CHAPTER 6

GENERAL DISCUSSION AND CONCLUSIONS

6.1. General Discussion

The main goal of this thesis was to develop strategies to enhance the breeding program of Myora Farm focusing on reproductive traits. To achieve this goal a set of genetic parameters were estimated for two maternal lines at Myora Farm. Estimates of direct piglet heterosis as well as sow and litter inbreeding and their impact on the reproductive performance were obtained. Finally, the performance of F1 sows at the commercial level was analyzed. The objective of this chapter is to discuss major findings of previous chapters and to derive strategies to enhance Myora Farm's breeding program.

Knowledge of genetic parameters and variance components from both maternal lines at Myora Farm are essential to "fine tune" the selection procedures at the purebred level. The use of genetic parameters derived from other populations in Myora's genetic evaluation could produce estimated breeding values (EBVs) that could be bad predictors of progeny performance directly affecting the genetic gains that could be achieved in future generations.

Not only is it important to know how heritable a trait is and what are its genetic relationships with other traits, but it is very important to analyze this trait with the best possible model. Different models could include maternal components, service sire components, and could also treat different parities as different traits. In Chapter 3 these possibilities were analyzed and it was concluded that the best model in order to analyze Myora Farm's data would be an animal model without random maternal and service sire effects. Parity 1 should be treated as a separate trait and parities 2 and older should be combined in a repeatability model in agreement with standard procedures implemented in PIGBLUP (Crump, 2003).

The trait NBA had a higher heritability than the mean estimate found in the literature, especially for the LW breed. It is in this breed where the hyperprolific family lines have been developed over

the last ten years and where the NBA EBVs played an important role at the time of selection. These high heritability results are in agreement with a study made by Johnson et al. (1999) where they selected eleven generations for increased index of ovulation rate and embryonal survival rate followed by three generations of selection for litter size and obtained a heritability of 0.17 with very similar variance components in comparison to this study.

The number of piglets weaned being the main goal of most pig breeding operations emphasized the importance of clearly defining this trait. However, different management practices implemented in different studies, i.e. (cross-fostering, use of foster sows), make comparisons across studies very unreliable. In Myora Farm the trait was defined as the number of piglets at 21 days post-farrowing including piglets fostered on and excluding piglets fostered off; it included all sows that had at least 2 piglets born alive. This definition did not consider the records of sows utilized as foster sows that weaned a second litter in their same parity period. However, it did consider the sows that had a weaning record of 0 after having all of their piglets fostered-off on to foster sows.

A negative genetic correlation was obtained between the traits NBA and NWea. This unusual negative genetic correlation can be attributed in part to the definition of the trait NWea, highly influenced by cross-fostering, as well as to the high levels of NBA especially in the Large White breed. In order to clarify this, a theoretical example will be considered:

Table 6-1 shows hypothetical NBA, AvBW, litter birth weight (LBW) and standard deviation of birth weight (SD BW) from three sows with different NBA performance (16, 10 and 6 piglets). Hypothetically, sow A with 6 heavy (1.8 kg) piglets born alive will be fostered on with either 5 or 6 piglets that will usually be healthy and heavy in order to survive in this competitive litter. Sow B with 10 normal weight piglets (1.4 kg) will have maybe 1 or 2 piglets fostered on, also trying to incorporate piglets of their same size in order to increase their chance of suckling and surviving. Sow C with 16 small piglets (1.2 kg) and with a higher variation in birth weight (Std Dev = 350 gr.) among them will have 4 or 5 of her heavier piglets fostered off assuming that the lighter piglets, if considered viable, will have a better chance to survive staying with their biological mother and the stronger piglets will be more capable of surviving under more stressful conditions with a foster sow.

Table 6-1 Hypothetical number born alive (NBA), average birth weight (AvBW), standard deviation (SD), litter birth weight and number of piglets weaned (NWea) of Sows A, B and C before and after cross-fostering

	Sow A	**Sow B**	**Sow C**
NBA	6	10	16
	Before Cross-fostering		
AvBW	1.8 kg	1.4 kg	1.2 kg
SD of BW	0.18 kg	0.25 kg	0.35 kg
Litter BW	10.8 kg	14.0 kg	19.2 kg
	After Cross-fostering		
AvBW	1.7 kg	1.4 kg	1.1 kg
Litter BW	18.7 kg	14.0 kg	9.9 kg
NWea	11	10	9

Therefore the lighter piglets, with higher chance to die from any disease, overlaying or from starvation remained with the sow that farrowed the larger litter size. As a result, the three litters will be evened with similar number of piglets (11 piglets) depending on the condition of the sow. However, assuming that the three sows are healthy and milking properly, the chance of weaning 11 piglets will depend on the viability of the piglets allocated to each litter. Acknowledging the importance of the piglet birth weight as an important factor influencing piglet survivability, Sow C has the lowest chances to achieve this goal.

It was concluded in Chapter 4 that the levels of direct piglet heterosis shown at the multiplier of Myora Farm were very low in all traits (TNB = -0.2%, NBA = +0.6%, NWea = -1.1%, AvBW = +1.3%, Av21dW = +0.4% and GL = -0.1%). Roehe (1998) concluded that individual piglet birth weight could only be increased by direct heterosis of the individual piglets and not by using crossbred sows. However, the breed combination plays a very important role in the expression of direct piglet heterosis. Roehe (1998) found significant heterosis expressed in the piglets from German LW and German Edelschwein combinations and found no heterosis in the piglets of German LR and German LW combinations. In addition, Rothschild and Bidanel (1998) stated that LW and LR combinations generally exhibit less heterosis than other crosses between European and American breeds. In summary, the lack of direct piglet heterosis found in Myora Farm's multiplier herd agreed with previous studies.

Sow and litter inbreeding at Myora Farm's maternal lines measured in 2003 were 5.74% and 5.0% in LW as well as 2.7% and 2.2% in LR. Overall inbreeding levels increased over the last ten years. The annual rate of increase was higher for the 2002-2003 period with an increment of 1.2% in sows and 0.6% in litters. The use of BLUP selection over this ten year period of time led to an increase in the sows' and boars' inbreeding levels due to the selection of related animals with high genetic merit for selected traits. Negative effects of inbreeding depression in purebred maternal lines at Myora Farm were shown in this thesis. Therefore, optimizing the mating decisions in order to address this issue should be a priority for Myora Farm. PIGBLUP (Crump, 2003) has a selection and mate allocation feature, which provides a tool to optimize selection decisions and to choose possible mating candidates after accounting for the genetic merit as well as the future inbreeding coefficient of the resultant litter.

For every purebred sow at Myora Farm there are five F1-sows at the Top Pork Network. This ratio reinforces the idea of setting the breeding goal towards the performance of the commercial level (Brandt and Täubert, 1998). It was shown in a simulation study made by Wei and van der Werf (1994) that using a combination of purebred and crossbred information for selection purposes will lead to 5% more genetic progress than using pure-line selection alone, assuming a genetic correlation of 0.7 between purebred and crossbred records and a heritability of 0.2 for purebreds as well as crossbreds. When there is a fixed number of purebred progeny this extra genetic progress increases to 13 %. They concluded that even if the crossbreeding parameters (heritability of crossbred animals and genetic correlations between purebred with crossbred animals) are unknown or imprecisely estimated, crossbred information should be used in improvement of current animal crossbreeding programs. However, the implementation of a breeding program that utilizes crossbred information from commercial piggeries in order to make selection decisions at the purebred level will not be possible at this stage. Therefore, optimizing the use of the available purebred information to make selection decisions that enhance the reproductive performance at the commercial level was one of the main goals of this thesis.

It was demonstrated in Chapter 5, that EBVs for NBA, AvBW and Av21dW are good predictors of the performance of their crossbred progeny at the commercial level. In addition, it was also shown how an increase in these EBVs at the purebred level impacted on the performance of the other reproductive traits at both, purebred and crossbred levels. This analysis was made to determine the

expression of non-additive effects of reproductive traits at the crossbred level, since the data structure did not allow estimation of maternal heterosis of the F1-sows or direct heterosis of the F2-piglets.

Rothschild and Bidanel (1998) presented a review of 15 studies with an average direct heterosis effect of 5.8% for the trait birth to weaning survival. The dam heterosis for the same trait was 5.0%. Piglet mortality increased exponentially from 5% for piglets of 1.6 kg to 1.8 kg to more than 40% for piglets of 1 kg or less and pre-weaning growth rate decreased linearly from 255 grams to 189 grams for corresponding weights, which resulted in a high economic loss (Kerr and Cameron, 1995; Roehe, 1998). Piglet mortality between birth and weaning is very difficult and costly to measure and has a very low heritability (Hermesch et al., 2001b). Therefore, several studies suggested different alternative traits for selection in order to improve pre-weaning survivability of piglets (Hermesch et al., 2001b, Kerr and Cameron, 1995; Roehe and Kalm, 2000; Suarez et al. 2005).

As part of the conclusions of Chapter 3, the trait AvBW was recommended to be included in the selection criteria in order to enhance the number of piglets weaned, especially in the LW breed. One of the reasons for choosing the trait AvBW instead of Av21dW was that the latter was influenced by cross-fostering and hence due to this source of bias the Av21dW EBV was not as reliable as the AvBW EBV. However, from the analyses made in Chapter 5 it was demonstrated that the Av21dW EBV predicted the performance of the crossbred progeny with only minor differences across LW and LR breeds. It was also demonstrated that a 1 standard deviation of EBVs (LW 0.09 kg and LR 0.08 kg) increase of the AvBW EBVs of purebred sows will reduce NBA performance at the purebred level nearly 2 and 3 times more than an increase of 1 standard deviation (LW and LR 0.17 kg) of the Av21dW EBVs in LW and LR respectively. The same increment in either AvBW or Av21dW EBVs will increase the NWea performance of the purebred LW sows by 0.06 and 0.15 piglets; however the decrease in NBA performance will be of -0.74 and -0.34 piglets respectively. In addition, analyzing similar increments in LR sows, NWea performance increased by 8 times when increasing Av21dW EBV with one third of the reduction in NBA compared to an increment in the AvBW EBV. In conclusion, there is an indication that selecting purebred sows for increasing AvBW EBV (single trait selection) will lead to selecting sows that farrow heavy piglets and hence smaller litters; on the other hand selecting purebred sows

for increasing Av21dW EBV (single trait selection) will lead to selecting sows with other maternal characteristics. In proportion, a smaller reduction in NBA performance will be observed in the latter.

Increasing Av21dW EBV in the purebred LR sows enhanced the NWea performance of their F1 sows more than 3 times the expected correlated response and reduced NBA two times more than expected. In addition, increasing Av21dW EBV in purebred LW sows did not enhance NWea performance in their F1-daughters. On the other hand, increasing AvBW EBVs in purebred LW sows enhanced NWea performance of their F1-daughters by only a fifth of the expected response, however enhanced Av21dW performance by almost three times more than expected. In conclusion, to enhance the NWea performance of F1-sows at the commercial level, through the genetic merit of their purebred dams at the multiplier herd of Myora Farm, different approaches should be taken in LW and LR dams. The inclusion of AvBW EBV as selection criteria in the LW breed and the inclusion of Av21dW EBV as selection criteria in the LR breed are recommended. In order to include these traits as part of the breeding objective, further work should be done to establish economic values, as well as to consider all the correlations with other important traits already included in Myora Farm's breeding objective.

6.2. General Conclusions

The main objective of a sustainable breeding program is to obtain the maximum possible gain in the breeding goal from the genetic resources available within the technical and environmental constraints that are applied to the breeding program (Bijma et al., 2002). Breeding schemes have had considerable success in generating rapid gains, in traits such as litter size using BLUP methodology. This increase in litter size was obtained mainly in maternal lines by selecting on indexes with high emphasis in litter size. This high emphasis placed on litter size left aspects such as health and welfare of piglets and sows to be addressed by management. Cross-fostering, creep-feeding, the use of foster sows are examples of management practices implemented to overcome these issues.

It is normally believed among pig breeders that it will be ideal to breed sows that can farrow consistently 12 piglets, and be able to wean all of them successfully as well. This will reduce many of the extra costs linked to cross-fostering, feeding, mortalities, etc. However reality differs significantly form this belief, so it is needed to breed sows that will be able to farrow high number of piglets in order to compensate, through cross-fostering, for other sows that farrow small litters to achieve high number of piglets weaned overall. Some breeding companies implemented this theory to extreme levels with "hyperprolific" breeding schemes, and encounter several difficulties, such as dealing with piglets with low birth weights and high mortality rates among them.

In Myora Farm's case, it is apparent that having "hyperprolific" families at the purebred level is not having a positive impact on the overall goal of the breeding program of increasing the number of piglets weaned at the crossbred level. However, further studies are required to confirm or deny this statement, in order to show if the availability of the extra piglets provided by the hyperprolific families together with extensive cross-fostering practices are responsible for having no differences in the NWea performance across all crossbred sows regardless of their genetic merit for litter size.

Further studies should consider analyzing the trait number of piglets weaned (from their genetic mothers) avoiding crossfostering at least in the nucleus herd, in order to evaluate the possibility of using this trait as part of the selection criteria of Myora Farm's future breeding program.

Selection for increase in litter size needs to be complemented with other selection tools and management practices in order to enhance the number of piglets weaned, to reduce the mortality and improve the welfare of piglets. Therefore, the inclusion of the 21 day litter weight trait (adjusted for the number of piglets in the litter) is recommended in the selection criteria of LR sows, as it is part of the PIGBLUP (Crump, 2003) standard settings and the trait has been recorded at Myora Farm for a long period of time. In addition the trait AvBW should be included as selection criteria for selection of LW sows.

Estimated breeding values for NBA, AvBW and Av21dW from purebred sows at Myora Farm, predicted the performance of their crossbred daughters at the commercial level. This is a very important finding of this study and reinforces the need of utilizing EBVs at the purebred level to enhance the reproductive performance at the commercial level.