



THE EFFECT OF GROWTH RATE AND LEAN MEAT CONTENT IN PIETRAIN×DUROC AND DUROC×PIETRAIN HYBRID BOARS ON THEIR SEMEN CHARACTERISTICS

B. SZOSTAK¹, Ł. PRZYKAZA² & V. KATSAROV³

¹Institute of Animal Nutrition and Bromatology, Faculty of Biology and Animal Breeding, University of Life Sciences in Lublin, Lublin, Poland; ²Department of Neurosurgery, Medical Research Centre PAS, Warsaw, Poland; ³Department of Animal Science, Faculty of Agriculture, Trakia University, Stara Zagora, Bulgaria

Summary

Szostak, B., Ł. Przykaza & V. Katsarov, 2016. The effect of growth rate and lean meat content in Pietrain×Duroc and Duroc×Pietrain hybrid boars on their semen characteristics. *Bulg. J. Vet. Med.*, 19, No 2, 145–152.

The aim of the study was to determine the effect of growth rate and lean meat content in Pietrain×Duroc and Duroc×Pietrain hybrid boars on their semen characteristics. On the basis of the results of performance testing carried out on the 180th day of life, the boars were divided into four groups according to their daily weight gain (I: 750–800 g; II: 801–850 g; III: 851–900 g; and IV: >900 g), and additionally into three groups according to lean meat content (I: 60–61%; II: 62–63%; and III: >63%). Ejaculates were evaluated for the following characteristics: volume, sperm concentration, percentage of sperm with progressive movement, number of sperm with progressive movement per ejaculate and per insemination dose, primary morphological defects and number of insemination doses obtained per ejaculate. Neither high daily weight gain in the hybrid boars during the rearing period nor their high lean meat content had a negative effect on their semen characteristics.

Key words: boars, ejaculates, growth rate, lean meat

INTRODUCTION

The role of the boar and insemination is vital in achieving rapid and significant genetic gain; hence, in addition to normal development of the reproductive organs, high libido and high-quality semen, males should also have very good feedlot performance and carcass traits. The main objectives of genetic improvement of pigs are to increase their growth rates and lean

meat content. However, apart from the benefits of intensive selection for these traits, it may have negative consequences as well, such as poorer development of the reproductive, digestive and musculoskeletal systems, an increase in circulatory system failure, and lower resistance to stress (Rydhmer, 1993; Kawęcka, 2002). Some feedlot and reproductive characteristics

are negatively correlated (Rydhmer, 1993; Weeb *et al.*, 1998). Łyczyński (1991), in a study on the correlations between performance test results of boars and their suitability for breeding, found that the semen of boars with high weight gain was characterised by lower ejaculate volume and a lower total number of sperm per ejaculate. Falkenberg & Hammer (1989) found that boars with better musculature showed a tendency to produce semen with sperm of greater motility, while those with greater fat cover produced semen of inferior quality. The authors found a higher percentage of sperm with anomalies in the semen of boars with high lean meat content. Kawęcka *et al.* (2000) state that an increase in muscularity can cause a slight deterioration in semen characteristics in boars. The authors found low but favourable correlations between daily weight gain up to the 180th day of life and certain semen characteristics in the boars analysed. Many authors, however, express the view that the correlations between growth rate and muscularity in boars and their semen characteristics are generally low and insignificant.

The discrepancies in results published by different authors may result from genetic differences in the animals tested and in the scale of the factors analysed. Boars of different breeds or hybrids may produce ejaculates with different physical characteristics (Bertani *et al.*, 2002; Kondracki, 2003; Wysokińska & Kondracki, 2005). Hybrid boars generally produce ejaculates with more favourable traits than purebred boars (Ciereszko *et al.*, 2000; Kondracki *et al.*, 2003; Szostak, 2003). In a study by Milewska (2007), ejaculate volume in Pietrain×Duroc and Duroc×Pietrain crossbred boars ranged from 238 to 245 mL, and sperm concentration from 343,000 to 356,000/mm³.

The aim of the present study was to analyse the effect of growth rate and lean meat content in boars produced from reciprocal crossbreeding of the breeds Pietrain and Duroc on their semen characteristics.

MATERIALS AND METHODS

The material for the study consisted of 1,150 ejaculates taken from 24 Pietrain×Duroc and Duroc×Pietrain boars used at the Sow Insemination Station in Białka. On the basis of the results of performance testing carried out on the 180th day of life, taken from breeding documentation, the ejaculates were divided into four groups (n=6 each) according to the daily weight gain of the boars they were collected from (I: 750–800 g; II: 801–850 g; III: 851–900 g; and IV: >900 g), and additionally into three groups (n=8 each) according to lean meat content (I: 60–61%; II: 62–63%; and III: >63%).

The meat content was measured using a Piglog 105 ultrasound scanner by a Danish manufacturer. During the growth period the boars were kept in groups and fed complete mixed rations according to Anonymous (1993). From the start of their exploitation for breeding (average age – 18 months) the boars were kept in identical environmental conditions, in the same room, in individual pens with litter, and fed the same mixture, according to Anonymous (1993).

Semen was collected from the boars every other day by the manual method, using a phantom. Directly following collection of the semen the volume of the liquid fraction, the percentage of sperm with progressive movement, and sperm concentration were assessed, and on this basis the number of sperm with progressive movement in the entire ejaculate was

calculated. Sperm concentration (number of sperm per mm³) was determined by colorimetric measurement using a Spekol 11 spectrophotometer. Sperm motility was evaluated using a light microscope at 200× magnification at 37 °C. Slides for morphological evaluation of sperm cells were prepared by negative staining with a 10% aqueous nigrosin solution (Bielański, 1977). Morphological changes in the sperm cells were evaluated according to the classification by Blom (1981). The observations were made under a light microscope at 1,200× magnification, with 500 sperm cells analysed in each slide.

The material was analysed statistically using one-way analysis of variance. The significance of differences between the

groups was determined using Duncan's test.

RESULTS

Table 1 presents the semen characteristics of the boars depending on their growth rate. The lowest mean ejaculate volume was noted in the boars with daily weight gain of 750–800 g (group I), which was significantly different (P<0.001) from the ejaculate volume for groups II and III. The greatest ejaculate volume was observed for the boars of group III (302.9 mL), and was significantly different from group I (P<0.001) as well as from groups II and IV (P<0.05).

Table 1. Traits of ejaculates depending on their intensity of growth. Data are presented as mean±SEM (n=6)

Traits of semen	Daily gain to 180 days of life (g)				Significance of differences
	Group I	Group II	Group III	Group IV	
	750–800 g	801–850 g	851–900 g	> 900 g	
Ejaculate volume (mL)	260.673±4.133	287.034±2.408	302.941±5.445	277.037±9.330	I–II***; I–III***; II–III*; III–IV*
Concentration of spermatozoa (×10 ³ /mL)	251.623±4.333	270.320±1.830	278.706±5.399	255.907±8.862	I–II***; I–III***; III–IV*
Percentage of progressive spermatozoa (%)	78.141±0.294	76.684±0.175	87.563±7.563	80.000±5.381	I–III**; II–III***
Number of live spermatozoa (×10 ⁹)	53.041±1.538	59.854±0.719	69.202±2.159	58.526±3.413	I–II***; I–III***; II–III***; III–IV**
Number of spermatozoa per insemination dose (×10 ⁹)	2.565±0.009	2.547±0.005	2.542±0.008	2.531±0.018	–
Number of insemination doses	20.889±0.638	23.680±0.292	27.546±0.863	23.167±1.358	I–II***; I–III***; II–III***; III–IV**
Spermatozoa without morphological defect (%)	80.12±8.818	80.62±2.917	74.57±4.66	74.72±15.77	–
Major morphological defects (%)	4.63±1.865	7.65±1.669	6.79±1.804	17.7±1.601	–
Minor morphological defects (%)	15.25±7.063	11.72±2.019	18.64±4.33	22.56±12.71	–

*** P<0.001; ** P<0.01; * P<0.05.

Table 2. Traits of ejaculates depending on their lean meat content. Data are presented as mean±SEM (n=8)

Traits of semen	Lean meat (%)			Significance of differences
	Group I	Group II	Group III	
	60–61%	62–63%	>64%	
Ejaculate volume (mL)	284.359± 6.701	282.116± 2.040	330.938± 13.428	I–III***; II–III***
Concentration of spermatozoa (×10 ³ /mL)	259.583± 5.282	267.444± 1.723	287.250± 10.315	I–III*; II–III*
Percentage of progressive spermatozoa (%)	77.864± 0.406	78.227± 0.896	78.750± 0.594	–
Number of live spermatozoa (×10 ⁹)	58.423± 2.102	59.201± 0.663	75.447± 3.998	I–III***; II–III***
Number of spermatozoa per insemination dose (×10 ⁹)	2.544± 0.013	2.550± 0.004	2.534± 0.024	–
Number of insemination doses	22.951± 0.855	23.438± 0.270	29.906± 1.597	I–III**; II–III***
Spermatozoa without morphological defect (%)	75.00± 3.651	80.69± 3.684	70.40± 11.263	–
Major morphological defects (%)	9.09± 2.568	7.90± 1.757	15.73± 7.036	–
Minor morphological defects (%)	15.91± 2.531	11.41± 2.950	13.87± 4.490	–

*** P<0.001; ** P<0.01; * P<0.05.

The highest sperm concentration was observed in the ejaculates of the boars with daily weight gain of 851–900 g (group III), which was significantly different from group I at P<0.001 and from group IV at P<0.05. The ejaculates of the group III boars also had the highest number of live sperm cells, differing significantly from the remaining groups.

The values for these ejaculate traits in boars with different growth rates influenced the number of insemination doses obtained per ejaculate. The highest number of insemination doses were obtained from the ejaculates of boars from group III (27.5) and the lowest – from the ejaculates of boars in group I (20.9). The differences between groups were statistically significant.

The semen of the hybrid boars obtained from reciprocal crossbreeding of the Duroc and Pietrain breeds had a high percentage of sperm cells with normal morphological structure, ranging from 74.6% to 80.6%. The highest percentage of sperm cells with normal morphological structure was noted in the ejaculates of boars with daily weight gain of 750–850 g. However, no significant differences were found between the groups of boars analysed.

The analysis of data presented in Table 1 reveals a tendency for improvement of semen parameters with increased growth rates in the period up to the 180th day of life.

Table 2 presents the average values for characteristics of the semen of the boars depending on their lean meat content on

the 180th day of life. The greatest ejaculate volume (330.9 mL) was noted in the boars of group III, whose lean meat content was over 63%. In the other two groups the average ejaculate volume was similar: 284.36 mL in group I and 282.12 mL in group II. The difference in ejaculate volume between the boars from the second and third groups was significant ($P < 0.001$).

Sperm concentration in the ejaculates showed a tendency to increase as lean meat content increased. The highest sperm concentration was noted in the semen of the boars from group III, which differed significantly from groups I and II ($P < 0.05$). With regard to the percentage of cells with progressive movement, no significant differences were found between groups of boars with different meat content.

A significant difference ($P < 0.001$) was observed in the number of sperm cells with progressive movement between the ejaculates of boars with the highest meat content and the other two groups. Owing to the more favourable parameters obtained in the ejaculates of the boars with meat content exceeding 63%, such as ejaculate volume, sperm concentration and number of sperm cells with progressive movement, the highest mean number of insemination doses per ejaculate (29.9) was obtained from them. The differences between group III and the other groups were highly significant ($P < 0.001$).

The highest percentage of sperm cells with normal morphological structure was noted in the ejaculates of the boars from group II with average meat content of 62–63%. However, no significant differences were observed between the groups analysed.

DISCUSSION

In order to achieve rapid genetic gain in terms of feedlot and meat characteristics in pigs, breeders order semen obtained from boars with very high performance testing results. Sow Insemination Stations attempt to meet this challenge and purchase boars with the highest performance testing parameters for semen production. The insemination boars included in our study had very good daily weight gain, ranging from 751 to 951 g (Table 1), and in this respect their results substantially surpassed those of purebred Pietrain and Duroc boar populations evaluated in Poland in 2013 and presented by Eckert & Szyndler-Nędza (2014). This is logical and consistent with the results of many studies, as in hybrid boars a heterosis effect results from cross-breeding between breeds.

Analysis of the traits characterising the ejaculates of boars with different growth rates revealed that boars with daily weight gain in the range of 851–900 g produced ejaculates with the most favourable parameters. They had the largest mean ejaculate volume (302.94 mL), differing significantly from the remaining groups. They also had the significantly highest sperm concentration and percentage and number of sperm with progressive movement. A study by Udała *et al.* (2005) found a somewhat lower percentage of sperm with progressive movement (72.16%) in the semen of hybrid boars produced from the same breeds.

The results obtained in this study for the quantitative and qualitative characteristics of semen depending on the growth rate of boars during rearing partially correspond to the results obtained by Kawęcka *et al.* (2000), who found that young boars with somewhat faster growth rates have better semen characteristics. In a

study by Falkenberg *et al.* (1989), boars with higher weight gain exhibited greater sexual activity during semen collection. Sexual activity in males has a positive effect on semen characteristics (Oberlander *et al.*, 2012; Kondracki *et al.*, 2013). The literature reports studies indicating that the rate of daily weight gain in boars is correlated with the size and weight of their testes, which according to many authors is closely linked to semen production (Schinckel *et al.*, 1983; Toelle *et al.*, 1984; Young *et al.*, 1986).

Faster weight gain in animals is correlated with sexual maturation, which may positively influence the process of spermatogenesis in boars during the period of exploitation. Łyczyński (1991), in a study on the relationship between performance testing results in boars and their suitability for breeding, found that increased daily weight gain shortens the period of exploitation for breeding. The author states that the semen of boars with rapid weight gain was characterised by lower volume, higher sperm concentration and a lower total sperm number per ejaculate. In a study by Milewska (2007), boars with high weight gain produced ejaculates of significantly lower volume than boars with lower weight gain. However, these ejaculates had significantly better parameters in terms of the percentage and number of sperm with progressive movement, which is consistent with the results of our study. In contrast, a study by Fiałkowska *et al.* (2000) suggests a lack of influence of growth rate in boars during rearing on the characteristics of their semen.

The number of insemination doses per ejaculate is very important and directly influences economic effects from semen production. A similar number of insemination doses per ejaculate from hybrid boars produced from the same breeds was

also noted by Borucka-Jastrzębska *et al.* (2008).

Our results pertaining to the effect of lean meat content of boars on semen quality indicate that the meat content of the Pietrain×Duroc and Duroc×Pietrain hybrid boars measured on the 180th day of life had no negative effect on most of the semen characteristics analysed. However, a decrease was noted in the percentage of sperm cells with normal morphology in the semen of boars with lean meat content exceeding 63%. The percentage of primary morphological defects (15.7%) was also higher than in the other groups of boars.

Excessive muscle growth in young boars during the rearing period may inhibit development of the testes, which in turn leads to a delay in sexual maturity and decreased serum concentration of sex hormones, and in consequence to lower semen quality (Dziadek, 1999; Kawęcka *et al.*, 2003).

CONCLUSIONS

High daily weight gain in the hybrid boars obtained from reciprocal crossbreeding of the Duroc and Pietrain breeds during the rearing period had no negative effect on the characteristics of their semen. The most favourable semen parameters in terms of insemination were noted in the boars with daily weight gain of 851–900 g. The differences between the semen of the boars of this group and the remaining groups were statistically significant for most characteristics.

Boars with high lean meat content (over 63%) had significantly greater ejaculate volume, higher sperm concentration and more sperm cells with progressive movement, which translated to significantly more insemination doses per

ejaculate in comparison with the other groups of boars.

The ejaculates of boars with the highest meat content had a lower percentage of sperm cells with normal morphological structure. However, these differences were not confirmed statistically.

REFERENCES

- Anonymous, 1993. Normy Żywienia Świń. IFiŻŻ PAN. Wyd. Omnitech-Press.
- Bertani, G. R., I. R. Scheid, R. Irgang, W. Barioni, I. Wentz & S. B. Alfonso, 2002. Gonadal sperm reserve in purebred Landrace and Large White boars of high average daily gain. *Theriogenology*, **57**, 859–867.
- Bielański, W., 1977. Rozród zwierząt. PWRiL Warszawa.
- Blom, E., 1981. Rating bull sperm morphological defects. Vol. II. Proposed new classification of defects in sperm. *Medycyna Weterynaryjna*, **37**, 239–242.
- Borucka-Jastrzębska, E., M. Białek, M. Brzezińska, D. Kawczuga, W. Drewnowski & L. Lisiecki, 2008. Semen parameters in relation to pig breed. *Medycyna Weterynaryjna*, **64**, 1248–1251.
- Ciereszko, A., S. Ottobre & J. Głogowski, 2000. Effects of season and breed on sperm acrosin activity and semen quality of boars. *Animal Reproduction Science*, **64**, 89–96.
- Dziadek, K., 1999. Reproductive usefulness of Duroc boars and line 990 depending on the characteristics of the litter from which came as well as their own fattening and slaughter. Roczniki Naukowe Zootechniki. Rozprawa habilitacyjna, Instytut Zootechniki. Kraków, **10**.
- Eckert, R. & M. Szyndler-Nędza, 2014. Results of performance tested boars. Report on pig breeding in Poland. Instytut Zootechniki, Kraków, XXXII, pp. 19–24.
- Falkenberg, H. & H. Hammer, 1989. Genetische und phänotypische Beziehungen zwischen Merkmalen der Mast- und Ansatzleistung von Ebern in zentralen Aufzuchtstationen der Besamungseignung dieser Tiere sowie der Wurfleistung ihrer Schwestern. *Archiv Tierzucht*, **32**, 163–171.
- Fiałkowska, B., J. Owsiany, A. Kołodziej & P. Kocięcki, 2000. The impact of the growth parameters of race Duroc boars during the rearing of their semen characteristics. *Zeszyty Naukowe AR Szczecin*, **39**, 45–53.
- Kawęcka, M., 2002. The relationship between growth rate and leanness of young boars population of the fathers and their suitability for reproduction. Habilitation thesis, AR Szczecin, nr 206.
- Kawęcka, M., R. Czarnecki, J. Owsiany, M. Różycki, K. Dziadek & M. Kamyczek, 2000. The relationship between growth and backfat thickness young boars and their sexual activity and sperm characteristics. *Zeszyty Naukowe Polskiego Towarzystwa Zootechnicznego*, **48**, 69–76.
- Kawęcka, M., R. Czarnecki, A. Pietruszka, E. Jacyno & J. Owsiany, 2003. Sexual activity and semen quality of young boars with different level of their leanness. *Zeszyty Naukowe Przeglądu Hodowlanego*, **68**, 95–103.
- Kondracki, S., 2003. Breed differences in semen characteristics of boars used in artificial insemination in Poland. *Pig News and Information*, **24**, 119–122.
- Kondracki, S., A. Wysokińska & Z. Kowalczyk, 2003. The effect of crossing of Duroc and Pietrain breeds on semen quality of crossbred boars. *Zeszyty Naukowe Przeglądu Hodowlanego*, **68**, 109–112.
- Kondracki, S., M. Iwanina, A. Wysokińska & K. Górski, 2013. The use of sexual activity measurements to assess ejaculatory performance of boars. *Archiv Tierzucht*, **56**, 1–12.
- Łyczyński, A., 1991. Factors affecting the efficiency of the breeder boars in insemination center. Habilitation thesis, AR Poznań, 216.

- Milewska, W., 2007. Intravital assessment traits and reproductive results of purebred Hampshire and Pietrain boars and cross-bred boars raised at insemination stations. *Medycyna Weterynaryjna*, **6**, pp. 708–711.
- Oberlender, G., L. D. S. Murgas, M. G. Zangeronimo, A. C. Silva & L. J. Pereira, 2012. Influence of ejaculation time on sperm quality parameters in high performance boars. *Journal of Animal Science Advances*, **2**, 499–509.
- Rydhmer, L., 1993. Pig reproductive genetics and correlations between reproduction and production traits. Dissertation, 106, SLU-Info/Repro, Uppsala.
- Schinckel, A., R. K. Johnson, R. A. Pumfrey & D. R. Zimmerman, 1983. Testicular growth in boars of different genetic lines and its relationship to reproductive performance. *Journal of Animal Science*, **56**, 1065–1076.
- Szostak, B., 2003. The effect of genotype, age of boars and season of use on the selected qualities of ejaculates. *Zeszyty Naukowe Przeglądu Hodowlanego*, **68**, 147–155.
- Toelle, V. D., B. H. Johnson & O. W. Robinson, 1984. Genetic parameters for testes traits in swine. *Journal of Animal Science*, **59**, 967–973.
- Udała, J., D. Gączarzewicz, B. Lasota, B. Błaszczuk, B. Seremak & T. Stankiewicz, 2005. Characteristics of the morphological defects of boars spermatozoa used in artificial insemination. *Folia Universitatis Agriculturae Stetinensis, Zootechnica*, **243**, 161–172.
- Weeb, A. J., P. R. Hampton & A. D. Hall, 1998. Crossbreeding strategies to break genetic antagonisms in pig breeding. In: *Proceedings of the 49th Annual Meeting of EAAP*, Warsaw, pp. 1–8.
- Wysokińska, A. & S. Kondracki, 2005. Frequency of sperm abnormalities of cross-breed boars Duroc × Pietrain and Hampshire × Pietrain and of purebred boars Duroc, Hampshire and Pietrain. *Folia Universitatis Agriculturae Stetinensis, Zootechnica*, **243**, 191–198.
- Young, L. D., K. A. Leymarter & O. D. Lunstra, 1986. Genetic variation in testicular development and its relationship to female reproductive traits in swine. *Journal of Animal Science*, **63**, 17–26.

Paper received 23.03.2015; accepted for publication 15.06.2015

Correspondence:

Bogdan Szostak
Institute of Animal Nutrition,
Faculty of Biology and Animal Breeding,
University of Life Sciences in Lublin,
Akademicka 13, 20-950 Lublin, Poland
Phone: 48 660 727 982
e-mail: bogdan.szostak@up.lublin.pl