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Estimation of ungulate population density in Kazakhstan: Case study from foothill ecosystems

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Abstract: Data on wildlife abundance is an important indicator both for the species concerned and the stability of entire ecosystems as well as for sustainable game management. Therefore, the abundance of ungulate game was verified in a foothill region of Kazakhstan. The methods of thermal imagery and faecal pellet group (FPG) census on transects were compared. The results obtained by the FPG counting method for moose (*Alces alces*, 0.34 individuals per 100 ha) and maral deer (*Cervus elaphus sibiricus*, 0.04 individuals per 100 ha) were relatively consistent with the data reported by the hunting ground tenants. Only one moose was detected by the thermal imaging transect count method. The results show that deer and moose abundance in Kazakhstan is significantly lower than in Central and Eastern Europe. Thus, for Kazakhstan, the method of FPG counting is well applicable for both routine and control counts. Detailed data on game populations can be obtained using the camera trap counting method, which has not been verified in Kazakhstan as yet.

Keywords: *Alces alces*; *Cervus elaphus sibiricus*; counting methods; wildlife management

The determination of wildlife population abundances has recently gained importance. On the one hand, it is necessary to know the abundance of threatened species to protect them effectively (Cromsigt et al. 2009; Le Moullec et al. 2017). On the other hand, we need to reduce the invasive, non-native species or overpopulated native species that threaten native ecosystems or cause damage to field crops and forestry (Noon et al. 2012; Marada et al. 2019; Mikulka et al. 2020; Valente et al. 2020; Carpio et al. 2021; Vacek et al. 2020; Cukor et al. 2022). Methods for determining population sizes can be distinguished into direct counts of individuals and indirect faecal pellet group (FPG) counts. For the direct counting, observational telescopes, thermal imaging devices, drones, aerial photography or camera traps have been used increasingly (Burton et al. 2015). The second category can be classified as the scat count method (Mayle et al. 1999) or counting of other presence signs. For monitoring of wild ungulates, it is necessary to choose the method of abundance counting for each species or population.

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Monitoring of environmental parameters and populations is an essential tool for sustainable management of natural resources. Keeping track of the abundance of wildlife populations plays a substantial role in management interventions, especially for species that are socio-economically significant and potentially at higher risk of overhunting, i.e. unsustainable hunting (Thompson et al. 1998; Witmer 2005; Weinbaum et al. 2013). For example, long-term monitoring of cervid populations can estimate the stability of a species population and identify declining or increasing trends in the abundance of individuals within the population (Milner et al. 2006; Macaulay et al. 2020). From this viewpoint, it is possible to assess whether the population is threatened and, at the appropriate time, prevent it from dramatically declining in abundance in the area or, conversely, from becoming overabundant (Milner et al. 2006; Macaulay et al. 2020; Gortázar, Fernandez-de-Simon 2022). Where populations are ecologically sustainable, a species can have a positive impact on other wildlife and their habitats, and thus on the overall biodiversity of an area (Gortázar et al. 2006; Newston et al. 2012; Arnett, Southwick 2015). In recent decades, a dramatic increase in the abundance or even overpopulation of cloven-hoofed game species has been observed in Europe (Valente et al. 2020; Carpio et al. 2021). In such cases, it is imperative to reduce the abundance of the population in question (Gortázar et al. 2006; Tack 2018). In Central Asia, by contrast, there have been significant declines, primarily due to excessive, uncontrolled, and often illegal hunting, which is a constant problem in this region (Jingfors 2015; Valente et al. 2020; Blank, Li 2021).

Kazakhstan serves as a typical example – a Central Asian country rich in cloven-hoofed game species. The list of cloven-hoofed game species includes the Altai argali (*Ovis ammon*), Central Asian red deer "hangul" (*Cervus hanglu*), Persian gazelle (*Gazella subgutturosa*), urial (*Ovis orientalis vignei*), Siberian musk deer (*Moschus moschiferus*), Siberian ibex (*Capra sibirica*), and wild boar (*Sus scrofa*) (Jingfors 2015). Owing to the World Wildlife Fund and the Altyn Emel National Park Service, the nearly extinct Bukhara deer (*Cervus elaphus bactrianus*) was successfully reintroduced into Kazakhstan in 1999 (WWF 2007). Another endangered species, the saiga antelope (*Saiga tatarica*), had been widely hunted for its meat and horns in the past, which, together with the loss of its natural habitat, led to a decline in the population. Due to a ban on hunting in its range countries (CITES), the antelope numbers have increased. In Kazakhstan, where 90% of the saiga population is found, the reintroduction has been so successful that the antelope have begun encroaching on farmers' pastures (Eurasianet 2021).

The main game species in the foothill ecosystems include the Siberian roe deer (*Capreolus pygargus*), moose (*Alces alces*) and the maral deer (*Cervus elaphus sibiricus*) (Jingfors 2015). This paper aims to assess the possibilities of censusing these main game species in forest ecosystems in Eastern Kazakhstan. The objectives are to (*i*) verify the potential of game census by the scat method; (*ii*) verify the abundance of game by the thermal imaging census method on transects; and (*iii*) compare the observed values with the hunting registration system established in Kazakhstan.

MATERIAL AND METHODS

Game monitoring was carried out in the Kaiyndy hunting ground, located in Eastern Kazakhstan (Figure 1). The area of the hunting ground is 22 246 ha and it is covered by mixed forest stands with dominance of birch, poplar and pine species and interspersed broadleaf tree species like ash or maple. The shrub layer is dominated by willow shrubs and other species e.g. cinnamon rose or caragana. The forest covers 66.6% of the hunting district. Agricultural and pasture areas account for 7.9% and water resources for 0.1%. The elevation fluctuates between 708 (min) and 1 412 (max) m a.s.l. The length of the growing season ranged between 135 and 170 days.

Due to the composition of the forest vegetation, the hunting ground has sufficient food for the common species of wild ungulates, taking into account the rich natural regeneration of the forest. At lower altitudes of the hunting area, near human settlements (villages, hamlets), signs of extensive cattle grazing were found at the forest edges and in the adjacent agricultural landscape. However, domestic animals did not occur inside the forest complexes and, therefore, they did not compete through foraging with wild ungulates. Hunting registration and planning in Kazakhstan is based on the game counts reported by the hunting ground tenants to the state administration (estimated numbers). The average ungulate game counts for 2017–2019 for the Kaiyndy hunting ground are presented in Table 1.

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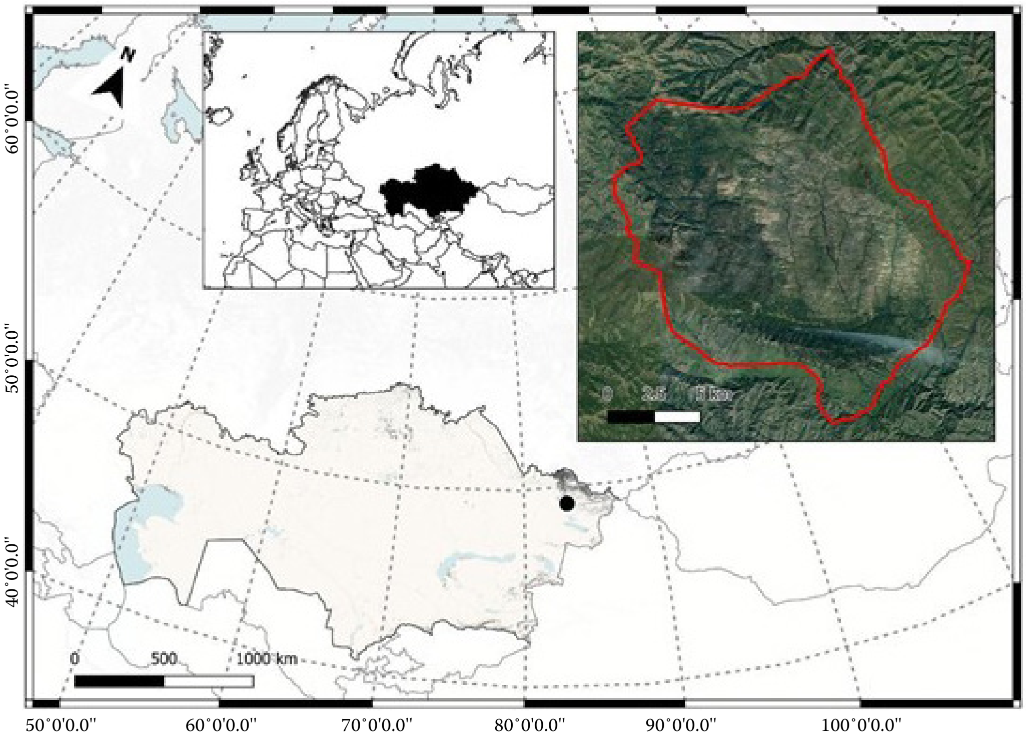

Figure 1. The area of interest (hunting ground) in Kazakhstan

For the purpose of an exact census, two potentially suitable methods of counting the game present in the hunting area (moose, maral deer, Siberian roe deer) were tested: the method of counting the game on transects using thermal imaging devices, and the method of counting the game based on droppings (FPG counting). These methods have proved successful for censusing wild game in Europe (Mayle et al. 1999; Havránek et al. 2019) but they had yet to be tested in the environment of Kazakhstan's foothills.

Thermal imagery for game census. Thermal imaging game census on transects (forest roads) was performed in the Kaiyndy hunting ground, using an off-road vehicle (counting speed approximately 5–10 km·h^{-1}). The car crew included the driver, who had the map data, and two counters who monitored the right and left side of the transect with thermal imaging devices (Pulsar Helion and Pulsar Accolade with integrated rangefinder; Yukon Advanced Optics Worldwide, Lithuania). When the game was detected, the GPS position of the recording, the species of the game, its sex, and perpendicular distance from the vehicle were recorded. Based on the average transect width, the Distance software (Version 7.3 Release 2, 2020) then determined the total number of cloven-hoofed game in the area of interest (hunting grounds). A description of the census methodology is detailed in Havránek et al. (2019). The field census was conducted in the Kaiyndy hunting area during September 27, 28 and 29, 2021, through the night hours (over two nights), i.e. after sunset.

Table 1. Average number of counted individuals for 2017–2019

Species	Total	Males	Females	Yearlings (1st year)
Alces alces	75.3	13.0	36.0	26.3
Capreolus pygargus	22.0	3.7	10.7	7.7
Cervus elaphus sibiricus	55.0	12.0	23.0	20.0

FPG method for game census. To verify the abundance of the ungulates, the FPG method of cloven-hoofed game counting on strip transects was used (Mayle et al. 1999). The number of individuals per ha is calculated using the following Equation (1):

$$n = \frac{n_{ha}}{n_d \times d} \quad (1)$$

where:

n – number of individuals per ha;

n_{ha} – average number of FPG·ha^{-1};

n_d – average defaecation rate of the species·day^{-1};

d – average length of faecal degradation in days (365).

The amount of moose faeces was 16 FPG per day, which corresponds to the average defaecation rate

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of moose in Northern Russia, which ranges from 12 FPG to 20 FPG (Semenov-Tyan-Shansky 1948; Chervonny 1975). The average number of FPG of maral deer was 19, which is consistent with the red deer values (Heinze et al. 2011; Vala, Ernst 2011). The average number of days of degradation per pile was considered to be 365 according to Mayle et al. (1999). Data for defaecation rates of moose and maral deer, including the average degradation time of FPG, are not available from Kazakhstan. One of the prerequisites for ensuring the objectivity of game abundance results is an appropriate location of transects across different habitats (Putman et al. 2011). For this study, monitoring was focused on the central part of the hunting area in loose forest stands with birch, pine, and poplar, predominating the entire hunting area (Semenov-Tyan-Shansky 1948; Chervonny 1975).

The FPG count was performed on September 29 and 30, 2021, on 6 transects with a total length of 14 664 m (min. 1 442 m, max. 3 782 m). A total of 59 moose FPG and 11 maral deer FPG were counted along the transects.

RESULTS

A total line of 56 km of transects was monitored by car using thermal imaging equipment in the Kaiyndy hunting area, with one female moose recorded at a distance of 73 m (Figure 2). A calculation based on the distance travelled (56 km) and the transect width over which the game was recorded (73 m) shows that an area of 817.6 ha was monitored by thermal imaging cameras during the field survey (ca. 3.7% of Kaiyndy hunting ground). When we convert the observed number of game to the total area of the hunt, the total number of moose is 27.2. No other species were recorded. However, it should be stressed that the number of recorded individuals was only 1, which does not allow for an accurate determination of the number of game animals for the entire area of interest (hunting ground).

A total of 59 moose FPG (20.11 FPG$\cdot$ha^{-1}) and 11 maral deer FPG (3.8 FPG$\cdot$ha^{-1}) were counted along the total length of the transects using the FPG method. Using calculations performed by Mayle et al. (1999), we determined the moose abundance at 0.34 individuals per 100 ha and maral deer at 0.04 individuals per 100 ha. When converted to the hunting ground area, the total abundance was 75.5 moose individuals and 11.1 maral deer individuals.

Figure 2. Recorded female moose in a forest stand in Kazakhstan

No Siberian roe deer faeces were found during the field surveys and therefore its abundance could not be determined.

DISCUSSION

The results of the game census in the model area of the Kaiyndy hunting ground prove that the observed cloven-hoofed game numbers are significantly lower than the red deer and moose numbers in Central and Eastern Europe, where ungulates have been spreading uncontrollably at present (Apollonio et al. 2010; Valente et al. 2020; Carpio et al. 2021). The low productivity of hunting grounds in Kazakhstan is probably due to predation and, possibly, poaching (Robinson, Milner-Gulland 2003; Jingfors 2015). The main predators of ungulates in Kazakhstan are wolves and bears. Niedziałkowska et al. (2019) reported that bears are a significant predator of moose and can cause on average 23% of total natural mortality in moose populations. The observed results of moose abundance determined by the FPG method (0.34 individuals per 100 ha) are relatively consistent with reported moose population densities in Russia, which range from < 0.01 to 0.5 individuals per 100 ha with the highest densities in Western Russia (Jensen et al. 2020). The population density of maral deer was 0.04 individuals per 100 ha, but due to the lack of reference literature on its abundance in Kazakhstan, it is not possible to compare the findings with other sources.

The census results obtained by the FPG counting method proved to be consistent with the values reported by local hunting ground tenants for moose. In contrast, the comparison of the observed abun-

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dance of maral deer (11 individuals per total hunting area) was significantly lower than the average reported values. It is clear that the scrutinized FPG counting method gives lower or equal numbers of ungulates in Kazakhstan when compared to the numbers reported by hunting ground users in hunting statistics. If we compare these values with data from Central Europe – for example, in the Czech Republic – the values reported by hunting ground users for red deer are several times lower than those obtained by the FPG counting method (Vala, Ernst 2011; Cukor et al. 2017). This discrepancy between the reported values and the abundance determined by the FPG counting method exposes a subjective error biasing of hunting ground users' estimates in hunting statistics. Different hunting philosophies tempt the users to report lower census values in places where game is overabundant than in places with low population densities. In contrast, in low population density hunting areas, higher numbers are reported in order to obtain higher hunting quotas. This is why a correct exact method for estimating the size of the ungulate population is substantial.

FPG counting method and thermal imagery counting approaches to the game census tested in Kazakhstan showed different results of applicability. Transect censuses using thermal imaging equipment were limited by the low population density of game and, therefore, the low number of data recorded. Consequently, the scarce road network, significantly lower than in Central Europe, is also limiting (Piekutin et al. 2015). For these reasons, this approach proves unsuitable for the aforementioned hunting ground as it does for other hunting grounds of this type throughout Kazakhstan. Conversely, estimating game numbers by their droppings can be a relatively well applicable method for routine and control censuses in Kazakhstan. Its applicability is the same as in Central European countries. However, the fact that game numbers were significantly lower than in Central Europe, where the method has been successfully used (Mayle et al. 1999; Vala, Ernst 2011; Cukor et al. 2017), can be a limiting factor as well. In Europe, an alternative method is used, when the surveyed areas are cleared of old dung piles. However, this approach is more suitable for smaller areas with high population densities. For large areas with a lower population density of ungulates, as is the case of the Kaiyndy hunting ground, it is preferable to use the FPG variant to assess a larger area within a single visit and avoid visiting the monitored transects twice (Smart et al. 2004). In this case, though, it is necessary to use faecal degradation rate modelling (Marques et al. 2001). The use of the single-visit group FPG method for large areas has been addressed by, for example, Campbell et al. (2004). They used the method without prior clearing of study plots and, in the case of deer and moose, recommended converting the number of faecal pellets found in relation to their different degradation rates. Conversions based on the terrain slope are also presented. Aerial surveys are cited as the most accurate method for determining the moose population size (Rönnegård et al. 2008; Boyce et al. 2012). However, due to their cost, they are not used to determine population densities in hunting areas.

Another option is to determine the abundance by evaluating images from a camera trap network (Caravaggi et al. 2017; Palencia et al. 2019). Pfeffer et al. (2018) conducted a comparison of camera trapping and scat count methods in Sweden. They reported that, compared to camera traps, the scat count method underestimates the population size for roe deer, while for moose the values for both methods are comparable. To determine the abundance of ungulates in large areas with low game populations, e.g. in Kazakhstan, it would be useful to validate the aforementioned method of game counts using camera traps. Undoubtedly, the advantages include low time consumption and detailed data on the populations of the target game species, such as the sex ratio. Another benefit is obtaining data on non-target game species, such as large carnivores. These data can help in long-term and sustainable management of game species.

CONCLUSION

Validation of two methods of counting ungulates in the foothill ecosystems of Eastern Kazakhstan has shown the relative suitability of the FPG counting method approach. Generally, the results corresponded with the data reported by hunting ground tenants. In contrast, the method of counting game by thermal imagery on transects had limited usage, mainly due to the low number of game detected. This limit is related to the low population density of ungulates in Kazakhstan, which may significantly bias the results of converting captures per census area. To obtain accurate data on the abun-

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dance of ungulate populations, the time-saving option of counting game using camera traps seems to be convenient. In comparison with the scat count method, it provides additional data on the population, such as the sex ratio of the target game species. Therefore, based on the comparison of the described census methods, it can be recommended to validate the camera trap method of game census, which has not been tested as yet in the specific environment of Kazakhstan.

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