

Heterosis effects on physical traits of ejaculate in Duroc × Pietrain and Hampshire × Pietrain crossbred boars

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Considered were 10,895 ejaculates manually obtained from 80 boars, including 16 Duroc × Pietrain and 16 Hampshire × Pietrain crossbreds, and 16 purebred boars from each of Duroc, Hampshire and Pietrain breed separately. All ejaculates analysed were collected for two years from the beginning of each boar performance. Each ejaculate was evaluated with standard methods and the following physical traits were measured: ejaculate volume, spermatozoa concentration, percentage of spermatozoa with proper motility, total number of spermatozoa per ejaculate and number of insemination doses obtained from one ejaculate. Heterosis effects on physical traits of ejaculate of crossbreds were calculated in relation to mean values of these traits in boars of parental breeds, (VR) and in relation to the parental breed with higher value of the trait (VR1).

The beneficial influence of crossbreeding on traits of ejaculate in both two-breed crossbreds was found as shown by marked and positive heterosis effects on the total number of spermatozoa (VR over 10%), spermatozoal motility, ejaculate volume and number of insemination doses per ejaculate.

KEY WORDS: boars / crossbreeding / ejaculate / heterosis / pigs

Crossbreeding is a method applied in order to use and adapt foreign genes in the improved population or in production herds, so that the differences between breeds, as well as heterosis effects can be used to improved the crossbreds performance. Individual, maternal and sire heterosis effects are employed in pig crossbreeding programmes. Heterosis effects may be more or less beneficial depending on the production trait(s) considered. The most significant influence is noticed on traits of reproduction performance, which are of low heritability. The benefits involve better fertility and prolificacy of crossbred sows [Schneider *et al.* 1982, McLaren *et al.* 1987,

Michalska 1996]. Crossbred sows, in comparison with purebreds, are characterized by stronger oestrous symptoms and higher conception rate. Heterosis effects are also proved in crossbred boars, which mature sexually earlier [Buchanan 1987], grow faster and are characterized by better breeding ability than purebred sires [Fent *et al.* 1983, Czarnecki *et al.* 1999, Smital *et al.* 2004]. Effect of crossbreeding was found stronger on qualitative than on quantitative traits of boar semen. In general, crossbred boars produce spermatozoa of high motility [Kondracki *et al.* 2003] and proper morphological structure [Kapelański 1995, Kondracki *et al.* 2002] and are usually characterized by favourable traits of sexual activity [Wysokińska 2003] and better mating efficiency than pure-bred sires. Therefore, studies were carried out on the possibility of improving reproduction results by using boars originating from two-breed crossbreeding [Rak *et al.* 1993, Kapelański 1995, Michalska 1996]. The aim of this study was to estimate the heterosis effects on physical traits of ejaculates of Duroc × Pietrain and Hampshire × Pietrain crossbred boars.

Material and methods

The study was carried out on 10,895 ejaculates collected from 80 boars, including 16 Duroc × Pietrain (DP) and 16 Hampshire × Pietrain (HP) crossbreds and 16 purebred boars from each of Duroc (D), Hampshire (H) and Pietrain (P) breed, separately. The boars were used in four sow insemination stations of the Mazovia Animal Breeding and Reproduction Centre (Tab. 1).

Table 1. Number of ejaculates obtained from boars at different sow insemination stations

Item	Station				Total
	1	2	3	4	
Number of boars	25	20	20	15	80
Number of ejaculates	3400	2775	2680	2040	10 895

Ejaculates were taken by the manual method [King and Macpherson 1973] every 4-5 days. In the study all ejaculates were considered collected from each boar over two years from the beginning of the animals' reproductive performance. Each ejaculate was evaluated using standard methods and estimating physical traits as follows: ejaculate volume, spermatozoa concentration, percentage of spermatozoa with proper motility, total number of spermatozoa per ejaculate, and number of insemination doses per ejaculate. Ejaculate volume was determined after isolating the gelatinous fraction. Sperm concentration in the ejaculate was determined by the colorimetrically using spectrophotometer. Percentage of spermatozoa with proper motility was evaluated microscopically with 200× magnification, setting the percentage of spermatozoa with proper motility in total number of spermatozoa seen in such magnification. Total number

of spermatozoa and number of insemination doses per ejaculate were calculated using the computer SYSTEM SUL programme.

The analysis of variation of semen traits was carried out according to the following mathematical model:

$$Y_{ij} = \mu + \alpha_i + e_{ij}$$

where:

Y_{ij} – trait value;

μ – population average;

α_i – boar breed effect;

e_{ij} – error.

Differences between means were evaluated using Tukey's test.

Heterosis effects on physical traits of ejaculates of crossbreds in relation to mean value of given trait measured in boars of parental breeds were calculated according to Harade [cited by Kołataj *et al.* 1973]:

$$VR = [(X_{F1} - X_{MP}) \times 100] : X_{MP}$$

where:

VR – heterosis effect;

X_{F1} – mean value of trait in boar crossbreds;

X_{MP} – mean value of trait in boars of parental breeds.

Heterosis effect on physical traits of ejaculates of crossbreds in comparison with boars of parental breed with higher value of the trait, was calculated according to the formula:

$$[(X_{F1} - X_{MP1}) \times 100] : X_{MP1}$$

where:

VR₁ – heterosis effect;

X_{F1} – mean value of trait in boar crossbreds;

X_{MP1} – mean value of trait in boars of parental breed with higher value of the trait.

Results and discussion

Heterosis effects on physical traits of ejaculates collected from DP crossbreds and calculated in relation to the mean value of the trait in D and P breeds (VR) or in relation to the breed with higher value of the trait (VR₁) are shown in Table 2. Heterosis effects estimated regarding the mean value of parental breeds were positive and ranged from 1.44% for ejaculate volume to 16.24% for total number of spermatozoa in one ejaculate. However, the differences in physical traits of ejaculate, which appeared between D and P, as well as DP boars, were found significant ($P \leq 0.01$) in each trait. In ejaculates of DP crossbreds the number of spermatozoa was higher by 7.48×10^9

Table 2. Heterosis effects on semen traits of Duroc × Pietrain crossbred boars in relation to mean value of a trait in boars of parental breeds (VR) or a breed with higher value of the trait (VR₁)

Item	Mean of the trait			Heterosis effects (%)	
	Duroc × Pietrain	Duroc	Pietrain	VR	VR ₁
Number of ejaculates	2143	1887	2494		
Ejaculate volume (ml)	209.37 ^A	159.52 ^B	253.27 ^C	1.44	-17.33
Sperm concentration (thousand/mm ³)	566.52 ^A	649.12 ^B	464.33 ^C	1.75	-12.72
Percentage of spermatozoa with proper motility	76.49 ^A	71.66 ^B	74.83 ^C	4.42	2.22
Total number of spermatozoa per ejaculate × 10 ⁹	89.83 ^A	72.22 ^B	82.35 ^C	16.24	9.08
Number of insemination doses per ejaculate	24.21 ^A	19.05 ^B	24.97 ^C	9.99	-3.04

^{ABC} Within lines means bearing different superscripts differ significantly at $P \leq 0.01$.

than in ejaculates of P boars and by as many as 17.61×10^9 than in D ejaculates ($P \leq 0.01$). The strongest VR effect amounted to 16.24% and that of VR₁ to 9.08% in relation to P breed. Higher number of spermatozoa per ejaculate was found in P than in D boars. Positive, however considerably weaker, heterosis effects were proved on spermatozoal motility. Per cent of progressively moving spermatozoa in ejaculates of crossbreds was higher both in relation to the mean value of parental breeds (VR=4.42%) and in relation to Pietrain breed (VR₁=2.22%). Marked domination was found of crossbreds over purebred boars regarding the number of insemination doses per ejaculate (VR=9.99%) In some cases negative crossing effects calculated with reference to the breed with higher level of ejaculate physical traits were found, namely for ejaculate volume (VR₁= -17.33% in relation to P breed), sperm concentration in one ejaculate (VR₁= -12.72% in relation to D breed) and number of insemination doses per ejaculate (VR₁= -3.04% in relation to D breed) were proved.

Effects of H × P crossing on ejaculate physical traits of crossbred boars are shown in Table 3. High and positive heterosis effects with regard to the total number of spermatozoa were found. Mean ejaculate from HP crossbreds contained about 9×10^9 spermatozoa more than that from purebred H and P boars ($P \leq 0.01$). VR effect on the trait amounted to 10.89% and that of VR₁ to 10.27% in relation to P breed. Positive, but considerably lower heterosis effects on spermatozoal motility and ejaculate volume were also proved. The per cent of progressively moving spermatozoa in ejaculates of crossbreds was higher than means for parental breeds (VR=4.71%) and mean for P breed, the latter having ejaculates with higher spermatozoal motility (VR₁=2.79%). The marked crossbreeding effect of H and P breeds was shown by heterosis indicators calculated for the number of insemination doses per ejaculate (VR=12.42% and VR₁=10.53%, respectively). Negative heterosis effect was found on spermatozoa concentration. Lower concentration appeared in ejaculates of HP than in pure-bred boars (VR= -3.26%).

Table 3. Heterosis effects on semen traits of Hampshire × Pietrain crossbred boars in relation to mean value of a trait in boars of parental breeds (VR) or a breed with higher value of the trait (VR₁)

Item	Mean of the trait			Heterosis effects (%)	
	Hampshire × Pietrain	Hampshire	Pietrain	VR	VR ₁
Number of ejaculates	2197	2174	2494		
Ejaculate volume (ml)	273.08 ^A	266.99 ^B	253.27 ^C	4.98	2.28
Sperm concentration (thousand/mm ³)	438.04 ^A	441.32 ^A	464.33 ^B	-3.26	-5.66
Percentage of spermatozoa with proper motility	76.92 ^A	72.09 ^B	74.83 ^C	4.71	2.79
Total number of spermatozoa per ejaculate × 10 ⁹	91.91 ^A	82.41 ^B	82.35 ^B	10.89	10.27
Number of insemination doses per ejaculate	27.60 ^A	24.14 ^B	24.97 ^C	12.42	10.53

^{ABC} Within lines means bearing different superscripts differ significantly at P ≤ 0.01.

The figures presented show a favourable effect of crossbreeding on ejaculate traits in both two-breed crossbreds. Positive and significant heterosis effects were found on the most important ejaculate traits in relation to both crossing variants. Both DP and HP crossbred boars showed heterosis effect exceeding 10% on total number of spermatozoa. It is of great economic importance, as it allows to prepare more insemination doses from a single ejaculate, with a large number of spermatozoa. The favourable effect of crossbreeding on ejaculate physical traits in crossbred boars was also proved by Gączarzewicz *et al.* [2000], Kawęcka [2002] and recently by Smital *et al.* [2004]. Considerable positive heterosis effects in Hampshire × Pietrain crosses on ejaculate volume (30.60%) and number of spermatozoa per ejaculate (18.24%) were found by Smital *et al.* [2004]. Much lower but still positive heterosis effects were found in Duroc × Pietrain crossbreds. Slightly different results in relation to Duroc × Pietrain crossing effects were shown by Czarnecki *et al.* [1999] who reported positive heterosis effects on ejaculate volume (14.79%), but negative on the total number of spermatozoa (-12.72%).

Moreover, favourable effect of crossbreeding was shown on semen quality. The spermatozoal motility in crossbred was significantly higher than in purebred boars, which was confirmed by positive heterosis effects in both crossing variants.

Spermatozoal motility is an essential trait, which characterizes semen quality and it is crucial for the conception process. According to Strzeżek [1998] the trait was a good determinant of fertility and liveability of boar semen. High littering rate and litter size could both be obtained by applying semen, in which at least 70% of spermatozoa show proper motility. Positive relationship between spermatozoal motility and litter size was shown by Buczyński *et al.* [2000] and Popwell and Flowers [2004].

The data presented in Table 2 and 3 show that ejaculates of D×P and H×P crossbred boars are characterized by high quality parameters. It was confirmed by significant positive effects of heterosis on qualitative and on most quantitative traits of ejaculates.

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Wpływ heterozji na cechy fizyczne ejakulatu knurów mieszańcowych Duroc × Pietrain i Hampshire × Pietrain

Streszczenie

Badania przeprowadzono na materiale obejmującym 10 895 ejakulatów pobranych metodą manualną od 80 knurów, w tym od 16 mieszańców Duroc × Pietrain (DP) i 16 mieszańców Hampshire × Pietrain (HP) oraz od czystorasowych knurów ras Duroc (D), Hampshire (H) i Pietrain (P), po 16 osobników każdej rasy. W ocenie uwzględniono wszystkie ejakulatory pobierane przez okres 2 lat od początku użytkowania każdego knura. Każdy ejakulat poddano standardowej ocenie, ustalając następujące cechy fizyczne: objętość ejakulatu, koncentrację plemników, odsetek plemników wykazujących prawidłowy ruch, ogólną liczbę plemników w ejakulacie i liczbę dawek inseminacyjnych uzyskanych z jednego ejakulatu. Obliczono efekty heterozji dla cech fizycznych ejakulatu knurów mieszańcowych w stosunku do średniej wartości cechy u knurów ras rodzicielskich i rasy rodzicielskiej o większej wartości danej cechy.

Wykazano korzystny wpływ krzyżowania na cechy ejakulatów knurów badanych mieszańców dwurasowych. Dodatkowo i wyraźnie zaznaczone efekty heterozji stwierdzono bowiem w zakresie najważniejszych cech ejakulatów w odniesieniu do obu wariantów krzyżowania. Zarówno mieszańce DP, jak i HP wykazywały efekty heterozji w ogólnej liczbie plemników (efekty przekraczające 10%), w ruchliwości plemników, objętości ejakulatu i liczbie dawek inseminacyjnych uzyskiwanych z jednego ejakulatu.

