Evaluation of sow productivity traits for selection of dam lines

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INTRODUCTION

The current genetic evaluation system on the Canadian Swine Improvement Program includes litter size at birth as measure of sow productivity for selection of dam lines, in addition to other traits of growth, carcass quality and feed efficiency. Recent estimates have shown an increase of about 0.2 pigs in litter size per year in the herds on the national program. As a result, these herds have made a significant contribution to the profitability of the commercial production in Canada. However, there are opportunities for further improvement. There are many sow productivity traits besides litter size which have a substantial economic value. They include, for example, age at first farrowing, farrowing or weaning to conception interval, litter or individual pig birth weight, survival rate post-partum and to weaning, litter weight at weaning, and maternal behaviour traits. However, some of these traits are correlated and have low heritabilities. In addition, their heritability depends greatly on the conditions in which they are recorded e.g. whether cross-fostering is used when the piglets are weaned etc.. As a result, selection for some of these traits may be less effective or even counter-productive. Therefore, before developing any new sow productivity evaluations, it is essential to assess the economic benefits of adding new traits, based on their effect on the economic gains.

The main objectives of this study were to identify suitable phenotypic traits for a sow productivity genetic selection program designed to meet producer needs, and to derive economic weights for those traits and compare the relative profits from the expected genetic progress.

MATERIAL AND METHODS

Target markets

The relative significance of the sow productivity traits depends upon the target market. In Canada there are two distinct markets for sale of pigs. A common market is that of finished pigs or commercial hogs. These pigs are sold for slaughter when they attain about 100 kg of live weight. Another important market is that of feeder pigs. These pigs are sold at a weight of about 25 kg to producers who wish to feed and raise them further. The feeder pig market is mainly popular in Western Canada and pigs are usually sold to the customers in the US.
The profits in the feeder pig market depend upon the sow productivity traits as well as the association of these traits with early post weaning growth rate of the litter. However, in

case of finished pig market, the association of sow productivity trait with piglet growth is not very important since is negligibly small and can be ignored. Therefore the derivation of economic weights and prediction of the resulting genetic and economic gains requires different assumptions and computations for the two markets.

Modified profit function approach for derivation of economic weights

Economic weights measure the change in profit as a result of a unit change in the trait. These can be derived in two ways. Under the simple accounting method, the revenue and costs associated with a unit change from the current mean of a single trait are calculated, avoiding double-counting and assuming all other traits remain constant. Alternatively, computer simulation of the entire production system based on a bio-economic model is used to estimate profit at the current mean, and after a unit change in one trait. These bio-economic models can describe much of the complexity of the relationship between and among the traits and management variables, so this approach is generally preferred to the more simple accounting method. However, both these methods require considerable expertise to update or to adapt to specific situations.

As an alternative, economic weights can be derived from a simplified form of a bio-economic simulation model, in which total profit is described by a single expression, known as a profit function, which includes all economically relevant traits. The economic weight for each trait can then be calculated in a straightforward manner from a formula based on current trait means, prices and management costs. This approach was used here, and a profit function was defined for each of the target markets. The economic weights were then calculated for three different herd means in each market. Data from Ontario Swine improvement Program were used for estimation of the necessary parameters.

Traits considered

It is important to consider those traits that make significant contribution towards and revenues and costs, can be recorded accurately and are less affected by day to management. For example, the commonly used trait is farrowing interval. However, a weaning to conception interval is a better measure since it does not include: conception rate which is not heritable; variation in age at weaning which is due to management; and variation in gestation which is unfavourably related to litter size. Therefore, following traits were considered:

1. Total litter size at birth (**LS**)
2. Perinatal survival rate (**PS**)
3. Rate of survival to weaning (**SW**)
4. Age at puberty (measured by age at first successful service) (**AP**)
5. Interval from weaning to conception
   (measured by next successful service date) (**IWC**)
6. Piglet market weight (predicted from average piglet weight at weaning) (**WW**)

The piglet market weight (WW) was not considered in a genetic selection program for the 100 kg market since there is little or no association between the sow's productivity traits and the final weight of her crossbred descendants in a weight based marketing system.

Estimation of relative merits

The relative significance of each trait was assessed by comparing the predicted increase in profit as a result of incorporating all the traits above into a selection program, and then excluding them one by one. The increased profit was calculated from the predicted selection response in all traits. Response from selection was predicted from an average of results from several models, in which differing amounts of information were assumed to be available for evaluation.

RESULTS AND DISCUSSION

The profit function approach is quite flexible, since the economic weights can be recalculated for specific needs, based on values relevant to a targeted production system and market, or on trait levels for closed herds. Economic weights are given in Table 1 for the 100kg market and three levels of expected total litter size at birth in the commercial herd, in order to illustrate this flexibility. Economic weights are given in Table 2 for the 25kg market for the same three levels of expected total litter size at birth in the commercial herd.

The amount of profit which would be expected if one or more traits were not included in the selection criterion is given in Tables 3 and 4, expressed as a percentage of the maximum. Maximum profit is realised when all traits are included in the selection criterion. These predictions are based on selection in a herd with an average commercial litter size of 12 piglets born, using appropriate economic values. The maximum profit is realised when all traits are included in the selection criterion. These percentages are appropriate for the short term, but are lower in the long term.

Age at first service and interval from weaning to next service caused the least reduction in profit for either market if one or both were excluded from the selection criterion. The next candidate trait for exclusion was piglet survival rate from transfer to weaning, and exclusion of all three of these traits reduced short-term profit by 2.3% in the 100kg. market, and by 6% in the 25kg. market. When these three traits were excluded, survival rate to weaning decreased for the 100kg. market, but increased for the 25kg. market, probably due to its positive genetic correlation with average piglet weaning weight. The largest reduction in profit of the reduced models for the 100kg. market occurred when litter size was the only trait excluded from the selection criterion, whereas the largest reduction for the 25kg. market occurred when litter size was the only trait in the selection criterion.

A comparison of economic gains resulting from stepwise inclusion of different sow productivity traits in the index for selection of dam lines is given in Table 5. These results suggests that, the most important trait after litter size is % mortality to 24 h (with a 10% to 12% increase in returns). This is true for the finished pig (100kg) maket as well as for the feeder pig (25kg) market. The next most important trait is % mortality to weaning in the commercial market (3% increase in returns) and weaning weight in the feeder pig market (12% increase). The other traits add substantially less economic gains once these most important traits are included.

RECOMMENDATIONS

Total litter size at birth is the only sow productivity trait in the current national selection criteria for dam lines. This means that about 88% of the potential profit due to selection response from sow productivity traits is already achieved in the 100kg. market. Almost 98% of the possible profit from sow productivity traits would be realised by adding perinatal survival to the criteria for the 100kg. market. It is therefore recommended that breeders interested in that market consider at least the addition of perinatal trait for the short term. Breeders for the 25kg. market should consider adding both average piglet weight at weaning and perinatal survival rate to their selection criteria. These are both short term recommendations, however, and in the long term, breeders interested in either market should also consider adding at least survival rate to weaning to the selection criteria. The reason for this is that although unfavourable changes in traits excluded from the selection criterion may be small in the short term, they may become substantial in the long term. There is also a need for additional extension work on the recording of total number born and number live after 24 hours. The research on prenatal survival and on other sow productivity traits such as weaning weight should be continued.

Table 1: Economic values ($/unit change) for sow productivity traits for a finished pig (100 kg.) market.

Average litter size in commercial herd	Economic weights				
	Litter size ($/pig)	Perinatal survival rate ($/% survival)	Survival rate tow weaning ($/% survival)	Age at puberty ($/day)	Interval from weaning to conception ($/day)
8	2.46	.21	.21	-.018	-.056
12	2.21	.32	.32	-.018	-.056
16	1.76	.43	.42	-.018	-.056

Table 2: Economic values ($/unit change) for sow productivity traits for a feeder pig (25 kg.) market.

Average litter size in commercial herd	Economic weights					
	Litter size ($/pig)	Perinatal survival rate ($/%survival)	Survival rate tow weaning ($/survival)	Weaning Weight ($/Kg)	Age at puberty ($/day)	Interval from weaning to conception ($/day)
8	1.29	.11	.11	1.81	-.018	-.056
12	1.16	.17	.17	2.71	-.018	-.056
16	.93	.22	.22	3.61	-.018	-.056

Table 3: Predicted profit for each reduced model, as a percentage of the maximum, and relative response to selection per trait: Finished pig (100kg.) market.

Traits ignored	% of Profit	AP (days)	LS (pigs)	PS (%)	SW (%)	IWC (days)
None	100	0.9	0.4	-0.1	0.0	-0.2
AP	99.6	1.3	0.4	-0.2	-0.0	-0.0
IWC	99.5	1.1	0.4	-0.2	-0.0	0.1
AP,IWC	99.1	1.4	0.4	-0.2	-0.1	0.2
SW	98.7	1.1	0.4	-0.4	-0.1	-0.0
SW,IWC	98.1	1.4	0.4	-0.4	-0.1	0.2
AP,SW,IWC	97.7	1.5	0.4	-0.4	-0.1	0.2
PS	89.9	1.1	0.4	-1.2	-0.2	-0.1
AP,PS,SW,IWC	87.8	1.6	0.4	-1.2	-0.3	0.2
LS	25.3	-2.5	-0.1	1.9	0.5	-1.0

LS =Total litter size at birth, **PS =** Perinatal survival rate (**PS**), **SW** = Rate of survival to weaning, **AP** = Age at puberty, **IWC** = Interval from weaning to conception

Table 4: Predicted profit for each reduced model, as a percentage of the maximum, and relative response to selection per trait: Feeder pig (25kg.) market.

Traits ignored	% of profit	AP (days)	LS (pigs)	PS (%)	SW (%)	IWC (days)	WW (kg.)
None	100	0.0	0.2	0.3	-3.6	-0.1	0.1
IWC	99.4	0.4	0.2	0.3	0.3	0.2	0.1
AP	97.9	1.2	0.2	0.2	-3.3	0.2	0.1
AP,IWC	97.3	1.2	0.2	0.2	0.3	0.4	0.1
SW	97.0	0.3	0.2	0.1	0.2	0.1	0.1
AP,SW,IWC	94.0	1.4	0.3	-0.0	0.2	0.4	0.1
PS	93.3	0.2	0.2	-0.5	0.2	0.0	0.1
AP,PS,SW,IWC	86.2	1.5	0.3	-0.8	0.0	0.5	0.1
WW	69.8	0.1	0.3	-0.1	0.0	-0.5	-0.0
LS	66.9	-1.8	-0.1	1.3	0.7	-0.4	0.1
AP,SW,IWC,WW	64.5	1.5	0.4	-0.4	-0.1	0.2	-0.0
AP,PS,SW,IWC,WW	51.3	1.6	0.4	-1.2	-0.3	0.2	-0.0

LS =Total litter size at birth, **PS =** Perinatal survival rate (**PS**), **SW** = Rate of survival to weaning, **AP** = Age at puberty, **IWC** = Interval from weaning to conception, **WW** = Piglet market weight

Table 5: Relative benefits (%) from additional sow productivity traits in comparison to selection only on litter size

	Traits in the index	Feeder pig (25kg) market	Finished pig (100kg) market
1	Litter size	100	100
2	% mortality to 24 h + (1)	112	110
3	Weaning weight* + (2)	124	*
4	% mortality to weaning +(3)	127	113
5	Days weaning to conception + (4)	129	114
6	Age at first service + (5)	132	114

* Weaning weight is not included the profit function for finished pig (100kg.) market