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RESEARCH PAPER

Drive counts fail to accurately estimate the population sizes of wild ungulates

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Abstract. The accuracy of drive count and pellet group counts for estimating the community structure and density of wild ungulates was assessed in the Roztocze National Park (south-east Poland) from 2003 to 2021. The estimates varied greatly among methods and years. The largest errors were found for assessing ungulate density using drive counts, mainly due to insufficient blocks. Errors for the pellet group counts were small for red deer (*Cervus elaphus*) and roe deer (*Capreolus capreolus*) and moderate for wild boar (*Sus scrofa*). Therefore, it is suggested that the pellet group method should be given priority in surveys of ungulate population abundance in the Roztocze National Park.

Key words: red deer, roe deer, moose, wild boar, assessment of ungulate numbers, protected areas

Introduction

Although estimation of the wild ungulate population size is mainly conducted for hunting management purposes (Chećko 2011), it is also important in protected areas, such as national parks, due to ungulates' impact on other elements of the environment (Hedwall et al. 2018, Borkowski et al. 2019), intra-specific competition (Borkowski et al. 2021), and their importance as a food base for strictly protected large carnivores (Jędrzejewska & Jędrzejewski 1998). Long-term data on the numbers of ungulates are also crucial to reveal human impacts on their population dynamics and habitat selection (Ciach & Pęksa 2019). Moreover, in Poland, national parks are obliged to pay compensation for crop damage made by wild ungulates within their area (Danecka & Radecki 2022); thus, data on ungulate abundance may help to predict and mitigate wildlife-caused losses in agriculture (van Beeck Calkoen et al. 2020, Carpio et al. 2021).

The number of wild ungulates is influenced by various factors, both natural (e.g. food base, climate, predation, diseases) and anthropogenic (e.g. hunting, traffic mortality, habitat fragmentation) (Jędrzejewska et al. 1994, 1997, Borowik et al. 2013). Despite local fluctuations, however, an increase in wild ungulate populations can be seen across Europe (Côté et al. 2004, Apollonio et al. 2010, Borowski et al. 2021). Along with growing wild cervids and suids populations, new challenges for agriculture, forestry, and nature conservation arise (Putman et al. 2011). Thus, their populations should be monitored using reliable methods to inform efficient strategies for managing wild ungulates. Previous experiences indicate that

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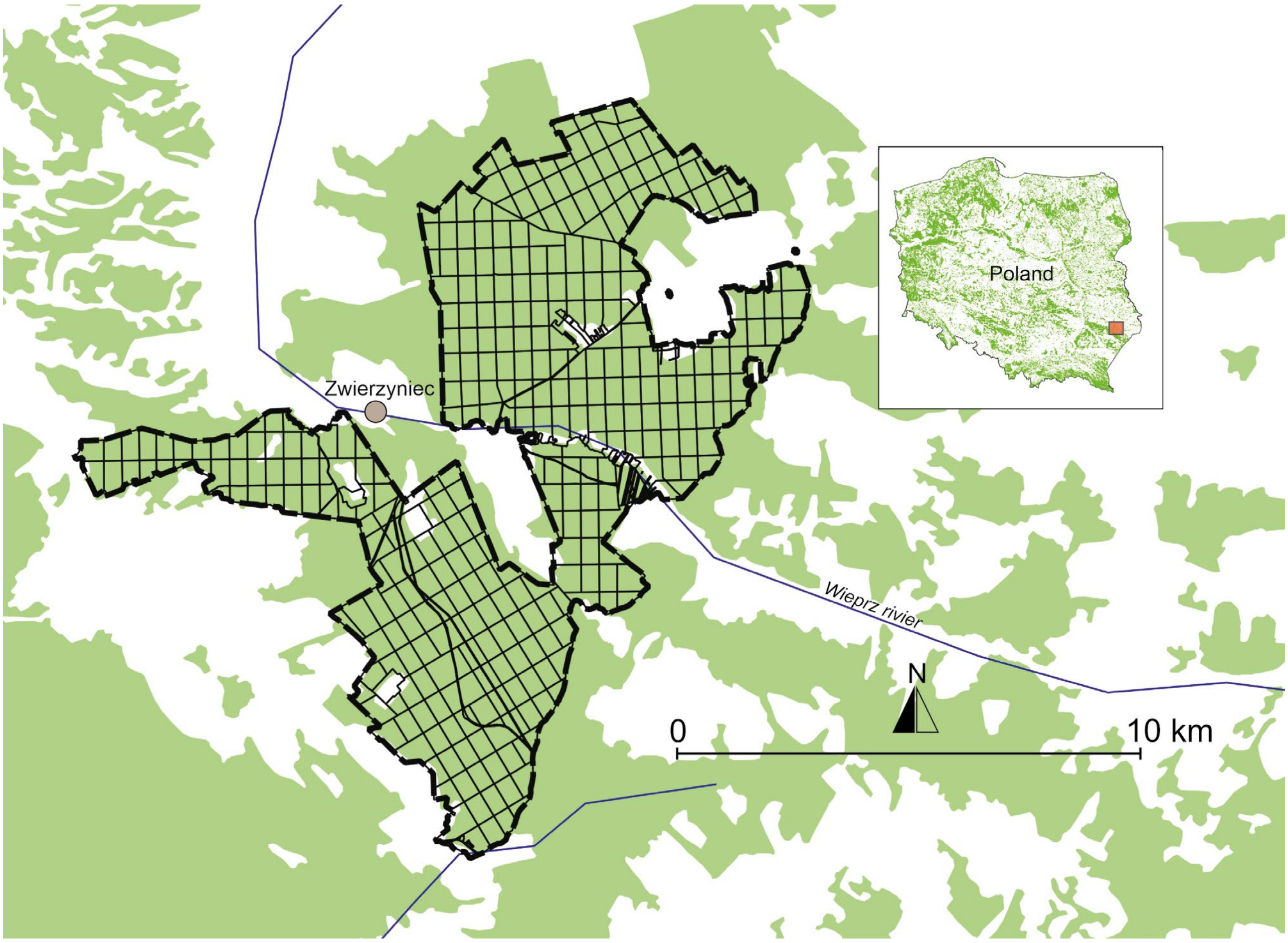

Fig. 1. The border (dashed line) of the Roztocze National Park against the background of forests. The boundaries of forest compartments inside the park are shown with solid lines. Transects for ungulate pellet group counting were located randomly within each compartment.

the selection of monitoring methods depends on the ecology and behaviour of given species and the configuration of landscape features, but economic and organisational aspects play an important role as well (Borkowski et al. 2011, Torres et al. 2015).

In Polish national parks, different methods are applied to assess the number of ungulates (Dzięciołowski et al. 1995, Głowaciński 2007, Witczuk et al. 2018), but their feasibility and reliability are rarely assessed. We took advantage of the availability of data from drive counts and pellet group counts performed in the Roztocze National Park to compare the reliability of these methods for estimations of ungulate community structure and density. We hypothesised that estimates of ungulate populations obtained through drive counts are less accurate than estimates based on pellet group counts.

Material and Methods

Study area

The study was conducted in the Roztocze National Park (84.83 km^2, hereafter RNP), established in 1974 to protect well-preserved forests situated in the uplands of south-east Poland (50°36′ N, 23°03′ E) (Fig. 1). The national park is also protected as a Natura 2000 Special Area of Conservation ‘Roztocze Środkowe’ (PLH060017). The majority of forests within the RNP usually grow on karst hills reaching 350 m above sea level separated by deep ravines and consist mainly of pine *Pinus silvestris* (35%), beech *Fagus sylvatica* (22%), fir *Abies alba* (16%), hornbeam *Carpinus betulus* (7%), oaks *Quercus* ssp. (6%) and spruce *Picea abies* (5%) stands. The southern part of the RNP is wetter and has extensive patches of black alders *Alnus glutinosa.* The climate is of a transitional Atlantic-continental character, with a mean temperature of –2.9 °C in January and 19.1 °C in June and an average annual precipitation of 691 mm (Tittenbrun 2019).

Four species of wild ungulates inhabit the RNP – moose *Alces alces*, red deer *Cervus elaphus*, roe deer *Capreolus capreolus* and wild boar *Sus scrofa* (Tittenbrun 2019), which co-exist with two large carnivores – grey wolf *Canis lupus* (Mysłajek et al. 2021) and Eurasian lynx *Lynx lynx* (Mysłajek et al. 2022).

Estimation of ungulate community structure and population density

We applied both drive count and pellet group counts to calculate the mean population density of wild ungulate species per 1 km^2 and the standard error of the mean using data from every block (drive counts) or transect (pellet counts). Standard error is the best way to estimate the accuracy of the mean as it depends on both standard deviation and sample size (Altman & Bland 2005).

Drive counts

Drive counts (Fattorini et al. 2020) were applied by the Roztocze National Park to estimate ungulate densities in 2003, 2016, 2017, 2018, and 2020. During drive counts, individuals of various species of ungulates were counted within well-defined blocks, usually entire forest compartments. Borders of each block were surrounded by a line of observers placed at a distance of sight. On a signal, observers (so-called 'beaters') placed on one side of the block started to drive ungulates towards stationary observers standing along the three remaining sides. Observers (both beaters and stationary ones) counted ungulates that escaped from the block on their right side within the distance to the next observer.

In RNP, drive counts were performed in different numbers of blocks of varying sizes. In 2003, 19 blocks were used with a mean size of 43.5 ha (SD = 5.9, range 23.34-50.88 ha). In 2016, ten blocks with a mean area of 96.13 ha (SD = 3.98, range: 87.99-102.65 ha) were used, while in 2017, 2018, and 2020, only eight blocks with a mean area of 97.24 ha (SD = 4.9, range 87.99-102.65). Blocks were evenly distributed across the RNP and included a representative share of forest types (Fig. 2, see Tables S1, S2, Figs. S1, S2 for the basic characteristics of stands within blocks).

Pellet group counts

‚Pellet group counting (faecal standing crop) (Mandujano 2014) was applied to estimate the density of wild ungulates in 2021. The pellet group counts were conducted along 200 m long and 2 m wide walking transects randomly selected in every forest compartment (n = 362) in the RNP (Fig. 1). Data were collected at the end of March and the beginning of April, after the snow melted, although before the beginning of the vegetation season, to avoid obstruction of pellet visibility by the ground plants. When moving in the field, the direction was kept with a hand-held GPS unit (GPSMap 64s, Garmin, USA). To avoid faeces misidentification, the fieldwork was performed by experienced staff, and pellets of particular species were differentiated by their size and shape (Jędrzejewski & Sidarowicz 2010).

We estimated the population density following the formula (Deer Initiative 2008):

$$D = \frac{n}{a \times t \times d}$$

where D – population density (n/km^2), n – mean number of pellet groups per km^2, a – study area (km^2), t – pellet accumulation time (days), d – defecation rate.

We chose November 15 as the beginning of the accumulation period, as by that time, most tree leaves in the RNP had fallen, and thus, they no longer concealed the pellet groups. The defecation ratios for the density estimation were assumed to be 14 for moose (Persson et al. 2000, Rönnegård et al. 2008), 25 for red deer (Deer Initiative 2008), 20 for roe deer (Mitchell et al. 1985), and 6.7 for wild boar (Fattorini & Ferretti 2020).

Fig. 2. Distribution of blocks used during ungulate drive counts in the Roztocze National Park in (a) 2003, (b) 2016, and (c) 2017-2020.

Table 1. Estimates of numbers and population densities of wild ungulates in the Roztocze National Park from 2003 to 2020, based on drive counts. SE – standard error of the mean. Note differences in the number and size of blocks used in the following years (see details in Methods).

Species	Population density (±SE) (n/km²)	Population number (±SE)	Estimate error (%)	Population range
2003				
Red deer	1.6 (±0.62)	134 (±51)	38.3	83-186
Roe deer	16.6 (±2.92)	1,373 (±242)	17.6	1,131-1,615
Wild boar	5.4 (±2.72)	447 (±225)	50.3	222-672
2016				
Red deer	6.3 (±1.42)	518 (±117)	22.7	400-635
Roe deer	7.4 (±2.35)	611 (±194)	31.8	416-805
Wild boar	16.1 (±6.59)	1,335 (±546)	40.9	789-1,880
2017				
Red deer	11.5 (±3.61)	948 (±299)	31.5	649-1,247
Roe deer	10.5 (±2.67)	866 (±221)	25.6	645-1,087
Wild boar	8.9 (±5.53)	735 (±458)	62.3	277-1,193
2018				
Red deer	5.2 (±1.23)	433 (±101)	23.4	332-534
Roe deer	4.9 (±1.20)	405 (±99)	24.5	306-504
Wild boar	2.2 (±1.29)	179 (±107)	59.7	72-286
2020				
Red deer	17.6 (±7.43)	1,453 (±615)	42.3	839-2,068
Roe deer	5.4 (±1.72)	450 (±143)	31.7	308-593
Wild boar	11.6 (±3.74)	962 (±310)	32.2	652-1,271

Workload assessment

To estimate the effort required for each phase of the two methods, i.e. sampling design, field data collection, data entry, and data analysis, we recorded the number of operators and the time taken.

Results

Ungulate population density estimated with drive counts

In 2003-2020, during drive counts, only three out of four wild ungulates inhabiting the Roztocze National Park were recorded, i.e. red deer, roe deer, and wild boar, but not moose. The number of ungulates varied greatly for every observed species: 134-1,453 for red deer, 405-1,373 for roe deer, and 179-1,335 for wild boar (Table 1). Although estimation errors were the largest for wild boar (49.1%, range 32.2-62.3%), they were also substantial for both red deer (31.6%, range 22.7-42.3%) and roe deer (26.2%, range 17.6-31.8%).

Ungulate population density estimated with pellet group counts

During the pellet group count in 2021, all four species of wild ungulates inhabiting the RNP were recorded. The most numerous were red deer (n = 353), followed by roe deer (n = 138) and wild boar (n = 48), while moose was scarce (n = 1). The lowest estimation errors were observed for both red deer (4%) and roe deer (6%) and much higher for wild boar (17%) and moose (39%) (Table 2).

Workload

Regarding the drive counts, the sampling sites were selected by one operator who worked for a day. Another single operator then recorded the count data in one day. Additionally, the coordination of the drive count required at least three days by one person. This technique required the presence of at least 45 operators in 2003 (for counts performed within 19 small blocks) and at least 80 operators in 2016-2020 (for counts performed within 8-10 large blocks) for two days of

Table 2. Estimates of numbers and population densities of wild ungulates in the Roztocze National Park in 2021, based on pellet group counts. SE – standard error of the mean.

Species	Population density (±SE) (n/km^2)	Population number (±SE)	Estimation error (%)	Population range
Moose	0.02 (±0.01)	1 (±1)	39	1-2
Red deer	4.52 (±0.18)	353 (±14)	4	339-368
Roe deer	1.76 (±0.11)	138 (±9)	6	129-147
Wild boar	0.62 (±0.11)	48 (±8)	17	40-56

fieldwork during the counts. In 2003, the total effort was assessed to be 310 working hours, while in 2016, it was 510. For 2017-2020, the total effort was 480 working hours. The Roztocze National Park provided a hot meal for all field operators during two days of the fieldwork.

The process of using GIS software to displace the plots for the pellet-group counts took a single operator a whole day to complete. Once the sampling was done, data entry could be performed by a single operator in two days. The count itself required four operators to work for 14 days. In total, the entire effort in 2021 required 140 working hours.

Discussion

Various methods are used to assess the population density of wild ungulates (Ministry of Environment, Lands and Parks 1998, Chećko 2011, Enetwild Consortium et al. 2018). Each differs in estimation errors depending on the behaviour, habitat selection, and spatial organisation of the populations of the target species. Furthermore, the organisation and performance of fieldwork play a crucial role (Daniels 2006, Putman et al. 2011, Amos et al. 2014, Marcon et al. 2019).

Although drive counts are presented as one of the most reliable methods of estimation of wild ungulate population numbers (Pucek et al. 1975, Enetwild Consortium et al. 2018), it may give high errors for low-density populations or when individuals are aggregated in larger groups (Borkowski et al. 2011). The estimation error increases when drive counts are performed on a limited number of blocks, as in the Roztocze National Park, where only eight blocks were used in 2017-2020. Furthermore, drive counts require many field staff and are logistically challenging (Borkowski et al. 2011). The low reliability of the data obtained on ungulate density, high labour input, and complex logistic burden raises questions about counts carried out with this method, especially considering the limited financial sources allocated to wildlife monitoring in national parks.

Estimations of ungulate population size obtained through pellet group counts tested in the Roztocze National Park in 2021 seem optimal, notably for red and roe deer populations. However, the critical aspect of applying this method is the proper identification of pellets of different ungulate species living in the area (Spitzer et al. 2019). It can be achieved by using experienced field staff trained in dung identification.

Although novel approaches are already available for the estimation of wild ungulate population numbers, e.g. analysis of genetic material from non-invasive samples (Koitzsch et al. 2022), camera traps (Pal et al. 2021), unmanned aerial vehicles, and thermal imaging (Witczuk et al. 2018), they are still too expensive and/or require specialist knowledge and technical background. Thus, they are suitable for small scientific projects rather than for regular use by the staff of national parks. Therefore, we are convinced that pellet group counts are the optimal solution for estimating the wild ungulate population size in the Roztocze National Park and similar protected areas, as they balance the reliability of obtained numbers with the efforts required to get them.

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Author Contributions

R.W. Mysłajek, P. Stachyra, M. Figura and S. Nowak performed the pellet group counts; R.W. Mysłajek analysed the data and wrote the manuscript. All authors read and approved the manuscript. The authors declare no conflict of interest.

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Supplementary online material

Table S1. Characteristics of forest stands within blocks used during a drive count of ungulates in 2003. Block numbers are shown in Fig. S1.

Fig. S1. Distribution and numbers of blocks used during drive count in 2003.

Table S2. Characteristics of forest stands within blocks used during a drive count of ungulates in 2016-2020. Block numbers are shown in Fig. S2. *marks block no. 3 and 6, which were omitted during drive counts in 2017-2020.

Fig. S2. Distribution and numbers of blocks used during drive count in 2003.

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