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ESTIMATING BROWN BEAR POPULATION DENSITY WITH CAMERA TRAPS IN CENTRAL BALKAN MOUNTAIN, BULGARIA

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Abstract: Estimating population size and density for mammals which are not individually recognizable is particularly challenging. However, these indicators are vital for species management. In this study we make the first attempt to estimate the population density of the endangered in Bulgaria brown bear (*Ursus arctos* L.) using camera traps. Thirty eight camera traps were set up at random locations (spaced at approximately 1 km from each other) between July and August 2017 in the State hunting enterprise "Rositsa", located on the Northern slopes of the Central Balkan Mountains, Bulgaria. Fifty independent registrations of brown bears were collected and analyzed through the newly developed method without the need for individual recognition proposed by Rowcliffe in 2008 – the random encounter method. The results indicate local population density of 1.78 ind./km2, which is unusually high especially in comparison to the observed densities in the neighboring National Park Central Balkan (0.1-0.2 ind./ km2). This is most likely due to the rich natural food base, the protection against poaching and the supplemental feeding in the hunting area which attracts many individuals and increases the density locally. This leads to a perceived "overpopulation", but in fact this is a local concentration of individuals and not a true high density. The proposed method is cost-effective and can be used to complement or enhance current monitoring schemes.

INTRODUCTION

Estimating population size and density for mammals is particularly important for their monitoring, conservation and management. With individually recognisable species (such as animals with distinctive stripes or spots) it is relatively easy to use robust Capture – Mark – Recapture (CMR) models through non-invasive methods like direct observations or camera trapping. However, for species that cannot be distinguished individually, this is not always possible. Physical capture and marking of each individual is not only invasive, but also very time-consuming and might alter their behaviour. Moreover, trapping large mammals with vast individual territories would require enormous field effort.

The brown bear (*Ursus arctos* L.) is protected by the Bulgarian Biodiversity Act (except for problem individuals) and is listed in the Red data book of Bulgaria as endangered (Siela, 2002; Golemanski et al., 2015). Studying its population parameters and the trends in the species' status is vital for its conservation. The currently utilized method for monitoring of the brown bear's populations in Bulgaria relies on track counts and direct observations at supplementary feeding sites (MoEW, 2008). However, it is questionable if these methods provide accurate results as individual differentiation based on track size is unreliable. Moreover, bears have been reported to visit up to 6 feeding sites per night (Jerina et al., 2012) and this can lead to multiple counts of the same individual and wrong estimates.

Being non-invasive, camera traps provide an alternative to pre-existing methods and ensure systematic and non-disturbing observations of the target species. With the simultaneous development of relevant analytical approaches the resulting data can have vast applications with a solid scientific basis. In the current study we attempt to estimate the population density of the brown bear using camera traps and the most current analytic approaches. For this purpose we apply a recently developed method to estimate population density without the need for individual recognition (Rowcliffe et al., 2008). The method has not been previously applied to brown bears, but is successfully used with other carnivores, such as the European pine marten (Manzo et al., 2012) in Italy, 11 species of mesocarnivores in Mexico (Hernández-Sánchez et al., 2017) and lions (Panthera leo) in Tanzania (Cusack et al., 2015).

MATERIALS AND METHODS

Study area

The current study was carried out within the territory of the State hunting enterprise (SHE) "Rositsa" (Rositsa - lagat", 2017), located in the Central Balkan Mountains. The total area of the enterprise is 250 km2, covered almost entirely by forests (98%), of which 82% deciduous and 18% coniferous forests. European beech (*Fagus sylvatica* L.), scots pine (*Pinus sylvestris* L.) and common hornbeam (*Carpinus betulus* L.) are the most widely distributed tree species. The altitude ranges between 250 and 1430 m.a.s.l. SHE "Rositsa" shares a border with two other state hunting enterprises ("Rusalka" to the West and

“Mazalat” to the South) and with Central Balkan National Park to the Southwest. It is a popular hunting area for red deer (*Cervus elaphus* L.), roe deer (C*apreolus capreolus* L.), wild boar (*Sus scrofa* L.), fallow deer (*Dama dama* L.) and grey wolf (*Canis lupus* L.) (“Rositsa-lagat,” 2017). Hunting of brown bear on the territory of the enterprise (as in all other parts of Bulgaria) is prohibited, except for problem individuals (i.e. bears that come dangerously close to humans and pose a threat to their life and property) (Siela, 2002).

Camera trap data and analysis

Thirty eight camera traps (Bestguarder DTC-880V) were set up in the field between July 10th and August 4th 2017, located at approximately 1 km from each other. The specific sites for the camera traps were chosen to maximize animal detection – typically trails or open spaces near the forest edges. The camera traps were set up to take 3 consecutive pictures (5 seconds apart) and a 10-sec video upon triggering. Next series of photos and a video can be taken one minute after the previous triggering. For each location a standard form was filled, containing information about the habitat characteristics. The resulting data was imported and analyzed through CameraBase 1.6 (Tobler, 2013), adapted and translated in Bulgarian (Zlatanova, unpublished). Photos showing the prolonged stay of an individual in front of the camera trap were considered as one individual registration to avoid overrepresentation of the species. Detection rate index (DR) was calculated for the brown bear (O’Connell et al., 2011) for 100 camera trap days. This index standardizes the data and allows comparison between the numbers of registrations from different studies with various numbers of camera trap days.

The data was analyzed with the method developed by Rowcliffe et al. (2008) for estimating animal density using camera traps without the need for individual recognition. This method is based on modelling the rate of the contacts between the animals and the camera trap. It takes into account the characteristics of the species: mobility of the species (average daily distance travelled) and the average number of individuals in a group. Additional needed parameters are the angle and radius of the detection zone of the camera trap (these were provided by the manufacturer in the manual book: the radius of the detection zone of the used camera traps is 25 m = 0,025 km and the angle of the detection zone is 65° = 1,13 radians.). The method uses the following formula:

$$D = \frac{y}{t}\frac{\pi}{vr(2+\theta)}$$

where:

D – population density (ind./km^2);

y - total number of independent registrations;

t - total number of camera trap days;

r - radius of the detection zone of the camera trap, km;

θ - angle of the detection zone of the camera trap, radians;

v – mobility of the species (distance moved in a day, km.);

RESULTS AND DISCUSSION

Due to malfunctioning of 2 camera traps the total number of accumulated camera trap days is slightly less than expected. However, it is still large enough to fit the requirements of the method – 748 camera trap days (Rowcliffe et al., 2008 recommended at least 500 camera trap days for accurate results). The absolute minimum number of independent registrations according to the method is 10, whereas 20 and above are recommended.

In the current study we obtained 50 independent brown bear registrations which fit in the method parameters (Figure 1). The random encounter model is not sensitive to repeated registrations of the same individuals, so individual recognition is not necessary.

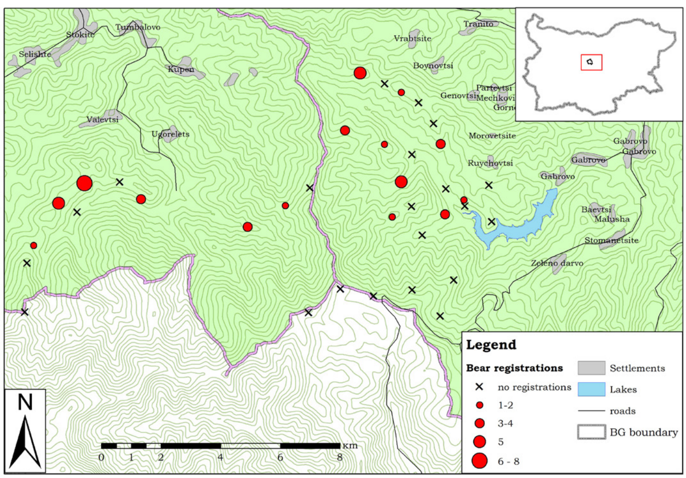

Fig. 1 Map of the study area and the camera trap locations with the resulting brown bear registrations.

This estimated detection rate index (DR) is very high - 6.68 independent registrations per 100 camera trap days. A previous study in 17 mountainous Natura 2000 sites in Bulgaria (Popova, 2017) reported much lower DRs for the bear – between 0.04 and 0.44 ind. reg./100 ctds (mean = 0.16). The only exception of a much higher value is reported from the same study, but the camera traps were set up on supplemental feeding sites – the estimated value for the DR there is 16.4 ind. reg./100 ctds.

In the current study brown bears were registered in 15 of the 38 camera trap locations, with a mean of 3.33 ± 1.78 independent registrations/site. Two registrations of a female with 2 cubs were recorded, which is evidence for breeding in the area (Appendix 1).The results from a telemetry study of 26 brown bears in Croatia (Huber and Roth, 1993) indicate that the mean distance moved by the species in a day is 1.60 km (v in the formula).

The estimation according to the random encounter method indicates that the population density in the study area is 1.78 individuals/ km2. This is much higher than the reported population density from a study in the Central Balkan Mountains which reported values of 1 individual per 15-18 km2 (MoEW, 2008; Golemanski et al., 2015). The limited disturbance and poaching, higher security and rich natural food base, as well as the supplemental feeding aimed at the ungulates in the state hunting enterprises leads to concentrations of bears in these regions and higher than usual tolerance among the individuals. This leads to a perceived "overpopulation" (MoEW, 2008), but in fact this is a local concentration of individuals and not a true high density. It is likely that large number of individuals, including ones from the neighboring Central Balkan National Park, are attracted to the area. Supplementary feeding sites affect the movements of bears (Selva et al., 2017). This is why additional studies, combining camera trapping and telemetry could provide a valuable input on the accuracy of these results and an unbiased measure of the species' mobility in the area (needed for the estimation). Furthermore, studies in the adjacent protected area are needed.

The currently utilized monitoring scheme for the brown bear in Bulgaria (Executive Environment Agency, 2010) involves observations throughout the year and transects for direct observations and recoding of signs of bear presence (tracks, scats, etc.) walked twice a year (in Spring and Autumn) with a duration of 3 days. It is necessary to cover the whole area of distribution of the species, which requires large field effort and a considerable number of participants. They also need to be specially trained to recognize the signs of bear presence and activity, and paired in teams of two. Yet, many large carnivore scientists doubt that this method could be reliable due to the fact that footprint measures can be influenced by experience and environmental conditions, which leads to unmeasurable error.

When applying the random encounter method, the field effort (and the necessary staff), as well as the training time could be minimized. An initial investment of funds for purchasing camera traps is needed. However, many of the National and Nature Parks, State Hunting Enterprises and State Forestries already possess and use camera traps in their territories, but not in a structured and scientifically sound way. Camera trap operation and maintenance is relatively simple and does not require extensive training. Deploying the camera traps randomly and evenly on the studied area is most likely to take less than 3 days and would require much fewer participants and time (depending on the size of the studied area). The camera traps need to be operational in the field for 2-3 weeks up to a month. The resulting number of brown bear registrations can be easily summarized and applying the model requires a simple estimation. Furthermore, the camera traps provide additional information regarding sex and age structure and behavior, which can be further analyzed.

All of this makes this camera trap approach a valuable contribution towards monitoring the brown bear population and its conservation in Bulgaria.

CONCLUSIONS

The proposed method of estimating population density by using camera traps is cost-effective and can be used to complement or enhance current monitoring methods.

The local brown bear population density appears to be much higher than the observed in the neighboring National Park Central Balkan and other protected areas. This is due to the concentration of the individuals caused by the the rich natural food base, the protection against poaching, and the supplemental feeding.

Conservation measures for the brown bear should consider unprotected areas which may host abundant populations. This is especially important considering the fact that a third of all brown bear habitats in Bulgaria are on the territories of State hunting enterprises.

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Appendices:

Appendix 1 Camera trap photo of a female bear with two cubs.

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