Quantitative Selection for Piglet Survival as A Safe Way to Reduce the Cost of Weaners

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▪ Introduction

Genetic variation between animals exists. There is no doubt about that. Variation in a trait, e.g. litter size, is caused by variation in a number of genes influencing the underlying processes of litter size such as ovulation rate, variation in elongation, and prenatal survival. Geneticists nowadays have two powerful toolkits available to choose individuals with the right alleles. One is the quantitative toolkit and the other the molecular one.

In this presentation, the trait piglet survival will be explored using quantitative methods, searching for genetic variation (Knol, 2001) and for biological explanations for possible genetic differences in piglet survival (Leenhouwers, 2001).

There are at least three reasons to try to improve piglet survival.

- Selection for increased litter size is successful in most breeding programs. The correlation between litter size and mortality is positive. Larger litters result, on average, in higher mortality.
- Larger litters increase the necessity of (cross) fostering in a time that farm size increases and input of labour per sow decreases. Therefore, more labour is needed, but less is offered.
- Beginning in Western Europe, concern for animal welfare is gradually accepted in a growing number of countries.

The result of this concern can be a government mandate for an increase in lactation days, a decrease in the possibility of mixing piglets, and an increase in space allowance for sows, piglets and finishers.

In general, it would be helpful for the economy of pork production if both sow and piglet could survive with little human intervention and still allow for an increase in litter size.

An Approach to Address Piglet Survival Genetically and Biologically

Definition of survival and of genetic effects

Losses in litter size occur in different phases, until weaning these are:

- Uterine survival (complement of number of mummified)
- Farrowing survival (complement of number of stillbirths)
- Preweaning survival (complement of number of lactation losses)

In this paper piglet survival is defined mathematically as the proportion of piglets surviving from late gestation to weaning: (# weaned/total # born). In many countries this is, on average, 80.3% (still born 7.4%, preweaning losses 12.8%). Uterine survival is excluded, as is survival after weaning.

Important genotypes for survival of a piglet are its own set of genes, the set of genes of the sow nursing it, and the set of genes of the sow that gave birth to the piglet. The latter is responsible for the prenatal environment; in genetic terms this effect is called the maternal effect. The effect of the genes of the piglet will be referred to as vitality and the effect of the nurse sow as mothering ability. It should be noted that in most cases the biological mother is also the sow nursing the piglets.

Quantitative selection for piglet survival

To explore this trait birth weights, fostering and survival observations were taken on individual piglets on 32 TOPIGS nucleus, multiplication and piglet production farms in different countries and under different health conditions. Full pedigrees for both sow and piglet were available for some 600,000 piglets.

Results

Genetic analysis

Genetic analysis yielded heritabilities of 0.02 for vitality on a piglet basis and 0.07 for mothering ability (Knol et al., 2002). A heritability of 0.02 is extremely low, but still promising because genetic variation is considerable and because a large number of observations are available per parent. Simulation **(Table 1)** showed that single trait selection for litter size will reduce piglet survival, as is expected. Simultaneous selection for litter size and birth weight will increase birth weight dramatically, but will not increase survival nor increase litter size. Eight years of selection on an index of litter size and piglet survival will increase litter size total born from 12.3 to 12.8 piglets per litter and at the same time increase survival from 80.3% to 84.2%.

Table 1: Simulation response of 8 years of selection on (1) only litter size (LS), (2) an index of litter size and birth weight (BW) or (3) an index of litter size and survival.

	2002	**2010**		
		Litter size	**LS + BW**	**LS + survival**
Litter index	2.32	2.35	2.35	2.35
Total born (LS)	12.20	13.70	12.26	12.80
Live born	11.30	12.72	11.22	12.11
Stillborn	0.90	0.98	1.04	0.69
Piglet survival	80.3	78.3	79.8	84.2
Weaned/litter	9.80	10.72	9.79	10.78
Weaned/sow/year	22.8	25.2	23.0	25.3
Ave. Birth weight (BW)	1.45	1.34	1.74	1.39
Variation in BW	280	280	310	268
Litter weight	17.7	18.4	21.3	17.8

Proof

200 gestating sows were assigned to one of two groups based on the Expected Breeding Value for Piglet Survival (EBV_{PS}) of their offspring; difference between the two groups was 4.0% expected survival. Realized difference was 3.97%. It was very interesting to note that the groups did not differ in litter size or average birth weight. They did differ, however, in within litter variation in birth weight and litter weight at birth. Both were significantly lower for the high survival group.

Mode of Action

Since genetic differences in piglet survival can be predicted accurately, high/low EBV_{PS} sampling can be done to investigate the underlying biological processes. A high and low EBV_{PS} group were formed of 25 gilts each, inseminated with semen of high and low EBV_{PS} boars, respectively, and piglets were delivered with caesarean section at day 111 of gestation (Leenhouwers et al, 2002). All piglets were sacrificed, dissected, and analyzed. Individual placentas were available.

Differences between high and low EBV_{PS} groups were found. For the high EBV_{PS} group, the placental weight was lower. Within the litter, the placental weight variation was more uniform. The liver, stomach, and small intestinal weights were higher. The glycogen content of the liver and muscles was higher and blood cortisol level was significantly higher.

The hypothesis is that selection for increased survival acts through an increase in cortisol, which plays an important role in the preparation of the piglet for the birth process. It enhances lung maturation and glycogen synthesis, both vital processes for early neonatal survival.

Genetic Cost of Selection for Piglet Survival

Survivability is only one of many traits important for efficient pork production. It is important to know the relationships between these traits. A statistical analysis revealed significant moderate genetic correlations (0.4-0.5) between piglet survival on one side and feed intake, daily gain, and protein and fat accretion on the other side. This indicates that selection for increased survival will definitely influence finishing traits, but also that intense selection on leanness will negatively affect piglet survival.

▪ Discussion

Quantitative Selection

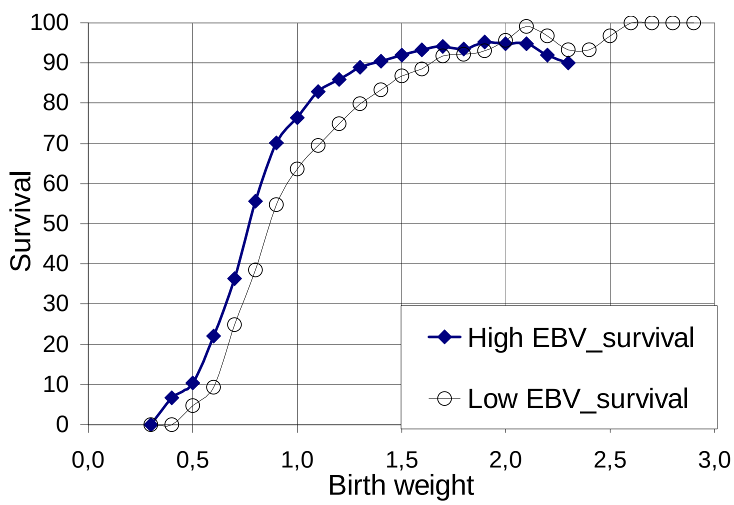
Almost all economically important traits can be improved genetically. The main concern is the correlated traits. At what costs can genetic improvement be generated. With a quantitative approach, observations are taken on relevant animals under diverse environments, correlations between traits and genotype environment interactions are assessed, and predictions on expected genetic change are made. Even for a trait with a very low heritability, such as piglet survival, considerable genetic progress can be realized. A proper analysis of the data can increase the biological understanding of the trait. From this genetic and biological understanding a search for important genes can begin.

Survival and Birth Weight

The phenotypic relation between birth weight and survival is very clear. In every farrowing room it is obvious that the heavier piglets have much better survival chances than their smaller littermates. The genetic relationship, however, is very low. Selection for increased birth weight will not lead to a clear increase in survival.

Differences between lines and breeds can provide some insight. The main example is the Meishan, one of the Chinese breeds. Meishan piglets have an average birth weight below 1 kg, but a survival rate similar or higher than Large White piglets with an average birth weight of 1.4 kg. In **Figure 1** weight survival curves are drawn for the high/low EBV_{PS} piglets discussed above. Survival increases especially for the lighter piglets. It is interesting to note the absence of the very heavy piglets in the high EBV_{PS} group, indicating that uniformity increases through the loss of heavy piglets instead of through the loss of small piglets.

Figure 1: Relation between birth weight and survival of piglets born from parents with a high versus parents with a low breeding value for survival (from Knol, 2001).



Survival and Fatness

The genetic correlation between survival and fatness is 0.5, which ismoderate and significant. The Meishan breed has strong piglets, especially considering the birth weight, and Meishan animals are very fat. McKay (1993) selected for increased lean tissue daily gain and found a correlated decrease in preweaning survival. Selection for lean tissue daily gain will increase mature body size, delay puberty and possibly delay early development somewhat. If gestation length is fixed, piglets will gradually become more premature at farrowing with negative consequences for later survival.

Survival and Feed Intake

The genetic correlation between survival and feed intake is of the same magnitude as with fatness and probably is the driving factor. Selection for increased survival will result in piglets with a larger stomach and larger small intestines (see *Mode of Action* in Results section), thus preparing for later increased feed intake. Feed intake itself has a heritability of 0.30 and is both a difficult and an optimum trait. It is difficult because feed intake for finishers is, on average, too low for young animals and too high for animals approaching the end of finishing. Feed intake should be higher during hot weather and sometimes lower in milder conditions. Feed intake for high producing sows should be high during lactation, but appetite low through gestation (high satiety). Feed intake through finishing should be high enough to allow for maximum protein deposition, but low enough to keep fatness levels acceptable.

Survival and Mothering Ability

Genetic variation in mothering ability is at least as promising as genetic variation in vitality. Biological mechanisms are being unravelled, but are left undiscussed here.

■ Conclusion

Piglet survival is heritable. Genetic selection for birth weight will not, or will in only a very limited way, increase survival. Selection on an index of litter size and piglet survival will lead to considerable progress in terms of piglets weaned per sow per year, through a small increase in litter size, a considerable increase in survival, and through lighter more uniform piglets. It will result in a more balanced, less labour demanding production structure with less pressure on the sow.

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