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and Other Suids

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Editors: Jiří Kamler, Jakub Drimaj

4th–7th September 2018, Lázně Bělohrad
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Abstract
An analysis of feeding conditions of certain wild animal species allows hunting farms to properly plan additional nutrition during the year, thus maintaining animal population on certain hunting territories and minimizing animal migration to neighboring hunting territories. Forage shortage is a limiting factor, especially during difficult periods of the year, like winter or early spring. The results of current research allow hunting farms to use data on animal feeding preferences in different seasons of the year and to organize biotechnical activities for the purpose of improving feeding conditions of such wild animals as Ussuri boar, red deer, Ussuri elk and Siberian roe deer. The authors identified the most preferable, commonly eaten, minor fodders, as well as forages that are needed during difficult periods of animal life, so called "limiting feeding stuffs". We have been studying fodder conditions in Eastern Siberia and Amur region for 8 years. An analysis of excrement found in various areas of the Republic of Buryatia and Amur Region was made to determine ungulates ration. Food elements were identified physically by clearly seen fragments and by conventional lab tests. Our research results allow hunting farms to improve their systems of biotechnical and reproductive measures, in order to increase wild ungulates' population and to improve hunting grounds quality. The attendance frequency of such feeding fields by wild animals depends on their location, season of the year and the abundance of vegetation. As a rule, those feeding fields are being located at 1-2 km. distance from human settlements or forest and field roads due to materials' delivery logistics and machinery access. Feeding fields' sowing happens annually in different areas of hunting grounds. In the Republic of Buryatia, the territory of 109 hectares was sown in 2015, over 31 hectares - in 2016, and 62 hectares - in 2017; in Amur Region 1,000 hectares were sown in 2015, 655 hectares - in 2016, 517 hectares - in 2017. Hunting farms and game hunting reserves of both territories under study try to diversify feeding fields composition and alternate crops. The best forage crops for hoofed species are: alfalfa, rape, sweet clover, soybean, rye, vetch and other plants that contain large amounts of protein. Hay is produced annually for ungulates' extra nutrition. In the Republic of Buryatia 95.4 tons of hay were harvested in 2015, 47.7 tons - in 2016, 78.8 tons - in 2017. In Amur Region 67.2 tons of hay were harvested in 2015, 38.9 tons in - 2016, 70.7 tons - in 2017.

Keywords: *Siberia, Amur region, forage crops, limiting factor, Ussuri boar, Siberian roe deer, Red deer, Elk*

An analysis of feeding conditions of certain wild animal species allows hunting farms to properly plan additional nutrition during the year, thus maintaining animal population on certain hunting territories and minimizing animal migration to neighbouring hunting territories (Senchik, Igota Hiromasa, Bormotov & Bochkarev, 2017). Forage shortage is a limiting factor for animal survival and safety, especially during difficult periods of the year, like winter or early spring. This occurs due to high snow and ice crust on the snow (Danilkin, 2014). The results of current research allow hunting farms to use data on animal feeding preferences in different seasons of the year and to organize biotechnical activities for the purpose of improving feeding conditions of such wild animals as Ussuri boar, red deer, Ussuri elk and Siberian roe deer. The authors identified the most preferable, commonly consumed, minor fodders, as well as forages that are needed during difficult periods of animal life, so called "limited feeding stuffs". We have been studying fodder conditions in Eastern Siberia and Amur region for 8 years. An analysis of excrements found in various areas of the Republic of Buryatia and Amur region was made to determine ungulates' ration. Food elements were identified physically by clearly seen fragments and by conventional lab tests, using a microscope and fractioning of found excrements. The research results allow hunting farms to improve their systems of biotechnical and reproductive measures, in order to increase wild ungulates' population and to improve hunting grounds quality.

To provide additional food for wild ungulates in Eastern Siberia and Amur region in the feeding fields a cultivation of oats, barley, triticale, wheat, corn and soy is most effective. (Table 1). Cultivation of these crops is suggested not because of their scientific validity, but because of their availability and economic efficiency of their sowing in the study area of hunting grounds.

Table 1: The chemical composition of the grain of the main agricultural crops

Crop	%				Feed units
	Proteins	Carbohydrates	Fiber	Fat	
Wheat	12,0	68,7	2,0	2,2	1,20
Barley	10,5	64,4	4,5	2,4	1,21
Oats	10,2	59,7	10,0	6,2	1,00
Corn	10,3	67,9	2,2	4,9	1,34
Soy	34,9	24,6	4,5	18,6	1,38

A promising crop is triticale, with an increased protein content (up to 18%) and essential amino acids (lysine, trypto-fan), which, according to grain yield and green mass, can successfully compete with traditional crops.

The introduction of a raw (grazing) conveyor provides uninterrupted flow of grain for feeding animals, and sowing crops at different times contributes to an increase in the duration of their use (Table 2).

Table 2: Scheme of the feed conveyor

Crop	The term of sowing	The term of use
Oats	April	August 01-15
Triticale	April	August 10-30
Oats	May 01-10	August 15-20
Corn	May 15-25	August 25 - September 15
Soy	May 15-30	September 10 - 20
Corn	June 01-10	September 10 - 20

Many years of our research confirm the need for regular winter feeding. Top dressing "softens" the main ecological factor to its minimum, which allows saving the animals as well as maintaining the population density at a level exceeding the natural forage capacity of the land. Feeding wild boar with crops in winter softens the negative impact of low temperatures, high snow and icy snow cover during January-February. Other important tasks that are solved by using dressing during winter are preservation of natural food; reducing damage to forestry and agriculture; concentration of wild animals in the right place at the right time; keeping them in a limited area and preventing migrations; as well as improving their physical condition.

The combined effect has the greatest result when fodder fields are used in the fall to attract and retain wild animals, and as the availability of feed and deep snow cover diminishes, animals switch to man-made feed. To do this, it is necessary to supply feed in a timely manner and in sufficient quantity.

Hay is one of the most important types of feed for wild deer during difficult winter periods. Harvesting hay is the oldest method of preserving feed, based on xero-anabiosis. Well-prepared hay should contain no more than 17% of moisture, have green color and a specific fresh smell of herbs. Hay is a good dietary food, which normalizes digestion processes and metabolism in wild animals. The presence of sugar in its contents contributes to constant and intensive development of microflora in the foreglobe, which leads to an increase in the digestibility of dietary fiber, saturating them with essential amino acids and B vitamins (Danilkin, 1986 and 1996).

Nutritional quality of hay depends on species composition of grass, timing and methods of harvesting. Hay is mowed, stacked in mop, bales and rolls, wrapping them with plastic wrap if possible to preserve the nutritional value of the feed, reducing its cost by 20-30%.

Hay consumption can be significantly increased if it is salted when it is laid out in a feeder rather than when it is laid for storage. Hay and salt become overly hygroscopic and mouldy. Top dressing from salted hay should be placed near watering spots, a river or a lake.

From various types of hay in natural hayfields, ungulates prefer meadow and forest hay with a large number of broad-leaved grasses. Hay from grass grasses is less preferred. Wild animals do not eat swamp and sedge hay, especially that which is harvested after flowering plants. These types of hay are not edible because they contain essential oils with an unpleasant odour and because of their rigidity and coarseness.

Such selectivity of hay types is explained by wild ungulates' habit to feed on forest vegetation and meadow and forest hay with greater nutritional value. Feed indicators and chemical composition of hay of different categories are shown in table 3.

Table 3: Chemical composition of hay, %

Types of hay	Protein	Albumen	Fat	Cellulose
Forest	8, 5	7, 2	2, 6	24, 1
Meadow	8, 4	7, 1	2, 6	55,0

Marshland	8, 5	7, 2	2, 3	24, 0
Sedge	8, 6	6, 4	2, 6	23, 8

Different categories of hay are harvested on artificially planted hayfields, such as cereal, legumes, mixed (cereal and leguminous), and feed grain together with straw (oatmeal hay). Mixed hay is preferable to hay of one type of grass, as it is more readily eaten and has a richer chemical composition. Independent studies were conducted in the chemical laboratory to prove that infer (Table 4).

Table 4: Nutritional value of the main types of hay

Type of hay	1 kg of feed contains				
	feed units	digestible albumen, gram	protein, gram	calcium, gram	phosphor us, gram
Cereals (mixture)	0,51	30	42	3,81	3,03
Meadow grass meadow	0,52	44	53	-	-
Meadow Fescue	0,55	38	50	-	-
Timothy grass	0,49	31	42	3,88	2,63
Hay from seed beans					
Vika	0,47	82	123	11,65	2,71
Clover	0,52	55	79	9,29	1,95
Alfalfa	0,49	87	114	14,37	2,21
Esparcetna	0,54	78	106	10,08	2,36
Mixed crop hay					
Vika-oatmeal	0,47	46	68	6,27	2,74
Timothy clover	0,50	37	52	7,4	2,4

In order to maintain optimum moisture and nutritional value of hay it is necessary to take into account early harvesting periods, preferably drying in the shade, while selecting hay types as an additional feed for wild deer.

Wild ungulates eat clover hay well. Clover red (*Trifolium pratense*) has a high feed value. It is used for grazing, green mass and for manufacturing vitamin feed and hay flour. Forage made from clover is rich in protein, vitamins, minerals. 100 kg of green mass contains 21 feed units and 2.7 kg of digestible protein on average, in hay it is 52 and 7.9, respectively. In Amur region clover produces high yields (Larin, 1952).

Figure 1: Clover red (*Trifolium pratense*)

Concentrated feed is used when feeding deer and wild boar in Amur region and Eastern Siberia: grain of oats, corn, wheat, rye and soy. At the same time, it is necessary to take into account the fact that the use of large amounts of wheat and soy in grain mixtures leads to digestive disorder. This does not occur if oats or corn predominate in the mixture. We believe that it is necessary to give grain to injured or small wild animals so that they can digest food better while the feed is consumed in less quantities with this technology of food feeding.

The attendance frequency of such feeding fields by wild animals depends on their location, season of the year and the abundance of vegetation. As a rule, those feeding fields are being located at 1-2 km. distance from human settlements or forest and field roads due to delivery logistics and machinery access. Feeding fields' sowing happens annually in different areas of hunting grounds. In the Republic of Buryatia, the territory of 109 hectares was sown in 2015, over 31 hectares - in 2016, and 62 hectares - in 2017; in Amur Region 1,000 hectares were sown in 2015, 655 hectares - in 2016, 517 hectares - in 2017.

Figure 2: Feeding field in the Republic of Buryatia, sown with clover and oats

Figure 3: Wild boar in the feeding area (a mixture of soybeans, oats and corn)

Hunting farms and game hunting reserves of both territories under study try to diversify feeding fields composition and alternate crops. The best forage crops for hoofed species are: alfalfa, rape, sweet clover, soybean, rye, vetch and other plants that contain large amounts of protein. Hay is produced annually for ungulates' extra nutrition. In the Republic of Buryatia 95.4 tons of hay were harvested in 2015, 47.7

tons - in 2016, 78.8 tons - in 2017. In Amur Region 67.2 tons of hay were harvested in 2015, 38.9 tons in - 2016, 70.7 tons - in 2017.

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COMPARING THE METHODS FOR ASSESSING THE WILD BOAR (SUS SCROFA) POPULATION NUMBERS USING ZAPOROWO FOREST DISTRICT AS AN EXAMPLE

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Abstract
In February and March 2013, within the area of Zaporowo Forest District (north-eastern Poland) the population number of wild boar estimates were conducted with the use of tracking on line transects, driving taxation plots, and by analysing the bags of collective hunts. The wild boar number obtained by tracking on line transects amounted to 1538 individuals (89.8/1000 ha), while the result obtained by drive census assessment belt was 1458 (83.2/1000 ha) animals. According to the bags of collective hunts, the population number of wild boar population amounted to 1419 individuals (81.0/1000 ha). The results obtained by these three methods did not differ in significant way which means that the method of the analysis of collective hunts can be used as a routine method for assessing the wild boar population number. In order to ensure better correspondence to the actual number of animals, it is necessary to calibrate the relationship between the number of wild boar bagged per one driving exercise and the population density (N/1000 ha) estimated by an absolute method i.e. the method where the absolute density of population is directly expressed in the number of individuals per a defined unit area e.g. N/1000 ha.

Keywords: *density, population number, tracking on line transects, drive census assessment belt, analysis of data from collective hunts*

1. Introduction

Over the most recent years, a remarkable increase in the population numbers of wild ungulates, including wild boar occurred, not only within Poland, but throughout Europe (Apollonio et al., 2010). At the same time, the increase was noted in the damage caused by this species in grasslands and cultivated fields (Schley et al., 2003, Frąckowiak et al., 2013). There are diversified reasons for the increases in wild boar population. The most important is probably the birth rate exceeding the number of animals bagged (Genov, 1981), lack of natural predators, as well as the changes in the structure of crops. During the last ten years, the area of maize cultivated for green fodder and area of rape cultivation, increased in Poland by a factor of 1.7 (Niszczota, 2015).

Wild boar is the species playing a positive role in forest ecosystems because, through rooting, it hampers the increase in insect pest numbers (Fruziński, 1993), nevertheless excessive density can adversely affect the environment. The high densities of wild boar are bringing about remarkable damage both to forest plantations and cultivated crops. The confirmation of the extent of the damage exerted by this species can be found in the expenditures borne by the State Forests on forest protection, and in the amount of compensations paid by hunters to farmers (Frąckowiak & Mikoś, 2015). Furthermore, the too high wild boar population density could probably increase the danger of spreading infectious diseases such as the African swine fever, which now constitutes a problem in many regions of Poland (www.wetgiw.gov.pl).

The population of wild boar inhabiting Zaporowo Forest District is a very important component of the local populations of big game animals because the wild boars have a serious impact upon budget of hunting clubs and in the hunting districts, which are managed by the State Forest Service. The game managers may obtain income by trade of carcasses and/or by organizing the. However, the management of wild boar at high-density population level is a very risky collective hunting decision, because of the damage to agriculture. Financial compensation paid for the wild boar damage may totally change the presented above optimistic level of income. Therefore, the crucial question to all hunters and wildlife managers is how to keep wild boars in forest and to reduce the probability of their movement to agricultural crops.

2. Data and Methods

The Zaporowo Forest district is situated in north-eastern part of Poland, In the Warmia-Masuria voievodship, between 19°4'50" and 20°5'20" east, and between 54°9'25" and 54°9'40" north. A

In administrative terms it is under the management of the Regional Directorate of the State Forests in Olsztyn. From the geographical viewpoint, it is situated in the mesoregions of the Elbląg and Warmia uplands, Iława Lake District, Lubawski Hump, and the Brodnickie Lake District. The elevation above sea level fluctuates between 0.3 and 115.8 m. The land relief of the area is formed mostly by moraine lowlands, moraine uplands, hills of end moraines, kame hills, subglacial troughs, river-derived forms, and forms created by vegetation (Kondracki, 2002).

The highest proportion among the soils of the area is that of brown soils, subtype brown podzolic soil, leached (Kondracki, 2002). The climate prevailing in the area is the lake-district type. This kind of climate is characterised by transitional features between the continental and Atlantic climates. The mean temperature and precipitation in the study area amount to 7 degree Celsius and 650 mm, respectively (Matuszkiewicz, 2008).

The forest in the District include 209 forest complexes of which most fell into the range from 1.01 to 5.00 ha. The deciduous stands prevail, constituting 72.2% of the forested area. The largest area is occupied by fresh forests occupying 62.7% of the area of the Forest District. In the fresh forests, the most numerous tree species is the oak (*Quercus sp*.). The subsequent tree species, in terms of percentage proportions are the birch (*Betula sp.*) and the Norway spruce (*Picea abies*). In its territorial reach the Zaporowo Forest District includes 9 hunting districts all of them covering also the grasslands and cultivated fields (Plan Urządzenia Lasu dla Nadleśnictwa Zaporowo). The large-area farming predominates in the study area. Cereals, particularly wheat and maize are dominant crops (Albrycht et al., 2016).

In order to compare the methods for the estimating wild boar population numbers, the data from tracking on line transects, drive census assessment belts, and the analysis of the bags in collective hunts completed in February and March 2013, was used.

Tracking on line transects. In the area of the Forest District, 99.6 km of line transects were delineated, in accordance with the premises of the Carpathian method (Bobek et al., 2007) that 50 km of transects should be marked in each 10,000 ha of forest. The transect usually went along the passable forest roads and rides. Prior to the beginning of tracking, one day earlier, all tracks on the course of tracking run were obliterated. In the next five days, the observers conducted the tracking, recorded the number of tracks of animals that crossed the transect in each 24 hours, and obliterated them again. Then, after the analysis of tracking cards, the index of relative density, i.e. the number of tracks per 1 km of transect (N/km) was calculated, separately for each 24 hrs of tracking. The index so obtained was then substituted to a regression equation where the absolute density (N/1000 ha) is a dependent variable, and the index of relative density (N/km) – an independent variable. The obtained result was used to determine the population number in the subsequent days of tracking used for the estimation of the mean population number in the study area (Bobek et al., 2007).

For calculations, the following relationship was used:

$$\mathbf{y = 12.60\,x + 15.6}$$

where

y – wild boar population density per 1000 ha of forest

x – relative population density (N/km of transect)

The relationship was calibrated during the assessment of wild boar numbers in the Rudziniec Forest District in 2007 by using the method of large taxation plots. The possibility to use the relationship was warranted by the similar environmental conditions to the Zaporowo Forest District situated in the same area.

Drive census in belt assessments. Within the area of the Forest District, 19 taxation plots were delineated in 9 hunting districts. Taxation belts constituted of several forest sections adjacent along their shorter sides. Walking along the belts involved 15 persons. Each participant was in visual touch with two neighbours, to his/her left and right. During the walk, the members of the battue team recorded the animals which ran back between the two members of taxation team. Any such animal was recorded by the participant which was passed on the right side. On flanks, the animals which ran out from the front of taxation belt were recorded. The final timing of the end of walk was recorded. The processing of data consisted in eliminating the animals seen several times, from the pool of observed animals. Next the population densities and numbers of wild boar in hunting districts were calculated. The sum of numbers from hunting districts provided the total number and the average population density in the whole study area (Bobek et al., 2009). This method increases the accuracy of the final result of assessment of population number (Bobek et al., 2007).

Analysis of the bags of collective hunts. In Poland, the collective hunts take place from October to the half of January. Usually 12 – 18 hunters, persons of driving battue team and hunting dogs participated in the hunt. The battue drove the animals on to the line of hunters, over an area of approx. 100 ha. The analysis included data from 7 hunts in which 42 plots were driven. The analysis covered the driven plots of similar sizes, and hunts with similar numbers of hunters, hunting dogs, and persons responsible for driving teams. The data pertaining to the animals seen by two hunters on neighbouring stations were eliminated. Next, the population density index was calculated. This index is the number of animals bagged per one driven plot. The obtained index is the value of independent variable. Substituting the index into the regression equation permits to estimate of the absolute wild boar population density and number (Bobek et al., 2007).

The obtained indices were then substituted in the following equation:

y = 101.5 * arctan (1.699 x)

where is the wild boar population density per 1000 ha of forest, and x is the average number of wild boar bagged per one drive

3. Results and Discussion

The wild boar population numbers were estimated by the drive census in belt assessments, by the Carpathian method (line transects), and by analysing the bags in collective hunts. The studies were performed in February and March 2013. The estimating of the wild boar number by the use of the Carpathian method was performed on 32 line transects of 99.6 km of combined length. In the study area, 19 taxation plots covering the combined area of 1644.4 ha, situated in all hunting district of the study area. The areas of particular driven plots ranged from 49.3 to 138.4 ha. The estimate on the basis of bags in collective hunts was completed on the data from 42 driven plots.

During five days of tracking on line transects, a total of 2854 tracks of wild boar were observed. In subsequent days of studies, the following numbers of individuals' tracks were recorded: 581, 549, 548, 576, and 600 individual tracks, giving a mean value of 570.8 tracks per day. After calculating the number of recorded tracks per 1 km of transect, the index of relative population density was obtained amounting to the average of 5.89 tracks/km of transect, falling within the range from 5.15 to 6.50 tracks per 1 km of transect. After substituting the values of relative density of tracks to the regression equation, the wild boar density per 1000 ha of forest in the study area was obtained. The mean wild boar density in the studied area reached the value of 89.8 individuals/1000 ha of forested are which permitted the estimate of wild boar number at 1573 individuals (Tables 1, 2).

During 7 collective hunts, 46 wild boar were bagged in 42 drives. By analysing the results obtained by this method, the population density was estimated to be 81.00 individuals/1000 ha, resulting in the total number of 1419 individuals (Tables 1, 2).

As a result of estimating the wild boar numbers by driving taxation plots, 137 wild boar were observed in 19 plots driven on the area of 1644.4 ha. Based on the obtained data, the wild boar population density was calculated which amounted to 83.31 individuals/ ha of forested area. The calculations concerned the number of observed individuals, and the total area covered by the study. The population number of wild boar was estimated at 1458 individuals Table 1, 2).

The wild boar population numbers estimated for the study area, calculated by aforementioned methods, was then divided into hunting districts in proportion to the forested areas they occupy.

The results of the assessment of the wild boar population number in the Zaporowo Forest District conducted by three different methods do not differ much between themselves. The population number estimated by tracking on line transects amounted to 1538 individuals, and this value was the highest among the methods used while the lowest estimate of wild boar number (N=1419) was obtained by the analysis of bags in collective hunts. The population numbers calculated with the use of all three methods stay within the 95% confidence interval, around the mean (mean ± $t_{3;\,0.05}$*SE).

In Poland, the plans for hunting management are based principally on round-the-year observations which are burdened by unknown measuring error. It all results in uncontrolled increases in the populations of game animals, including wild boar (Budna, 2005; Domaszkiewicz, 2016). The high numbers of the latter are the reason of high damage incurred by the animals in cultivated crops and forest plantations. These phenomena are confirmed by remarkable expenditures borne by the State Forests on the forest protection measures and by high compensations paid by hunting associations to farmers (Frąckowiak & Mikoś, 2015). Moreover, too high wild boar densities can increase the probability of the spread of infectious diseases such as the African swine fever already posing a major problem in many regions of Poland (www.wetgiw.gov.pl). Thus the methods for estimating population numbers which allow the assessments of measuring errors, and are repeatable should be used.

Table 1: Numbers of wild boar population in Zaporowo Forest District estimated in 2013 by tracking on line transects, drive census assessment belt and collective hunt data method.

Number of hunting district	Forest area	The number of the wild boar population		
		Tracking on line transects	Drive census assessment belt	Analysis of data from driven hunt
24	2099	129	122	148
25	1622	125	119	115
26	2526	264	250	184
27	925	164	156	152
54	1650	200	189	106
55	1912	140	133	223
56	2000	241	228	119
81	3365	161	152	243
83	1419	115	109	129
Suma	**17518**	**1538**	**1458**	**1419**

In order to ensure the effectiveness of the methods, there are, however, certain guidelines to be adhered to when applying particular methods, correct selection of combined forest transect lengths together with regression equations calibrated in the field where the population number is assessed, correct proportion of blocks or taxation belts to the studied area, proper matching of a method to the species assessed and, finally, the reliable conduct of field work.

The hunting management plans also employ driving sample plots and taxation belts (Bobek et al., 2009; Borkowski et al., 2011), using taxation blocks (Maruyama, 1992), analyses of multi-year harvests of population (Ziółkowska, 2014; Bobek et al., 2015), tracking on line transects (Bobek et al., 2012), estimates of population numbers of wild ungulates with the use of bags in collective hunts (Bobek et al., 2005, Bobek et al., 2015). In the most recent years, the methods of estimating the population numbers of wild ungulates involving thermovision-based techniques have been tested, but the results of these studies require verification with other methods, apart from the fact that they had major limitations, and require great financial outlays (Pierce et al., 2015). The required financing for the application is an essential factor in the selection of a given method. Therefore the method for assessing the population number using the analyses of bags in collective hunts seems to be a good solution (Bobek et al., 2005). It is, above all, based on data which can be easily collected during routinely performed collective hunts, by which the major financing outlays could be avoided. Nevertheless, the calibration of the relationship between the number of animals bagged per one driving, and the population density determined by an absolute method, such as driving sample plots, taxation blocks or the driving census on taxation belts, as it was done in the Zaporowo Forest District. The analysis of bags in collective hunts could be commonly applied in the hunting management planning exercises throughout Poland. It is assessed that in every year during collective hunts there are approx. 125 thousand of various plots being driven in Poland. These activities could be used for estimating population densities without incurring any additional financial outlays (Bobek et al., 2015).

Table 2: The comparison of the population density of wild boars and the number of the wild boar population estimated by three methods in Zaporowo Forest District in 2013

	Density of wild boar population (N/1000 ha)	The number of the wild boar population (N)
Tracking on line transects	87.80	1538
Drive census assessment belt	83.23	1458
Analysis of data from driven hunt	81.00	1419
Mean ± 95% confidence interval	84.01 ± 6.36	1471 ± 111
SE	2.00	35.03
Range	77.65 – 90.37	1360-1582

To run the proper wild boar population management and to keep it at correct size involving the acceptance of the level of damage by these animals by all interested parties, it is necessary to have the precisely determined assessment of wild boar population level which can be obtained by using statistical methods. Irrespective of the method used, the collection of relevant number of samples is necessary allowing the calculation of measuring error at a predefined confidence interval (Krebs, 2009). As found by Pierce et al. (2012), the measuring error not exceeding 10% of the mean for 95% of the confidence interval is a precondition for the use of the obtained results in hunting management plans.

4. Conclusion

Developing and applying reliable methods for the assessment of the wild boar population numbers is an essential element of the sustainable management of this population. It will warrant keeping the population on proper level ensuring good health and sanitary status of the animals. Keeping the damage caused by wild boar on the level acceptable to all interested parties, and not calling for great financial outlays.

The recommended method can be applied in hunting plans but only under the condition that each hunting district provides the suitable volume of data from collective hunts. Only then it will be possible to conduct statistical calculations improving the accuracy of the results and allowing the calculation of measurement error.

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DETERMINATION OF RADIONUCLIDES ^{137}CS AND ^{40}K IN WILD BOAR MEAT IN VARIOUS REGIONS OF THE CZECH REPUBLIC

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Abstract
The aim of the study was to investigate the contamination of wild animals by radionuclide ^{137}Cs in various regions of the Czech Republic 30 years after the Chernobyl accident.
Since the ^{137}Cs content in wild boars (Sus scrofa L.) muscular tissue from areas with a higher area contamination (over 13 kBq/m^2) has been monitored regularly, attention was focused on areas with low and medium area contamination (below 1 kBq/m and 2,2-5,5 kBq/m^2 respectively) immediately after the accident.
The activities of ^{137}Cs and ^{40}K radionuclides were determined by the gamma-ray spectrometric method in 38 samples of muscular tissue. The methodology for the determination of both radionuclides was adapted depending on the different sample sizes of the meat collected. The activities of both radionuclides in individual samples in four different locations are presented, including combined uncertainty of determination. The results of ^{137}Cs activities in wild boars indicate that after such a time the type of ecosystem (either forest or agricultural ecosystem) in which wild boars live is more influential than the initial deposition of radionuclide ^{137}Cs in April and May 1986. The concentration of radionuclide ^{40}K is similar for all wild boars and corresponds with the metabolism of this biogenic element.

Keywords: *gamma-ray spectrometry, radionuclides ^{137}Cs and ^{40}K, wild boar meat, Sus scrofa*

1. Introduction

The territory of the Czech Republic was evenly contaminated by the radionuclide ^{137}Cs in the period of the nuclear weapons testing in the atmosphere (1945-1964) (Izrael, 2003). Following the accident at the Chernobyl nuclear power plant (1986), contamination with ^{137}Cs radionuclide has been more diversified (National Radiation Protection Institute, 2003). The half-life of ^{137}Cs radionuclide is relatively long (30.1 years), therefore the ^{137}Cs persists in the environment and enters the food chain.

Radionuclide ^{137}Cs is concentrated in the forest ecosystem, especially in mushrooms and berries, and then passes into wildlife, including the wild boar (*Sus scrofa* L.), the omnivorous species abundant in Czech forests. Because the radionuclide ^{137}Cs is chemically similar to sodium and potassium, it is deposited mostly in wild boar muscles, followed by kidneys, heart and liver (Gulakov, 2014).

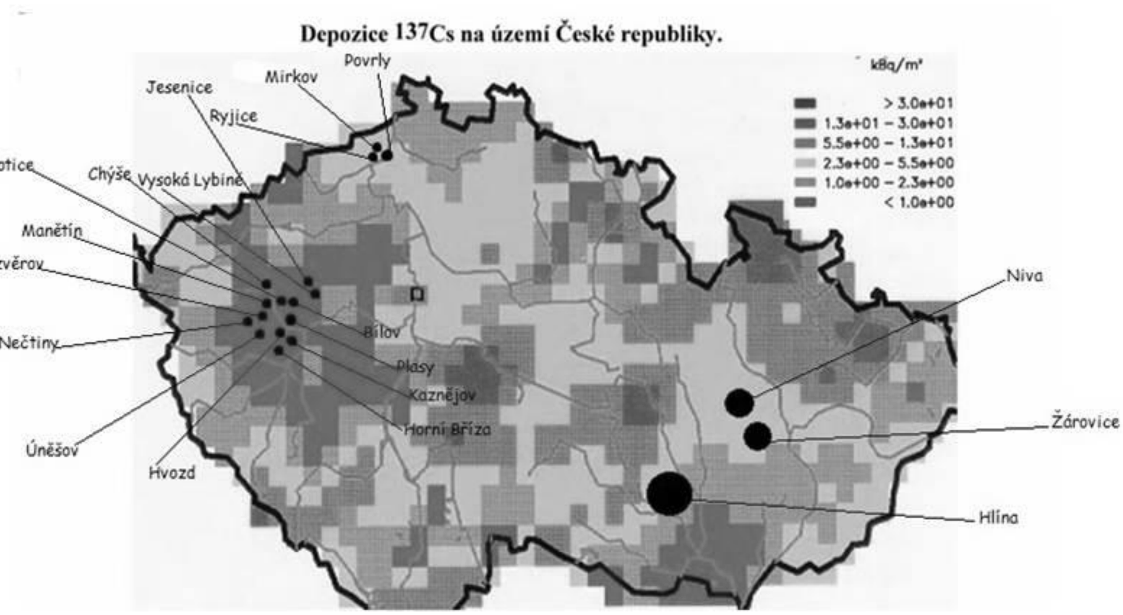
The distribution of natural radionuclide ^{40}K in the environment is uniform.

2. Data and Methods

Sampling

The samples of wild boars muscular tissue were collected during the hunting season 2016-2017 in different regions of Bohemia (N=20) and Moravia (N=18) (Figure 1). The samples in the regions of Pilsen and Ústí nad Labem were collected by the hunters. In Moravia, the samples were gathered by the researcher from Department of Forest Protection and Wildlife Management, Faculty of Forestry and Wood Technology, Mendel University in Brno.

Figure 1: Sampling sites of wild boars meat in the ^{137}Cs deposition map the Czech Republic following the accident of the Chernobyl nuclear power plant



Source: National Radiation Protection Institute (2003)

The meat samples were frozen, transported to the laboratory and stored in the freezer until processing.

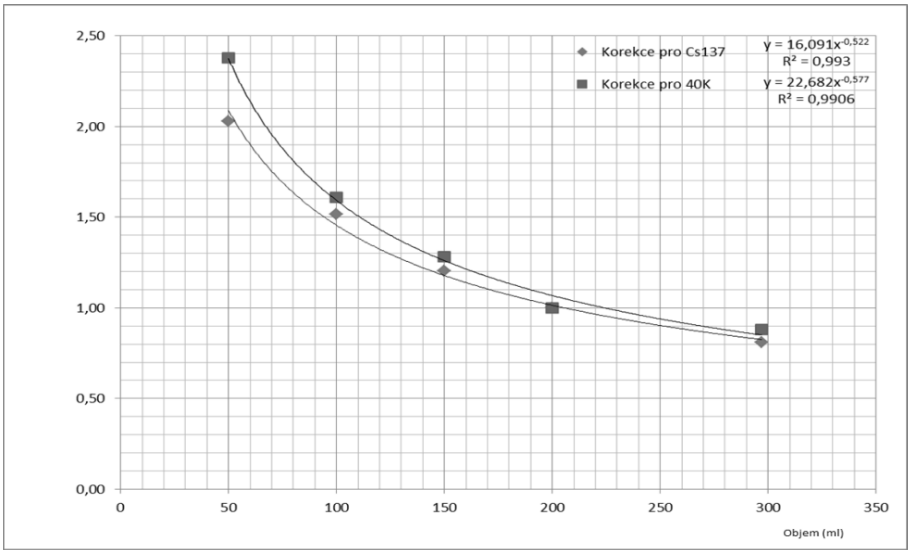
Preparation of samples

After defrosting, the meat samples were stripped of fat and cut into small pieces (2-3 mm). The meat was dried (on average to 28.2 + 2.1% of the original weight) and the solids were pressed into a cup (diameter of 65 mm and a height of 88 mm, maximum volume 297 ml), their volumes ranging from 65 to 297 ml, the average sample density was 0.52 ± 0.5 g/ml.

Gama-ray spectrometry analysis

Samples were measured using a semiconductor High-purity Germanium (HPGe) detector (resolution 2.1 keV (FWHM) for photon energy 662 keV), placed in a 10 cm lead shield. The electrical signal was processed by an amplifier, AD converter and 8196 channel analyser MCA 35+, all components made by Canberra Industries. Calibration was performed using the standards of the Czech Metrology Institute in a 200-ml cup for ^{137}Cs and a standard ^{40}K made of KCl p.a. were used for calibration at same geometry. Activity ^{137}Cs was determined from photo peak 661.6 keV, activity ^{40}K from photo peak 1460.7 keV. Correction to different sample volumes was determined experimentally by measuring one sample in a geometry volume of 50, 100, 150, 200 and 297 ml (Figure 2). The sampling time ranged from 20,000 to 66,000 s. Minimal Detectable Activity (MDA) for selected measurement geometry and depending on the sample volume and time measurements ranged from 0.50 to 1.47 Bq/kg.

Figure 2: Factors F for correcting the determination of ^{137}Cs and ^{40}K activity for different sample volumes (volume of standards - 200ml)



F = a(v)/a(200)

a(v) - *mass activity [Bq/g] for sample volume* *v* *[ml]*

a(200) - *mass activity [Bq/g] for sample volume 200 ml (as the volume of the standard)*

3. Results and Discussion

The measured activities are related to the weight of the meat in the native state. The individual measurement results, including the combined uncertainty of the measurements, are presented in the tables according to the sampling site Pilsen region (large area) (Table 1), Ústí nad Labem region (Table 2), Brno-venkov region (Table 3) and Prostějov region (Niva and Žárovice) (Table 4).

Table 1: ^{137}Cs and ^{40}K activity in wild boar meat, including combined uncertainty of measurement in Pilsen region

Location	Cs-137 (Bq/kg)	K-40 (Bq/kg)
Bílov	0.7 ± 0.3	72.9 ± 5.6
Vysoká Libyně	< 0.5	74.7 ± 6.6
Nečtiny	46.6 ± 2.3	106.9 ± 8.7
Plasy	1.2 ± 0.4	103.8 ± 9.4
Hvozd	46.6 ± 2.3	106.9 ± 8.7
Mladotice	< 0.6	103.4 ± 7.0
Horní Bříza	46.6 ± 2.3	89.7 ± 8.1
Úněšov	54.9 ± 2.7	120.1 ± 9.8
Jesenice	48.7 ± 2.7	95.8 ± 9.0
Chýše	47.3 ± 2.4	92.9 ± 6.7
Manětín	51.5 ± 2.6	114.7 ± 8.7
Bezvěrov	50.4 ± 2.5	100.2 ± 8.0
Kaznějov	65.6 ± 3.3	111.0 ± 7.2
Pšov	53.0 ± 2.7	90.7 ± 7.0
Kralovice	< 1.0	110.2 ± 8.9

Table 2: ^{137}Cs and ^{40}K activity in wild boar meat, including combined uncertainty of measurement in Ústí nad Labem region

Location	Cs-137 (Bq/kg)	K-40 (Bq/kg)
Ryjice	< 0.5	117.5 ± 9.6
Povrly 1	0.9 ± 0.2	107.3 ± 6.6
Mírkov	< 1.0	114.5 ± 9.8
Povrly 2	0.9 ± 0.3	93.4 ± 8.0
Blansko	0.8 ± 0.2	101.8 ± 7.7

Table 3: ^{137}Cs and ^{40}K activity in wild boar meat, including combined uncertainty of measurement in Brno-venkov region

Location	Cs-137 (Bq/kg)	K-40 (Bq/kg)
Hlína 11	< 0.9	108.7 ± 8.1
Hlína 12	< 0.8	95.8 ± 7.4
Hlína 13	< 1.5	110.9 ± 9.3
Hlína 14	2.3 ± 0.4	106.1 ± 7.2
Hlína 18	0.7 ± 0.2	99.4 ± 6.2
Hlína 20	0.7 ± 0.3	99.1 ± 7.0
Hlína 25	< 1.0	99.7 ± 7.6
Hlína 27	< 0.5	82.8 ± 7.0

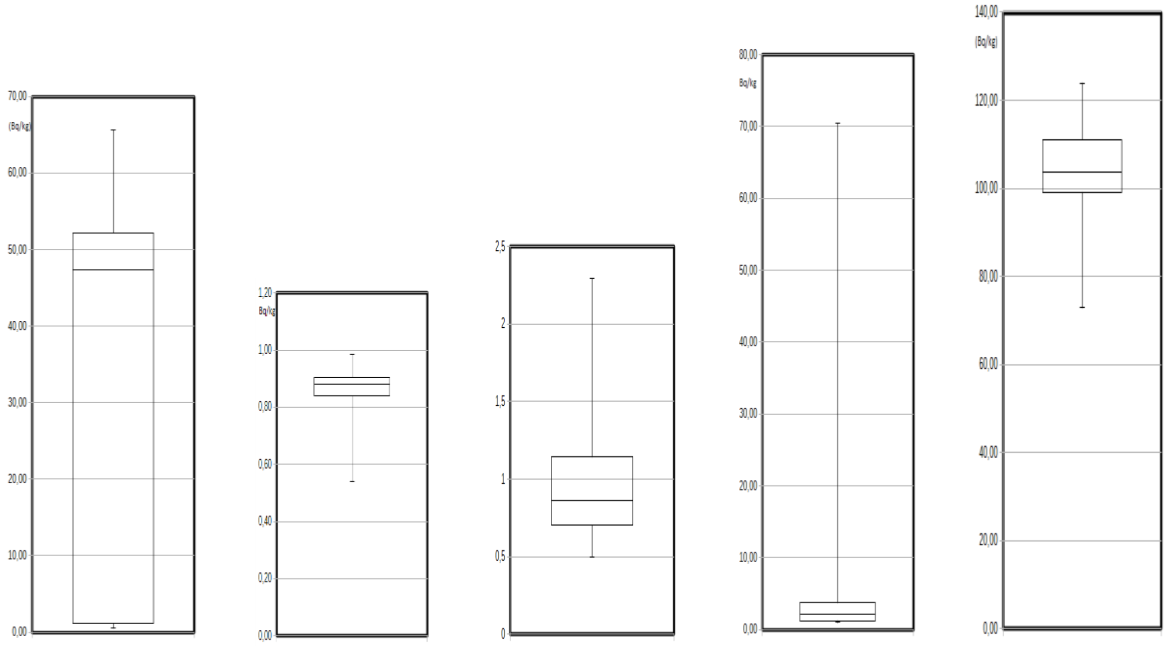
Table 4: ^{137}Cs and ^{40}K activity in wild boar meat, including combined uncertainty of measurement in Prostějov region

Location	Cs-137 (Bq/kg)	K-40 (Bq/kg)
Niva č1	3.1 ± 0.5	108.3 ± 9.4
Niva č2	< 1.1	101.5 ± 7.9
Niva č4	1.5 ± 0.3	100.7 ± 7.6
Niva č18	1.0 ± 0.3	112.8 ± 7.8
Niva č19	1.3 ± 0.3	99.7 ± 7.3
Žárovice z2	2.9 ± 0.4	115.1 ± 7.6
Žárovice z3	70.4 ± 3.5	118.5 ± 9.9
Žárovice z10	19.2 ± 1.2	111.1 ± 7.5
Žárovice č26	< 1.2	120.6 ± 9.2
Žárovice 28	4.0 ± 0.5	101.4 ± 7.6

The datasets were statistically processed and the processing results are shown in the box plot for the radionuclide activity of ^{137}Cs from individual regions and for the ^{40}K radionuclide activities for all samples. (Fig. 3)

Figure 3: ^{137}Cs activity in wildlife in individual localities and ^{40}K activity for all samples (box plots)

^{137}**Cs activity** (Bq/kg)				^{40}**K activity**
Pilsen region	Ústí n.L. region	Brno region	Prostějov region	(Bq/kg)



The sampling area can be characterized by the size of the radionuclide cave immediately after the Chernobyl accident. In the area of Pilsen, the area activity was found to be less than 1.0 kBq/m^2, in all other areas ranging from 2.3 to 5.5 kBq/m^2 (National Radiation Protection Institute, 2003). However, measured ^{137}Cs activity in wild boars is higher in the Pilsen region - a median of 47.3 Bq/kg, a maximum value of 65.6 Bq/kg. Migration of Cs radionuclide in soil differs for the areas of agricultural use and forest ecosystems. In agricultural areas, Cs migrates more rapidly to depth, as well as due to soil erosion and migration out of the fall area (Hůlka & Malátová, 2006). The highest activity value of Cs 70.4 Bq/kg was measured in the cultivated soil of Žárovice (Prostějov region), but immediately adjacent to the Vyškov military area, which is an extensive natural ecosystem. The dietary habits of individual wild boars and their metabolism also influence the size of the contamination. The concentration of radionuclide ^{40}K is similar for all localities, the average value with a standard deviation of 104 $\pm$ 12 Bq/kg is comparable to the 113 $\pm$ 4 Bq/kg measured in the mountain forest ecosystem in Croatia (Šprem, Babić, Barišić & Barišić, 2013).

4. Conclusion

^{137}Cs and ^{40}K activities were determined in wild boars meat from various regions of the Czech Republic with a low and medium size surface contamination with radionuclide ^{137}Cs after the Chernobyl accident. The measured values are insignificant in relation to radiation protection of consumers of meat (Act No. 263/2016 Coll., the Atomic Act and Decree No. 422/2016 Coll., on radiation protection and security of a radioactive source) and much lower than the values have found in the natural ecosystems of Šumava National Park, in which the maximum is 20 kBq/kg, median is 1,1 kBq/kg (81 samples in 2015) (J. Matzner, State Office for Nuclear Safety (SONS 2015)). The concentration of ^{137}Cs in wild boars meat is more dependent on the ecosystem (forest or agricultural ecosystem) in which wildlife lives than the amount of the fallout during the Chernobyl accident. The number of measured samples is insufficient for a thorough statistical evaluation, which will be carried out after the collection and analysis of more samples.

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HUNTING DOGS FOR HUNTING WILD UNGULATES (SUS SCROFA USSURICUS, ALCES ALCES CAMELOIDES, CERVUS ELAPHUS XANTHOPYGUS, CAPREOLUS PYGARGUS PALLAS) ON THE HUNTING GROUNDS IN SIBERIA AND FAR EAST OF RUSSIA

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Abstract
Practical research on the use of two main breeds of Eskimo or Laika dogs (West Siberian and East Siberian breeds) were conducted while hunting wild ungulates in Siberia and Far East of Russia. The most common method to hunt wild ungulates in Eastern Siberia and Amur region is hunting for wild boar with dogs. A group of hunters, usually consisting of two or more people (in Amur region it is no more than eight), is divided into riflemen and beaters. The hunters are usually chosen among those who know well the local terrain and can easily orient on hunting grounds, as well as the youngest and most physically fit, able to walk for more than a mile on deep snow or fallen bushes and trees. Their task is to drive the animals out onto the shooting line as correctly as possible, while it is important that the beaters themselves frequently extract the animals from under the dogs. It is quite often that hunters who specialize in wild boar hunting own 2 to 10 hunting dogs. This type of hunting often leads to dog injuries. Hunters walking along a wild boar's typical habitat find a fresh trace of a group of boars. Most often they are individual animals of different sex and age, ranging from 8 to 12 individuals in smaller groups and 15 to 35 in large groups, and, rarely up to 45 individuals in one group, where 50 to 60% of them are young. After locating a group of animals the hunters release the dogs on the trail. In Amur region hunters use West Siberian Eskimo or Laika dogs when hunting Siberian roe deer. Dogs with strong endurance and maliciousness are needed to hunt the Ussuri red deer, because they are supposed to quickly catch the red deer on a stone rock and hold it for a long time, sometimes even for 8-10 hours. We recorded cases of dogs holding an animal for 24 hours. When hunting elks, husky dogs behave differently, responding to its other characteristic qualities. Possessing malice and assertiveness in hunting for an elk, the dog is almost immediately subject to death. Elks most commonly leave hunters without their best helpers in the hunt, allowing no mistakes from unexperienced dogs during their work. This is especially characteristic for the northern areas of the region where snow cover exceeds the average long-term indicators of 30-40 cm.

Keywords: *Siberia, Amur region, hunting, hunting dogs, Ussuri boar, Siberian roe deer, red deer, elk*

Hunting is the oldest human occupation. Hunting and fishing have always served as the material basis for the life and development of mankind, there lived hunting tribes and ethnic groups whose livelihoods were based mainly on hunting (this was due to the natural and geographical conditions of their habitat regions). The motivation of primitive hunts was extremely simple - the extraction of food, material for clothing and homes, protection from predators. The guns of the most ancient hunters were fragments of rocks, boulders, sticks, hunting pits. Numerous petroglyphs depict hunting with bows and darts on various antelopes and deer, group attacks with spears and sticks on large wild hoofed animals: bison, elephants and mammoths. Directed pens of animals to rocky cliffs, the construction of hunting pits and ditches were common.

After many years, the hunting economy of various countries, including the Russian Federation, has changed greatly, undergoing various reorganizations. In more developed European countries, the hunt has adopted its more ethical look, and as for our country, its western and central parts also strive for European experience, to some extent develop and embellish their hunting look, rushing to the “fashionable hunts” that have become already far from expensive pleasures, a variety of hunting ammunition, the choice of foreign weapons, ammunition and equipment.

Replaced methods of hunting for wild animals. Now the goal of hunting is getting hunting bliss and a sense of inner hunter satisfaction from the physical difficulties of the kilometers traveled while hunting, which a real man experiences, for example, while hunting from approaching a red deer male during the rut. This hunt requires skills and endurance. As well as a complex hunt, like with dogs of hunting breeds for a bear during its feeding on an acorn or a nut in Siberia and in the Far East of Russia.

The interest of hunters in hunting with dogs with good exterior and beast qualities has been known in Siberia for a long time. But nowadays it is often replaced with East-Siberian or West-Siberian huskies with thermal imaging cameras or remote light devices, snowmobiles or quadracycles. Only an insignificant part of real hunters, patriots of dogs, prefer not to change the interests of their fathers and grandfathers, keeping the traditions of dog breeding. They keep and breed hunting dogs working on wild ungulates and fur-bearing animals and invariably honor the experience of hunting from the approach of a large hunting beast.

Hunting with dogs, as a rule, requires a very reverent attitude to both the hunting process itself and the great ability to cultivate and inculcate the qualities of a real helper to a person, for example, in the far Siberian or Far Eastern taiga, sometimes remaining alone in hundreds of kilometers from the nearest village.

A real hunter must necessarily know the structure of the cages, medical vaccinations, good conditions for keeping, feeding and training hunting dogs.

In addition, it is necessary to know and understand the nature of a particular breed of dog, the habits and character of the dog as a “personality”, its ability to hunt, endurance under different weather conditions, its ability to work with other dogs and much more, described by many famous scientists and hunters.

Figure 1: The aviary, built for dogs of hunting breed Laika (photo by Aleksandr Senchik)

Practical research on the use of two main breeds of Eskimo or Laika dogs (West Siberian and East Siberian breeds) were conducted while hunting wild ungulates in Siberia and Far East of Russia. The most common method to hunt wild ungulates in Eastern Siberia and Amur region is hunting for wild boar with dogs. A group of hunters, usually consisting of two or more people (in Amur region it is no more than eight), is divided into riflemen and beaters. The hunters are usually chosen among those who know well the local terrain and can easily orient on hunting grounds, as well as the youngest and most physically fit, able to walk for more than a mile on deep snow or fallen bushes and trees. Their task is to drive the animals out onto the shooting line as correctly as possible, while it is important that the beaters themselves frequently extract the animals from dogs.

A collective hunt for the Ussuri wild boar in the Far East of Russia is carried out with the participation of no more than 8 people (the number of hunters is limited to the license for catching 1 wild animal), it is more effective with good hunting dogs that have a strong and developed sense of smell and can detect and drive out wild boars on the hunters' shooting line.

It is quite often that hunters who specialize in wild boar hunting with 2 to 10 hunting dogs. This type of hunting often leads to dog injuries. Hunters walking along a wild boar’s typical habitat find a fresh trace of a group of boars. Most often they are individual animals of different sex and age, ranging from 8 to 12 individuals in smaller groups and 15 to 35 in large groups, and, rarely up to 45 individuals in one group, where 50 to 60% of them are young. After locating a group of animals the hunters release the dogs on the trail.

The probability of a successful wild boar hunt is 90-95%, subject to the participation of well-trained hunting dogs, which in turn help the beaters to detect the beast, drive it to the shooters, or keep it in the pen until the beaters arrive. At the same time, they often use huskies, which are able to hold a wild boar for quite a long time, barking it, thus giving the hunters an opportunity to go the distance of a successful shot.

Laika is a group of breeds of sharp-eared dogs of various specializations, created by the peoples of the taiga zone, for fishing for furs, game birds and large wild hoofed animals. On hunting, huskies are intelligent, well adapted to the habits of various game animals, try to be friends and helpers of the hunter-host. Laika, released to search for wild animals in the forest, works completely independently, it is almost not visible in the forest until she finds a hunting animal, about which she lets her know with her voice-bark. She maintains contact with the master-hunter herself by ear and voice.

There are several breeds of Laika:

1. Karelian-Finnish;
2. Russian-European;
3. West Siberian;
4. East Siberian.

In Amur region hunters use West Siberian Eskimo or Laika dogs when hunting Siberian roe deer. We interviewed 207 hunters and a survey showed that about 60% hunt with a West Siberian husky, noting its greatest advantage is the work on the cooled blood trace.

Figure 2: A female of the West Siberian Laika with a puppy of the second litter (photo Andrey Ryabchenko)

Figure 3: Hunting for a roe with Laika (Mazanovsky district, hunting grounds of MUMP "Mazanovsky hunting farm", photo Andrey Ryabchenko)

The smell of a person is one of the factors, unmistakably perceived by hunting animals as a sign of danger. Elk, Siberian roe deer and red deer react more vigorously to the smell than to the fact of recognizing danger by sight or even hearing.

Professional hunters and simply experienced hunters, who have more than one experienced hunting dog, prefer hunting deer with dogs in mountainous places. This type of hunting applies exclusively to the noble deer, preferring to escape on steep stone cliffs, usually along river banks, in case of danger. If a dog finds a deer, being an excellent runner, he tries to quickly get to the places he knows well with a rock, where he, being not accessible to dogs and wolves, is before their departure. However, hunters who know the terrain well and their hunting grounds use this chance. Releasing dogs, hunters strive to rocky places known to him, focusing on dogs barking, where they shoot red deer.

Dogs with strong endurance and maliciousness are needed to hunt the Ussuri red deer, because they are supposed to quickly catch the red deer on a stone rock and hold it for a long time, sometimes even for 8-10 hours. We recorded cases of dogs holding an animal for 24 hours.

Figure 4: Hunting of the Ussuri red deer using rocks and the work of hunting dogs (December 2016, Photo by Maxim Bormotov)

Another of the most interesting and quite effective ways of hunting wild ungulates with dogs is hunting from an approach, while hunting for elk, Ussuri red deer, Ussuri wild boar, bear.

Some feature in our opinion with such a hunt is the age category of hunters and good physical training. Having conducted a survey among the hunters of the Amur Region, we found that this method of hunting was widely applicable only in the territory of Mazanovsky, Selemdzhinsky, Zeysky and Tyndinsky districts in the 70s, 80s of the last century, during the active occupation of hunting in professional state hunting farms participation in the hunting and harvesting of hunting products of a large number of professional hunters from the indigenous peoples of the North, whose average age was 40 - 45 years.

The best time of year for such hunting with hunting dogs on the ground where there is no snow - autumn. The absence of squeaky snow under their feet, or a small amount in the forest, allow the hunter to move noiselessly in hunting places, while hunting dogs detect and hold wild animals in their voices until the hunter arrives. Given that wild ungulates feed in the morning and evening hours, the hunter pre-examines the land and determines the places of feeding. In order to catch the grazing animals, the hunter arrives at the hunting place, discovers fresh traces of wild animals and feeding places, and launches hunting dogs to detect wild ungulates. At the same time, he is slowly approaching deer or wild boar at a distance of a good shot (40-50 meters), preferably going to the wind. The ideal condition for such a hunt is the possibility of using radio collars for hunting dogs with built-in GPS trackers (the most popular are Garmin Alpha and Garmin Astro), which allow the hunter to track the movement of hunting dogs in search of wild animals. Thus, a hunter can coordinate his actions to choose the shortest and most convenient way to approach the beast, which can significantly reduce the time and strength of the hunter.

GPS collars for hunting dogs with a navigator in the Amur region and in Siberia are not very common. This is due to the relatively high price of such devices (in the range from 1000 to 3000 US dollars.). As a rule, their use occurs in a period of relatively cold air temperatures (up to -20 degrees Celsius). This is due to the fact that at low temperatures (about -40 degrees Celsius), the batteries of such devices are quickly discharged and require frequent recharging, which is impossible in the forest hunting grounds.

Most often, hunters use smooth-bore weapons and cartridges equipped with grapeshot, because the animals shoot from the dogs at small distances in dense forest thickets or young aspen or birch trees. Under favorable weather conditions and hunter accuracy, the probability and success of hunting with dogs is 80-90%.

When hunting elks, husky dogs behave differently, responding to its other characteristic qualities. Possessing malice and assertiveness in hunting for an elk, the dog is almost immediately subject to death. Elks most commonly leave hunters without their best helpers in the hunt, allowing no mistakes from unexperienced dogs during their work. This is especially characteristic for the northern areas of the region where snow cover exceeds the average long-term indicators of 30-40 cm.

Our research in Eastern Siberia and the Far East of Russia showed that hunters use universal dogs when hunting wild deer and an Ussuri boar. The main breed of dogs is East Siberian Laika, it is widely and successfully working on the Siberian roe, the Ussuri noble deer and the Ussuri moose. The use of hunting dogs gives a great chance of successful hunting in the harsh natural and climatic conditions of Siberia and the Far East of Russia.

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LOCAL WILD BOAR (SUS SCROFA L.) HUNTING BAG DYNAMICS AND THEIR INFLUENCING FACTORS IN THE PALATINATE FOREST-NORTH VOSGES BIOSPHERE RESERVE. WHICH FACTORS INFLUENCE THE POPULATION DYNAMICS?

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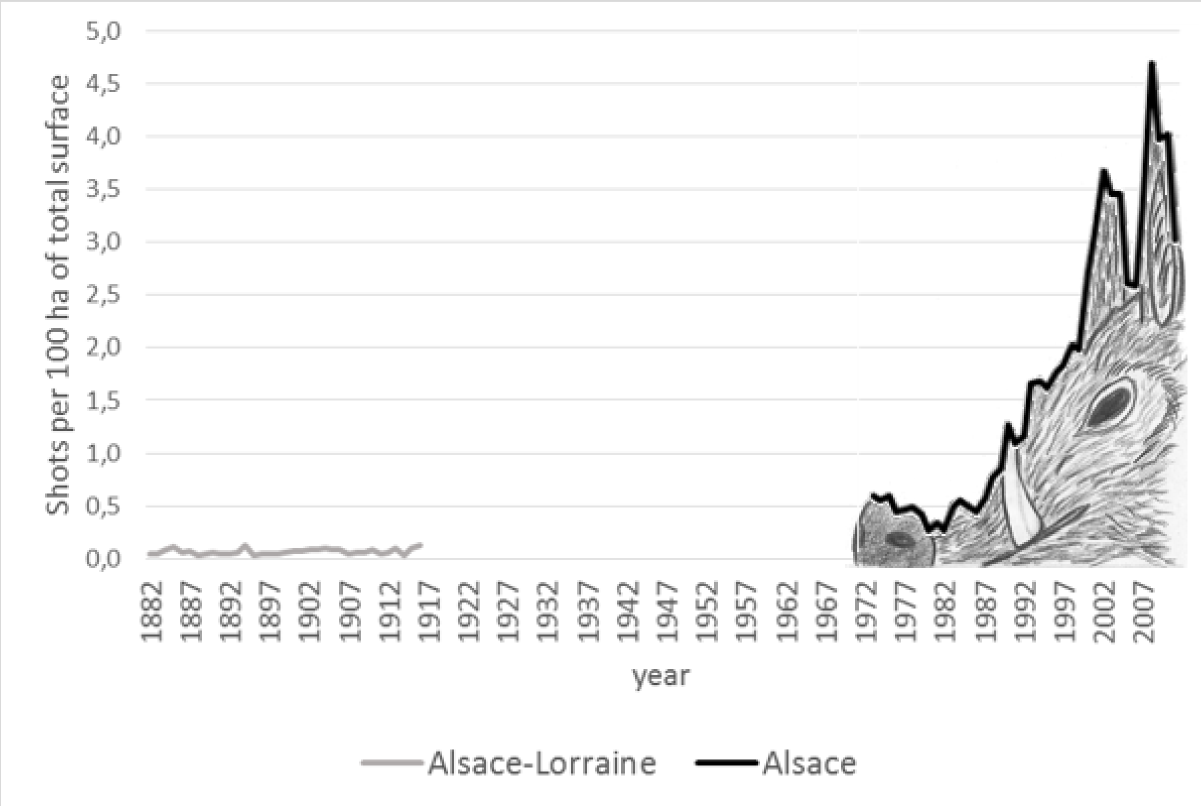
Abstract
The examination of wild boar hunting bags on 71 000 ha state forest in the Franco-German border region Palatinate Forest-North Vosges (41 000 ha of state forest in the Palatinate Forest and 35 000 ha in the North Vosges), a homogeneous and mostly closed forest, showed differences between both sides of the border. The hunting bags in France were about 3 times higher than in Germany (6,8 wild boars in the North Vosges to 1,9 wild boars in the Palatinate Forest per 100 ha and year; from 2006 to 2016; without game killed by disease or accidents). Due to similar conditions, for example an equal percentage of mast producing species (beech and oak) in both areas (53 % - 54 %) and a mean January temperature between 1.4°C and 1.7°C, rather the hunting approach should explain the different hunting bags. Especially the feeding quantities vary and is higher in France (10 kg per day and 100 ha in the North Vosges to 0.6 kg per day and 100 ha in the Palatinate Forest). Distinctive hunting pressure or age and gender differences in the hunting bags were not apparent but couldn't be examined in detail. Therefore our conjecture is that the feeding practice is accountable for the higher hunting bags in France. If this is true, in times while the African swine fever expands through Europe, French hunters and lawmakers should reduce their feeding quantities too.

Keywords: *forest, population dynamics, supplemental feeding, wild boar*

1. Introduction

Since wild boar hunting bags increased the last decades throughout Europe (Massei et al. 2014; fig. 1) and the relevance of wild boars for economic costs in agriculture, forestry and pest prevention is high, it is important to know more about their population dynamics. When is the rise due to (local) human manipulations and not to overall climatic changes – so that we also have the possibility to reduce populations by changing our behavior?

Figure 1: Historical hunting bags per 100 ha of total land area in Alsace-Moselle and later in Alsace (source: data from Sebastian Vetter, University of Vienna, referring to Schwenk (1982) for historical data and ONCFS for recent data; author's illustration)



In the Franco-German border region Palatinate Forest-North Vosges there is a homogeneous and mostly closed forest of about 300,000 ha. While the natural conditions where supposed to be mostly homogeneous, a hypothesis that was confirmed in this study, the hunting legislation differs on both sides of the border, especially concerning supplemental feeding. Is this the reason for higher hunting bags in the French part of the forest?

2. Data and Methods

The hunting bags of wild boar from the hunting years 2006/07 to 2015/16 on 34,000 ha in the North Vosges were compared with them on 41,000 ha in the Palatinate Forest (table 1). All studied forest areas were state owned. In the German part most hunting grounds were under the direction of the state forest administration, while their French counterparts were mostly leased to private hunters. To take into consideration a possible edge effect in the hunting grounds on the border of the forest area to an agrarian-oriented landscape, all districts nearer then 2 km to fields were put aside for a second analysis of the hunting bags.

Table 1: Key information of the studied units (= junction of a number of hunting grounds) (source: author's calculations)

	mean surface	*standard deviation*	*Coefficient of variation*	*number of districts*	*total surface*
North Vosges	1 107 ha	494	45%	27	35 400 ha
North Vosges - central districts	1 015 ha	486	33%	18	19 500 ha
Palatinate Forest	1 577 ha	441	28%	24	41 000 ha
Palatinate Forest - central districts	1 546 ha	336	31%	18	27 900 ha

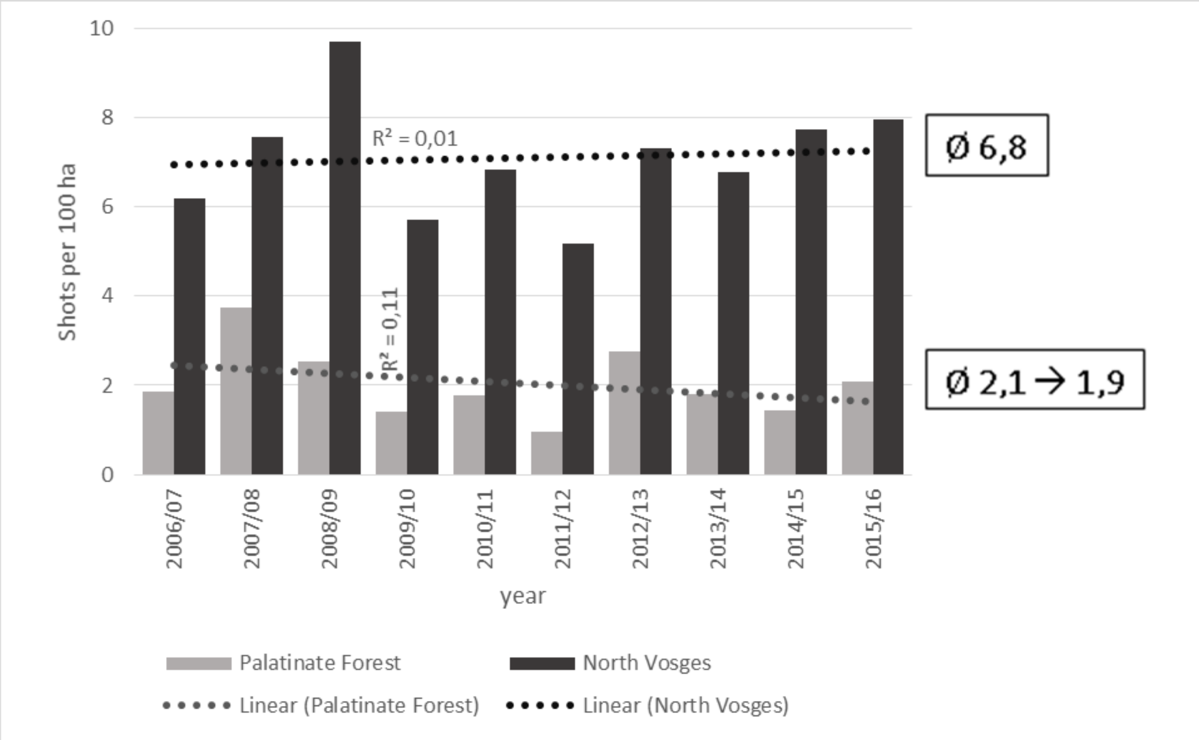
To compare the bags of both countries, it was important to ensure that difference between the hunting legislations was more relevant than variations in natural factors. Therefore the composition of tree species, in particular of beech (*Fagus sylvatica*) and oak (*Quercus petraea* and *Q. robur*) as food providers, were contrasted by information from the state forest inventory of ONF respectively Landesforsten Rheinland-Pfalz. The use of Copernicus Forest Type (2012) did not provide data that was reliable enough for this issue.

Another factor was land use around the forest-only hunting grounds. It was analyzed by data from CORINE Land Cover 2012 taken from a 3-km-buffed area around the grounds. To round out the analysis, the mean temperature of January, a critical month for the mortality, was provided by the German Meteorological Service (DWD) and extrapolated with help from heights of a digital terrain model to the French part.

3. Results and Discussion

First of all, the mean result show a huge difference between the average hunting bag in both areas: While 2.1 wild boars per 100 ha and year where reported in the Palatinate Forest (around 1.9 without game dead by accidents), it were 6.8 wild boars in the North Vosges (only death by shooting)! This is to say 3.5 times more on a timescale of 10 years (fig. 2). Interesting to say, the “central” districts (at least 2 km inside the forest area) gave exactly the same numbers. This is in concordance with results from a GPS-monitoring around La Petite-Pierre, also in the North Vosges (Durante, Hamann, Baubet & Said, 2016). From 13 wild boars, only 4 left the forest, mostly between July and September. 8 from 13 even stayed in the research ground without supplemental feeding.

Figure 2: Shots per 100 ha and hunting season in the Palatinate Forest and the North Vosges. Trend line: linear. Second German mean: Without kills by disease and accident (source: data from Landesforsten and ONF)



On the same time, environmental factors were the similar:

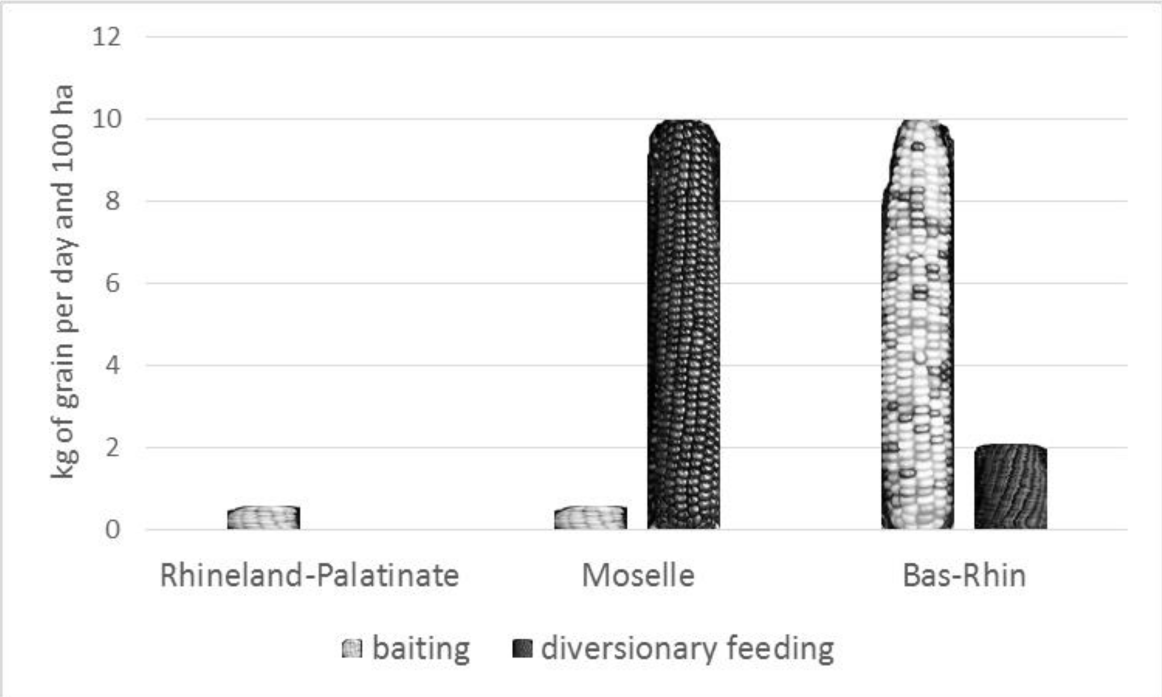
The share of the beech was 39% in the Palatinate Forest and 34% in the North Vosges. For the oaks they were 14% respectively 20%. So the sum was equal while the distribution in the North Vosges was more equal. Maybe the effects caused by a missing mast of one species can better be mitigated. But in Bas-Rhin the results were the same as in Palatinate, without differences in the shots to Moselle. Therefore the proportions of the species cannot be an explanation for the different hunting bags.

This apply also to the climate: The mean temperature in January was 1.4°C in the Palatinate Forest and 1.7°C in the North Vosges. Realizing that only in the federal state Rhineland-Palatinate the difference between the coldest and warmest region is 3°C, the mismatch is insignificant.

Last but not least the land use: Altogether the land uses around the area studied is similar. Only the agricultural use varies from 11.3% in the North Vosges to 3.5% in the Palatinate Forest. Regarding that there is no difference of kills between the “central area” and the total study region, as mentioned above, this does not seem to have any relevant influence.

Only the hunting legislation and practice remain as explanation. While the hunting approach (raised hide and battue) and the hunting season (all year) are the same in both regions too, the feeding legislation are deeply distinct. In Rhineland-Palatinate, 1 liter (about 0.6 kg) of grain per day and 100 ha is allowed as baiting, whereas in Moselle and Bas-Rhin it is 10 kg per day and 100 ha (fig. 3). This input seems to have a significant effect on the wild boar population.

Figure 3: Diversionary feeding and baiting allowed in the area studied, in kg per day and 100 ha, assuming a hunting ground of 400 ha. Diversionary feeding in Bas-Rhin is 30 kg per 1 km twice a week, here the spreading on 1 km per hunting ground is presumed



source: legislation in 2012; photo: © Sam Fentress / Wikipedia Commons / CC-BY-SA-2.0)

Interestingly, the total amount of shots was different, but the factors of mast and weather still seem to have some influence on the hunting bags – though on disparate base levels. A mast in autumn raises the shots in the following hunting season from April to March, as well as a warm January (cf. figures 4 and 5).

Figure 4: Correlation between mast index (beech and oak) and the shots in the following hunting season (source: author's calculations)

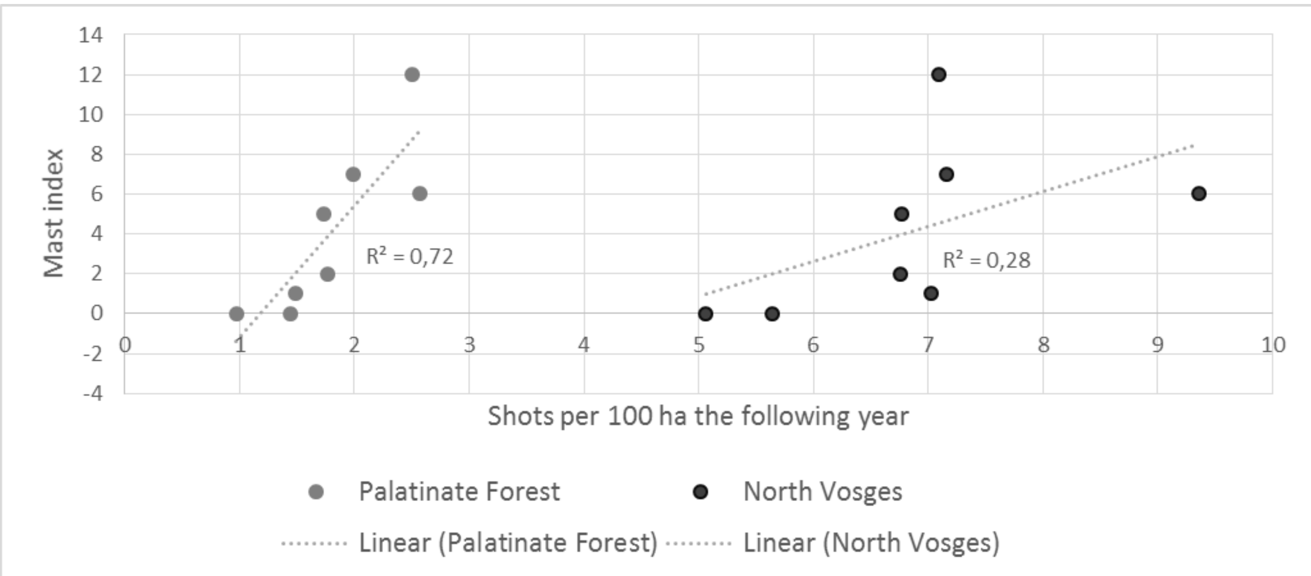
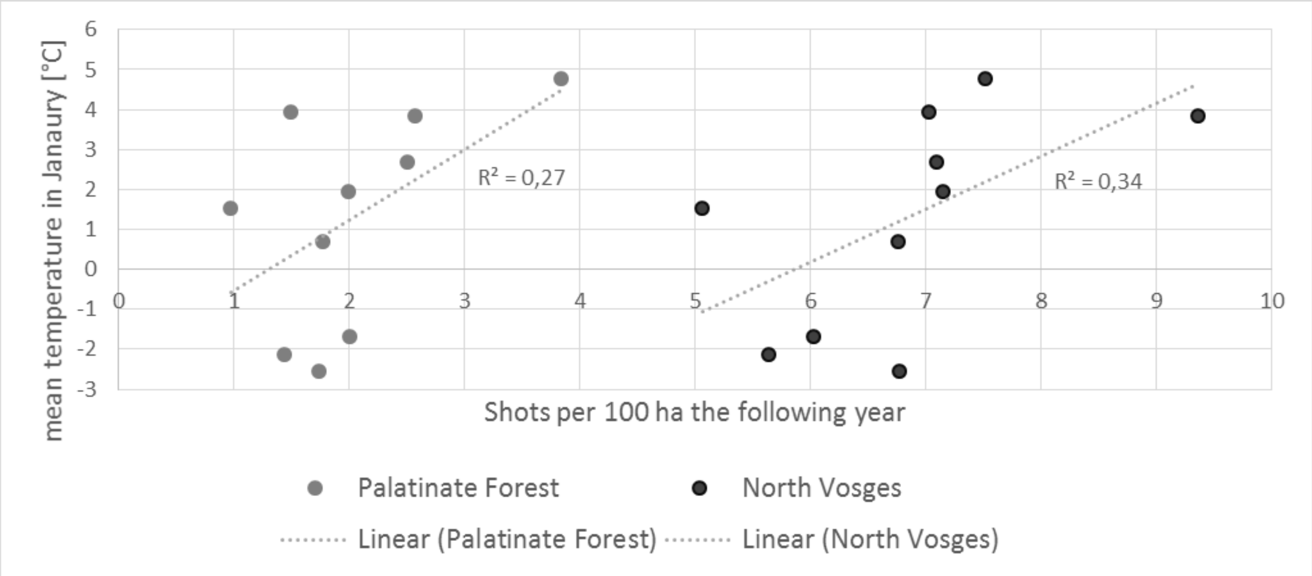


Figure 5: Correlation between mean temperature in January and the shots in the following hunting season (source: author's calculations)



The data is about hunting bags and is not per se representing population densities. Other studies in the Palatinate Forest show that the decrease of wild boar kills goes along with a population decrease (Hohmann, Hettich, Ebert & Huckschlag, 2017). For the North Vosges it was not checked, but as the shots rather goes up than down, it is unlikely that the population is decreasing. Subjective observations from the author give a hint, that the density is effectively higher in the North Vosges. Absolute numbers (estimations) in the Palatinate Forest around Hinterweidenthal are known from genotyping faeces, a comparison with a similar study in the North Vosges would be insightful.

4. Conclusion

When the annual changes of hunting bags are analysed alone in one region, it can lead to the conclusion that they are the main influence today. But at least in this forest region, the principal parameter seems to be the feeding practice. Apparently, grain feeding leads to high population densities also in large forests, where natural limits could stop an exponential grow of wild boar population. Therefore the admission of feeding by the administration should be monitored critically.

Acknowledgements

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MANAGEMENT OF SUS SCROFA THROUGH OUTREACH EDUCATION AND PRIVATE CITIZEN ACTION: LESSONS FROM TEXAS

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Abstract
Worldwide, wild boar and their domestic relatives pose concerns to agriculturalists, conservationists, and others. Since their introduction to present-day United States of America by Spanish explorers in the 1500s, wild pigs (Sus scrofa) fed, frustrated, and fascinated humans. We examined the history of interactions and perceptions of humans with wild pigs in Texas. Since the 1980s, both abundance and range of wild pigs has increased, as well as outreach education activities on control. Using the outreach education efforts of Texas A&M University's Wildlife Extension Unit as a model, we identified (1) growth of a recreational economy on feral swine hunting, (2) changing landowner goals and attitudes, and (3) a lack of a unified government policy to wild pigs as contributing factors to wild pig damage increase. Newer approaches to educating various publics as well as community planning, facilitated decision-making, and active control. We end with recommendations for proactively managing damage from swine from both grassroots (i.e. private citizen) and governmental organization actions, specifically for areas not yet far progressed in wild pig range and extent.

Keywords: *Texas, wild pigs, outreach, damage management*

1. Introduction

Worldwide, wild boar and their domestic relatives-turned-feral (*Sus scrofa*; hereafter wild pigs) pose concerns to agriculturalists, conservationists, and others. A native species throughout most of their range, the wild boar has captivated the interest of human societies from antiquity to present (Tisdell, 1982). For much of human history, cultures in the Old World intensively managed these animals for either sport or food, with little chance for overabundance to occur.

Since their introduction to present-day United States of America (hereafter USA) by Spanish explorers in the 1500s, wild pigs fed, frustrated, and fascinated humans (Towne & Wentworth, 1950). Over the past 500 years, humans in North America valued wild pigs in many different ways, based on era, culture, area of residence, occupation, and age, to name only a few factors. Traditionally, humans managed domestic swine as free-ranging livestock, capturing them during the Fall and early Winter, and slaughtering them for overwinter food rations. Such activities were critical to the survival of early English colonies in the present-day USA (Conover, 2007). In the late 19th century, however, technology allowed for refrigeration and easier transportation of food, humans allowed swine to become feral. This brought about a change in the status and management of swine.

Early in the 20th century, many USA states outlawed the practice of free-ranging domestic pigs. Many owners abandoned their remaining swine, lest they face punitive action (Towne & Wentworth, 1950). Following this, wild pigs steadily grew in numbers through the 20th century, despite opportunistic removal. Where they occurred, humans largely considered wild pigs a pest of farming activities, and to a lesser extent, livestock and natural resources. By the 1970s the presence of wild pigs began to grow in some areas, prompting notice by wildlife managers (Synatzske, 1979).

Texas developed a fee hunting economy early in its history, owing largely to open spaces, diversity of game, and few public lands (Benson, Shelton & Steinbach, 2005; Pope III, Adams, & Thomas, 1984). Hunting lodges introduced wild-type Eurasian wild boar directly to the Texas in the 20th century. Repeated introductions over the years created a wild pig–wild boar hybrid throughout many areas of the state. Experts disagree to the extent of "wild" behaviour exhibited by these introductions (Coombs & Springer, 1974). Nevertheless, this altered the appearance of Texas' wild pigs to something more akin to wild boar. Concurrently, the fee hunting industry in Texas began to market hunts of wild pigs, given no regulation on season or take. Properties engaged in fee hunting quickly integrated the income related to such hunting, possibly with an eye towards unbridled take. At that time, many believed that recreational hunting would provide a solution to wild pig damage, as well as curtail increasing range and abundance, with limited governmental spending. Thus, many government agencies encouraged recreational hunting. However, the following decades proved that this would not solve the problem of wild pigs.

For most humans interacting with wild pigs in Texas, methods of management other than opportunistic shooting remained unknown, and thus take of wild pigs remained low as abundance increased, as did range due to intentional translocations. Although agricultural producers expect to experience some losses due to wildlife damage, the volume of loss and impact of damage from wild pigs reached a level beyond tolerance. As densities of pigs increased, the public sought information on effective methods of removal of groups of swine to curb increasing density. The people needed a reliable source of information on management techniques, and a clearinghouse for the latest science on wild pig management. They needed an advocate with no aim of profit, and the best interest of the people in mind.

Chartered by the Congress of the USA in 1862 with an aim to educating the common man (Duemer, 2007), USA law mandates the existence of so-called "Land Grant" universities. These institutions of higher learning exist to solve the problems of common people, traditionally with regard to agricultural and natural resources. At each such university, scientists are charged with providing solutions to public problems based on the latest science. Armed with such solutions, these faculty and local staff affiliated with the university provide outreach education to the public.

In Texas, Texas A&M University (hereafter TAMU) faculty associated with the Texas A&M AgriLife Extension Service (hereafter TAEX) and its predecessor agencies began targeted efforts on wild pig management in this outreach education method in the 1990s. At that time, the range extent of the wild pigs in Texas was limited to less than 33% of the land area of the state. Since that time, both efforts of TAEX faculty and range extent of wild pigs have increased dramatically. In the course of this document, we retrospectively evaluate the work of the TAEX wild pig management education program to provide insights for other regions experiencing increases in wild pigs. We recognize the strategies employed and the topics engaged by TAEX, changes in public perception, interactions, and problems with wild pigs, and the variety of publics engaged. We end with recommendations for other regions to improve upon the successes and shortcomings of the Texas program.

2. Origins of Public Outreach

The first educational efforts in Texas that focused exclusively on the control of wild stepped into an unknown world of landowner needs and interests. Rising concerns prompted TAEX to take up the mantle of public education related to wild pigs. The first wild pig management education event occurred in 1990. Dr. William J. Higginbotham of TAMU led the event, held in a town-hall style in the local public school auditorium. He recalls that the room was packed and the crowd energized to have help controlling pigs. At this time, the public present in this locale exhibited a unified view of wild pig values (i.e. negative-only), and direction for management (i.e. eradication). Thus, the educational goal was quite clear: provide the latest tools and techniques in order to help citizens privately remove pigs in significant volume.

To provide the people with what they needed most, early efforts focused intensely on demonstrations of management approaches to wild pigs, as well as emphasizing the negative impacts of swine on agriculture, natural resources, and human health. The hallmark of outreach education in the TAEX system, the “Results-Demonstration” provided hands-on, believable education. This methodology involves the local application of a management technique already proven elsewhere. The local educator employs these methods, and invites the general public to view the results, thus demonstrating their efficacy.

Although aimed at introducing the public to efficient wild pig removal techniques, the earliest educational events inadvertently served as some of the first community organizing platforms in the grassroots response to wild pig incursion and damage. Due to the agrarian profession of most people experiencing wild pig damage at that time, and limitations of technology for social networking, in-person events held at a local level were imperative to begin a coordinated response. Nevertheless, these events also provided an opportunity to provide local communities a broad-scale understanding of the scope of problems associated with wild pigs, as well as their increase. To wit, although wild pig abundance and range had already noticeably increased in local communities, but few understood exactly how far it had progressed or the rate at which it was growing.

In the USA, the United States Department of Agriculture Animal Plant and Health Inspection Service (USDA-APHIS) Wildlife Services program (hereafter WS) performs direct control of wildlife damage to agriculture, human health, and natural resources. The Texas WS program is the largest in the USA. Its first recorded wild pig removals occurred in 1982, removing 86 pigs. A thirty years later, today the program takes roughly 35,000 wild pigs per year, a roughly 40,000% increase (M. Bodenchuk, Personal Communication). Similarly, current estimates of the number of wild pigs in Texas range somewhere between 3–7 million (Mellish et al., 2014). Clearly, recreational take did not match or overcome the intrinsic rate of increase. To understand why, one must look further still.

At first, there was no official State of Texas stance on the management of wild pigs. Given widespread damage to crops and the environment (Chavarria, Lopez, Bowser & Silvy, 2007; Seward, VerCauteren, Witmer & Engeman, 2004), the government presumed the public maintained a negativistic perception of pigs, and a strong desire to remove these animals. As a result, many government agencies implicitly assumed that take from recreational hunting would manage numbers, and citizens would either self-regulate wild pig populations or drive them to extirpation. While these sentiments were not necessarily wrong, the attitudes exhibited towards pigs were based on both geography and profession of the public (Adams et al., 2005).

In serving the people at-large, government-sanctioned outreach education professionals recognize the diverse stakeholders and interests (Rollins, Higginbotham, Cearley & Wilkins, 2007). Outreach efforts focused on arming stakeholders with the knowledge of wild pig damage, basic awareness of control methods, and some specific points on improving the implementation of control efforts. TAEX faculty undertook projects to test various trapping methods' efficiencies, develop improvements in trap hardware, and other such hands-on methodologies. As time passed, it became clear that, while some efforts resulted in improved efficiency in wild pig take by private citizens, other factors worked against efficacious management of wild pig population growth and expansion.

3. Evolving Problems, Perceptions, and Educational Goals: Lessons from Texas

Retrospectively, wild pig issues became worse as financial incentives to maintain wild pig populations increased. Efforts to reach landowners and managers initially targeted awareness of wild pigs and their impacts, and methods of control. Assumptions related to public perceptions of pigs fell short of the reality of both (1) human interactions with wild pigs, and (2) the ability of common people to capitalize on the presence of pigs. As the years progressed, changes in these brought about increased difficulty in the management of wild pigs in Texas.

At first, Texas' government implicitly assumed that take from recreational hunting would manage wild pig numbers, and citizens would either self-regulate wild pig populations or drive them to extirpation. Some policymakers perceived wild pigs as an exclusively rural problem, and thus a financial liability of the rural landowner and agricultural producer. As a result, recreational take was encouraged as an alternative income source while government interest minimized.

Throughout much of Texas, rural citizens until the early 1990s considered wild pigs a nuisance of farmers, but of little to no consequence for those engaged in animal agriculture (aside from sheep and goat raisers), wildlife management, or other land uses (Rollins, 1993; Tolleson, Pinchak, Rollins & Hunt, 1995). Although present, many were unaware of wild pig effects on ecosystem health, predation, damage to water quality, and other negative effects During this time, the transportation of wild pigs across Texas for purposes of establishing populations to recreationally hunt became increasingly common. Although natural rates of wild pig range expansion in Texas remain unknown, it is well understood that humans can accelerate this process by actively stocking areas of habitat, as has been demonstrated by the restoration of many game and non-game species (Seddon, Armstrong & Maloney, 2007). Given the generalist nature of wild pigs, it seems clear that this stocking process would be successful when and where attempted, providing fuel to the fire of wild pig recreational hunting.

Texans long ago established fee-hunting businesses concurrently with animal agriculture, and this revenue source quickly rose to pre-eminence in the western, more arid regions of the state (Benson et al., 2005; Pope III et al., 1984). In many such situations, exotic animals, largely from Africa and India, were imported to provide hunting opportunity in an era when native game faced extirpation (Baccus, 2002). The movement of wild pigs with the goal of expanding hunting opportunity created a new, distinct public: the wild pig hunting enthusiast. This group shows strong positive association with wild pig presence, and many staked their livelihoods on the continued sustainable cropping of pigs. As access fees for many native game animals increased, wild pigs provided a more economical big game animal for hunters to pursue. By the mid 1990s, some areas had already developed a burgeoning wild pig hunting economy, generally those regions of Texas best known for fee-hunting as a primary land use, whereas other regions of the state had not yet developed such enterprises (Tolleson et al., 1995).

Unlike the earliest days of wild pig awareness in Texas, the social landscape related to pigs now boasts complex structures based on economy, ethics, and education (Rollins et al., 2007). Questions of pig eradication must now pass tests of economics and social palatability. Some stakeholders experience positive interactions with wild pigs, whether from wildlife viewing, recreationally hunting, consuming meat, or selling wild pigs to slaughter. In a recent experience, the impending sale of a toxicant for wild pigs brought together a rather unconventional coalition of wild pig hunting stakeholder groups and animal rights activists, to bring considerable pressure upon elected officials to deny legal authorization for the use of such a product in Texas. Citing importance of tradition, economy, and food supply to the hunters' organization, and humaneness concerns to that of the animal rights organization, a successful campaign removed the toxicant from the market.

This experience taught those concerned with wild pig damage management two lessons. First, that a complex economy based on positivistic interactions with wild pigs not only existed, but was well-established and strong. Second, that the publics concerned with wild pigs were no longer limited simply to recreational hunters or agricultural producers. Those concerned with the well being of animals broadly adopted wild pigs into the suite of species deserving support, and in some cases, citizens believed that wild pigs evolved in Texas alongside other native wildlife. Thus, the reaction to the needs of public in educational support could no longer be contained within removal methods or discussions of broad impacts to agriculture and natural resources.

Educational efforts must evolve with the public to remain relevant and impactful. In recent years, the TAEX model of outreach education incorporated overt public organizing and coordination of control activities. This model allows communities to seek professional assistance through non-regulatory employees of the university embedded in each community, the TAEX County Agent. These individuals are community members, and thus both credible and trusted relative to an unknown government employee. They act as a conduit of knowledge from the university and other experts to the common people. Through this model, one can shift public perceptions and opinions through a gradual education campaign, all without mandating action through regulation. To wit, one of the great missteps of the Texas program was a lack of early-adopted policy by governmental agencies with regards to wild pigs. In areas where wild pig numbers are on the rise, but before the development of firmly-held beliefs regarding wild pigs, a policy of eradication to benefit both ecosystems and agriculture can be directed by experts and based on the best available science, with examples of experiences in other regions of the globe as an example.

Today, TAEX conducts educational seminars aimed at a variety of goals. These help enroll private lands in public wild pig control activities, organize neighbours to coordinate control at a local level, and generally to rally support in local communities.

To these ends, such events present a variety of science-based information on control methods, impact of wild pigs on ecosystems, emerging damage and disease issues, and hands-on demonstrations of control techniques to increase practice adoption by participants. When conducting educational seminars in urban areas, the emphases often shift to awareness of issues posed by wild pigs, and away from hands-on management, given that most municipalities prohibit citizens from trapping or shooting within city limits. Rather, these events serve to incentivize stakeholders to pressure their elected officials to enact more effective, stringent wild pig management policies at both the local and state level.

In areas with broad extents of public lands, one can conduct a government-led, unified eradication effort (Lombardo & Faulkner, 2000). In Texas, however, a mosaic of private lands dominates the landscape, with little opportunity for direct government control over land. Private action alone without guidance and intervention from professionals, however, often produces less than desirable results. At the same time, it is impossible for a management action to have success without buy-in from all stakeholders and landowners. In Texas, the present model promotes a solution based on a partnership between private and public entities. WS brings to bear their infrastructure and professional damage management staff to conduct intensive wild pig removals. TAEX then follows up with education to private citizens on best management practices to maintain decreased wild pig numbers and enhance removal efforts.

4. Toward a Purposeful Management of Wild Pigs Through Public-Private Partnerships

An evaluation of government programs in the USA dedicated to wild pig eradication noted that eradication through public efforts alone is likely to be ineffective without private citizen participation on lands not controlled by governmental entities (Centner & Shuman, 2015). This seems logical where privately owned lands dominate the landscape, and government funding is limited. Application of government funds for control must be employed when and where they may provide the maximum return on public investment. The role of government direct control programs, then, should be to provide support when broad scale take is needed over large spatial extents, generally where logistics are prohibitive to private citizens (Engeman et al., 2007). Beyond this, it is incumbent on the private citizen to take upon themselves the duty and responsibility of removing wild pigs. Results of surveys of Texans engaged in wild pig management on their land clearly indicated a trend towards self-action early (Rollins, 1993) and more recently (Adams et al., 2005). In order to achieve this goal, one must provide private citizens with a combination of hands-on management technique education, to ensure both competency and comfort with the application of these methods, as well as a venue for community organizing of control efforts. The latter may occur organically when the former is employed.

Ultimately, the most expedient path to managing damage from wild pigs is through grassroots efforts to spur private citizens to exercise control methods on the lands they manage. This requires a public convinced to remove wild pigs. Arriving at this juncture is no simple task, and does not occur without purposeful efforts at managing both wild pigs and humans. Scientists, wild pig managers, and other experts should promote a unified management narrative driven by science, rather than numerous narratives based on tradition, opinion, and politics. Although we recognize the existence of centuries or millennia-old traditions on recreational hunting of wild pigs, economies related to wild pigs should be eliminated or minimized. Lastly, governments must show a willingness to invest side-by-side with their citizens to the coordinate goal of wild pig eradication.

Government policy that considers recreational hunting, or any other for-profit industry a solution sufficient to control wild pigs presents fatally flawed logic. Economies based on the existence of wild pigs in sufficient enough numbers to ensure easy access by nature cannot tolerate decrease of wild pigs below some minimum economic viability threshold. Texas' experience should be treated as both model and warning: realization of the full potential of the general public to find positive value in the presence of pigs predicted by Tolleson et al. (1995), as well as the development of complex economies and publics related to wild pigs, took time. Although it will difficult for Texas to eradicate wild pigs from the landscape, the TAEX model employed today shows distinct promise to mobilize the control of pigs by the common people. This model offers incorporation of the "results-demonstration" approach to create seminars that incorporate tangible benefits of control, hands-on training, increased awareness of problems related to wild pigs, and grassroots organizing. Other regions now experiencing an increase in wild pig range, damage, and abundance may follow this model to prevent the development of a Texas-like situation.

Ultimately, success will come from early education, proactive efforts to organize private citizen control, and targeted government removals of wild pigs. Worldwide, the need for purposeful management of wild pigs is reality. For those not yet enjoined in war on wild pigs, the day is coming to muster to the challenge. Victory will be dictated by unified sentiments and actions of a people towards careful management of wild pigs, but the mettle of managers will be tested in human interactions, not those with wild pigs. Humans possess the skills, technology, and ability to eradicate wild pigs from an area if desired. By the same token, so too does humanity possess the ability to expand these animals abundance and range far above any natural equilibrium. We must all work towards management of wild pigs according to science, lest we relive the history of Texas' war on wild pigs.

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OCCURRENCE AND CHARACTERISATION OF SELECTED BACTERIAL PATHOGENS IN THE INTESTINAL TRACT OF WILD BOARS HUNTED IN THE CZECH REPUBLIC

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Abstract
Presence of zoonotic pathogens in the intestines of food animals represents a potential source of meat contamination. Faeces of wild boars hunted in years 2014-2016 in 70 hunting areas in different parts of the Czech Republic were analysed for presence of selected pathogens by cultivation methods (ISO norms). Very low prevalence of Salmonella spp. (0.4%), E. coli O157 (0.8%) and L. monocytogenes (3.3%) was found (N=242), suggesting that the population of wild boar in the Czech Republic is not an important reservoir of these pathogens. However, the overall prevalence of thermotolerant campylobacters was 54.6% (N=606), with C. coli being the predominant species present in 46.9% of samples, followed by C. jejuni (13.4%). The results suggest that there's a significant probability of contamination of wild boar meat by campylobacters in the case that the gut content spills out on meat surface, emphasizing the importance of good shot placement and good practice during evisceration and further handling of the carcasses.

Keywords: *Campylobacter, Listeria, Salmonella, Sus scrofa, zoonosis*

1. Introduction

The number of wild boars hunted in the Czech Republic has been rising steadily. Thanks to the legislation permitting hunting throughout the year and the intense hunting ordered by the State Veterinary Administration in connection with the occurrence of African swine fever, further strengthening of this trend can be expected, leading to an increased availability of this meat on the Czech market.

Wild boars are hosts to a wide range of zoonotic pathogenic bacteria, viruses and parasites that can be shared with livestock, pet animals and humans (Ruiz-Fons, 2017). As such, they might represent an important reservoir for some pathogens and act as a source of foodborne infections in humans (Chiari, Zanoni, Tagliabue, Lavazza & Alborali, 2013), although so far, no pandemic neither severe outbreak of zoonosis coming from wild boars has been reported in humans and the risk is limited to local outbreaks only, mostly affecting hunters and game-related professionals (Ruiz-Fons, 2017).

As the wild boars are omnivorous scavengers, they are highly exposed to pathogenic bacteria from the environment and carcasses of other wildlife, as well as to the pathogens of farm animal origin in areas with intensive animal farming. The majority of pathogenic bacteria reside primarily in the gastrointestinal tract of the animals from which they are shed into the environment and can contaminate the hide (Chiari et al., 2013). Due to the hunting practices used for wild boars (drive hunts having an increased frequency of shots in the abdomen) and poor hygiene during evisceration and further handling of the carcasses, a cross-contamination from the gastrointestinal tract to muscles can occur (Paulsen, Smulders & Hilbert, 2012). Humans can be consequently infected when consuming undercooked meat or meat products (Ruiz-Fons, 2017).

The aim of this study was to determine the occurrence of selected pathogenic bacteria (*Campylobacter* spp., *Salmonella* spp., *Listeria monocytogenes* and *Escherichia coli* O157) in the intestinal tract of wild boars hunted in the Czech Republic, which will allow assessment of risk of exposure to these pathogens for humans.

2. Data and Methods

In total, 606 wild boars (*Sus scrofa*) hunted during the hunting seasons (September-January) in years 2014-2016 in 70 hunting areas in different parts of the Czech Republic were sampled. The samples were taken by employees of the Faculty of Forestry and Wood Technology at Mendel University in Brno. From each animal a sample of faeces from the distal part of the large intestine was taken after evisceration, placed in a plastic faeces container and transported as quickly as possible to the Department of Meat Hygiene and Technology at the University of Veterinary and Pharmaceutical Sciences Brno, where the samples were processed immediately.

The microbiological analysis included determination of the presence of thermotolerant *Campylobacter* spp. (CSN EN ISO 10272-1), *Salmonella* spp. (CSN EN ISO 6579, Annex D), *Listeria monocytogenes* (CSN EN ISO 11290-1) and *Escherichia coli* O157 (CSN EN ISO 16654). Confirmation of *Campylobacter* spp. was performed by mPCR (Dennis et al., 1999), allowing the identification on the genus and species level. Confirmation of *Salmonella* spp. and *E. coli* O157 was performed by latex agglutination test (Oxoid, UK) and biochemical identification by VITEK2 (bioMérieux, France). Confirmation of *L. monocytogenes* was performed by biochemical identification using VITEK2 (bioMérieux, France) and by mPCR (Huang et al., 2007).

The percentages and confidence intervals were computed using Microsoft Excel 2010.

3. Results and Discussion

The data on occurrence of selected pathogenic bacteria in the intestinal tract of wild boars are showed in Table 1. The number of positive findings for *Salmonella* spp. and *E. coli* O157 was very low (<1%), followed by *L. monocytogenes* (3.3%). The positive findings originated from multiple hunting areas. Similar prevalence for *Salmonella* was found by Díaz-Sánchez et al. (2013), who sampled in 33 hunting estates in 4 geographical areas of Spain and reported only 0.3% of rectal faeces positive (N=301) and 9% positive for STEC (shiga toxin-producing *E. coli*), but no *E. coli* O157. Similarly, in the Swedish study of Sanno, Aspan, Hestvik and Jacobson (2014) only 1.1% of faeces were positive for *Salmonella* and no *E. coli* O157 was found (N=88). In Swiss, Wacheck, Fredriksson-Ahomaa, König, Stolle and Stephan (2010) didn't find any *Salmonella* or STEC in 73 samples of faeces using cultivation methods. Other authors reported much higher prevalence of *Salmonella* spp. in faeces of wild boars – 22% in Northern Portugal (Viera-Pinto et al., 2011) and 11%, 19% and 25% in Italy (Chiari et al., 2013; Magnino et al., 2011; Zottola et al., 2013). A little higher prevalence than in our case for *E. coli* O157:H7 was reported by Sánchez et al. (2010) from Spain (3.3%). Recent data on presence of *L. monocytogenes* in faeces of wild boars are very limited. Wacheck et al. (2010) reported a prevalence of 1% in animals hunted in Swiss and Weindl et al. (2016) a prevalence of 2.9% in Germany.

Table 1: Prevalence of selected pathogenic bacteria in the intestinal tract of wild boars

	n/N	% positive	CI 95%
***Campylobacter* spp.**	331/606	54.6	50.7%; 58.6%
***Salmonella* spp.**	1/242	0.4	0.0%; 1.2%
Listeria monocytogenes	8/242	3.3	1.1%; 5.6%
***E. coli* O157**	2/242	0.8	0.0%; 2.0%

n number of positive samples
N total number of samples
CI confidence interval

The overall prevalence of *Campylobacter* spp. was very high (54.6%). The prevalence within the hunting areas ranged between 0% up to 100%; however, the number of animals sampled varied between the individual hunting areas, so no relevant comparison could be made. Comparing the hunting seasons, the prevalence of campylobacters was 70.6% in 2014/2015 (N=153), 68.0% in 2015/2016 (N=234) and only 29.2% in 2016/2017 (N=219). *C. coli* was the predominant species found in 46.9% of samples, followed by *C. jejuni* (13.4%). In total, 7% of animals harboured both *C. coli* and *C. jejuni* in their intestines. Only 9 out of 331 strains were not identified on the species level by the method used.

Whereas Wacheck et al. (2010) didn't find any campylobacters in faeces (N=73), Díaz-Sánchez et al. (2013) reported an overall prevalence of 66% (N=287), with 82% of the hunting estates positive and the prevalence ranging between 33% and 100%. However, most of isolates remained unidentified on the species level. In our study, almost all the isolates were identified as *C. coli* or *C. jejuni*, which are the main agents (especially *C. jejuni*) of human campylobacteriosis. *Campylobacter* has been the most commonly reported gastrointestinal bacterial pathogen in humans in the EU since 2005, with Czech Republic showing the highest rate per 100,000 population (EFSA, 2017).

4. Conclusion

Very low prevalence of *Salmonella* spp., *E. coli* O157 and *L. monocytogenes* was found in the faeces of wild boars, suggesting that the population in the Czech Republic is not an important reservoir of these pathogens. On the other hand, the prevalence of campylobacters was very high with more than half the faecal samples found positive, which means that there's a strong probability of meat contamination in the case of inappropriate handling of carcasses.

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POPULATION STRUCTURE OF WILD BOAR (SUS SCROFA) IN THE CZECH REPUBLIC

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Abstract
Sex ratio, age and social structure are the key factors for the growth and development of all animal populations with sexual reproduction. In the case of wild boar under Central European conditions, the population structure plays a significant role in favour of its population growth and density. Despite obtaining historically high numbers of hunted boars in recent years, we are still not successful in wild boar population reduction in free range hunting grounds. In our study, we focused on the evaluation of the sex and age structure in selected wild boar populations in two unfenced hunting grounds (UHG) and in one private hunting preserve (PHP) during the main reproductive season. The criteria for localities selection were: the absence of individual boar hunting during the year and hunting only by common hunts (battues). The age and sex were evaluated for all hunted boars from October to the end of January in three seasons (2015/2016, 2016/2017 and 2017/2018).
In total, 665 wild boar (UHG: 416 indd, PHP: 249 indd), of which 58% were females, were examined. The primary sex ratio in all localities was about 1:1.17 (in favour of females). In the case of yearlings, the ratio of sex was 1:1.86 in FHG (again in favour of females) and 1:0.75 in PHP (in favour of males). The predominance of females in PHP is the result of the ease of successfully-hunting males that have been excluded from the sounder (to avoid inbreeding). The absence of the yearling-females in PHP is the result of their being selectively protected (in a breeding enclosure) in a non-hunted area of the PHP For boar over 2 years of age, the sex ratio was 1:3.55 in UHG (in favour of females) and 0:1 in PHP (as adult males were hunted in advance to ensure the safety for hunting dogs and hunters).
Females dominated in all age ranges of the wild boar population, reflecting the current population boom in Central Europe. This is the result of inappropriate wildlife management, especially inadequate regulatory pressure upon reproductively active females.

Keywords: *Sus scrofa, age, sex, reproduction, hunt, wildlife management*

1. Introduction

Wild boar (*Sus scrofa* L.) is a significant species of game that has increased its abundance in Central Europe in recent decades to such levels that the state administration, with the risk of spreading dangerous diseases, has ordered an intensive reduction in its numbers and has allowed the use of previously prohibited hunting methods. It is also contemplated the payment of bonuses for each successfully hunted wild boar. The current environment of cultural landscape creates optimal living conditions for wild boar. Conditions are characterized by minimal lethal factors, enough food all year round, cover and resting areas. All this, thanks to agricultural policy, which is oriented towards large monocultures of energy-rich crops (*Zea mays*, *Brassica napus* etc.; Cahill, Llimona & Gracia, 2003; Herrero, García-Serrano, Couto, Ortuño & García-González, 2006), along with a favourable climate (Frauendorf, Gethöffer, Siebert & Keuling, 2016), inappropriate wildlife management (*i.e.*, supplementary feeding (Oja, Kaasik & Valdmann, 2014; Plhal et al., 2018) and minimal hunting pressure focused on adult sows.

A key population factors that reflect the high reproductive capacity of wild boar are the sex and age structure; respectively the proportion of sexually active females involved in the reproduction process. The main reproductive season runs from October to early spring. The old sows and female-yearlings begin the main reproduction season from October (Drimaj & Kamler, 2017). The female-piglets are gradually involved in the reproductive process when they reach minimum bodyweight thresholds. The aim of this study was to evaluate the population structure of wild boars in the Czech Republic in the main hunting seasons in the selected localities (in hunting grounds without fence and fenced hunting preserve).

2. Data and Methods

In the three main hunting seasons (from October to the end of January), 2015/2016, 2016/2017, 2017/2018, data collection was carried out on selected localities, through common (group of hunters hunting together) hunts for wild boars. Locations were selected where intensive reduction in the number of boars was carried out by common non-selective hunting in the autumn and winter, with a preliminary intention to kill at least 20 boar and more. At the same time, emphasis was placed on minimal individual hunting during the year in order to preserve the real population structure of wild boar until the main hunting season.

The studied localities were two unfenced hunting grounds and one hunting preserve. The first locality was the private hunting preserve „PHP" (fenced area, oak forest altitudinal zone, with the dominant trees: oak (*Quercus robur*) and spruce (*Picea abies*), the density of the wild boar was about 1,200 individuals per 1,000 ha). Unfenced hunting grounds (UHG) were represented by UHG1 (without fence, beech forest altitudinal zone, with the dominant trees: spruce, and the density of the wild boar was about 200 individuals per 1,000 ha) and UHG2 (without fence, beech-oak forest altitudinal zone, with the dominant trees: oak, and the density of the wild boar was about 200 individuals per 1,000 ha).

In the common hunts, in these hunting grounds, the successfully hunted females and males were age classed according to the development and wear on their teeth. Age was determined to within months for individuals less than 24 months old and to within years for older individuals. In order to minimise errors during data collection, age determination was carried out by one, trained, worker. Weight was determined (in kilograms) using certified equipment.

3. Results and Discussion

During the three hunting seasons, 665 wild boars (PHP: 200 ind., UHG1: 216 ind. and UHG2: 249 ind.) were collected for this analysis, of which 58% were females. In the case of piglets there was a M:F sex ratio of 1:1.17, which shows the primary sex ratio skewed in favour of females because hunting of boars was still indiscriminate of sex (the reason for this are the utterly negligible weight and morphometric differences). In the yearlings category, the ratio of sex was 1:1.86 in favour of females in UHG; in PHP the sex ratio was 1:0.75. Nearly twice the number of yearlings-females in free populations was due to the absence of males of this age group in the population, because yearlings-males were shot before the main hunting season. Adult females expel the sexually adolescent yearlings-males from the family group to prevent inbreeding with other females in their family group (Andrzejewski & Jezierski, 1978). These inexperienced young males move in the landscape and because they lack experiences, they are easily hunted. Most of these males have therefore been killed, in the autumn. Exceptionally, it was possible to find them during common hunting in the autumn or winter. The opposite was the case with the yearlings-males in PHP, where wildlife management was built on the selective killing of inappropriate individuals (reproduction of unwanted). Selected, quality, sows that were preferred for breeding the next generation were protected and enclosed (secured) in a non-hunted part of the PHP. At common hunts in the PHP there was predominance of yearling-males, because yearling-females were protected. In adult wild boar older than 2 years of age, the ratio was 1:3.55 in favour of females in UHG and 0:1. The low proportion of adult males in UHG results from the small number of yearling-males in the population. Adult males are most attractive to the hunters (trophies) and they have much larger home range (including a larger number of hunting grounds with active hunters). The low population of adult males in PHP was to ensure the safety of hunters and hunting dogs and was the result of individual hunting before the common hunting season.

4. Conclusion

The structure of the assessed populations of wild boar in the main hunting season was different in the hunting preserve and in the free hunting grounds. The sex ratio varied in the piglets slightly to the benefit of females; in the yearlings category caught in free hunting grounds, females predominance was very noticeable. In adult wild boar, the old males appeared very sporadically. In the wild boar population from UHG, therefore, the females in all age groups predominated, with the older the age group being, the higher the proportion of females. In the hunting preserve there was an anomaly in the category of yearlings, where the males dominated. The reason was the rearing management based on the protection of young females (mothers) that were enclosed during hunting period and protected away from hunters. In the mature age class, the old males were intensively hunted in autumn to protect hunters. Females dominated in all age ranges of the wild boar population, reflecting the current population boom in Central Europe. This is the result of inappropriate wildlife management, especially inadequate regulatory pressure upon reproductively active females.

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PRELIMINARY FINDINGS OF FACTORS INFLUENCING WILD BOAR DISTRIBUTION IN TEMPERATE FOREST DURING THE WINTER

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Abstract
Wild boar is a highly adaptable occasional omnivore that perfectly exploits the conditions of contemporary cultural landscape in Central Europe. In the growing season it lives in agricultural crops, where it has enough rest, shelter and food. In the autumn, after the maize harvest, it moves into the forests, where its living conditions are more unfavourable. There wild boar is disturbed by intense hunting, forest cutting, recreation and other human activities, also food resources are limited (depending on mast trees and mast years presence and quantity). The question then remains, to what extent the wild boar reacts to these environmental factors. This study focused on the evaluation of the in the study forest complex in the north-eastern part of the Czech Republic, using faecal pellet group counting. Distribution was evaluated at 617 sample plots (each with an area of 100 m^2), at the end of two winters (2017 and 2018). The number of faecal pellet group was related to the type of forest environment, geomorphological characteristics, hunting grounds, distances from the nearest feeding site, forest roads, hiking trails, forest edge, intravilan and streams.
This study confirmed that wild boar faecal pellet group density was inversely proportional to the distance from the food source and the forest edge. The highest density of faecal pellet groups was in young dense forest stands, regardless of hiking trails, forest roads and areas with intensive forest cutting. The impact of geomorphological characteristics or the distance from the water streams was not demonstrated. Human interference does not affect the distribution of wild boar in the forest and does not have a significant impact on wildlife management.

Keywords: *Sus scrofa, wildlife management, environment, habitat, faecal pellet group, GIS*

1. Introduction

Wild boar is a significant species of game that has spread to new territories of the world and it intensely increases its abundance in these areas (Massei et al., 2015). The accompanying phenomena of this species existence, depending on its density in the environment, could be considered as a conflict between ecological (Saniga, 2002), economical (Ficetola, Bonardi, Mairota, Leronni & Padoa-Schioppa, 2014), social (Hladíková, Zbořil & Tkadlec, 2008) and hygienic (e.g. Kaba et al., 2010) requirements of contemporary human society. Thanks to its wide ecological valence, hidden existence and adaptation ability to food sources and cover conditions, wild boar is able to take advantage of changes in landscape use and extands its abundance exceedingly. Current cultural landscape environment offers ideal conditions for its life.

At the beginning of the growing season, wild boar in Central European landscape looks for food in rape fields (*Brassica nappus*), then goes into wheat (*Triticum aestivum*) and other cereals (*Avena sativa*, x *Triticosecale*). After their harvest, wild boar moves to maize (*Zea mays*) and it continues to forests with plenty of acorns (*Quercus* sp.) and beech nuts (*Fagus sylvatica*) in the autumn. Winter hardship does not occur, because intensive hunting care in the form of feeding sites often offers ad libitum of energy rich food in high quality and quantity. What is the spatial distribution of the wild boar during the winter, when its occurrence is limited more or less only within the forest environment? And what factors are key to its movement in the forest? This study focused on these factors monitoring within the chosen forest ecosystem in northeastern part of the Czech Republic.

2. Data and Methods

The study area spreads over 11.59 km^2 of forest complex located in the northeastern part of the Czech Republic, about 40 km north of Olomouc city. It is the first forest complex following up on the fertile lowland agricultural area of the Upper Morava Vale. Forest environment was researched around the hill called “Bradlo”, which is considered to be the first peak of Jeseníky Mountains. This unbroken forest complex is situated at the altitude of 305–599 m, with mean annual temperature 5–8 °C. Also, an intensive forest extraction (the result of longtime soil drying, wind and bark beetle forest calamity) appears in the southeastern part of the area. The species composition of the forest stands is highly homogeneous: 90% Norway spruce (*Picea abies*), 7% beech and other trees less than 3%. Owing to spruce management as the dominant species, the shrub, herb and moss floors are very poor, in places virtually non-existent. Forest complex in the study area is commonly open to the public, however tourism has been confined to the hiking trails network (the main tourist destination is the top of “Bradlo” located in the middle of the study area). Also, there is evenly distributed forest road network.

Wild boar is a natural part of local forest ecosystem environment. Then, a lower numbers of roe deer (*Capreolus capreolus*), fallow deer (*Dama dama*), mouflon (*Ovis orientalis musimon*) and brown hare (*Lepus europaeus*) can be observed there. There live also foxes (*Vulpes vulpes*) and badgers (*Meles meles*), other large carnivores do not occur. During the growing season, the wild boar appears in the fields, after harvest, it moves into the forest complex. The study area included three hunting grounds (A, B and C) with a similar way of wild boar management (wild boars are hunted at feeding sites during the winter).

Wild boar distribution during the winter was evaluated according to the occurrence of their faecal pellet groups (FPG) in early spring, in two seasons (2017, 2018), by the (Plhal, Kamler, & Homolka, 2014a; Plhal, Kamler, Homolka & Drimaj, 2014b). The FPG accumulation period was determined from 15th November to 9th April, controlled by the wild boar presence in the forest and by an attempt to monitor the decomposition process (Drimaj, 2014).

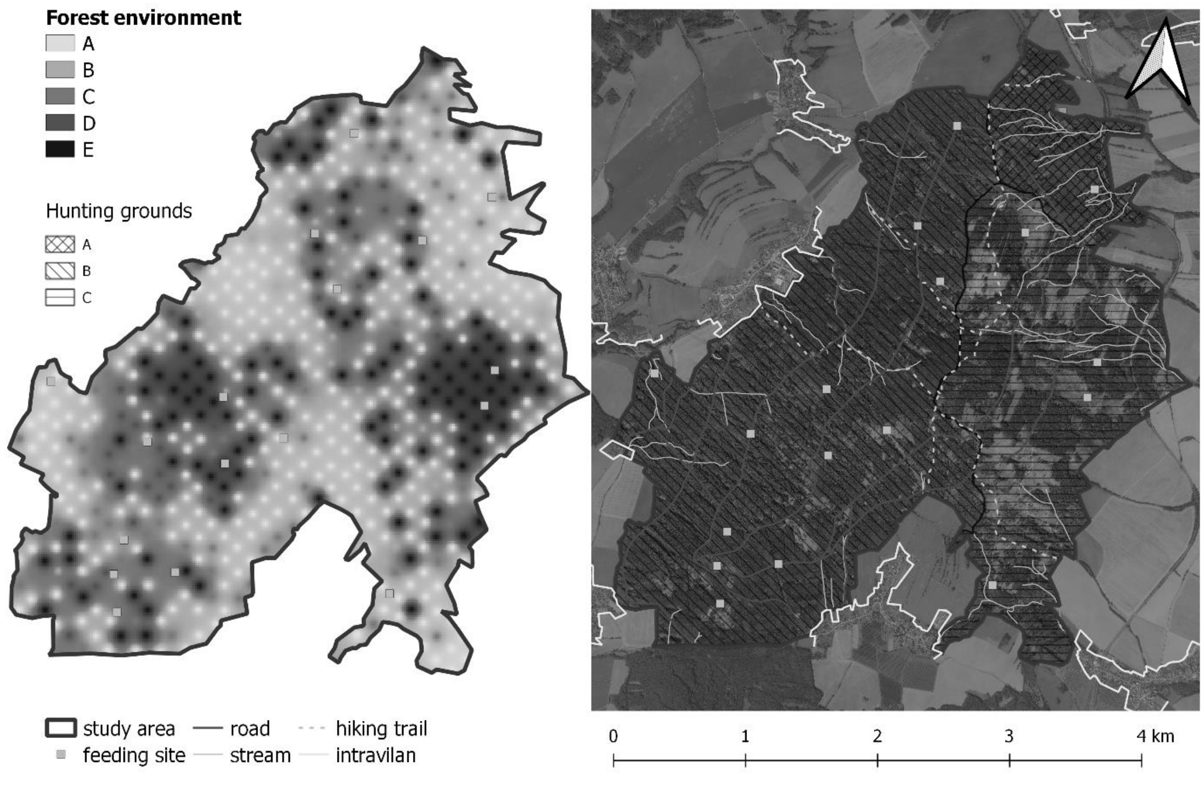
Prior to field monitoring, a base map for GPS receivers was created in ESRI ArcMap 10.6. This map included bounded study area and a network of regularly distributed sample plots (with 200 m spacing; n = 617). This base map was uploaded to GPS devices (Trimble Juno ST equipped with TerraSync Pro Field software) which were then used for field navigation. The sample plots in the map determined the centers of circles with 5.64 m radius (i.e. 100 m^2) that represented the particular sub-research areas. In each sample plot, the number of wild boar FPGs was counted and cover conditions (suitability) of forest environment were assessed (A – clearing, grown forest stands without undergrowth, B – adult stands with grassy and herbal undergrowth, C

– medium-old forest stand, D – thicket after thinning, E – dense and impenetrable thicket). FPGs were counted within the entire area on 9th April 2017 and 9th April 2018, a one to two weeks after the snow cover melting. Every counter (5 people in total) was equipped by a GPS device with the network of points recorded and a particular part of the study area was assigned to him where he performed the FPG counting and environment assessment (in each sample plot). In both seasons, each counter evaluated the same area to minimize errors.

Upon field work concluding, the digital geo-database was backed up on a PC and processed in geoinformatical systems (GIS) software (QGIS 3.0.0, GRASS 7.4.0) in context with local abiotical conditions in study area. For visualization FPGs and environment assessing data were interpolated into the scale maps. As the interpolation method, Inverse Distance Weighting (IDW) was used. This method is the most suitable procedure for interpolation of regularly distributed point datasets. By this calculation the interpolated point value is determined by weighted arithmetic mean of surrounded known point values, as closer points have a greater weight than distant points (Watson, 1985).

In the next step, the geomorphological characteristics were analysed, as the average altitude, aspect and slope for each sub-area were counted using Digital Terrain Model of the Czech Republic of the 5th Generation data. Further analyses included calculating the sub-area distance from the nearest stream, road, hiking trail, feeding site, forest edge and intravilan (built-up areas). Sub-areas located at a maximum distance of 50 and 100 m from the linear features were selected as well. All these calculations served as a base material for subsequent statistical evaluation.

Figure 1: Study area, sample plots, quality of environment and other characteristics



For the modeling of the FPG number per sample plot the generalized linear model (GLM) with zero inflated negative binomial distribution (ZINB) was used. Detailed information about ZINB model can be found in Zuur et al.(2009). Model of ZINB can be written by the equations (Zuur et al., 2009):

$$E(Y_i) = \mu_i \times (1 - \pi_i) \quad (1)$$

$$\mu_i = e^{\beta_0 + \beta_1 X_{1_i} + \beta_2 X_{2_i} + \beta_3 X_{3_i} + \cdots \beta_j X_{j_i}} \quad (2)$$

$$\pi_i = \frac{e^{\gamma_0 + \gamma_1 X_{1_i} + \gamma_2 X_{2_i} + \gamma_3 X_{3_i} + \cdots \gamma_j X_{j_i}}}{1 + e^{\beta_0 + \beta_1 X_{1_i} + \beta_2 X_{2_i} + \beta_3 X_{3_i} + \cdots \beta_j X_{j_i}}} \quad (3)$$

$E(Y_i)$ is mean value of distribution of faecal pellet group number per sample plot *i*, μ_i is fitted mean for the negative binomial count data, π_i is fitted probability of false zeros for the binomial distribution, β_{0i}, β_{1i}, β_{2i}, β_{3i}, $\ldots\beta_{ji}$ and γ_{0i}, γ_{1i}, γ_{2i}, γ_{3i}, $\ldots$ γ_{ji} are model parameters, X_{1i}, X_{2i}, X_{3i}, $\ldots X_{ji}$ are explanatory variables *j* of sample plot *i*.

We used ZINB distribution due to overdispersion in the data. Overall model significance was tested by the likelihood ratio χ^2 test. Z-test was used for model parameters significance testing. Pseudo R^2 (Nagelkerke, 1991) and AIC (Akaike, 1973) were used as a goodness of fit characteristics. All analyses were performed in R software (R Core Team, 2017) with a significance level α = 0.05.

The wild boar population density was calculated according to the following formula:

$$PDi = \frac{x_i}{AP \times DDR} \times P_i \quad (4)$$

PDi is population density in study area, x_i is average FPG density per hectare (FPG per ha), *AP* is accumulation period (145 days), *DDR* is daily defecation rate (5 FPGs per day per animal; by Plhal et al., 2014a) and P_i is study area (1,159 ha).

3. Results

In the first year, 912 FPGs were found in the study area, and 26% less in the second year. In the first year, the presence of wild boar FPG was not recorded at 61% of the sample plots and at 65% of sample plots in the second year (density of FPGs after modelling is show in figure 2). The density of FPG findings corresponds to the following wild boar density: 20.4 ind./km^2 in 2017 and 15.1 ind./km^2 in 2018. The population density decrease was due to the ordered intensive hunting in connection with the occurrence of ASF in the Czech Republic.

According to goodness of fit characteristics, the best ZINB model of FPG number was selected (χ^2 (DF=10) = 701.69; p value < 0.0001; pseudo R^2 = 0.6817; AIC = 2806.2). Fitted values of the final model were explained by the distance of the sample plot from the forest edge and from the feeding site and by the suitability of forest environment. Fitted values were respectively different between hunting grounds and studied years. Estimated parameters of the best model are in table 1 (only significant parameters). Results show that with increasing distance of sample plot from the forest edge the number of FPGs increases and with increasing distance of sample plot from the feeding site the number of FPGs decreases. All five categories of forest environment suitability were statistically different to each other. From the values of estimated parameters in table 1 is clear that higher number of FPGs was in categories E and B and lower was in D, A and B. The number of FPGs is same in hunting grounds A and B but in the hunting ground C it is significantly higher. The FPG number was distinctly lower in year 2018 in comparison with year 2017.

Figure 2: Density of FPG in study area in 2017 and 2018 (after modelling)

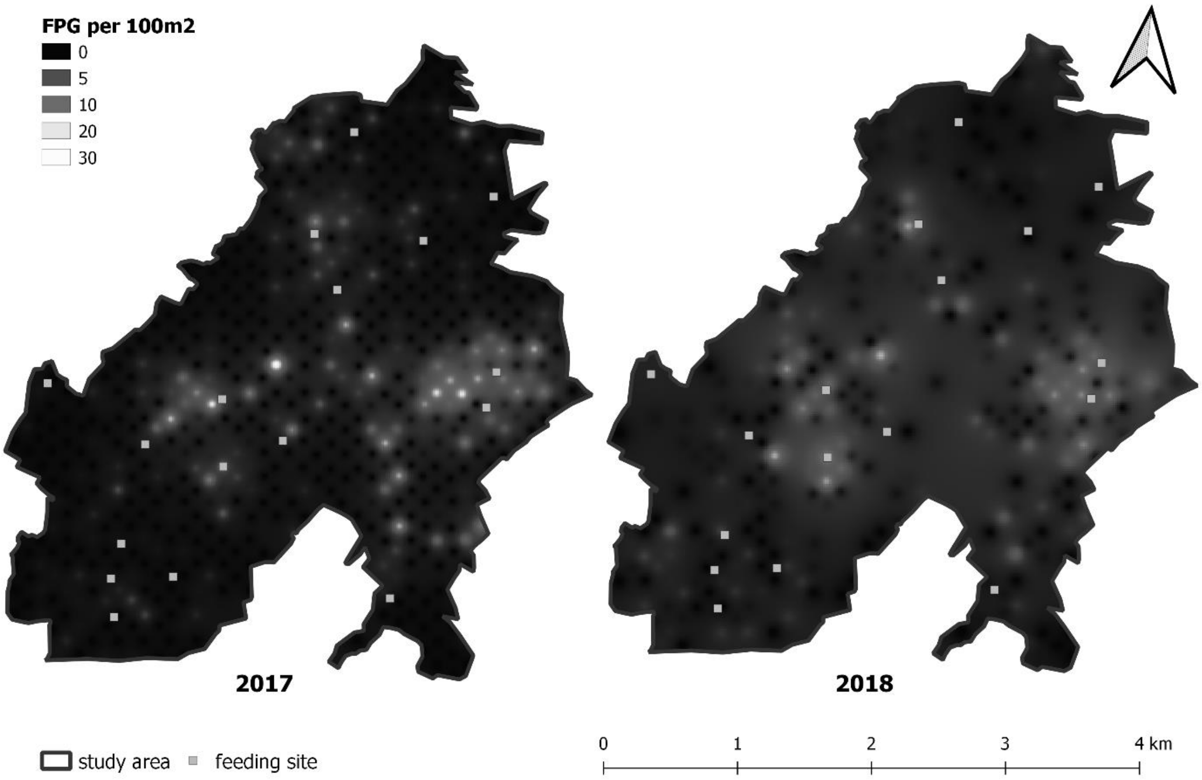


Table 1: Estimated parameters of the best FPG number model

Parameter	Explanatory variable	Level of variable	Estimation	SE	z value	p value
β_0	intercept	-----	-1.2306	0.1597	-7.707	<0.0001
β_1	forest edge	-----	0.0004	0.0002	2.357	0.0184
β_2	feeding site	-----	-0.0006	0.0002	-2.766	0.0057
β_3	location	C	0.2752	0.0918	2.997	0.0027
β_4	environment	B	2.3840	0.1561	15.304	<0.0001
		C	0.9103	0.1478	6.160	<0.0001
		D	1.1969	0.1980	6.046	<0.0001
		E	2.9191	0.1099	26.548	<0.0001
β_5	year	2018	-0.2039	0.0909	-2.244	0.0248
γ_5		2017	-2.0434	0.3514	-5.816	<0.0001
		2018	-1.6748	0.3086	-5.428	<0.0001

SE – standard error, β_0, β_1, β_2, β_3, β_4, β_5, γ_5 – model parameters, forest edge – sample plot distance from the forest edge, feeding site – sample plot distance from the feeding site, location – hunting ground (A, B and C), environment – suitability of forest environment (B–E)

4. Discussion

In the study area relatively high wild boar population density was found [for example, compared to: 10.6 ind./km^2 in Canton of Geneva, Switzerland (Hebeisen, Fattebert, Baubet & Fischer, 2008), 12 ind./km^2 in Italian Tuscany (Massolo & Mazzoni Della Stella, 2006), 0.7–7 ind./km^2 in some localities in England, United Kingdom (Massei et al., 2017), but lower than other population in the Country, 18.55 ind./km^2 in Stonařov (Plhal et al., 2018)]. This is due to the generally higher densities of wild boars in the Czech Republic and winter concentration caused by wild boar withdrawal from the wide agricultural landscape area. Because food sources are significantly limited to sporadic adult beeches and oaks, wild boar was depended on frequent visits of feeding sites. Limited wild boar movement in winter was probably caused by effort trying to save energy – using easily accessible food sources than expending energy by searching for food insecure sources (Massei, Genov, Staines & Gorman, 1997). The unproven dependence of FPG density on water streams was a little surprising, as it can be attributed to the relatively rich network of small watercourses in the area and to the emergence of a large number of temporary pools or the drainage ditches along the melting snow paths (to which warm mild winters contributed in the years under study – absence of long-term snow cover). The impact assessment of forest environment categories confirmed that wild boar is looking for young forest stands with good cover conditions (Keuling, Stier & Roth, 2008; Podgórski et al., 2013; Plhal, Kamler, Homolka & Drimaj, 2014b), where it spends most of the day. In addition, feeding sites are often located close to young stands. This is in line with the knowledge of Fonseca (2008), who found that each home range has to include food sources and appropriate bedding sites. According to Geiger (1965), young coniferous stands are more suitable for wildlife presence because of more favourable winter climate. The failure to prove the influence of altitude, slope and exposure to wild boar occurrence was somewhat surprising. Likewise, wild boar did not respond to tourism or the presence of intensely used forest roads in the sampling season. With regard to the intensive logging operations in hunting ground C (south-eastern slope) highest concentrations of FPGs in local young forest stands were surprising. This proved the hypothesis that wild boar spatially responds to disturbances caused by man and is able to inhabit dense forests close to the hiking trails or clear cut.

5. Conclusion

This study confirmed that wild boar faecal pellet group density was inversely proportional to the distance from the food source and the forest edge. The highest concentration of faecal pellet groups was in young dense forest stands, regardless of hiking trails, forest roads and areas with intensive forest cutting. The impact of geomorphological characteristics or the distance from the water streams were not demonstrated.

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PREVALENCE OF SELECTED EMERGING AND RE-EMERGING PATHOGENS IN POPULATION OF WILD BOAR IN THE CZECH REPUBLIC

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Abstract

Wild life, especially wild boars, are hosts to a number of pathogenic viruses, bacteria and parasites. More often these pathogens are silent or asymptomatic in their natural hosts. In some instances they can infect other species, and this cross-species transmission might lead to human infection. Several of these viruses, bacteria or parasites are emerging or re-emerging in nature. Present study describes prevalence of such pathogens in wild boar population in the Czech Republic. A total of 361 wild boars were tested for presence of hepatitis E virus, suid herpes virus 1 (Aujeszky's disease virus), Toxoplasma gondii and Trichinella spiralis. Analysed samples were collected in period of two years (2016 and 2017) and originated from 22 location of the Czech Republic. Detection of selected pathogens was performed by molecular methods (qPCR or RT-qPCR). Hepatitis E virus and Aujeszky's disease virus were found in at least one sample of 54 (15 %) and 13 (4%) animals, respectively. Presence of Toxoplasma gondii was detected in samples of 23 (6 %) tested wild boars, while all analysed samples were negative for presence of Trichinella spiralis. The prevalence of selected pathogens seems to be low in wild boars, however obtained result should not be underestimated. According to found prevalence of hepatitis E virus (15 %) and an annual wild boar catch in 2016 (over 160,000 animals), 24,000 wild boars could be infected by this virus and thus could serve as source of human infection.

Keywords: *Wild boar, Hepatitis E virus, Aujeszky's disease virus, Trichinella spiralis, Toxoplasma gondii, zoonoses*

1. Introduction

In the last forty years, wild boars (*Sus scrofa* L.) have become a key species of hunted ungulates in the Czech Republic (CR). These animals are a highly adaptable game species that takes advantages of living conditions such as monoculture grown crops (e.g. rape and corn) on large areas. Important factor is the capability of their reproduction, when young wild sows (less than one year old) are able to give birth to piglets. These factors, together with mild climate conditions during winters, cause an exponential growth in the wild boar population posing not only economical concerns. Wild boars have been shown to harbour a wide range of pathogenic agents of viral, bacterial a parasitical origin, that are transmissible to domestic pigs and other animal species including humans. More often these infectious agents are silent or asymptomatic in their natural reservoirs (i.e. wild boar does not reflect visible sign of ongoing infection), however they can cause serious diseases of other animal species. Representatives of this kind of pathogens are hepatitis E virus (HEV), suid herpes virus 1 (Aujeszky's disease virus; SHV-1), *Toxoplasma gondii* (*T. gondii*) and *Trichinella spiralis* (*T. spiralis*). While SHV-1 is not transmissible to human beings and causes serious infection of e.g. cattle, sheep, goats and dogs, HEV, *T. spiralis* and *T. gondii* are able to cause serious health complications in humans.

HEV is an important causative agent of humans' hepatitis in European countries (Chandra V., Taneja S., Kalia M. & Jameel, 2008; Panda, Thakral & Rehman, 2007). Among previously identified hepatitis viruses, this is the only one with zoonotic potential (Pavio, Men, Renou, 2010). Although the majority (>70%) of humans' infections are asymptomatic, symptomatic cases show mild to fulminant acute self-limiting hepatitis (fatality rates generally under 0.5%) with fatigue, nausea and fever. The hepatitis may reach chronicity or neurological symptoms, organ injuries or haematological disorders in patients with poorly functional immune systems (e.g. transplant patients or oncology patients), or those with other liver comorbidity. In European countries HEV is transmitted mainly by consumption of raw or undercooked meat and offal of reservoir animals, however direct contact with infect animals is also risky for HEV transmission. Domestic pigs, wild boars and likely deer are recognised as natural reservoir of the virus. In wild swine, HEV infections are asymptomatic, therefore, it is not recognizable during a routine veterinary inspection and thus the meat and offal of infected animals can be freely distributed to the market (Yugo & Meng, 2013).

SHV-1 causes Aujeszky's disease or also called pseudorabies, a worldwide widespread disease. The domestic pigs and wild boars are natural host of the virus. The infection in adult wild boars generally do not cause mortality but may result in latent infection. SHV-1 can also infect other mammals (e.g. dogs, cattle and sheep. The infected animals suffer from a fatal nervous disease. First typical symptom of infection is intense pruritus localized near the site of virus entry and presented as severe licking, rubbing or gnawing. The disease progresses rapidly; convulsions, bellowing, teeth grinding, cardiac irregularities and rapid, shallow breathing are common. Affected animals become progressively weaker, and eventually recumbent. These cases are almost always fatal, the death occurs in a few days (24-48 hours). SHV-1 is not transmissible to humans or other primates (Romero, Meade, Homer, Shultz & Lollis, 2003).

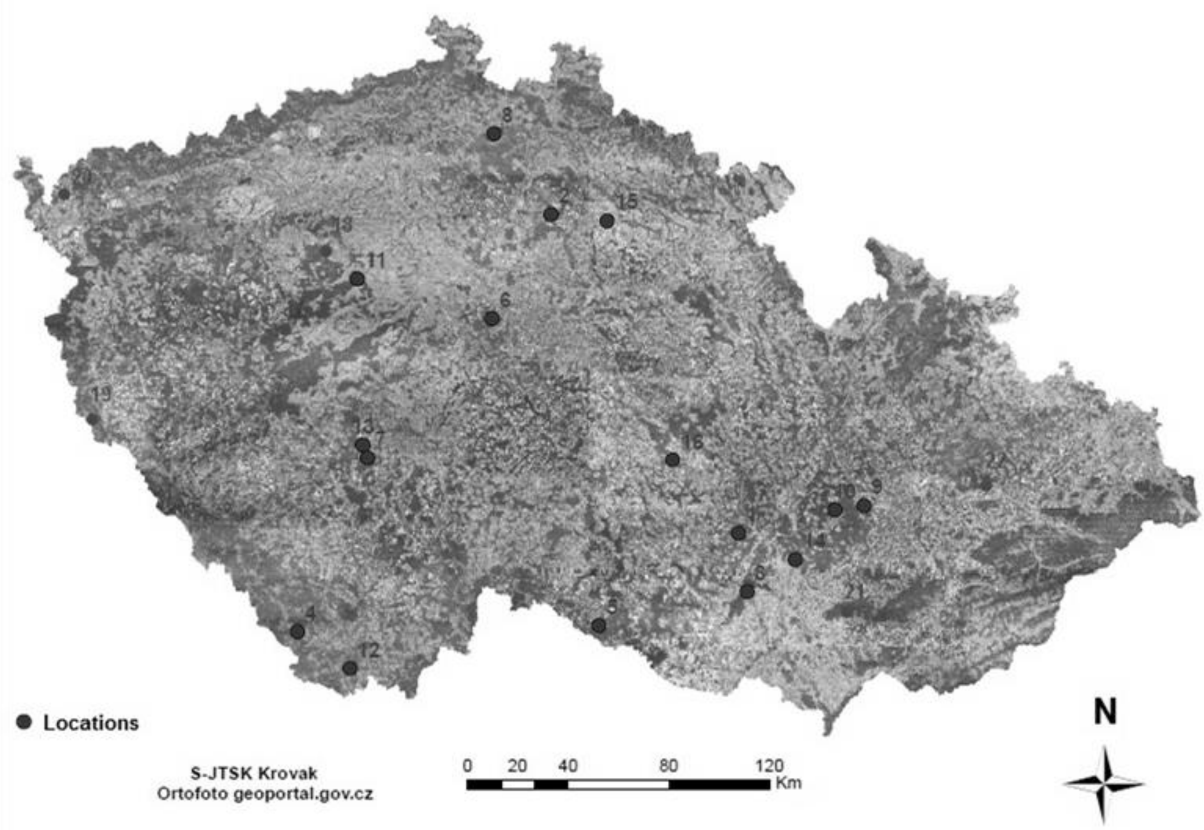
Trichinella sp. is able to infect a human beings and the infection, called trichinosis, belongs between an emerging zoonotic diseases in several European countries. The first clinical symptoms of trichinosis are diarrhoea, vomiting and abdominal pain, followed by fever, anorexia, fatigue, swelling of the face, muscle pain, breathing difficulties, and coma (Förstl, 2003). The pathogenicity is dependent on the number of ingested larvae. Infection of domestic pigs is usually asymptomatic and there is no published report on clinical sign or disease also in wild boars. The source of infection is raw or inadequately heat-treated meat (Hui, Gorham, Murrell & Cliver, 1994).

Protozoan parasite *T. gondii* causes toxoplasmosis in humans. Albeit infection in humans is mostly subclinical or asymptomatic, it is dangerous for pregnant women particularly (Hafid et al., 2005). Resents data suggest that T*. gondii* causes morbidity and severe CNS damage also in immunocompromised persons (e.g. AIDS). Ingestion of contaminated food is major route of the transmission and according to European multicentre study consumption of raw or undercooked wild boar meat likely belongs between risk factors of infection (Cook et al., 2000).

2. Material and Methods

During years 2016 and 2017 a total of 361 wild boars were tested for the presence of HEV, SHV-1, *T. gondii* and *T. spiralis*. Sampling was carried out in connection with other surveys and was situated in 22 location evenly distributed across the Czech Republic (Fig. 1). Samples from 20 wild boars (10 males and 10 females) were collected from each site (the effort to capture even the entire age spectrum of the population). Collected samples are summarised in table 1. The age of individually sampled animals was determined according to the ontogenic state of dentition (juvenile or adult) and teeth wear (in adult animals).

Figure 1: Sampling locations

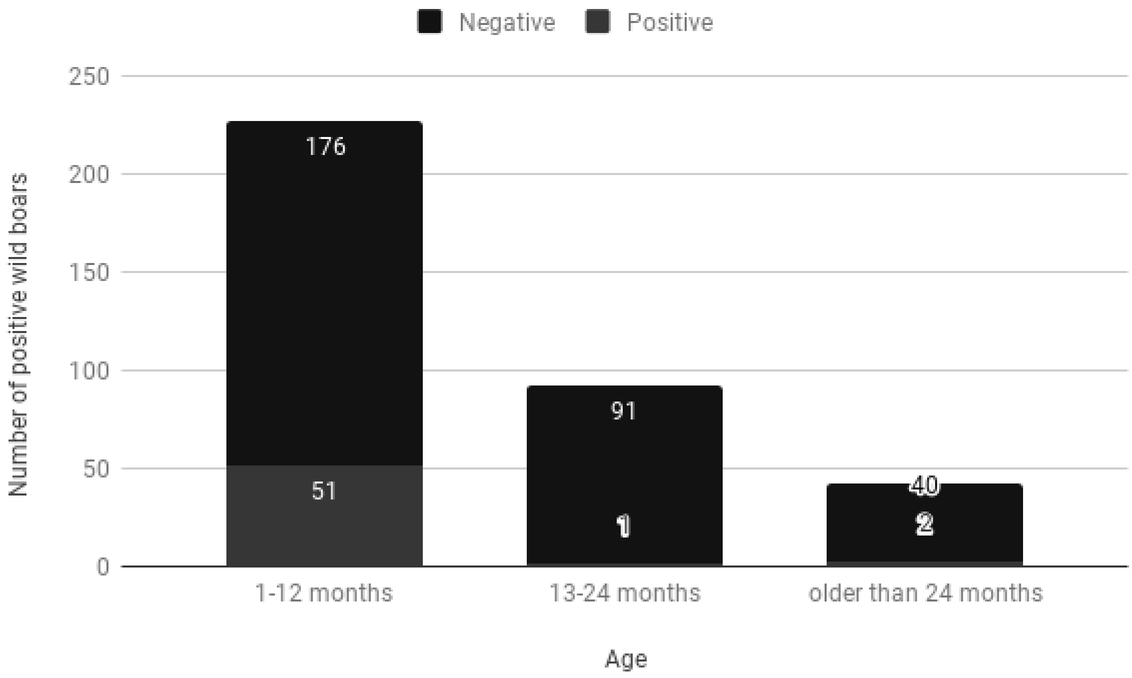


Detection of mentioned pathogens (i.e. genome of these pathogens) was done by molecular methods. Briefly, presence of HEV was determined by triplex reverse transcription real-time polymerase chain reaction (RT-qPCR) according to Vasickova, Kralik, Slana & Pavlik (2012). Detection of SHV-1 and *T. gondii* was performed by qPCR described by Slany (2015) and Slany & Lorencova (2014), respectively. qPCR targeting genome of *T. spiralis* was carried out according to Cuttel et al. (2002) and Emameh, Kuuslahti, Näreaho, Sukura & Parkkila (2016).

3. Results and Discussion

RT-qPCR HEV revealed HEV RNA in at least one sample of 54 (15%) tested wild boars originating from 14 locations, while presence of HEV was confirmed in all three analysed matrices (bile, live and intestinal content) of 23 animals. In the process, RNA HEV was the most frequently detected in liver, followed by bile and intestinal content samples. To the contrary Kubankova et al. (2015) reported that HEV RNA was most often found in bile, liver and intestinal contents samples, respectively. When categorised according to the age, the highest prevalence of HEV was revealed in piglets (six and 12 months of age); distribution of HEV according to age structure of analysed population is summarised in Fig 2. In general, obtained results are in concordance with published data from other European countries; a similar prevalence was found in Hungary (12.2%; Reuter et al., 2009) and Spain (19.6%; de Deus et al., 2008). However higher HEV prevalence was reported from Italy (25%, Martelli et al., 2008) and Germany (68.2 or 14.9%; Adlhoch et al., 2009; Schielke et al., 2009).

Figure 2: The incidence of hepatitis E virus (HEV) by the age of hunted wild boars



Presence of SHV-1 was found in samples of 13 (3.6%) wild boars, in the process the virus was the most frequently detected in serum. One wild boar was found to be SHV-1 positive in all three tested matrices (liver, lymph nodes and serum). The presence of SHV-1 was found out in animals originated from 8 localities. Results related to detection of SHV-1 and age structure of tested wild boars can be observed in Fig. 3.

T. gondii detected in diaphragm pillar of 23 tested wild boars originating from 12 sampled localities (Fig. 4). *T. spiralis* was not found in any analysed diaphragm pillar samples. In the Czech Republic, each hunted wild boar must be subjected to a veterinary examination for the presence of T. Spiralis.

Figure 3: The incidence of suid herpesvirus 1 (SHV-1) by the age of hunted wild boars

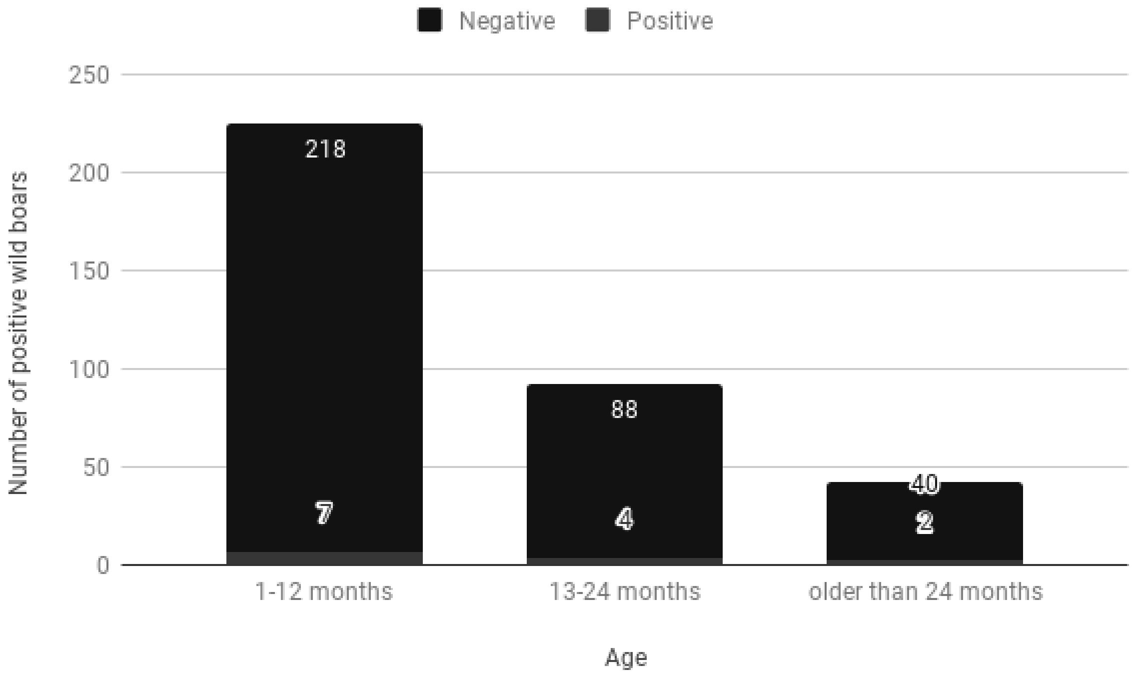
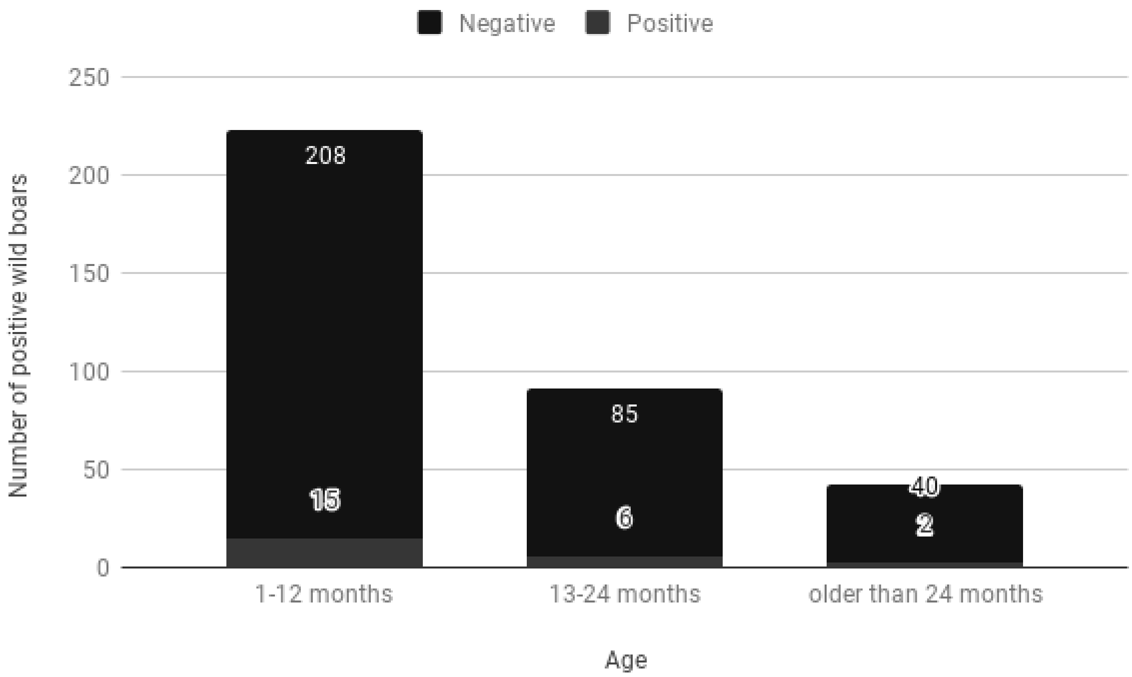


Figure 4: The incidence of *Toxoplasma gondii* (*T. gondii*) by the age of hunted wild boars



In the Czech Republic, the last human infection occurred in 1954 in Smrdov near Pacov. During this outbreak 11 people were infected by *T. gondii* and three of them died. A large outbreak of trichinosis was also reported in the Slovak republic in 1998;

a total of 336 people were infected after consumption of insufficiently heat treated sausages prepared from contaminated dog meat (Koudela, 2001).

The detailed results broken down by gender and the matrix examined can be found in Table 1.

Table 1: The occurrence of selected pathogens in wild boars

Pathogen	Sample	Male	Female	Total	% positive
HEV	Liver	19/175	22/184	41/359	11,4
	Bile	19/165	20/174	39/339	11,5
	Intestinal contents	14/177	17/184	31/361	8,6
SHV - 1	Liver	1/175	0/184	1/359	0,3
	Serum	6/134	7/136	13/270	4,8
	Lymph nodes	1/173	0/179	1/352	0,3
T. gondii	Diaphragm pillar	8/177	15/179	23/356	6,5
T. spiralis	Diaphragm pillar	0/177	0/179	0/356	0

4. Conclusions and recommendations

The game management and hunting of wild boars have undoubtedly played a priority interest in current game keeping in the Czech Republic. Due to a similar situation in neighboring countries, it is an important area of interest within other European countries as well. Present study brings an overview of the prevalence of selected pathogens in wild boars; 15%, 3,6%, 6,5% a 0% prevalence of HEV, SHV-1, *T. gondii* and T. spiralis was found out, respectively.

Due to the increasing consumption of game, also increases the risk of infection by the aforementioned food-borne pathogens. However freezing may not be effective, all afore mentioned pathogens can by destroyed by proper heat treatment. HEV is inactivated at 71°C continuing at least 21 min, while SHV-1 requires thermal treatment of 60°C for 60 min or 100°C for at least of 1 min. *T. gondii* and *T. spiralis* are immediately inactivated by temperature of 67°C and 62°C, respectively. Therefore due to keeping proper hygienic habits and proper heat treatment, venison can become high-quality and a very tasty part of the diet.

Acknowledgements

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THE "ROUND TABLE WILD BOAR" IN BADEN-WÜRTTEMBERG

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Abstract
Similar to other regions of Europe, also in Germany the wild boar population is increasing. Parallel to the population development, the associated problems, such as crop damages show an increase. In order to cope with those growing conflicts, the "Landesbeirat Jagd", a board in the frame of the hunting legislation of the federal state Baden-Württemberg, established the "round table wild boar". Since October 2016, the round table is active in several working groups on various key aspects of wild boar management. Aim is to support and to intensify the reduction of wild boar population by providing public support on the regional level, reducing obstacles and improving communication between stakeholders.
One example is the working group "epidemics", which is currently establishing the action plan for the event of an outbreak of African swine fever (ASF). The working group "agriculture", is analysing the situation of crop damages and adapting the system for damage appraisers. Results are to be integrated in the amendment of the JWMG (Jagd- und Wildtiermanagementgesetz [hunting and wildlife management law of Baden-Württemberg]). Further key topics of the "round table wild boar" are the reduction of hunting restrictions and support of the game market.
Within the platform "round table wild boar", the diverse concerns and issues are represented by the diverse stakeholders. In order to successfully resolve conflicts, well-founded data sets are indispensable to maintain objectivity in all discussions and decision-making processes.

Keywords: *hunting practice, human dimension, management, policy, Sus scrofa*

1. Introduction

During the last decades the wild boar population increased throughout Europe and significance of regional conflicts between wild boar and human population is augmenting (Massei et al., 2015). Damages in agriculture as well as higher probability of road casualties generate increasing problems. Especially in cities were wild boar have established small populations, not only a high human – boar encounter rate but also the general management of wild boar challenges the public authorities, hunters and residents. With the ASF (African swine fever) crossing the border of the EU and spreading in eastern Europe the control of epidemics becomes the main objective for public authorities (Cortiñas Abrahantes, Gogin, Richardson & Gervelmeyer, 2017; FLI, 2017). Decreasing the wild boar population seems to be the essential step to mitigate the various conflicts. The federal state of Baden-Württemberg in Germany decided in the "Landesjagdbeirat" (advisory hunting council for the federal state Baden-Württemberg) in 2015 to establish the "round table wild boar". Task of the round table is to promote the exchange of all involved stakeholders (hunting and agricultural associations, public authorities) and to frame solutions based on mutual consent (Arnold, 2016). The implementation is subsequently taking place in cooperation with local authorities and should imply regional characteristics.

2. Data and Methods

Basic task for the statewide "round table wild boar" is to identify courses of action and ensure corporate action by all stakeholders and associations for management measures. The aim is to push the reduction of the wild boar population by providing support on regional level, reducing barriers and facilitate communication between actors.

For this purpose several working groups with different focus started in October 2016 (fig. 1). For each working group related associations and government department representatives as well as experts are involved. Each group is working on defining solution statements and developing required adjustments on legal basis or supporting measures. All actions are discussed and agreed by all actors of each group. The results serve as basis for political decisions for the government of Baden-Württemberg. On a second, subordinated level, up to date information, guidelines and cooperation structures are communicated to local actors and public administrations (districts). At the same time practical experiences and problems within implementing measures can be returned to the federal government.

Figure 1: Overview of the different working groups of the round table wild boar. Active working groups are black encircled, inactive groups are grey.

Source: Wildlife Research Unit of Baden-Württemberg

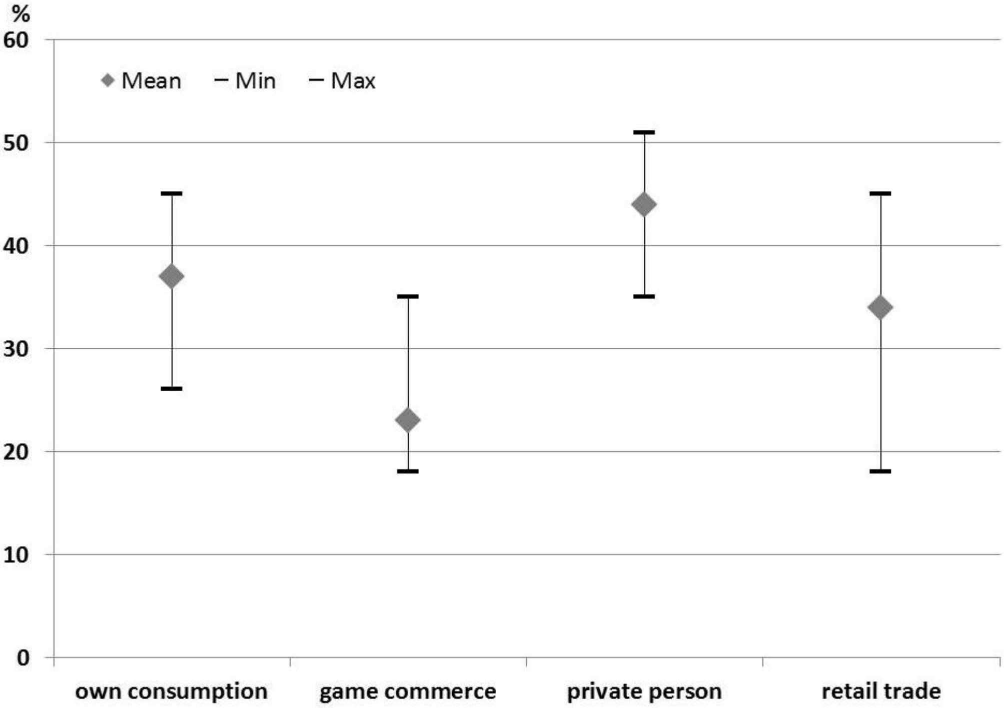
3. Results and Discussion

First results were obtained in the work group "epidemics", with the establishment of the expert group according to article 15 paragraph 2 of the directive 2002/60/EG. With the threating possibility of an ASF outbreak in Germany, a management plan with respect to different scenarios is developed and the legal frame verified. Different management tools are discussed and examined for successfully reducing the wild boar population before an AFS outbreak and in case of an AFS outbreak. Here exists a strong overlap with the work group "hunting practice", which mainly focuses on strengthening possibilities and success for hunting wild boar. As a first step the ministry for rural areas and consumer protection released a decree, in which e.g. hunting with light source is temporary allowed and invoke to shoot adult females (not leading dependent piglets) during drive hunts in autumn and winter. Furthermore, the goal of the work group "hunting practice" is to reduce hunting obstacles. In particular a change of opinion among hunters is needed (Keuling, Strauß & Siebert, 2016), which are locally still more focusing on maintaining a wild boar population, than regulating it.

The work group "agriculture" on the other hand focuses on situation and trends in damages in crops and meadows caused by wild boar. The group is currently working on the amendment of the JWMG (Jagd- und Wildtiermanagementgesetz [hunting and wildlife management law of Baden-Württemberg]) for an advancement of a consistent and practical damage refund procedure.

Within the work group „game marketing" the marketing structure of hunters in Baden-Württemberg were analysed by a survey in six districts. The evaluation shows that the hunters mainly sell their game meat locally (fig. 2), avoiding professional game commerce. This allows the hunters in Baden-Württemberg to still obtain high prices per kg for game meat. 60% of the surveyed hunters sell their wild boar meat for still over 3.00 € / kg, 21% sell between 2.00 – 3.00 € / kg and only 5% under 2.00 € / kg. Compared to other federal states in Germany, especially in east Germany (< 1.00 € / kg) the prices are still high. But regionally, especially when increasing wild boar population meets a rural area apart from congested urban area, selling game meat from person to person, reaches its limit. Thus supporting programs and investment assistance for hunters or licensed game butchers are to be established. Supporting the game marketing and the market itself, is supposed to reinforce the hunting of wild boar.

Figure 2: The diagram shows the distribution in percent of different selling options of the game meat for hunters for six districts in Baden-Württemberg.



Source: Wildlife Research Unit of Baden-Württemberg

4. Conclusion

For the government of Baden-Württemberg, the "round table wild boar" is a major supporting tool for decision making as well as specifying and identifying options for action. Incorporating the different stakeholders and interests provide the possibility to find mutual solutions. At the same time, it reveals the multifaceted conflicts revolving around the species wild boar. Reliable data sets about the biology of the wild boar and also specific data on damages or the game market are necessary to maintain objectivity and acceptance in all discussions. The round table also illustrates the rising public awareness regarding conflicts emerging with increasing wild boar population.

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THE DEVELOPMENT OF THE WILD BOARS ABUNDANCE IN THE CZECH REPUBLIC, AND INFLUENCE OF WILD BOAR ON SMALL GAME POPULATIONS

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Abstract
Already Emperor Joseph II. In 1786 banned the breeding of wild boar in freedom in the whole of Austria-Hungary. This action has caused a strong reduction in the number of wild boar throughout Central Europe. In the Czech Republic population growth began in the 1980s. In 2017, a record number of this game was hunted, namely 230,035 (an average of 33 ind./1000 ha). In some areas, up to 86 ind./1000 ha were killed. The increase in the hunting bag of wild boars is more than a thousand times higher in the Czech Republic since the end of World War II. The number of wild boars significantly affects small game species (brown hare, pheasant, rabbit, grey partridge) in the Czech Republic. The bigger hunting bags of wild boar were in hunting grounds, the smaller the number (or hunting) of small game there was found. Statistically significantly more (p <0.05) small game was counted in hunting grounds, where the wild boar were shot down to 20 ind./1000 ha. Conversely, the level of the hunting bag of the wild boar did not have a negative effect on the hunting rate of roe deer. The more wild boars were hunted, the more roe deer were hunted in the hunting grounds. In hunting grounds, where up to20 wild boars per 1000 ha were hunted, significantly fewer (p <0.05) roe deer was hunted than in other hunting grounds. On the contrary, in hunting grounds where more than 80 wild boars per 1000 ha were hunted, significantly more roe deer were hunted (p <0.05). When we analyzed the impact of the environment on the level of the wild boar hunting bags, it was found that in hunting grounds with a proportion of farmed land up to 40% there were hunted significantly more (p <0.05) wild boars than in hunting grounds with a larger proportion of farmland. On the other hand, in hunting grounds with forest representation up to 40%, significantly fewer (p <0.05) wild boars were hunted, than in hunting grounds with a larger proportion of the forest. The greater the proportion of the forest was in hunting ground, the more wild boars were hunted in it.

Keywords: *count development, Czech Republic, environment, small game, wild boar*

1. Introduction

The number of hoofed game has changed significantly over the years in the Czech Republic mainly due to climate change (Laštůvka & Krejčová, 2000). Great changes have been brought by the first farmers. At that time, for example aurochs or European elk, later wolfs, bears (19st century), and European bison (18st century) were eradicated, in the Bohemia. (Turek, Bučko, Tomeček & Kahuda, 2017).

Empress Maria Theresa issued a patent in 1766, which was ordered by owners of hunting rights to cover damages (Vodňanský, Krčma & Zabloudil, 2003). Already

Emperor Joseph II. In 1786 banned the breeding of wild boar in freedom, where wild boar could be hunted by everyone (Pikula, Beklová & Pikula, 2002). Žalman (1948) states that wild boars lived more continuously only in eastern Moravia. Hanzák and Veselovský (1965) say that in Britain and Denmark the wild boars was completely exterminated, as in the neighboring Alps. After World War II, this game was predominantly in the game parks and has spread from Poland, Slovakia and Germany.

Wild boars also feed on small mammals as a brown hares, picking bird nests, and attacking young born roe deer (Wolf & Rakušan 1977). The high number of wild boars in hunting grounds can therefore have a negative impact on small game populations (Hromas, 2003).

The aim of this work is to describe the development of black game abundance in the Czech Republic from the historical point of view and determine its possible influence on small game populations and describe influence the environment on the pig population to.

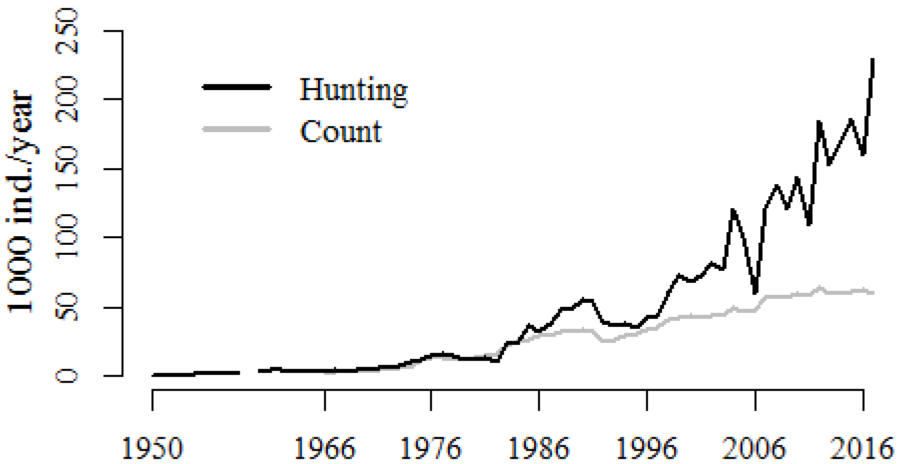
2. Data and Methods

The survey used hunting records published by the Czech Statistical Office, since 1950 and the Ministry of Agriculture since 1966. The data comes from 5815 hunting grounds found in the Czech Republic and covers an area of 6 887 969 ha. Data on agricultural land and forests are part of the hunting record. Data on hunting bag of wild boars are documented on the basis of recorded seals. Game data is obtained based on the spring census of the game, which is always on 31 March of the previous year. Counting is done by hunters only on the basis of their own experience, not on the basis of solid methodology. Conversely, game counts may not fully correspond to reality. The size of the populations can therefore only be estimated by the size of the hunting bag of each species. The data from game parks and pheasantries were filtered out to determine the influence of the wild boar (*Sus scrofa*) on roe deer (*Capreolus capreolus*). And when detecting the impact of a wild boar on small game populations, data from hunting grounds where the game was artificially discharged was also filtered out. In this case, small game is considered to be brown hare (*Lepus europaeus*), wild rabbit (*Oryctolagus cuniculus*), pheasant sp. (*Phasianus* sp.) and grey partridge (*Perdix perdix*). The statistical data from hunting grounds was displayed by districts of the Czech Republic. The data was divided into the grid Kartierung der Flora Mitteleuropas (KFME), too. KFME is a system of squares for the mapping of abundance of the Central European biota. Statistical data processing was performed using the software STATISTICA. The hypotheses were tested using the non-parametric Kruskal-Wallis test or by using the Mann-Whitney U-test. The HSD test was used for data with different N; and the multiple comparison of *p*-values was applied for non-parametric data. The graphs in text show average, standard error of average and standard deviation.

3. Results and Discussion

After the First World War, the stock of wild boar in the Czech Republic was at its long-term minimum. The hunting bag was only 161 in 1925, while Vodňanský et al. (2003) reported that wild boar was shot in the Czech Republic between 1874 and 1911, ranging between 470 and 882 pieces per year. Population growth began in the 1980s. Thereafter, the number of hunted wild boars growth steeply and only the strong winters in 2005 and 2010 were negatively affected. At present, the wild boar is the most frequently hunted hoofed game in the Czech Republic. In 2017, a record number of this game was killed, namely 230,035 (an average of 33 ind./1000 ha). This is more than a thousand times higher than the 1950 catch, when 198 pieces (0.03 ind./1000 ha) were hunted in the Czech Republic (fig. 1). Also the spring conditions of pigs counted by hunters growth from 1910 in 1966 to 62,134 in 2016. Turek et al. (2017) suggests that the increase in the number of the wild boar population in the last 20 years is in the Czech republic similar to that in Slovakia (5.2 and 5.3 times respectively).

Figure 1: Hunting bag and spring census of a wild boar in the Czech Republic in the years 1950-2017



In 1997, 43,053 pieces of black game were hunted in the Czech Republic, twenty years later (2017) it was 230,035 pieces, which represents more than five times the increase. In 1997, a maximum of 20 pieces of wild boars per 1000 hectares of hunting area were killed, while in 2017 it was almost 90 units per 1000 ha in some districts (tab. 1 and fig. 2 and 3). Last year, there is a presumption of a reduction in the number of black game due to increased catches and occurrence of African swine fever.

Table 1: Hunting bag of the wild boar in 1997 and 2017 in the Czech Republic by individual districts.

	1997	2017
hunting bag ind./1000 ha	**number of districts**	**number of districts**
0-1	3	0
1-4	22	0
5-6	21	0
7-10	23	1
11-20	8	6
21-30	**-**	26
31-40	**-**	23
41-90	-	21

Figure 2: Map of wild boar shot in the Czech Republic by districts in 1997 (hunting on 1000 ha of hunting area)

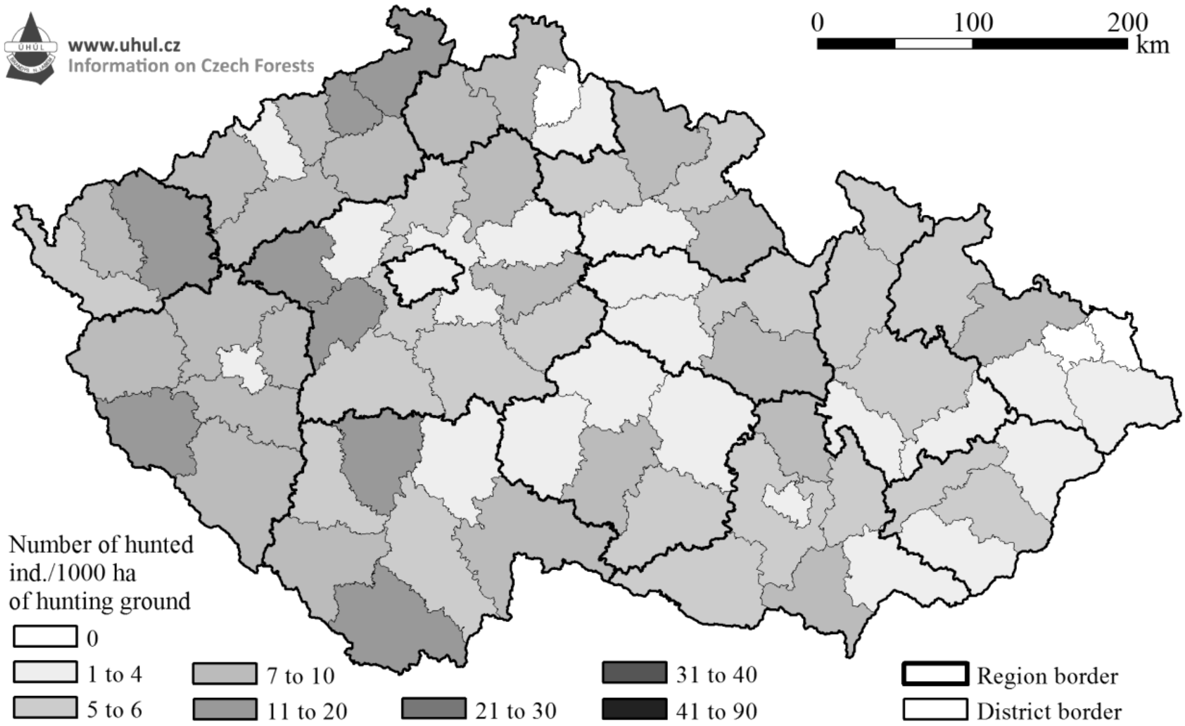
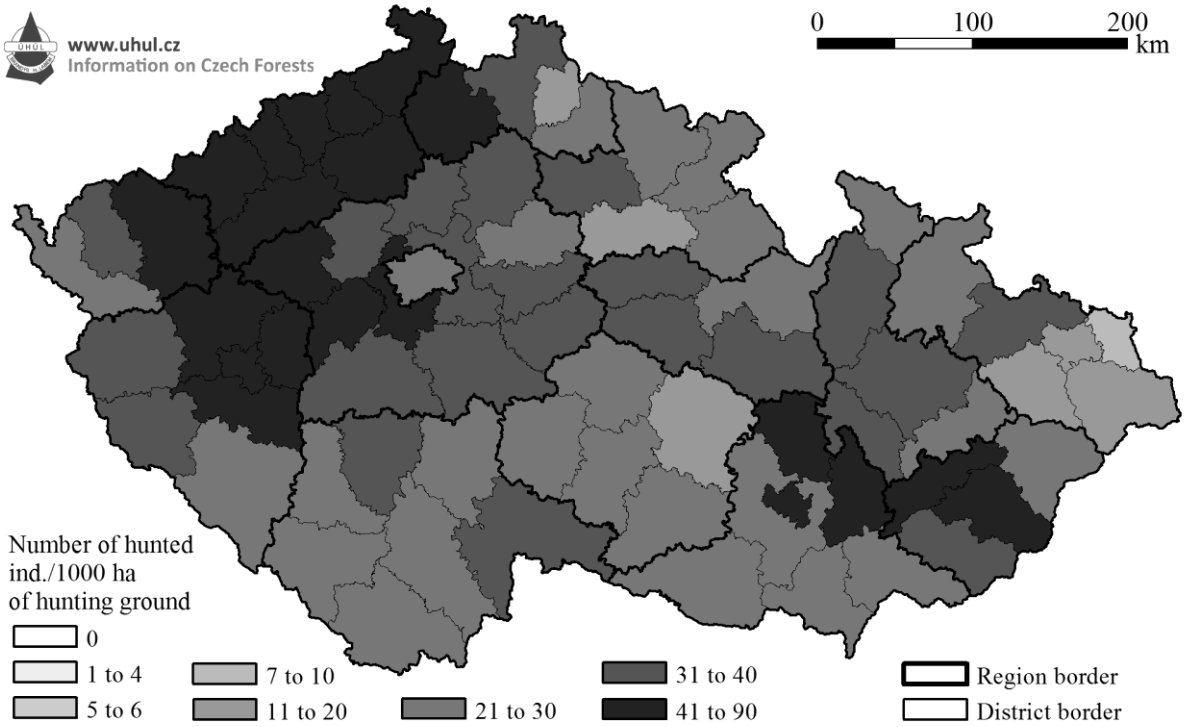


Figure 3: Map of wild boar shot in the Czech Republic by districts in 2017 (hunting on 1000 ha of hunting area)



In 2016, in the Czech Republic, 160,448 wild boars was hunted before the outbreak of African swine fever. Hunting bag culminated in mid-range between 300 and 500 m above sea level, and above 800 m above sea level only a minimum of wild boars was killed. In 2016, a maximum of 842 wild boars were killed in one square KFME, equivalent to 63.2 units per 1000 ha of hunting area. In 2017, even 1150 pieces were killed in one square, equivalent to 86.3 pieces per 1000 ha of hunting area (tab. 2 and fig. 4 and 5). The wild boar catching grew between 2016 and 2017, when African swine fever occurred in the Czech Republic by 43%. The increase is evident especially in the southeast of the Czech Republic in the Zlín region.

Table 2: Hunting bag of wild boar in the Czech Republic in 2016 and 2017 in the mapping quadrants of the KFME Network of Biological Mapping (before and after the outbreak of African swine fever)

	2016		2017	
hunting bag ind./quadrant	**number of quadrants**	**hunting ind./1000 ha**	**number of quadrants**	**hunting ind /1000 ha**
1-180	258	7.3	151	8.1
181-320	177	18.7	181	15.8
321-500	123	30.2	172	30.4
501-850	68	44.8	125	47.4
851-1150	-	-	25	73.9
maximum		**63.2**		**86.3**

Figure 4: Map of wild boar hunting in the Czech Republic in map quadrants of the KFME Network of Biological Mapping in 2016 (shot in pieces on a hunting area in a quadrate)

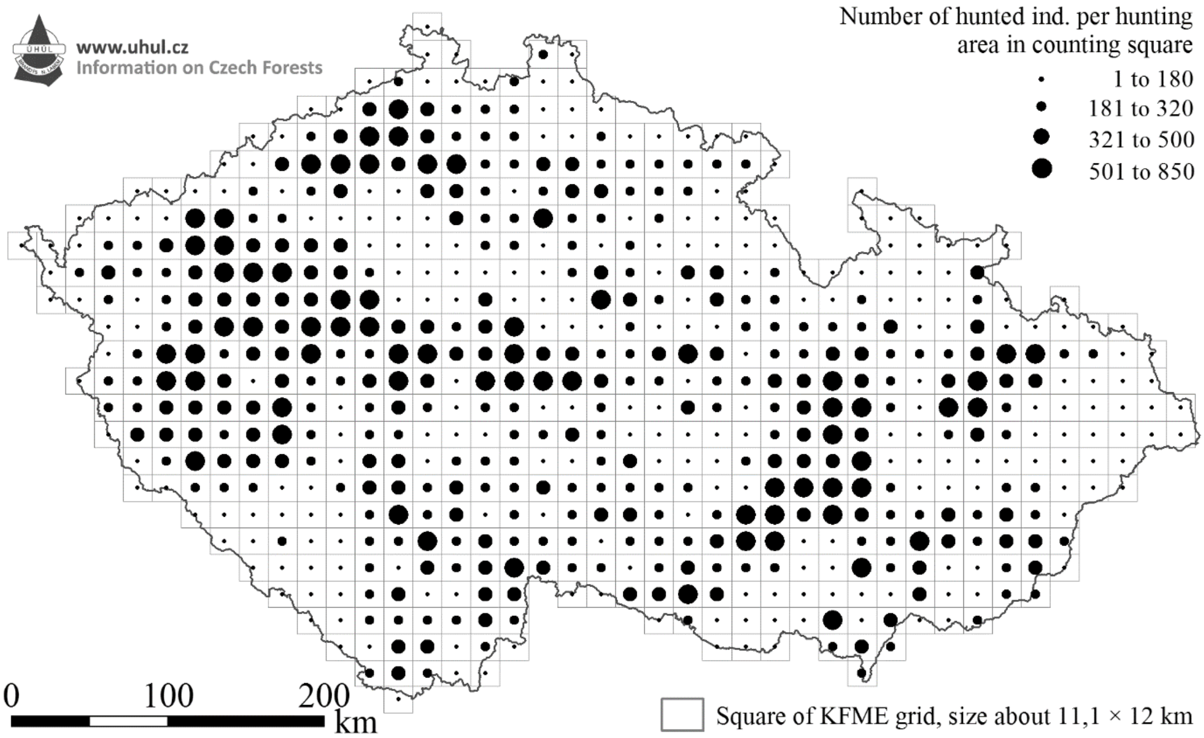
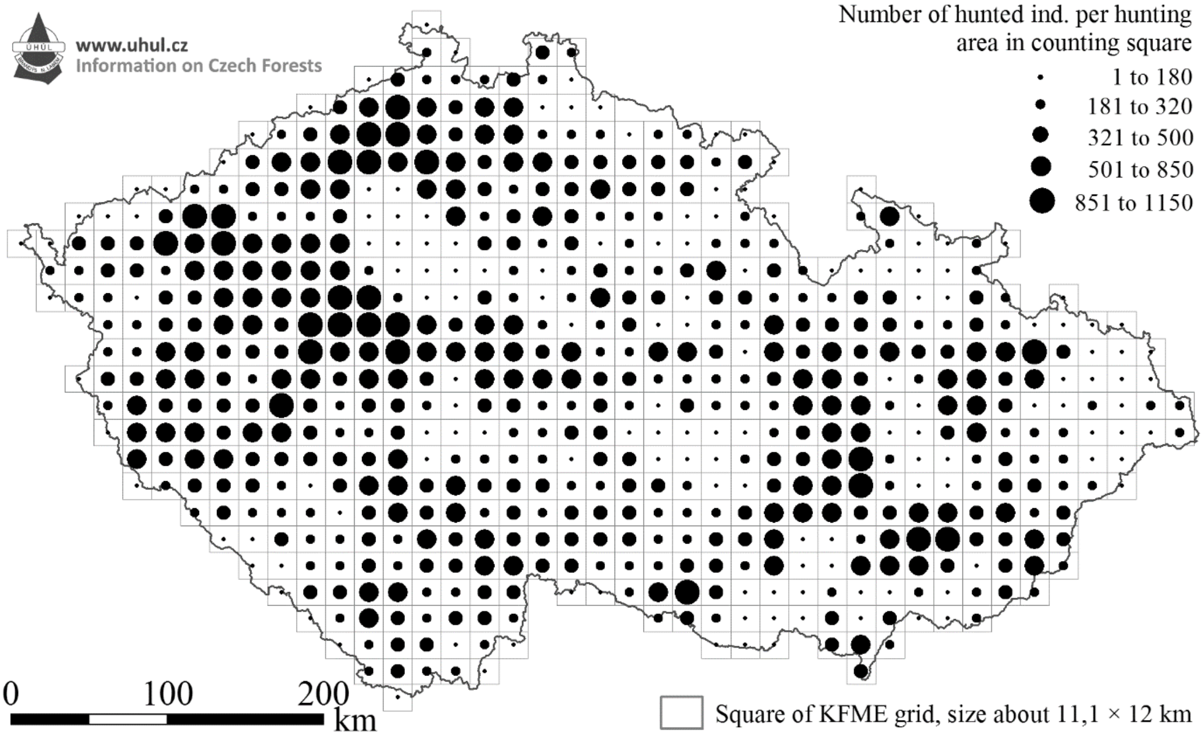


Figure 5: Map of wild boar hunting in the Czech Republic in map quadrants of the KFME Network of Biological Mapping in 2017 (shot in pieces on a hunting area in a quadrate), after the outbreak of African swine fever (ASF)



We considered that the number of wild boar affected small game species (hare, pheasant, rabbit, partridge). In analyzes, therefore, the states and hunting of these game species were compared in individual hunting grounds. The bigger hunting bag of wild boar were in hunting grounds, the smaller the number (or hunting bag) of small game there was found. Statistically significantly more ($p < 0.05$) small game was counted in hunting grounds, where the wild boar were shot down to 20 ind./1000 ha. At the same time, in these hunting grounds, statistically significantly more ($p = 0,00$) small game was hunted than in hunting grounds, where 20 or more pigs per 1000 ha were caught (fig. 6).

Conversely, the level of the hunting of the wild boar did not have a negative effect on the hunting rate of roe deer. The more wild boars were killed, the more roe deer were killed in the hunting ground. In hunting grounds, where up to 20 wild boars per 1000 ha were hunted, significantly fewer ($p < 0.05$) roe deer was hunted than in other hunting grounds (fig. 7). On the contrary, in hunting grounds where more than 80 wild boars per 1000 ha were hunted, significantly more roe deer were hunted ($p < 0.05$). Black game apparently does not make the predatory pressure on roe deer game as expected.

Figure 6: Graph of wild boar and small game hunting bag per 1000 ha

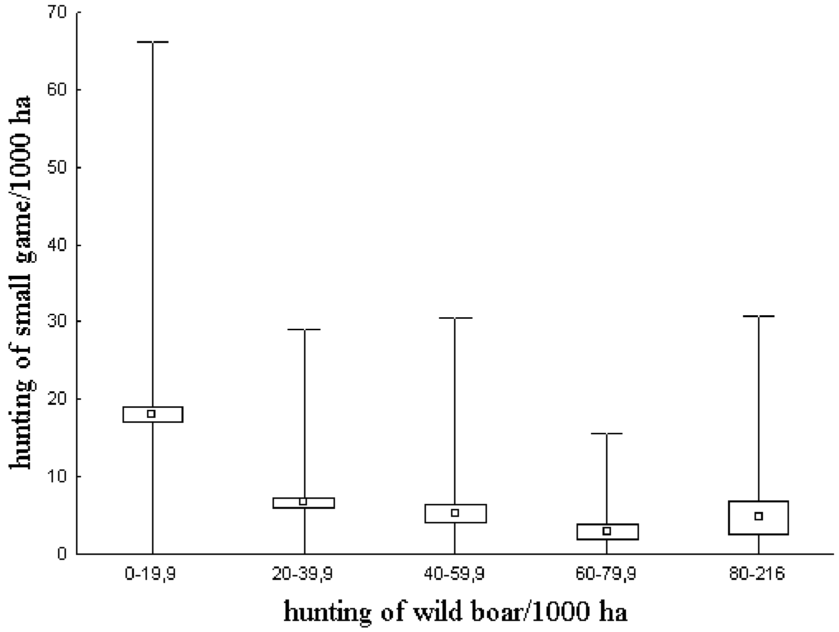
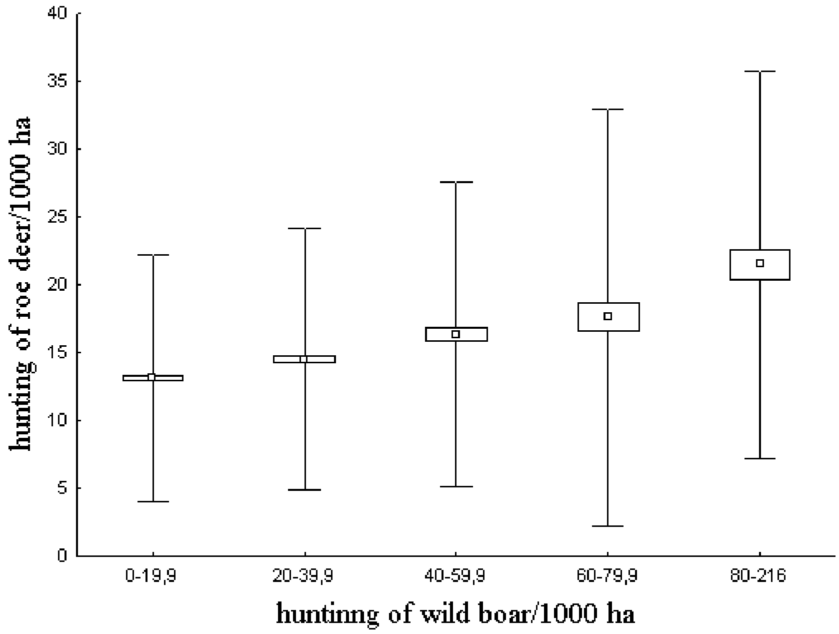
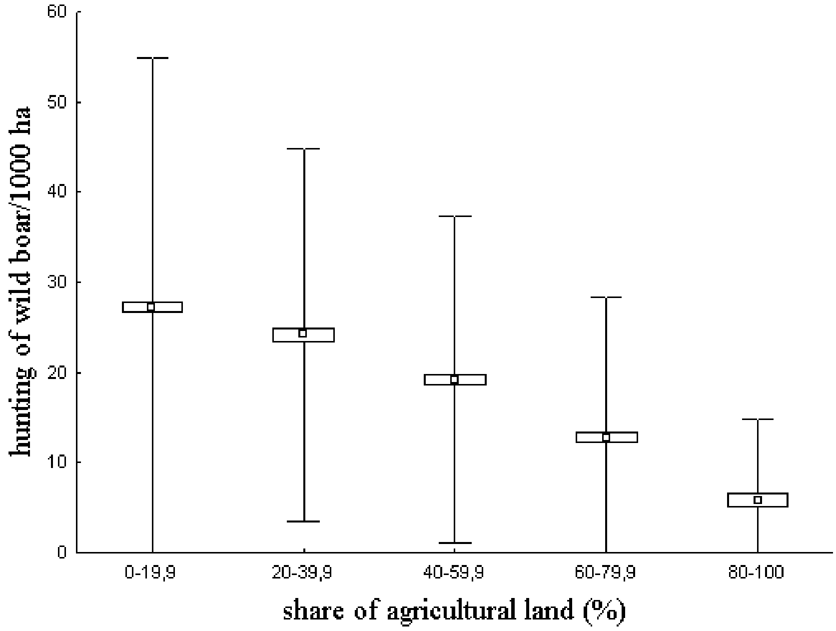


Figure 7: Graph of wild boar and roe deer hunting bag per 1000 ha



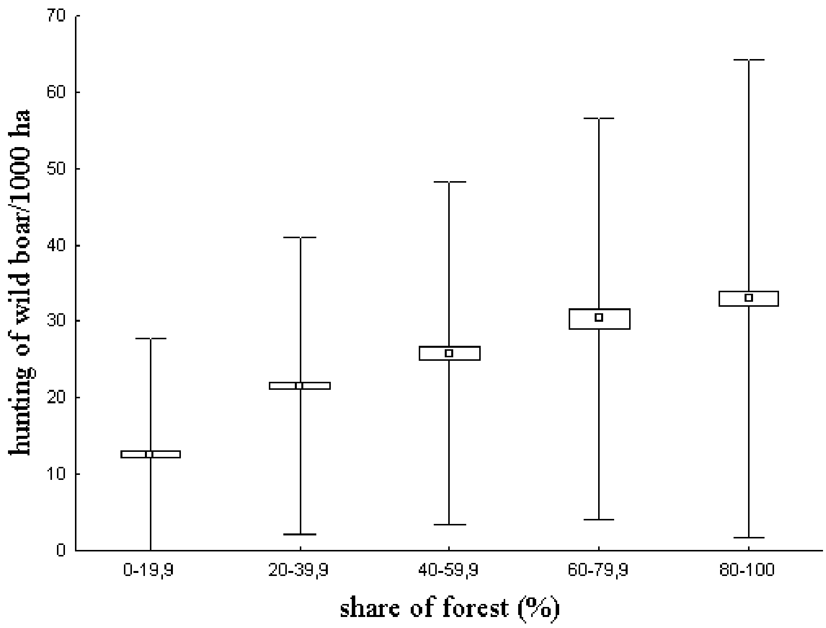
It has been assumed that the number of wild boars also affects the environment in which they live. For this reason, the agricultural and forest land analysis was carried out in individual hunting grounds and their representation was compared to the amount of hunted wild boars. It was found that in hunting grounds with a proportion of farmed land up to 40% there were hunted significantly more ($p < 0.05$) wild boars than in hunting grounds with a larger proportion of farmland (fig. 8).

Figure 8: Graph of wild boars hunting per 1000 ha and representation of farmland cultivated land in hunting grounds (%)



And in the hunting grounds with forest representation up to 40%, significantly fewer ($p < 0.05$) wild boars were hunted, than in hunting grounds with a larger proportion of the forest (fig. 9). The greater the proportion of the forest was in hunting ground, the more wild boars were hunted in it. It seems that the share of the forest in hunting grounds has a considerable influence on the number of wild boars. It seems that the optimal environment for pigs is found in hunting grounds with a maximum of 40 percent of the fields and a maximum of 40 percent of the forest.

Figure 9: Graph of wild boars hunting per 1000 ha and forest representation in hunting grounds (%)



In general, it was assumed that a large proportion of fields in hunting grounds where pigs can reproduce peacefully, was considered to be essential for the growth of the wild boar population (Vodňanský et al, 2003). It is therefore possible that a stronger influence on the numbers of wild game populations has feed and the intensity of its hunting, rather than the representation of farm land in hunting grounds. Agricultural crops provide to wild boars food for only 2 to 4 months a year and cover only slightly longer. For the rest of the year, wild boar is hiding in the woods, where they also find food that hunters present to a large extent.

4. Conclusion

In the Czech Republic wild boar population began growth in the 1980s. In 2017, a record number of this game was hunted, namely 230,035 individuals. An average 33, and in some areas up to 86 ind./1000 ha were hunted. The increase in the hunting of wild boars is more than a thousand times higher in the Czech Republic since the end of World War II.

The number of wild boars significantly affects small game species in the Czech Republic. The bigger hunting of wild boar were in hunting grounds, the smaller the number (or hunting) of small game there was found. Significantly more small game was counted in hunting grounds, where the wild boar were shot down to 20 ind./1000. Conversely, the level of the hunt of the wild boar did not have a negative effect on the hunt rate of roe deer. The more wild boars were hunted, the more roe deer were hunted in the hunting ground. Black game apparently does not make the predatory pressure on roe deer game as expected.

When we analyzed the impact of the environment on the level of the wild boar hunting, it was found that in hunting grounds with a proportion of farmed land up to 40% there were hunted more wild boars than in hunting grounds with a larger proportion of farmland. And in the hunting grounds with forest representation up to 40%, fewer wild boars were hunted, than in hunting grounds with a larger proportion of the forest. The greater the proportion of the forest was in hunting ground, the more wild boars were hunted in it.

Acknowledgements

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THE OCCURRENCE OF LUNG WORMS (METASTRONGYLUS SP.) IN A WILD BOAR (SUS SCROFA) POPULATIONS IN THE CZECH REPUBLIC

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Abstract
The wild boar has become the most important species of wild animal in the Czech Republic. Its importance grows also in terms of intensive research into its health condition. This study analyses the occurrence of lung worm in selected wild boar populations in the Czech Republic. This parasitic disease is caused by the presence of adult individuals of Metastrongylus sp. in lungs of wild boars.
Samples were collected during the collective wild boar hunting events (driven hunts) within 13 localities in two consecutive hunting seasons 2016 and 2017. At each site, samples were taken from 7 wild boars. From each individual, a lung sample and a dung sample were taken. In addition to sampling, the sex was determined for all sampled boars and morphometric measurements of the basic body dimensions, weighing and age estimation were performed according to denture development. In lung samples, the number of adult worms was determined by helminthological autopsy. Dung samples were evaluated by the McMaster method for the presence eggs and oocyst of lung worms - eggs/oocyst per gram (EPG/OPG). The observed numbers of lung worms and EPG/OPG within each wild boar were compared to each other. In addition, an analysis of the intensity of infection of wild boars, depending on their age and weight was also performed.
By helminthological autopsy, the presence of lung worms was detected in 94% of all lung samples. Using McMaster's method, eggs/oocyst were detected in 75% of dung samples. The correlation between the number of adult individuals of lung worms and number of EPG/OPG was analysed by Pearson´s correlation coefficient r=0.58. In the case of yearlings (12-24 months), the number of worms within males was up to twice as high as in females. Most lung worms were found in males at the age of 15 months and in females at 14 months of age. In the case of EPG/OPG, the highest numbers were recorded in males aged 5-7 months and in females at 25 months of age. Regardless of gender, the most lung worms were found in 81-90 kg individuals, but the highest number of EPG/OPG was found in pigs weighing 51-60 kg.
In general, this research has shown a high prevalence of lung worms in wild boar populations in the Czech Republic. Also, the intensity of infection of some wild boar individuals is considerable and can affect their overall condition, especially among younger individuals. The deaths of wild boars caused by lung worms are not yet recorded in the Czech Republic.

Keywords: *bronchus, density, earthworm, parasite*

1. Introduction

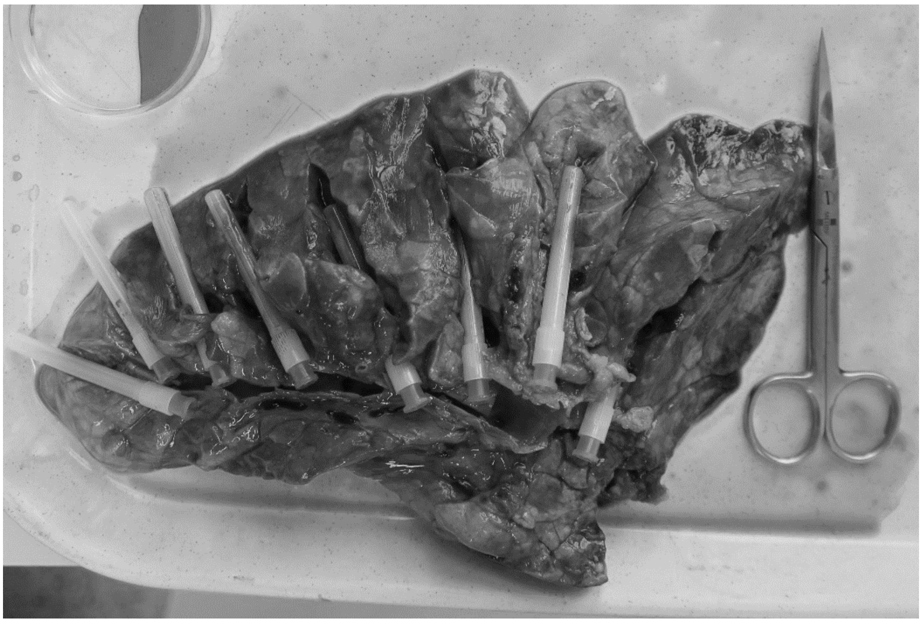
The wild boar has become the most important species of wild animal in the Czech Republic. The presence of this species in the environment significantly reduces the economic performance of agricultural holdings, limits the natural restoration of forest ecosystems, damages valuable ecosystems and populations of protected animals and also causes farm animal health risks. The wild boar is therefore intensively monitored, solved in the media, and is an object of many research teams interest. Its importance grows also in terms of intensive research into its health condition. This study analyses the occurrence of lung worm in selected wild boar populations in the Czech Republic. This parasitic disease is caused by the presence of adult individuals of *Metastrongylus* sp. in lungs of wild boars. The following species of lung worm were described in the Czech Republic (according to Chroust, 2001): *Metastrongylus apri*, *M. pudendotectus* and *M. salmi*. In Austria and the Netherlands has also been described kind *M. confusus*. Therefore, its unconfirmed presence in wild boar in the Czech Republic can be predicted. At present, the conditions in farmed domestic swine are very good, so the incidence of metastrongylosis is very rare. Lung worms are likely to occur in all countries where are pigs/boars and where lives intermediate host, an earthworm. The lifecycle of *Metastrongylus* sp. is indirect. Adult worms live in the lungs of pigs produce eggs. These are expectorated and swallowed, and subsequently release into the environment in the faeces. The eggs are then eaten by earthworms. The cycle ends with the consumption of earthworms by a pig/boar. Larvae from earthworms penetrate into the intestine and travel through the lymph nodes or blood vessels into the lungs.

2. Data and Methods

Samples were collected during the collective wild boar hunting events (driven hunts) within 13 localities in two consecutive hunting seasons 2016 and 2017. At each site, samples were taken from 7 wild boars. From each individual, a lung sample and a dung sample were taken. In addition to sampling, the sex was determined for all sampled boars and morphometric measurements of the basic body dimensions, weighing and age estimation were performed according to denture development and abrasion. In lung samples, the number of adult worms was determined by abbreviated helminthological autopsy. Abbreviated helminthological autopsy included the presence of adult worms only in the right pulmonary lobe. A cut was led through the main bronchus and then into the 8 lateral bronchi (fig. 1). Then the absolute number of worms found in the bronchi and the bronchioles was determined. The species of *Metastrongylus* sp., sexual maturity, dimensions, etc. were not evaluated.

Dung samples were evaluated by the McMaster's method (Wood et al., 1995) for the presence eggs and oocyst of lung worms - eggs/oocyst per gram (EPG/OPG). The observed numbers of lung worms and EPG/OPG within each wild boar were compared to each other. In addition, an analysis of the intensity of infection of wild boars, depending on their age and weight was also performed.

Figure 1: Labelling of the sites in the pulmonary lobe from which the lung worms were taken and counting (the needles point to the sites of the lateral incisions into the bronchioles)

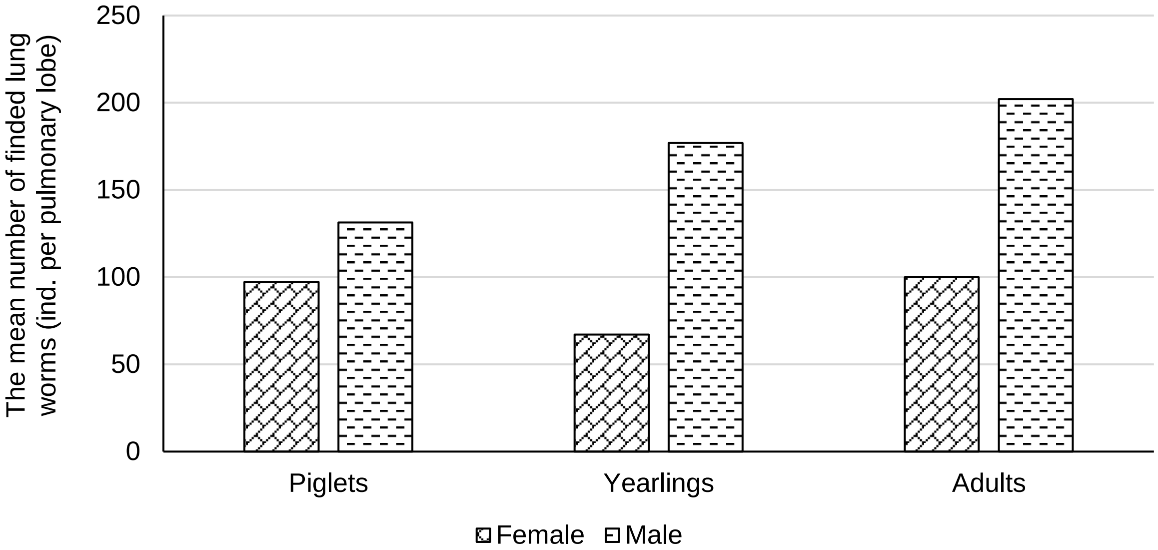


3. Results and Discussion

By helminthological autopsy, the presence of lung worms was detected in 94% of all lung samples. This corresponds to the high prevalence found by Humbert and Henry (1989); Barutzki, Schoierer and Gothe (1991); Järvis, Kapel, Moks, Talvik and Mägi (2007). Prevalence in wild boars from free hunting grounds was 96% and in the fenced hunting pressures was 100%. From 13 studied localities was not any place with 100% healthy wild boars. Using McMaster's method, eggs/oocyst were detected in 75% of dung samples. The correlation between the number of adult individuals of lung worms and number of EPG/OPG was analysed by Pearson´s correlation coefficient r=0.58. In the case of yearlings (12-24 months), the number of worms within males was up to twice as high as in females. Most lung worms were found in males at the age of 15 months and in females at 14 months of age. In the case of EPG/OPG, the highest numbers were recorded in males aged 5-7 months and in females at 25 months of age. Regardless of gender, the most lung worms were found in 81-90 kg individuals, but the highest number of EPG/OPG was found in pigs weighing 51-60 kg.

In all age classes, infection was higher in males than in females (fig. 2), which is not in accordance with García-González et al. (2013). It is also worth mentioning the fact that wild boars in free-range hunts showed almost twice the number of worms recorded (mean was appropriate 56 lung worms per pulmonary lobe) than in the fenced hunting preserves (mean was appropriate 123 lung worms per pulmonary lobe). This may be due to the application of medicated feeding stuffs in hunting preserves. And conversely, the treatment of wild boar in free hunting grounds is very sporadic. In addition, in some free hunting grounds, the number of boars may be higher than in the hunting preserves, which may have serious consequences for the health and condition of the wild boars. Nágy, Csivincsik and Sugár (2015) suggest that high wild boar density and supplementary feeding in enclosures increase both the abundance and the larval *Metastrongylus* infections of earthworms. Chroust and Forejtek (2010) suggest that metastrongylosis in piglets may cause secondary bacterial or viral infections. These can lead to the death of piglets. Infected piglets lose weight and lagging in growth. In adults, metastrongylosis does not cause serious medical complications, except for the susceptibility of the damaged lung tissue to secondary infections.

Figure 2: The average number of lung worms by sex and age classes of wild boar



4. Conclusion

This research has shown a high prevalence of lung worms in wild boar populations in the Czech Republic. Also, the intensity of infection of some wild boar individuals is considerable and can affect their overall condition, especially among younger individuals. The deaths of wild boars caused by lung worms are not yet recorded in the Czech Republic.

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WILD BOAR DISTRIBUTION AND HABITAT PREFERENCE IN LITHUANIA

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Abstract
In Lithuania, the wild boar attributed to problematic species because of damage caused to agriculture and forestry and due to overabundant population that becomes a source of contagious diseases. In the critical situation, we have to decide whether a population should be exterminated (actually impossible) or manage it. Under an insufficient control, the population increases further while it stimulates a self-control and spread of diseases. Population control is the feedback strategy under the danger of AFS outbreak determining potential role of species in disease transmission and its repression. Decisions of control measures are impossible without knowledge of animal distribution depending on local natural and anthropogenic conditions. The population size and harvesting in the different climatic sub-districts, continentality and habitat suitability were ascertained by long-term surveys. The wild boar herd indices were determined by the long-term annual mean increment considering offspring susceptibility to diseases and mortality, age-dependent differences in reproduction and long-term survey. Forests were distributed into categories in line with their parameters and suitability for the wild boar: pure pine (A – maritime, B – Southern zones), pine-spruce (C – Eastern and D – Central zones), mixed spruce-deciduous, and deciduous with spruce forests (F – Northern zone). The territorial suitability expressed in points was: 1 – pure pine, 2 – pine-spruce, 3 – mixed spruce-deciduous, and 4 – deciduous with spruce forests. The long-term annual increment of the population was 60% (2-3 in B, 3-4 in A, 3-4 in C, 4-5 in D and 5 in the deciduous with spruce forests while 4-5 in F). In B (continental dunes, prevailed arenosols, podzols), the clumped distribution prevails (δ=6.8). Dependence on the soil fertility decreased (r=0.47) in comparison with the dependence on the long-term data of soil fertility (r=0.73). In C and D (more podzols, less poor forest sites, soil fertility is 2.1-2.9), the wild boar distributed more randomly (δ=3.4) as in the mixed spruce-deciduous forests (soil fertility, r=0.37, t=1.86). The regional differences withered due to human activities but are still positive. To control population, this parameter needs to be considered. Despite population decline, due to implementing ASF measures, the most abundant local populations are still in the deciduous forests with spruce and mixed spruce-deciduous forests, where natural and anthropogenic conditions are most suitable.

Keywords: *distribution, forest, habitat, Lithuania, wild boar*

1. Introduction

The control of renewable natural resources including the wild boar (*Sus scrofa* L.) promotes the restoration of ecosystems. Simultaneously, a high adaptability of the wild boar allows further increase in number under conditions of the intensification of forest management and agriculture. Wild boar abundance exceeds permissible levels, and the damage to agriculture and forestry caused by the wild boar and spread of contagious diseases becomes a challenge not only at the national but already at the international levels. Unfortunately, humans themselves have established favourable conditions for the above-mentioned situation. They enhance habitat conditions (e.g. agricultural land mosaic provides food and shelter; increase in area under oak stands, etc.). However, simultaneously, wild boar hunting is non-intensive. Moreover, the natural regulation of overabundant population by large carnivores is doubtful because of their scarce number. The supplemental feeding being a common management practice during decades. Foods from the supplemental feeding are found in 70% of wild boar stomachs and comprise even 40% of the total stomach contents (Andrzejewski & Jezierski, 1978; Briedermann, 1986; Schley & Roper, 2003; Biebier & Ruf, 2005; Cellina, 2008). The annual increment of population was strongly related to the supplemental feeding (Janulaitis & Padaiga, 1983a). Despite supplemental feeding aimed to help animals during severe winters, to bait them and keep away agricultural crops, because of their behavioural plasticity wild boars have not only adapted to such feeding but still visited and damaged crops (Belova, 2001; Bieber & Ruf, 2005; Belova, 2015). It had violated territorial behaviour, disordered trophic relations and caused clumped distribution of animals, their physiological adaptation and increase in population abundance. Moreover, such localities attributable to the greater risk of spread of infection in short time (Aliešiūnienė, 2010; Lange, 2012, 2015; EFSA, 2014, 2015, 2018; Risco et al., 2014; Sorensen, van Beest & Brook, 2014; Ozols, 2015, Jokelainen, Velström & Lassen, 2015; Śmietanka et al., 2016; Oja, Velström, Moks, Jokelainen & Lassen, 2017). Unsatisfied needs (Maslow, 1943, 1954) of animals disturb adaptation to changeable environmental conditions. Consequently, distribution, moving, grouping and abundance of wild boar, primarily, depend on the key drivers as sufficient food supply, safety and assurance of reproduction. Once again, it should be emphasized that, despite of omnivorousness, wild boar diet predominantly consists of vegetative food, and more food they find in the deciduous and mixed forest then in the coniferous ones (Grodziński, Maycock & Weiner, 1984; Padaiga, 1996; Fonseca, 2008; Belova, 2015, 2018). In the mixed landscape, where middle-sized and small forests and agricultural lands coexist in a mosaic pattern (e.g. Lithuania), most attractive food for wild boars are wheat, oat mixtures, potatoes, maize, rye and faintly beetroots (up to 1.2%) (Janulaitis, 1983; Janulaitis & Padaiga, 1983, 1987; Baubet, Bonenfant & Brandt, 2004). However, wild boars cause marked damage to agriculture, which is worth of hundreds of thousands of Euros. Conflicts among landowners, hunters and other concerned groups regarding wild boar have increased, respectively. Although wild boar is inseparable from forests, their effect on forests is not so significant, and rooted area comprises only 0.9-2.9% regardless of very high density of wild boar (e.g. 15-82/1 000 ha) (Janulaitis & Padaiga, 1983b). However, due to abundant population and preference to gather in forests, wild boars can negatively affect forest litter (losses reach 80-95%). Moreover, rare plant species are vanishing and damage to tree roots cause slope erosion (Bratton, 1974; Howe, Singer & Ackerman, 1981). In hot summer, the rooting is impeded by droughts (Cahill, Llimona & Gràcia, 2003) but increases during warm winters, autumn and spring (Cahill et al., 2003; Łabudzki, Górecki, Skubis & Wlazełko, 2009). It shows that we have to consider weather conditions. Wild boar distribution differs from one of other ungulates as they usually leave home range even before depletion of food supply when animals are still in good condition and mortality is low (Saez-Royuela & Telleria, 1986). As young males leave their maternal family group (sounder) at the age of 18-months, they become “innovators occupying new territories” (Erkinaro, Heikura, Lindgren, Pulliainen & Sulkava, 1982; Spitz, 1992; Belova, 2001). Typically, wild boars migrate within their territory seasonally, depending on availability of food. In the areas of scarce forest cover, wild boar sounders more distribute then animals in the more forested areas despite their density is larger (Cargnelutti, Spitz & Valet, 1992; Belova, 2001). Although animal distribution correlated with their density negatively (Janeau & Spitz, 1990, Truvé et al., 2004), the density does not affect the distances of spread (Truvé, Lemel &

Söderberg, 2004). Moreover, in the territories of less abundance and density of wild boar, their social groups are unstable and more isolated (Spitz, 1992; Belova, 2001, 2008). Previously, wild boar density has not related to the annual increment of the population in Lithuania (Janulaitis & Padaiga, 1983a) despite of the higher density in the mixed spruce-deciduous forests and low density in the pure pine forests. As far back as 1983, in Lithuania, the density norms were approved depending on the forest categories and damage level caused by wild boars. Preceding information shows the importance to consider the density of the wild boar. In the context of recent ASF spread, it is necessary to recognize the habitat preferences and distribution of wild boar. Outputs of this study would be helpful tool to develop models and implement preventive measures for effective management of wild boar population. In this study, we have investigated the distribution of wild boar depending on the habitat suitability in the different natural regions and changes in wild boar abundance.

2. Data and Methods

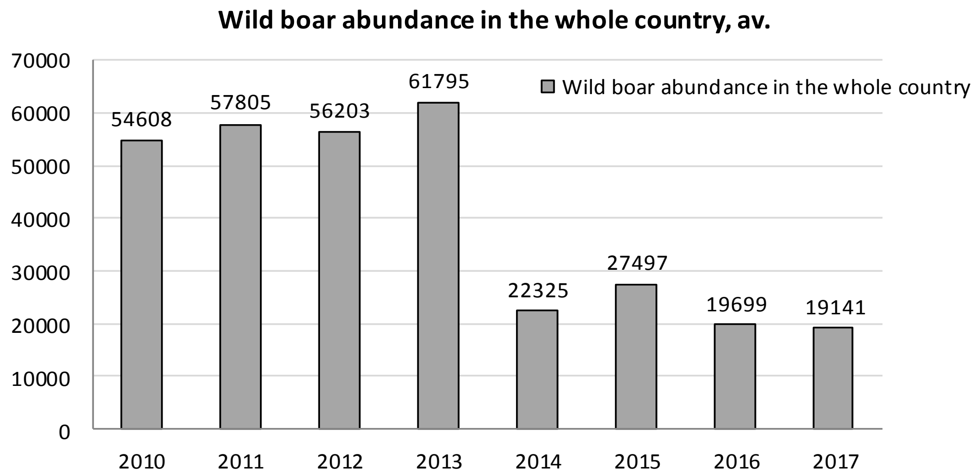
The study was conducted in 2010-2017 in the different natural regions, including the model territory of the total area of 5,646 ha in the northwestern part of Lithuania. We have used an integrated method to assess distribution and habitat preferences of the wild boar on the model area. The method combines the direct observations at the baiting points, during hunting and an indirect method by snow-track survey and dung count within belt transects. Additionally, long-term data on wild boar abundance and harvesting were collected using official statistics obtained from hunting ground units on entire area of the country. All the area was specified by abiotic and biotic factors determining the main key factors for each area depending on the predominant stands and climatic sub-region (after K. Kaušyla – Bukantis, 1994; Belova, 1996, 1999, 2012) and their suitability for animals. Meteorological and forest inventory data have been collected from the local stations and the State Forest Service considering the delineation of the whole territory of Lithuania for game animals (Belova, 1999). The key climatic factors, which most effect animals, were determined as the snow cover (duration of the period with snow cover, the depth, structure, number of thaws, number of winters without snow cover), air temperature in the growing and cold periods, wind speed during the cold period, soil freeze depth, precipitation amount, weather severity $S_a = (1 - 0.004 \times t\ °C) \times (*1 + 0,272)$ (Bodman formula by Vize 1940) and rain factor $L_f = \sum mm/\ t\ °C$ (Puppe, 1966). We considered the climatic region and continentality of the territory. The conformity of weather conditions with needs of animals is one of the main indicators of the territory suitability. Considering the delineation of territory for game animals (Belova, 1996), forests were divided into four categories as follows: pure pine forests (here, GP, A – maritime zone, and B – Southern Lithuania), pine-spruce forests (here, PE, C – Eastern Lithuania, D – Central Lithuania), mixed spruce-deciduous forests (EL) and deciduous forests with spruce (LE). The important parameter of the territory suitability is a character of animal distribution expressed as distribution $\delta^2/I_i \gtrless 1$, where δ is the dispersion and I is the intensity of territory use (Belova, 1996, 2001, 2015). Data collected from field works and official statistics sets were stored in the database. Analyses were performed using the *Statistica 8* package.

3. Results

The distribution and abundance of wild boar did not vary significantly in the different natural regions until 2014. The long-term changes in wild boar abundance within the whole country are presented in the fig. 1.

There, further decrease in number directly related to the first detection of African swine fewer (ASF) in wild boar and, correspondingly, implementation of the preventive measures in Lithuania. The contagious diseases spread in the abundant populations, where the contacts among the different herds and moving through the territory are unavoidable despite wild boar territoriality. However, on areas, where wild boar is not abundant and food supply is scanty, animals move and group in the habitat with suitable feeding conditions. It is evident in the pure pine forests of Southern Lithuania (fig. 2).

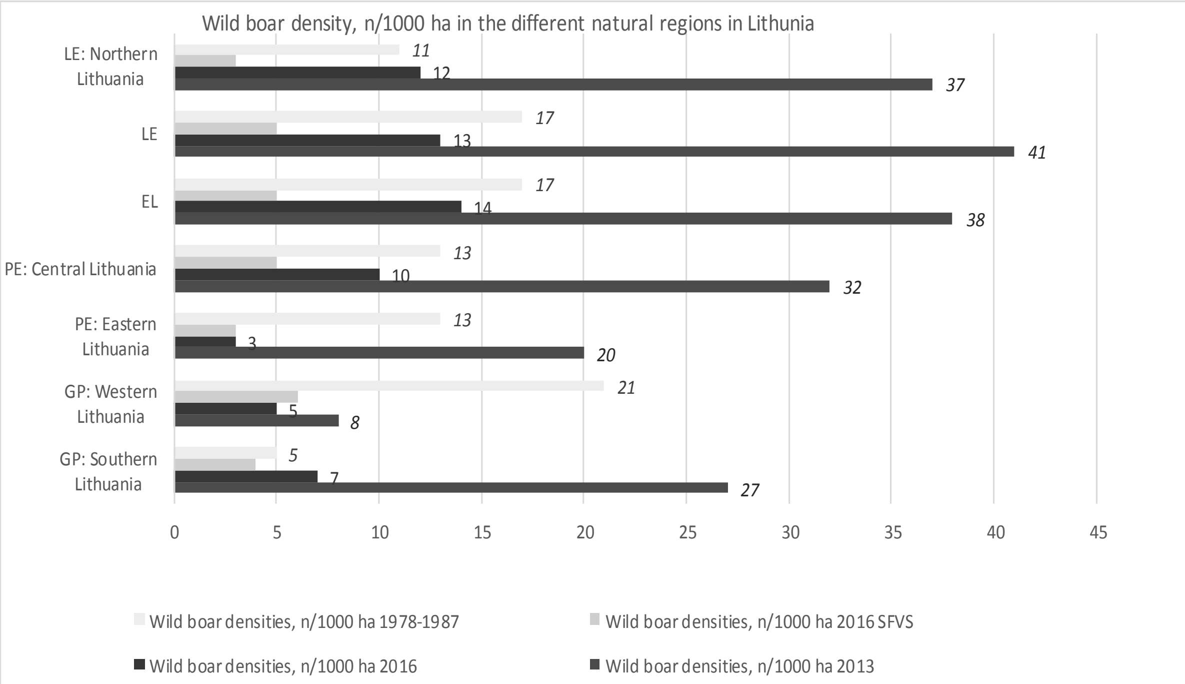
Figure 1: Changes in wild boar abundance in Lithuania



Although the long-term density of the wild boar was low in the Southern pure pine forests in comparison with corresponding forests in Western Lithuania, ASF was detected namely on this area, close to the border with Belarus (i.e. in 2013 ASF outbreaks were detected in Grodno region, Belarus, at a distance of 40 km from the Lithuanian-Belarus border). Simultaneously, since 2014, wild boar hunting is premised all year round. Further changes in wild boar abundance related to the hunting.

Wild boars most prefer habitats of deciduous with spruce and mixed spruce-deciduous forests, where not only natural (biotic and abiotic) conditions but also human activities (e.g. supplemental feeding, comparatively non-intensive hunting despite mentioned changes in Hunting Regulation) were suitable for animals. In Northern Lithuania, the wild boar is less abundant in comparison with other natural regions.

Figure 2: Long-term changes in the wild boar densities in the different natural regions of Lithuania



Note: LE – deciduous forests with spruce admixture, EL – mixed spruce-deciduous forests, PE – mixed coniferous (pine with spruce) forests, GP – pure pine forests; SFVS – State Food and Veterinary Service data

Climatic factors are considered as limiting factors essential for wildlife. In Lithuania, eucontinental climate prevails. According to the Köppen climate classification, Lithuania belongs to the Dfb zone of mid-continental/humid continental climate. It is maritime to the west and gradually shifts over to continental towards the east and less to the south-eastern and southern areas. The Baltic Sea territory belongs to the southern Baltic sub-region of the lowest continentality. The characteristic continentality index is more than 75-87% (Gorczynski index, while Conrad continentality index is 28-46) in the south-eastern plain of the pure pine forests, while only 50% in the littoral pure pine forests. Such situation caused wider fluctuations in annual and daily temperatures, colder winters, and more stable snow cover for longer period and drier air. However, the continentality decreases recently, and until the mid-century, climate warming is expected for 1.5-1.7 °C (Bukantis, 2001; Galvonaitė, 2007; Belova, 2008, 2013). Winter are changeable including frequent thaws, whirlwinds, cloudiness, sleets, glazed frosts and freezing rains increase in number and frequency during the last decade, while the number of rainfalls increases in the intertidal zone. The average temperature ranges from -3 °C in the West to -6 °C in the East during the non-growing period. Springs becomes also changeable with snowfalls in March and sudden frost or sleets in May; however, recently, cold and warm and rainy stages fluctuated more frequently. This situation is unsuitable for wild boar offspring, their susceptibility to parasitic diseases increases and population increment decreases. Summer is moderately warm while the heat number increases and fluctuates with cool and rainy weather. Autumn is often cool, windy and rainy, especially in the western zone. Previously, winters were cold (sometimes due to moving of cold air masses from the East, temperatures reached -34 °C in the western pure pine forests and -43 °C in the eastern ones, e.g. in January 1941–1942, 1949-1951, 1955–1956 and 1984–1985,). The duration of the cold (non-growing) period decreased from the characteristic 149-

150-day period until the 46-80-day period today with some fluctuations till 150 days (Belova, 2008, 2013). In the areas under pure pine forests of Southern Lithuania (GP, B), the forest cover is one of the largest, 69.3-79.7%, while open area comprises only 0.9%-2.8%. Snow cover on average is 25 cm and persists for 70-75 days. Relative humidity and weather severity (S_a=1.97-2.1) are low (79.7%) in comparison with maritime zone (S_a= 2.8) (table 1). Wild boar foraging most depends on the soil frost depth (55-120 cm). However, despite such less suitable conditions, the wild boar local population was numerous until 2014 (e.g. Varėna forest enterprise territory). Wild boars enable to adapt to the different weather conditions physiologically and changing behaviour (group thermoregulation, locality of dens, baths and shady points in the forest sites of greater canopy closure in summer despite lower temperatures are in the clover and lucerne in the agricultural lands, such cultures are missed here due to poor soils (*Arenosols*). Carrying capacity depends on the great forest cover, stand size (45-108 thousand ha), less fragmentation and scarce food supply while such conditions cause wild boar grouping in the most suitable sites (clumped distribution).

The pure pine forests of western Lithuania (GP, A) belong to the 1a climatic sub-region on the Curonian spit and most affected by maritime climate. The annual precipitation reaches 912 mm and even 75% falls in the warm period. The weather severity, S_a= 2.53, is specific for the littoral zone but the rain factor of 51.8 is the greatest in comparison with other regions. Autumn and winter are warmer than spring with thermal difference of 3-5 °C in comparison with the eastern region. However, climatic parameters and absence of agricultural lands do not disturb wild boars as gradual seasonal and daily changes are suitable for animals (Belova, 1996, 2012, 2013), but scarce food supply cause the lower density 5/1000 ha in comparison with other regions (fig. 3). Snowy stages are not suitable for the wild boar because of poor morphological adaptation to movement in deep snow (the snow depth of 20-30 cm limited movements, 30-40 cm is the critical level, while 20-30 cm is the critical level for juveniles). Animals consume much energy that should be recovered through feeding while it is pressed due to food scarcity and availability. Snow cover, however, often exceed 50 cm during the snowy period and induced animal distribution in the peripheral forest blocks and sites, where snow density is greater than in the open lands. As highly adaptable social animals, wild boars able to survive under above mentioned conditions (use of the tracks, paths of other animals and human, change in habitats, grouping, feeding on carrion, etc.) (Belova, 2001).

Above mentioned factors are important to forecast wild boar abundance and possible infection in the points of gathering or feeding. An increase in number related to human activity is observed, as it is seen from the analysis of census data within the territory of pure pine forests and other regions. Long-term rich supplemental feeding before adopted restrictions since 2014/2015 induced numerous gathering of the different herds in the feeding sites. During the warm period, the temperature regime is more stable than in other regions and suitable for animals excluding weather severity and rain factor.

Figure 3: Wild boar abundance in the different climatic subregions and natural regions of Lithuania

Here: average long-term wild boar abundance, N (observed decrease due to implementation of preventive measures against ASF since 2014)
Natural regions: 1 – Žemaičiai Highland; 2 – North eastern; 3 – Littoral lowland; 4 – Southern Lithuania; Climatic sub-regions: 1a – littoral lowland and seashore (av. long-term snow cover depth is 18-20 cm;
1b – Žemaičiai highland and Venta mid-river upland (av. long-term snow cover depth is 20-22 cm;
2a and 3a – Neman lowland (av. long-term snow cover depth is 16-20cm); 2b – Mūša-Nevėžis (av. long-term snow cover depth is 17-20 cm); 2c – Aukštaičiai (av. long-term snow cover depth is 22-30 cm);
3b – Dzūkai and Sūduva sub-region (av. long-term snow cover depth is 20-25 cm).

The territories of the mixed coniferous (pine and spruce) forests (PE) belong to several natural and climatic regions and sub-regions. The sea influence weakens toward the east and weather is often changeable due to mixed littoral and continental climate, which especially characteristic in the western part of country and less occur in the continental territories. The soil frost depth is greater and the snow cover is more stable than in other regions that disturb feeding during the cold periods. The softer climate and less precipitation is in the littoral zone (mixed climatic sub-region (1a+1b+2b) (e.g. area of Šilutė forest enterprise). For the continental eastern territories (most belonging to 2c climatic sub-region), snowstorms, stable and deeper snow cover and later spring are characteristic while for the north-western Žemaičiai highland, the precipitation is greatest as in 1a sub-region (Kretinga forest enterprise). On the one part, changeability in snow cover and temperature regime mitigate feeding and moving and wild boar distribute more evenly. However, on the other part, animals induced to change habitats and activity. Such situation causes transmission of diseases and weakens immunity. In the territories of 3a sub-region (Šakiai, Kazlų Rūda, Alytus, Dubrava EMMU, less Prienai and Jonava forests), winters are softer and ratio of feeding-refuge sites and carrying capacity are favourable for the wild boar. Such conditions cause greater abundance of wild boar. In the eastern region (Aukštaičiai sub-region 2c), snow conditions are unfavourable for wild boar and cause their gathering in the most suitable sites, The usual snow depth exceed the critical level for young animals (20-30 cm), later frosts, spring snowstorms and weather changeability are the key drivers of their susceptibility to diseases, affect the age structure of the local populations and reproduction. Although wild boars are able to adapt, the risk of susceptibility to diseases still remains. Despite of the global warming, the weather changeability affects animals negatively and suppresses immunity. There is the less share of infertile soils (near 0.8% but more in the eastern Aukštaičiai region, 11 %,) and long-term average soil fertility comprises 2.1 -2.9 points.

The mixed spruce-deciduous forests (EL) and adjacent areas belong~~s~~ to the different natural regions and climatic sub-regions, and habitat suitability for wild boar differs markedly. As Lithuania belongs to the zone of surplus humidity, local animals are able to adapt to higher amount of precipitation. The most abundant precipitation (long-term annual amount is 1,012 mm) and prevailing south-western – western winds are observed in the north-western territories of 1b sub-region. Despite of the moist weather and later spring, the wild boar is abundant even in the northern part of 1b sub-region (wild boar abundance is 1300-1600 until 2014). The soil fertility fluctuated from 2.6 (Telšiai forest enterprise, 56.048386, 21.957166 - 55.730299, 22.482734, WGS) up to 3.7 (Kaunas, 55.013195, 23.88999 - 54.808588, 23.771189), the prevailing soils are ones of the normal moisture and temporarily overmoistured; correspondingly, the local populations of wild boar are numerous (r = 0.73, t =4.25). Severe winter conditions in the eastern part of the EL natural region affect the wild boar; however, the recent weather anomalies although these are short-term, affect the wild boar negatively, caused an increase in energy expenditures for travelling to the feeding or refuge sites. Young animals most suffered (Belova, 2001, 2008).

The most of the deciduous with spruce admixture forests belong to 2b sub-region. Some territories belong to the mixed climatic sub-regions, such as Joniškis (56.28303, 23.463794 - 56.074984, 23.883159), Šiauliai (56.044469, 23.106157 - 55.805919, 23.347978), Kėdainiai (55.47359, 23.845189 - 55.158192, 24.361223), Ukmergė (55.430874, 24.767109 - 55.17404, 25.092373) forest enterprises. The soil is more frozen not only in the northern area (snow frost depth reached 104 cm) but also in the central part of the country (e.g. Kėdainiai, 107 cm). However, snow cover and its stability are not limiting factors for the wild boar. The fertile soils (high fertility indices, 3.5-4.3) provide them favourable feeding conditions.

Table 1: Assessment of the key weather parameters in the different climatic sub-regions in Lithuania

Regions		Littoral			Žemaičiai		Mid-lowland		South-eastern highland		
Sub-regions*		Kuršių Nerija 2a*	Seashore 1a+1b+2b	Littoral lowland 2a + 2b	Žemaičiai highland 1b, 2b+1b	Venta mid-river upland 1b	Mūša-Nevėžis 2b, 2b+2c,3a, b, 1b, 1b+2b	Neman upland 3b, 3a	Sūduva 3b	Dzūkai 3b	Aukštaičiai 2c, 3b+2c, 2b+2c
Temperature °C	av. annual	8.0	7.8	7.4	6.3-6.7	6.8	6.5-7.0	7.1-7.4	7.0	6.8	6,1-6,7
	the warmest month and its av. t °C	July-August 18.4	August 17.8	July 17.8	July 17.0-17.5	July 17.7	July 17.4-18.1	July 18.0-18.1	July 17.9	July 17.9	July 17.7-18.0
	the coldest month and its av. t °C	February -1.5	February -1.4	January -1.9	January-February -3.4 - -2.9	January-February -3.2 - -3.0	January -3.6 - -3.1	January-February -3.6 - -3.1	January -3.4	January -3.7	January -4.8 - -3.8
	Absolute min.	-29.0	-27.8	-32.2	-32.1	-32.0	-33.6	-31.2	-30.5	-35.9	-32.8
	Absolute max.	34.3	33.6	35.8	35.0	35.4	35.7	35.1	34.7	35.6	35.3
Precipitation, annual		770	897	912	1012	670	560-700	600-640	620-630	700	610-690
Snow cover duration, N days		65	85	65	75	60	81,2	65-80	80	90	90-105
Winters with unstable snow cover, %.		50	50	43	27	26	13,3	26,5	14	12	4
Soil frost depth, cm: av.		37	37	37	41	41	44	55	55	54.2	44
max.		70	85	85	80	80	93	101	120	118	94
Weather severity, S_a		2.8	2.7	2.4	2.7	2.5	2.4	2.5	2.2	2.1	2.5
Rain factor, L_f		40.3	45.4	47.4	56.3	40.8	38.7	38.7	37.5	39.3	36.1
Relative humidity, av. %		81.8	83	83	82	82	81.4	81	80.6	79.7	72.4
The key factors caused exceptionality		*Transport of the air masses from the sea towards the continental part of the country; seashore basic circulation; high level of ground waters*			*Abundant precipitation - transport of air masses from the Sea and elevation along the southwestern and western slopes*		*Soil overmoistured, insufficient outflow through the flat surface*		*Influence of land elevation, marked thermal deviation in winter; increase in air mass changes in the hilly localities*		

Source: LHMT DB, 1965-2016) Analysis: Belova, O.

* Number and name of the sub-region: 1a, 1b, 2a, 2b, 2c...3b.

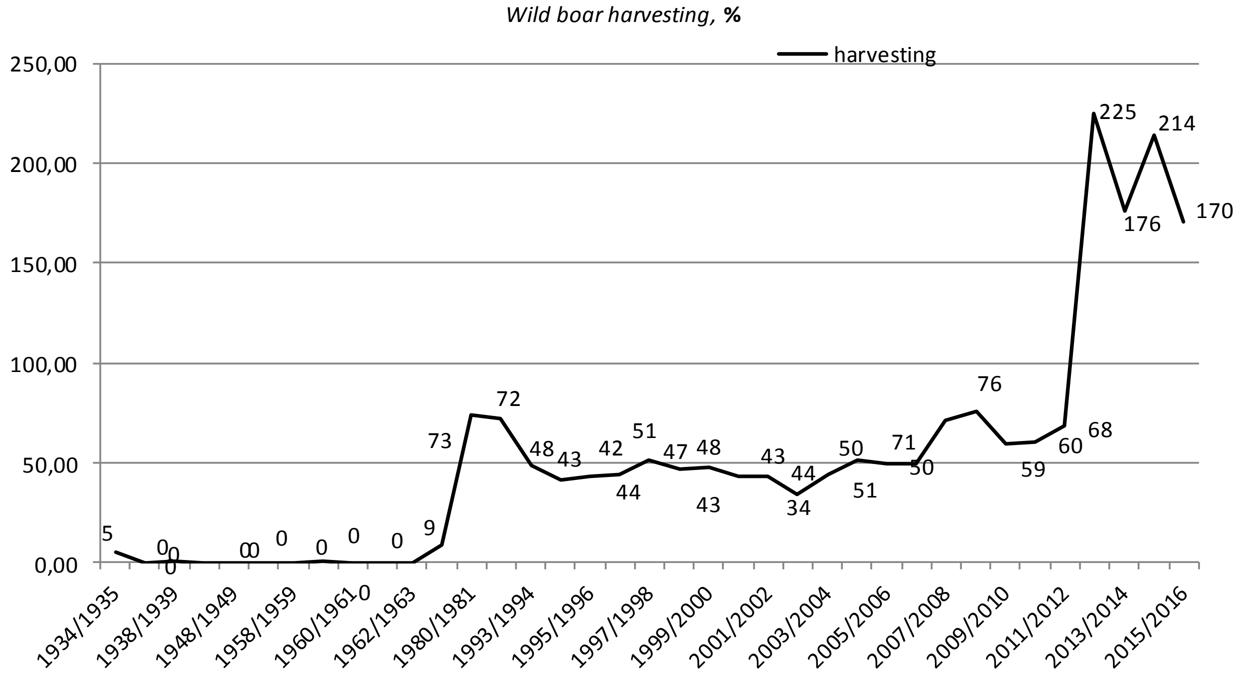
Therefore, according to the natural conditions, wild boars mostly select habitats in the natural region of deciduous forests with spruce admixture in the central part of the country with prevailed fertile soils, and in the mixed spruce-deciduous forests and adjacent lands. There are most abundant local populations of the wild boar; however, the wild boar abundance depends not only on natural conditions but also human activities (previous overabundant supplemental feeding, non-intensive harvesting, suitable ratio of the forest stands and adjacent agricultural lands and forest edges, landscape diversity, etc.). Mentioned conditions induced an increase in wild boar number throughout the country. The changes in wild boar numbers and harvesting intensity in the different regions show the evident flexibility but also due human interference that repealed essential differences through decades.

The effect of changes in wild boar abundance, distribution and harvesting is observed throughout country. For instance, in the area of Mažeikiai forest enterprise (56.391603, 22.033859; 56.296597, 22.431299 WGS), the number of wild boar was 1,300-1,600 before 2014. However, since 2014 until today, it decreased rapidly up to 400 animals (harvesting reached 151-250%). The similar situation was observed in all the regions. In the Eastern territories (Aukštaičiai region, Širvintos 55.095831, 24.628168 - 54.912402, 25.112855, Rokiškis 56.084168, 25.158311 - 55.777301, 25.69117 forest enterprises), the wild boar abundance and harvesting are less in comparison with other territories: 60-80% were harvested until 2014, and 102-179% since 2014 (fig. 4).

The first detection of ASF was more related to boar moving during the rutting season and herd gathering in the sites of favourable feeding in Southern Lithuania, GP region, 3b climatic sub-region, continental dunes, least favourable soils (1 point) *Arenosols* and some area of *Podzols*; wild boar distribution: clumped, δ= 6.8). The movement of animals from the neighbouring country along the ecological corridors was detected (Belova, 2013a, b). The herd index was 2-3, the long-term density of wild boars was 5/1,000 ha, and the actual density reached 27/1,000 ha in 2013 while in 2016 it was up to 7/1,000 ha. In the GP A (Curonian Spit, the western littoral zone), the herd index was 3-4, and the density was 21/1,000 ha, 8/1,000 ha, 5/1,000 ha, respectively. The main reason of the less density in 2013 was more social because of high synanthropy of the wild boar caused disturbances in human settlements that has induced intensive hunting here). The recent dependence on soil fertility (r=0.47; t=1.86) decreased in comparison with long-term index (r= 0.73) but is still positive. The reasons were mentioned above.

In the mixed coniferous forests (PE) of Eastern and Central Lithuania, the index of suitability for wild boar is 2 points; the climatic sub-regions 3b and 3a are prevailed but there are most severe 2c and mixed littoral 1a+1b+2b sub-regions; the prevailed soil type are *Podzols* and the soil fertility reached 2.1-2.9 points, the less number of the poor forest sites as in the natural region GP, the wild boar distributed more evenly, δ= 3.4). The herd indices were 3-4 within the Eastern part of the region and 4-5 within the Central one. Unfortunately, the indices were not considered previously. There is the reason why incompatibility between animal number and harvesting was revealed (as the harvesting reached from 120 to 400-550%). The soil fertility has less changed (r=0.52, t=1.23) in comparison with previous average long-term soil fertility (r=0.65). In Eastern and recently in Central Lithuania, the greatest outbreaks of ASF was recorded; however, after implemented preventive measures, the wild boar density reached 3-4/1,000 ha according to the data of SFVS but, actually, it was 3/1,000 ha in Eastern Lithuania and 10/1,000 ha in Central Lithuania.

Figure 4: Long-term changes in the wild boar harvesting (%) in Lithuania



In the mixed spruce-deciduous forests, the habitat suitability index is 3 points. *Albeluvisol*, *Luvisol* and *Podzol* soils are prevailed in the forest sites, mostly of the mesoeutrophic or of normal moisture as well as gleyic soils temporarily overmoisturised (47%), eutrophic soils of the of normal moisture and temporarily overmoisturised comprise less share (35.5%).The 2b climatic sub-region is prevailed but climatic factors of the mixed and complex sub-regions 2b+1b have not limiting character. Wild boars distributed most evenly; the herd index reaches 5 – 5.5. The soil fertility is less important (r=0.37, t=1.86). Before ASF outbreaks were detected, the wild boar density was 27/1,000 ha (Kaišiadorys forest enterprise, 54.871992, 24.390053 -54.848084, 24.462537) and 82/1,000 ha (Kaunas forest enterprise, 55.163197, 23.519766 - 54.92995, 24.10049). In these forests and natural region, the recommended density should be 10-15/1,000 ha. After the preventive measures were implemented, the densities were reduced up to 14 and 22/1,000 ha, respectively, i.e. twice and 4 times less and comprised even 526%. Such share of harvested animals indicates an imprecision of animal count and neglect of the herd index characteristic to certain natural region. Despite of the density reduction, the territory was attributed to the 3rd risk zone (i.e. an infected area where ASF was detected in wild boars and domestic pigs). In 2015, the harvesting has decreased almost twice, up to 262%, and in 2016 only 22.3% were harvested.

In the deciduous forests with admixture of spruce, the habitat suitability reaches 4 points. The soils are more fertile (3.5-4.3). The soil fertility is not limiting factor and shows weak dependence between variables (r=0.2, t=0.65). The *Cambisols* and *Luvisols* are prevailed and soils are less contrasted. The prevailed forest sites are eutrophic gleyic of temporarily overmoisture and very eutrophic gleyic of temporarily overmoisture, less mesoeutrophic of normal moisture and some eutrophic of normal moisture. In the northern part of the region, the density of the wild boar was less (21/1,000 ha in 2013 and reduced up to 6/1,000 ha in 2016) than in the main territory of the deciduous forests with admixture of spruce (37-

41/1000 ha), which is distinguished by particularly abundant local populations of wild boar (the density exceeds the ecological density level, 10-15/1,000 ha, even 4-5 times). The herd index is 5, and 4-5 in the northern part of the region. It shows that the population regulation was insufficient and the herd index and specificity of the natural region were not considered although the wild boar density was reduced significantly up to permissible levels in 2016.

4. Discussion and Conclusions

The distribution and abundance of wild boar did not differ significantly in the different natural regions until 2014. Although the regional differences withered due to human activities but are still positive. Despite population decline after implemented ASF measures, the wild boar still mostly prefers the deciduous forests with spruce admixture and mixed spruce-deciduous forests, where natural and human conditions are most suitable.

Depending on the natural region conditions and forest category, the habitat suitability is as follows: 1 for pure pine forests, 2 for mixed coniferous forests, 3 for mixed spruce-deciduous forests and 4 for deciduous with spruce forests. The herd index was defined on the ground of the annual mean long-term increment that reaches 60% taking into consideration species-specific susceptibility to diseases and mortality, differences in age-related reproduction of females and long-term observations. The herd index in the different natural regions is as follows: 2-3 for pure pine forests in southern Lithuania, and 3-4 for the same forests in western Lithuania, 3-4 for mixed coniferous forests in eastern Lithuania and 4-5 for the same forests in central Lithuania, 5-5.5 for mixed spruce-deciduous forests, and 5 for deciduous forests with spruce admixture, including herd index 4-5 for the same type of forests in northern Lithuania.

For the wild boar, climatic factors cause quantitative, qualitative and territorial changes. Gradual changes in habitats enable animals to adapt. However, unusual and unexpected changes including annual, monthly and daily ones, cause atypical responses. These responses expressed in activity, habitat selection, foraging, seasonal migrations and, simultaneously, animal damage caused to agriculture and forestry. Therefore, it is important to consider a significance of above-mentioned density-independent factors in the context of climate change. Considering recent climate anomalies and global warming, when the winter severity decreases, the annual mean increment of wild boar population reaches 50%.

In light of results of the study of wild boar distribution in the different natural regions, it is obviously that the natural distribution process is disordered because of the long-term inappropriate management of wild boar population. The distribution directly related to changes in animal numbers in all natural regions. Since 2014 noteworthy as the first detection of ASF and implementation of the set of preventive measures within the whole country are independent to biotic and abiotic conditions of natural regions excluding hunting. Wild boar hunting is used as the strong control measure in the extreme situation.

In such situation, the population use should be not less than 100%. However, 100% use of the wild boar number that annually provided by hunters, will not reduce population as further reproduction recover losses. The intensive hunting up to 150% of the pre-reproductive population abundance, will allow reducing wild boar number. To avoid negative effect of the natural regulation including an increase in migration, disorder in the social structure, search and occupation of the new and free habitats and niches, susceptibility to diseases and epidemiological situations as well as damage caused to agriculture and forestry, the hunting is an important prevention and regulation activity during the critical situation. Moreover, we have to consider animal mobility and female tendency to philopatry.

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