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Institute of Genetics and Animal Breeding, Jastrzębiec, Poland

Body and carcass measurements and organ weights of Lithuanian indigenous pigs and their wild boar hybrids

Violeta Razmaite[1]*, Sigita Kerziene[2], Virginija Jatkauskiene[1]

[1] Department of Animal Breeding and Genetics,
Institute of Animal Science of Lithuanian Veterinary Academy,
R. Žebenkos 12, LT-82317 Baisogala, Radviliškis distr., Lithuania

[2] Department of Social Sciences and Informatics,Lithuanian Veterinary Academy,
Tilzes 18, LT-47181 Kaunas, Lithuania

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With the aim to investigate a possibility of supporting conservation of Lithuanian indigenous pigs (LIW) their external body and carcass measurements were compared with their wild boar (WB) hybrids to see whether crossing can improve the quality of pork, which in purebreds is inferior to other breeds. Depending on the proportion of WB in the crosses (1/4 or 1/2) purebred pigs were respectively 3.2 cm and 4.3 cm shorter at withers (P<0.05). Correspondingly, hind feet in 1/4 WB and 1/2 WB genotypes were 1.8 cm and 2.2 cm longer (P<0.05) whereas ear length was shorter by 1.9 cm and 3.0 cm (P<0.05) in the hybrid pigs. LIW pigs tended to have longer body and shorter snouts than hybrids (0.05<P<0.10). The body shape of hybrid pigs was more rounded than body of purebred pigs but only pigs from 1/2 WB genotype had larger body circumference. Weights of head, feet, leaf fat and organs including heart, spleen, lungs were higher but the size of the gastro-intestinal tract was smaller in hybrids than in LIW. Crossing of LIW pigs with WB decreased carcass length but increased backfat thickness in 1/2 WB genotype (P<0.05). The gender effect was less pronounced at the studied range of ages. The main benefit of crossing, though statistically insignificant, was the increase of rib eye area in hybrid genotypes with increasing WB proportion.

KEY WORDS: carcass / conformation / hybrid / native pigs / wild boar

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*Corresponding author: razmusv@one.lt

The European Union is self-sufficient for animal products, including pork, and among the new challenges there is a necessity to increase the quality of products and food diversification to satisfy the consumer requirements. Farming of alternative species such as wild boar is becoming increasingly common in many countries [Booth 1995, Haris *et al*. 2001, Gongora *et al*. 2003, Randi 2005]. Many studies [Giuffra *et al*. 2000, Larson *et al*. 2005, Scandura et al. 2008] have shown that the domestic pig originates from Eurasian wild boar (*Sus scrofa)* and clear evidence was obtained for domestication to have occurred independently from wild boar subspecies in Europe and in Asia. Although Asian pigs were introduced into Europe during the 18th and early 19th centuries, it is evidenced that local wild boars might have represented an important source for European domestic pigs and that wild boar breeds successfully with the domestic pig. Although Santos *et al*. [2006] have reported that in western Iberian Peninsula adult wild sows appear to be able to give birth at any time of the year, in other European areas to the North, including Lithuania, wild boars normally produce one litter per sow per year averaging 4-6 piglets in spring [Kontrimavičius *et al*. 1998, Booth 1995, Gongora *et al*. 2003]. Wild boar has a slower growth rate than domestic pigs; therefore, in Lithuania, with a growing interest in captive wild boar breeding, there is an interest in the domestic pig and wild boar crossbreeding. Lithuanian multicoloured indigenous pigs are less demanding in terms of feeding and maintaining conditions, but they are quite fat and inferior to actual commercial hybrids in overall pig production, while this breed itself is in danger of extinction.

In 1995 the FAO Mission for Central and Eastern Europe has recognized Lithuanian indigenous wattle pigs as an internationally watched pig breed. In the new millennium, agro-food research have to be engaged in a strategy based on the protection of autochthonous genetic resources [Matassino 2006]. Food diversification is an internationally defined food quality concept with a distinct market potential. Conservation of the breeds may be considered successful if the endangered breeds can be integrated into regional crossbreeding schemes, adapted to ecological production niches or designed for specific quality products [Chainetr *et al*. 2002, Glodek *et al*. 2001, Franci *et al*. 2001, Labroue *et al*. 2001]. The current interest in the hybrids of Lithuanian indigenous wattle pigs and wild boar originates from the search for the possibilities of adaptation of conserved Lithuanian indigenous pigs to production niches and meets the global challenge to increase the consumer awareness on food diversification through sustainable use of domestic and wild genetic resources.

Genetic homogeneity of both Lithuanian indigenous pigs and wild boar populations should be preserved. Descriptive characteristics should help to distinguish hybrids from wild boars and purebred Lithuanian indigenous pigs as well as to anticipate the quality of carcasses from different terminal crosses. Therefore, the objective of the present study was to describe morphological characteristics of Lithuanian indigenous pigs and their different wild boar hybrids, starting with the coat colouration patterns through external body and carcass measurements to anatomical body components.

Material and methods

Eighty seven animals of three genotype groups were used in the investigation. The groups were purebred Lithuanian indigenous wattle pigs (LIW), their F_1 cross with wild boar (WB) and the backcross LIW x F_1. The numbers of animals used for evaluation of body measurements were 13 gilts and 13 barrows in the LIW group, 9 gilts, 9 barrows and 11 boars in F_1, and 12 gilts, 17 barrows and 5 boars in LIWxF_1. The animals were reared indoors in mixed-gender groups of 5-7 animals in the pen from birth to slaughter at approximately 90 kg live weight and consuming twice a day the same standard concentrate feed**.** The composition and nutrient value of the concentrate feed are presented in Table 1. Body measurements were taken on live animals when they exceeded 80 kg of live weight**.** Height at withers was taken as the straight-line distance from the dorsal midline of the shoulder to the base of the foot with forelimb positioned in a normal upright manner. Body length was measured with a tape in a straight line on animal's back from scapula to tail. Heart girth as body circumference was measured immediately posterior to the scapula. Hind foot length (length of *metatarsus*) was measured from the proximal end of *calcaneus* to the distal end of the longest hoof. Snout length was measured from the distalmost dorsal point of the *rhinarial* pad to a point equidistant between the eyes and ear length – from the notch to the farthest point of the distal edge.

Table 1. Composition and nutrient value of concentrate feed

Ingredients	Amount of ingredient
Crude protein (%/kg feed)	14.5
Crude fibre (%/kg feed)	6.39
Ether extract (%/kg feed)	2.82
Metabolisable energy (MJ/kg)	12.2
Lysine (%/kg feed)	0.78
Calcium (%/kg feed)	0.78
Phosphorus (%/kg feed)	0.27
Sodium chloride (%/kg feed)	0.39

The animals (females and castrated males) were slaughtered according to standard procedures, following 5km transportation. The internal organs and intestinal tract were removed. Head, feet, internal organs and leaf and visceral fat were weighed. The length of small and large intestines was taken with a tape measure. The volume of stomach was determined by filing with water. The head was removed by a cut at the *occipito-atlas* joint; forefeet, by cuts at *carpus-metacarpal* and *tarsus-metatarsal* joints. Afterwards the carcass was split longitudinally down the midline.

Eviscerated carcasses were weighed to determine hot carcass weight and chilled for 24 h at 2 to 4^0C. Carcass weight was measured without head, feet and tail. Twenty-four hours *post-mortem* the carcasses were weighed again to determine cold carcass weight. Dressing percentage was measured as ratio of carcass weight 1 h after slaughter and live weight. Cooling loss was expressed as percentage difference between hot and cold carcass weights over hot carcass weight. Carcass length was measured from the cranial edge of first neck segment to the anterior edge of the *symphysis pubis*. Bacon length was measured from the cranial edge of first rib on the sternum to the anterior edge of the *symphysis pubis*. Measurements of midline backfat thickness were carried out with a ruler on the left side of cold carcass at the crest, at 6/7, 10, at the last rib, at the thinnest lumbar backfat point and at three points over the *gluteus medius* (the anterior part, above the highest point and at the posterior part). Measurements of the ventral part of belly thickness were carried out with along the line of teats at three points: 5 cm caudally from the last teat, parallel with the last thoracic vertebra and 3 cm caudally from sternum. From the semi-carcass three primal cuts were separated. The hind leg was removed by cutting through the knee joint. The ham was separated by a straight cut at next-to-last vertebrae and the shoulder was separated between 5/6 thoracic vertebra. All the parts were weighed. A picture was taken to record the shape of the *longissimus dorsi* at 1/2 lumbar vertebra, and loin and fat area were measured planimetrically.

Statistical analysis was performed with the GLM procedure in MINITAB, release 14.20. The model included genotype (LIW, 1/4WB and 1/2WB) and gender as fixed factors. Least significant difference test (α=5%) was used to asses the significance of differences between the groups.

Results and discussion

The differences between the Lithuanian native pigs and their F_1 and backcrosses with WB can, besides the additive differences, be also influenced by the heterosis possibly present in full in F_1 and in half in backcrosses. That, nevertheless, cannot be estimated without having a group of pure WB animals, as it is a case in the current study.

The colour range of Lithuanian indigenous pigs is quite wide – white, black, brownish and in most cases spotted. The colouration in all 1/2 WB genotype from spotted LIW pigs and wild boars consisted of solid red/light brown. However, they also had some bristles that were black and grey. The colouration in 1/4 WB genotype varied from spotted and white to solid red/light brown indicating standard, mendelian mode of inheritance.

Weight, age, growth rates and external body measurements are presented in Table 2. The hybrids were growing slower – daily gain of 1/4 WB and 1/2 WB genotype hybrids from birth was, respectively, 37.8 g and 128.5 g lower than that of the native pigs ($P<0.05$); therefore their age at taking measurements was correspondingly higher. Although LIW pigs were 2.4-6.0 kg heavier than hybrids, their height at withers was 3.2 cm and 4.3 cm lower than those of 1/4 WB and 1/2 WB crosses ($P<0.05$). Length

Table 2. Body measurements of Lithuanian indigenous pigs and their wild boar (WB) hybrids

Variables	Lithuanian indigenous	1/4 WB	1/2 WB
Number of animals	25	33	29
Age (days)	219.8±5.6[a]	231.0±4.5[a]	297.0±8.4[b]
Weight (kg)	89.5±1.0	87.1±0.6[c]	83.5±1.0[b]
Height at withers (cm)	58.1±0.3[a]	61.3±0.4[c]	62.4±0.5[b]
Body circumference (cm)	107.3±0.8	106.8±0.7[b]	109.1±0.8[a]
Length (cm)	114.5±0.9[A]	112.0±0.8[B]	113.7±1.1
Snout length (cm)	16.6±0.2[A]	21.7±2.8[B]	20.9±0.3
Hind foot length (cm)	27.7±0.3[a]	29.5±0.2[b]	29.9±0.2[b]

[ab...]Means with different superscript differ significantly at P<0.05.
[AB...]Means with different superscript are considered as trends at 0.05<P<0.10.

of hind foot (*metatarsus*) in 1/4 WB and 1/2 WB genotypes was 1.8 cm and 2.2 cm higher (P<0.05) and ear length 1.9 cm and 3.0 cm lower (P<0.05) than in LIW. The Lithuanian pigs also tended to have longer bodies and shorter snouts than hybrids (0.05<P<0.10). The body shape of hybrid pigs was more rounded than that of purebred pigs but only the pigs from 1/2 WB genotype had larger body circumference. Increase of WB proportion in hybrids resulted in a larger difference to purebred pigs.

Analysis by gender showed that barrows had larger body circumference than gilts but only the difference between genders in LIW was statistically significant (P<0.05). Hybrid barrows had longer snouts than gilts, yet the difference between these genders was only statistically significant (P<0.05) in 1/2 WB genotype. 1/2 WB entire boars were taller at withers while their snout and hind foot lengths were quite identical to that of barrows. Other differences in external body dimensions between genders were insignificant. Alionienë and Janilionis [2004] studied *metacarpal* and *metatarsal* bones of Lithuanian White pigs and WB, that were hunted in Lithuania and found no significant differences between domestic gilts and castrated males. However, descriptive statistics showed that 97.1% wild boar males and 89.5% females can be correctly distinguished [2004]. As many other authors reported [Kontrimavičius *et al* 1998, Moretti 1995, Gallo Orsi *et al*. 1995, Mayer and Brisbin 1991, Mattioli and Pedone 1995] sexual size dimorphism is typical for wild boars, but Pedone *et al.* [1995] have shown that sexual dimorphism in size was not statistically detectable in young and subadult (12-23 months old) wild boars. In contrast, Moretti [1995] has reported that the difference in body growth between males and females is noticeable. Maturation of LIW pigs begins earlier than in WB, but in our study we have analysed body measurements of young animals (7-10 months old). On the other hand, in our study castrated males were used and groups were formed according to the weight of animals.

At similar slaughter weight, WB genotype effects were detected for carcass and organ weights and dressing percentage. Animals from 1/4 WB genotype had only 2.6% and 4.6% ($P<0.05$) lower slaughter weight than LIW and 1/2 WB pigs (Tab. 3). WB genotypes showed insignificant effects for dressing percentage. Cooling loss was higher in hybrids than in LIW pigs. Increase of WB proportion in hybrids resulted in lower dressing percentage and higher cooling losses. This is in agreement with other results. Müller *et al*. [2000] reported that cooling loss was significantly higher in wild boar than in Meishan and Pietrain and the loss was positively correlated with the meat amount in carcass. Although in our study wild boar hybrids had higher backfat thickness, they also had higher loin area, and higher cooling loss indirectly indicates higher meatiness.

Table 3. Body components of Lithuanian indigenous pigs and their wild boar (WB) hybrids

Variables	Groups of animals		
	Lithuanian indigenous wattle pigs	1/4 WB genotype	1/2 WB genotype
No of animals	22	29	11
Slaughter weight (kg)	90.9±0.9	88.6±0.8[b]	92.7±1.0[a]
Hot carcass without head, feet and tail (kg)	62.0±0.7	60.2±0.7	62.1±0.6
Dressing percentage (%)	68.2±0.5	67.9±0.4	67.0±0.5
Cold carcass without head, feet and tail (kg)	60.8±0.7	59.0±0,7	60.2±1.0
Carcass cooling loss (%)	1.96±0.10[a]	2.08±0.10[a]	3.49±0.75[b]
Body components			
head (kg)	5.00±0.08[a]	4.88±0.08[a]	5.56±0.08[b]
feet (kg)	1.29±0.02[a]	1.31±0.02[b]	1.32±0.02[c]
heart (kg)	0.28±0.01[a]	0.30±0.01[a]	0.38±0.05[b]
liver (kg)	1.53±0.03[a]	1.41±0.03[b]	1.51±0.08
kidney (kg)	0.28±0.01	0.28±0.01	0.29±0.02
spleen (kg)	0.13±0.01[a]	0.15±0.01[b]	0.18±0.01[c]
lungs (kg)	0.56±0.03[a]	0.71±0.04[b]	0.69±0.06[b]
leaf fat (kg)	1.58±0.08[a]	1.63±0.07[a]	2.29±0.15[b]
stomach (kg)	0.74±0.02[a]	0.65±0.01[b]	0.69±0.01
stomach volume (ml)	808±70	702±102	541±33
length of small intestine (m)	19.92±0.43[a]	18.83±0.32[b]	17.94±0.31[b]
length of large intestine (m)	5.95±0.16[a]	6.03±0.16[a]	5.33±0.11[b]

[abc]Means with different superscript differ significantly at $P<0.05$.

The influence of wild boar genotype was also observed for body component weights. Head weight of 1/2 WB genotype was the highest ($P<0.05$). Weights of feet, leaf fat and organs, including heart, spleen, and lungs were higher in hybrids than in LIW pigs which is in agreement with the findings of Müller et al. [2000]. However, in the present study the increase of WB proportion in hybrids resulted only in significantly higher feet, leaf fat and spleen weights. Literature data for spleen size of WB [Fernandez-Llario *et al*. 2004] shows that high spleen size variation is caused by the action of sex hormones for individuals older than 1 year of age and season of the year. In our case, we used females and castrates and slaughtered all of them in winter before reaching the age of 1 year. It appeared that the WB effect for the spleen size was one of the highest. Andersson-Eklund et al. [1998] found a decrease in liver weight, at the same carcass weight, with an increased proportion of wild boar alleles. We only found significant decrease in liver weight in 1/4 WB with no significant difference detected for 1/2 WB genotype. The gastro-intestinal tract of LIW pigs was longer than in hybrids. Uhr [1995] has reported that the total intestine of the domestic pig is 27.7% longer than in WB. Lundstrőm et al. [1995] even used the length of small intestine as a criterion to distinguish between different proportions of WB in hybrids of WB and Large White. In the present investigation the entire intestine of LIW pigs was, respectively, 3.9% and 10.1% longer than in 1/4 and 1/2 WB genotypes. However, although the length of the small intestine was significantly ($P<0.05$) higher in LIW pigs than in both hybrid groups, the length of large intestine was higher than in 1/2 WB only. The weight of empty stomach was lowest in 1/4 WB hybrids. The increase of wild boar proportion in hybrids resulted in lower volume of stomach, but due to a high variation differences were statistically insignificant.

Crossbreeding of WB with LIW pigs decreased carcass and bacon lengths parallel to WB proportion in hybrids but only the difference between LIW and 1/2 WB was significant ($P<0.05$ – Table 4). WB crossing has increased backfat thickness in 1/2 WB genotype ($P<0.05$) with the highest (8.5 mm) fat layer increase at 10 rib and the lowest (2.73 mm) fat layer increase over the *gluteus medius*. Other studies of lean pig breeds and WB crosses indicated that fatness increased with increasing proportion of WB [Lundstrőm *et al*. 1995, Andersson-Eklund *et al*. 1998, Knott *et al*. 1998]. LIW pigs are fatty pigs and our results are in agreement with findings of Müller *et al*. [2000], who reported that the crossing of WB and Meishan resulted in extremely fat animals. However, backfat thickness in 1/4 WB genotype was insignificantly lower than in purebred LIW pigs. This is in contrast with the above mentioned studies and cannot be explained by different WB proportion. Although the effect of genotype on carcass characteristics and organ weights during the growth of animals has not been studied, it can be assumed that extreme increase in lipid deposition of WB hybrids started at a weight lower than 90 kg. This can be confirmed by other authors who noticed that WB deposits fat at an earlier age [Lundstrőm *et al*. 1995].

Differences in loin area were statistically insignificant between observed genotypes though an increase of loin area in hybrid groups with increasing WB proportion could be seen. This would be in agreement with Andersson-Eklund *et al*. [1998] who reported that WB alleles increased the *longissimus* muscle area. Phenotypic negative correlations between loin area and backfat thickness at different points of LIW pigs ranged from -0.34 to -0.63 ($P<0.01$). Negative moderate correlations, respectively, -0.45 and -0.51 were only estimated between loin area and backfat thickness above *M. gluteus medius* of 1/4 WB and 1/2 WB genotypes. Correlations of -0.08 to -0.42 between loin area and backfat thickness at other points were statistically insignificant

Table 4. Carcass characteristics of Lithuanian indigenous pigs and their wild boar hybrids

Variables	Group of pigs		
	Lithuanian indigenous	1/4 wild boar	1/2 wild boar
Carcass length (cm)	90.6±0.6[a]	89.6±0.6	88.4±0.7[b]
Bacon length (cm)	72.2±0.5[a]	71.0±0.5	70.1±0.9[b]
Loin area (cm[2)]	26.26±0.60	27.29±0.68	28.15±0.64
Fat area (cm[2)]	26.10±1.45[a]	27.57±1.15[a]	35.93±1.56[b]
Backfat thickness (mm)			
at crest	45.05±1.47[a]	44.62±1.17[a]	50.73±1.22[b]
at 6/7 rib	35.95±1.50[a]	32.0±1.19[b]	41.18±1.17[c]
at 10 rib	26.05±0.97[a]	24.41±0.88[a]	34.55±1.65[b]
at last rib	26.59±0.86[a]	25.45±0.85[a]	31.55±1.43[b]
at thinnest lumbar point	27.95±0.99[a]	26.28±0.89[a]	32.36±1.27[b]
over the *gluteus medius* at the anterior part	35.18±1.15[a]	34.86±1.06[a]	39.45±1.52[b]
over the highest point of the *gluteus medius*	30.36±1.22	30.76±1.18	33.09±1.64
over the *gluteus medius* at the posterior part	37.00±1.13	36.52±1.29	39.82±1.69
side fat thickness	26.00±1.45[a]	24.59±1.04[a]	34.00±2.98[b]
Thickness of ventral part of belly along the line of teats (mm)			
5 cm caudally from the last teat	20.55±0.35[a]	19.45±0.24[b]	19.91±0.34
in parallel with the last thoracic vertebra	18.59±0.28[a]	17.90±0.20[b]	18.27±0.27
3 cm caudally from sternum	20.23±0.31[a]	19.21±0.25[b]	20.18±0.42
Weight of carcass halves primal cuts (kg)			
ham	10.16±0.15[a]	10.07±0.15[b]	10.00±0.13[c]
middle part of carcass	9.07±0.16	8.58±0.16	9.86±0.25
shoulder	11.07±0.20	10.92±0.16	10.89±0.18

[abc]Means with different superscript letter differ significantly at P<0.05.

and suggested no relationship between these traits in WB hybrids. Nonetheless, correlations between loin area and leaf fat were negative and moderate: -0.37, -0.41 and -0.55 (Tab. 5). Thickness of ventral part of belly at three points in LIW pigs was higher than in hybrids but only the difference between purebred pigs and 1/4 WB hybrids was significant ($P<0.05$). Ham weight and weight of ham expressed as percentage of the left semi-carcass decreased as WB proportion increased in hybrids ($P<0.05$) (Fig. 1). Weight of shoulder as percentage of semi-carcass increased only in pigs of 1/4 WB genotype; it was not affected by the WB proportion in hybrids. It was estimated that in 1/2 WB genotype pigs there was an increase of the percentage of the middle part of the carcass.

Table 5. Correlation between loin area and backfat thickness and leaf fat in different genotypes

Variables	Loin area		
	LIW	¼ WB	½ WB
Backfat thickness:			
At crest	-0.63**	-0.07	-0.39
At 6/7 rib	-0.59**	-0.16	-0.34
At 10 rib	-0.36	-0.08	-0.42
At last rib	-0.34	-0.10	-0.30
At thinnest lumbar point	-0.39	-0.19	-0.42
Over the *gluteus medius* at the anterior part	-0.47*	-0.27	-0.32
Over the highest point of the *gluteus medius*	-0.47*	-0.45**	-0.51*
Over the *gluteus medius* at the posterior part	-0.44*	-0.31	-0.53*
Leaf fat	-0.41	-0.37*	-0.55*

*P<0.05; **P<0.01.

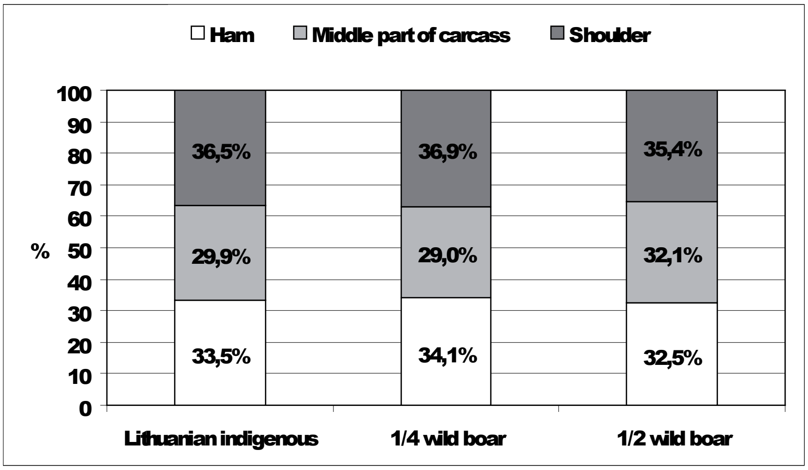

Fig. 1. Proportional weight expressed as percentage of primal cuts of the left semi-carcass.

The results obtained in the study showed that hybrids Lithuanian indigenous pigs and wild boar differed from Lithuanian indigenous pigs by coat colouration patterns, bristles, internal and external body measurements. Crossing of WB with LIW pigs decreased growth rate, carcass length but increased backfat thickness in 1/2 WB genotype. Also some increase of loin area in hybrid genotypes with increasing of wild boar portion could be noticed. When the pork production is considered 1/4 WB hybrids demonstrated superiority over 1/2 WB ones. Yet, producing a terminal backcross is more complicated as F_1 generation has to be created anyway, which can make the system less profitable economically.

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Violeta Razmaite, Sigita Kerziene, Virginija Jatkauskiene

Pomiary ciała, tuszy i masy wybranych organów u lokalnej świni litewskiej i jej krzyżówek z dzikiem

S t r e s z c z e n i e

Celem badań była charakterystyka morfologiczna i rzeźna lokalnych świń litewskich (LIW) i ich krzyżówek z dzikiem (WB) z punktu widzenia wsparcia programu zachowania rasy. Ponieważ w czystości rasy świnie LIW ustępują walorami rzeźnymi innym rasom wykorzystanie dzika do krzyżowania zmierza do stworzenia lokalnego produktu. W zależności od udziału WB w krzyýówce (Ľ lub ˝) czystorasowe úwinie byůy, odpowiednio, 3,2 i 4,3 cm niýsze w kůćbie. Stosownie, tylne kończyny u Ľ WB byůy důuýsze o 1,8 cm a u ˝ WB o 2,2 cm. Świnie LIW miały ogólnie dłuższe tusze o krótszych pyskach, w porównaniu do krzyżówek. Tusze krzyżówek były bardziej wypełnione, chociaý wićkszy obwód stwierdzono tylko u ˝ WB. Krzyýowanie úwiń LIW z WB zwićkszyůo gruboúă tůuszczu na grzbiecie u ˝ WB. Wpływ płci na cechy rzeźne nie zaznaczył się na przestrzeni analizowanego wieku uboju. Główną korzyścią wynikającą z krzyżowania był wzrost powierzchni mięśnia najdłuższego grzbietu wraz ze wzrostem udziału WB w krzyżówce.