SELECTION STRATEGIES FOR BREEDING OBJECTIVES IN GROWING PIGS

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SUMMARY

Breeding objectives (BO) have been extended recently for sire lines in Australia to include average daily gain (ADG), backfat, post-weaning survival (PWS), loin weight and belly weight and some consideration of feed cost as either feed conversion ratio (FCR) or daily feed intake (DFI). This study evaluated six selection strategies for two BO that included either FCR or DFI using genetic parameters previously estimated for Australian populations. Response was expressed for one round of selection and a selection intensity of one which is similar to the annual genetic gain that can be achieved in practice. The predicted response in the BO with FCR varied from $3.61 to $4.59 per pig and from $3.48 to $4.00 for the BO with DFI. The lower response in the BO with DFI was partly due to unfavourable genetic association of DFI with ADG. Although PWS was the most important trait in the BO relative to the genetic variation, response in PWS was less than 0.0009 (or 0.09%) due to limited information available for selection candidates. No genetic associations between PWS and other traits were modelled because this information is currently lacking and response in PWS will depend on its genetic associations with other traits. Adding FCR records to the selection index increased response in the BO by 3.6% only because FCR has multiple favourable genetic associations with other traits. In contrast, selection response in DFI was achieved only when juvenile IGF1 and/or DFI were recorded. Therefore, considering feed costs in the BO with DFI is most effective if DFI is also recorded.

INTRODUCTION

Breeding objectives (BO) have been extended over time to better reflect the economic importance of a wider range of traits. Barwick *et al*. (2011) summarised the development of BO used in beef, sheep and pigs in Australia in their review. In pigs, bio-economic models have been used to define BO which may have hindered extension of BO due to the complexity of the underlying models. Recently, Amer *et al*. (2014) and Hermesch *et al*. (2014) presented an alternative approach to derive the economic value of individual traits directly using independent sub models which facilitates future extensions of BO. Hermesch *et al*. (2014) presented economic values for traits of growing pigs which can be used to setup a BO for sire lines. The relative economic importance of traits was outlined based on the genetic standard deviation of each trait indicating the importance of post-weaning survival (PWS) for selection decisions. However, predicted response from different selection strategies was not evaluated by Hermesch *et al*. (2014). The aim of this study was to compare six selection strategies for two BO that are relevant for Australian sire lines.

MATERIALS AND METHODS

The BO included average daily gain (ADG), backfat (BF) and feed conversion ratio (FCR) or daily feed intake (DFI). Further, PWS as well as loin and belly weight (LW, BW) were considered. Economic values for the BO traits were based on Hermesch *et al*. (2014) and Hermesch and Jones (2010, Table 1). Two BO were considered including either FCR or DFI to take feed costs into account. The economic value for ADG, shown in $/pig, was 0.09 or 0.16 $ per g/day when either

FCR or DFI was part of the BO, respectively. The economic value for ADG differs for these two BO because FCR accounts for savings in feed costs due to higher growth (Hermesch *et al*., 2014).

Six different indexes were compared for both BO. The base index (index 1) included records for ADG and BF only. The number of selection criteria was extended through stepwise inclusion of piglet birth weight (PBW, index 2), PWS (index 3), LW and BW (index 4), juvenile insulin-like growth factor 1 (IGF1, index 5) and lastly FCR or DFI (index 6). Piglet birth weight and IGF1 were considered as selection criteria because both traits have favourable genetic associations with efficient lean meat growth (Hermesch *et al*., 2001; Bunter *et al*., 2005) and are recorded in young growing pigs. Genetic parameters are outlined in Table 1 based on these previous studies outlined above as well as Hermesch (2008). No information was found about genetic or phenotypic correlations between PWS and other performance traits which consequently were assumed to be zero. Index calculations were performed using the MTIndex program of van der Werf (http://www.personal.une.edu.au/~jvanderw).

It was assumed that ADG, BF and PBW were available for the selection candidate, six full sibs and 30 half sibs. Although PWS is available for all animals, only surviving pigs are selected and no distinction can be made between pigs with high or low liability for survival. For this trait, family selection is more effective because it is a threshold character with low incidence (Falconer and Mackay, 1996). Therefore, it was assumed that information about PWS was only available for the sire because the mean reliability for survival of sires is better known based on information about progeny from multiple litters. The carcase traits LW and BW were available for two full sibs and ten half sibs. For IGF1, information was available for the selection candidate, one full sib and ten half sibs. Feed intake is most expensive to measure and it was assumed that FCR or DFI were only recorded on the selection candidate and five half sibs.

Table 1. Genetic standard deviations (GSD), heritabilities (h^2), economic values (EV) and genetic (below diagonal) or phenotypic (above diagonal) correlations for traits.

	GSD	h^2	$EV_{FCR/DFI}$ [A]	ADG	BF	FCR	DFI	PWS	LW	BW	IGF1	PBW
ADG	30.000	0.31	0.09/0.16[A]		0.11	-0.20	0.32	0.00	-0.14	0.20	0.09	0.38
BF	1.000	0.33	-1.70	0.02		0.06	0.11	0.00	-0.37	0.11	0.06	-0.14
FCR	0.150	0.12	-27.44/0.00[A]	-0.37	0.10		0.00	0.00	-0.14	0.02	0.15	-0.10
DFI	0.094	0.24	0.00/-36.12[A]	0.50	0.35	0.00		0.00	-0.05	0.05	0.09	0.10
PWS	0.038	0.05	182.88	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00
LW	0.680	0.42	3.60	-0.15	-0.54	-0.40	-0.20	0.00		-0.29	-0.05	0.05
BW	0.390	0.27	1.20	0.16	0.30	0.25	0.20	0.00	-0.51		0.05	-0.05
IGF1	13.070	0.21	0.00	0.06	0.21	0.65	0.41	0.00	-0.20	0.20		0.04
PBW	0.064	0.04	0.00	0.56	-0.43	-0.30	0.20	0.00	0.20	-0.20	-0.33	

Trait abbreviations: ADG: average daily gain (g/day), BF: back fat (mm), FCR: feed conversion ratio (kg feed/ kg gain), DFI: daily feed intake (kg/day), PWS: post-weaning survival (0/1), LW: loin weight (kg), BW: belly weight (kg), IGF1: juvenile insulin-like growth factor-I (ng/ml), PBW: piglet birth weight (kg).
[A] Economic values ($/pig) differ for breeding objectives with either DFI (first value) or FCR (second value)

RESULTS AND DISCUSSION

The response to selection is shown per generation assuming a selection intensity of one. This response is similar to expected annual genetic gains because the selection intensity achieved in practice is similar to the generation interval of about 1.65 years. For the BO with FCR, the overall response was \$3.61 per pig for Index 1. This index, which has traditionally been used in pig industries, leads to favourable responses in FCR and LW due to favourable genetic associations with ADG and BF. Individual PBW has a low heritability and recording PBW (index 2) is of limited value for genetic improvement of efficient lean meat growth in growing pigs.

Post-weaning survival was the most important BO trait in both BO accounting for 38% (FCR) or 35% (DFI) of the selection emphasis relative to genetic standard deviations of traits. Using information about PWS for the sire in index 3 resulted in a predicted response of 0.0009 (or 0.09%) which implies that it would take about 12 generations to improve PWS by one percent. The index calculations in this study assumed no genetic associations between PWS and other traits. Additional analyses demonstrated (results not shown) that response in PWS was lowly negative when unfavourable genetic correlations with a magnitude of 0.2 were assumed with other BO traits. Knap (2014) demonstrated favourable genetic trends for survival of pigs from birth to slaughter based on combined pre- and post-weaning survival. Genetic trends for PWS were not explicitly shown. It is therefore important to estimate genetic associations between PWS and other performance traits to monitor genetic trends in PWS better and to establish whether genetic improvement of PWS is feasible.

Table 2. Traits measured in index, accuracy of index (Acc), overall selection response (ΔG in \$/pig) and response in breeding objective traits per generation with selection intensity of one – breeding objective includes feed conversion ratio instead of daily feed intake.

Index	Traits measured[1]	Acc	ΔG	ADG	BF	FCR	PWS	LW	BW
1	ADG, BF	0.361	3.61	15.63	-0.467	-0.036	0.00000	0.121	-0.0228
2	Index 1 + PBW	0.364	3.63	15.90	-0.466	-0.037	0.00000	0.119	-0.0202
3	Index 2 + PWS	0.372	3.72	15.55	-0.455	-0.036	0.00090	0.116	-0.0197
4	Index 3 + LW + BW	0.414	4.13	13.75	-0.429	-0.047	0.00081	0.224	-0.0611
5	Index 4 + IGF1	0.444	4.43	12.99	-0.416	-0.062	0.00075	0.220	-0.0644
6	Index 5 + FCR	0.460	4.59	12.62	-0.396	-0.069	0.00073	0.230	-0.0684

[1] for trait abbreviations see Table 1.

Adding information about LW and BW led to the highest marginal gain in the overall BO with FCR. The response increased by 11.0% from 3.72 to 4.13 \$/pig due to genetic gain in LW for the BO with FCR. No favourable response was achieved in BW due to unfavourable genetic correlations with LW or BF. In comparison, adding IGF1 and FCR to the selection index for the BO with FCR increased the overall response to \$4.43 and \$4.59 per pig equivalent of an increase of 7.3% and 3.6% relative to the preceding index. Therefore, recording FCR does not lead to substantial additional response once other traits with favourable genetic correlations to FCR (IGF1, LW, ADG and BF) have already been considered.

Responses in ADG and FCR contributed most to the overall response of the BO with FCR accounting for 39% and 27% in index 1, and 25% and 41% in index 6, respectively. As more traits were added to the index, responses in BF decreased while responses in the additional carcase trait LW increased. Backfat and LW accounted for 22% to 15% and 12% to 18% of the overall responses in the BO which demonstrates that selection for carcase traits related to lean meat content continues to provide economic returns.

Including DFI in the BO is an alternative selection strategy to consider feed cost (Table 3). Selection response in DFI was only achieved after juvenile IGF1 or DFI were recorded (index 4 and 5). All other selection strategies did not lead to any response in DFI due to its unfavourable genetic correlation with ADG of 0.50. Consequently, the response in the overall BO with DFI was lower in comparison to the previous BO with FCR ranging from $3.48 to $4.00 per pig for index 1 to 6. The favourable genetic correlation between DFI and BF implied that more response was obtained in BF in comparison to the BO with FCR. Further, the added response in the BO due to recording an additional trait was highest for DFI contrary to recording FCR in the previous BO. Therefore, considering feed costs in the BO with DFI is most effective if DFI is also recorded.

Table 3. Traits measured in index, accuracy of index (Acc), overall selection response (ΔG in $/pig) and response in breeding objective traits per generation with selection intensity of one – breeding objective includes daily feed intake instead of feed conversion ratio.

Index	Traits measured[1]	Acc	ΔG	ADG	BF	DFI	PWS	LW	BW
1	ADG, BF	0.383	3.48	11.84	-0.583	0.000	0.00000	0.179	-0.049
2	Index 1 + PBW	0.386	3.51	12.15	-0.580	0.000	0.00000	0.176	-0.046
3	Index 2 + PWS	0.396	3.60	11.86	-0.566	0.000	0.00093	0.172	-0.044
4	Index 3 + LW + BW	0.406	3.69	11.47	-0.560	0.000	0.00091	0.226	-0.059
5	Index 4 + IGF1	0.416	3.78	11.30	-0.556	-0.003	0.00088	0.228	-0.062
6	Index 5 + DFI	0.440	4.00	10.13	-0.557	-0.015	0.00084	0.221	-0.064

[1]: for trait abbreviations see Table 1.

ACKNOWLEDGEMENTS

This study was supported by Australian Pork CRC under project 2B-104. Mathieu Arnal contributed to this study while staying at AGBU and CSIRO as a visiting MSc student from Agrocampus Ouest in Rennes, France.

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