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Original Paper

The comparison of the selected morphometric traits in three medium-sized rabbit breeds

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The aim of the study was to determine the growth characteristics of three rabbit breeds (Czech Solver, CSo, *n* = 11; Czech Spotted, CS, *n* = 28; Blanc de Hotot, BH, *n* = 24) under small-scaled stock conditions as a basis for their potential meat performance. The body morphometric characteristics live weight (LW), head length (HL), body length (BL), ear length, thoracic circumference (TC) and body compact index TC/BL were recorded in growing rabbits from 21st to 91st day of their age. At the end of the trial, the highest LW value was recorded in the BH breed (2,700.0 g) as compared to the CSo and CS breeds, respectively (1,887.5 and 1,545.4 g). The values of the HL were significantly affected by a rabbit breed up to the 63rd day of their age (P <0.01). The highest values of BL and TC were found in the BH breed as compared to the CSo breed and also the CS breed (P <0.01). The BH breed showed also the longest ears (P <0.01) while the different dynamics of the ear growth among the evaluated breeds was found. Concerning the body compact index TC/BL, the growing rabbits of the BH breed showed wider body given by their musculature proportion as compared to the representatives of the CSo and CS breeds (P <0.01). Our findings suggest that the Blanc de Hotot breed possesses suitable growth and morphometric characteristics for intended meat production.

Keywords: rabbit, breeds, growth analysis, body measurement, morphometric parameters

1 Introduction

According to the EU overview report, a substantial proportion (34%) of produced rabbit meat came from backyard small-scaled stocks that is different to other livestock species (EU, 2017). Under conditions of the Czech Republic, this proportion is underlined by local historical background of husbandry of domestic rabbit and its main role as a productive animal (Mach et al., 2010). Approximately 95% of fattened rabbits reared in the Czech Republic originated from small-scaled stocks. Although, annual consumption of the rabbit meat per capita shows a decreasing tendency in the Czech Republic currently, local meat consumption ranks still among European countries with the highest stated consumption of this meat (Josrová, 2018). Number of studies dealing with productive and reproductive traits of rabbit breeds included in the Czech genetic resources programme revealed that some selected breeds show a good potential for meat production (Zita et al., 2010; Tůmová et al., 2011; Tůmová et al., 2014). Similarly, a Nitra rabbit breed, Slovak national breed, showed suitable promise for meat production in small-scaled stocks (Fik et al., 2018). Generally, morphometric measurement of animals is served for recording of their phenotypic characteristics (Khan et al., 2017), what aids to selection in animal genetic improvement (Hassan et al., 2012). The measurement of the specific parts of the rabbit carcass belongs to the important meat traits finding after rabbit slaughtering (Blasco and Ouhayoun, 1993; Hernández et al., 1996). Whereas, chosen specific morphometric parameters were used successfully for assessment of the rabbit body composition and can serve as indirect indicators of adipose tissue mass in rabbits (Sweet et al., 2013).

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The aim of the study was to evaluate selected morphometric parameters among three rabbit breeds normally reared in the Czech Republic. An integral part of the work was to determine the growth characteristics of these rabbit breeds under small-scaled stock conditions as a basis for their potential meat performance.

2 Material and methods

2.1 Animals and husbandry conditions

The study was performed on a total of 63 young rabbits belonging to the medium-sized breeds, specifically the Czech Solver (CSo, *n* = 11), the Czech Spotted (CS, *n* = 28) and the Blanc de Hotot (BH, *n* = 24). The adult rabbits of the CSo breed weigh usually around 3.50–4.25 kg and possess a unique genotype for coat colour which seems a yellowish river sand. The adults of the CS breed (3.30–4.00 kg) show a typical coloured marking where coloured patterns are situated on the pure white base colour. Adult rabbits of the BH breed (4.00–5.00 kg) possess a maximally reduced colour marking, just in form of the gentle black eye bands, while the rest of the body is of pure white colour (Zadina, 2003; Whitman, 2004). The rabbits included in the present study came from the common hobby stocks which perform exhibition activities under guidelines of the Czech Association of Breeders. Parents of these rabbits belonged to the typical representatives of the respective breeds. The rabbits were housed in the outdoor hutches with pens of a recommended size. Rabbit kits were housed with their does up to 8th week of their age. Subsequently, after weaning, the growing rabbits were housed in small groups (2–3 rabbits per group) up to the end of the monitored period (91st day of age). The young growing rabbits received a complete pelleted diets with similar nutrient composition. The rabbits were fed once a day. The animals had unlimited access to drinking water and meadow hay.

2.2 Morphometric parameters and data collection

The body morphometric measurement was performed according to Dalle Zotte et al. (2013) with certain technical modifications. The characteristics such as the live weight (LW), head length (HL), body length (BL), ear length (EL), thoracic circumference (TC) and body compact index TC/BL were recorded in growing rabbits. Orientation using specific anatomical points at the rabbit body was used within the measurements. The measuring tape was used for recording the BL (measured from atlas to the first coccygeal vertebra), the HL (measured from the tip of the nostrils to atlas) and the TC (measured behind a shoulder blade). Subsequently, the TC/BL index was calculated. The special ear measuring ruler was used for the EL recording. The base of this instrument was placed between the ears at the ears´ base and both ears were put on the measuring scale, then the value at the top of the ear was recorded.

All monitored morphometric parameters of individual rabbits were recorded for the first time at the age of 21 days and subsequently in two-week period up to the age of 91 days. All data collection was performed at the same day period and prior to feeding. All measurements were performed by the same person with the aim to eliminate measurement errors.

2.3 Statistical analysis

The obtained data were statistically analysed using a software STATISTICA CZ, version 10 (StatSoft Inc., 2011). One-way variance analysis (ANOVA) was used to determine differences in the evaluated morphometric traits. When ANOVA showed significant differences among the evaluated breeds a post-hoc HSD test was used. The differences were considered significant at $P < 0.05$.

3 Results and discussion

The breed effect on the evaluated morphometric parameters in pre-weaning rabbit kits is presented in Table 1. The effect of rabbit breeds on the evaluated morphometric parameters in the post-weaning period is presented in Table 2.

Generally, it follows from the results that all monitored morphometric parameters were significantly affected by a particular rabbit breed.

In meat-type rabbits, their live weight (more specifically slaughter weight) is essential trait in relation to the economy of rabbit meat production (Szendrő et al., 2012). In our trial, the rabbits of the CS breed showed the lowest LW values among monitored breeds within an entire monitored period ($P < 0.01$). These findings were expectable due to foregoing selective breeding of the CS breed. Martinec et al. (2017) state that the CS breed is a typical hobby breed historically selected mainly for an exhibition purpose, while its exterior traits that have been included in the selection effort in the past are not directly related to meat performance of rabbits. This fact was repeatedly verified also in studies dealing with evaluation of meat performance of rabbit breeds included in the Czech genetic resources of animals (Tůmová et al., 2011; Tůmová et al., 2014). On the other hand, the highest LW values were found in the BH breed. At the age of 91 days, the BH rabbit showed significantly higher LW ($P < 0.01$) as compared to the CS rabbit (+1,545.4 g) and also the CSo rabbit (+812.5 g). It can be highlighted that the final LW of the BH purebred rabbits is similar to that of common slaughter weights in meat-type rabbit hybrids (Szendrő et al., 2012, Josrová, 2018). The very good growth potential

Table 1 Selected morphometric parameters in the monitored rabbit breeds in pre-weaning period.

Parameter	Breed						P
	Czech Solver		Czech Spotted		Blanc de Hotot		
	x	SEM	*x*	SEM	*x*	SEM	
Age 21 days							
LW (g)	211.8^{B}	10.86	178.9^{B}	9.40	392.5^{A}	15.41	**
HL (mm)	$82.2^{A,B}$	0.18	77.1^{B}	1.29	87.1^{A}	0.79	**
BL (mm)	141.3^{B}	3.58	121.7^{C}	3.44	178.5^{A}	1.96	**
EL (mm)	47.0^{B}	0.69	42.8^{B}	0.92	60.9^{A}	1.05	**
TC (mm)	94.7^{B}	4.05	96.1^{B}	2.50	148.0^{A}	4.11	**
Index TC/BL	0.67^{B}	0.03	0.78^{A}	0.01	0.83^{A}	0.02	**
Age 35 days							
LW (g)	460.9^{B}	26.81	371.1^{B}	25.26	823.8^{A}	26.08	**
HL (mm)	$89.1^{A,B,b}$	1.,9	$86.8^{B,b}$	1.9	$108.0^{A,a}$	0.95	**
BL (mm)	202.4^{B}	7.21	191.1^{B}	4.76	239.3^{A}	2.38	**
EL (mm)	71.5^{B}	0.65	61.9^{C}	1.33	89.2^{A}	1.64	**
TC (mm)	120.5^{B}	5.71	115.2^{B}	4.08	186.4^{A}	5.44	**
Index TC/BL	0.60^{B}	0.02	0.60^{B}	0.01	0.78^{A}	0.02	**
Age 49 days							
LW (g)	812.2^{B}	23.73	614.8^{B}	30.64	1353.7^{A}	46.28	**
HL (mm)	106.3^{B}	1.8	99.0^{B}	1.57	120.4^{A}	1.48	**
BL (mm)	$255.4^{A,B,b}$	6.4	$225.7^{B,b}$	4.31	$280.7^{A,a}$	2.41	**
EL (mm)	$87.1^{B,a}$	0.96	$78.5^{B,b}$	1.38	104.7^{A}	1.79	**
TC (mm)	148.4^{B}	4.61	141.8^{B}	5.06	216.1^{A}	5.59	**
Index TC/BL	0.58^{B}	0.01	0.62^{B}	0.01	0.77^{A}	0.02	**

x – arithmetic mean; SEM – standard error of the mean; LW – live weight; HL – head length; BL – body length; EL – ear length; TC – thoracic circumference

a, b – means within a row with different superscript letters differ at (P <0.05); **; A, B, C – means within a row with different superscript letters differ at (P <0.01)

of the BH breed was not described in recent literature yet. At the present time, the BH breed is considered as a typical hobby rabbit breed reared mainly for exhibition purposes. However, its original breeding goal was focused to create a multi-purpose breed using for meat and fur productions and also for exhibition activities. The BH rabbits showing the large body frame, white coloured coat and black eyes (Whitman, 2004), while their standard markings are underlined by the combination of English spot gene and Dutch gene (Hinkle, 2011); this gene combination is rare among the rabbit breeds. The present form of the BH rabbits was obtained from a breeding programme that based on crossing of the Giant Papillon, the White Flemish Giant, the Vienna White and other breeds (Whitman, 2004). The crossbreeding leads to increase of level of heterosis, whereas the breed complementarity and correct selection process must be taken into consideration to achieve favourable traits for meat performance (Ouyed et al., 2011; McNitt et al., 2013). An initial increase of the rabbit genetic diversity normally occurs because of initial crossbreeding (Queney et al., 2002). It can be assumed that the favourable growth rate of the BH breed in the present study could be influenced by its various genotypes passed from the initial crossing of included breeds due to a heterosis effect.

Besides that, when compared to ideal standard LW values at the age of 3 months (Zadina, 2003), LWs found in the CS breed and also in the CSo breed are closed to the ideal standard LW values (1,500 and 1,800 g, resp.) according to Zadina (2003). Concerning the BH rabbits, they showed the obviously higher LW as compared to the published standard LW value (1,500 g). It should be pointed out that the exterior traits of each breed are developing with ongoing time and therefore the breed standards are regularly updated. Besides that, a recent study of Tůmová et al. (2011) showed slightly different

Table 2 Selected morphometric parameters in the monitored rabbit breeds in post-weaning period.

Parameter	Breed						P
	Czech Solver		Czech Spotted		Blanc de Hotot		
	x	SEM	*x*	SEM	*x*	SEM	
Age 63 days							
LW (g)	1,205.0^{B}	27.45	901.2^{C}	41.50	1,853.3^{A}	34.37	**
HL (mm)	123.6^{B}	15,707	112.9^{C}	1.50	138.9^{A}	1.37	**
BL (mm)	260.6^{B}	25.64	256.8^{B}	4.03	323.2^{A}	3.83	**
EL (mm)	98.1^{B}	0.93	92.7^{B}	1.15	115.2^{A}	1.28	**
TC (mm)	165.4^{B}	1.69	160.6^{B}	4.24	232.1^{A}	3.25	**
Index TC/BL	0.77	0.19	0.62	0.01	0.72	0.01	ns
Age 77 days							
LW (g)	1,606.3^{B}	34.48	1,188.8^{C}	44.63	2,267.6^{A}	58.19	**
HL (mm)	136.6	2.48	128.4	1.65	148.4	1.64	ns
BL (mm)	321.5^{A}	6.14	282.2^{B}	5.22	346.8^{A}	3.57	**
EL (mm)	106.1^{B}	1.08	104.0^{B}	1.09	120.2^{A}	1.60	**
TC (mm)	192.0^{B}	4.3	174.7^{B}	4.75	244.0^{A}	4.44	**
Index TC/BL	0.60^{B}	0.02	0.62^{B}	0.01	0.70^{A}	0.01	**
Age 91 days							
LW (g)	1,887.5^{B,a}	72.23	1,545.4^{B,b}	50.25	2,700.0^{A}	54.46	**
HL (mm)	140.9	2.72	137.7	1.45	157.7	1.85	ns
BL (mm)	355.8^{A}	3.19	322.5^{B}	5.24	369.2^{A}	3.71	**
EL (mm)	111.1^{B}	1.32	112.0^{B}	0.98	121.2^{A}	2.02	**
TC (mm)	204.6^{B}	3.13	190.8^{B}	4.07	264.4^{A}	6.54	**
Index TC/BL	0.58^{B}	0.01	0.59^{B}	0.01	0.72^{A}	0.02	**

x – arithmetic mean; SEM – standard error of the mean; LW – live weight; HL – head length; BL – body length; EL – ear length; TC – thoracic circumference; ns – not significant

a, b – means within a row with different superscript letters differ at (P <0.05); **; A, B, C – means within a row with different superscript letters differ at (P <0.01)

LW of the 91-day-old CSo rabbits (2,453 g) and CS rabbits (2,240 g). In accordance with this finding, the CS breed showed a lower LW as compared to the CSo breed in the present study.

The rabbit head is a part of the carcass when a hot carcass weight is determined. The proportion of the head play a role when the carcass dressing percentage is calculated (Blasco and Ouhayoun, 1993). Wang et al. (2016) found that the proportion of the rabbit head is significantly affected by a rabbit genotype, while the commercial meat-type hybrid rabbits show a lower proportion of the head as compared to the purebred rabbits. Concerning findings in the present study, HL was significantly affected by a rabbit breed up to the 63rd day of their age (P <0.01). Thereafter, HL didn't differ significantly among monitored breeds (P >0.05).

The dorsal linear length belongs to the important meat traits measured after rabbit slaughtering. This trait is associated with length of the *m. longissimus lumborum*, one of the main part of the rabbit carcass (Blasco and Ouhayoun, 1993). In the present study, the breed had a significant effect on values of BL in course of an entire monitored period. At the end of the monitored period, the highest values of BL were found in the BH breed (P <0.01) as compared to the CSo breed (+13.4 mm) and also the CS breed (+46.7 mm).

In present study, the highest values of EL were recorded in the BH breed within the entire monitored period. At the age of 91 days, the BH rabbits showed significantly (P <0.01) longer ears as compared to the CSo rabbits (+10.1 mm) and also the CS rabbits (+9.2 mm). The EL belongs to the important exterior traits stated in a breed standard. The found ELs of 91-day-old rabbits of all

the evaluated breeds were in accordance with values (CSo, 110–120 mm; CS, 105–110 mm; BH, 120–125 mm) published in the current breed standards (Zadina, 2003). It can be noted that values for EL at 21 day-old rabbit represented only 38.2% from its value at the age of 91 days in the CS breed, while the BH rabbits only doubled (+49.8%) their EL within the monitored period. Besides that, Lukefahr and Ruiz-Feria (2003) found in rabbits the moderate to high positive correlation between the EL and growth traits, while they point out that growth rate of rabbits may be influenced also by their fur clipping.

The body compact index TC/BL determines relationship between the length and width proportions of a rabbit body. When the TC/BL increases, the rabbit shows wider body given by musculature proportion whereas the decreasing TC/BL index results in poor muscling of their body. Except for the age of 63 days in the present study, it can be highlighted that the growing rabbits of the BH breed showed the highest values of TC/BL index among the monitored breeds (P <0.01). At the end of the monitored period, the BH rabbits showed a higher value (P <0.01) for TC/BL index as compared to the CSo rabbits (+0.14) and also the CS rabbits (+0.13). Parameters of the *m. longissimus lumborum* are essential for meat quality of rabbits (Blasco and Ouhayoun, 1993; Gondret et al., 1998, Tůmová et al., 2014). Generally, based on findings of the present study, it can be assumed that the growing rabbits of the BH breed displayed promising preconditions for the meat purpose.

4 Conclusions

Based on the obtained results, it can be concluded that both live weight and all monitored morphometric parameters of rabbits were significantly affected by a rabbit breed.

As for meat production potential, the least favourable values for observed morphometric measures were found in the Czech Spotted breed. Thus, the Czech Spotted breed can be considered still as a breed suitable mainly for exhibition purpose, while its meat production potential remains low. On the other hand, the highest values for the live weight and morphometric parameters were found in the non-traditional Blanc de Hotot rabbit breed. Especially, the values of the live weight and body length in the 91-day-old growing rabbits were quite high, what are desirable traits of this breed. These preliminary findings suggest that the Blanc de Hotot breed possesses suitable growth and morphometric characteristics for intended meat production. However, further studies are needed to deepen our knowledge about productive and reproductive traits of the Blanc de Hotot rabbits reared also under intensive farming conditions.

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