Proc. Assoc. Advmt. Anim. Breed. Genet. 20:483-486

ECONOMIC WEIGHTS FOR MATERNAL PIG TRAITS IN AUSTRALIA MOTIVATE GENETIC IMPROVEMENT FOR ROBUSTNESS

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SUMMARY

A new model was developed to provide Australian pig breeders with an ability to estimate economic values and economic weights of key traits in a way that was more flexible and relevant to pig producers. Economic weights were converted using a genetic standard deviation scalar so that the relative contributions of each trait to the overall maternal breeding objective could be made. Number of piglets born alive had the greatest contribution (30.9%) to the maternal index followed by daily gain (maternal) (20.5%) and sow mature weight (13.6%). Other traits considered in the maternal breeding objective were pre-weaning survival (13.2%), sow longevity (11.3%), gilt age at puberty (7.9%), and piglet survival at birth (2.6%). The emphasis on growth rates in pigs has led to heavier sow mature weights and associated economic and animal welfare costs. Inclusion of the mature weight trait into the maternal index will allow farmers to assess the trade-off between their desired rates of progress in pig growth traits and that of sow mature weight.

INTRODUCTION

The application of crossbreeding is fundamental to modern pig production systems and has important implications for breeding programs (Harris 1998). This includes the need for separate development of maternal and terminal breeding lines of pigs. For genetic improvement of maternal lines, both maternal traits such as litter size and sow longevity and also terminal traits such as growth rate, feed efficiency and carcass attributes are highly relevant. Terminal traits tend to have higher heritabilities, and are recorded earlier in the lives of selection candidates, making them easier to improve than maternal traits. Greater emphasis has been placed on terminal traits in pigs in Australia, resulting in the potential genetic progress in maternal traits being underutilised.

The number of traits in genetic evaluations of Australian pigs has increased over time. In regard to maternal traits, only litter size was considered in breeding objectives initially based on the model developed by Stewart *et al*. (1990). The bio-economic models developed by De Vries (1989) was used by Cameron and Crump (2001) to derive economic weights for litter size based on production and market parameters relevant for Australian conditions at the time. However, breeders require greater flexibility to set up company-specific breeding objectives for a wider range of traits. This paper provides a general overview of the Pig Economic Value (PigEV) model and lists economic weights for maternal traits based on Australian pig industry data. We also compare the relative contribution each trait's economic weight has to the maternal breeding objective.

MATERIALS AND METHODS

PigEV model. The PigEV model includes independent sub-models to derive economic values for maternal and terminal traits. However, only the maternal trait sub-model is described in this paper. Inputs are divided into those required to customise the breeding objective for a certain situation or operation and those which are not expected to change over time, or across farms. Input parameters include production and price assumptions for growing pigs, replacements, and sows, as well as operational costs including the facility costs, depreciation and discount rates.

Partial economic values from the PigEV model are a quantification of the change in profit for a unit-change in a trait, expressed independently to each other. Maternal economic values included: the longevity of the sow; piglet survival at birth, piglet survival pre-weaning; number of piglets born alive; gilt age at puberty; mature weight of sow; and average daily gain (maternal) of piglets. Equations to estimate the economic value of each of these traits were described in more detail by Hermesch *et al*. (2012).

Trait units. The economic value of longevity (LONG) was calculated based on the marginal economic benefit of a sow achieving an extra parity over her lifetime. Survival at birth (SB) is a trait of the sow defined as the number of live born piglets divided by the total number of piglets born including still births. The economic value for survival at birth accounts for the gestation cost of the sow associated with the stillborn piglet and disposal costs. The pre-weaning survival (SW) trait was defined as the number of piglets surviving divided by the number of piglets born alive. Two alternative scenarios were considered to estimate the economic value of number of piglets born alive based on the pig operation being limited by a fixed number of piglets (NBAp) or a fixed number of sows (NBAs). Both of these traits cannot be applied in the same breeding objective at the same time and will depend on the pig operation. Larger pig operations may have less flexibility to sell more pigs into their existing supply contracts, without price reductions. Therefore, these producers may opt for the method based on fixed number of piglets. In contrast, smaller pig operators tend to sell opportunistically into larger markets. Hence, the approach based on a fixed number of sows is more appropriate for smaller producers. The gilt age at puberty (AP) trait was based on a one-day increase in the number of days a gilt required to achieve a weight suitable for mating. A one-gram-per-day increase in average daily gain of piglets as influenced by maternal genes (ADGm) was used for the average daily gain (maternal) trait. The mature weight (MW) trait (measured in kg of live weight at maturity) was a combination of more than one 'component' trait. Component traits represent different economic aspects of a change in a trait which contribute to its overall relative economic weighting. The economic value for mature weight for example accounted for the economic impact of a change in: energy requirements for replacement gilts to achieve final mature weight (MWg); sow maintenance energy requirements (MWm); sow capital costs (MWk); and sow cull value (MWc), for a one-kilogram increase in sow mature weight.

Discounted genetic expressions. Economic values do not take into account the timing and contribution a selection candidate's genes make to a trait over an extended period of time. Values were discounted back to the time of birth of a gilt replacement. The traits SB, SW, NBA, MWm, MWk and ADGm were traits expressed once per parity. LONG and MWc were expressed at the end of the sows life, while AP and MWg were assumed to be expressed at the time of first farrowing. Economic values were multiplied by the discounted genetic expression (DGE) coefficients, which account for the timing and frequency of expression of selection candidate's genes over an extended period of time, to produce an economic weight for each trait.

Trait genetic standard deviations. Absolute economic weights ($\left|EW\right|$) with different trait units can be multiplied by their genetic standard deviation (σ_G) to facilitate a comparison of the relative importance of traits to the breeding objective. The fixed-number-of-piglets variant of the number of piglets born alive economic weight was used for the comparison. Percent importance of traits to the breeding objective was calculated as the values of $\left|EW\right| \times \sigma_G$ divided by the sum of these values across all traits. The relative importance of each trait was computed either within maternal traits only (corresponding to a maternal sub index) or across a broader maternal role index (maternal line) that also included economic values for finishing pig (terminal) traits.

RESULTS AND DISCUSSION

The values of the three DGE coefficients required were 3.68 for traits expressed once per farrowing, 0.88 for traits expressed at the end of the sow's life and 0.96 for traits expressed at the time of first farrowing. Table 1 summarises the economic weights of the maternal traits and their relative contributions within the maternal sub index (M%) and also considering a more complete maternal line index which also includes terminal traits (I%).

The trait with the greatest overall contribution to the maternal pig breeding objective was number of piglets born alive. This was followed by average daily gain (maternal) and mature weight (overall). The economic value for number of piglets born alive for a fixed number of piglets (AU$31.4) estimated here was similar to that estimated by Cameron and Crump (2001) (AU$31.7). However, the economic value with a fixed number of sows was more than double that estimated for a fixed number of piglets. This demonstrates the importance of defining the specific limiting factor of each commercial production system. To our knowledge this effect of the production system on the economic value for litter size has not previously been considered.

Table 1. Genetic standard deviations (σ_G), economic values (EV, $AU), economic weights (EW=economic value × discounted genetic expression) and the relative contribution of maternal traits within the maternal sub index (M%) and the contribution of maternal and terminal traits to a more complete maternal line index (I%) in the Australian PigEV model

Trait	Units	σ_G	EV	EW	M%	I%
Longevity	Parities	0.4	99.0	86.9	11.3	6.1
Piglet survival at birth	Proportion	0.08	27.0	99.7	2.6	1.5
Pre-weaning survival	piglets·farrow^{-1}	0.03	404.4	1354	13.2	7.1
Number of piglets born alive	piglets·farrow^{-1}					
Fixed number of piglets		0.82	31.4	115.7	30.9	16.5
Fixed number of sows		0.82	68.6	252.89		
Gilt age at puberty	Days	10	-2.51	-2.4	7.9	4.2
Mature weight overall	kg live weight	10		-4.2	13.6	7.3
Gilt energy			-0.40	-0.39		
Sow maintenance			-0.37	-1.35		
Sow capital costs			-1.29	-4.79		
Sow cull value			2.66	2.33		
Average daily gain (maternal)	grams·day^{-1}	20	0.85	3.14	20.5	11.0
Other terminal traits						46.3

Knap (2005) defined robustness traits as pre-weaning survival, growing pig survival, and the number of litters a sow has over a lifetime. In that study, the robustness traits were shown to contribute significantly to overall pig production profitability (31%) in relation to conventional production traits such as carcass lean content (17%), days to slaughter (21%), average daily feed intake (19%), and litter size at farrowing (11%). It can be argued that the broader suite of maternal traits included in this study would further contribute to improvements in robustness. Selection pressure to slow increases in mature weight and maintain age at puberty will reduce the rate of genetic gain in growth rate. Maternal weaning weight also reflects the ability of the sow to support piglet production. Thus at 37.2%, the relative importance of the new maternal traits (excluding NBA) will have a significant impact on an overall maternal line index.

As the population average for traits change, so too can the optimal weighting for each trait. A Canadian study (Quinton *et al.* 2006) suggested additional emphasis needed to be placed on piglet perinatal survival for Canadian herds with litter sizes over 10 piglets. In our model, as litter size increases, the number of discounted genetic expressions of piglet survival traits increases modestly. In addition, we would expect increasingly unfavourable genetic correlations for NBA with SB and SW.

Ongoing selection pressure on growth rates in Australian pigs is increasingly leading to concerns that mature weight may require additional emphasis in selection goals. Economic progress brought about by selection for growth traits will be tempered by the positive correlation between growth rates in pigs and mature weight of sows. Lewis and Bunter (2013) for example estimated a genetic correlation of 0.32 between weight of pigs at 20 weeks and weight of sows at mating for the fifth parity. Furthermore, Hermesch *et al.* (2010) suggests there is a 3kg increase in sow mature weight for every 10 gram per day increase in ADG. In terms of the overall effect of mature weight in a pig operation, our study shows that the small benefits from higher sow cull values will be outweighed by greater feed requirements for sow maintenance and replacement gilts, as well as higher capital costs for housing facilities.

CONCLUSIONS

The PigEV model provides greater flexibility for pig breeders to create breeding objectives for their own breeding programs. The relative contributions of these new traits to the breeding objective suggest that both recording effort within breeding programmes and infrastructure development to include genetic evaluation capability for these traits within PIGBLUP is warranted. In addition to improving the profitability of maternal line pigs selected on this expanded index we would expect the resulting sows to be more robust with more modest mature size and better survival.

ACKNOWLEDGEMENTS

This project was supported by the Australian Pork CRC under project 2B-102.

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