IN VIVO ASSESSMENT OF GROWTH TRAITS AND MEAT PRODUCTION IN CHAROLLAIS AND KENT LAMBS*

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The objective of this study was to determine the effect of lambing year, month of lambing, sex of lamb, sire effect, dam's age effect, and effect of litter size on the indicators of meat production of Charollais and Kent breeds. The evaluation was conducted between the years 2009–2011, when 591 of Charollais and Kent lambs were monitored. The lambing year had a significant effect only on birth weight. Similarly, the month of lambing was manifested in significant birth weight differences. We observed a higher growth intensity in lambs born in spring (March, April). These ram-lambs had greater birth weight, live weight at 100 days of age, average daily gains from birth to 100 days of age, and *musculus longisimus lumborum et thoracis* (MLLT) depth compared with ewe-lambs. Similarly, a greater fat thickness was measured in ram-lambs. Comparing individual sires, the most significant differences were obvious in birth weight, in MLLT depth, and in fat thickness. On the other hand, the highest growth abilities and the lowest fat thickness were observed in sheep at the age of 4 years. Comparing litter size, the highest attributes were achieved in singles rather than in twins and triplets.

sheep; meat utility; ultrasound measurement; growth parameters

INTRODUCTION

The Charollais breed is classified among meat type-sheep. Horák et al. (2007) noted that from the viewpoint of meat utility, it belongs to the best breeds overall. This is confirmed by the data of Performance Recording: live weight at 100 days of age 30.4 kg and daily gain from birth to 100 days of age 270 g (Bucek et al., 2011). Horák et al. (2007) noted very good reproduction parameters, and Bucek et al. (2011) added the accurate fertility value of 162.3% in the pure-bred population. Horák et al. (2007) defined the Kent breed as resistant, undemanding, combined (wool-meat), exhibiting good pasture abilities. Bucek et al. (2011) specified the growth abilities – 29.6 kg in live weight at 100 days of age and 264 g in daily gain from birth to 100 days of age, while fertility in the pure-blood population amounted to 153.6%.

Although the average consumption of mutton in the Czech Republic reaches 0.25 kg per capita (Roubalová, 2011), which is deeply below the average of the EU, meat utility determinates the economy in sheep breeding. This is reflected in the composition of sheep population when almost 90% of sheep in the Czech Republic belong to the combined- and meat-type. Pinďák, Milerski (2007) state that loin, lower back, and rump belong to the most valuable slaughter parts of the carcass (influencing the meatiness of the carcass as a whole).

Meat parameters and meat quality are annually recorded by the Association of Sheep and Goat Breeders. These indicators are influenced by many other effects, as demonstrated by Navajas et al. (2008), Bünger et al. (2009), Kuchtík et al. (2010, 2011), Ptáček et al. (2011), and Štolc et al. (2011). In the present study we investigated the effects of year and month of lambing, gender of lamb, bloodline of Sire, age of ewe and litter size in the meat-type sheep Charollais and combined-type (wool-meat) sheep Kent.

Hypothesis: Meat production parameters in lambs are influenced by the following internal and external factors: race, sire of lamb, age of ewe, sex of lamb, litter size, year and month of lambing.

MATERIAL AND METHODS

The farm selected for the study is situated at the foothills, ca. 600 m above sea level. The farm manages a total area of 1684 ha of agricultural farmland, and the basic stock numbers about 350 Charollais ewes, 35 Charollais rams, 200 Kent ewes, and 12 Kent rams. In this area, the average annual rainfall and temperature reports are ca. 518 mm and 7.8°C respectively. From

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May to October the sheep are kept only on pasture without the possibility of housing in sheep pens and thus the feeding ration of ewes is composed of pasture only. From November to April the sheep are housed in sheep pens, and the feeding ration is composed of hay (*ad libitum*) and haylage (3.0 kg/day per ewe). The feeding ration of lambs consists of mother's milk, from the 1st week of age supplemented with concentrates (called early weaning of lambs in a quantity of 300 g per lamb), and of hay (*ad libitum*) offered via lamb creep.

The monitoring was performed as a field test within a pure-bred population of Charollais and Kent sheep. Data of the Performance Recording and records from the selected farm from 2009–2011 were kept, and 591 lambs of both breeds (460 Charollais and 131 Kent) were monitored in all. Lambs were born from the mating of nine Charollais and two Kent rams (eleven different bloodlines).

A total of 111 lambs were born to sheep at the age of 1–2 years (mainly primiparous), 123 lambs to ewes at the age of 3 years, 135 lambs to ewes at the age of 4 years, 102 lambs to ewes at the age of 5 years, and 120 lambs to ewes at the age of 6 years and more (6+). Finally we grouped one- and two- year-old sheep and six and more year-old ewes due to a low number of sheep at these age categories.

Lambs' birth weight (BW) and live weight at 100 days of age (LW 100) – weighed on scales for small ruminants (kg) – were recorded. Lambs were weighed from 80 to 120 days of age, and the age was recalculated by linear interpolation on an average of 100 days. Subsequently the daily gain from birth to 100 days of age (DG 100) was calculated.

The muscle depth (*musculus longisimus lumborum et thoracis* – MLLT) (mm) as well as fat thickness on the back behind the last rib at 100 days of age (mm) were measured using ultrasound Aloka 500 (Hitachi Aloka Medical, Ltd.; Tokyo; Japan) and a 5 MHz linear probe.

In accordance with these variables, the influence of lambing year, month of lambing, sex of lambs, sire effect, age of ewe, and litter size were evaluated. Statistical evaluation was performed using the Statistical Analysis System (GLM Procedure) (SAS/STAT®, Version 9.1., 2009).

$$Y_{ijklmop} = \mu + A_i + B_j + C_k + D_l + F_m + G_o + e_{ijklmop}$$

where:
$Y_{ijklmop}$ = value of dependent variable (birth weight, weight at 100 days of age, daily gain from birth to 100 days of age, MLLT depth, fat thickness)
μ = general value of dependent variable
A_i = fixed effect of i^{th}-year of lambing (i = 2009, n = 193; i = 2010, n = 195; i = 2011, n = 203)
B_j = fixed effect of j^{th}-month of lambing (j = January, n = 172; j = February, n = 58; j = March, n = 204; j = April, n = 157)
C_k = fixed effect of k^{th}-lamb gender (k = ram-lambs, n = 289; k = ewe-lambs, n = 302)
D_l = fixed effect of l^{th}-bloodline of sire (l = Charis, n = 37; l = Chinin, n = 26; l = Chiron, n = 26; l = Chleb, n = 24; l = Chlor, n = 67; l = Chlost, n = 64; l = Chotik, n = 122; l = Christian, n = 44; l = Chural, n = 50; l = Knop, n = 38; l = Storm, n = 93)
F_m = fixed effect of m^{th}-age of ewe (m = 1st and 2nd years of age, n = 111; m = 3 years of age, n = 123; m = 4 years of age, n = 135; m = 5 years of age, n = 102; m = 6 years of age and more, n = 120)
G_o = fixed effect of o^{th}-litter size (o = singles, n = 179; o = twins, n = 377; o = triplets, n = 35)
$e_{ijklmop}$ = residual error

Table 1. Effects of year of lambing, month of lambing, and sex of lambs on selected attributes

	BW (kg) LSM ± SEM	LW 100 (kg) LSM ± SEM	DG 100 (g) LSM ± SEM	MLLT (mm) LSM ± SEM	Fatness (mm) LSM ± SEM
Year of lambing					
A. 2009 (n = 193)	3.12 ± 0.085^{bC}	27.51 ± 2.090	265.59 ± 24.675	23.26 ± 1.515	3.61 ± 0.844
B. 2010 (n = 195)	3.08 ± 0.073^{a}	27.06 ± 1.948	222.64 ± 22.316	23.04 ± 1.340	3.03 ± 0.746
C. 2011 (n = 203)	2.94 ± 0.075^{A}	27.17 ± 2.018	219.59 ± 23.563	22.91 ± 1.447	2.91 ± 0.806
Season (month) of lambing					
A. Jan (n = 172)	3.08 ± 0.069	25.24 ± 2.399	194.88 ± 28.844	21.05 ± 1.742	2.70 ± 0.970
B. Feb (n = 58)	3.20 ± 0.097	26.68 ± 2.364	208.81 ± 27.800	22.00 ± 1.670	3.02 ± 0.930
C. March (n = 204)	3.17 ± 0.057^{d}	27.85 ± 1.338	261.57 ± 15.603	24.48 ± 0.946	3.50 ± 0.527
D. April (n = 157)	2.99 ± 0.084^{c}	29.22 ± 1.473	278.52 ± 17.306	24.74 ± 1.046	3.52 ± 0.583
Sex of lambs					
A. ram-lambs (n = 289)	3.16 ± 0.049^{b}	28.46 ± 0.826^{B}	247.71 ± 8.763^{B}	23.45 ± 0.528^{b}	3.23 ± 0.294
B. ewe-lambs (n = 302)	3.06 ± 0.050^{a}	26.03 ± 0.890^{A}	224.17 ± 9.501^{A}	22.69 ± 0.577^{a}	3.14 ± 0.321

BW = birth weight, LW 100 = live weight at 100 days of age, DG 100 = daily gain from birth to 100 days of age, MLLT = MLLT muscle depth, fatness = fat thickness, LSM = least square means, SEM = standard error of means

a, b, c, d, e – P < 0.05, A, B, C, D, E – P < 0.01 (different letters confirm statistical significance)

Differences among the variables were evaluated at the levels of statistical significance of $P < 0.05$ and $P < 0.01$.

RESULTS

Effect of lambing year

The year of lambing had a significant effect only on BW ($P < 0.05$; 0.01), as presented in Table 1. The highest BW was recorded in 2009, when differences in this parameter fluctuated between 0.04 kg ($P < 0.05$) and 0.18 kg ($P < 0.01$). No other statistically significant differences were found in all the indicators evaluated, although we observed differences in average values in the years 2009–2011 in the meat parameters: LW 100 0.11–0.45 kg; DG 100 3.05–46.00 g; MLLT 0.13–0.35 mm, and fat thickness 0.12–0.70 mm.

Effect of lambing month

Lambs on the selected farm were born from January to April, as presented in Table 1. The first two months represent the winter lambing system, and the second two months the spring lambing system. We observed that statistically significant differences in lambing month – and related lambing systems – were recorded in BW only, and only between March and April ($P < 0.05$), which means two spring lambing system months. Statistically significant differences in other meat parameters evaluated were not evident. Nevertheless, after more detailed analysis of the results in Table 1, we observed higher average values of other meat indicators in the months representing spring lambing compared with those representing winter lambing system ($P > 0.05$). A systematic increase in the evaluated indicators connected with later months of lambing was found. Thus, the highest values of LW 100, DG 100, and MLLT depth were obtained in April, while the lowest were found in January. This increase also applied to fat thickness. Namely, the differences in the month observed amounted to an average of 1.17–3.98 kg in LW 100, 52.76–83.64 g in DG 100, 2.48–3.69 mm in MLLT depth, and 0.48–0.82 mm in fat thickness.

According to the results presented, we can summarize that the spring lambing system is more advantageous for the growth intensity of lambs, although the results cannot be statistically confirmed at the levels of $P < 0.05$ and $P < 0.01$.

Effect of lamb's sex

According to Table 1, the sex of the lambs influenced all meat parameters except for fat thickness. Ram-lambs had BW on the average by 0.1 kg higher than ewe-lambs ($P < 0.05$). Also, ram-lambs had LW 100 by 2.43 kg and DG 100 by 23.54 g higher on the average compared to ewe-lambs ($P < 0.01$). An interesting finding was an average lower level of back fat in ewe-lambs (–0.09 mm), although the statistical difference cannot be considered significant at $P < 0.05$ and $P < 0.01$.

Effect of sire

In accordance with the results presented in Table 2, we can observe the influence of sire effect in the stud. There were found differences among sires within the evaluated breed as well as among sires of both races

Table 2. The sire effect on selected attributes

	BW (kg) LSM ± SEM	LW 100 (kg) LSM ± SEM	DG 100 (g) LSM ± SEM	MLLT (mm) LSM ± SEM	Fatness (mm) LSM ± SEM
Sire effect (blood line of sire)					
A. Charis (n=37)	3.46 ± 0.120^{EFGHiJ}	27.19 ± 1.726	235.26 ± 17.184	22.77 ± 1.069^{e}	3.09 ± 0.595^{B}
B. Chinin (n=26)	3.37 ± 0.137^{eFghJ}	27.36 ± 1.864	237.71 ± 18.500	22.26 ± 1.130^{e}	4.58 ± 0.629^{Adefgi}
C. Chiron (n=26)	3.24 ± 0.124^{fJ}	26.18 ± 1.664	223.75 ± 16.854	23.33 ± 1.095	2.90 ± 0.610
D. Chleb (n=24)	3.31 ± 0.135^{fgJ}	28.49 ± 1.783	248.45 ± 17.767	23.56 ± 1.093	3.31 ± 0.609^{b}
E. Chlor (n=67)	3.05 ± 0.087^{AbJk}	27.82 ± 1.154	240.89 ± 11.805	25.17 ± 0.714^{abijK}	3.09 ± 0.398^{b}
F. Chlost (n=64)	2.87 ± 0.086^{ABcdjK}	28.10 ± 1.384	243.46 ± 14.334	23.70 ± 0.892	2.98 ± 0.497^{b}
G. Chotik (n=122)	2.97 ± 0.078^{AbdJK}	27.29 ± 1.191	236.19 ± 12.249	23.65 ± 0.763	2.93 ± 0.425^{b}
H. Christian (n= 44)	3.01 ± 0.135^{Abjk}	28,03 ± 3,410	228.19 ± 40.206	25.63 ± 2.449	3.43 ± 1.363
I. Chural (n=44)	3.06 ± 0.109^{aJ}	28.16 ± 1.469	242.65 ± 15.114	23.13 ± 0.961^{e}	2.87 ± 0.535^{b}
J. Knop (n=38)	$2.55 \pm 0.132^{ABcDEfGhIK}$	23.42 ± 4.278	158.43 ± 51.336	18.89 ± 3.111^{e}	1.93 ± 1.732
K. Storm (n=93)	3.32 ± 0.090^{eFGhJ}	27.67 ± 1.705	240.40 ± 17.156	21.66 ± 1.072^{E}	3.92 ± 0.597

a, b, c, d, e – P < 0.05; A, B, C, D, E – P < 0.01; different letters confirm statistical significance. Key: BW – birth weight; LW 100 – live weight at 100 days of age; DG 100 – daily gain from birth to 100 days of age; MLLT – the MLLT muscle depth; fatness – the fat thickness evaluated (sires of bloodlines Charis-Chural were Charollais breed, those of bloodlines Knop-Storm were Kent breed). Statistically significant differences were apparent in BW, MLLT depth, and fat thickness ($P < 0.05–0.01$). The lowest BW was recorded in the Kent sire Knop bloodline. The differences in these parameters were statistically more significant in all the other bloodlines evaluated (thus in both breeds evaluated). The differences ranged from 0.32 to 0.82 kg ($P < 0.05–0.01$). Statistically higher differences in the MLLT depth were found in the Chlor bloodline compared with Charis sire (+ 2.4 mm; $P < 0.05$), Chinin sire (+ 2.91 mm; $P < 0.05$), Chural sire (+ 2.04 mm; $P < 0.05$), Knop sire (+ 6.98 mm; $P < 0.05$), and Storm sire (+ 3.51 mm; $P < 0.01$). The most distinct differences were recorded in the two last-mentioned sires (both are representatives of the Kent breed). MLLT depth is an important indicator of the overall meatiness of a lamb. This factor allows us comparsion of the key meat production between both breeds. Despite lower MLLT depth ($P < 0.05–0.01$) compared with the Chlor bloodline, the Kent bloodline showed lower average values in MLLT depth compared with other Charollais sires (6.74–0.60 mm; $P > 0.05$). Although statistically significant differences in fat thickness were observed at $P < 0.05$ and 0.01, they were not recorded between the breeds. Rather statistically significant differences ($P < 0.05–0.01$) were apparent just among Charollais sires.

Dam's age effect

The effects of dam's age and litter size on selected meat production parameters are presented in Table 3. The age of the dam had a significant effect ($P < 0.05–0.01$) on all monitored indicators except for fat thickness. The lowest values were achieved in groups of 1–2-year-old and 6+ year-old sheep. The first group, 1–2-year-olds, was composed mainly of primiparous sheep, because of the mating system on the selected farm. Ewe-lambs are not introduced to the ram in the first year of life, and thus the first lambing comes in the second year of age.

Culmination in meat production was evident in 4–5 year-old sheep, where, compared with other sheep groups, definitely the highest LW 100 and DG 100 ($P < 0.05–0.01$) were observed. Precisely at the age of 4 years the ewes exceeded the selected parameters (0.41–2.56 kg in LW 100, 3.87–24.38 g in DG 100, and 1.00–2.45 mm in MLLT depth). Along with with the highest growth indicators in ewes at the age of 4 years, we found the lowest fat thickness overall (0.06–0.41 mm; $P > 0.05$). These results made this group the most appropriate one for lamb production, for example in insemination or embryotransfer performed in practice. Ewes at the age of 5 years also showed excellent meat parameters as mentioned before. These sheep exceeded the groups of 1–2- year, 3-year, and 6 or more-year-old sheep with more than 1.59–2.15 kg in LW 100, 13.97–20.51 g in DG 100, and 0.25–1.45 mm in MLLT depth. It is necessary to mention that in this group of ewes exhibited the highest fat thickness (+ 0.04–0.41 mm). Group 6+ was found to be the least suitable group of ewes with the lowest growth intensity (LW 100, DG 100, and MLLT depth) and fat thickness.

From the viewpoint of commercial studs it is acceptable to keep sheep above the 5th year of age. In the case of pedigree studs – the primary objective is to produce pedigree rams and ewe-lambs – we can definitely recommend culling sheep with regard to their age as presented in Table 3.

Effect of litter size

The effect of litter size influences all meat indicators as presented in Table 3 and thus it proved to

Table 3. Effects of age of dams and litter size on selected attributes

	BW (kg) LSM ± SEM	LW 100 (kg) LSM ± SEM	DG 100 (g) LSM ± SEM	MLLT (mm) LSM ± SEM	Fatness (mm) LSM ± SEM
Age of sheep					
A. 1st and 2nd year of age (n = 111)	2.78 ± 0.072^{BCDE}	26.21 ± 1.033^{Cd}	230.84 ± 10.492	22.59 ± 0.647^{C}	3.07 ± 0.361
B. 3rd year of age (n = 123)	3.11 ± 0.063^{A}	26.75 ± 1.058^{c}	230.90 ± 11.051	23.11 ± 0.673^{ce}	3.06 ± 0.375
C. 4th year of age (n = 135)	3.23 ± 0.067^{A}	28.75 ± 0.981^{AbE}	248.74 ± 10.341^{E}	24.36 ± 0.623^{AbE}	3.00 ± 0.347
D. 5th year of age (n = 102)	3.21 ± 0.064^{A}	28.34 ± 0.983^{ae}	244.87 ± 10.379^{e}	23.36 ± 0.631	3.41 ± 0.351
E. 6+ years of age (n = 120)	3.22 ± 0.066^{A}	26.19 ± 1.026^{Cd}	224.36 ± 10.746^{Cd}	21.91 ± 0.655^{bC}	3.37 ± 0.365
Litter size					
A. singles (n = 179)	3.68 ± 0.051^{BC}	31.70 ± 0.854^{BC}	274.17 ± 9.121^{BC}	26.00 ± 0.551^{BC}	3.84 ± 0.307^{cB}
B. twins (n = 377)	3.07 ± 0.038^{AC}	26.80 ± 0.719^{Ac}	231.30 ± 7.937^{Ac}	22.49 ± 0.478^{Ac}	3.13 ± 0.266^{A}
C. triplets (n = 35)	2.58 ± 0.104^{AB}	23.24 ± 1.539^{Ab}	202.36 ± 15.504^{Ab}	20.71 ± 0.947^{Ab}	2.58 ± 0.528^{a}

a, b, c, d, e – $P < 0.05$; A, B, C, D, E – $P < 0.01$; different letters confirm statistical significance. Key: BW – birth weight; LW 100 – live weight at 100 days of age; DG 100 – daily gain from birth to 100 days of age; MLLT – the MLLT muscle depth; fatness – the fat thickness be very significant. The highest values were clearly achieved by singles ($P < 0.01$). BW of singles was by 0.61 kg higher compared with twins ($P < 0.01$) and even by 1.1 kg higher compared with triplets ($P < 0.01$). Concerning the other evaluated parameters, growth abilities of singles exceeded 8.46 kg in LW 100, 71.81 g in DG 100, and 5.29 mm in MLLT depth. All these results were obtained comparing singles with triplets ($P < 0.01$). Along with the highest growth abilities, singles also showed the highest fatness; differences between singles and twins or triplets in fat thickness amounted to 0.71 mm ($P < 0.01$) or 1.26 mm ($P < 0.05$). While high statistical differences among lambs coming from singles and twins were demonstrated at $P < 0.01$, differences among twins and triplets at the same level of significance appeared only in BW. Other growth intensity indicators (LW 100, DG 100, and MLLT depth) were demonstrated at $P < 0.05$. Values in the twins compared to those in the triplets were by 3.56 kg in LW 100, 28.94 g in DG, and by 1.78 mm in MLLT depth higher. Statistically significant differences among lambs coming from twins and triplets did not appear, although in general fat thickness in triplets was by 0.71 mm lower. Concerning litter size, interestingly only 35 lambs were born as triplets, twins appeared in 63.8 and singles in 30.1%.

DISCUSSION

Effect of lambing year

The importance of the lambing year is a commonly accepted effect confirmed by a wide range of authors. The effect of lambing year on BW was obvious not only in this study, but its significance was confirmed by Mavrogenis (1996), Suarez et al. (2000), Ptáček et al. (2011), and Štolc et al. (2011). On the other hand, Momani (1995) considered the effect of year on BW nonsignificant.

Of the other meat utility indicators evaluated, no statistically significant differences were obvious ($P < 0.05$ and 0.01). These results are in contradiction with those of a wide range of authors, e.g. Demirören et al. (1995), Mavrogenis (1996), Suarez et al. (2000), Ptáček et al. (2011), and Štolc et al. (2011). Ptáček et al. (2011) found statistically significant differences in LW 100 and DG 100. Štolc et al. (2011) described statistical significance even in all the parameters evaluated in our study. Mavrogenis (1996) confirmed high statistically significant differences of the year's effect on weight at 105 days of age and on daily gains. Krame, Vangen (2007) documented the effect of year on MLLT depth and on the fat thickness.

We can describe the year 2009 as the most successful year from the breeding point of view. This year the highest growth abilities of all the meat indicators evaluated were apparent.

A generally positive finding is an increase in lambs' growth indicators at 100 days of age during the period monitored. This can be explained by genetic progress (a positive breeding program) and by procedures collectively described as herd management. Unfortunately, within the monitored herd this progress was not observed ($P < 0.05$–0.01). Although statistically significant differences ($P < 0.05$–0.01) were obvious in BW only, we can state that it is an important factor, which is supported by the variability of individual parameters in particular years ($P < 0.05$) and by a wide range of literary sources.

Effect of lambing month

Month of lambing did not have a significant effect on all the indicators evaluated. Nevertheless, there are many studies confirming the significance of this effect. Yilmaz et al. (2007) stated that lambs born in winter had higher BW ($P < 0.01$) than lambs born in spring. In our study the value of BW in particular months notably varied, without any trend. However, some trends in the results ($P > 0.05$) were apparent in LW 100, DG 100, and MLLT depth. In addition, in the spring lambing systems (March and April) the highest average values were attained. These results confirm those of Yilmaz et al. (2007), Kuchtík et al. (2010), and Ptáček et al. (2011).

In accordance with the above results, we can summarize that lambs born from the spring lambing systems showed higher growth intensity (BW, LW 100, and DG 100) and lower fat thickness. This evidences the suitability of the spring lambing system. The foundation of the spring lambing system was supported by Mátlová, Loučka (2002), who saw its advantages in higher reproductive activity of dams and sires and a better assumption of lactation in connection with better forage quality. They also emphasized that this system of lambing uses forage for feeding ewes in lactation and lambs, which decreases the total input in lambs' rearing. We suppose that one of the key factors affecting the growth intensity of lambs is food ration in the particular systems of lambing.

Effect of lamb's sex

Horák et al. (2007) mentioned that ram-lambs used to be by 7% heavier compared with ewe-lambs. According to Yilmaz et al. (2007), ram-lambs had by 0.5 kg higher BW than ewe-lambs, which is in agreement with our study. Gootwine, Rozov (2006) and Esmailizadeh et al. (2011) also presented identical conclusions. Higher live weight at rearing (90 days of age) in ram-lambs was also presented by Yilmaz et al. (2007). Along with live weight, they documented higher daily gain from birth till rearing, which is in agreement with our study as well. Ram-lambs also reached higher DG 100 in studies published by Ptáček et al. (2011) and Štolc et al. (2011). These statements are not in full agreement with Kuchtík et al. (2010, 2011), who did not find statistically significant differences in growth abilities from the viewpoint of lambs' sex, although from their studies it follows that ram-lambs showed higher daily gains as well.

MLLT depth together with growth abilities are important indicators reflecting the entire meatiness of lambs. According to our results, we can say that ram-lambs had higher LW 100, DG 100 ($P < 0.01$), and MLLT depth ($P < 0.05$) compared with ewe-lambs. Just the MLLT depth is in opposition to studies by Ptáček et al. (2011) and Štolc et al. (2011). They found higher MLLT depth in ewe-lambs reflecting their greater meatiness ($P > 0.05$). Higher meatiness in ewe-lambs was also confirmed by Stanford et al. (2001) and Johnson et al. (2005). Growth allometry of individual parts of ram-lambs and ewe-lambs was mentioned by Horák et al. (2005).

Jeremiah et al. (1998) found lower fatness of ram-lambs compared with ewe-lambs. In our study,a lower fat thickness exhibited ram-lambs. This is in contrary to many other studies, among others, those by Ptáček et al. (2011) and Štolc et al. (2011). In agreement with our study are, on the other hand, Stanford et al. (2001), who noticed higher fat thickness in ram-lambs at the age of 105 days.

According to this study, better nutrient conversion was evident in ram-lambs ($P < 0.01$). The entire fatness of the carcass increased at the same time, which is documented by greater fat thickness. Separate fattening of lambs (based on the sex of lambs) is not common in practice. Despite this claiming we summarized that ram-lambs yield 92.34 CZK higher takings per lamb compared with ewe-lambs (in average mutton purchase price 38 CZK per kg). The realization of mutton in Czech Republic is dominantly in firmly live (butcher lambs) or firmly in dead (carcasses). These systems do not include meat quality despite the fact that the SEUROP system has been methodically described in detail in the Czech Republic (Pulkrábek, 2003).

Effect of sire

We described 11 different sires of two breeds. In the Czech Republic, the Kent breed is classified as a combined-type breed, while the Charollais breed is a typical representative of a meat-type breed. Sire effect was obvious in BW which was in agreement with Esmailizadeh et al. (2011). According to their study, the breed of the sire influenced live weight at 90 days of age. Comparing sires both within and between the particular breeds, we cannot confirm the results of Esmailizadeh et al. (2011) at $P < 0.01$ and 0.05 in DG 100 and LW 100. On the other hand, our results are in agreement with those of Momani et al. (1995), values evaluated at 130 days of age. On the contrary, Štolc et al. (2011) point out the significant influence of the sire in LW 100 and DG 100 at $P < 0.05$.

Differences in the MLLT depth were significant only in one sire ($P < 0.05$ and $P < 0.01$), both within and between the particular breeds. Statistically significant differences in MLLT depth were published also by Štolc et al. (2011). In close connection with MLLT depth, we can mention the study by Navajas et al. (2008), who refer to sire effect in meatiness evaluation. Similarly, Štolc et al. (2011) confirmed the influence of sire effect on fat thickness ($P < 0.01$). In our study, statistical differences were also obvious in fat thickness ($P < 0.01$), but the differences were found in sires within the Charollais breed. This finding is interesting in terms of the claimis of Horák et al. (2007), who pointed out the distinctive fatness in the Kent breed.

Dam's age effect

The group of 1–2-year-old sheep along with the group of 6+ ewes belonged to the groups with the lowest meat utility of lambs ($P < 0.01$). The group of 1–2-year-old sheep was composed mostly of primiparas. The effect of dam's age was confirmed by Peeters et al. (1996), who noted that lambs coming from yearlings had lower BW and growth abilities. This fact is also documented by Jakubec et al. (2001) and Esmailizadeh et al. (2011), who noted that older ewes use to have heavier lambs compared with younger sheep.

In agreement with our study were Cloete et al. (2002), who reported that BW increases with the age of sheep. There was an increase in meat performance of lambs in sheep of the monitored stud until the 4^{th} year of age. At the age of five there was a weak decrease of meat production of lambs; nevertheless, all the indicators were still higher than in the group of 1–2-year-old sheep. The influence of ewes' age on gain from birth to 30 days of age is also affirmed by Momani et al. (1994).

Effect of litter size

Jakubec et al. (2001), Gootwine, Rozov (2006), and Horák et al. (2007) found the highest BW in singles. This is in accord with our study. Statistically very significant differences ($P < 0.01$) were obvious among singles and twins and singles and triplets. Depending on litter size of lambs, Horák et al. (2007) noticed that BW of twins ranged 3–3.5 kg and BW of triplets made 2–3.5 kg. According to the results published in our study, we can definitely confirm their claim, because BW of lambs was exactly in the range published by Horák et al. (2007). This opinion is also in agreement with Gootwine (2005), who claimed that BW decreases with increasing litter size. As a possible explanation of this fact Gootwine (2005) noted that with increasing litter size each fetus gets a lower supply of nutrients and lower metabolite lysis.

Higher LW 100 in singles was also documented by Kuchtík et al. (2010). On the other hand, statistically significant differences among twins and multiple litters were not shown. Higher LW 100 in singles at $P < 0.01$ was documented in our study, while differences among twins and triplets were shown at $P < 0.05$. Identical results among singles and twins were also presented by Suarez et al. (2000).

An explanation of the differences in growth abilities of lambs coming from various litter sizes Snowder, Glimp (1991) saw in their different opportunities of milk suckling. In singles milk consumption is almost equal to *ad libitum*, while in twins or triplets milk production of sheep is influenced by the rate of milk production as a limiting factor.

CONCLUSION

In the present study the influence of year of lambing, month of lambing, sex of lamb, sire effect, effect of age of dam and litter size on selected meat production parameters were evaluated. The evaluation took place within the years 2009–2011 when 460 Charollais and 131 Kent lambs were observed. Statistically significant differences were obvious in all the evaluated parameters, although statistical differences in the year of lambing and month of lambing were recorded only in BW. More important was the comparison of the sex of lambs. Ram-lambs were born more frequently and had higher growth intensity (LW 100, DG 100, MLLT depth) compared with ewe-lambs ($P < 0.05$ and 0.01). Also, fat thickness was greater in ram-lambs ($P < 0.05$). Sire effect influenced BW, MLLT depth, and fat thickness ($P < 0.05$ and 0.01). In evaluation of sire effect we also compared two different sheep breeds (Charollais and Kent). Sheep at the age of 1 and 2 years together with the group of 6+ ewes showed the lowest indicators of all evaluated parameters. The highest meat performance was observed in sheep at the age of 4 and 5 years. We can state a definite conclusion concerning the effect of litter size. Singles showed the highest values in all the evaluated parameters, compared with twins as well as triplets ($P < 0.01$). Similarly, statistically significant higher differences were observed also between twins and triplets. The study comparing two breeds under the same breeding conditions brought findings concerning qualitative and quantitative meat production parameters. Hopefully the gained knowledge will contribute to stud management (e.g. sheep lambing system, sheep culling).

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REFERENCES

Bucek P, Kvapilík J, Kölbl M, Milerski M, Hanuš O, Pinďák A, Mareš V, Kondrád R, Rafajová M, Roubalová M, Kuchtík J, Škaryd V (2011): Annual report of sheep and goat breeding in the Czech Republic in 2010. Czech-Moravian Breeders Society and Sheep and Goat Breeders Association in Czech Republic. July 2012, Prague.(in Czech)

Bünger L, Navajas EA, Stevenson L, Lambe NR, Maltin CA, Simm G, Fisher AV, Chang KC (2009): Muscle fibre characteristics of two contrasting sheep breeds: Scottish Blackface and Texel. Meat Science, 81, 372–381.

Cloete SWP, Scholtz AJ, Gilmour AR, Olivier JJ (2002): Genetic and environmental effects on lambing and neonatal behaviour of Dormer and SA Mutton Merino lambs. Livestock Production Science, 78, 183–193.

Demirören E, Shrestha JNB, Boylan WJ (1995): Breed and environmental effects on components of ewe productivity in terms of multiple births, artificial rearing and 8-month breeding cycles. Small Ruminant Research, 16, 239–249.

Esmailizadeh AK, Miraei-Ashtiani SR, Mokhtari MS, Asadi Fozi M (2011): Growth performance of crossbred lambs and productivity of Kurdi ewes as affected by the sire breed under extensive production system. Journal of Agricultural Science and Technology, 13, 701–708.

Gootwine E, Rozov A (2006): Seasonal effects on birth weight of lambs born to prolific ewes maintained under intensive management. Livestock Science, 105, 277–283.

Gootwine E (2005): Variability in rate of decline in birth weight as litter size increases in Sheep. Animal Science, 81, 393–398.

Horák F, Dobeš I, Loučka R, Mareš V, Milerski M, Novák V, Novotný L, Pinďák A (2005): Texel – significant meat type breed of sheep. Sheep and Goat Breeders Association and Texel Breed Club. (in Czech)

Horák F, Axmann R, Červený Č, Doležal P, Doskočil J, Jílek F, Loučka R, Mareš V, Mileski M, Pinďák A, Tůma J, Veselý P, Zeman L (2007): Sheep and their breeding. 1st Ed. Brázda Publishing House, Prague. (in Czech)

Jakubec V (2001): Sheep breeding. 1st Ed. Rapotín. (in Czech)

Jeremiah LE, Tong AKW, Gibson LL (1998): The influence of lamb chronological age, slaughter weight, and gender on flavor and texture profiles. Food Research International, 31, 227–242.

Johnson PL, Purchas RW, Mcewan JC, Blair HT (2005): Carcass composition and meat quality differences between pasture-reared ewe and ram lambs. Meat Science, 71, 383–391.

Krame T, Vangen T. (2007): Selection for lean weight based on ultrasound and CT in a meat line of sheep. Livestock Science, 106, 232–242.

Kuchtík J, Dobeš I, Hegedüšová Z (2010): Growth of lambs of crossbreeds of Romanov, Suffolk and Charollais breeds – effect of sex, litter size and season. Acta Universitatis Agriculturae et Silvicuturae Mendelianae Brunensis, 53, 233–238. (in Czech)

Kuchtík J, Dobeš I, Hegedüšová Z (2011): Effect of genotype, sex and size on growth and basic traits of carcass quality of light lambs. Acta Universitatis Agriculturae et Silvicuturae Mendelianae Brunensis, 54, 111–116. (in Czech)

Mátlová V, Loučka R (2002): Grazing system in sheep and goat breeding. Agrospoj, Praha. (in Czech)

Mavrogenis AP (1996): Environmental and genetic factors influencing milk and growth traits of Awassi sheep in Cyprus. Heterosis and maternal effects. Small Ruminant Research, 20, 59–65.

Momani MS, Sada I, Štolc L (1994): Reproductive characteristics and growth-rate in lambs of Charollais breed in the Czech Republic. Živočišná výroba, 39, 1021–1028. (in Czech)

Momani MS, Sada I, Stolc L, Vohradsky F, Vecerova D (1995): The effects of internal and external factors on lamb growth in Charollais breed. Živočišná výroba, 40, 149–153. (in Czech)

Navajas EA, Lambe NR, Fisher AV, Nute GR, Bünger L, Simm G (2008): Muscularity and eating quality of lambs: effects of breed, sex and selection of sires using muscularity measurements by computed tomography. Meat Science, 79, 105–112.

Peeters R, Kox G, Van Isterdael J (1996): Environmental and maternal effects on early postnatal growth of lambs of different genotypes. Small Ruminant Research, 19, 45–53.

Pinďák A, Milerski M (2007): Test of fattening and carcass value of sheep in field test condition in 2006. Zpravodaj Svazu chovatelů ovcí a koz, 1, 17–18. (in Czech)

Ptáček M, Štolc L, Stádník L (2011): The influence of selected factors on growth abilities and meat utility attributes of Suffolk and Charollais lambs. Výzkum v chovu skotu, 4, 49–61. (in Czech)

Pulkrábek J (2003): Classification of pig, cattle and sheep carcasses. 1st Ed., Institute of Agricultural Economics and Information, Prague. (in Czech)

Roubalová M (2011): The situational and outlook report sheep – goats. Ministry of Agriculture of the Czech Republic, Prague. (in Czech)

Snowder GD, Glimp HA (1991): Influence of breed, number of suckling lambs, and stage of lactation on ewe milk production and lamb growth under range conditions. Journal of Animal Science, 69, 923–930.

Stanford K, Bailey DRC, Jones SDM, Price MA, Kemp RA (2001): Ultrasound measurement of *longissimus* dimensions and backfat in growing lambs: effects of age, weight and sex. Small Ruminant Research, 42, 191–197.

Štolc L, Ptáček M, Stádník L, Lux M (2011): Effect of selected factors on basic reproduction, growth and carcass traits and meat production in Texel sheep. Acta Universitatis et Silviculturae Mendelianae Brunensis, 54, 247–252.

Suarez VH, Busetti MR, Garriz CA, Gallinger MM, Babinec FJ (2000): Pre-weaning growth, carcass traits and sensory evaluation of Corriedale, Corriedale X Pampinta and Pampinta lambs. Small Ruminant Research, 36, 85–89.

Yilmaz O, Denk H, Bayram D (2007): Effects of lambing season, sex and birth type on growth performance in Norduz lambs. Small Ruminant Research, 68, 336–339.

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