Performance of Gilts and Boars with High and Low EBV's for Litter Size, Average Daily Gain and Backfat

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Introduction

" What about the genetic improvement of litter size " was the title of a paper by Skervold (1979) who discussed possible reasons for the lack of genetic improvement in litter size and showed strategies for selection methods to improve litter size. However, no significant genetic trends in litter size have been achieved in various countries as shown in a summary by de Vries and Kanis (1994). Skervold (1979) suggested that low heritability and/or low selection differential may be the reason for this lack of improvement, and suggested use of information on paternal halfsisters and the maternal granddam in addition to the dam's performance. Best Linear Unbiassed Prediction (BLUP) procedures make use of information from all relatives. This should make better selection for litter size possible. Longterm performance recording, as it is available on some farms today, allows the comparison of EBV's for litter size in gilts with their phenotypic performance in their later life. This will give an indication of the possibility for improving litter size using BLUP technology.

In contrast to litter size, average daily gain and backfat have been improved genetically. In their review, de Vries and Kanis (1994) showed that genetic trends of growth rate and backfat in commercial breeding populations was 1-2% per annum. In order to analyse causes of these differences in genetic trends between litter size and performance traits, EBV's for average daily gain and backfat in gilts and young boars will also be compared with their phenotypic performance. Results for average daily gain and backfat will then be compared with results for litter size.

Description of data set

Aztec Farms started performance recording in 1980 and therefore data were available comprising 16 years until October 1996. This total data set data included 178336 animals with production records and 6037 sows with reproductive performance from a synthetic line developed at Aztec Farms. PIGBLUP (Henzell 1995) has been used for genetic evaluation on Aztec Farms since November 1993. In order to obtain EBV's for litter size in gilts, genetic evaluations were performed using data from 1980 until January 1989, June 1989, January 1990, and so forth until June 1993. These EBV's were based only on pedigree information, since gilts had no records available themselves. On average a sow has 2.2 litters per year in Australia (Meo and Cleary, 1995) and with this time frame of 3 years and 3 months from the cut off date in June 1993, gilts had the opportunity to have had up to seven litters until October 1996. From the 10 genetic evaluations a total of 30018 gilts had EBV's for litter size. Grouping of gilts based on their EBV for litter size was done within each genetic evaluation. Gilts were then linked with their phenotypic performance as sows. From the original 30018 gilts, 1862 gilts were kept as breeding sows and had reproductive performance records.

The same principles were applied to obtain EBV's for growth rate and backfat. The animal's own performance is included in an estimate of an EBV and therefore only animals were taken which had no own performance available for the two production traits when the EBV was estimated. In total 22,225 gilts and 22,450 boars had EBV's and performance records for growth rate available while backfat was only recorded on 5615 gilts and 3773 boars.

Analysis of litter size

1. Comparison of EBV's between all gilts and selected gilts

Mean EBV's of the four traits analysed in PIGBLUP are summarised in Table 1 for all gilts before selection and selected gilts only. The average EBV for number born alive was 0.103 for all gilts prior to selection and 0.075 for gilts that were kept in the herd as sows. Selected gilts had also a slightly lower EBV for 21 day litter weight and average daily gain in comparison to the unselected group. In contrast, the EBV for backfat was -0.023 for the selected group in comparison to 0.017 for all gilts. The main selection emphasis in gilts during 1989 to 1993 was therefore on reduction of backfat with the consequence of slightly reduced EBV's in other traits.

Table 1. Number of records (N) and EBV's for number born alive (NBA), 21 day litter weight (LW21), average daily gain (ADG) and backfat (BF) for unselected and selected gilts from genetic evaluations between 1989 and 1993

	N	NBA (piglet/litter)	LW21 (kg)	ADG (gr)	BF (mm)
All gilts	30018	0.103	0.952	13.55	0.017
Selected gilts	1862	0.075	0.844	13.08	-0.023

2. Difference in EBV's of top and bottom percentile of gilts based on EBV's in litter size

Before selection, the top and bottom 10 percentiles for litter size included 2948 and 2932 gilts, respectively. From these gilts, 172 gilts remained in the herd from the top class and 192 for the bottom class (Table 2). The difference in EBV's for litter size between these two classes was 0.96 piglets. However, this difference was not used in selection decisions, since more gilts were selected from the class with low EBV's for litter size. The higher proportion of gilts selected from the bottom 10 % class resulted from their lower EBV in backfat of -0.09 in comparison to 0.05 of the top 10 % class. EBV's for average daily gain and 21 day litter weight were slightly higher for the top 10 percentile class of gilts.

The difference in EBV's for litter size was 0.96 piglets per litter for gilts and the difference in phenotypic performance in their later life is expected to be of the same magnitude. Number born alive was analysed using repeated records, and this difference in EBV's has to be compared with the average difference in number born alive over all parities. Table 3 shows an average difference over the first seven parities of 0.91 between the two classes. Sows with unsatisfactory performance in litter size were culled in later parities, which is indicated by a greater reduction in records for the bottom class than for the top class. The observed difference in litter size is in good agreement with the difference in breeding values estimated by PIGBLUP.

Table 2. Number of gilts (N), means and standard deviations (s.d.) for EBV's in number born alive (NBA) and 21 day litter weight (LW21), average daily gain (ADG) and backfat (BF) for gilts with 10 % highest and 10 % lowest EBV's for number born alive

	Top 10 percentile			Bottom 10 percentile			
EBV for	N	Mean	s.d.	N	Mean	s.d.	Diff.
NBA (pig/litter)	172	0.57	0.16	192	-0.39	0.10	0.96
LW21 (kg)	172	1.36	1.78	192	0.63	1.76	0.73
ADG (gm)	172	13.91	15.20	192	12.59	15.20	1.32
BF (mm)	172	0.05	0.66	192	-0.09	0.58	0.14

3. Phenotypic performance in litter size

Table 3 also lists the difference in phenotypic performance between both classes for individual parities. The genetic potential for litter size seems not fully expressed in the first two parities. For these two parities the phenotypic performance differs by 0.82 and 0.78 piglets. In contrast, the difference between both classes was 1.31 for the third parity and 1.06 for the fourth parity. Differences for later parities are influenced by culling decisions and are calculated using fewer animals, which limits our ability to draw conclusions from these parities.

Table 3. Number of gilts (N), means and standard deviations (s.d.) for phenotypic performance in number born alive from the first to seventh parity for gilts with 10 % highest and 10 % lowest EBV's for number born alive

	Top 10 percentile			Bottom 10 percentile			
	N	Mean	s.d.	N	Mean	s.d.	Diff.
NBA_1	159	9.19	2.77	192	8.37	2.63	0.82
NBA_2	133	9.84	2.92	147	9.06	2.50	0.78
NBA_3	107	10.81	2.73	114	9.5	2.57	1.31
NBA_4	70	11.11	2.52	74	10.05	2.93	1.06
NBA_5	46	10.37	2.78	45	10.13	3.09	0.24
NBA_6	29	9.96	2.64	27	9.26	3.28	0.70
NBA_7	13	10.85	1.67	13	9.38	2.10	1.47
Average		10.30			9.39		0.91

Besides mean phenotypic difference between the top 10 % and bottom 10 % classes, the phenotypic performance for individual parities is of further interest, to draw conclusions about reliability of EBV's in litter size for selection decisions. EBV's for litter size are shown for each 10 percentile class in Figure 1. Each class contains approximately the same number of animals. Therefore, differences in EBV's between classes are larger between the extreme classes on either side. The extreme values in EBV's for the two bottom and two top classes, are expressed in their average phenotypic performance over the first three parities which are

8.98 and 9.09 for the bottom two classes and 9.83 and 9.84 for the top two classes. Phenotypic differences between groups are not linear for intermediate classes which is due to smaller differences in EBV's between these groups.

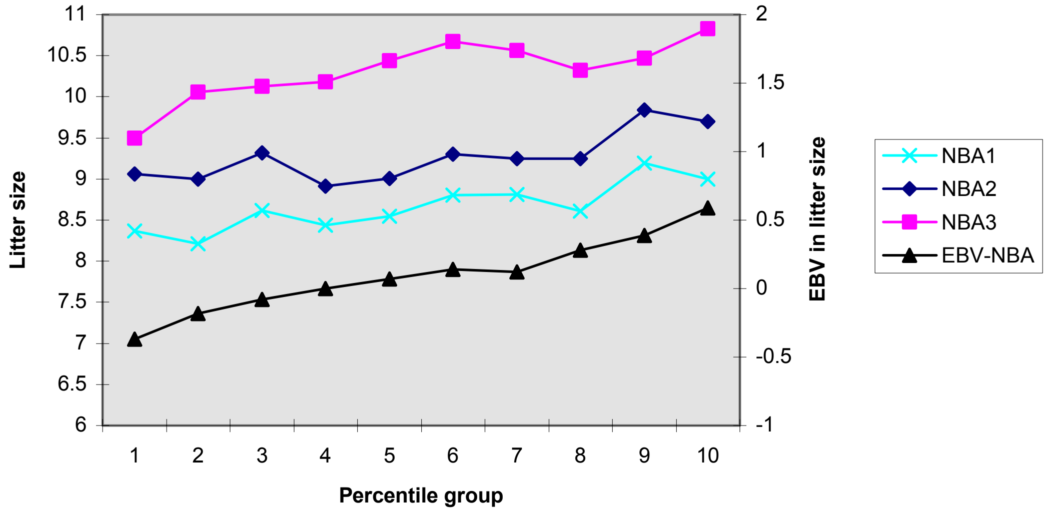

Figure 1. EBV's in number born alive (EBV-NBA) and phenotypic performance in number born alive from the first to third parity for gilts grouped according to their EBV in number born alive (10 % classes)

A number of traits are incorporated in selection decisions and this information on litter size provided by PIGBLUP can be used in different ways, depending on the main emphasis of the breeding program. If the breeder wants to put the main emphasis of selection decisions on litter size, selection of gilts from the top two classes will maximise response in this trait. When more emphasis is put on growth rate and backfat, at least avoiding gilts with low EBV's will be a possibility to avoid deterioration in litter size, as was seen in the past.

Analysis of production traits

Differences between EBV's for the top and bottom percentile group are similar between gilts and boars (Table 4). The difference in EBV's is 49 grams for backfat in both sexes while the difference in backfat was smaller in gilts (2.23 mm) than in young boars (2.31 mm). Each percentile group included around 2200 animals for average daily gain in contrast to backfat groups. Those groups contained 563 and 508 gilts and 366 and 367 boars. Differences between gilts and boars might therefore be due to the reduced data set.

Table 4. Number of gilts and boars (N), means and standard deviations (s.d.) for EBV's in average daily gain (ADG) and backfat (BF) for gilts and young boars with 10 % highest and 10 % lowest EBV's for average daily gain and backfat

	Top 10 percentile			Bottom 10 percentile			
EBV for	N	Mean	s.d.	N	Mean	s.d.	Diff.

ADG (gilts)	2214	35.9	7.69	2218	-13.2	7.53	49.1
ADG (boars)	2248	36.0	7.57	2244	-13.2	7.56	49.2
BF (gilts)	563	-1.06	0.29	508	1.17	0.32	2.23
BF (boars)	366	-1.05	0.28	367	1.26	0.35	2.31

These differences in EBV's have been realised by gilts and boars in their later phenotypic performance. The phenotypic performance is "spot on" for average daily gain, while differences in phenotypic backfat performance between the bottom and top percentile group are 2.40 for gilts and 2.20 for young boars. The higher difference in phenoytpic performance in gilts might be an indication that the heritability used in PIGBLUP for backfat is too low for gilts.

Table 5. Number of animals (N), means and standard deviations (s.d.) for phenotypic performance in average daily gain and backfat for gilts and young boars with 10% highest and 10 % lowest EBV's for average daily gain and backfat

	Top 10 percentile			Bottom 10 percentile			
	N	Mean	s.d.	N	Mean	s.d.	Diff.
ADG (gilts)	2214	609	44.2	2218	560	37.4	49
ADG (boars)	2248	610	43.3	2244	562	37.8	48
BF (gilts)	563	11.1	2.37	508	13.55	2.50	2.40
BF (boars)	366	10.0	2.14	367	12.2	2.42	2.20

The trend in EBV's for average daily gain and backfat is plotted in Figure 1 and Figure 2 over all percentile groups. In addition, phenotypic performances of gilts and boars are shown for each percentile group. The trend in phenotypic performance in average daily gain over all groups is the same in boars and gilts and follows the patterns of the trend in EBV's for average daily gain.

Backfat in gilts also reflects the trend in EBV's for backfat while one class is slightly higher than expected in boars. However, as explained earlier, fewer animals have backfat information available and this slight inconsistency between groups might be due to the small data set.

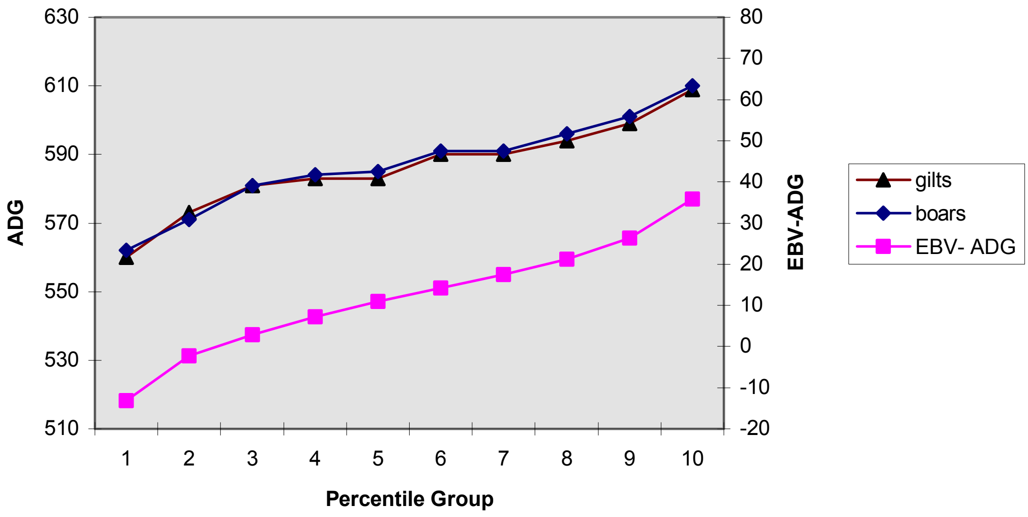

Figure 2. EBV's in average daily gain (EBV-ADG) and phenotypic performance in average daily gain for gilts and young boars grouped according to their EBV in average daily gain (10 % classes)

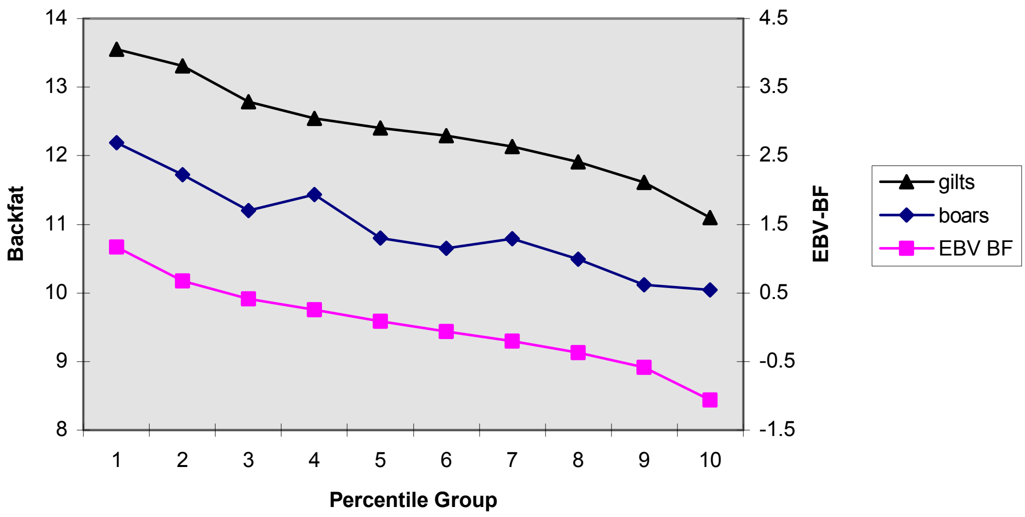

Figure 3. EBV's in backfat (EBV-BF) and phenotypic performance in backfat for gilts and young boars grouped according to their EBV in backfat (10 % classes)

Does selection influence difference in EBV's between classes?

Selection reduces the additive genetic variance and consequently the heritability which is commonly described as the "Bulmer effect". Although not shown in this paper, animals at Aztec Farms have been selected for average daily gain and backfat and genetic response has been achieved in both traits. Therefore, further PIGBLUP analyses were performed for six month intervals ending January 1994 to January 1996. Animals were again grouped in 10% classes and EBV's of the bottom and top class are presented in Table 6 for the three analysed traits.

The difference in EBV's is one piglet for number born alive which is slightly higher than the difference obtained for the earlier data set. In contrast, EBV's for average daily gain and backfat are slightly lower for gilts and boars performance tested from 1994 to 1996. There was no trend of a continuous reduction in differences between the bottom and the top class for each six month analysis. It might therefore be too early to see these results as a consequence of the "Bulmer effect" since it also could just be the result of using different animals. However, should this reduction be caused by selection it is expected to be largest in the first generation. With continuous selection, reduction of variance is progressively smaller in further generation (Falconer and Mackay, 1996) and given its magnitude it is not of practical importance.

Table 6. Number of gilts and young boars (N) and means for EBV's in average daily gain (ADG) and backfat (BF) for gilts and young boars with 10 % highest and 10 % lowest EBV's for average daily gain and backfat (1994 to 1996 data sets)

EBV's in	Bottom 10% class		Top 10% class		Difference
	N	Mean	N	Mean	
NBA	291	-0.16	291	0.84	1.00
ADG (gilts)	1100	8.4	1109	52.3	43.9
ADG (boars)	1102	8.8	1101	52.4	43.6
BF (gilts)	1104	0.60	1098	-1.43	2.03
BF (boars)	1099	0.61	1107	-1.42	2.03

Differences between litter size and production traits

To compare differences in EBV's between the top and bottom percentile class, differences in EBV's are expressed as a percentage of the mean of each trait. Averaging results from gilts and boars, the difference in backfat between both classes accounts for 20% of the phenotypic mean, for average daily gain the difference in EBV's is 8%. The difference in EBV's between the top and bottom percentile class of 0.96 piglets represents approximately 10% of the mean in litter size.

It was shown that the difference in EBV's for litter size is realised in the lifetime performance of gilts. Although the mean in EBV's is well reflected in the average performance of each group, the standard deviation of phenotypic performance in litter size is large. Phenotypic performances in litter size are overlapping over a wide range between the top and bottom percentile group (Figure 4). This implies that 37.5% of gilts from the top percentile group have a phenotypic performance below the mean of the bottom percentile group of gilts. For the other two analysed traits, average daily gain and backfat, phenotypic performances overlap to a lesser extent. For example, only 13% and 15% of gilts from the top percentile group for average daily gain and backfat are expected to have a phenotypic performance below the mean of the bottom percentile group of gilts (Figure 5 and Figure 6). Therefore, genetic improvement in litter size is possible given the one piglet difference between EBV's of the top and bottom percentile group of gilts. However, this difference is caused by the large variation in litter size and not a high heritability resulting in these overlapping distribution curves as shown in Figure 4.

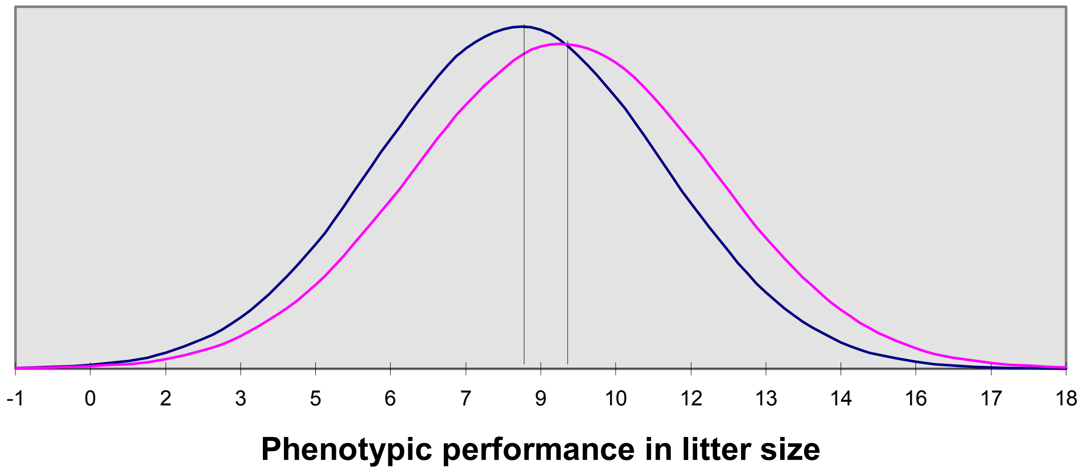

Figure 4. Distribution curve for phenotypic performance in litter size for top and bottom percentile groups of gilts

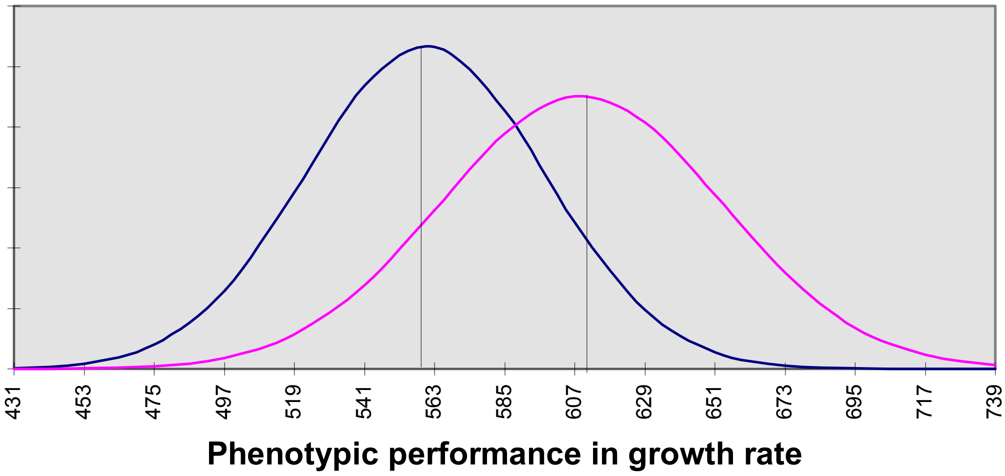

Figure 5. Distribution curve for phenotypic performance in average daily gain for top and bottom percentile groups of gilts

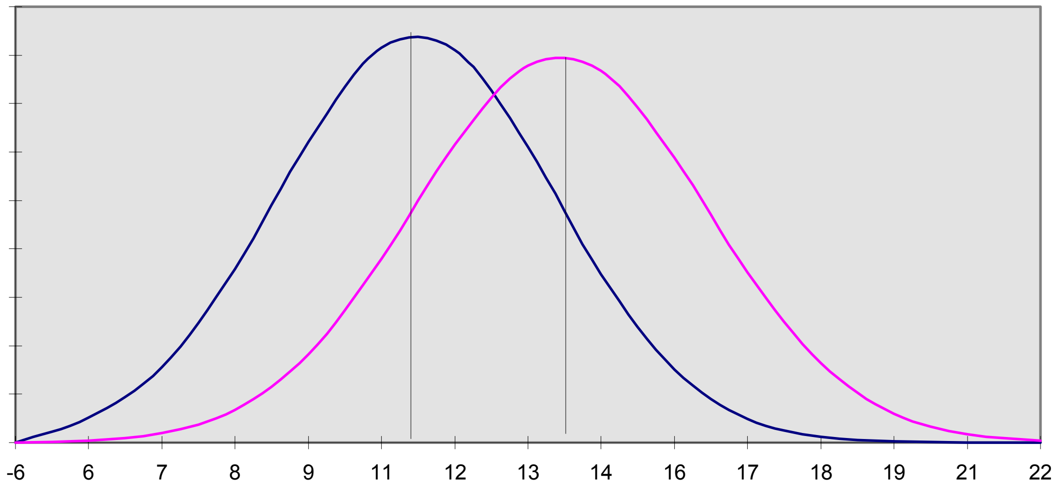

Figure 6.Distribution curve for phenotypic performance in backfat for top and bottom percentile groups of gilts

Summary

The main message is: PIGBLUP works. Differences in EBV's for litter size and average daily gain are realised in the later phenotypic performance. Phenotypic performance in backfat is higher than the difference in EBV's which might be an indication that the heritability used in PIGBLUP is too low for backfat measured on gilts.

Differences in EBV's for average daily gain and backfat are lower for the later data set from 1994 to 1996. This might be the consequence of selection. However, this reduction is expected to be highest for the first generation and does not have practical implications.

The difference in EBV's between the top and bottom percentile group expressed in percentage of the mean is 10% for litter size, 8% for average daily gain and 16% for backfat. The phenotypic variation is large in litter size which implies that 37.5% of the gilts from the top percentile group have a phenotypic performance below the mean of the bottom percentile group of gilts. Genetic improvement in litter size is possible given the one piglet difference between EBV's of the top and bottom percentile group of gilts. However, this difference is caused by the large variation in litter size and not a high heritability

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