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The use of an automatic data acquisition system (RFID) to analyse the impact of parental genotypes of pigs on the fattening and slaughter traits of their offspring

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Selection of animals for mating is one of the main factors influencing improvement in production indicators in pigs, but appropriate selection requires accurate information concerning the potential of genotypes and the effects of crossbreeding them. The aim of this study was to estimate the production potential of fatteners on the basis of paternal genotype, maternal genotype and crossbreeding schemes. Modern automatic technology for identification and tracking of pigs (UHF RFID) was used for the analysis. The study was conducted on 394 crossbred pigs obtained from four lines of purebred Landrace sows paired with purebred boars of three genotypes (Duroc, Pietrain and Landrace) and one commercial hybrid line. Pronounced differentiation of indicators of fattening and slaughter traits were found between both paternal and maternal genotypes. The highest daily weight gain was noted in the offspring of the Duroc breed (598.5 ±43.1 g), and the lowest (555.6 ±40.4 g) in the offspring of boars of the Landrace genotype. The best slaughter values were found in pigs derived from Pietrain genotype (59.8 ±1.6% meat content), and the worst in those from the hybrid line (57.6 ±2.6% meatiness). The greatest efficiency in terms of fattening traits was obtained by matching the best paternal genotype, Duroc, with the best maternal genotype, L6 (613.9 ±47.9 g), whereas the best slaughter traits were obtained from the best paternal genotype, Pietrain, and a worse maternal genotype L7 (61.7 ±0.8% meatiness). The technology of automatic identification and tracking of pigs proved to be an effective tool for acquiring and analysing production data. Further research is needed to verify the results in a larger population of animals with greater genetic diversity.

KEYWORDS: genotype / RFID / identification / slaughter traits / fattening traits

For many years, a major direction in pig breeding and a priority of research and development, alongside improving reproductive performance, has been the achievement of better fattening and slaughter results through improvement of pure breeds, by evaluating weight gain and estimating meat content. It is believed that progress in terms of the meat content of pigs can lead to poorer meat quality and reproductive performance [1, 7, 20]. Appropriate selection of animals for breeding is not only skilful exploitation of the assets of the available breeding material, but also a means of improving outcomes on the pig farm [12]. Accordingly, one of the key factors influencing the quality of live pigs is their genotype, and intensive selection is carried out to achieve the desired results [32]. However, the fastest results are obtained by crossbreeding of suitable maternal and paternal breeds [9]. Producers using programmes that cross breeds and genotypes having genetic potential for high meat content, such as Pietrain, Duroc and crossbreeds between them, with native or maternal breeds can achieve a significant increase in lean meat content in the carcass in a relatively short time, while preserving the reproductive potential of sows [6, 9]. But this must go hand in hand with appropriate environmental conditions, especially a properly balanced diet. Ensuring adequate market supply of quality carcasses and meat requires, in addition to intensive research and breeding work, cooperation between livestock producers and the meat processing industry, through the use of additional payment for suppliers of better quality raw material [26].

In the European Union, one of the platforms for cooperation between agricultural production and the processing industry is the EUROP classification of pig carcasses, which aims to standardize the criteria for paying producers for pigs and to facilitate trade in half-carcasses, while at the same time indicating preferred directions of breeding work [29, 31]. However, effective improvement of fattening and slaughter results requires knowledge of the individual values achieved by individual fatteners. In 2001, attempts were made to implement a ‘new’ (at that time) evaluation system for pigs [4], which involved meticulous documentation based on this system. The piglets were marked with plastic ear tags and data were assigned to the number of the tag in the documentation: the voivodeship where the animal was kept, the number of the farm, the number and breed of the sire and dam, and the animal’s date of birth and gender. Subsequently, a second portion of the data was collected, concerning slaughter performance. According to Eckert and Blicharski [4], implementation of the project has entailed considerable difficulties associated with the volume of data (labour-intensive data collection and analysis) and the durability of the ear tags, but at the same time the authors indicated that the project was reliable and should be continued for automation of information acquisition and analysis.

An innovative system using RFID (Radio Frequency Identification) technology has emerged to meet the expectations of the market. This technology uses radio waves to exchange data between an ear tag equipped with a transmitter and a reader which is directly connected to a server collecting the data. The idea itself is not new, as it has long been used in electronic feeding stations for sows, but at the current level of information technology, a similar approach to identifying and analysing data from growing pigs seems increasingly justified. The basic technical problem has to do with the fact that fatteners are not fed at costly feed stations, but with relatively inexpensive automatic feeders for ad libitum feeding. Hence a new technology was needed that would significantly increase the range at which ear tags could be read, from a dozen or so centimetres to the entire area of the pen, i.e. several meters. Despite work conducted in many EU countries, this effect has thus far been achieved in only one system (SLIDE®), where the commonly used low frequency radio waves (LF) are replaced with ultra-high frequency waves (UHF) . One of the key elements of the SLIDE® system (Simplum Gliwice, Poland) which distinguishes it from other, similar solutions is the long, approximately 4-5 metre range of readability, which enables automation of the data acquisition process. The system enables not only animal monitoring, but also a very accurate analysis of the individual parameters of each marked pig, taking into account the factors influencing them and the interactions between individuals. Ensuring individual identification of the piglet from birth to slaughter not only enables analysis of the production parameters of each pig but also provides precise information on the reproductive performance of sows, which is currently not feasible in commercial herds due to widespread standardization of litters. Until now, a thorough analysis based on the complete identification of animals owing to individual and unique marking has only been carried out on animals from pig breeding farms [21]. In the currently used analogue systems, the data stream connection ends when the piglets are separated from their mother, which often takes place as early as the first week of lactation due to widespread fostering of piglets to even up litter size, which increases the survival rate of piglets but at the same time causes most of the piglets in large-scale production to be weaned from foster mothers rather than their biological mothers. This means that the origin of the fattener sold to the slaughterhouse cannot be identified.

In addition to the important question of identification of pigs, RFID also offers the possibility of acquisition and practical exploitation of ‘big data’. This term is now widely used in reference to information technologies used to collect, analyse and process vast amounts of information from various sources. Due to the time factor and the degree of analytical complexity, systems working in ‘big data’ must have the architecture and capability of automated data collection and be able to order them for analysis according to a specific algorithm. Such systems are in place in areas such as industry, transport, or meteorology, where the increase in the number of information sources and the scope of data subject to automated interpretation enables better prediction and thus better management of human resources, stocks, a fleet, crisis-management centres, and evacuation logistics. In livestock production, systems based on big data have not yet found application, largely due to technical complications that are difficult to overcome.

The aim of the study was to analyse the production data of fattening pigs obtained using Radio Frequency Identification technology, in relation to the genotype of the father, the genotype of the mother and the crossing scheme, in conditions of large-scale commercial production, and on this basis to evaluate the potential and practical utility of a prototype installation of an RFID system.

Material and methods

The research was conducted on a large commercial pig farm located in the Silesian Voivodeship. We analysed the performance parameters of 394 growing pigs obtained from the crossing of sows of four genetic lines of Landrace (L0, L6, L7 and L8) with boars of four genotypes, including three purebred, i.e. Duroc, Pietrain and Polish Landrace, and one crossbred from a commercial terminal line. A prototype of an automated system for animal tracking and acquisition of production data (SLIDE®; Simplum Gliwice, Poland) was installed on the farm.

All pigs under observation were marked on the first day of life with Radio Frequency Identification (RFID) tags operating with a system of antennas distributed on the farm and handheld terminals, enabling continuous monitoring of the animals and ongoing acquisition and collection of digital data with automated information flow to the server. An analogous part of the system, consisting of scanners on the production line, was installed at a slaughter and processing plant which purchased the animals after fattening. Installed as a complementary whole, the system made it possible to gather information on the most important events for each fully identifiable individual, treated individually. The system recorded the following data:

– movement of animals between sectors (farrowing, rearing and fattening)
– results of individual weighing after birth and at transfer times, using a manual hanging scale (after birth and on weaning) and a floor scale (on transfer to the fattening building and before slaughter)
– slaughter date
– weight of live animal
– results of slaughter analysis

The data from the system were easily adapted to Excel and Statistica software for further detailed analysis, including the following:

– weight gain during 25.2 ± 4.8 days of rearing with dam
– weight gain during 28.6 ± 5.4 days of rearing after weaning
– weight gain during 109.1 ± 11.4 days of fattening
– age on day of slaughter
– live weight
– hot carcass weight
– length of loin eye
– dorsal backfat thickness
– estimated meatiness
– EUROP class of carcass

The production indicators of the pigs were evaluated in relation to the following:

– the paternal genotype, comprising four groups (Duroc, Pietrain, Landrace and crossbred), with an average of 98.5 ± 34.7 pigs per group

– the maternal genotype, comprising four groups of purebred landrace lines (L0, L6, L7 and L8), with an average of 98.5 ± 14.3 pigs per group

– the mating scheme, comprising 14 groups, with an average 28.1 ± 11.7 pigs per group

All production data are shown as mean ± standard deviation ($\bar{x}$ ± SD). The numerical material were analysed by one-way ANOVA to separately determine the effect of the paternal or maternal genotype and two-way ANOVA to determine the effect of the mating, taking into account the influence of the paternal and maternal genotype. Duncan's multiple range test was used to determine the significance of differences between groups.

Results and discussion

The average body weight of the piglets born in the experiment was 1.35 ± 0.30 kg, the weight of weaned piglets was 6.18 ± 1.21 kg, and their weight on entering the fattening building was 12.01 ± 2.93 kg. Fattening on the farm is aimed at producing light animals for slaughter, so it was continued until an average body weight of 93.99 ± 5.43 kg was attained.

Several methods are used in production practice to improve the performance indicators of pigs. These involve the use of environmental factors, including the correct level and quality of feed, adjusted for the genotype, optimization of environmental conditions, preservation of the health status of the herd, and organization of production to ensure the animals' comfort [31], as well as genetic effects – primarily the selection of breeds for crossbreeding and animals for mating, as the development and production efficiency of the future individual is determined by the genotype of both parents [22, 33].

In our own study, the progeny of Duroc boars was significantly ($P \leq 0.01$) superior to that of Pietrain, Landrace and crossbred boars, both in terms of growth rate and the associated length of the fattening period (Table 1). However, fatteners derived from boars of this breed did not exhibit the best gains at every stage of rearing and fattening. In the rearing room better weight gains were noted in the progeny of the crossbred and Pietrain boars ($P \leq 0.05$). However, during fattening proper, which lasts the longest, generates the highest costs and at the same time has the greatest effect on the total value of fattening parameters, the superiority of the fatteners sired by Duroc boars was undeniable ($P \leq 0.01$). From an economic point of view, good production results depend on the length of the fattening period. Efficient fattening and rearing of piglets aimed at surpassing the average value of two production cycles should last about 160 days [13]. The progeny of Duroc boars were sent to slaughter at an average age of 156.7 days, which was significantly better than in the case of the offspring of other genotypes, whose age ranged from 162 to 167 days (Table 1). These results support the widespread view that the Duroc breed has the best

Table 1
Influence of paternal genotype on fattening traits of fatteners ($\bar{x}$±SD)

Genotype ♂	Average daily weight gain (g)				Slaughter age (days)
	farrowing room	rearing room	fattening room	total	
dur (n=83)	199.5 ± 49.8^{A}	177.8 ± 78.6^{ABab}	794.5 ± 70.9^{A}	598.5 ± 43.1^{A}	156.7 ± 11.1^{A}
pbz (n=62)	185.4 ± 61.3^{ABab}	157.5 ± 66.2^{Aa}	730.6 ± 65.6^{Ba}	555.6 ± 40.4^{Ba}	167.1 ± 10.3^{Ba}
piet (n=106)	189.6 ± 51.7^{ABa}	185.4 ± 50.7^{ABb}	742.7 ± 58.9^{Bab}	566.9 ± 34.4^{Bab}	163.1 ± 10.7^{Bb}
hyb (n=143)	166.6 ± 50.9^{Bb}	205.6 ± 73.5^{B}	755.2 ± 66.2^{Bb}	572.3 ± 40.2^{Bb}	162.5 ± 10.4^{Bb}

dur – Duroc; pbz – Polish Landrace; piet – Pietrain; hyb – hybrid line
a, b, c – different superscripts in columns designate significant differences within a category (P≤0.05)
A, B, C – different superscripts in columns designate significant differences within a category (P≤0.01)

genetic potential for economically important fattening traits, which makes it of one of the most useful genotypes in crossbreeding [24].

As regards the effect of the maternal genotype, considered independently of the paternal genotype, the best weight gains were noted in the progeny of the L6 sows, which significantly (P≤0.01) differed from the fatteners from sows of the remaining maternal genotypes at each stage of both rearing and fattening (Table 2). This advantage was so great that despite the fact that the L6 fattening pigs had the highest final weight (95.36 ± 5.26 kg), their slaughter age was also significantly lower (P≤0.01) than that of the offspring of sows of the remaining genotypes (Table 2). According to Żak et al. [33], pigs should gain about 800 g/day during fattening. In our own study, the daily weight gain of fattening pigs

Table 2
Influence of maternal genotype on fattening traits of fatteners ($\bar{x}$±SD)

Genotype ♀	Average daily weight gain (g)				Slaughter age (days)
	farrowing room	rearing room	fattening room	total	
L0 (n=116)	165.3 ± 44.6^{Aa}	177.9±64.8	743.9 ± 60.8^{A}	560.0 ± 35.9^{A}	165.4±11.0A
L6 (n=82)	217.3 ± 57.2^{B}	203.3±73.4	782.8 ± 64.7^{B}	598.6 ± 42.5^{B}	157.3±10.0B
L7 (n=94)	190.4 ± 56.2^{Ab}	186.0±66.8	743.4 ± 70.7^{A}	571.3 ± 42.5^{A}	161.4±10.7AB
L8 (n=102)	173.2 ± 53.9^{Aab}	203.2±72.6	756.8 ± 66.7^{AB}	573.8 ± 41.8^{A}	162.5±10.2AB

L0, L6, L7, L8 – lines of purebred Landrace
a, b, c – different superscripts in columns designate significant differences within a category (P≤0.05)
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derived from fathers of four different genotypes ranged from 730 g (Landrace) to 794 g (Duroc). The range of fluctuation in daily weight gain depending on the maternal genotype was smaller, from 743 g (line L7) to 783 g (line L6). The results should be regarded as average with respect to the expectations of large-scale production. However, the low body weight of pigs sent to slaughter should be kept in mind, since given the intensification of the growth rate at the end of the fattening stage this could have resulted in a significant reduction in fattening indices as compared to the standard genetic potential of the genotypes used in the experiments.

Crossbreeding carried out according to an appropriate scheme is a method which ensures improvement of production efficiency as well as the acquisition of numerous, viable progeny with good growth [9]. Several principles should be followed to achieve the desired effect of crossbreeding. According to Leroch [12], animals selected for breeding should be of different breeds, but should have similar use value (similar daily gains, meatiness, etc.). Hence the best results are obtained by pairing animals with the best per-

Table 3
Influence of crossbreeding scheme on fattening traits of fatteners ($\bar{x}$±SD)

Genotype ♂ x ♀	Average daily weight gain (g)				Slaughter age (days)
	farrowing room	rearing room	fattening room	total	
dur x L0 (n=33)	200.9±45.5^{ABa}	199.8±63.2^{ABb}	804.4±83.1^{Bac}	592.5±45.7^{Ab}	160.8±12.6^{ABab}
dur x L6 (n=19)	226.0±56.3^{Ac}	185.6±115.4^{ABab}	800.2±73.0^{Bb}	613.9±47.9^{Ac}	151.1±10.3^{Ac}
dur x L7 (n=31)	167.6±32.1^{Bb}	133.4±16.3^{Ba}	771.9±45.3^{Bb}	590.9±32.2^{Ab}	156.3±6.6^{Aa}
pbz x L0 (n=19)	206.1±30.3^{Aa}	137.0±24.0^{Ba}	700.1±39.4^{Aa}	539.2±24.1^{Bc}	167.9±9.2^{Bb}
pbz x L7 (n=13)	252.3±54.3^{Ac}	165.7±92.1^{ABab}	750.9±85.9^{ABb}	576.1±46.3^{ABa}	162.0±12.1^{ABab}
pbz x L8 (n=30)	150.3±41.4^{Bb}	160.2±62.3^{ABa}	731.0±60.1^{Aa}	551.7±39.1^{Ba}	169.0±9.4^{Ba}
pie x L0 (n=36)	166.2±29.6^{Bb}	176.7±35.3^{ABab}	742.4±54.3^{ABa}	564.2±30.9^{Ba}	166.1±10.9^{Bab}
pie x L6 (n=20)	223.9±63.0^{Ac}	213.1±35.4^{Ab}	781.8±49.3^{Bb}	596.5±38.5^{Ab}	158.2±7.6^{ABa}
pie x L7 (n=19)	165.6±38.8^{Bb}	202.9±29.2^{ABb}	692.1±50.4^{Aa}	534.0±31.7^{Bc}	165.1±12.9^{Bab}
pie x L8 (n=31)	207.1±56.3^{Aa}	182.5±65.1^{ABab}	744.5±59.9^{ABa}	569.3±42.9^{Ba}	161.3±10.1^{ABab}
hyb x L0 (n=28)	150.4±46.2^{Ba}	180.1±80.1^{ABab}	738.0±52.5^{ABa}	553.3±33.6^{Aa}	165.6±11.0^{Bb}
hyb x L6 (n=23)	193.5±51.0^{Ba}	213.4±37.9^{Ab}	758.7±77.1^{ABb}	579.1±37.6^{Ba}	165.1±8.1^{Bab}
hyb x L7 (n=31)	182.6±52.1^{Bb}	196.5±64.9^{ABb}	746.1±70.1^{ABa}	573.6±41.8^{ABa}	161.4±10.4^{ABab}
hyb x L8 (n=61)	166.2±50.3^{Bb}	224.5±70.8^{Ab}	769.5±68.5^{Bb}	582.2±39.8^{Ab}	161.0±9.8^{ABab}

dur – Duroc; pbz – Polish Landrace; piet – Pietrain; hyb – hybrid line
L0, L6, L7, L8 – lines of purebred Landrace
a, b, c – different su-perscripts in columns designate significant differences within a category (P≤0.05)
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formance indicators. This is confirmed by the results of our own research (Table 3). After singling out the best male and female genotypes, the fatteners that were their offspring (Duroc x line L6) had the best weight gains for their entire lifetime (614 g/day) and the lowest age at slaughter (151 days), which was statistically confirmed ($P \leq 0.01$) – Table 3. The fattening pigs derived from mating of Landrace x line L8 genotypes were oldest on the day of slaughter (169 days), with significantly lower ($P \leq 0.01$) average weight gain than most of the other crossbreeding variants (except for two with even lower weight gains, with no significant difference in the age at slaughter as compared to the Landrace x L8 variant).

Obtaining a 110-115 kg fattener in a 150-day period indicates good use of genetic material and proper herd management, and is associated with daily gains of 730-750 g. From an economic perspective, poor selection of breeds for crossbreeding can cause losses due to decreased production [23]. One exception to this rule is fattening of primitive breeds and production aimed at maximizing quality parameters of meat and fat, to produce expensive, luxury products. In Italy, for example, some pigs are slaughtered at 300-365 days, which results in a high body weight of 150-170 kg, a high hot carcass weight from 125 to 140 kg, and significant fat content, required for the production of cuts with a long ageing period [17]. In contrast, in the United Kingdom pigs are commonly fattened to a low body weight of up to 90 kg, which is dictated by the culinary preferences of consumers and the prohibition of surgical castration of male piglets. Such a system leads to the production of fattening pigs with high meat content, but their growth potential is not fully exploited, as the pigs are slaughtered before reaching the maximum potential in this regard, as was the case in our experiment [11].

As reported by Lisiak et al. [15], the optimum meat content of fatteners is 55-60%. Similarly, Orzechowska et al. [20] warn against single-trait selection for carcass meatiness, as this may adversely affect suitability for processing. Meat content of 55% in the carcass is the European standard, although some purebred and crossbred pigs attain meat content of over 60% [2]. The level of meatiness of Polish fatteners in the 25th week of 2012 was on average 56.6%, with an average carcass weight of 89.7 kg [28]. The average carcass weight in December of the same year, with the same meat content (56.6%), was 90.9 kg, and had increased by 3.4% as compared to the same period of the previous year (2011) [27].

In the present study, fatteners of all analysed genotypes attained on average over 55% meat content in the carcass (Tables 4, 5 and 6). Analysis of slaughter results in relation to the paternal genotype shows that the Pietrain genotype was significantly ($P \leq 0.01$) better than the other paternal lines. Fatteners sired by Pietrain boars had the highest meat content (59.84%), the longest loin eye (56.75 mm) and the thinnest backfat (11.28 mm). These data are in full agreement with the results of numerous studies indicating the outstanding slaughter performance of the Pietrain breed. Unfortunately, the exceptional meatiness of pigs of this breed is associated with inferior technological quality of the meat. Most analyses indicate that among the pure breeds used in Poland, the meat of Duroc fatteners has the best features, while meat from Pietrain fatteners is considered to be much worse [5].

The genotype of the mother [8, 10] may also have a significant effect on the meat content of the carcass, the size of the loin and the thickness of the backfat. This is confirmed by the results of our own research, which indicate substantial variation in the slaughter results of fattening pigs from dams of the same breed but different genetic lines (Tables 4, 5 and 6). In terms of meatiness, the best results were obtained in the L6 line, mainly due to the thinnest backfat, despite the thinnest loin. The poorest slaughter performance parameters were obtained by fatteners derived from the L7 line, which had the thickest backfat, with no significant differences in loin thickness in comparison with the L6 line (Table 5). Irrespective of the diversity between groups, the average meat content in the fatteners from all maternal lines ranged between 57.8% and 59.0%, which means that they belong to the optimum E class of the EUROP system, and the differences observed were not statistically significant.

In the analysis of slaughter performance of fatteners from 14 mating schemes (Table 6), the most favourable results were expected from the combination of the Pietrain and L6

Table 4
Influence of paternal genotype on slaughter traits of fatteners ($\bar{x}$±SD)

Specification	Genotype ♂			
	Duroc (n=83)	Polish Landrace (n=62)	Pietrain (n=106)	hybrid line (n=143)
Loin thickness (mm)	48.7±5.2^{A}	48.4±6.2^{A}	56.8±4.7^{B}	51.8±7.2^{B}
Fatback thickness (mm)	12.8±2.4^{Aab}	12.6±2.6^{ABb}	11.3±2.2^{Bc}	13.8±3.4^{Aa}
Meatiness (%)	57.8±1.6^{A}	57.9±1.7^{A}	59.8±1.6^{B}	57.6±2.6^{A}
Live weight (kg)	94.85±5.25	93.92±5.51	93.52±5.05	94.85±5.62
Carcass weight (kg)	75.88±4.20	75.13±4.41	74.82±4.04	75.28±4.49
SEUROP classification:				
class S (%)	6.7	13.5	50	17.2
class E (%)	90	84.6	50	65.7
class U (%)	3.3	1.9	–	15.7
class R (%)	–	–	–	1.4

a, b, c – different superscripts in columns designate significant differences within a category (P≤0.05)
A, B, C – different superscripts in columns designate significant differences within a category (P≤0.01)

Table 5
Influence of maternal genotype on slaughter traits of fatteners ($\bar{x}$±SD)

Specification	Genotype ♀			
	L0 (n=116)	L6 (n=82)	L7 (n=94)	L8 (n=102)
Loin thickness (mm)	53.6±7.5	51.6±6.2	51.8±7.1	51.9±6.6
Fatback thickness (mm)	12.8±2.8^{AB}	11.6±1.7^{A}	13.41±4.0^{B}	13.0±3.0^{AB}
Meatiness (%)	58.5±2.2^{ab}	59.0±1.3^{a}	57.8±3.1^{b}	58.1±2.3^{ab}
Live weight (kg)	93.59±5.68	95.36±5.26	93.43±5.28	94.33±5.34
Carcass weight (kg)	74.87±4.54	76.29±4.21	74.75±4.22	75.46±4.28
SEUROP classification:				
class S (%)	22.4	20	25.9	66.3
class E (%)	70.7	80	55.6	24.4
class U (%)	6.9	-	16	8.7
class R (%)	-	-	2.5	0.6

a, b, c – different superscripts in columns designate significant differences within a category (P≤0.05)
A, B, C – different superscripts in columns designate significant differences within a category (P≤0.01)

genotypes, as these achieved the best results in the separate analyses. These were expectations based on the results of the fattening analysis, where the best paternal genotype mated with the best maternal genotype produced fatteners with the best rate of weight gain (Table 3). However, in the case of slaughter indices, the results were not consistent with predictions. The highest slaughter indices for loin eye thickness, backfat thickness and meat content were obtained by pigs from mating of the Pietrain paternal line with the L7 maternal line, which in the separate analysis of maternal genotypes attained the poorest results. Interestingly, the live weight and weight after slaughter of fatteners from this mating were the lowest. The highest live weight and hot carcass weight were obtained by pigs from the paternal crossbred genotype and the L6 maternal line, which had poorer slaughter parameters as compared to the other mating combinations. The results largely confirm the findings of a study by Strzelecki et al [26] conducted on 1,777 fattening pigs from 117 suppliers, where the average hot carcass weight was 77.3 kg, and in individual classes showed an upward trend as meat content decreased: class E – 75.4 kg, U – 76.8 kg, R – 79.1 kg, O – 81.5 kg and P – 83.2 kg. The percentage shares of carcasses in each

Table 6
Influence of crossbreeding schemes on slaughter traits of fatteners ($\bar{x}$±SD)

Specification	Genotype ♂x♀													
	Duroc x			Polish Landrace x			Pietrain x				hybrid line x			
	L0 (n=33)	L6 (n=19)	L7 (n=31)	L0 (n=19)	L7 (n=13)	L8 (n=30)	L0 (n=36)	L6 (n=20)	L7 (n=19)	L8 (n=31)	L0 (n=28)	L6 (n=23)	L7 (n=31)	L8 (n=61)
Loin thickness (mm)	48.1^{Aa} ±4.9	49.6^{Aa} ±5.6	48.8^{Aa} ±5.7	45.3^{Aa} ±5.2	48.7^{Aa} ±6.9	49,1^{Aa} ±6,1	56.6^{Bb} ±5.3	55.9^{Bb} ±3.0	58.1^{Bb} ±4.8	56.8^{Bb} ±4.5	54.3^{ABb} ±7.9	47.7^{Aa} ±7.4	51.9^{ABa} ±7.0	50.7^{Aa} ±6.5
Fatback thickness (mm)	14.2^{Aa} ±2.1	11.0^{ABb} ±1.5	12.8^{ABa} ±2.5	11.2^{Ab} ±3.1	13.8^{Aa} ±2.2	12.5^{ABab} ±2.5	11.6^{ABb} ±2.2	11.3^{ABb} ±1.6	8.6^{Bc} ±1.4	11.6^{ABb} ±2.1	13.5^{Aab} ±2.9	12.8^{Aab} ±1.6	14.3^{Aa} ±4.2	13.7^{Aa} ±3.3
Meatiness (%)	56.9^{ABb} ±1.4	59.1^{ABa} ±0.8	57.9^{Aab} ±1.8	58.4^{ABab} ±1.7	57.2^{ABa} ±1.6	58.1^{ABab} ±1.6	59.7^{BCa} ±1.8	59.7^{BCa} ±1.1	61.7^{Cc} ±0.8	59.6^{BCa} ±1.5	58.1^{ABab} ±2.4	57.7^{ABb} ±1.5	57.3^{ABab} ±3.3	57.5^{ABab} ±2.4
Live weight (kg)	96.2^{Bb} ±5.6	93.8^{ABab} ±4.6	93.8^{ABab} ±5.6	91.8^{ABa} ±6.1	94.4^{ABb} ±5.0	94.3^{ABb} ±5.6	94.6^{ABb} ±4.0	95.7^{ABb} ±6.2	89.5^{Aa} ±5.6	92.9^{ABab} ±5.0	92.6^{ABab} ±6.3	97.1^{ABb} ±4.7	93.8^{ABab} ±5.1	94.9^{ABb} ±5.4
Carcass weight (kg)	77.0^{Bb} ±4.5	75.1^{ABab} ±3.7	75.0^{ABab} ±4.5	73.5^{ABa} ±4.9	75.5^{ABb} ±4.0	75.5^{ABb} ±4.4	75.7^{ABb} ±3.3	75.5^{ABb} ±5.0	71.6^{Aa} ±4.5	74.3^{ABa} ±4.0	74.1^{ABab} ±5.0	77.7^{ABb} ±3.8	75.1^{ABa} ±4.1	75.9^{ABb} ±4.3
SEUROP classification:														
S (%)	–	11.1	12.5	22.2	7.7	13.3	38.9	40	100	21.2	17.2	–	19.6	16.8
E (%)	92.3	88.9	87.5	77.8	84.6	86.7	61.1	60	–	48.8	70.7	100	53	67.3
U (%)	7.7	–	–	–	7.7	–	–	–	–	–	12.1	–	23.5	14.9
R (%)	–	–	–	–	–	–	–	–	–	–	–	–	3.9	1.0

a, b, c – different superscripts in columns designate significant differences within a category ($P \le 0.05$)
A, B, C – different superscripts in columns designate significant differences within a category ($P \le 0.01$)

EUROP class were as follows: class E – 34.2%, U – 34.1%, R – 22.4%, O – 8.4% and P – 0.9% [26]. A similar correlation was demonstrated by Orzechowska et al. [20] in their analysis of the fattening and slaughter parameters of domestic maternal breeds; the authors found that as meat content in the carcasses increased, weight gains significantly decreased. At the same time, however, animals with faster growth rates and reduced meat content have been found to have better meat quality and a more favourable intramuscular fat content [16]. In light of our results, it appears that fattening parameters are easier to predict in crossbreeding, since the value of both parents is reflected in the productivity of the offspring. The effects of crossbreeding in terms of slaughter results are not so evident, and are additionally complicated by the negative correlations between fattening parameters and slaughter parameters and between quantitative and qualitative slaughter parameters.

As a consequence of the systematic improvement of pig meatiness in Poland, the share of carcasses assigned to the highest EUROP classes has increased [14, 25]. The increase in the meat content of pig carcasses has also increased the percentage of the most valuable cuts in the carcass and decreased its fat content [18]. A study by Borzuta et al. [3] conducted on two commercial farms on four-breed crosses (Polish Large White x Polish Landrace) x (Hampshire x Duroc) found a high carcass value, with meat content of 58.3% on one farm and 58.8% on the other, with an average carcass weight of 92.9 and 84.5 kg, respectively. The results of our own research were similar in terms of meat content, which averaged 58.2%, with a significantly lower average live weight (94.0 kg) and hot carcass weight (75.2 kg). In 2008, 84.8% of carcasses were assigned to classes S, E and U (with the highest carcass value, associated with the highest prices), including 6.6% in class S and only 3.3% in the fatty O and P classes [25]. The monthly analysis of December 2012 by the Ministry of Agriculture and Rural Development presented the breakdown of carcasses of slaughter pigs of each class as follows: class S – 13.7%, class E – 58.3%, class U – 23.6%, class R – 4.0%, class O – 0.4% and class P – 0.0%. The most carcasses were assigned to classes E and U (81.8%) and the fewest to O and P (0.4%) [27]. The carcasses used in the present study were classified and labelled in the EUROP system on the basis of the measurements of backfat thickness and the length of the loin eye, as well as estimated meat content. In the analysis of carcass quality in relation to the parental crossbreeding component, the greatest number of carcasses were assigned to E class (more than 50% in each of the genotypes tested). The best results were obtained for the carcasses of fatteners from Pietrain boars, where the ratio of class S to class E was 1:1. The most diverse results were obtained in the crossbred line, in which four carcass grades were noted (Table 4). In a study by Nowachowicz et al. [19], the share of commercial cuts with high meat content in carcasses in the well-muscled classes (E and U) was higher than in class R carcasses. Zybert et al. [30], on the other hand, reported a statistically confirmed increase in the weight of the most valuable primal cuts (including the loin) accompanied by a reduction in the weight of parts with high fat content (e.g. the backfat) as the conformation class of the fatteners increased.

Regarding the pig carcass classes in relation to the maternal genotype, the results were more varied. Pigs derived from the L6 line were assigned to the best conformation classes (S – 20% and E – 80%). In the remaining genotypes, class U and a small number of class R carcasses were noted as well (Table 5). Despite the heterogeneous distribution of L8 carcasses in the EUROP classification, associated with the occurrence of four classes, the highest percentage of carcasses of this line were in the highest class, S – 66.3% (Table 5).

In terms of carcass muscularity, the carcasses from each mating combination were predominantly assigned to classes S (24.7% on average) and E (on average 69.9%), while classes U (on average 4.7%) and R (on average 0.4%) had a marginal share (Table 6). The best results were obtained by fatteners from the Pietrain paternal genotype and L7 maternal line, with all carcasses in class S. A lower but also uniform result was obtained by carcasses from the paternal crossbred line and maternal L6 line; all carcasses from this crossing variant were in class E. The greatest heterogeneity in class distribution was observed for mating of crossbred boars with L7 and L8 maternal lines. These were the only combinations in which carcasses belonged to each of the four classes S, E, U and R. This seems to indicate increased differentiation of characteristics and thus reduced homogeneity of the performance parameters of fattening pigs derived from male crossbred lines as compared to pigs sired by purebred boars.

The data show clear differentiation of selected fattening and slaughter parameters, depending on both the paternal and maternal genotype, while confirming the importance of the mother's genetic potential for the fattening and slaughter performance of the offspring. The dependence of fattening characteristics on the mating scheme indicates that the most effective combination is paternal genotypes showing the best effect in the offspring (in this case Duroc) with maternal genotypes which also have the greatest potential to maximize the production of the offspring. In the case of slaughter characteristics, the best results were also obtained by fatteners derived from the pairing of the paternal genotypes showing the best effect in the offspring (in this case Pietrain), but with maternal genotypes whose offspring in the analysis independent of the paternal genotype showed the lowest production potential. These rather unexpected dependencies require further research to confirm them in a larger population.

To conclude, the RFID technology for pig monitoring with the potential 'big data' effect resulting from its use is an excellent tool for acquiring and analysing information. In addition, it can improve production management on large-scale farms and has the potential to assist and improve breeding work in terms of selection of pairs for breeding and for crossbreeding.

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