

Full Length Research Paper

## Research on the efficiency and performance of camera traps and dome system for wild goat inventory

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This study, carried out in 2009-2010, aims to use imaging technology for wild goat inventory in the study area, because direct counts done by means of labor intensive techniques give high error rates. Camera traps and dome systems are used to investigate the replacement of direct counts done by authorized institutions, using manpower in vast and rough terrains for *Capra aegagrus*. In a total area of 555 hectares, of which 50 were for establishing dome and camera traps, the monitoring system recorded images in predefined hours (07.00 to 09.00; 17.00 to 19.00). These periods also coincide with the selected hours for point counts during periodical inventories for wild goat by the relevant official department. The group size of wild goat was determined as 18. 1, which was captured by the dome camera or camera traps. While dome camera system was not able to monitor the entire group, significant information on the number of the wild goats was via camera system. As a result, if used together, camera traps and dome camera system could contribute effectively to wildlife inventory work, providing 70% of the need for the inventory. The study has shown that it is possible to transfer load of manmade inventory to technology and to achieve much more economical inventories by eliminating the risks and disadvantages caused by human factor

**Key words:** Wild goat (*Capra aegagrus*), inventory, direct counts, camera traps, dome system.

### INTRODUCTION

As the developing imaging technologies have acquired usage in almost all fields, idea of overcoming some deficiencies in wildlife inventories by the help of technology has come into existence (Silveiraa et al., 2003). For the reason, we have designed a wildlife monitoring project with the aim of using technological opportunities.

#### Developing imaging technologies and wildlife inventory

The main focus of the project, conducted in 2009-2010, was to develop and test a new technology based approach

for wildlife inventories in Turkey. The main target of this approach was to transfer the load of direct counts to technology because the former require labor intensive techniques and give erroneous outputs due to extra harassment and pressure brought on observed populations. Accordingly, suitability of camera traps and camera system was investigated as an alternative method for monitoring important hunting and wildlife population.

The study area selected for the project was Yazılıkaya, a potential reserve area planned to be included amongst the 109 wildlife reserve areas of Turkey. Yazılıkaya area lies within the natural distribution for wild goats (*Capra aegagrus* (Erx. 1877)) (Turan, 1987; Gündoğdu, 2006),

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one of the most important game animals in Turkey. Hunting permission was given for the species in a broader area comprising Yazılıkaya by the Isparta Directorate of National Parks (The Official Gazette, 2010; Ünal, 2010). This area is unfortunately under the influence of severe poaching which causes nearly 350.000 TL annual financial loss (Ünal, 2011). It is estimated that at least 30% of the total population is being poached every year.

In order to determine the actual size of the population of the species, a census is carried out by the authorized institution- General Directorate of Nature Protection and National Parks- twice a year (winter and summer periods). Much labor and higher expenses are needed for these types of counts. Furthermore, unrest occurs in the wild goat populations because of the observers who are in charge of the census (Ünal, 2011).

### **Why using technology for wildlife inventory?**

The system used in the study can save data without any need for an observer (Yıldız, 2007). Therefore, this study aimed to eliminate the risks of human factor and disadvantages of direct counts, by using camera traps and dome system.

Using alternative inventory system for wildlife inventory, the hypothesis of this study is that the planned system will reduce cost and improve census quality by minimizing need for manpower and errors originating from observer (Oğurlu, 2003). Apart from being expensive and time consuming, wildlife inventory observations based on direct counts usually have high error rates. Thus, for wildlife inventories, it is obligatory to develop new alternatives, making use of new technological opportunities, in addition to being practical, precise and economical (Ertuğrul, 2007).

On the other hand, owing to the need for an observation method in which error and human factor can be eliminated in order to test direct count success in wildlife inventory, like wild goats in Turkey, camera traps and dome systems should be installed and tested in the study area.

Since there is no mechanism for testing accuracy of widely practiced direct counts in Turkey and no alternative data source is presently used, degree of reliability cannot be measured. Thus, another data source is required for checking of the inventory results. For this reason, the main motive of the study is to evaluate two different data sources together and test the data produced by these comparing previous surveys via direct observations with surveys carried out by camera traps or the dome system.

### **Why are the camera traps and camera system suitable means for inventory?**

Suitability of the camera traps and camera system for inventories, which were tested as an alternative monitoring

method, was investigated in the study area. One of the main targets of the study was to get images of the carnivores hitherto unrecorded but known to be distributed in the area, together with the *C. aegagrus*.

The most important function of the developed imaging technology is to provide possibility of remote observation, which by reducing difficulties of direct counts that need labor-intensive techniques and the disturbance to observed animals minimizes errors of observation (Ertuğrul, 2007).

One of the most essential systems that one may consider for this purpose is to install the dome system that can be set in the field and produce data without any observers and additional camera traps. These can function in observation free of human intervention and produce reliable data. Success rates of camera traps were compared with that of line transect and direct observation counts in a study (Silveiraa et al, 2003), in which camera traps produced very similar results to that of line transect counts. Camera traps can function in the field without any interference for one or two years (Rowcliffe et al., 2008).

Camera traps not only take photos, but also can capture video images by the help of recent technological developments. Installing such equipment into camera trap kit, the data can be obtained as video images instead of photographs. In the so-called 'dome' system, sensors which are able to detect moving objects are present in the camera. The camera activates when an object is detected and it can be followed in the 150° view angle (Yıldız, 2007; Thompson and Thompson, 2007).

Although camera traps have been largely used for surveys, nowadays they are also used for inventories. This is because new age camera traps can store number of detected individuals in their memory with date, day and hour (Wallin, 2005; Sequin et al., 2003).

### **Will the system be successful for inventory as in forest fire monitoring studies?**

The success of dome camera systems in forest fire monitoring studies in Turkey encouraged their use in wildlife inventories, and thought of using dome systems, with sufficient number of camera traps for inventories of targeted animal species in certain areas has emerged in time (Yıldız, 2007).

As the camera traps are fixed in a certain spot, we established a system using dome system in addition to camera traps, and investigated the potential of the system to do wild goat inventory, which is a suitable species for point counts.

With the study, we planned to test the success of direct counts practiced so far for the inventory of game species like wild goat, using camera trap and dome camera systems as an alternative monitoring method in which the human factor and observation error could be eliminated.

Because in such a system, targeted wildlife element can be viewed without intervention in the study area.

Camera data are transferred to computer as moving or still images, and inventory of the target species can be made by analyzing images (Connolly, 2007). The system can follow automatically movements and thus information about the presence/absence of species, habitat use and ethology can be extracted. As the human induced factors are eliminated, animals can exhibit their natural behaviors in the field and their visibility simultaneously increases (Wallin, 2005).

The system has been used by documentary movie producers and wildlife experts. BBC producers used the system for monitoring *Panthera pardus nimr* for two years. The system was also used in National Geographic documentary "King Penguin" (Connolly, 2007). In Turkey, we applied the dome technology, successfully used previously in forest fire monitoring, for wildlife inventory purposes and wild goat. The study's goal was to determine the size of the targeted group of goat population and to identify other species in the study area in 2009-2010.

## MATERIALS AND METHODS

### Study area

The study area is located in a potential wildlife reserve area, Yazılıkaya, in Isparta-Sütçüler-Turkey. This area covered a forest of 18953,5 ha and some cultivated areas of 1079,0 ha. Observations were made in a steep and rocky habitat at the study area which covered 555 hectares of Sütçüler forest, where a wild goat population (2.5 individual/km<sup>2</sup>) lives. With various researches carried out previously in the study area, the following has been found: 65 bird species belonging to 9 order and 29 families from the aves; 11 species of the mammalia, belonging to 5 order and 8 families and also plant species of 42 order and 63 families. The main tree species of the study area were *Pinus brutia*, *Cedrus libani*, *Quercus coccifera* and *Juniperus* spp.

### Establishing the monitoring system and treatments

Four camera traps, 1 dome camera system, 1/25000 topographic maps and Google Earth satellite images of the area were used in the field studies (Figure 1). A 4 x 4 land vehicle (pick up) was used for accessing the study area. During observations, a pair of 10x50 binoculars, one photo camera, one camcorder were used, and to determine altitude and geographic coordinates, a GPS device was used. Camping tents, sleeping bags, coming bags and other camping materials were also used during the camping period.

Along with its biology, distribution and habitat use of the target species in the field are to be taken into account while setting the camera traps. We placed them along lane points, feeding areas, and resting beds of the wild goat group to determine the size of the group with photographs.

Dome camera system, established at the locality where camera traps were placed, was set to capture images from 7.00 to 9.00 am and from 17.00 to 19.00 pm from the visual field of camera traps. Highest diurnal activity hours were selected for the time intervals, also corresponding to the hours chosen by the department (DKMP) for vantage point counts in annual periodic inventories. The dome and camera traps were placed upon an area of 50 hectares within the study area of 555 ha.

We used a camera trap model digitally storing photographic data in 1 GB SD memory cards, allowing 1300 photos on average to be

stored. The dome camera system specifically designed for wildlife studies produces images at 640 x 480 (25 fps). The system works with solar energy as it is used in the terrain.

As the aim of the study was to investigate the feasibility of wildlife inventories using technology, areas frequently used by wild goats were selected in preliminary studies to test the new technology. For a one month period, trails and feces were observed to determine precise points to mount camera traps and the dome system.

According to preliminary data recorded during project, camera traps and the dome system were placed along a certain line matching with locations frequently used by the target species, such as stream banks, lane points and entrances to hiding places or resting beds. With this, the aim was to prove the presence and distribution of any individual detected by the first trap even if he was not in any other traps on the line (Oğurlu, 2003; Campbell, 2008).

### Locations of the camera traps and home range size of the wild goat

As the home range of wild goat changes between 150 to 400 hectares (Gundogdu, 2006), 4 camera traps were arranged along a single line, preferably shaded places at lane points, feeding areas and resting beds at 1.5 km intervals to get a semicircular visual field of 750 m radius. In that way, the slope of a certain mountain could be scanned with camera traps.

The recorded data were analyzed and computerized once a week. Captured wild goat individuals were evaluated via WGGAP3 computer program. Individual determination was made by taking age classes of individuals into consideration.

Dome camera system was used as a closed circuit system. The data, obtained at the programmed time intervals during the day, were transferred to 500 GB hard disks. As the data size was approximately 300 GB per week, the hard disks were checked once a week. The camera was programmed to work in limited hours and monitor the land in the day time.

In order to assess the success of the established system, one of the points most frequently used by species was determined and also utilized by DKMP for point counts; the visible area was determined as the sample area. In this area, some observations were carried out by taking advantage of the existing monitoring network and the vantage point counts system used for wild goat between 2004 and 2006 by GUNDOGDU (2006). Periods of the highest activity, 2 to 3 h after dawn and 2 to 3 h before sunset, were determined as the time of observation in summer period. Considering that the wild goats are active throughout the day in winters, winter observations continued from sunrise to sunset in the winter period.

In calculating the observation results, population density within the sample area was evaluated independently. Population size was estimated by comparing each observation data with that of previous observations. Thus, possibility of duplicating observation counts was eliminated.

## RESULTS

### Observed numbers of wild goats in direct counts

In the area surveyed by both direct observations and monitoring system-dome and camera traps- those count data were obtained from observation (Table 1).

According to the field data given in Table 1, the largest wild goat group was determined in 15<sup>th</sup> August, 2010 as 18 individuals. The area is utilized by a single group under the leadership of a six year old male, which could be observed moving with females only during courtship

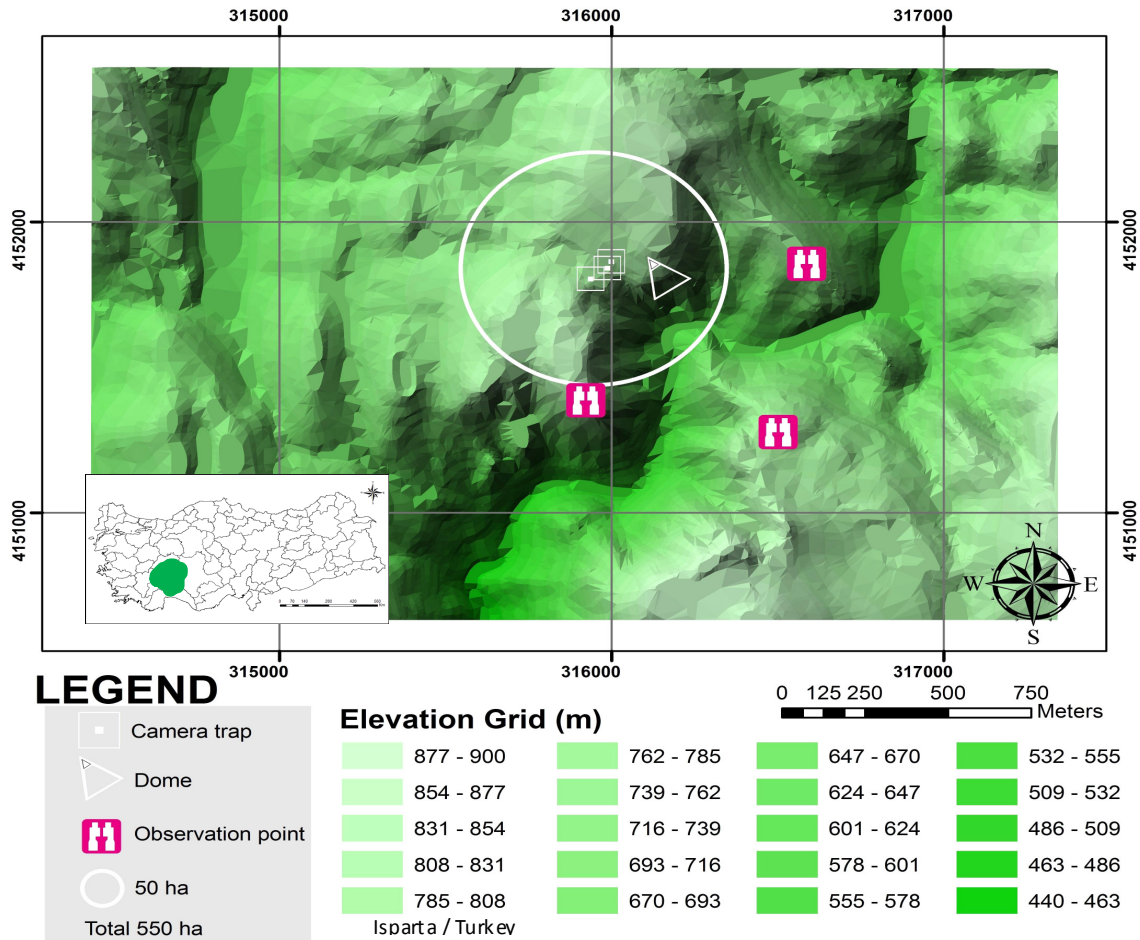


Figure 1. Camera traps and dome system in the study area.

Table 1. Direct observation (point count) data of wild goats from the study area.

Dates of direct observation and recorded wild goat numbers				
20.07. 2010	11.08.2010	15.08.2010	01. 09.2010	15.09.2010
5 Females	2 Males	3 Males	1 Male	1 Male
2 Young male	5 Females	6 Females	-	4 Females
1 Kid	4 Young males	4 Young male	-	5 Young males
-	6 Kids	5 Kids	-	-

period. The other males were 3 to 4 years old and found always mixed with females.

**Comparative numbers with direct counts and camera traps**

In direct observations during April and May (breeding season), no individuals could be seen. Likewise, the camera traps and dome systems could not record any individuals in the same period. On the other hand, camera traps recorded 14 different wild goat individuals in this period.

As the camera trap data are compared with that of direct observations, a similarity of 78% can be seen with these two observation techniques.

It is seen that GB memory cards were fairly enough for the aim of the study. Besides, the camera traps produced photos having 3 megapixel picture quality, which gave much better results during the day than night. However, it has been determined that the infrared rays used by the camera traps were affected negatively by sunlight in day shots.

Except for the target species, *Alectoris chukar*, *Sus scrofa*, *Vulpes vulpes*, *Martes foina*, *Lepus europaeus* and

*Buteo rufinus* were the species recorded during direct counts. Among these, three species (*V. vulpes*, *S. scrofa* and *M. foinea*) could be photographed by camera traps.

## Conclusion

Wildlife surveys are an effort to detect species that are of conservation or management concern. Most of the focus is on locations where species of interest are detected. Of equal importance is there are areas where the species is not detected. It is only through a rigorous comparison of detection and non-detection sites can managers learn the factors that regulate the distribution of species. Therefore, a critical issue is discriminating between non-detection sites where the animal is absent and non-detection sites where the animal is present but not recorded (Girman et al., 2009). Regarding this we believe that the use of cameras does eliminate some problems of detection based on sign in wild animal census in the study area.

It seems to be a standard protocol or operating procedure that general wildlife census needs to be established at the national level, which suits local needs and the environmental setting (Azlan, 2009) in Turkey. Such a census must also be assured minimum efforts and design needs to be determined based on habitats (Azlan, 2009). For this reason, we hope that the study can lead authorities to apply a new inventory system in Turkey,

This study aimed to test a new and technology based inventory system to replace the direct count based inventory system used to be practiced for *C. aegagrus* inventories in the study area. The basic of the system is to perform counts done so far by labor intensive methods with the help of imaging technology. Dome system and camera traps were used in this study to investigate replacement of direct counts having been applied in vast areas with rough terrain. This system was chosen due to its capability to strongly replace the old system, though it is not able to fully replace it.

## Functionality and usability of imaging technologies against direct counts

The study involves a general full year survey performed by direct and indirect observations and imaging based wildlife observations. According to the inventory of one year period, in the study area selected for census of the target species *C. aegagrus*, imaging technologies proved to be functional.

As the main target and focus of the study was to test the new technology, in the preliminary study camera traps were placed subjectively to points most frequently visited by the wild goat to give a chance to this technology. This type of locating is also in accordance with the principle of direct counts. As the group size is determined by the largest group observed in direct counts, aiming the largest number of images is considered a realistic and consistent

approach.

## Comparison data from camera traps to direct count results

Wild goats recorded by the dome system and camera traps showed the same appearance with the individuals observed during direct counts. Establishment of the dome system in an area where we surveyed via direct observations enabled the testing of the two data sources together. Camera traps, when compared with the results of the inventory based on direct counts, yielded approximately 78% success. According to the targets of the study this result can be accepted as a good success. It is notable that this success has been brought by systematic arrangement of the camera traps and experience with the study area. 1 GB memory cards used for storing image data were found to be satisfying for reaching the targets of the study.

Although, the camera traps produced fairly good results in day shots, infrared rays were found to be affected by the sunlight; this disadvantage was eliminated by moving camera traps to shaded locations.

## Usability of imaging system for wildlife inventories in Turkey

Dome system was used in Turkey for wildlife monitoring for the first time. For approximately one year period, suitability of the dome system in wildlife monitoring was tested and convenience of the system for the purposes of the study was investigated.

The system was used in field conditions, thus could be fed by sun energy. But this added more dimensions to the equipment and a new problem affected the safety of the system, which formed the most important disadvantage of the system.

The technology used in the study is found to be suitable for wildlife inventories. According to the results of the study, the performance of the dome system is thought to be less successful than expected. Although results of camera traps were found satisfactorily enough, and even better than expected, dome system records produced images with poor clarity in occasions due to low capabilities of the software to detect movements in the range of only 100 to 200 m. This is a disadvantage. Usually, focusing on a moving object occurred, but because of clarity problem, target species in some images could not be identified. On the other hand, individuals or groups of the target species could be observed by eye in the same parts of the habitat scanned by the system. This means that an object that can be seen during direct observations may not be identified or seen in dome system records. Therefore, it can be said that the dome system was successful in detecting the target objects in the study area, but unsuccessful in producing clear images for identification. But, supporting the dome system by means

of advanced software in the future will eliminate this disadvantage.

The study showed that camera traps, when located precisely and at the frequently visited points could easily give sufficient information about group sizes. But to achieve this, different individuals recorded by camera traps should be identified and this necessitates probable group structure of target species to be known before hand to form a basis for analysis of potential images.

One of the targets was to determine mammal species other than target species in the study area (Çanakçioğlu and Mol, 2006; Başkaya et al., 2008). The study can be said to be successful regarding the target and camera traps that were used to determine other mammal species in the area. Especially, the nocturnal species, *V. vulpes* and *M. foina*, which are seldom recorded during the day were determined by camera trap records. Failure to detect rarer species *Lynx lynx* and *Caracal caracal* means the camera traps were not placed in habitats suitable for such species.

Density may not be the end goal of camera-trap studies. In some situations, an abundant estimate may be preferred (for monitoring population trends in a given area) (Foster and Hamsen, 2011). However, another target of our study was the determination of the population size of wild goat. Population size was determined as 18 in 2009–2010 period. Year round point counts revealed no individuals in April and May, as well as direct observations or camera traps and dome system. April and May coincide with the end of the breeding season of the *C. aegagrus* (Gündoğdu, 2006; Ünal, 2011); hence this condition is explained by preference of females to move around in their late pregnancy. On the contrary, in daily observations in the field, sightings of *C. aegagrus* peaked in December-January and June-August periods. Also the camera trap data were most abundant in these periods.

As widely practiced *C. aegagrus* inventories are based on point counts in Turkey, success is largely dependent on the number of observation points and observers. However, once set in the field, controlling of the camera traps only by a single person in certain intervals may be enough to get an idea of relative abundance of the targeted species. On the other hand, the camera trap set can be transported to another location after finishing a study to be used repeatedly. These account for subtle saving from personnel expenses.

In Turkey, wildlife inventories are held by the Provincial Organization of General Directorate of Turkish Nature Protection and National Parks. In the context of these studies, the inventory of wild goat is carried out by applying direct counts, being the commonest census method for the species in Turkey. To successfully apply this method, according to Isparta Directorate of Forest and Environment (ULKER, 2010), an annual cost of approximately 20000 TL (involving winter and summer census) is needed. However, it is seen that similar results can be obtained by regular control of the dome system.

On the other hand, same system can be used for years and in different areas for *C. aegagrus* inventory. As the system has practically no expense except for the periodical care, the sole item of expense remains the first establishment cost. Accordingly, as the dome system can be used for years and repeatedly in other areas, it is possible to say that the dome system is more economical than the other systems used so far by the directorate (Ulker, 2010).

Furthermore, in inventory studies carried out at national level, full responsibility is given directly to census team and the study is finalized without processing the produced data. But the success lies behind full control of the whole team, which is linked to having knowledge of the error and success rates of the census to predict observation error. As no supporting data source is used to test census data, there is no possibility to judge error rates, which complicates control of the accuracy of census.

According to the results of the study, camera traps and dome system supported with convenient software can produce image data, which create the possibility of mutual testing between the method and direct observation data produced within the context of inventory plan of the directorate.

In the study of Gündoğdu (2006), conducted in 2001-2005 period, it was stated that the main factor affecting behavior of wild goats was security requirement and they safe-guarded their position principally against enemies during movement and feeding. Considering this information, when using techniques based on direct observations in wild goat census studies, it is not possible to approach wild goats but from a distance and an observer has to observe animals relatively in short durations to record age, sex etc. Data become oblivious. Otherwise, some gaps in observation errors become inevitable.

Along with the wild goat, the camera trap system established in the study area was able to record *V. vulpes*, *M. foina*, and *S. scrofa* individuals and hence confirmed their presence in the area. Furthermore, exact information about sex, age, group size, sex among the young ones was also obtained. Suitability of camera traps, as reported by Can (1998), to fill the gaps and to minimize error rates in monitoring studies for the presence of mammal species, relative abundance and species diversity are also supported in this study.

The inventory repeated annually in the study area by directorate is based on results of direct counts conducted in 50 census points by 50 observers. As a dome camera costs 10.000 TL, the first establishment expenses of the dome system to be placed on 25 most suitable points will cost 250.000 TL (=25 x 10.000). Total expenses of the system, including suitable software and regular controls, will be 300.000 TL. This figure accounts for less than economic loss caused by poaching. In other words, the system redeems itself less than a year. Besides, as the population of the target species protected from poaching will have chance to express its biotic potential and repro-

reproduce, a considerable increase in hunting income can be expected by the second year (Steinhart, 1989; Baker, 1997).

Single camera trap used in the study costs 200 USD. In the study area, 4-10 camera traps were used. Therefore, it is understood that 10 camera traps can be enough for 50 hectares of wild goat habitats. Even though 25 camera traps are placed together with dome system, total cost will be 5000 USD at most. If only camera traps are used, this method can be followed in order to choose a more economical way.

In the light of the results discussed so far, suggestions for using imaging technology wildlife inventory and monitoring studies in Turkey are given as follows. Inventories for game species carried out by the directorate in Turkey should be pre-planned to concentrate on technology based solutions, rather than labor intensive census techniques like direct counts which demand high expenses and high numbers of census personnel. This will decrease census expenses, and hence the expenses of the inventories.

It is possible to apply reliable and economical census techniques for wild goat, using developing technological opportunities and image monitoring systems like camera traps and dome camera system. This will also ensure minimal harassment to the animals sharing the same habitats with wild goats. Accordingly, if supported by sufficient number of camera traps, dome system should be immediately used in investigation and monitoring of game species other than the *C. aegagrus* inventories in Turkey. If only camera traps are to be used to lower costs instead of the dome system, using sufficient number of camera traps and planning arrangements precisely, a sampling based inventory technique may be developed.

To get maximum success from imaging systems in the field, the area should be evaluated in detail and system should be established at frequently visited locations by target species and sheltered spots unaffected by direct sunlight for day shots. The software to be used in the dome system should be capable of detecting movements of the target species from far distances (at least 500 m) and system should be sustained by consistent support with such software and technological updates.

The study presents promising results on potential use of imaging technologies in Turkey. According to our results, technology used only in a year round period is able to serve inventory of the target species.

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