods and their combinations (Silver et al., 2004).

2. Material and method

2.1. Material

Antalya Düzlerçamı Wildlife Development Area is the only area in Turkey where the fallow deer live naturally (Anonymous, 2013). Düzlerçamı WDA was declared as a land of 28,972 ha area in 2005. The area is divided by the road between Antalya and Korkuteli. It was determined that the fallow deer lived in numerous regions in Turkey, based on drawings and remains from the period of Hittites, as well as fossils found in various places such as Van, south of the Salt Lake, and the Marmara Region (Ducos, 1988). The fallow deer, known to had lived in the Marmara, Aegean and Mediterranean Regions naturally in the 19th century, remained only in the Antalya-Düzlerçamı region today in small numbers due to illegal hunting and disruption of their habitat (Figure 1). Turan (1966) determined that fallow deer were living in Antalya-Düzlerçamı and Manavgat Regions and led to the departure of Düzlerçamı region as Wildlife Conservation Area and establishment of a fallow deer breeding stations in it. In 1974, the first station in operation was inadequate in terms of the number of animals it hosted, fallow deer were transported to the EFDBS in 2003 in the natural environment and in wider and more favorable conditions (Figure 2).

The study area is located 25 km west of Antalya, within the borders of Antalya Regional Directorate of Forestry, Antalya Central Administration, Düzlerçamı Forest Administration Management. It is surrounded by the Güver Cliff Canyon, Yukarı Karaman residential area and Korkuteli Road in the east; Termessos National Park following Korkuteli Road, Yeşilkayrak and Akkaya in the north, Gürkavak, Mecene Canyon and Kozdağ in the west; and residential areas of Doyran, Aşağı Karaman and Antalya in the south. The area provides to fallow deer for suitable habitat with its rich flora, water resources and geographical structure.

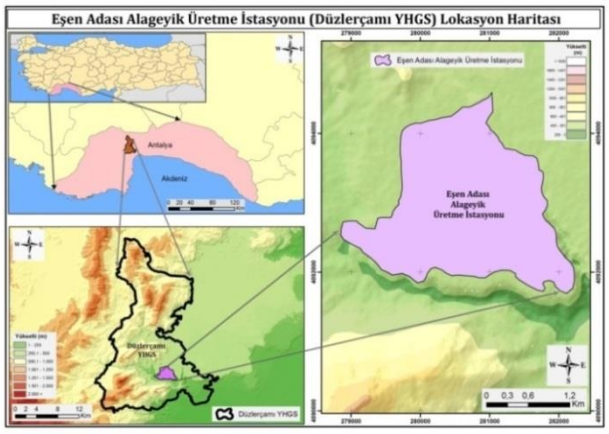

Figure 1. Düzlerçamı Wildlife Development Area and Eşenadası Fallow Deer Breeding Station

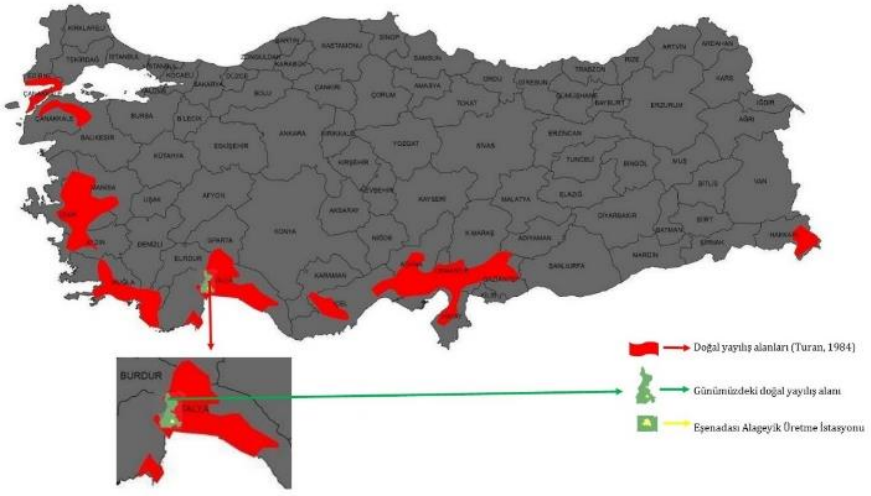

Figure 2. Distribution of the fallow deer in Turkey in the past (Red) and today (Yellow)

In the study, we used 16 Cuddeback Attack Model: 1149 camera traps to determine for deer number, Canon EOS 600D to take photographs for fallow deer habitat and Magellan Trioton 400D to measure for each plot's altitude, coordinates of sampling plots.

2.2. Method

Preliminary studies were carried out to determine tracks and sings of the fallow deer in the region before the camera traps were set in the area. As a result of these studies, fallow deer footprints and feces were observed. During the camera trap study, 16 Cuddeback Attack IR 5MP passive camera trap were used. Field studies were carried out in two periods between 2014 and 2015 in pre-determined camera trap stations set in intervals of 400 m (Figure 3). The data obtained from the camera traps that were set across each other were transferred to the electronic center, stored and the office work was done to calculate the density (Figure 4). Population density was determined by dividing the estimated population size by the effectively sampled area, and variance was calculated as described by Karanth and Nichols (1998). The information collected by camera traps set across each other was transferred to electronic environment, stored, and used to calculate density. Total 80 camera trap stations were distributed in the region in a certain systematic and across each other.

2.3. Identification of individuals

Microsoft Paint was used as an alternative method for individuals' identification. The images obtained from camera traps were analyzed in detail, image data in each plot suitable for identification were divided into plots and years, and stored. The most important characteristics distinguishing fallow deer from other deer are the white spots on their bodies and their prong-shaped antlers. Except for the winter months, all fallow deer have spots. Considering these morphological features of fallow deer, female individuals were identified using the distributions of their spots, while male individuals were identified in the same way except for the winter months and using their antler structure in winter months. In the following stage, with these data, individuals were identified starting with the first two plot areas, considering antler structure and spot distribution. Against the possibility of different individuals having similar spot distributions and antler structures, the images were transferred to the Microsoft Paint software. Here, spot distributions and antler structures were compared by drawing in the software and different individuals were numbered (Figure 5a, 5b, 6a, 6b).

Individual identification of fallow deer in the area was achieved using the capture-recapture method based on the morphological characteristics of the deer. Our analyses were carried out based on the data obtained by camera traps. The data obtained from the camera traps that were set across each other were transferred to the electronic center and stored and the office work was done to calculate the density (Table 1).

Figure 3. Camera trap stations

Figure 4. Opposing camera traps (plot 4-8)

Figure 5a. Male individual No: 9

Table 1. Capture-Recapture calculation

$$\frac{x}{y} \cong \frac{X}{T}\dot{T} \cong \frac{y}{x} .X$$

X	number of individuals captured and marked in the first sampling
y	number of individuals independently captured in the second sampling
x	number of previously marked and recaptured individuals
T	total size of population (total number of individuals)
Ṫ	Estimated population size

Figure 5b. Male individual No: 50

Figure 6a. Female individual No: 2

Figure 6b. Female individual No: 31

"The Capture" population size estimation software was used to determine the maximum, minimum and average population size, as well as population density (Rexstad and Burnham 1991; Soria-Diaz and Monroy-Vilchis, 2015; González-Pérez, 2003; Ortega et al., 2011). In order to estimate population size, capture-recapture information was entered (Silver et al., 2004), and the data obtained from population estimation methods of Jackknife-M(h) (Silver et al., 2004) and Removal-M(bh) were utilized. While the resulting values ended up very close to each other, *Jackknife Population Density Values*, recommended by Orekici-Temel et al. (2012) and reported to have better results, were used.

3. Results

A total of 8,120 camera trap days was reached in 80 plot areas for 203 days. Totally 1232 images and videos were obtained in 2014 and 2105. Respectively 527 and 464 wild animals' images and videos were determined in these stations (Table 2).

As a result of the study, 19 females and 33 males in 2014, 14 females and 14 males in 2015 totally 80 fallow deer were determined and identified. 15 fallow deer were recaptured in the study (Table 3).

Confidence interval in Jackknife-M(h) population size and density detection was found as 95%, and SE was found as 6.25. Table 4 shows the minimum, maximum and average population size values and density values.

Based on the obtained results, a maximum of 120, minimum of 96 and average of 105 fallow deer individuals were identified. Additionally, the number of individuals found in our studies in 2014 and 2015 were based only on adult individuals and fawns were not taken into account. About 20 fawns were found in the data obtained using camera traps and Capture-Recapture method provided us with the total number of adults and fawns as 105 + 20 = 125. According to these results, fallow deer population density was 20.1 / km^2 in the study area.

Table 2. Analysis of camera trap images

Year	Total camera trap station	Number of images	Number of empty camera trap images		Total number of wild animal images obtained from camera traps		Number of fallow deer images (=D)	
		A	B	B*100/A	(A-B)= C	C*100/A	D	D*100/C
2014	40	654	127	19.4%	527	80.5%	500	94.8 %
2015	40	578	114	19.7%	464	80.3%	408	87.9 %
Total	80	1232	241	19.5%	991	80.4%	908	90.8 %

Table 3. Fallow deer captures and recaptures by study site, with estimated capture probability (average p-hat) per sampling occasion under the jackknife model of variable probability of capture (M(h)).

Year (2014-2015)	Total Capture - Recapture	Individuals / year		Individuals recaptured	Individual fallow deer census					Average p-hat
		2014	2015		Male	Male Rate %	Female	Female rate %	Population size	
Total	80	52	28	15	33	58.75	19	41.25	97 (± 22)	0.51

Table 4 Results of fallow deer density estimates using the Jackknife and Removal population model M(h) and variable probability removal estimator in which capture probabilities vary

Jackknife-M(h) Model				Density average (km^2)	Removal-M(bh) model				Density (km^2)
SE	Min.	Max.	Average		SE	Min.	Max	Average	
6.25	96	120	105	20.1	7.48	97	126	108	20.7
Population Density (95% confidence interval)									

4. Discussion

This study was conducted in the EFDBS, Antalya Düzlerçamı WDA by the department of Wildlife Ecology and Management at the Faculty of Forestry, Süleyman Demirel University. In this context, this study will provide sufficient resources on literature and methodology to the other similar studies. It was carried out to determine the population size and density of the fallow deer populations in the study area. Some similar studies (Arslangündoğdu, et al., 2010; Saribaşak, et. al., 2005) had been carried out to determine the population size and density of the fallow deer population in the study area, but this is the first study in Turkey which used the camera trap method to determine the population of fallow deer. The camera trap study and set up of the stations were achieved after finding the general distribution of the fallow deer in the area.

A field study of 203 days, including 82 in 2014 and 121 in 2015, was carried out in the area. In these studies, camera trap station was established and in a certain period of time, it has been left fixed. In studies carried out in two periods, it was obtained 3,280 camera trap days in the year 2014 and 4,840 days in the year 2015. In a similar study by Soyumert (2010), again in Turkey to determine wild animal species by camera traps, daily camera trap value of 4,142 was achieved by 55 camera trap stations. Considering the obtained data, 80 different individuals (47 male, 33 female) were identified in the field. In one of the similar studies, Mcshea et al. (2011) used camera traps to estimate deer population densities in Catoktin National Park (24.2 km^2) and Antietam National Park (13.5 km^2). Mcshea et al. (2011) placed 20 camera traps in each area with 200 m intervals and collected data in intervals of 2-5 days. As in various wild animal species such as lynxes and tigers, fallow deer also have natural signs. The most obvious of these natural signs are the spots and antlers. Since the deer are spotted species, the spot arrangements and the antler structures of each individual are different from each other, allowing these individual identification studies to be carried out easily. In their study, Carbone et al. (2001) also reported that this method is effective in determining the existence of the wild species and individuals that are shy or hard to see. In this way, the method of identification of individuals by means of the natural signs and morphological features used in the thesis study has been made easily. As stated by Mengüloğlu (2010) in his studies, individuals can be identified from its pattern or spot and suggested that this method could be effective in individual detection studies in many types of cats. In the light of the results of this method we used in this thesis work and considering the previous studies and projections, it was found that camera traps may be used in identification of individuals and they may provide easiness in other methods.

Based on the obtained results, a maximum of 120, minimum of 96 and average of 105 fallow deer individuals were found. Additionally, the number of individuals found in our studies in 2014 and 2015 were based only on adult individuals and fawns were not taken into account. About 20 fawns were found in the data obtained using camera traps and Capture-Recapture method provided us with the total number of adults and fawns as 105 + 20 = 125. According to these results, fallow deer population density was 20.1 / km^2 in the study area. Kasper et al. (2015), in their study on leopards in an area of 17,500 ha using the capture-recapture method with camera traps, identified 21 individuals from 113 records based on the data collected in 2005, and concluded a population density of 0.26 leopards per 1 km^2. If we compare the results of their study to those of our study, it may be seen that our results are better and more reliable.

The most frequently seen problems for camera traps studies is the failing of some devices. Although batteries and memory cards were suitable for usage, some camera traps did not work in any condition. This may have been caused by the sensor. Considering the image quality in the camera traps, it is considered that the spots of fallow deer passing by in close range especially in the dark reflect a lot of light and this may have decreased image quality. It is additionally thought that the water resources in the area are limited and individuals experience scarcity of water in summer months. Therefore, wet areas such as flowing ponds should be established to satisfy the water needs of the fallow deer.

It is not believed that the wire fences around the area can form a protection element for the entire area. In our walks, it was seen that the area may be entered from various points easily and illegal hunting activities may be seen. Necessary precautions should be taken.

Acknowledgements

The Directorate of Scientific Research Projects Management Unit at Suleyman Demirel University, which funded my thesis with the project no. 4122-YL1-14.

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