EFFECT OF DIET SUPPLY AND CLIMATIC CONDITIONS ON POPULATION DYNAMICS OF THE WILD BOAR (*SUS SCROFA*) IN THE KŘIVOKLÁT REGION (CENTRAL BOHEMIA, CZECH REPUBLIC)

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Abundance of the wild boar (*Sus scrofa*) has rapidly increased in the Czech Republic and all over the world especially over the past 30 years. The main causes are high adaptability on changing environment, adaptive foraging strategies, and high fecundity. The aim of the paper is to put into context increase of the wild boar abundance (as estimated from numbers of hunted game in various age groups) with food offer in agricultural land and in the forest in hunting districts of the Křivoklát protected landscape area. As a correlation factor, minimum temperature at the ground surface in February and March was considered. All the monitored variables were divided into food and statistical factors and they were evaluated by principal component analysis (PCA). The highest variance in relation to the number of hunted wild boars is explained by breadths of spring crops (by 30%), followed by breadths of winter crops along with minimal temperatures above ground surface in February and early March (by 22%). Variance of minimal temperatures in the second and third decades of March in conjunction with occurrence of oak and beech mast years is explained only by 18%. More distinctive increase of hunted wild boars was always a year following the mast year.

Sus scrofa; population dynamics; abundance; feeding ecology; Czech Republic

INTRODUCTION

The wild boar (*Sus scrofa*, Linné 1758) is one of the few animal species whose abundance has rapidly increased within last few decades. Increasing population size is not the question only in the Czech Republic but also in many countries all over the world (Saez-Royuela, Telleria, 1986; Neet, 1995; Bieber, Ruf, 2005). While hunting wild boars was quite rare in free range in the 1950's, approximately 50 years later yearly hunting bags were higher than 120,000 individuals, with a permanently increasing trend. The wild boar is a species very adaptable to changing living conditions including food offer. Specific food spectrum is very broad with majority of plant component both in areas with intensive farming (Schley, Roper, 2003; Herrero et al., 2004, 2006) and in areas with extensive agriculture with higher proportion of meadows and grassland (Baubet et al., 2004). Percentage of plant components in the food of the wild boar varied from 80% to 99% (Fruziński, 1993). The main components of plant origin are seeds of forest tree species (acorns, beechnuts), green plant parts, agricultural crops, roots and bulbs (Schley, Roper, 2003). The majority of plant food (especially grain, roots, herbs, various seeds and fruits) was reported also by Malinová (2008). Representation of the above-mentioned plant components can differ according to the monitored area in connection with agricultural extent and representation of fructiferous tree species – oak (*Quercus*) and beech (*Fagus*) and occurrence of mast years and can vary in the course of the year. In Luxembourg, in the areas with higher intensity of agricultural production, the natural food of wild boars could be divided into three groups with occurrence of agricultural crops in food from the end of April and with culmination in July, August and September and followed up by rapid decline (Cellina et al., 2008). Natural plant component of food starts to dominate in March with culmination in April and May and with subsequent gradual decrease. The third food component were acorns and beechnuts; wild boars started to feed on them at the turn of August and September, with culmination during all winter months and rapid decline in March.

Connection between food offer in the field and in the forest and wild boar abundance (derived from hunting bags) was searched e.g. by Neet (1995) and Geisser, Reyer (2005). Their results show relationship between the number of hunted wild boars, areas of corn and occurrence of oak and beech mast years. Improved food offer along with mild climatic conditions especially in winter and spring influenced favourably condition of female wild boars, reproduction parameters and piglet natality in both studies. The same conclusions were made by Gethoffer et al. (2007) in Germany.

Similar results were reported also by Maillard and Fournier (2004). They monitored wild boar populations in southern France in areas with frequent evergreen oak (*Quercus ilex*). Natality of piglets (with culmination

in February and March) was correlated with high crops of acorns. On the contrary, when the crop of acorns was low, natality culminated less markedly and appeared later (in April, May and June).

Abundance of wild boar population and average annual recruitment depend upon climatic conditions. Jadrzejewska et al. (1997) mention that the average annual recruitment of wild boar population is 19% in Poland in years with minimal or zero snow cover in winter. But in years when the snow cover exceeded 15 cm the annual increase tended to zero.

The high snow cover complicates game motion and frozen earth surface impedes food accessibility. Geisser and Reyer (2005) evaluated impact of ecological factors (food and climatic conditions) on wild boar abundance in Switzerland and they found out that the population growth relates especially to food availability and average air temperature. Unfavourable climatic conditions can influence negatively survival not only of juvenile, subadult, and adult individuals, but also piglet natality. Depth of the snow cover and minimal day temperature measured on earth surface are important.

With increasing wild boar abundance also the extent of damage to agricultural crops rises (Mackin, 1970; Kristiansson, 1985; Groot Bruinderink, Hazebroek, 1996; Schley, Roper, 2003; Baubet et al., 2004; Herrero et al., 2006; Schley et al. 2008). There is obvious preference of wheat, corn, oat, and potatoes. Schley et al. (2008) draw attention to the fact that there were no damages in the stands of cereals with awns (barley, rye).

The number of hunts, unsuitable structure of crops with majority of winter crops, winter rape and corn that form permanent cover for most of the year, all this contributes to the extent of damage in conditions of the Czech Republic (Štípek et al., 2010). Thurfjell et al. (2009), on the basis of monitoring in mixed areas (field – forest) in Sweden, adviced to utilize more supplementary feeding in forest areas, because it is more attractive than ripe farm crops.

MATERIAL AND METHODS

Study area

The Křivoklát region is situated in the northwest part of Central Bohemia. It is the protected landscape area which extends to five former townships of Central and Western Bohemia (Kladno, Rakovník, Beroun, Rokycany and Plzeň-North). The total area is 628 km^2 and covers the area of Křivoklát-Uplands and the northern part of Plasy-Uplands. The altitude varies from 223 to 616 metres above sea level. Forest coverage is 62% with dominance of broad-leaved and mixed stands. Fructiferous tree species (oak, beech) occupy 33% of the total forest area. The dominant soil type is brown soil; pararendzina and pseudogley can also occur.

Annual mean temperature varies from 7.5 °C to 8.5 °C. The whole area is situated in rain shadow of the Krušné Mts., the total annual rainfall is only 530 mm.

Data and statistical analysis

Our analysis of the wild boar densities is based on the data from 1994–2008. Data on number of hunted wild boars in hunting districts of the Křivoklát region were provided within hunting statistics – annual statements about hunting district and game hunting.

The statistical enquiry was realized in two hunting districts coming under municipal corporation with extended competence in Kladno, 36 hunting dictricts coming under municipal corporation with extended competence in Rakovník, 6 coming under municipal corporation with extended competence in Hořovice and 13 coming under municipal corporation with extended competence in Beroun. The development of the wild boar abundance was evaluated by correlation and regression analysis.

The data about areas with crops were got from the Czech Statistical Office and from the County Agrarian Associations in Beroun and Rakovník. The meteorological data were provided by the Czech Hydrometeorologial Institute; minimal temperatures registered at the ground surface in February and March from the meteorological stations in Lány and Kněževes.

Information about oak and beech mast years have been got from the company "Forests of the Czech Republic" of Křivoklát. Fruit production of deciduous trees can vary considerably between different years. Years with high fruit production are called mast years. In mast years mast availability is high, meaning that food conditions for wild boars are very good. Data on mast availability are based on yearly estimates of forest rangers.

The statistical treatment was performed by the principal component analysis (PCA) in the program Statgraphics Plus 5.1. Components with eigenvalue higher than 1 were considered significant. Sixteen variables, six describing temperatures in February (d1–d3) and March (d4–d6) and

Table 1. Independent variables tested for their potential effects on the population density of the wild boar from 1994 to 2008

Abbreviations
PC – principal component
d1 – first decade in February (temperature)
d2 – second decade in February (temperature)
d3 – third decade in February (temperature)
d4 – first decade in March (temperature)
d5 – second decade in March (temperature)
d6 – third decade in March (temperature)
wh – wheat
ba – barley
ry – rye
oa – oat
mg – maize for grain
ms – maize for silage
ra – rape
pc – pulse crops
po – potatoes
my – mast years of oak and beech

ten describing food, were available for each year of the study period. Variables are described in Table 1 and mast years of oak and beech are shown in Fig. 4.

RESULTS AND DISCUSSION

Number of hunted wild boars in years 1994–2008

The numbers of hunted wild boars in Křivoklát region represent an increasing trend in years 1994–2008 except for the years 2003, 2005, and 2006. Throughout the fifteen year period the rate between the number of hunted piglets and hunted hoggets increased from 109% to 200%. Perhaps, increasing division between grown piglets and hunted piglets can lead to more intensive increase of wild boar population in this area.

Abundance of wild boar population and biotope carrying capacity

The statistical evaluation of monitored variables via PCA indicates five main components. They represent 85% of the total variability of the data set. Top are food components (particularly spring crops), which explain 30% of dispersion of the values. Combination of food factors (represented by areas of winter crops) and climatic factors (minimal temperatures at the ground surface in February and early March) is the second most important component = 22%. The minimal temperatures in 2nd and 3rd decades of March along with occurrence of oak and beech mast years explain the variance only by 16%. The full mast was recorded in the years 1996, 1998, 2000, 2003, 2006 and 2008. Positive influence of the mast year always took effect in marked increase of wild boar population and consequently in large number of hunted wild boars in following years, which corresponds with conclusions of Neet (1995) and Geisser, Reyer (2005). The reason can be seen in increased food offer in connection with the fact, that individual hunting is more difficult in feeding places, where wild boars are attracted, because they prefer fruits of forest tree species (acorns and beechnuts) and do not visit these places regularly.

The trends in areas of particular grown crops (Fig. 3) represent marked impact of areas with winter crops (rape

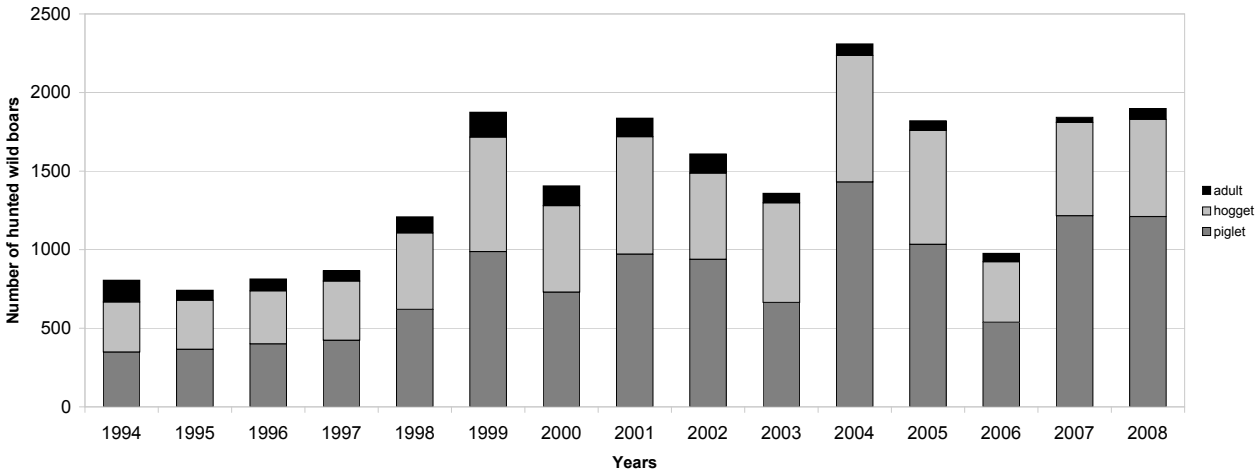

Fig. 1. Numbers of hunted wild boars in Křivoklát region in the years 1994–2008

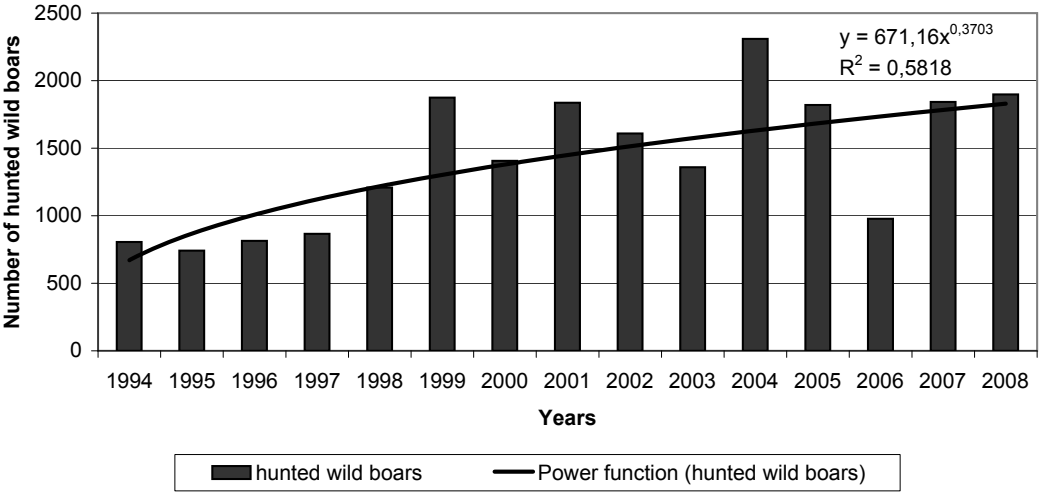

Fig. 2. Development of numbers of hunted wild boars in Křivoklát region in the years 1994–2008

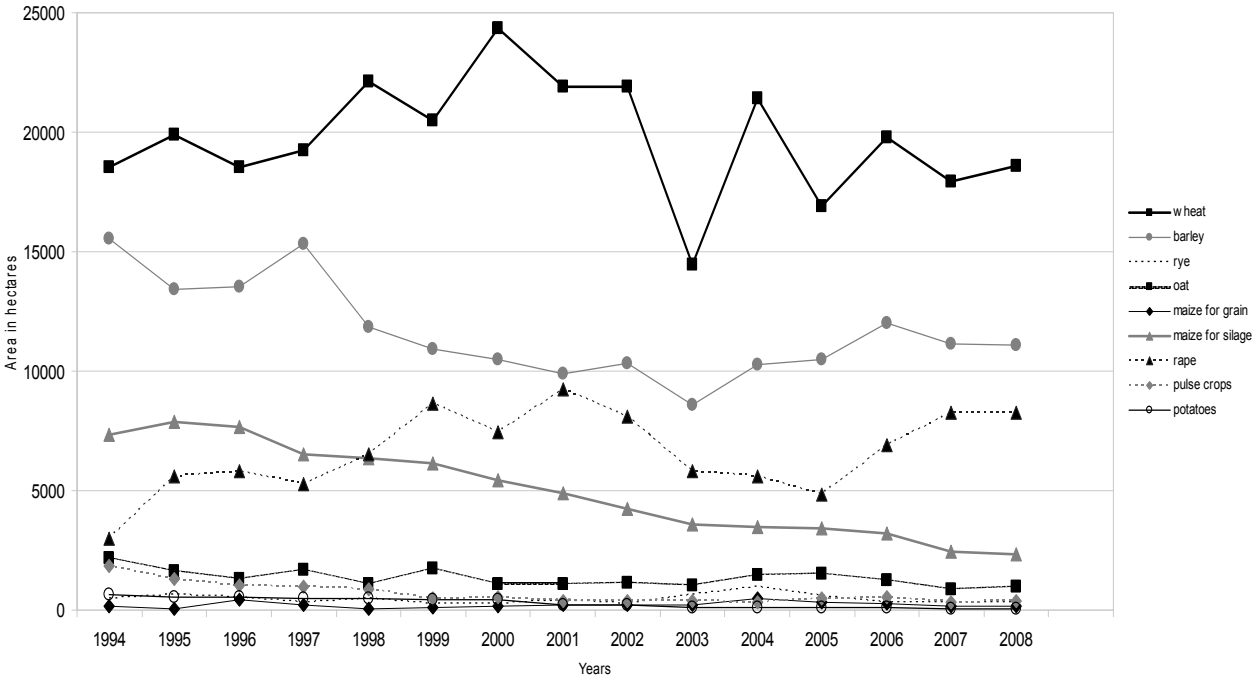

Fig. 3. Acreage development of the main farm crops in Rakovník and Beroun districts in the years 1994–2008

and wheat), which also provide very good cover conditions due to long vegetation period. This marked impact could influence the population number of wild boars in Křivoklát region and its neighbourhood. Portion of the winter crops was approximately 50% until 1997 and since 1998 was ca. 60% and nowadays it is within the range of 60–65%. Permanent increase of wild boar numbers in the region of Křivoklát is also evidently caused by high rate of autumn and winter supplementary feeding (especially by corn and waste cereals).

Evaluation of occurrence of oak and beech mast years in the area of Křivoklát was performed by the staff of the company Forests of the Czech Republic, namely by the forest administrations of Křivoklát and Lužná. The intensity of occurrence of mast trees in given year was evaluated by five-place scale.

Wild boar abundance and climatic conditions in early spring

If we accept correlation between yearly bags of wild boars and population size, then fluctuation in the years 2000 and 2005, but especially in 2003 and 2006 can be caused to a certain extent by climatic conditions. Very low air temperature at the ground surface could influence mortality of newborn piglets, which corresponds with conclusions of G e t h o f f e r et al. (2007). Figs 5 and 6 represent average minimal temperatures at the ground surface in decades in February and March when piglets incubate. It is obvious that very low temperatures were recorded especially in years 1996, 2003, 2005, and 2006. There is always marked fall of hunted wild boars with exception of 1996 (Fig. 1) in given year-direct impact of unfavourable climatic conditions at the time of piglet delivery. From the statistical evaluation by means of PCA arise to dispersion of the values that contribute particularly values measured in 2nd and 3rd decades of February and early March (PC2: 0.35; 0.37 or 0.32 – Table 2). Duration and depth of snow can be important factors affecting also natality and fecundity.

CONCLUSIONS

The results of the statistical enquiry of number of hunted wild boars in the Křivoklát region in period 1994–2008 show permanent increase of wild boar numbers together with increasing rate of piglets in population. Principal component analysis revealed that value variance of number of hunted wild boars is explained especially by food factors and partly by combination of food and climatic conditions in early spring. Minimal temperature measured at the ground surface partly influenced survival of piglets born in the second part of February and as early as March. Occurrence of oak and beech mast years led to increased numbers of hunted wild boars in the subsequent year. The reason can be the fact that increased food offer of acorns and beechnuts can influence positively wild boar reproduction but also it can influence negatively success of individual hunting on places where wild boars are attracted.

Acknowledgements

The authors would like to thank Jaroslava Nešvarová (Municipal Office in Beroun), Jiří Tomica (Municipal Office in Rakovník), Josef Konvalinka (Ministry of Agriculture), and Jiří Reich (ZZN Rakovník) for sharing their data.

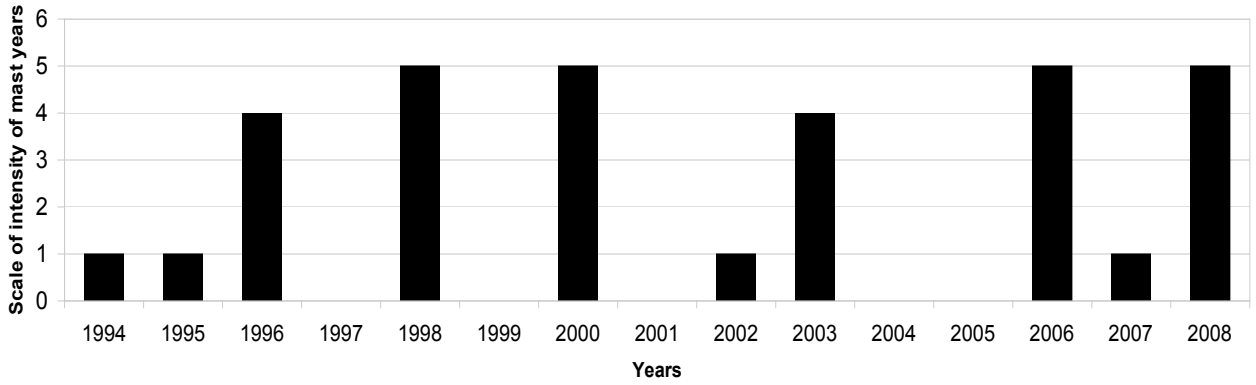

Fig. 4. Occurrence of oak and beech mast years in Křivoklát region in the years 1994–2008

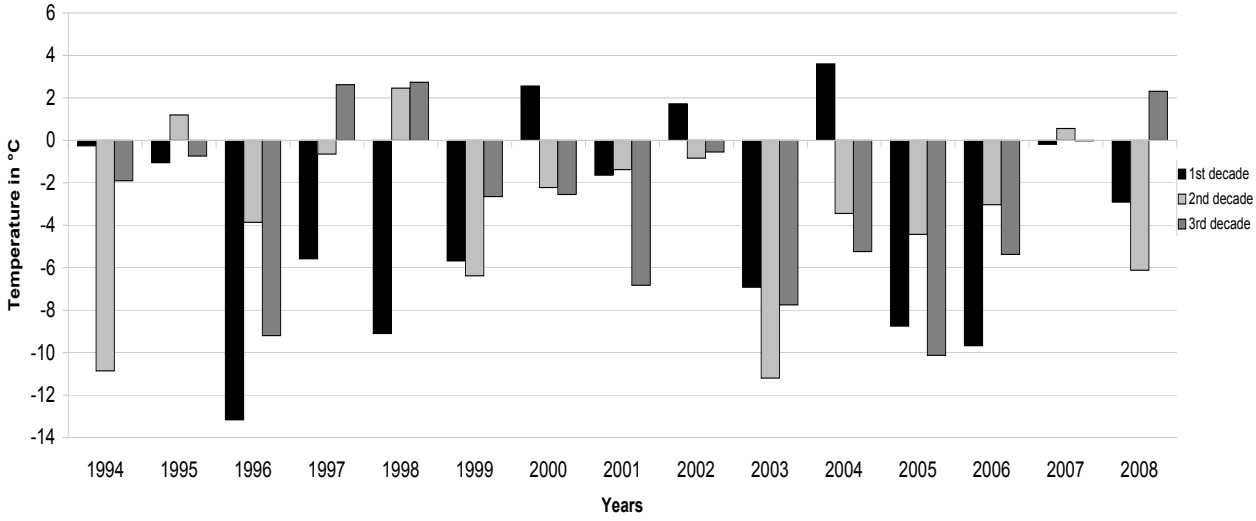

Fig. 5. Average minimal temperatures at the ground surface in February

Table 2. Results from a principal component analysis based on data from 1994–2008 for sixteen variables (bold type indicates statistical significance)

Eigenvectors					
Variable	PC1	PC2	PC3	PC4	PC5
d1	–0.02622	0.203171	**0.469631**	0.194268	0.234808
d2	–0.02442	**0.348342**	–0.22902	**0.398284**	0.030568
d3	0.225101	**0.365058**	0.101638	0.134304	–0.19205
d4	0.22054	**0.324427**	0.210442	–0.11741	–0.24949
d5	–0.04755	0.044661	**0.510871**	0.255981	0.053927
d6	0.045853	–0.07187	**0.317117**	**–0.55027**	**0.395697**
wh	0.038968	**0.363634**	0.002906	0.167944	**0.626624**
ba	**0.399218**	–0.0736	–0.08554	0.075788	–0.00974
ry	–0.05517	**–0.33776**	0.077802	**0.501158**	0.012178
oa	**0.324017**	–0.24603	0.200869	–0.06789	0.163706
mg	–0.20646	**–0.3296**	–0.04922	0.252726	0.306198
ms	**0.401679**	0.00468	–0.11959	0.125344	0.073813
ra	–0.2362	**0.382062**	–0.05981	–0.11863	–0.01546
pc	**0.428726**	–0.12573	–0.00188	0.043307	–0.01997
po	**0.42583**	0.030293	–0.09	0.0478	0.097103
my	0.03491	0.089954	**–0.47822**	–0.12475	**0.395404**

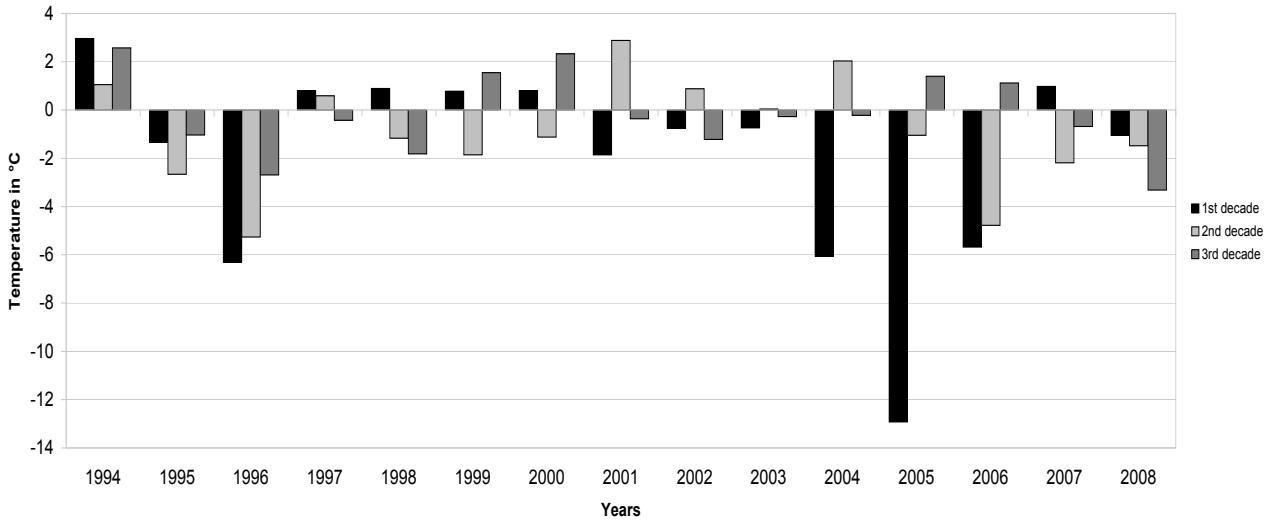

Fig. 6. Average minimal temperatures at the ground surface in March

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Received for publication on September 27, 2010
Accepted for publication on December 21, 2010

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Vliv vývoje potravní nabídky a klimatických podmínek na populační dynamiku prasete divokého *(Sus scrofa)* v oblasti Křivoklátska.

Scientia Agric. Bohem., *42*, 2011: 24–30.

Početní stavy prasete divokého **(***Sus scrofa*) zaznamenaly stejně jako v celém světě i u nás strmý vzestup zejména v posledních třiceti letech. Hlavními příčinami jsou jejich značná přizpůsobivost při získávání potravy, adaptabilita na prostředí a také velká reprodukční schopnost. Cílem příspěvku je dát do souvislosti nárůst početních stavů prasete divokého, odvozený z počtů ulovené zvěře v jednotlivých věkových kategoriích, s potravní nabídkou na zemědělské půdě (strukturou pěstovaných polních plodin) a v lese, přesněji zastoupení plodonosných dřevin (dubu a buku) v honitbách CHKO Křivoklátsko nebo na něj bezprostředně navazujících. Jako pomocný faktor zpřesňující vývoj početních stavů v následujících letech byla uvedena minimální teplota nad povrchem země v měsících únoru a březnu. Všechny sledované proměnné byly rozděleny na faktory potravy a klimatické faktory a dále statisticky hodnoceny analýzou hlavních komponent (PCA). Největší míru rozptylu ve vztahu k počtu ulovených jedinců vysvětlují plochy jarních plodin (z 30 %), následované plochami ozimů společně s minimálními teplotami nad povrchem země v únoru a začátkem března (z 22 %). Pouze ze 16 % vysvětlují míru rozptylu minimální teploty v II. a III. dekádě března společně s výskytem semenných roků dubu a buku. V roce následujícím po semenném roce došlo vždy k výraznějšímu nárůstu počtu ulovených jedinců prasete divokého.

Sus scrofa; populační dynamika; početnost; potravní ekologie; Česká republika

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