Reproductive and morphometric characteristics of wild boar (*Sus scrofa*) in the Czech Republic

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ABSTRACT: Our study aimed to determine morphometric data for wild boar (*Sus scrofa*) in various areas of the Czech Republic and the potential influence of environment on its body measurements. Three localities with varying agricultural systems and overall landscape structure were selected. Hunted boars were measured for height at the withers, body length, ear length, metatarsal length and weight (depending on the circumstances, either dressed with head, without head, or undressed). We also determined the age of the hunted boars according to teeth development. During 2003–2007, a total 654 boars were examined in various age categories. Body development was similar in all areas and without statistically significant differences until the age of 6–7 months. From 8 months, statistically significant differences in body proportions occur across all localities. It is just at that time that carrying capacities change in the selected localities. The results show that morphometric differences among boars of the same age are influenced by external environmental conditions in which the boars live.

Keywords*:* environmental factors; juvenile individuals; morphometry; *Sus scrofa*; wild boar

Problems of growth in the wild boar population are today a subject of interest for numerous researchers throughout Europe. In all countries where wild boar is found, there has been a population explosion in the last 30 years (Hladíková et al. 2007), and the species has expanded its territory into areas where it did not previously exist (Nordic countries and Portugal). In most European countries, the wild boar's population growth has been of an exponential character. This situation has been associated with high fertility of adult females, environmental changes and, in recent years, also involvement of physically immature individuals in reproduction (Gethoffer et al. 2007). A very important factor causing an increase in the numbers of wild boars is the quality of their environment, which influences the growth of juvenile individuals, or, more precisely, their sexual maturation (Santos et al. 2006).

The main objective of the study was morphometric evaluation of three wild boar populations and to determine in these areas the morphometric parameters in different age groups. Since statistics hunting show that juvenile and sub-adult individuals comprise the largest part of a wild boar population (Gethoffer et al. 2007), determination of physical development of this class is important for acquiring data about reproduction.

MATERIAL AND METHODS

Three localities with varying agricultural systems and different overall landscape structure were selected: Kostelec nad Černými lesy (280–350 m a.s.l., intensive agriculture, in the vicinity of Polabí lowland), Doupov area (350–800 m a.s.l., a specific area within military territory) and Šumava area (450–1,000 m a.s.l., low carrying capacity as extensive agriculture). In all areas, measurements of hunted wild boars were made during the years 2005–2007. Measurements were taken both from individually hunted boars as well as, in most cases, from individuals killed during common hunts. In total we measured 682 pieces of wild boars.

The morphometric data were measured according to Anděra and Horáček (2005). Body length (LC) was measured from the tip of the snout to the root of the tail, tail length (LCd) from the root of the tail to the tip where the tail vertebrae can still be found (without the ending and often extended hairs), metatarsal length (LTp) from the calcaneal joint to the tip of the hoof, ear length (LA) from the root of the ear to the tip, and height at the withers (AC) as the distance from the tip of the fore leg to the highest point at the withers. Weight was determined according to circumstances: (*i*) the whole undressed individual, (*ii*) the weight of a dressed individual including head and legs, or (*iii*) the weight of a dressed individual without head and legs.

Age was determined in all animals. In individuals up to the age of 2 years, age was determined according to Wolf's methodology (Wolf, Rakušan 1977) that is based on the development of permanent teeth and for the adults was age determined by tooth wear according to Briedermann (1986).

For statistical evaluation of the collected data, we used the programme STATISTICA for Windows, Vers. 7.0. To identify differences between the individual localities, one-factor ANOVA was used, with locality taken as a factor. The purpose of this method is to test significant differences between means by comparison of variances.

For all variables, tests for normal distribution (Kolmogorov-Smirnov and Lilliefors test for normality) and for homogeneity of variances (Cochran's, Hartley's and Barlett's tests) were performed. Tukey's test was used to determine differences between individual groups. For the analysis of variables that did not meet the requirement of homogeneity of variance, the Kruskal-Wallis nonparametric test was used.

When there was insufficient data to process for one group, we used Student's two-sample *t*-test for independent variables to compare the other two localities.

RESULTS AND DISCUSSION

Differences in morphometric parameters

The morphometric parameters observed in all age categories fall within their ranges for values found in the Czech Republic (Kratochvíl et al. 1986; Wolf 1987), as well as in Europe (Briedermann 1986; Niethammer, Krapp 1986; Babet et al. 1995; Gallo Orsi et al. 1995; Moretti 1995). Overall, wild boars in the Czech Republic are bigger than in central Italy (Mattioli, Pedone 1995) and their size is comparable for individuals from Central Europe (Gethoffer et al. 2007; Hebeisen 2007).

The influence of locality as a factor affecting the morphometric parameters is very important in individuals up to 1 year of life (Fig. 1). Inasmuch as there was sufficient data available in these categories, this result can be regarded as authoritative (statistically significant). Data obtained in this study can be compared with the results found in Switzerland (Moretti 1995; Hebeisen 2007). In those studies, similar age classes were chosen. In other studies, individuals are classified according to broad age scales, mostly in the categories of piglet (0–12 months), sub-adult (13–24) and adult (24+) (Wolf 1987; Pedone et al. 1991; Gallo Orsi et al. 1995; Mattioli, Pedone 1995), or the morphometric data was recorded in individual months of the year in the categories of piglet and

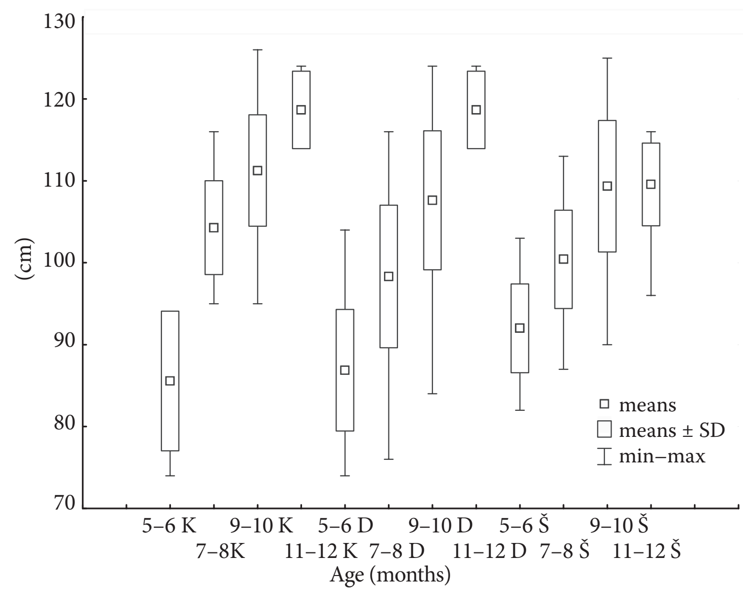

Fig. 1. Average body length in juvenile boars (K – Kostelec, D – Doupov, Š – Šumava)

Table 1. Average body length, dressed weight of individual with head, height at the withers, metatarsal length and ear length by area

Age (months)	Kostelec	*N*	Doupov	*N*	Šumava	*N*	*P*
Ø body length (cm)							
5–6	85.5 ± 8.5	7	86.9 ± 7	17	92.0 ± 5.4	17	0.080
7–8	104.3 ± 5.8	46	98.3 ± 8.7	79	100.4 ± 6.0	45	0.000
9–10	111.3 ± 6.8	82	107.6 ± 8.5	35	106.3 ± 8.0	23	0.095
11–12	118.7 ± 4.7	3	117.5 ± 3.5	4	109.6 ± 5.0	14	–
13–14	–	0	–	0	113.4 ± 4.5	10	
15–16	–	0	–	0	118.3 ± 3.5	22	
17–18	122.0	1	116.4 ± 5.6	7	122.2 ± 4.8	10	0.003
19–20	131.0 ± 1.0	1	126.9 ± 7.2	14	125.3 ± 6.2	21	0.000
21–22	136.0	1	135.3 ± 4.9	14	127.6 ± 5.7	21	0.000
Ø dressed weight of individual with head (kg)							
5–6	11.4 ± 1.5	7	1 2.0 ± 3.01	16	12.7 ± 26	17	0.410
7–8	24.4 ± 5.8	45	20.4 ± 6.6	71	19.9 ± 4.4	44	0.000
9–10	29.5 ± 6.9	82	28.7 ± 7.8	34	25.5 ± 6.8	23	0.090
11–12	38.0 ± 2.6	3	30.8 ± 1.8	4	27.2 ± 5.9	14	–
13–14	–	0	–	0	32.8 ± 5.5	10	–
15–16	–	0	–	0	35.7 ± 5.7	22	–
17–18	42.0	1	40.7 ± 8.1	7	44.5 ± 7.5	11	0.264
19–20	51.6 ± 2.1	3	46.5 ± 7.7	17	44.4 ± 5.3	17	0.342
21–22	60.0	1	56.0 ± 6.6	14	48.3 ± 6.6	21	0.002
Ø height at the withers (cm)							
5–6	54.7 ± 6.9	7	51.5 ± 6.3	17	50.5 ± 4.0	16	0.038
7–8	63.3 ± 5.3	46	58.9 ± 6.6	79	58.7 ± 5.6	45	0.000
9–10	67.3 ± 6.3	82	63.9 ± 7.7	35	64.2 ± 6.4	23	0.005
11–12	76.7 ± 2.3	3	65.5 ± 3.5	4	64.8 ± 4.9	14	–
13–14	–	0	–	0	71.0 ± 4.7	10	–
15–16	–	0	–	0	71.5 ± 5.2	22	–
17–18	82.0	1	67.3 ± 8.1	7	71.0 ± 4.7	10	0.009
19–20	78.7 ± 1.2	3	75.2 ± 4.6	17	74.7 ± 4.9	17	0.773
21–22	85.0	1	78.1 ± 2.9	14	76.4 ± 4.2	21	0198
Ø metatarsal length (cm)							
5–6	22.0 ± 2.4	6	20.9 ± 2.1	12	21.4 ± 1.2	17	0.765
7–8	24.6 ± 2.7	38	22.5 ± 2.3	72	23.3 ± 1.9	45	0.000
9–10	25.8 ± 1.2	53	24.6 ± 2.0	34	24.3 ± 1.3	23	0.000
11–12	27.3 ± 1.5	3	25.5 ± 0.7	4	25.7 ± 1.6	14	
13–14		0		0	27.0 ± 1.7	10	
15–16		0		0	26.7 ± 2.6	20	
17–18	27.0	1	26.5 ± 0.7	3	28.6 ± 1.7	11	
19–20	28.0 ± 1.0	3	26.4 ± 2.3	17	27.3 ± 1.5	17	0.207
21–22	28.0	1	28.5 ± 1.51	14	26.3 ± 5.2	21	0.134

Table 1 to be continued

Age (months)	Kostelec	*N*	Doupov	*N*	Šumava	*N*	*P*
Ø ear length (cm)							
5–6	8.2 ± 0.75	7	8.2 ± 0.67	17	9.7 ± 1.4	16	0.040
7–8	10.0 ± 1.3	46	9.2 ± 1.1	79	10.0 ± 1.5	45	0.220
9–10	10.6 ± 0.9	82	10.6 ± 0.9	35	11.3 ± 1.7	23	0.000
11–12	10.3 ± 0.4	3	8.5 ± 0.7	4	11.1 ± 0.9	14	–
13–14	–	0	–	0	11.8 ± 1.0	10	–
15–16	–	0	–	0	12.7 ± 0.8	22	–
17–18	14.5	1	11.3 ± 1.1	7	12.9 ± 1.2	10	–
19–20	11.7 ± 1.2	3	11.6 ± 0.6	17	12.2 ± 0.9	17	0.038
21–22	11.9 ± 1.2	2	11.7 ± 0.6	14	12.0 ± 0.9	21	0.028

sub-adult without determining the absolute age of an individual (Stubbe et al. 1980). Therefore, the comparison with these studies can only be considered as indicative.

Body length at the age of 5–6 and 7–8 months is slightly higher than the value given by Moretti (1995) in Switzerland. At the age of 9–10 and 11–12 months, the body length is greater in the Kostelec area, and it is the same in the Doupov area and Šumava as in Switzerland. At the age of 13–18 months, the average body length in all our localities is substantially less than in Switzerland.

Concerning height at the withers, individuals from the Doupov area and Šumava are identical with Switzerland in all categories, but individuals from the Kostelec area show higher values (Table 1). Other morphometric data show a similar pattern (metatarsal length, tail length and ear size) (Table 1). The reason for these differences may lie in the different environment types in the localities. Moretti (1995) examined individuals in a mountainous region with an altitude of 200–1,800 m a.s.l., with forest coverage of 60% and an agricultural landscape (with an intensive type of agriculture) constituting only 10% of the area, similar to the Doupov area and Šumava.

The comparison of weights with other studies show a similar results. Compared to Wolf (1987), who was ascertaining weights of wild boars in the Kolín and Nymburk areas (areas similar to the Kostelec area), there are slightly lower values in the Kostelec area, however the maximum values are nearly identical. The Doupov area and Šumava have averages well below those reported by Wolf (1987). Weights found in this study fall within the ranges of survey data from other European countries (Briedermann 1971; Pedone et al. 1991; Gallo Orsi et al. 1995; Mattioli, Pedone 1995; Moretti 1995; Gethoffer et al. 2007; Hebeisen 2007). A more detailed comparison, however, would be misleading because of difference among the various studies in how the individuals were categorized into age classes.

Comparing of juvenile and sub-adult individuals only in the categories of piglet and sub-adult is very imprecise. Relative to the nearly linear growth of boars under 24 months of age, when during the first 12 months an individual gains 50% of its adulthood weight and it gains 70% within 22 months (Pedone et al. 1995), comparison of such broad categories is conditioned upon the unification of the samples compared.

Relation to environmental factors

Differences in morphometric parameters between different localities are probably caused by external conditions. At the age of 5–6 months, the differences are small and they become greater as the animals grow older. The accumulated data has been compiled into a growth curve without distinction by sex (Fig. 2).

The growth curve in boars from Doupov area can be expressed by the folloving equation

$$y = -2.2717 + 3.3348x - 0.0383x^2$$

where:
y – weight,
x – age in months.

The growth curve in wild boars from Kostelec area has a pattern similar to that for individuals from Doupov area, but it is shifted upward

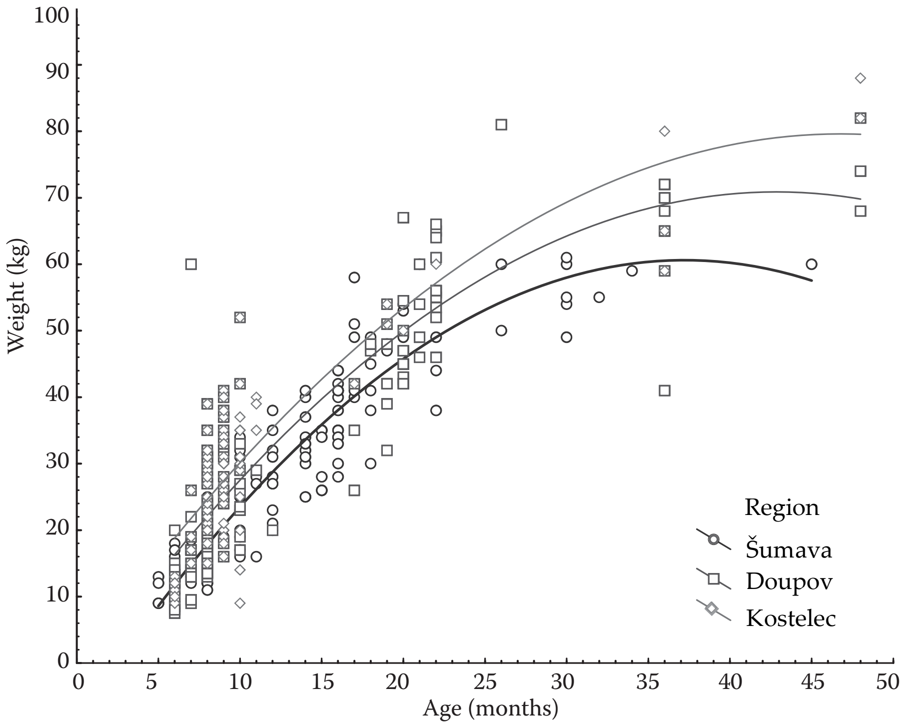

Fig. 2. Growth curves of wild boar

on the y axis (higher weight of wild boars in Kostelec area). It can be expressed by the equation $y = -3.7267 + 3.875x - 0.0465x^2$. For Šumava, we can express the curve using this equation $y = -1.8362 + 2.7262x - 0.0196x^2$.

The growth curves created for each of the studied areas show similar trends as do other studies from Europe (Pedone et al. 1991; Gallo Orsi et al. 1995; Moretti 1995; Peracino, Bassano 1995).

From the data in Šumava we can distinguish a weight differentiation between males and females at 18–20 months. The same age boundary for differentiation is indicated by Pedone et al. (1991) in southern Italy, while in northern Italy Gallo Orsi et al. (1995) uses 14–15 months, and in Switzerland Moretti (1995) uses 13–14 months. On the other hand, Moretti's (1995) opinion that females grow faster than males within 12 months was not confirmed. The reason for weight differentiation given by those authors is a change in strategy of energy use, whereby the males invest all their energy into growth while females divide their energy after 12 months be-

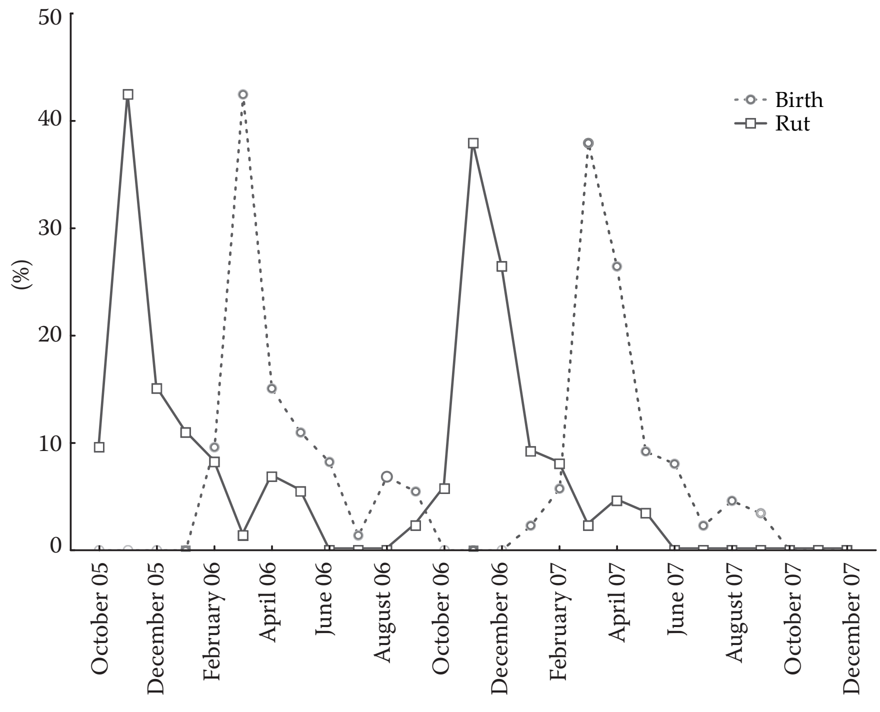

Fig. 3. Farrowing and rut in Doupov area

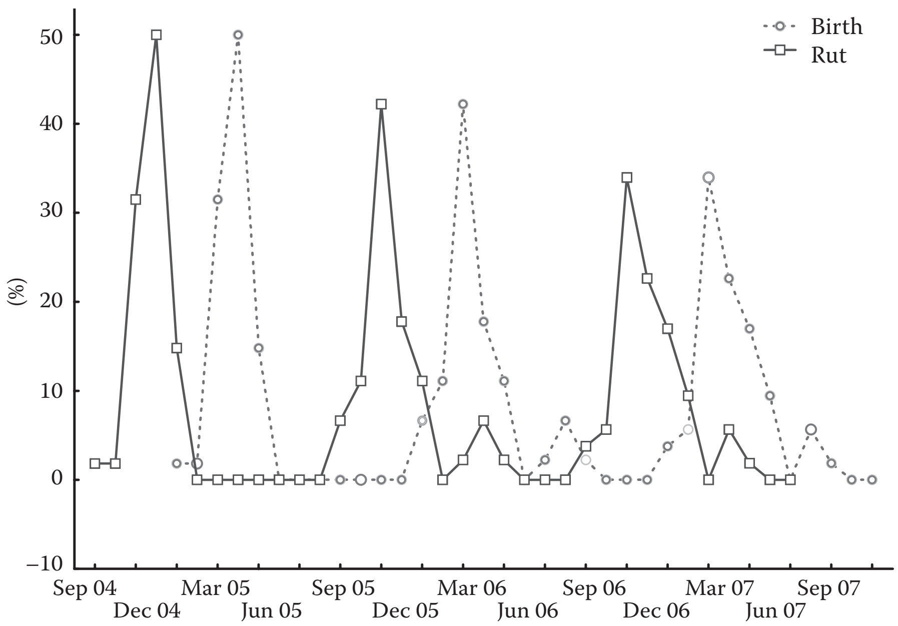

Fig. 4. Farrowing and rut in Kostelec area

tween growth and reproduction (Pedone et al. 1991; Moretti 1995; Gallo Orsi et al. 1995).

In all three locations the growth shows a polynomial character, whereby at a certain age weight starts to decrease. The polynomial character of the growth curve in wild boar is reported also by Pedone et al. (1991). By contrast, Markina et al. (2004) report logarithmic growth.

Figures of farrowing and rut in the individual months of the year were created for all three areas (Figs. 3–5). For Kostelec and Doupov areas they were created for 2005–2007. For Šumava, due to a lack of data, they were only created cumulatively for 1995–2007.

In Kostelec area, the greatest part of females farrows in March (2006 – 43%; 2007 – 38%) and April (2006 – 16%; 2007 – 27%). A second peak occurs also in August, but this is not significant (2006 – 6%; 2007 – 5%). Most of the females are impregnated during November and December. In Šumava, the greatest number of females farrows throughout May (26%) and April (18%), and a second peak comes in October (7%). Most of the females are impregnated in November and December.

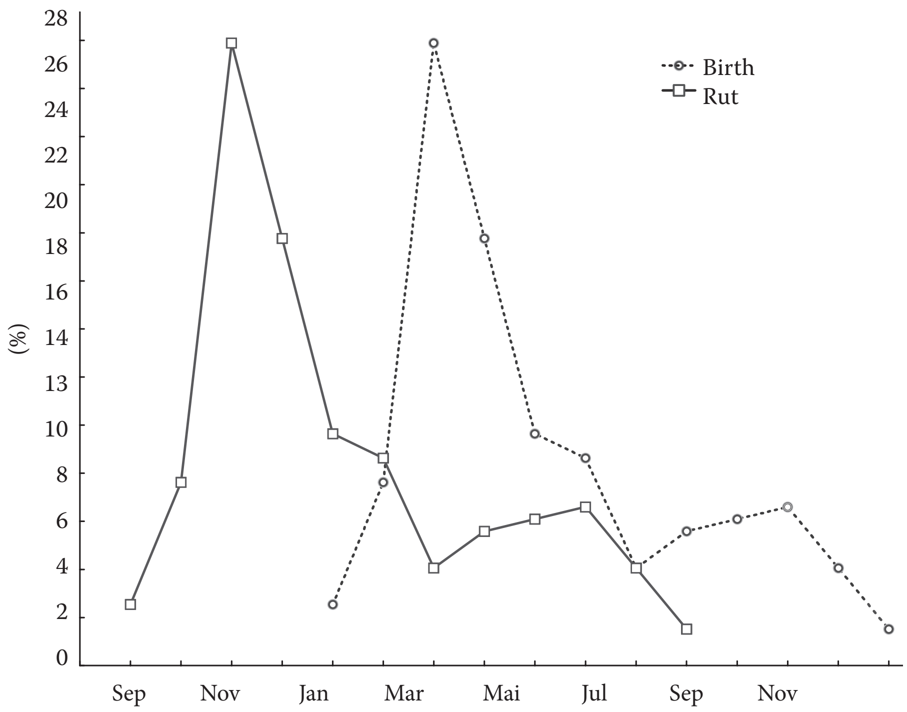

Fig. 5. Farrowing and rut in Šumava

The farrowing and rut times show a similar trend in all three localities. The reason for greater dispersal of farrowing during the year in the individuals from Šumava might be due to harsher weather conditions, which cause an early spring litter to die owing to low temperatures and the sows then rut again in the course of several following weeks and become pregnant (Hebeisen 2007). Another reason why the second farrowing peaks occur from August to October might be the involvement of juveniles in reproduction during spring, provided they did not become pregnant already at the time of the main breeding period. Gethoffer et al. (2007) indicates that 60% of juveniles which did not become pregnant in the main breeding season (November and December) will become pregnant in the spring months. Compared to other studies from Europe, the distribution of litters under Czech conditions is similar.

In Germany, according to Gethoffer et al. (2007), most young animals are born at at the turn of March and April, while in Switzerland Hebeisen (2007) indicates that it is March–May when 50% of young boars are born. These values correspond to the data found in this study.

In southern Europe, the distribution of farrowing is different during the year in a part of studies, or the time period is longer than that found in our study. In Spain and Portugal, Fonseca et al. (2004) indicate March–April as the most common farrowing period and Santos gives the beginning of March to the end of April. In southern France, Maillard and Fournier (2004) report April–May and Moretti (1995) from the Southern Alps gives approximately the same distribution of farrowings in the months from May to July. The recorded second farrowing peak seen in all three Czech localities during July–September is the most notable in Switzerland (Hebeisen 2007), where it represents a similar proportion (5–8%), and in Germany (Gethoffer et al. 2007), where this second peak is generated by females of 13–16 months.

The high proportion of piglets farrowed in March and April in the Kostelec area (up to 80%), in contrast to the Doupov area (55%) and Šumava (46%), may again signify the influence of the area with regard to both the time of farrowing and the morphometric parameters. This confirms the findings of Maillard and Fournier (2004) that in case there is an abundance of food available during the preceding autumn and favourable environmental factors, the time of farrowing comes earlier and it is more synchronized than in those years with poor food availability. The study was conducted in southern France in an area where most of the wild boar's food consists of acorns and where the oaks' seed productivity varies by year. Under the conditions of the Czech Republic, the factor of food availability could be taken over, especially in the Kostelec area, by agricultural crops attractive for wild boar, and in particular corn grown for grain, whose share is very high in the Kostelec area but on the other side minimal in Šumava and the Doupov area, or possibly by year-round feeding of wild boar, which is practiced especially in the Doupov area. This effect of availability of food on the synchronization of farrowing was also reported for studies in Spain (Santos et al. 2006), Portugal (Fonseca et al. 2004) and Germany (Gethoffer et al. 2007). The study of Delcroix et al. (1990) shows an accurate synchronization in the reproductive processes within the social group of female wild boars, irrespective of the time of reproduction. It suggest the opinion, that in Doupov region can absent the dominate female. But on the other side, many of sudies describe the absence of adult male as main factor affecting the time of farrowing (Brooks, Cole 1970; Walton 1986; Fernandéz-Llario, Mateos-Quesada 2005).

CONCLUSION

Environmental conditions influence the physical development of wild boar. The results suggest that the differences between areas vary considerably, and these increase with age. This may result in an earlier (Kostelec area) or later (Šumava) involvement of juvenile individuals in reproduction. Thus, the areas may significantly differ in their population dynamics. This finding is important for determining the appropriate management of a game population that is now a major issue in professional circles. As the main management suggestion is stopped the increasing of population density in all study regions, and change the social and age structure on behalf of dominant female and adult males in the Doupov and Šumava region.

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