JOURNAL OF FOREST SCIENCE, *60*, 2014 (4): 174–180

An assessment of the applicability of dung count to estimate the wild boar population density in a forest environment

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ABSTRACT: Wild boar is a native species in the fauna of the Czech Republic. It is becoming a problematic game species both in the Czech Republic and in other European countries due to its harmful impacts. So far no suitable method of its sustainable management has been devised. Yet, a correct abundance estimate is essential for proper management, field crop damage prevention and proper hunting planning. This paper employed faecal pellet group count to estimate the wild boar density in a forest environment. The research was conducted in a study area covering 12.83 km^2, which is surrounded by farmland. The count was done under ideal conditions in early spring, after snow had melted. The study area was organised into several differing environments in which different dung densities were expected. The presence of feeding sites, where wild boars concentrated, was taken into account. The conducted count confirmed differences in the utilization of different habitats within the study area. The resulting wild boar abundance was estimated at 64.3 (± 8.9; 95% CI) indd·km^{-2}.

Keywords: accumulation; defecation; distribution; faeces; *Sus scrofa*

The wild boar (*Sus scrofa*) is an indigenous part of the Czech Republic's fauna, and its population density has changed markedly over the last centuries. Due to the increased number of wild boars and favourable climatic conditions, a targeted reduction is necessary to protect agricultural land (Hladíková et al. 2008; Braga et al. 2010). After the World War II the wild boar started recolonisation of the Czech Republic and its steadily growing population presents a serious economic, ecological and social threat across central Europe (Frank 2008; Kirschning et al. 2008). The most serious consequences of the increase in wild boar density are damage to agricultural crops, road accidents, transmission of infectious diseases and the destruction of managed green space in populated areas (Geiser 1998; Brauer et al. 2006; Herrero et al. 2006; Acevedo et al. 2007).

The crucial goal for wildlife managers is to reduce and stabilize the density of wild boar. There are several possibilities of the wild boar population control, including poisoning, sterilization of females and trapping (Killian et al. 2006; West et al. 2009; Gentle 2010; Braga et al. 2012) mostly used outside Europe. In Central Europe practically the only method widely used is intensive hunting (Fruzinski, Labudzki 2002). The intensity of hunting in recent years should not have allowed the wild boar population to expand. Wildlife managers therefore need accurate estimations of wild boar density to take decisions on the numbers of individuals that need to be removed, but methods of density estimation, used for large herbivores, are not generally suitable for wild boar. The low accuracy of current estimations of wild boar density limits the effectiveness of the wild boar popula-

Supported by the Mendel University in Brno, Project No. 47/2012, and by the Ministry of Education, Youth and Sports of the Czech Republic, Project No. CZ 1.07/2.3.00/20.0267) co-financed by the European Social Fund and national budget of the Czech Republic

tion control (Merli, Meriggi 2006) and for this reason, improved methods to determine wild boar numbers are crucial in the management of this species. Density of wild boar has been estimated by modifications of direct observation (Focardi et al. 2002); by repeated counting of marked individuals (Waithman et al. 1999); by counting of tracks on snow cover (Fonseca et al. 2007) or by photo-traps combined with marked individuals (Sweitzer et al. 2000; Hebeisen et al. 2008; Huckschlag 2008; Morimando et al. 2008).

The objective of this study was to evaluate the suitability of faecal pellet group (FPG) counting for estimation of the wild boar population in winter. FPG counting is often used for estimation of wild ruminants, but data on its applicability to wild boar has not been proved.

MATERIAL AND METHODS

Study area. The study area covering 12.83 km^2 is situated in the Czech Moravian Highlands, 11 km south of the town of Jihlava in the southern part of the Czech Republic – 49°15'52.643"N, 15°37'46.266"E (Fig. 1). It is fully forested and surrounded by farmland to a great extent. Its elevation ranges between 550 and 660 m a.s.l. The mean annual temperature is 6.8°C. Forest stands in the study area encompass primarily Norway spruce (*Picea abies*) stands regenerated through natural regeneration, which is highly successful in this area. Broadleaved stands, particularly beech (*Fagus silvatica*), ash (*Fraxinus excelsior*), maple (*Acer pseudoplatanus*) and alder (*Alnus glutinosa*) stands, were established artificially. On the whole, however, broadleaved stands in the study area represent max. 5%. Owing to the forest management used in the area and the predominance of Norway spruce, the species composition of the herb layer is very poor and more herbaceous species can be found only in places where forest regeneration is taking place.

A total of 15 feeding sites, where wild boars are fed throughout the year, are situated in the study area. Feeding is more intensive during the hunting season and in wintertime. Larger amounts of inferior quality feed are often available at the feeding sites. Apart from the studied game species (wild boar), the area houses other ungulate game species as well, notably roe deer (*Capreolus capreolus*) and migrating mouflon (*Ovis musimon*). No large predators occur in this area. The wild boar population in the study area is stable in wintertime. Its migration is limited particularly by the neighbouring farmland and adjoining roads (Špinar, personal communication).

Field data collection. The FPG count was conducted in the study area on March 23–25, 2012. Three basic types of habitats, where significantly different defecation densities were expected, were identified in the study area. We assumed that in an environment where no other food sources except the feeding sites can be found, the wild boar distribution will be affected by cover availability. The first habitat type represented an environment which wild boar could use for cover and as resting place. It consisted of young dense saplings of the predominantly natural regeneration origin up to the stage of first pruning (19% of the study area). The second habitat type consisted of an environment where wild boar did not stay permanently, as

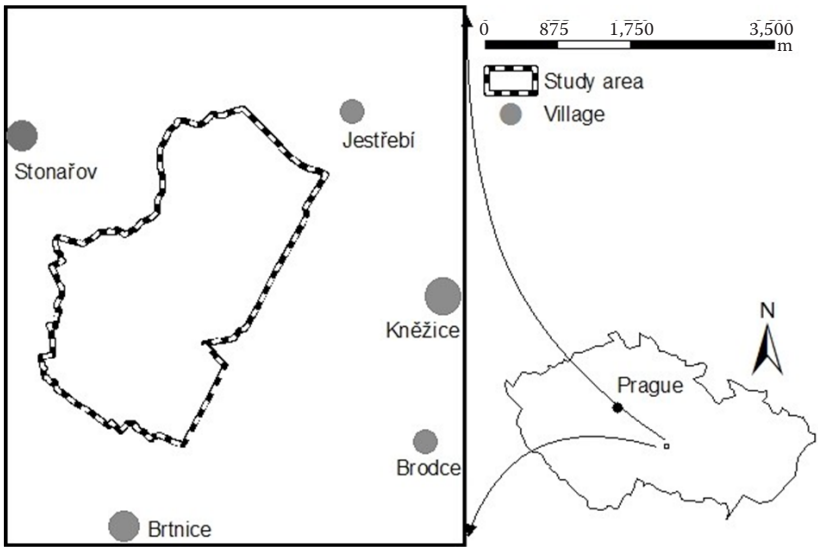

Fig. 1. Location of the study area

it did not provide any cover (49% of the study area). This consisted of mature forest stands with no undergrowth or sporadic clearings after harvesting. The third type of habitat consisted of stands which provided wild boar with only partial cover (32% of the study area). This included particularly thinned young forest stands, but also mature stands with sporadic or low natural regeneration. The ratios of individual habitat types within the study area were determined on the basis of forest management records and field assessments of the vegetation condition.

Wild boar abundance was determined based on a faecal standing crop approach (FSC) count in strip transects 100 m long and 2 m wide. These strips were evenly distributed throughout the entire study area, except for the vicinity of individual feeding sites where the transect network was arranged differently. A total of 516 out of feeding site (OFS) transects (200 m^2) were marked in the individual habitat types in study area, as well as 600 feeding site (FS) transects (100 m^2) in the vicinity of feeding sites. The feeding sites (circular zone areas 200 m in diameter) were divided into three parts: the immediate vicinity – FS1 (circular zone areas 50 m in diameter – 10 sampling strips of 50 × 2 m at each of the 15 feeding sites), a more distant area – FS2 (circular zone areas of 50 and 100 m radius – 10 sampling strips) and a transition zone – FS3 (circular zone areas of 100 and 200 m radius, 20 sampling strips). The number of wild boar FPG and the respective habitat type were recorded for each transect.

Density calculation. Based on the FSC count results, FPG densities in individual habitat types and in the vicinity of feeding sites were estimated and consequently converted to the number of animals according to the following formula (1):

$$PDi = \frac{x_i}{(AP \times DDR \times TA)} \times P_i \quad (1)$$

PDi – population size for each habitat or circular zone,
x_i – average FPG density per transect,
AP – accumulation period (145 days),
DDR – daily defecation rate,
TA – transect area,
P_i – habitat or circular zone area (m^2).

The decomposition period of FPG was determined with respect to the local climatic and natural conditions as of 1.11.2009 to the count day, i.e. 144–146 days (an average of 145 days). The daily defecation rate was set at 5 FPG per day per animal. Densities in individual habitats and in the vicinity of individual feeding sites were then counted up, thus determining the wild boar population density in the study area.

Data analysis. A difference in the mean FPG density between individual habitat types was evaluated using one-factor ANOVA (SPSS, Tulsa, USA). Data distribution was normal (good and medium cover conditions), in the "no cover" category the data distribution was not normal but the large amount of data collected (232 samples) allowed us to use the parametric test as well. Scheffe's post hoc test was used for mutual testing of differences in the means of FPG between individual habitat types, as the number of samples in individual sets varied. A similar procedure was adopted for determining the average number of FPG per transect when studying the wild boar distribution in the vicinity of feeding sites.

RESULTS

The average FPG density per transect (200 m^2) in all three habitat types (cover, partial cover, no cover) varied (ANOVA, $F_{2.513}$= 163.7; $P < 0.001$; Scheffe's post hoc test, $P < 0.001$). The highest FPG density was in the area of good cover (16.3 ± 8.35 SD FPG·200 m^{-2}), while the lowest number was determined in places with no cover (4.5 ± 4.27 FPG·200 m^{-2}). In places with partial cover, the FPG density was similar to the mean density of the entire study area (8.0 ± 6.65 and 9.0 ± 8.12 FPG·200 m^{-2}, respectively) (Fig. 2). As a result, the calculations of wild boar density had to be done for each habitat type separately.

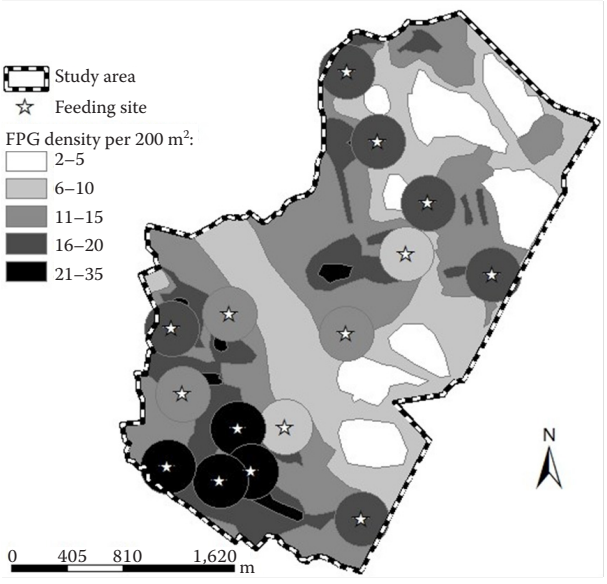

Fig. 2. Results of the spatial distribution of wild boar FPG within the study area

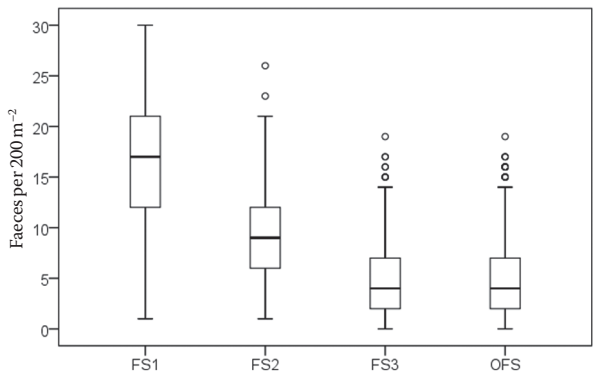

Fig. 3. The wild boar FPG density in the study area in winter period

The average FPG density in the vicinity of feeding sites (FS1) was approximately double compared to that outside of the feeding sites (17.6 FPG·200 m^{-2}). The wild boar distribution at individual feeding sites was relatively even, only the relatively high density at feeding site 14 (34.5 FPG) differed from the average number of FPG per 200 m^2, while densities at sites 8 and 12 was low (6.1 and 9.7 FPG, respectively). FPG density at the remaining feeding sites ranged from 12.4 to 21.3 FPG·200 m^{-2}.

Data were analysed by the ESRI ArcMap10 software (ESRI, Redmont, USA).

Differences in FPG density between individual zones were statistically conclusive (ANOVA, $F_{2.597} = 272.8$; $P < 0.001$; Scheffe's post hoc test; $P < 0.001$ for all cases). Following our assumption, the wild boar FPG density was highest (32.2 indd·200 m^{-2}) in the immediate vicinity of feeding sites – FS1 (up to the distance of 50 m) and lowest (9.8 indd·200 m^{-2}) in the transition zone – FS3 (100–200 m from the feeding site). FPG density in the transition zone did not differ from that in the open forest (*t*-test; $t_{814} = 1.359$; $P = 0.175$) (Fig. 3).

FS1 – FPG on the feeding sites within 50 m from the centre; FS2 – FPG in the area of 51–100 m from the centre; FS3 – FPG in the area of 101–250 m from the centre; OFS – FPG outside of the feeding site areas.

The total of 229 ((± 47; 95% CI) wild boar individuals in the circle zones around the feeding sites was calculated using means for individual feeding sites. The total of 596 wild boar (± 67; 95% CI) was calculated using FPG density means at the OFS transects in all habitats. The resulting population density in the entire study areas was thus determined at 64.3 (± 8.9; 95% CI) individuals per km^2.

DISCUSSION

Considering all aspects of the results the wild boar is a very problematic species compared to other wild-living ungulates. This is mainly due to their intensive reproduction, hidden way of life (Fernández-Llario 2004), nocturnal activity (Lemel et al. 2003), migration over longer distances and different feeding behaviour. In wild boar there is no sexual dimorphism, which, in other ungulates, can be used to correct the results of the counting. For these reasons, the counting methods, commonly used in other ungulate species, require some modifications in order to eliminate potential inaccuracies ensuing from different behaviour of wild boar.

The objective of this study was to verify applicability of the FPG count method for estimating the population density of wild boar in a forest environment. FPG count is one of the most common (Neff 1968; Hemami, Dolman 2005) and the most accurate (Barnes 2002; Campbell et al. 2004) methods estimating counts of wild animals; however, in the case of wild boar it is often left out, mainly due to the lack of data on defecation rate, seasonal migrations over long distances, until recently low population density and uneven distribution of faeces in the environment (Hebeisen et al. 2008). Generally speaking, FPG count can be employed to estimate numbers of wild boar similarly like abundance of ruminants, bearing in mind its limiting conditions. In this study the use of defecation rate due to outside field experiment (unpublished data), the animals did not migrate outside of the area during winter, their density was relatively high and their faeces showed normal distribution thanks to the suitably chosen size and number of the transects.

One of the main reasons why FPG count is not so frequently used is very few results about daily defecation rate of wild boars. It is not possible to determine the daily defecation rate in wild animals. Both the quality and quantity of food accessible to wild boar will vary markedly throughout the year (Massei et al. 1996; Schley, Roper 2003); hence, the defecation rate value can also fluctuate. At present, however, food supply is greatly affected by additional feeding and baiting, which has an impact on the wild boar behaviour in winter (Hahn, Eisfeld 1998; Geisser, Reyer 2005). In the periods with limited supply of natural food, cereal grains from feeding stations can make up 90% or more of wild boar diet (Plhal et al. 2011). Using a wild boar daily defecation rate of 5.00 FPG was very similar to the value 4.5 (Tottewitz et al. 1996), mentioned in the works of Cristescu and Ion (2007) and Heinze et al. (2011). Rather higher values were reported in the work of Musial

et al. (1999), who had determined the number of defecations in experimental dwarf pigs between 4.8 and 9.4 per individual and day. Similar results (10 defecations per individual and day) were found in Iberian pigs during the autumn mast period (Rodríguez-Estévez et al. 2005). Such high values, however, may have been caused by laboratory environment and feeding *ad libitum*.

A very important condition of FPG counting for estimating the wild boar population density is the correct analysis of decomposition rate. The technique is similar to the FSC method. Faecal Accumulation Rate (FAR) approach could be more problematic and less effective due to the uneven distribution of faeces and higher amount of transects. The values of decomposition rate can vary greatly depending on vegetation, air temperature, humidity, precipitation and dung beetle activity (Massei et al. 1998; Laing et al. 2003; Hemami, Dolman 2005). The most intensive decomposition occurs during periods of full dung beetle activity in the habitats with dense ground vegetation; in contrast, the longest decomposition has been observed in coniferous stands without ground vegetation (Tsaparis et al. 2009). Winter is an ideal period for faeces counting (Massei et al. 1998). During this season, faeces are subject to minimum decomposing factors and so they remain in the environment in almost unchanged state until the time of counting before the start of new growth of vegetation. Massei et al. (1998) determined the period of wild boar faeces disappearance in winter in the area of Mediterranean climate to be approx. 120–240 days in relation to the type of habitat.

The density of wild boar population that we have estimated by FPG count in the study area was 64.3 indd·km^{-2}. This value seems to be extremely high in comparison with the abundance of wild boar found in other works – i.e. in the Bialowieza National Park – [3.5–5.9 indd·km^{-2}; Jedrzejewska et al. (1994)] or in forests of other European countries [1.5–12 indd·km^{-2}; Hebeisen et al. (2008)]. The very high population density in this area is probably due to improper game management and to the concentration of animals in the winter season. Because all around the study area there are neither suitable shelters nor other available food sources for wild boar in wintertime, so wild boars have no reason to migrate away and stay here in such high population density.

The accuracy of wild boar FPG counting is significantly affected by the uneven distribution of faeces in different types of habitat. This variation is caused by the fact that wild boars defecate less often than ruminants, they prefer places where they feel safe and in sounders they often defecate together. Putten (2000) reported that wild boars never defecate directly in the resting area, but only at a certain distance from it. The theory of uneven faeces distribution corresponds with the observation of Mussial et al. (1999) that defecation of wild boar usually happens during food intake. This is the reason why in wild boar, the distribution of FPG is markedly more patchy than in ruminant ungulate species (Abaigar et al. 1994), invoking the need to monitor the population on a sufficiently large area, to define the habitat categories precisely and to determine their share in the total area of the studied region. In our study area, the highest concentration of faeces was found in saplings that provided mainly a good shelter for wild boar – mean ± SD (16.3 ± 8.35 indd·200 m^{-2}) and about four times lower in places without undergrowth (4.5 ± 4.27 indd·200 m^{-2}). Our results correspond with previously published data. For example, Gerard et al. (1991), Lemel et al. (2003) or Keuling et al. (2008) reported that during daylight wild boars usually seek shelter and rest in young dense stands. According to Fonseca (2008), during the winter in southeastern Poland, wild boar stayed mainly in beech-hornbeam stands where they had the opportunity to feed on the beech-mast crop. Thurfjell et al. (2009) confirmed that young boars prefer young coniferous stands to broadleaved stands in winter in conditions very similar to our study area, including intensive additional feeding except in a seed year. In our study area, there were minimum natural sources of food available at the time of data collection and so the animals depended upon the food from feeding stations (Plhal et al. 2011). Due to this, most of the faeces were found in the stands close to the feeding stations that also served as resting places for the boars.

We have confirmed that FPG counting conducted in winter is an applicable method to estimate the wild boar abundance in a forested area. Moreover, FPG counting involves no expensive equipment and the level of training required to achieve competency compares favourably with other methods. To prove accurate, it is our opinion that the initial FPG counting requires sample sizes obtained from as large an area as possible with similar condition to minimize the errors due to the uneven distribution of faeces. Further research is required to determine the distribution of faeces in different environments, to verify the

defecation rate of wild boar in relation to the type of diet and to further test the accuracy of the wild boar abundance estimation by FPG counts compared to other methods.

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Received for publication December 11, 2013
Accepted after corrections April 16, 2014

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