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FACTORS DETERMINING SURVIVABILITY TRAITS OF CHAROLLAIS, KENT LAMBS, AND THEIR CROSSBREDS DURING REARING

Anežka Málková[1], Martin Ptáček[1], Luděk Stádník[1], Jaromír Ducháček[1]

[1] Department of Animal Science, Faculty of Agrobiology, Food and Natural Resources, Czech University of Life Sciences Prague, Kamýcká 129, 165 00, Prague 6 - Suchdol, Czech Republic

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Abstract

The aim of this work was to evaluate the effect of birth weight on the survival of Charollais, Kent and their crossbreds in breeding and also on their meat performance for Charollais and Kent lambs. Data were evaluated for the six years period in the commercial flock. The total number of lambs used for evaluation was 1,197. The data were passed through the SAS STAT program using the MIXED method. In the model equation, all the dependent variables of the survival indicator were significantly statistically detectable with a significance level of $P < 0.01$. The results indicated that survivability lambs was significantly influenced by birth weight and litter size ($P < 0.05$). Meat performance of lambs was affected the most combined year and month, breed and litter size ($P < 0.05$). The results suggest better survivability abilities for the crossbred than the pure-bred population. Despite the lack of meat performance data, it is interesting to consider a possible selection program for the breeds, Charollais and Kent, to improve the survival of lambs for extending extensive farming methods. However, also by improving flock management we will achieve better survivability results for lambs.

Keywords: survivability, growth ability, birth weight, Charollais, Kent, crossbreds

INTRODUCTION

Production of healthy and strong lambs in optimal slaughter weight determinates an effective sheep farming management. Contrary, the lambs losses have an adversed effect on the breeding profitability, or genetic gain in the flock. Improvement can be achieved by animals selection, flock management modification, and reducing the risk factors for lamb mortality (Vostrý and Milerski, 2013; Getachew *et al*., 2015). Wolfová *et al*. (2009) estimated the economic loss at 2.1 euros per year per ewe; so the profit is in negative numbers without government subsidies. Their study shows a significant impact of lamb survivability, litter size and growth characteristics on the overall sustainability of breeding. Optimizing survivability traits is important in generally preffered extensive sheep farming with minimal inputs. This offers a possibility of crossing extensive breeds (mostly Kent: 3,127 ewes, and Sumava: 2,425 ewes according to official statistics; Bucek *et al*., 2019) in maternal position with intensive meat purpose breeds (mostly Suffolk: 4,245 ewes; Texel: 1,034 ewes, and Charollais: 403 ewes according to official statistics; Bucek *et al*., 2019) in terminal sire positions for finishing lambs production. In this sense the Charollais sheep shows a regular decrease across previous years; however, potential for lambs survivability should be in particular interest in its potential wider use with regards to prime finishing lambs production.

Heritability of overall lamb survival is around 0.28–0.39 and gradually decreases to 0.08 with the age of lamb (Riggio *et al*., 2008; Cloete *et al*., 2009). This offers a potential success on animal selection for these traits as to reduce the number of dead lambs. Above genetic predisposition, the lambs survivability is influenced by other genetic and non-genetic factors, such as breed (Mousa-Balabel, 2010), age of ewe (Aktaş *et al*., 2015), litter size (Ptáček *et al*., 2017), sex (Hatcher *et al*., 2009; Getachew *et al*., 2015), or birth weight (Ptáček *et al*., 2017). The importance of birth weight related to survivability traits confirmed previous studies (Greenwood *et al*., 2002; Thomson *et al*., 2004; Casellas *et al*., 2007; Schreurs *et al*., 2010) performed on Kent, Ripollesa, Merino breeds and their crossbreds or Suffolk crossbreds.

Above survivability and successful rearing of the lambs, the farms profits in meat flocks is also determined by lambs meat performance. Knowning, importance factors influencing the growth capacity of lambs, these traits are affected by lambs birth weight (Štolc *et al*., 2011; Ptáček *et al*., 2013; Aktaş and Doğan, 2014; Ptáček *et al*., 2015; Ptáček *et al*., 2017; Janoš *et al*., 2018). These are one of many factors that have a major impact on meat yields, and by monitoring and optimizing it is possible to achieve better rearing results and subsequent meat production (Çelik and Yilmaz, 2010).

The aim of this work is to monitor survivability traits in Charollais, Kent lambs and their crossbreds. Another aim was to determine the optimal birth weight for Charollais, Kent and their crossbreds with respect to subsequent survivability indicators, or meat performance respectively.

MATERIALS AND METHODS

Flock Management

The monitoring was carried out at a commercial meat sheep flock (Charollais, Kent, and their crossbreds) located at the Plzeň-sever district, Czech Republic (GPS – 49.9566583N, 13.1566792E, average annual temperature – 8.4 °C, average annual precipitation – 550–650 mm, inclination – moderate, 3–7 °C). In the grazing season (from April to mid-October), the main sheep nutritional requirements were provided by grazing pasture, with predominant grasses and clover species: *Lolium perenne, Festuca pratensis, Festuca rubra, Poa pratensis,* and *Trifolium repens* and *Trifolium pratense*. The pasture management was realized as rotational pasture with the maximum stocking rate of 3–4 livestock units per hectare in particular plots. Sheep had access to a light prefabricated canvas stable, ad libitum access to water, salt mineral licks and hay. In the non-grazing season (mid-October to April), the animals were housed in a brick sheepfolds and their feeding ration was composed of hay (ad libitum) and silage (3–5 kg). Additionally, feeding ration of pregnant and nursing ewes was enriched for molasses (50 ml per ewe per day) and extra mineral licks (Star Bloc BEBIGEST, MIKROP). All animals had ad libitum access to drinking water, hay, and mineral licks during the whole year. Lambs feeding ration was composed of ad libitum mother's milk, grassland pasture, hay (ad libitum) and concentrated feed in the average amount of 200 grams per head per day. The breeding season takes place using natural breeding from November to January. Lambing takes place from March to the first half of May in the sheepfold. After birth, the sheep were separated into the lambing pens for one to two days and then, after marking the lambs with ear tags, transferred to nurseries of about 10–12 ewes. In good climatic conditions, they were released to grazing pasture after 7–14 days of age.

Data Collection

The flock analysis included 1,197 Charollais, Kent and their crossbreds monitored over a six years period (2013–2018). Immediately after birth all lambs (dead and live) were weighed (BW, kg). All lamb losses were recorded across the period of their rearing (till 100 day of age), for estimation of parameters of live born lambs (LB, %), lambs weaned at 72 hours (WEAN72, %), lambs weaned at 14 days (WEAN14, %), and lambs weaned at 100 days (WEAN100, %).

In pure-bred populations of Charollais and Kent lambs the collected data were added about the lambs live weight at 100 days of age (LW100, kg), (Milerski, 2005), dorsal muscle depth (*musculus longisimus lumborum et thoracis*) at 100 days (MLLT100, mm) and subcutaneous backfat thickness at 100 days (BT100, mm), (Milerski, 2007). MLLT100 and BT100 were measured by ultrasound and 5MHz linear probe behind the area of last rib arch. Average daily gain at 100 days (ADG100, g) was calculated according to the formula:

$$\mathrm{ADG100} = [(\mathrm{LW100} - \mathrm{BW})/100] \times 1000. \quad (1)$$

Additionally, information about year of lambing, ewes age, sex of lambs, litter size, and lambing season were obtained from the farm's records.

Statistical Evaluation

Statistical analyses were performed in the statistical program SAS STAT, MIXED procedure. For evaluation of dependent variables live-born lambs, rearing up to 72 hours, rearing up to 14 days, rearing up to 100 days lamb age – the followed model equation was used. Results were visualized in forms of figures by MS Excell software.

$$Y_{ijklmn} = \mu + \mathrm{Year} - \mathrm{Season} + \mathrm{Breed}_i + \mathrm{Age}_j + \mathrm{Sex}_k + \mathrm{Litter\ size}_l + \mathrm{Birth\ weight}_m + e_{ijklmn}. \quad (2)$$

Y_{ijklmn}................dependent variable (LB, WEAN72, WEAN14, WEAN100);

Year – Season..combined randomized year seasonal effect (1–9 levels);
Breed................fixed effect of breed (i = Charollais, n = 729; i = Kent, n = 220; i = Kent × Charollais crossbreds, n = 257);
Age....................fixed effect of ewe's age (j = 1-year old and 2-year ewes, n = 271; j = 3-year old ewes, n = 314; j = 4-year old ewes, n = 267; j = 5-year ewes, n = 169; j = 6-year-old ewes, n = 106; j = 7-year-old and ewes, n = 109);
Lamb sex........fixed effect of lamb sex (k = males, n = 603; k = females, n = 631);
Litter size ....fixed effect of litter size (l = singles, n = 277; l = twins, n = 878; l = triplets, n = 81);
Birth weight ..fixed effect of lambs birth weight (m = birth weight 0.5–1 kg, n = 83; m = birth weight 1–2 kg, n = 89; m = birth weight 2–3 kg, n = 395; m = birth weight 3–4 kg, n = 242; m = birth weight 4–5 kg, n = 208; m = birth weight 5–6 kg, n = 79; m = birth weight 6–7 kg; n = 131);
e_{ijklmn}..................residual error.

The same statistical model, however, with different number of observation in particular classes was applied for meat performance characteristics analysis (live weight at 100 days of age, daily gain from birth till 100 days of age, MLLT depth and fat thickness lambs):

$$Y_{ijklmn} = \mu + \text{Year – Season} + \text{Breed}_i + \text{Age}_j + \text{Sex}_k + \text{Litter size}_l + \text{Birth weight}_m + e_{ijklmn}. \quad (3)$$

Y_{ijklmn} ....dependent variable (ADG100, LW100, MLLT100, BT100);
Year – Season..combined randomized year seasonal effect (1–9 levels);
Breed................fixed effect of breed (i = Charollais, n = 729; i = Kent, n = 220);
Age....................fixed effect of ewe's age (j = 1-year old and 2-year ewes, n = 271; j = 3-year old ewes, n = 314; j = 4-year old ewes, n = 267; j = 5-year ewes, n = 169; j = 6-year-old ewes, n = 106; j = 7-year-old and ewes, n = 109);
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e_{ijklmn}..................residual error.

Differences between variables were estimated by the Tukey-Kramer test at significance level of P < 0.05.

RESULTS

Model Description

Litter size and birth weight were major factors influencing lambs survivability traits as reported in Tab. I. Some support for significance (significant or close to significant) was also detected for ewe age category. Model for WEAN100 was significant also for factors of breed and sex of lambs above mentioned factors. Additionally, Tab. I shows in detail significance of evaluated factors for meat performance characteristics in purebred lambs population.

I: *Effects influences on survivability and meat performance of lambs*

Parameters	YEAR-MONTH	BREED	LS	SEX	AGE	BW0
LIVE	NS	NS	***	NS	NS	***
WEAN72	NS	NS	***	NS	0.059	***
WEAN14	NS	NS	***	NS	*	***
WEAN100	NS	**	0.08	*	0.08	***
LW100	***	***	***	***	***	***
MLLT100	***	***	***	NS	*	NS
BT100	***	NS	**	NS	NS	NS
ADG100	***	***	***	***	***	NS

* P < 0.05; ** P < 0.01; *** P < 0.001; NS – non significant
YEAR-MONTH – combined randomized year seasonal effect; BREED – breed of lambs; LS – litter size; SEX – sex of lambs; AGE – ewe's age; BW0 – birth weight; LB – live born lambs (%); WEAN72 – percentage of lambs weaned at 72 hours; WEAN14 – percentage of lambs weaned at 14 days; WEAN100 – percentage of lambs weaned at 100 days; LW100 – lambs live weight at 100 days of age; MLLT100 – MLLT (*musculus longisimus lumborum et thoracis)* depth at 100 days of age; BT100 – subcutaneous backfat thickness at 100 days; ADG100 – average daily gain at 100 days of age

Survivability Analysis

Fig. 1 shows lambs survivability traits in relation to lambs BW. Significantly lowest survivability was detected in lambs with a BW of 0.5–1 kg during the whole trial. This supported significant differences detected for these lambs in comparison to the all others evaluated groups concerning LB, WEAN72, and WEAN14 traits. Lambs with BW 1.1–2.0 kg reached similar survivability in comparison with heavier contemporaries during LB, and WEAN72; however, a noticeable significant decrease was noticed in WEAN14, and WEAN100 especially. On the end of the rearing period these lambs reached practically same survivability as did the lightness lambs with BW 0.5–1.0 kg. Exactly these two groups differed significantly at the end to all the heavier lambs. In general, the highest survivability of the lambs was observed in lambs weighing 4.1 kg and more. Their survivability was higher than 93% in all the monitored parameters ($P < 0.001$), and these lambs did not differ mutually in their survivability during the whole rearing period.

Other evaluated factors contributing to survivability can be found in Figs. 2–5 in detail. Significantly lowest LB, WEAN72, and WEAN14 was demonstrated for singles in comparison with multiple litters, however the difference overlapped with WEAN100. Contrary, opposed shape was demonstrated for sex of lambs when same results between sexes were demonstrated for LB, WEAN72, and WEAN14. Significant 4% decrease was demonstrated for males compared to females in WEAN100. Additionally, no significant differences were detected in lambs survivability in relation to ewe's age during the whole trial. Positive effect of crossbreds was demonstrating at the end of the rearing period (WEAN100) when these lambs differed significantly with both pure-bred Charollais (+ 9.7%) and Kent lambs (+ 8.1%) populations. Till this time similar lambs survivability were demonstrated for all threes lambs populations, despite of nonsignificantly lowest survivability in Charollais lambs.

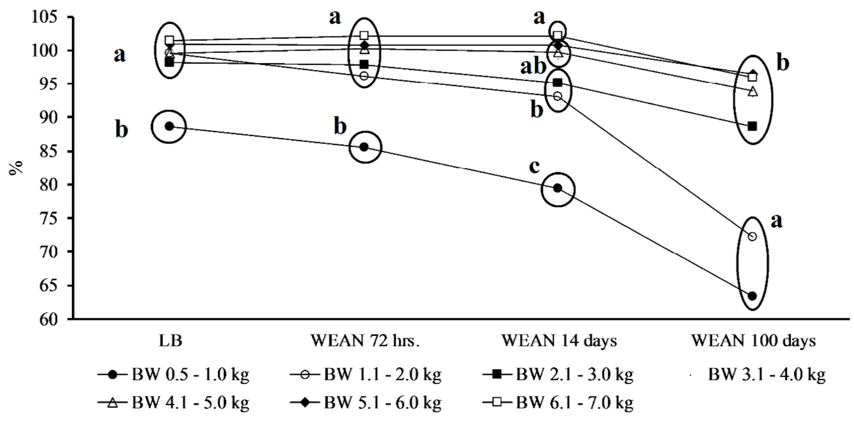
Growth Analysis

BW0 influenced only LW100 from all the evaluated meat performance characteristics. Significantly lowest LW100 was detected for lambs with a BW0 1.1–2 kg (25.87 kg). Significant differences were detected between these lambs and those in groups BW0 3.1–4 kg (28.38 kg), BW0 4.1–5 kg (29.11 kg), BW0 5.1–6 kg (29.62 kg) and BW0 6.1–7 kg (30.48 kg). Additionally, the highest LW100 (30.48 kg) had lambs with a birth weight of 6.1–7 kg. The difference between the lambs weighing 1.1–2 kg and 6.1–7 kg was 4.6 kg ($P < 0.05$).

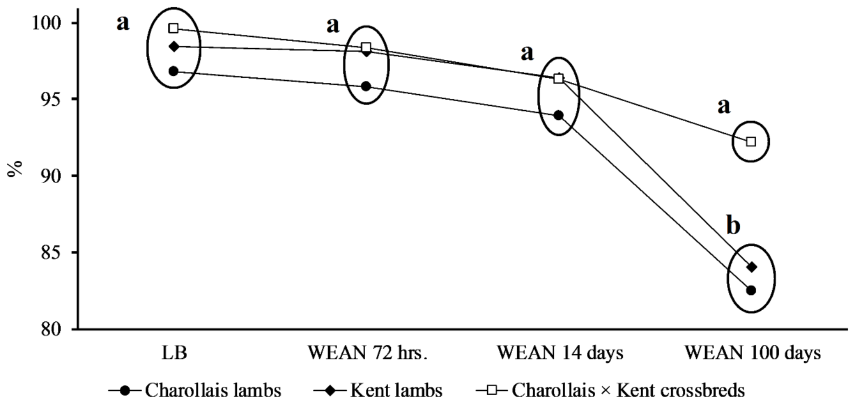
Tab. II shows the effects on the growth parameters of lambs. Significantly heigher ADG100 (+ 43.5–72.16 g), LW100 (+ 4.4–7.28 kg), MLLT100 (+ 2.44–4.08 mm), and BT100 (+ 0.63–0.84 mm) were observed in singles higher than in twins and triplets ($P < 0.05$), where triplets were significantly slower in terms of growth. In addition, a significant difference between males and females was found for indicators ADG100 and LW100 ($P < 0.05$); males had 22.8 g higher ADG100 and 2.3 kg higher LW100 than females.

The best results were achieved in lambs from 4 years old ewes (ADG100 263.94 g, LW100 29.94 kg, MLLT100 24.28 mm; $P < 0.05$). Lambs from 3-year-old ewes also had good results over 1-2-year-old ewes. Overall, 1 to 2-year-old ewes had a negative impact on the lamb's meat performance.

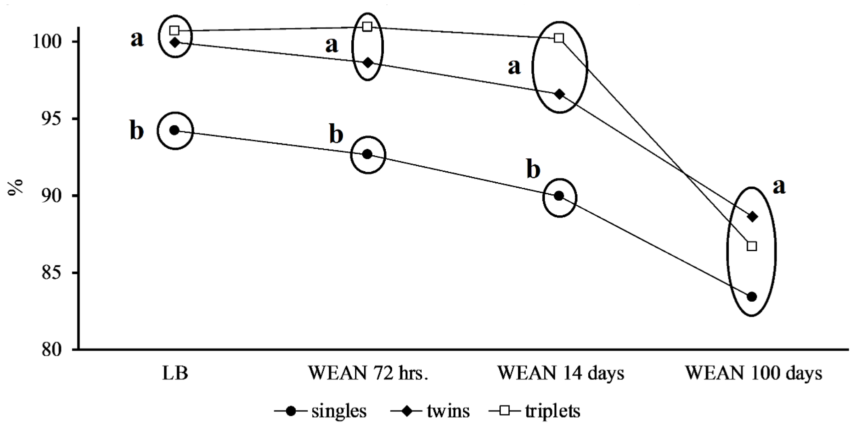
Charollais lambs had the best meat performance characteristics in general. This concerned all the evaluated traits, and thus higher ADG100 by 53.2 g, LW100 by 5.3 kg and MLLT100 by 4.7 mm ($P < 0.05$) than Kent lambs.



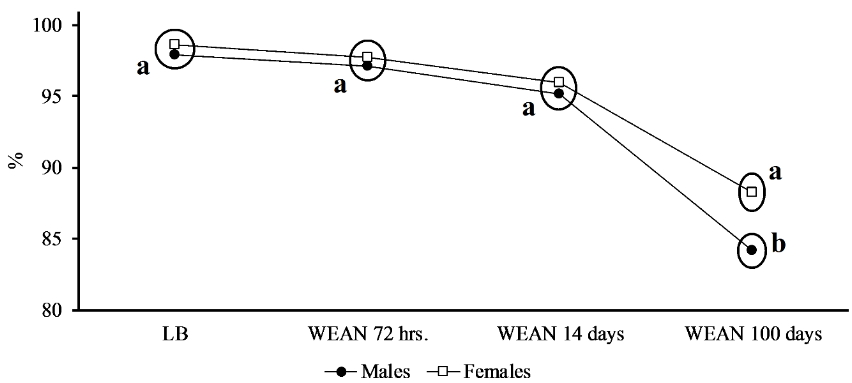
1: *Effect of birth weight on survivability traits lambs (LSM values)*
a, b, c – different letters among circled means within individual traits (within column) indicate statistical significance at $P < 0.05$ level;
LB – live born lambs (%); WEAN 72 hrs. – percentage of lambs weaned at 72 hours (%); WEAN 14 days –percentage of lambs weaned at 14 days (%); WEAN 100 days – percentage of lambs weaned at 100 days (%); BW – birth weight lambs (kg)



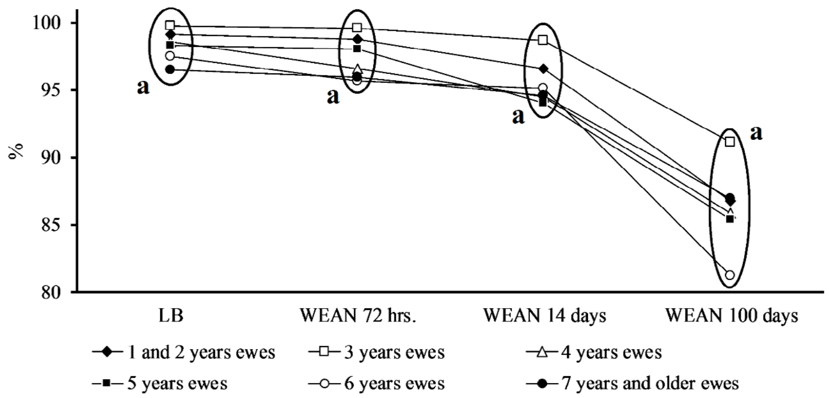
2: *Effect of breed on survivability traits lambs (LSM values)*
a, b – different letters among circled means within individual traits (within column) indicate statistical significance at P < 0.05 level;
LB – live born lambs (%); WEAN 72 hrs. – percentage of lambs weaned at 72 hours (%); WEAN 14 days – percentage of lambs weaned at 14 days (%); WEAN 100 days – percentage of lambs weaned at 100 days (%)



3: *Effect of litter size on survivability traits lambs (LSM values)*
a, b – different letters among circled means within individual traits (within column) indicate statistical significance at P < 0.05 level;
LB – live born lambs (%); WEAN 72 hrs. – percentage of lambs weaned at 72 hours (%); WEAN 14 days – percentage of lambs weaned at 14 days (%); WEAN 100 days – percentage of lambs weaned at 100 days (%)



4: *Effect of sex on survivability traits lambs (LSM values)*
a, b – different letters among circled means within individual traits (within column) indicate statistical significance at P < 0.05 level;
LB – live born lambs (%); WEAN 72 hrs. – percentage of lambs weaned at 72 hours (%); WEAN 14 days – percentage of lambs weaned at 14 days (%); WEAN 100 days – percentage of lambs weaned at 100 days (%)



5: *Effect of age of ewe on survivability traits lambs (LSM values)*
a, b – different letters among circled means within individual traits (within column) indicate statistical significance at P < 0.05 level;
LB – live born lambs (%); WEAN 72 hrs. – percentage of lambs weaned at 72 hours (%); WEAN 14 days – percentage of lambs weaned at 14 days (%); WEAN 100 days – percentage of lambs weaned at 100 days (%)

II: *Effect of selected factors on meat performance*

	ADG100	LW100	MLLT100	BT100
	LSM ± SELSM	LSM ± SELSM	LSM ± SELSM	LSM ± SELSM
Breed				
CH	275.98 ± 4.111[a]	31.12 ± 0.411[a]	25.89 ± 0.339[a]	3.46 ± 0.171[a]
K	222.77 ± 5.024[b]	25.81 ± 0.502[b]	21.22 ± 0.432[b]	3.42 ± 0.218[a]
Litter size				
Single	287.93 ± 4.656[a]	32.36 ± 0.466[a]	25.73 ± 0.392[a]	3.93 ± 0.198[a]
Twins	244.42 ± 3.307[b]	27.96 ± 0.331[b]	23.29 ± 0.287[b]	3.30 ± 0.145[b]
Triplets	215.77 ± 7.846[c]	25.08 ± 0.785[c]	21.65 ± 0.638[c]	3.09 ± 0.321[b]
Sex				
Male	260.75 ± 4.143[a]	29.61 ± 0.414[a]	23.52 ± 0.348[a]	3.36 ± 0.175[a]
Female	238 ± 4.121[b]	27.33 ± 0.412[b]	23.60 ± 0.351[a]	3.52 ± 0.177[a]
Ewe age				
1–2 year	237.34 ± 5.41[a]	27.24 ± 0.541[a]	22.64 ± 0.452[a]	3.45 ± 0.228[a]
3 year	254.88 ± 4.405[b]	29.01 ± 0.441[b]	23.95 ± 0.376[b]	3.67 ± 0.189[a]
4 year	263.94 ± 4.738[b]	29.94 ± 0.474[b]	24.28 ± 0.403[b]	3.59 ± 0.203[a]
5 year	246.94 ± 6.170[ab]	28.26 ± 0.617[ab]	23.50 ± 0.516[ab]	3.51 ± 0.260[a]
6 year	250.73 ± 7.887[ab]	28.58 ± 0.789[ab]	23.71 ± 0.655[ab]	3.26 ± 0.330[a]
7 and more year	242.41 ± 8.088[ab]	27.78 ± 0.809[ab]	23.26 ± 0.681[ab]	3.17 ± 0.343[a]
Birth Weight				
0.5–1 kg	255.94 ± 9.991[a]	27.61 ± 0.999[abc]	23.36 ± 0.819[a]	3.17 ± 0.412[a]
1.1–2 kg	233.58 ± 8.228[a]	25.87 ± 0.823[a]	22.73 ± 0.693[a]	3.73 ± 0.349[a]
2.1–3 kg	251.95 ± 4.481[a]	28.21 ± 0.448[ab]	23.72 ± 0.382[a]	3.36 ± 0.192[a]
3.1–4 kg	248.78 ± 4.865[a]	28.38 ± 0.487[bc]	23.83 ± 0.420[a]	3.55 ± 0.212[a]
4.1–5 kg	251.09 ± 5.513[a]	29.11 ± 0.551[bc]	23.93 ± 0.463[a]	3.33 ± 0.233[a]
5.1–6 kg	251.52 ± 7.411[a]	29.62 ± 0.741[bc]	23.26 ± 0.607[a]	3.76 ± 0.306[a]
6.1–7 kg	252.77 ± 7.018[a]	30.48 ± 0.702[c]	24.07 ± 0.570[a]	3.17 ± 0.287[a]

a, b, c – different letters within columns for individual traits means statistical significance at P < 0.05 level;
ADG100 – average daily gain at 100 days of age; LW100 – lambs weight at 100 days of age; MLLT100 – MLLT (*musculus longisimus lumborum et thoracis)* depth at 100 days of age; BT100 – subcutaneous backfat thickness at 100 days; CH – Charollais lambs; K – Kent lambs

DISCUSSION

Survivability Analysis

This article describes not only the survival of lambs in rearing, but also their subsequent meat performance in Charollais, Kent and their crossbreeds. Survivability is associated not only with the growth characteristics of lambs; therefore, this issue should be addressed comprehensively. In general, breeders are largely neglected to record data on childbirth and the postpartum period. Over the past 40 years, there have been no significant changes in the survival of lambs and the average mortality rate is around 15% (Dwyer *et al*., 2015). Therefore, relationships between survivability of lambs, or their meat performance and factors that influence them should be, as far as possible applied to the flock management, or scientific knowledge, in a simply form easy to understand.

The results show that survivability affected most the examined indicators. The major influence was found in the birth weight, which had a significant effect on the whole monitored rearing period. Optimal birth weight exceeding 4 kg was determined for the evaluated lambs in their typical flock conditions. These lambs had much higher chance to survive till weaning than lambs with a lower birth weight. Riggio *et al*. (2008) reported in their study that survival is positively correlated with the birth weight of lambs. However, the question arises as to whether the mortality of the lambs is due to the birth weight factor itself or whether the rearing method already plays a more important role. For example, the effect of hypothermia is most threatening in the first 5 days after birth. Rationale for our decline survivability after 3 days after birth such as injury, illness, nutrition or other flock problems (Plush *et al*., 2016). Weak lambs, low birth weight, despite sufficient milk intake, increase the possibility of mortality (Nash *et al*., 1996). Abdelqader *et al*. (2017) reported in their research that the difficulty of childbirth caused lambs losses. Most of the lambs after a difficult childbirth died a few days after birth. Also, lambs that died after difficult labor were 2.1× heavier from the average birth weight of the lambs and with 1.6× higher mortality in male lambs. However, lambs with a higher birth weight were favoured and achieved better results than lambs with a birth weight below 3 kg. Other results were also achieved by Gowane *et al*. (2018) who found higher mortality of lambs with birth weight below 2 kg.

Litter size, as an important factor in the rearing of lambs, had a significant impact on survivability of lambs. Multiple litters strongly exceeded the survivability singles within 14 days of age in lambs. Significant differences were found between singles and triplets in rearing up to 72 hours and 14 days of lamb age. Similar results in weaned lambs were achieved by Turkson and Sualisu (2005), Holmøy *et al*. (2014) and Ptáček *et al*. (2017). By contrast, Mousa-Balabel (2010), Gavojdian *et al*. (2012) and Getachew *et al*. (2015) in their research reported opposed result. The low survival of lambs from multiple litters is usually explained by the low birth weight as compared to the singles; however, birth weight was part of our model, so our low survivability detected in singles can be caused by complicated labors that Dalton *et al*. (1980) and Holmøy *et al*. (2014) have reported.

In this study, the sex of the lambs was reflected in the survival of the lambs so that males were more likely to die than female lambs, however, significant support for this thesis was obvious after 14^{th} day of age. The same results were obtained by Riggio *et al*. (2008) and Abdelqader *et al*. (2017). Survivability decrease be connected with flock management, when lambs at approx. 14 days after birth were moved from brick sheepfolds to pasture with their mothers (Everett-Hincks *et al*., 2005). Ferreira *et al*. (2015) in their study reported that females within 1 day of age had a lower survivability than males, but then before and after weaning had a higher survivability.

Lambs from 2-year-old ewes had the highest survivability. Additionally, also older ewes (over 6 years of age) can be used successfully in reproduction under conditions of the evaluated flock as survivability of their lamb does not significantly decrease. This is in some controversion with previously published results of Knight *et al*. (1988), Thomson *et al*. (2004) or Aktaş *et al*. (2015).

The survivability up to 100 days was influenced by genetic predisposition, when significantly the best results were detected in Charollais × Kent crossbreds. Positive effect of crossbreeding was largely confirmed by Gamma *et al*. (1991) Thomson *et al*. (2004), Kutluca Korkmaz and Emsen (2018) and Freking and Bennett (2019) who reported that the crossing had a demonstrable effect on the survivability of lambs. Charollais sheep is generally considered as sensitive breed prone to lambs deaths during rearing (Dwyer and Lawrence, 2005). Anyway, this potential disadvantage was effectively suppressed by crossing with Kent breed, very resistant sheep breed suitable for all-year outdoor breeding systems (Knight *et al*., 1988). Higher survivability of crossbred lambs supported by significant difference, confirmed this assumption. On the contrary, Elizalde *et al*. (2019) found better survivability of purebred lambs of the breed Corriedale over crossbreeds with Texel, Dorset and Suffolk ram.

Growth Analysis

The birth weight of the lambs influenced live weight, when lambs heavier than 4.1 kg showed higher LW100 over lighter contemporaries. Contrary, lambs weighing up to 2 kg demonstrated the worst results in general. The lambs that had a higher birth weight were mostly singles, males and lambs from ewes with better condition and better nutrition. Therefore, it is essential to achieve optimal birth weights for lambs to attain faster slaughter weight. Moreover, higher survivability of heavier lambs, was detected, despite the possible increase in difficult births (Thomson *et al*., 2004; Sušić *et al*., 2005).

Significantly faster growth intensity of single lambs compared to those from multiple litters (Dixit *et al*., 2001; Ptáček *et al*., 2013) was demonstrated in our study as well. Similarly better growth ability of males were previously confirmed by Momani Shaker *et al*. (2010), Taskin *et al*. (2012), Simeonov *et al*. (2014) and Ghafouri-Kesbi and Notter (2016). Differences between the sexes may be due to the different configuration and muscle growth of females and male lambs. The male lambs deposit more of their muscle mass in the chest area than in the dorsal area where ultrasonography is performed (Milerski *et al*., 2006). The effect of lamb sex is also reported by Burfening and Carpio (1993); El Fadili *et al*. (2000); Peña *et al*. (2005); Kuchtík and Dobeš (2006); Hošek *et al*. (2008); Rashidi *et al*. (2008); Štolc *et al*. (2011) and Rahimi *et al*. (2014). Ewes 1–2 years old had in our study significant negative effect on the meat performance of lambs. The best results were achieved in lambs from 3–4 years old ewes, but with good survivability and meat performance, ewes over 6 years of age may also be well-suited. Similar results were obtained by Dixit *et al*. (2001) and Baneh and Hafezian (2009).

Further monitoring was performed to obtain data for evaluating the meat performance of Charollais and Kent breed. The growth of lambs was influenced by genotype, when Charollais lambs reached significantly better results than Kent reared under identical breeding conditions. This performance is largely due to the focus of the breed's performance. Genes of certain breeds have the ability to improve the overall performance of animals (Paim *et al*., 2013). The influence of breeding affiliation is also documented by Ptáček *et al*. (2011) and de Vargas Junior *et al*. (2014). Paim *et al*. (2013) reported in their study that purebred animals of the Ile de France breed had the same growth capabilities or higher than crossbreds with other meat breeds. The influence of breed Charollais and its crossbreds was describe by Petr *et al*. (2009) in our conditions. Otherwise, Charollais and Kent are mostly kept in pure form in the Czech Republic, and their crossing is not so common (Bucek *et al*., 2019). Disposition of our study did not allow this interesting crossing between these breeds. However, comparing both purebred populations in our results indicated on potentially improved meat performance in crossbreds over Kent. In context of previously demonstrated survivability traits our results indicate on perspective hybrid combination applicated under extensive production systems in the Czech Republic.

CONCLUSION

Effects of birth weight, ewe age, litter size, sex and breed on survivability and growth indicators in Charollais, Kent and their crossbreds, were studied in this study. Birth weight was one of the main driving factors affecting the survivability lambs throughout their rearing. Its influence was observed followed by growth of lambs, especially for live weight. The birth weight from 4 to 7 kg was estimated to be most beneficial. Unfortunately, crossbreds were not available for subsequent analysis of growth abilities. However, confrontation of purebred populations clearly shows better indicators of meat performance for Charollais breed over Kent lambs. In combination with the survivability evaluation, where results of survivability traits were even better compared to the generally respected resistant Kent breed, the use of the Charollais breed looks perspective. The susceptibility of the pure-bred Charollais breed presented in some works can thus be eliminated using this crossing scheme. This study thus indicated some perspective tools of flock management for farmers breeding their sheep under extensive breeding conditions.

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Contact information

Anežka Málková: malkovaa@ af.czu.cz
Martin Ptáček: ptacekm@af.czu.cz
Luděk Stádník: stadnik@af.czu.cz
Jaromír Ducháček: duchacek@af.czu.cz