and will drop by 0.09 of a piglet in LR. The same increment in the Av21dW EBV of the dam will cause a reduction in the F1 NBA of 0.87 and 0.38 piglets in LW and LR. AvBW will show no significant changes as well as the NWea in LW. However NWea in LR had an increase of 0.34 of a piglet for such increment in the Av21dW of the dam.

5.3.2 Least Square Means for deciles groups

The criteria for assigning the groups of dams was a fixed number in each group regarding their NBA EBV, and due to the distribution of the EBVs (Appendices 6 and 7), the difference between the groups at the extremes (i.e. 1 and 2 or 9 and 10) was higher than the difference between groups in the middle (i.e. 4 and 5 or 5 and 6). It follows that the mean NBA EBVs of the dams across deciles groups were non-linear.

Due to the existence of hyperprolific family lines in the LW breed and assuming that all the hyperprolific sows will be in the highest 10% deciles for NBA, the F1 daughters at group 10 will be called "hyperprolific" sows from this point on.

The curves that indicate the average NBA EBV of dams shown in Figures 5-1 to 5-6, represent half of the average genetic merit for the NBA performance of the F1 sows in each group. The scale of the y axis in Figures 5-1 and 5-2 where the NBA EBVs of the dams' were plotted was set to half of the scale of the y axis where the actual performance of the F1 daughters were plotted, so that the curve of NBA EBVs represents the expectation of NBA performance of the F1 daughters.

5.3.2.1 Number Born Alive

5.3.2.1.1. F1 sows with Large White dams

The least square means (LSM) of NBA performance of the F1 daughters at Piggery 'A' and at Piggery 'B' showed a positive trend across the deciles groups, similar to the curve that represented the dams' NBA EBV across groups. Least square means for the NBA performance of the F1 sows of the "hyperprolific" group presented in Figure 5-1, were the highest in Piggery 'B' (11.63 ± 0.13 piglets) but not in Piggery 'A' (11.10 ± 0.39 piglets), however the difference was not significant (P>0.05). The performance of groups 9 and 10 differed across piggeries decreasing 0.52 piglets in the LSM of group 8 to 10 in Piggery 'A' and rising 0.54 piglets in Piggery 'B'. In contrast the difference in LSM from deciles groups 1 to 4 was +1.46 piglets in Piggery 'A' and +0.6 piglets in Piggery 'B'.

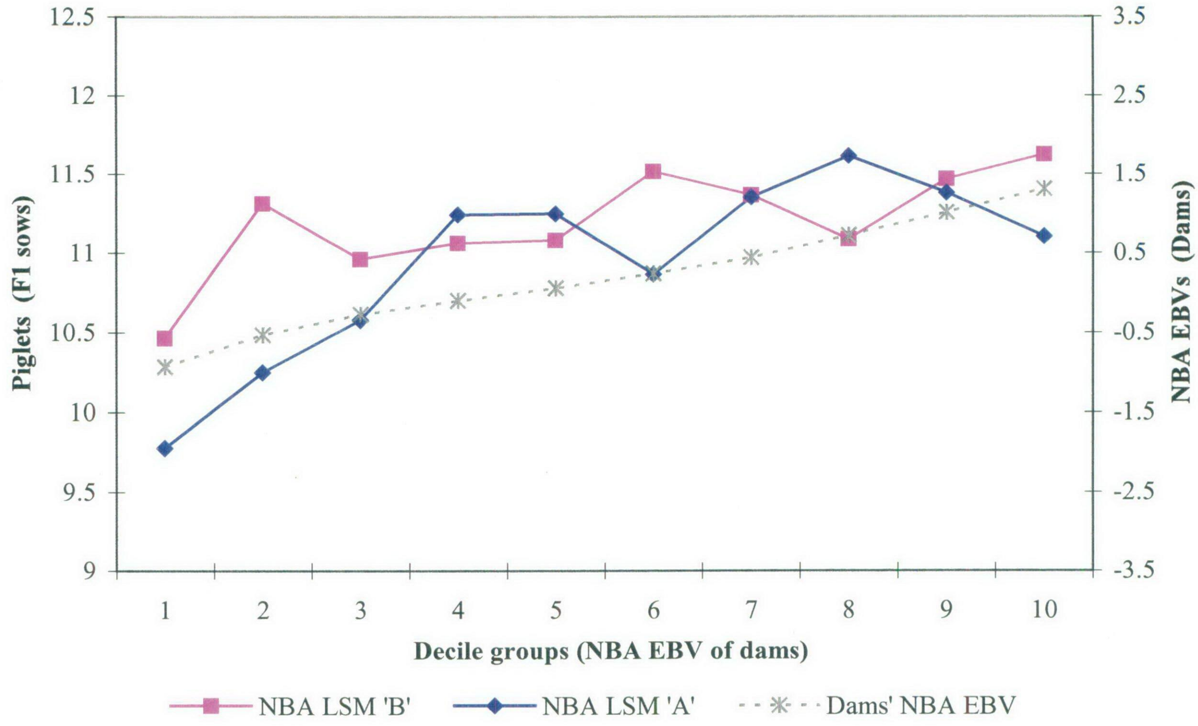

Figure 5-1 Least square means (LSM) for NBA for groups of F1 sows, from Large White dams, recorded at Piggeries 'A' and 'B', plotted by groups of dams' NBA EBV. Average dams' NBA EBV for each group was also plotted (LSM std errors range from 0.11 to 0.51)

5.3.2.1.2. F1 sows with Landrace dams

The F1 sows at Piggery 'B' had LSM across the ten decile groups (Figure 5-2) that followed the trend of the dams' NBA EBVs. Only groups 6 and 9 vary slightly from this trend. In contrast, the

LSM for Piggery 'A' had a more scatter distribution across groups. This piggery had less number of records and hence higher standard errors (Appendix 7).

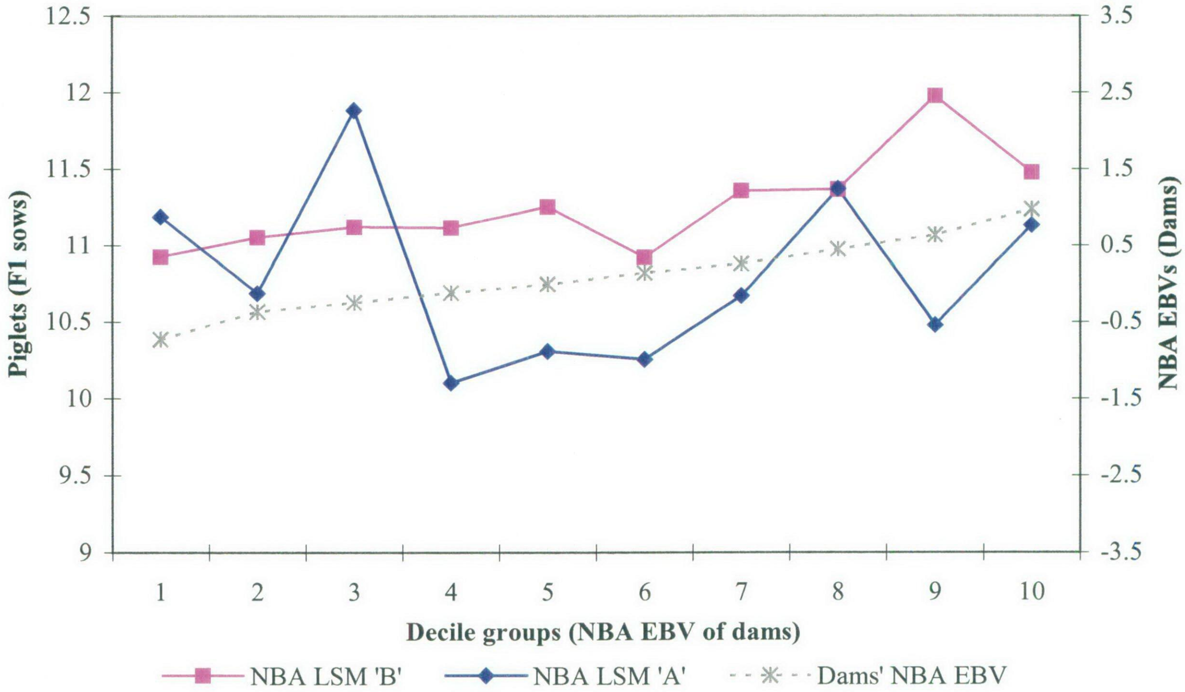

Figure 5-2 Least square means for litter size at birth for groups of F1 sows, from Landrace dams, recorded at Piggeries 'A' and B, plotted by groups of dams' NBA EBV. Average dam NBA EBV for each group was also plotted. (LSM standard errors range from 0.15 to 0.66)

5.3.2.2 Average Piglet Birth Weight (AvBW)

5.3.2.2.1. F1 sows with Large White dams

A scattered trend in the AvBW was observed for both piggeries (Figure 5-3). The LSM of the F1 sows in the "hyperprolific" group had the lowest AvBW in Piggery 'B' (1.47 ± 0.04). In comparison, a steady decline was observed for the LSM from group 7 onwards in Piggery 'A' with the hyperprolific group having an AvBW of 1.49 ± 0.04.

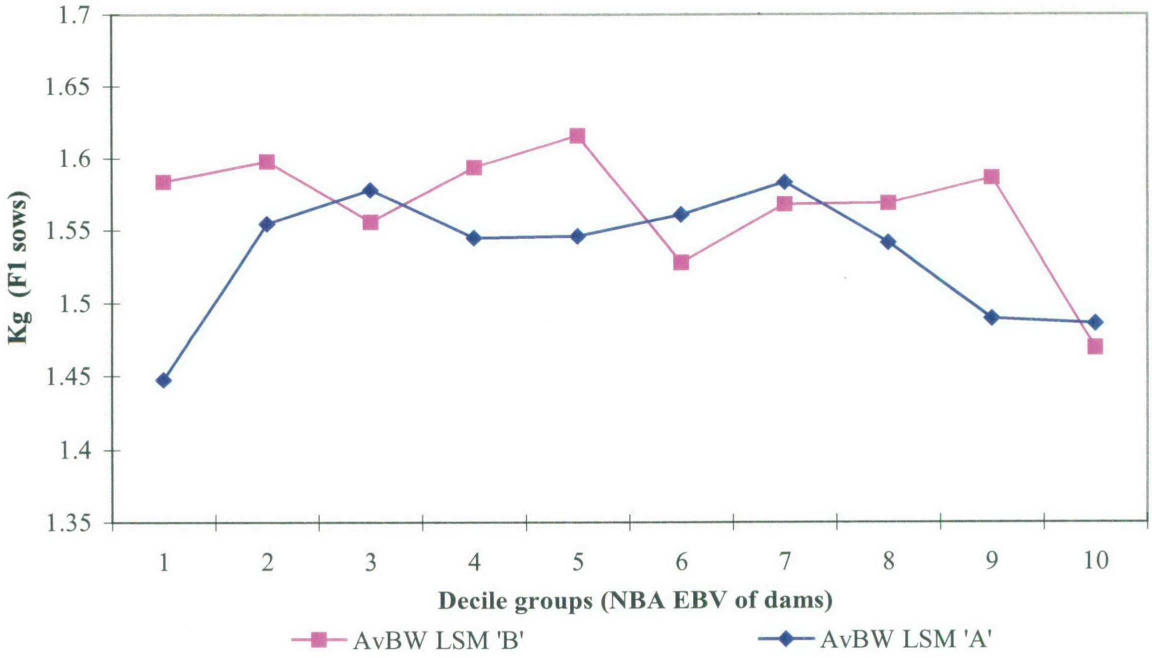

Figure 5-3 Least square means for average piglet birth weight from groups of F1 sows, from Large White dams, recorded at Piggeries 'A' and 'B', plotted by groups of dams' NBA EBV (LSM standard error range from 0.03 to 0.05)

5.3.2.2.2. F1 sows with Landrace dams

Least square means for AvBW in F1 sows from Landrace dams had a non-linear relationship with no clear trend across groups in Piggery 'A'. In contrasts, a clear decreasing trend was observed at Piggery 'B' from group 6 (1.62 kg.) to group 10 (1.48 kg.) corresponding to the four groups with the dams with higher genetic merit for NBA.

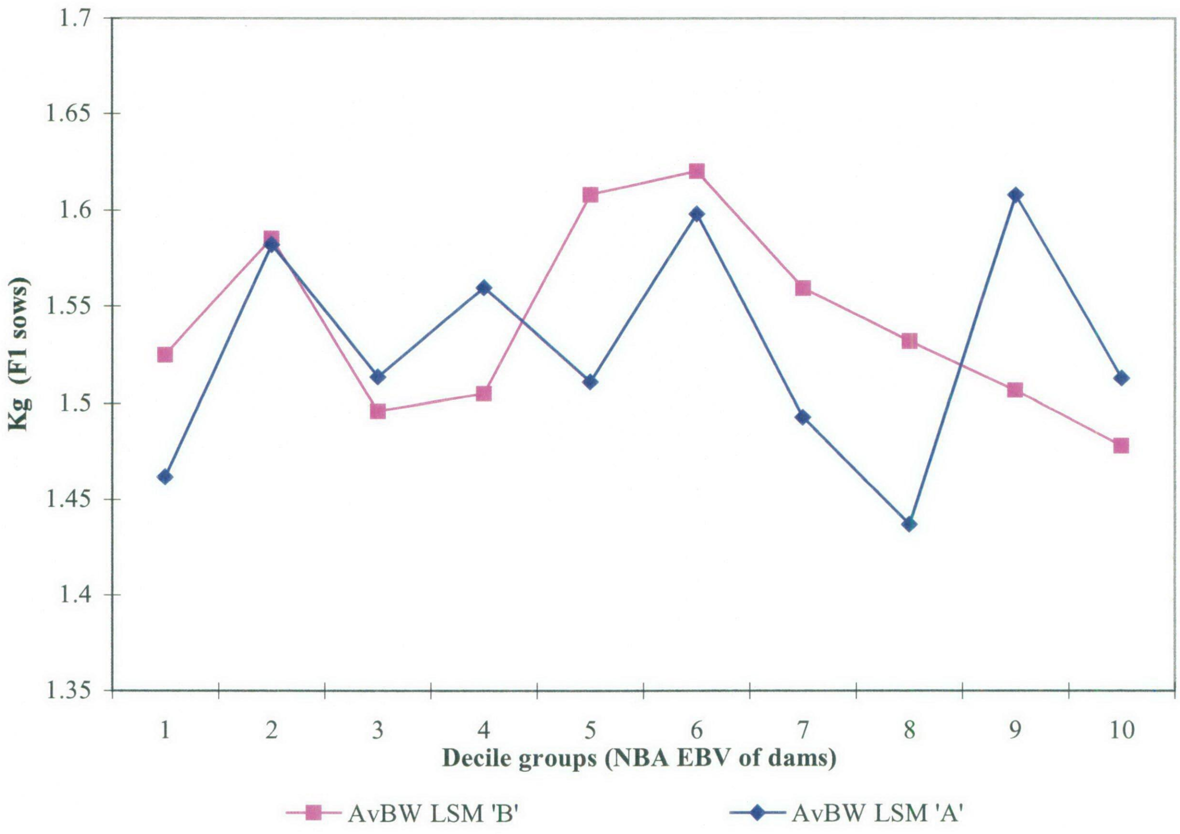

Figure 5-4 Least square means for average piglet birth weight for groups of F1 sows, from Landrace dams, recorded at Piggeries 'A' and 'B', plotted by groups of dams' NBA EBV (LSM standard errors range from 0.04 to 0.06)

5.3.2.3 Average Piglet Weaning Weight (AvWW)

5.3.2.3.1. F1 sows with Large White dams

There was a clear difference in the LSM for AvWW between piggeries. This difference in performance ranged from 290 grams at group 5 and 1,290 grams at group 1. In addition, the difference between hyperprolific groups was 700 grams. This group had the lowest value for the LSM of AvWW for both piggeries (Figure 5-5).

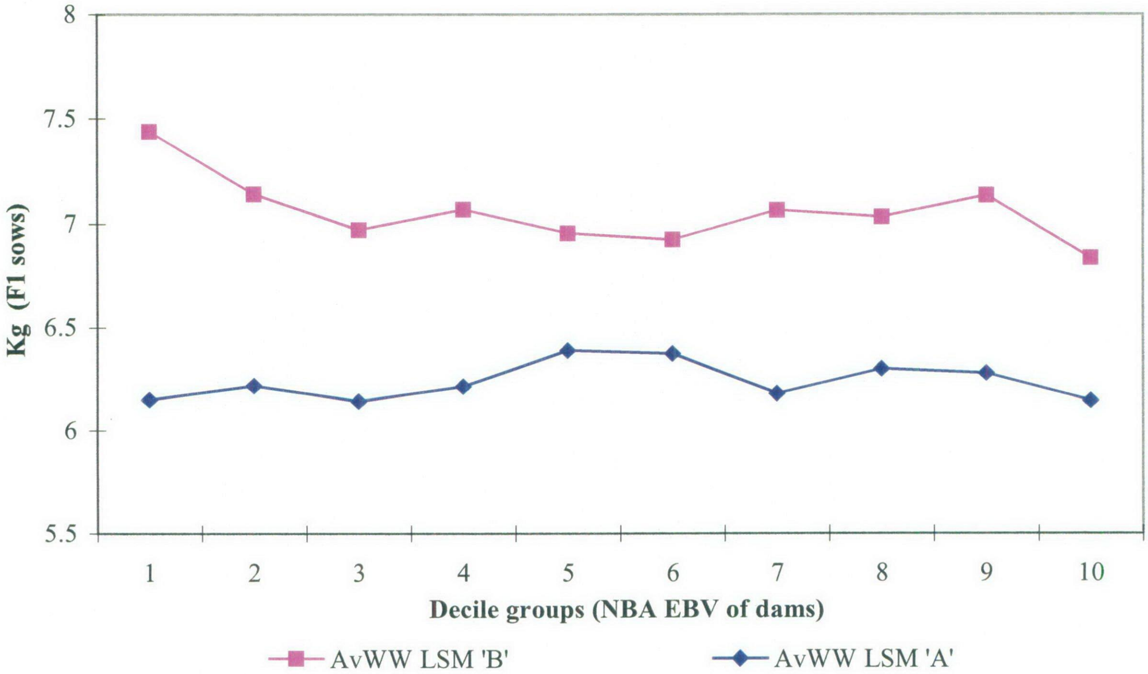

Figure 5-5 Least square means for average piglet weaning weight for groups of F1 sows, from Large White dams, recorded at Piggeries 'A' and 'B', plotted by groups of dams' NBA EBV (LSM standard errors range from 0.11 to 0.18)

5.3.2.3.2. F1 sows with Landrace dams

Similar to what occurred with the daughters of Large White dams, the differences across piggeries ranged from 690 grams in group 9 to 1,160 grams in group 4. The F1 sows with Landrace daughters had their highest LSM in group 10 (with dams with higher genetic merit for NBA) In contrast daughters of LR dams (Figure 5-6) in both piggeries had their highest LSM values for AvWW in group 10.

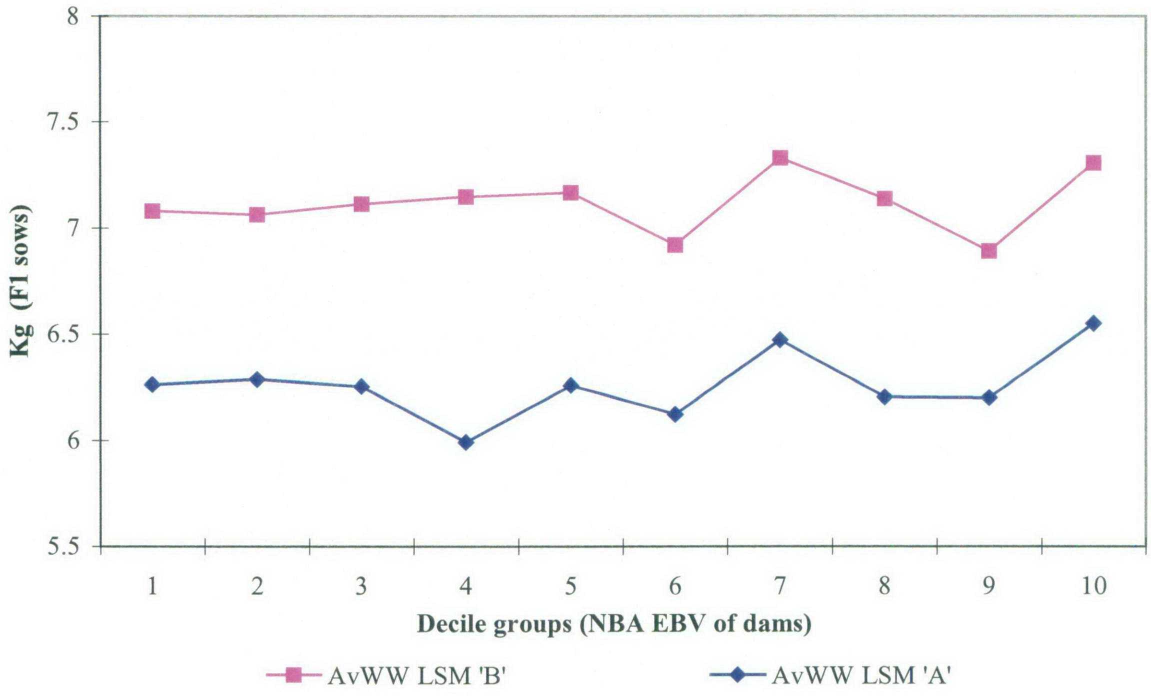

Figure 5-6 Least square means for average piglet weaning weight for groups of F1 sows, from Landrace dams, recorded at Piggeries 'A' and 'B', plotted by groups of dams' NBA EBV (LSM standard errors range from 0.15 to 0.24)

5.4 Discussion

Having only the dam side of the pedigree for the F1 sows population, due to cover-mating at the multiplier herd of Myora Farm with different, unrecorded boars, made it very difficult to analyze the data. The genetic correlation between purebred and crossbred data could not be accurately estimated due to this problem with the data structure.

In addition, due to not having F1 sows performing at the multiplier level or purebred sows performing at the commercial level, maternal heterosis and other effects were confounded. Therefore, a different approach was taken in this study to try to quantify non-additive effects influencing reproductive performance in the crossbred population.

5.4.1.1 Reproductive performance of the purebred dams at Myora Farm

The regression coefficients obtained by regressing NWea of the dams on their NBA EBVs were in line with their expected correlated response (Falconer, 1981) as shown in Table 5-8. It can be seen how increasing the NBA EBV will impact negatively on the trait NWea in both breeds with a higher negative impact in LW. This decrease in NWea is smaller than expected in LR and higher than expected in LW. It is clear that LW sows will not benefit from increasing NBA any further while LR sows are in the boundary of starting to decrease their NWea.

An increase in one unit (1 kg) of the AvBW EBV in the LW dams, decreased NBA by 8.19 piglets, raised the Av21dW by 1.61 kg and enhanced NWea by 0.84 piglets, as shown in the 2nd row of Table 5-8. This drop in NBA was almost twice the expected correlated response value, in contrast, NWea dropped slightly lower than expected. In comparison, similar increment in the AvBW EBV in LR dams decreased NBA by 5.93 piglets, raised the Av21dW by 2.01 kg and enhanced the NWea by a quarter of expected (0.15 piglets). In summary, both breeds had similar correlated expectations for NBA (LW -4.9 and LR -4.45) after an increment of one unit in the AvBW EBV, in addition, LR dams are expected to increase their NWea by less than half (0.57 piglets) than LW dams (1.35 piglets). However, LW sows had higher reduction in NBA (LW -8.19 and LR -5.93) and higher increment in NWea than LR sows (LW 0.84 and LR 0.15).

Increasing Av21dW EBV in LW dams by one unit (1 kg) reduced NBA by 2.01 piglets, raised AvBW by 0.37 kg and enhanced NWea by 0.86 piglets. In addition, a similar increment in the LR dams decreased NBA by 0.90 piglets, increased AvBW by 0.41 kg and enhanced NWea by 0.58 piglets. Therefore increasing Av21dW EBV in LW dams enhanced NWea to expected levels. A similar increment in NWea was observed after increasing the AvBW EBV by one unit (1 kg). However, only a quarter of the reduction in NBA was observed for an increase in Av21dW EBV in comparison to AvBW EBV. In contrast increasing Av21dW EBV in LR dams boosted NWea almost four times more with six times less reduction in NBA than after a one unit increase in the AvBW EBV. It has to be noted that one unit (1 kg) is equivalent to 11.5 standard deviations in AvBW and 5.5 standard deviations in Av21dW.

Table 5-8 Actual values for the regression of reproductive performance of Large White (LW) and Landrace (LR) dams on their own EBVs. Expected correlated response is also shown.

Dam EBVs	Dam Breed	Actual regression coefficients of the Purebred dams ± std errors and Expected correlated responses (below)			
		NBA	AV BW	AV 21dW	NWea
NBA	LW	-	-0.12 ± 0.01 -0.08	-0.10 ± 0.02 -0.16	-0.25 ± 0.08 -0.19
	LR	-	-0.16 ± 0.01 -0.11	-0.14 ± 0.03 -0.04	-0.06 ± 0.14 -0.09
AvBW	LW	-8.19 ± 0.45 -4.90	-	1.61 ± 0.13 1.24	0.84 ± 0.63 1.35
	LR	-5.93 ± 0.53 -4.45	-	2.01 ± 0.16 1.14	0.15 ± 0.75 0.57
Av21dW	LW	-2.01 ± 0.23 -2.66	0.37 ± 0.03 0.31	-	0.86 ± 0.32 0.87
	LR	-0.90 ± 0.28 -0.40	0.41 ± 0.03 0.27	-	0.58 ± 0.39 0.22
NWea	LW	-0.51 ± 0.12 -0.81	0.04 ± 0.02 0.09	0.20 ± 0.04 0.23	-
	LR	-0.59 ± 0.83 -5.98	0.16 ± 0.10 0.89	0.58 ± 0.25 1.48	-

In conclusion, in order to enhance the NWea in both maternal lines at Myora Farm, the use of Av21dW appears to be a better option than the AvBW EBV. It seems that the difference between the EBVs for AvBW and Av21dW in the purebred dams relies in that the first one will facilitate the selection of sows with heavier piglets at birth which are the sows that farrow the smaller litters as well. On the other hand selecting for Av21dW EBV will facilitate the selection of sows that wean heavier piglets not necessarily with smaller litters at birth, presumably the ones with better mothering ability. Selection for both weight traits will reduce NBA.

Large White and Landrace dams had different responses when considering an increment in the AvBW or Av21dW EBVs. Large White dams enhanced their NWea performance similarly for the increase of either EBV and dropped their NBA performance four times more when considering the increment in AvBW EBV. In contrast, LR dams enhanced their NWea performance four times more when considering a rise in the Av21dW with a drop in the NBA performance six times smaller than when increasing AvBW EBV.

This discrepancy between LW and LR breeds indicates that LR dams will not benefit from an increase in the AvBW EBV, however LW dams will. This could occur due to the difference in performance for NBA and AvBW between breeds shown in Table 2-2 in Chapter 2, where the LW sow was shown to be more prolific while the Landrace sows had heavier piglets at birth as well as at weaning suggesting better mothering ability.

5.4.1.2 Reproductive Performance of the F1 sows at the Top Pork Network

The expected regression coefficients obtained from regressing the phenotypic performance of a sow on the EBV for the same trait of her dam is 0.5 as shown on the diagonal of Table 5-9. This expected value of 0.5 will be achieved if the trait measured in the purebred dams is 'genetically' the same trait than the trait measured in their crossbred daughters. These regression coefficients could differ from the expected values of 0.5 if the heritabilities used to estimate the EBVs from the dams were over- or under-estimated. Another reason that could make these values differ from the expected 0.5 could be the use of EBVs obtained from bi-variate or multi-variate analyses (with more than one trait) where one of the traits at the purebred level is not exactly the same trait measured at the crossbred level (i.e. weight at 21 days at the purebred level is measured exactly at 21 days whereas at the crossbred level the weighing at weaning was done at 22 to 23 days), or if one of the traits used for this analysis has a certain bias (i.e. cross-fostering in Av21dW). Adding to this, another reason that could make these regression coefficients differ from the expected 0.5 will be the use of assortative matings since EBVs of boars are ignored in these analyses i.e. if dams with higher EBVs for NBA were mated to the boars with higher EBVs for NBA and the dams with lowest EBVs were mated to the boars with lowest EBVs for NBA, then the slope of this regression (F1-sows performance on NBA EBV of the dam) would be steeper and the regression coefficient will be higher from the expected 0.5. Finally the accuracies of these EBVs could also cause that these results deviate from their expected value.

The regression coefficients obtained from regressing the NBA and AvBW phenotypic performances from F1-sows on their dams' EBVs for NBA and AvBW respectively are presented on the diagonal of Table 5-9. These coefficients were not significantly different ($P<0.05$) from the expected value of 0.5. These two traits are not influenced by cross-fostering practices, therefore neither the data used for the estimation of the dam EBVs' nor the performance recorded from the F1 sows were influenced (or biased) by this management practice. In contrast, the traits AvWW and NWea, were influenced by cross-fostering practices, therefore the EBVs obtained for these traits were not as reliable as the EBVs for NBA and AvBW. Despite this, the regression coefficients of the AvWW of F1-sows on the EBVs for Av21dW of their dams were not significantly ($P<0.05$) different from 0.5, showing higher standard errors than the previous traits due to the less number of records, as well as the influence of cross-fostering already mentioned and the fact that different piggeries measured this trait at different weaning ages. The regression coefficients obtained at the diagonal for NWea was significantly different ($P<0.05$) from the expected 0.5 value for LW daughters. The reason for this was the low heritability for the trait NWea as described in Chapter 3.

Table 5-9 Actual values for the regression of reproductive performance of F1-sows on the EBVs of their Large White (LW) and Landrace (LR) dams, and the expected correlated responses

Dam EBVs	Dam Breed	Actual regression coefficients of the F1-sows ± std errors and Expected correlated responses (below)			
		NBA	AvBW	AvWW	NWea
NBA	LW	0.40 ± 0.05	-0.03 ± 0.01 -0.04	-0.14 ± 0.04 -0.08	-0.02 ± 0.03 -0.09
	LR	0.44 ± 0.10	-0.03 ± 0.03 -0.06	-0.01 ± 0.08 -0.02	0.05 ± 0.05 -0.05
AvBW	LW	-0.86 ± 0.44 -2.45	0.51 ± 0.10	1.47 ± 0.31 0.62	0.12 ± 0.24 0.67
	LR	-2.59 ± 0.66 -2.22	0.50 ± 0.13	0.46 ± 0.41 0.57	-0.09 ± 0.36 0.28
Av21dW	LW	-0.87 ± 0.20 -1.33	0.04 ± 0.05 0.16	0.61 ± 0.16	0.01 ± 0.11 0.43
	LR	-0.38 ± 0.32 -0.20	-0.01 ± 0.07 0.13	0.35 ± 0.21	0.34 ± 0.18 0.11
NWea	LW	-0.32 ± 0.11 -0.41	-0.02 ± 0.03 0.05	-0.03 ± 0.09 0.12	0.00 ± 0.06
	LR	2.91 ± 0.82 -2.99	-0.51 ± 0.19 0.45	-0.75 ± 0.60 0.74	0.15 ± 0.45

The actual regression coefficients obtained after regressing the AvBW performance of F1-sows on their dams' NBA EBV was -30 grams for both breeds and the expected values were -40 grams and

-60 grams for LW and LR respectively. This difference represents a 10 and 30 grams boost in NBA for the AvBW of F1-daughters of LW and LR dams compared to the expectations. The expected reduction in AvWW resulting from an increase in the NBA EBV of their dams of 1 piglet was 80 and 20 grams, while the actual reduction was 140 and 10 grams for LW and LR respectively as shown in Table 5-9. Crossbred sows with different maternal breed respond differently for an increase in the NBA EBV of their dams, while daughters of LR dams enhanced their performance in AvWW by almost 10 grams, daughters of LW dams drop their performance by 60 grams. In addition, the expected values for NWea were -0.05 and -0.09 piglets and the actual values were -0.02 and +0.05, indicating that daughters from LR dams slightly increase the number of piglets weaned with an increment in the NBA EBV of their dams. In conclusion, daughters of LW and LR dams had more favorable regression coefficients for NBA EBV on performance in F1 daughters, with the exception of Av21dW in LW daughters. Finally, F1 sows with LR dams slightly increased their NWea performance after increasing the NBA EBVs of their dams.

A one unit (1 kg) increase in the AvBW EBV of LW and LR dams, decreased the NBA performance slightly more than expected (-2.59 versus -2.22 exp) for the daughters of LR dams but decreased performance less than expected (-0.86 versus -2.45) for the daughters of LW dams. In addition, the actual decrease in NBA was three times bigger for daughters of LR dams (-2.59 piglets) than for daughters of LW dams (-0.86). This increment in the AvBW EBV of dams was associated with an increase in AvWW performance of F1-sows from both dam breeds. However, daughters of LW dams had an increase three times bigger than daughters of LR dams. Finally, NWea performance was enhanced by 0.12 piglets in daughters of LW, while it dropped by 0.09 piglets in daughters of LR dams. In conclusion, F1 sows respond differently to an increase in their dams AvBW EBVs, while F1-sows with LW dams slightly reduced NBA and clearly enhanced their performance in later traits, showing that having heavier piglets at birth boost later performances. On the other hand F1 sows with LR dams decreased NBA and NWea indicating that heavier piglets at birth will not enhance their performance in later traits.

Increasing the Av21dW EBV of dams by one unit (1 kg.) reduced NBA performance of their crossbred daughters by 0.87 (LW dams) and 0.38 piglets (LR dams) (Table 5-9). This increment in the Av21dW EBV of the dams enhanced the NWea performance by 0.34 piglets in the daughters of LR dams, three times higher than the expected response. On the other hand, no change was observed for the NWea performance of daughters of LW dams, while their expected increment was 0.43 piglets. In conclusion, F1 sows again respond differently to an increase in their dams Av21dW EBVs, while F1-sows with LR dams slightly reduced NBA and clearly enhanced their performance in NWea, showing that selection for Av21dW will have a positive impact on the mothering ability of the F1-sows. On the other hand F1 sows with LW dams decreased NBA and didn't improve their NWea performance.

In summary, selection of purebred dams for increased NBA will slightly decrease the AvBW of their crossbred progeny in both breeds and will slightly enhance the NWea performance only in daughters of LR dams. In addition, selecting for AvBW EBV will produce an important drop in NBA as well as in NWea of daughters of LR dams and will decrease slightly the NBA and raise the NWea performance in the daughters of LW dams. The use of Av21dW EBV for purebred selection will cause a slight reduction in the NBA and will enhance the NWea of crossbred sows with LR dams.

5.4.1.2.1. LSM of decile groups

A considerable increase in the LSM of F1 NBA (1.5 piglets) was shown across the first four groups at Piggery 'A' for the daughters of LW dams (Figure 5-1). In contrast a decline of 0.52 piglets was observed from group 8 onwards in this piggery. On the other hand Piggery 'B' with a less scattered line increased the NBA from group 8 onwards by 0.54 piglets. This difference in performance for the last two groups could indicate a difference in adaptation of the hyperprolific group to Piggeries 'A' and 'B'. A similar thing occurred with the hypoprolific sows at the first groups. Higher litter size for the hypo- and hyperprolific groups of Piggery 'B', although non-significantly different ($P<0.05$) from Piggery 'A' could probably be related to the number of records in each group and the sampling error. Another reason that could be responsible for this difference across piggeries is a genotype by environment interaction with environmental differences in nutrition of the pregnant sow, management of the sow during gestation as well as farrowing and mating procedures. Least square means of the daughters of LR dams at Piggery 'B' have a smooth increase across groups, while LSM of Piggery 'A' were unevenly distributed across groups due to the small sample size of these groups.

Least square means from crossbred daughters of LW dams for AvBW decreased significantly ($P<0.05$) from group 9 (1.59 kg.) to 10 (1.47 kg.) in Piggery 'B'; in comparison Piggery 'A' drop the AvBW from group 7 (1.58 kg) till 10 (1.49 kg.). This steeper slope of reduction presented in the hyperprolific group in Piggery 'B' and in the last four groups in Piggery 'A' reflect a non-linear trend in the average weight of the piglets across the groups with higher prolificacy. In comparison daughters of LR dams at Piggery 'B' drop their AvBW consistently from group 6 (1.62 kg.) till group 10 (1.48 kg.).

Adjusted performance for AvWW from daughters of LW dams in Piggery 'A' were evenly spread across groups with a slight decrease showed in group 10. In addition Piggery 'B' showed a similar trend for this hyperprolific group. In contrast daughters of LR dams have in both piggeries their highest LSM for AvWW in group number 10. There is a high influence of cross-fostering in this is trait, and this management practice could be causing this discrepancy between crossbred sows. The difference in performance observed between piggeries was caused by differences in management for this trait. Lactation length was on average 22.3 and 21.9 days for daughters of LR and LW dams at Piggery 'A' and was 23 and 23.2 days at Piggery 'B' for daughters of LR and LW dams respectively.

5.5 Conclusions

This study demonstrated that the EBVs for NBA, AvBW and Av21dW from Myora Farms' LR and LW dams are good predictors of the performance of the crossbred F1 daughters at the commercial level. In contrast, the EBV for NWea did not predict the daughters' performance.

Selecting for NBA EBVs in purebred LR dams will slightly increase NWea performance in their crossbred daughters, contrary to the expected lowly negative response. In contrast, selecting for AvBW in these LR dams will reduce NBA performance as expected and will decrease the NWea performance opposite to the expectations. The selection on Av21dW EBV will drop NBA and increase NWea less than expected. In comparison, selecting LW dams on NBA EBVs will cause a bigger than expected reduction in the AvWW performance of their crossbred daughters. In addition, selecting for AvBW in these dams will increase NWea less than expected and will raise AvWW more than two times the expected value.

After analyzing the performance of the F1 sows in deciles groups it can be concluded that the F1 daughters of "hyperprolific" dams had the highest litter size in Piggery 'B'. However the performance of these F1 sows was not the highest in Piggery 'A' indicating that this could be due to a genotype by environment interaction that needs further studies in order to verify it.

It was shown how selection for different traits at the purebred level will cause different outcomes in the crossbred level depending on the breed of the dam. While selection using AvBW is recommended in LW dams to enhance the NWea of their crossbred daughters, selection using Av21dW EBV is recommended in LR dams in order to achieve similar outcome.