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ANALYSIS AND COMPARISON OF MEAT PERFORMANCE PARAMETERS IN POLISH AND FRENCH LIMOUSINE BULLS

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Abstract. The study covered bulls of the Limousine meat breed, whose parents were of Polish and French origin, kept on farms in Poland. This study aimed to assess whether individuals of Polish origin cover their genetic potential compared to bulls of French origin. These studies were carried out under the program of the Ministry of Science and Higher Education "Implementation Doctorate" DWD3 / 53/2019 in cooperation with the Polish Association of Beef Cattle Breeders and Producers in 2019-2022. The research material consisted of 925 bulls, 447 by French father and 478 by Polish father. Among breeders of Polish origin, special attention was paid to the fact that parents of French origin did not appear in the pedigrees in the previous two generations. The following factors were taken into account in the comparative analysis: the country of origin of the bull's father, the country of origin of the bull's mother, body weight after calving (kg), body weight at 210 and 420 days of life (kg) and gains (g) in this period, standardized weight in 210 and 420 days (kg), as well as the height at withers (cm), chest circumference (cm), ultrasound measurement of the longest back muscle (cm³), muscle index, development index, collective evaluation index, calibre, muscle and bone share, functional features and state. The individual calendar months were taken into account as the calving period. Statistical analysis was performed by multivariate ANOVA using SPSS.23 software. A significant influence of the father's origin on the vital parameters of bulls was shown. After the birth of a Polish father, the mean body weight of bulls was 39.08 kg and was lower by 0.95 kg ($p \geq 0.01$) than males of French origin. Bodyweight, daily gains, standardized body weight in the 210th and 420th day of life, height at the withers, chest circumference, ultrasound measurement of the longest back muscle, meatiness index, development index, and aggregate evaluation index spoke in favour of bulls of French origin. However, there were no significant differences in maternal origin, size, muscle and bone proportion, functional components, and condition.

Key words: bulls, limousine, origin, growth index.

INTRODUCTION

The breeding of beef cattle in Poland began only 30 years ago, and its low profitability is the main reason for the low level of about 30.000 cows. Therefore, for many years to come, beef will be produced in Poland mainly from dairy herds, unlike the powerhouses in this field, including North and South America, Australia, France, Italy, Great Britain, and Spain (Grodzki and Przysucha 2009).

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Beef produced in Poland is not of the highest quality; therefore, many breeders, wanting to improve their herds' genetics, have imported the best males from France for breeding. The features that characterized beef were its darker colour and poorer tenderness compared to other countries because it was obtained mainly from cattle of dairy or dairy-meat breeds – otherwise known as two-sided use – or animals of meat breeds or their hybrids with dairy breeds (Dobicki and Łobarzewski 1987; Wajda 1996; Daszkiewicz and Wajda 2002; Oprządek and Oprządek 2003). Inbreeding material brings from to create the first meat herds and bring in breeding material from abroad, the production of live cattle was carried out based on breeds with meat and milk utility and dairy breeds with commercial crossing (Guliński 1999; Trela and Choroszy 2011).

The bulls from meat breeds were initially imported to Poland for experimental purposes, followed by the semen, heifers, and cows of meat breeds from Great Britain (Aberdeen-Angus and Hereford breeds) and France (Charolais breeds). The scale of commodity crossing during this period was approximately 20% of the cows (Szarek et al. 2008).

The breeding of beef cattle on a slightly larger scale in our country began in the late 1980s when Limousine cattle from France were imported to the Bieszczady Mountains and Czarna Dolna, and Charolais to Janków near Kamienna Góra.

The Limousine breed is one of the most widespread meat breeds in the world today. The largest pure-breed population is maintained in France – the breed's origin – with over 700.000 cows, but this breed is also bred with great success in more than 60 countries across almost all climatic zones.

Imported to Poland in 1980 from France, Limousine is known as the leading cattle breed for beef quality and yield. Over time, the Limousine breed adapted to Poland's not so ideal environmental traits (mainly feeding regime), which allowed the animals to develop a little leaner. It is believed that Limousine are amongst the oldest cattle breeds in existence. Ancient French cave paintings estimated to be 20. 000 years old depict animals striking resemblance to today's Limousine beef cattle. In Poland, the Limousines breed is also the most numerous and most popular meat breed of cattle. It is characterized by a good ratio of meat to fat and bones, a high percentage of culinary elements, and, very importantly, bright colour and good sensory quality. An important feature is its great capacity for producing well-muscled pieces, which results in a high slaughter efficiency (Daszkiewicz and Wajda 2002; Czerniawska-Piątkowska 2016).

Properly conducted breeding work in beef cattle herds requires the selection of the best animals for reproduction. A helpful tool in this respect is the assessment of their use and breeding value. In a meat herd, particular emphasis is placed on evaluating bulls intended for breeding. Because of the paternal genotype, the characteristics that determine the exterior, growth rate, feed conversion, and carcass quality are transmitted to the offspring.

The research aimed to compare meat performance parameters in Polish and French Limousine bulls.

MATERIAL AND METHODS

The research material consisted of 925 Limousine bulls, part of which had French parents (447) and part of which had Polish parents (478). The bulls were of 100% Limousine breed genotype. The research was conducted during 2016–2020 in cooperation with the Polish Association of Beef Cattle Breeders and Producers as part of the "Implementation Doctorate"

program. In sires whose father was of Polish origin, special attention was paid to the fact that parents of French origin did not appear in the pedigrees in the previous two generations. The environmental factor was examined by dividing the calving month. The comparative factors included: the country of origin of the bull's sire, the country of origin of the bull's dam, birth weight [kg], body weight at 210 days [kg], body weight at 420 days [kg] for rockers and gains for 210 and 420 days [g], standardized weight for 210 and 420 days [kg], and the height at the withers [cm], chest circumference [cm], ultrasound measurement of the longest back muscle [cm³], muscle index, development index, collective evaluation index, calibre, muscles, bones, functional features, and overall assessment.

Data were processed statistically using SPSS version 23.0 software (Stat Soft 2021). The effects of cattle category (Polish and French bulls) on the weight and meat traits were determined by the least square's method, using the formula:

$$Y_{ijk} = \mu + O_i + S_j + M_k + x_{ijk}$$

where:

Y_{ijk} – is value of the analysed parameter;

μ – is population mean;

O_i – effect of sire's origin, $i = 1, 2$ (1 – Polish, 2 – French);

S_j – effect of the bull's month birth, $j = 1, 2, \dots, 12$ (1 – January, 2 – February etc.);

M_k – effect of the dam's origin, $k = 1, 2$;

x_{ijk} – is random error.

Differences between means were estimated by Tukey's test.

The data set included: N – number of animals tested, min. – minimum values for the tested features, max. – maximum values for selected features, mean – mean values of the analysed features, and SD – standard deviation. The assessed properties were: average weight of calves after a given bull [kg], the average weight of calves after birth [kg], the average daily weight gain at 210 days [g], the average weight of calves at 210 days [kg], the average daily weight gain for bulls at 420 days of age [g], and the mean body weight of calves at 420 days of age [kg].

The calculation of the animal's standardised body weight (MCS) for a specific day of its life was performed according to the following formula:

$$\text{MCS} = [(\text{MCB} - \text{MCU}) / \text{WW}] \times \text{WS} + \text{MCU}$$

where:

MCS – standardized animal body weight [kg];

MCB – mean body weight of the animal at the actual weighing [kg];

MCU – actual body weight set for 48 hours, at birth [kg];

WW – mean age of the animal at the weighing [days];

WS – standardized age of the animal [s].

The mean daily weight gain of an animal (PDMC) from birth to 210 days of age was calculated according to the formula:

$$\text{PDMC} = (\text{MCK} - \text{MCP}) \times 1000 / (\text{WK} - \text{WP})$$

where:

PDMC – mean of the increase in daily body weight [g];

MCK – final body weight of the animal on the weighing day [kg];

MCP – initial body weight of the animal at the weighing [kg];

WK – mean age of the animal at the final weighing [days];

WP – mean age of the animal at the initial weighing [days] (milk yield in dairy cows is expressed in kg of milk per convention).

The index showing body weight was called the Index Development (WR) – is calculated according to the formula:

$$WR = 100 + (24.99 \times BWM210 + 0.51 \times BWM420 - 1.73 \times WKL^* + 4.89 \times OKLP^*) / 1000$$

where:

BWM210 – body weight at 210 days of age [kg];

BWM20 – body weight at 420 days of age [kg];

WKL – height at withers [cm];

OKLP – chest circumference [cm].

Meat index (WM) was calculated according to the formula:

$$WM = 35.235 + 0.133 \times POW^* + 0.052 \times PUM + 0.286 \times OOP$$

where:

POW – ultrasound measurement of the cross-sectional area of the longest muscle [cm²];

PUM – the number of points for the evaluation of the muscles (points);

OOP – number of grade points for the habit assessment (points).

The index of ten corresponding to the standardization (SMW) according to the formula:

$$SMW = 100 + 10 \left(\frac{WM - \overline{WM}}{\sigma_{WM}} \right)$$

where:

WM – Standardized Meat Index,

\overline{WM} – average meat rate of bulls in a given season,

σ_{WM} – standard deviation for the meatiness index of bulls assessed in season.

Standardization allows us to present the meatiness of a bull as an average value of 100, with a standard deviation of 10. This value should be in the range of about 70 to about 130.

Development Index (WR) and Standardized Meat Index (WM), with appropriately assigned weights were used to calculate the Modified one Collective Assessment Index (WOZ):

$$WOZ = 0,6 \times WM + 0,4 \times WR$$

where:

WM – Standardized Meat Index,

WR – Index Development.

RESULTS AND DISCUSSION

Arthur et al. (1997) have been showing, the main factor determining the profitability of rearing and breeding beef cattle is its growth and development rate. Therefore, the profitability of breeding and breeding is associated with obtaining healthy, well-developed calves from cows. Work towards improving calf rearing rates and reproductive performance is of great economic importance (Przysucha et al. 2005a; Przysucha et al. 2007; Przysucha and Grodzki 2007; Wójcik and Bilik 2007; Kotnik et al. 2009). According to Andersen (1978), of all the factors determining the calf's weight at birth, the breed and genotype of the bulls are the most important. Apart from the sex of the calf, the order of calving, the calving season, and the feeding of cattle, these factors are always mentioned by other authors as necessary (Hanset 1981; Holland and

Odde 1992; Gregory et al. 1992; Bartoň et al. 2003; Johanson and Berger 2003; Albertí et al. 2005; Nogalski et al. 2014). The latest research concerns proteomic and nutrigenomic relationships. Ellies-Oury et al. (2017) described the effects of gene expression and nutrition on the ability to accumulate muscle in cattle of three French breeds, including the limousine.

The mean body weight of calves (at birth, at 210 days of age, and, for bulls, at 420 days of age), daily weight gain at 210 and 420 days, and standardised body weight for 210 and 420 days are presented in Table 1. In bulls of Polish origin, birth weight was lower by 0.95 kg. Body weight at 210 and 420 days, 296.52 kg and 554.47 kg respectively, also favoured bulls of French origin. Calves that were heavier at birth made better gains and ended their rearing at a higher body weight, which is the primary goal of the breeder but sometimes causes calving problems (Liu and Makarechian 1993; Przysucha 2009). Przysucha et al. (2002b) reported that the average body weight of Limousine calves, both at birth (34 kg) and 210 days of age, was 230.3 kg, which was similar to those reported other Polish authors. Piasecki (1999) gives the average weight of calves at birth: 34.7 kg and 210 days – 239.7 kg. Trela and Jodko's (1998a) study was carried out on an imported herd of Limousine cattle and indicated an average weight of calves at the birth of 38–39 kg (from min. 28 to max. 41 kg). The same authors reported that the average weight of calves at weaning was 255–274 kg, depending on the calving season.

Table 1. Comparison of the birth weight on the 210 and 420 days of life of the animals as well as the daily increase and standardized body weight on the 210 and 420 days of life of bulls from Polish and French bulls

Feature	Father's origin	LSM	SEM
Birth weight	French	40.03 ^A	0.231
	Polish	39.08 ^B	0.217
Body weight at 210 days	French	296.52 ^A	1.820
	Polish	284.17 ^B	1.709
Body weight at 420 days	French	554.47 ^A	2.402
	Polish	538.51 ^B	2.255
PDMC from birth to 210 days of age	French	1176.50 ^A	5.994
	Polish	1154.98 ^B	5.628
PDMC) from birth to 420 days of age	French	1257.41 ^A	7.282
	Polish	1196.32 ^B	6.837
Standardized body weight at 210 days	French	287.11 ^A	1.307
	Polish	281.62 ^B	1.228
Standardized body weight at 420 days	French	549.35 ^A	2.022
	Polish	531.90 ^B	1.898

LSM – least-square means; SEM – standard error of the mean.

^{A, B}Least-square means within a country origin with different superscript letters in the same row indicate pairwise differences at $P < 0.01$ in the post hoc analysis.

French data (Institute de L'Elevage 2021) show that the mean birth weight of bulls was 43.4 kg, 179 kg at the age of 120 days and 295 kg at the period of 210 days, while for heifers, the mean birth weight was 41.1 kg, 168 kg at 120 days of age and 268 kg at 210 days of age. Chladek and Kucera (2000) reported the average weight of Limousine calves to be 261.5 kg at 210 days of age. Slightly lower body weight for Limousine calves at birth (32.5 kg in the winter

season and 32.7 kg in the summer season) was reported by Litwińczuk et al. (1999). Przysucha (2009) stated that an exciting, but not yet fully understood, a factor that influenced a calf's body weight at birth, and thus the frequency of difficult births, was the geographical location. Heavier calves are born in harsher, colder climates than calves born in mild and warm temperatures. A case in point was an experiment in the United States in which a herd of Hereford cows were moved from the warm climate of Florida to the harsh conditions of Montana. A second related herd of Hereford cows was moved in the opposite direction. The average weight of calves born to cows transferred from a cold to a warm climate decreased from 40.5 to 32.0 kg, and the importance of calves born to cows transferred from the mild to severe environment increased from 33.0 to 38.5 kg (Ritchie and Anderson 1994). Many authors have demonstrated the significant effect of postnatal body weight on weight weaning at 210 days of age. Calves with the highest weight at birth usually have the highest body weight at the end of their rearing period (Przysucha et al. 2002a, c, d; 2003). For example, Wójcik and Bilik (2007), in describing a purebred imported Limousine herd, stated that the birth weight for bulls was 39.0 kg, while the body weight at weaning (210 days) age was on average 251.0 kg.

In beef cattle, an intensive selection is carried out for ease of calving, mainly achieved by selecting bulls for reproduction, after which calves of moderate body weight are born. According to Massey et al. (1999), the birth weight of a calf should be 7–9% of an adult cow.

Much research has been done on the factors influencing the growth rate. For example, the body weight of calves and their daily weight gains are influenced by factors such as herd, region, calving year and month, calving order, mating method, sex, the calves' muscularity, weaning age, condition, and the age of the cow (Stadník et al. 1999; Ríha et al. 2001; Goyache et al. 2003; Jakubec et al. 2003; PZHiPBM 2015).

The highest daily gains at 210 days of age were recorded in bulls of French origin, which amounted to 1176.49 g, and were higher than bulls of Polish origin by 21.51 g. A similar dependence was noted in the increment for 420 days, where bulls of French origin also had a higher value. Pogorzelska et al. (1998) reported that Limousine cattle imported from France found that the daily weight gains for Limousine bulls from birth to weaning amounted to over 1000 g. At the age of 3–4 months, they had gained a bodyweight of approximately 170 kg. Wójcik and Bilik (2007) reported that the daily gains in calves were relatively high, amounting to over 1000 g/day for the period from birth to weaning. As a result, bodyweight standardised for 210 days of age was higher by 5.49 kg in favour of French bulls. A similar situation was observed at 420 days of age, where bulls of Polish origin had a lower standardised body weight of 17.44 kg. In the cited studies, Limousine calves were characterised by high gains during the rearing period: 900–1009 g for female calves and 973–1088 g for bulls, depending on the year of evaluation. It should be noted that since 2002, bulls have exceeded 1000 g daily increments. Such increases mean that after a short extra fattening period of about one month, bulls previously eliminated from breeding can be sold for export at an attractive price with an approximate body weight of 300 kg. Furthermore, the daily gains in calves, which are significantly higher than those specified in the breeding standard, guarantee that after weaning, with appropriate nutrition, they will obtain the bodyweight required for mating at the age of 15 months (Przysucha et al. 2005b).

The comparison of the birth weight, body weight, and daily weight gain per 210 days for individuals of both origin Polish and French bulls are presented in Table 2 (owner research and data from literature).

Table 2. Body weight of limousine calves at birth at 210 days of age and increases by day 210 according to various sources

Source	Body weight at birth [kg]	Body weight at 210 days of age [kg]	Daily weight gain from birth to age 210 days [g]
Own analysis (2021)	PL ♂ – 38.6–39.5 FR ♂ – 39.5–40.4	PL♂ – 280.8–287.5 FR♂ – 292.5–300.0	PL♂ – 1143.9–1166.0 FR♂ – 1164.7–1188.3
PZHiPBM (2021)	♀ – 35.7 ♂ – 38.8	♀ – 250.0 ♂ – 271.0	♀ – 1021.6 ♂ – 1110.4
Institut de L'Elevage (2021)	♀ – 41.3 ♂ – 43.7	♀ – 268 ♂ – 295	nd
Przysucha et al. (2015a)	♀ – 33.1–34.7 ♂ – 34.3–37.7	♀ – 222–253 ♂ – 238–274	♀ – 900–1009 ♂ – 973–1088
Institut de L'Elevage (2012)	♀ – 40.3 ♂ – 42.6	♀ – 261 ♂ – 289	nd
Grodzki et al. (2012)	♀ – 35 ♂ – 40	nd	nd
Romaniuk et al. (2012)		♀ – 254 ♂ – 291	
Choroszy et al. (2011)	♀ – 33.7 ♂ – 34.5–36.2	♀ – 221.7–246.2 ♂ – 238.5–249.0	♀ > 900
Wójcik and Bilik (2007)	♀ – 36 ♂ – 39 (import)	251 (import)	> 1000 (import)
Pogorzelska Wroński M. (2005)	♀ – 36 ♂ – 39	nd	nd
Przysucha et al. (2002b)	34	230.3	♀ – 929 ♂ – 1032
Trela et al. (2000)	PL ♀ – 34 ♂ – 35.7–38.5 FR ♀ – 39 ♂ – 41.5	PL ♀ – 232.5–235 ♂ – 254–258 FR ♀ – 257 ♂ – 296	PL ♀ – 944–953 ♂ – 1026–1058 FR ♀ – 1038 ♂ – 1211
Chladek and Kucera (2000)	nd	261.45	nd
Litwińczuk et al. (1999)	32.5 (summer season) 32.7 (winter season)	nd	nd
Piasecki (1999)	34.7	239.7	nd
Kamieniecki et al. (1998)	♀ – 32.57 ♂ – 34.41	♀ – 216.9 ♂ – 250.4	nd
Trela and Jodko (1998b)	38–39 (import)	255–274 (import)	nd
Pogorzelska (1998)	nd	nd	> 1000
Puchajda (1997)	♀ 37.5 ♂ – 44	nd	nd
Wroński et al. (1996)	♀ – 35.8 ♂ – 38.7 (import)	nd	nd

♀ – heifer, ♂ – bull., nd – no date.

Calf growth indicators obtained in the presented research, i.e., weight at birth for bulls of Polish origin, 38.65–39.50; mass at 210 days of age, 280.82–287.52; and daily increments up to 210 days for bulls, 1143.93–1166.02; do not differ from those presented by Polish authors

(Trela and Jodko 1998b; Trela et al. 2004; Wróblewska et al. 2007; Choroszy et al. 2011; Przysucha et al. 2015a), but are slightly lower than those reported in French sources (Institute de L'Elevage 2021).

The comparison of selected vital parameters for bulls, depending on the origin of the bull's sire, are presented in Table 3. Specimens of French origin were 0.43 cm taller at the withers, and the chest circumference was 0.74 cm greater. The longest back muscle measurement was also longer in French paternal sires at 108.09 cm³. Significant differences were demonstrated in the parameters tested between Polish and French origin individuals. Developmental, meatiness, and aggregate indices were more favourable for individuals of French origin.

Table 3. Comparison of selected vital parameters of bulls depending on the origin of the bull's father

Traits	Father's origin	LSM	SEM
Height at the withers	French	132.60 ^A	0.135
	Polish	132.17 ^B	0.142
Chest circumference	French	196.55 ^A	0.265
	Polish	195.80 ^B	0.279
Ultrasound measurement	French	108.09 ^A	0.675
	Polish	104.85 ^B	0.710
Meat Index	French	74.13 ^a	0.157
	Polish	73.74 ^b	0.166
Development Index	French	108.18 ^A	0.044
	Polish	108.03 ^B	0.047
Collective Assessment Indicator	French	104.01 ^A	0.365
	Polish	102.93 ^B	0.385

LSM – least-square means; SEM – standard error of the mean.

^{A, B}Least-square means within a country origin with different superscript letters in the same row indicate pairwise differences at $P < 0.01$.

Numerous studies have shown that the birth season significantly influences the growth of reared calves (Makulska et al. 2002; Przysucha et al. 2002b; Szewczuk et al. 2006). The season of birth significantly impacts the viability and growth rate of reared calves, which directly affects the economic effects of breeding (Przysucha et al. 2005b). In studies by Przysucha et al. (2002a), Hereford calves born during the winter season (from November to April) showed a slight advantage in body weight across all the studied periods of life compared with calves born during the summer season (from May to October).

The calving seasonality in breeding meat herds is significant because the correct calving date allows magnificent quality farm animals to be obtained in the future at the lowest rearing costs (maximum use of pastures). Many authors believe (Dobicki 1995; Jasiorski et al. 1996; Przysucha et al. 2015b) that the mating period and the resulting greening time should not be longer than 2–3 months. Cows of meat breeds kept on the pasture all year round should produce offspring, preferably at the end of winter. After completing the first period of milking, calves born in this period are prepared for the full use of the pasture, resulting in a fast growth rate, calves that are healthy and well developed, and the lowest rearing costs for the breeder. It is also not without significance that in cows that give birth in winter, the “physiological peak

of lactation” falls in the first months of the year, and then, after leaving for the young pasture in May, we observe a second, smaller nutritional peak in lactation). In the case of winter calves, the moment of weaning coincides with the depletion of the pasture in autumn, resulting in the calves’ natural drying. During winter calving, cows calve most often in barns, making it easier to monitor the births and provide help in case of complications (Przysucha et al. 2015b).

When analysing the obtained results and assuming that the most favourable period for calving cows is November to April, it should be noted that 52.8% of cows calved in the relevant period in recent years in Polish Limousine cattle herds. It follows that almost half of the calves born at other times of the year can only take advantage of the pasture to a small extent.

CONCLUSION

The results should be stated that despite the decreasing trend in weight gain for bulls up until the age of 210 and 420 days, the overall results regarding calf growth should be considered good in the current market situation. Insemination is the primary reproductive technique used with beef cattle herds in Europe, which allows for almost unlimited use of the world's best genetic resources. In Poland, most farmers sell beef at the prices of slaughter material, even with the current boom and questionable profitability of beef production, therefore natural cover dominates in reproduction. Additionally, to sum up, the most important tool to improve beef productivity could be co-financing the insemination with semen of the best French bulls, which would significantly increase the interest in using the known origin of the semen and could translate into a rapid improvement in the quality of the breeding value of our beef cattle population. and purebred beef cattle herds should be developed.

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ANALIZA I PORÓWNANIE PARAMETRÓW UŻYTKOWOŚCI MIĘSNEJ BUHAJÓW RASY LIMOUSIN POCHODZENIA POLSKIEGO I FRANCUSKIEGO

Streszczenie. Badaniami objęto buhaje rasy mięsnej limousin utrzymywane w gospodarstwach na terenie Polski, których rodzice byli pochodzenia polskiego i francuskiego. Celem badania było oszacowanie, czy osobniki pochodzenia polskiego dorównują swoim potencjałem genetycznym zwierzętom pochodzącym z Francji. Badania prowadzono w latach 2019–2022 w ramach programu MNiSW „Doktorat wdrożeniowy” DWD3/53/2019, we współpracy z Polskim Związkiem Hodowców i Producentów Bydła Mięsnego. Materiał do badań stanowiło 925 buhajów, w tym 447 po ojcu francuskim i 478 po ojcu polskim. W przypadku buhajów polskiego pochodzenia zwrócono uwagę na to, by w rodowodach we wcześniejszych dwóch pokoleniach nie wystąpili rodzice

pochodzenia francuskiego. W analizie porównawczej uwzględniono następujące czynniki: kraj pochodzenia ojca buhaja, kraj pochodzenia matki buhaja, masę ciała przy wycieleniu [kg], masę ciała w 210. i 420. dniu życia [kg] oraz przyrosty [g] w tym okresie, masę standaryzowaną w 210. i 420. dniu [kg], a także wysokość w kłębie [cm], obwód klatki piersiowej [cm], pomiar USG mięśnia najdłuższego grzbietu [cm³], wskaźnik mięsności, wskaźnik rozwoju, wskaźnik oceny zbiorczej, kaliber, udział mięśni i kości, cechy funkcjonalne oraz kondycję. Dane analizowano w poszczególnych miesiącach roku. Analizę statystyczną wykonano przy użyciu wieloczynnikowej analizy wariancji ANOVA, za pomocą programu SPSS.23. Wykazano istotny wpływ pochodzenia ojca na parametry życiowe buhajów. Średnia masa ciała urodzeniowa buhajków po polskim ojcu wynosiła 39,08 kg i była mniejsza o 0,95 kg ($p \geq 0,01$) niż samców francuskiego pochodzenia. Masa ciała, przyrosty dobowe, standaryzowana masa ciała w 210. i w 420. dniu życia, wysokość w kłębie, obwód klatki piersiowej, pomiar USG mięśnia najdłuższego grzbietu, wskaźnik mięsności, wskaźnik rozwoju, wskaźnik oceny zbiorczej przemawiały na korzyść buhajków pochodzenia francuskiego. Nie wykazano natomiast istotnych różnic dla takich cech, jak: pochodzenie matki, kaliber, udział mięśni i kości, cechy funkcjonalne oraz kondycja.

Słowa kluczowe: buhaje, limousin, pochodzenie, indeksy wzrostu.

