*Contributed paper*

# ECONOMIC BENEFIT OF ADDITIONAL RECORDING FOR WELFARE TRAITS IN MATERNAL BREEDING OBJECTIVES FOR PIGS

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## SUMMARY

The purpose of this study was to investigate, using selection index calculations, the economic benefits of improving welfare by expanding recording within traditional pig breeding programs to include welfare-related traits. The genetic parameters were adapted from several Australian studies. A basic breeding objective including average daily gain, backfat thickness and number of piglets born alive was extended to include welfare traits and feed conversion ratio (FCR). Welfare traits were: survival of piglets at farrowing (FS) and until weaning (PWS), weaning to conception interval (WCI), sow mature weight (MWT) and sow longevity (LONG). Sow appetite before farrowing (FRBF) and body condition before farrowing (CAL) were considered as additional selection criteria. When welfare traits were absent from the breeding objective and selection criteria, this resulted in reduced LONG, higher MWT, prolonged WCI and overall lower genetic response in the index in comparison with other scenarios. Valuing and recording welfare traits resulted in desirable responses for both production and welfare traits and increased overall economic merit. Including FCR in the breeding objective made it more difficult to improve welfare traits, particularly if FCR was recorded.

## INTRODUCTION

Historically, pig breeding programs focused on only economically important production and reproductive traits in breeding goals. Although very successful, this can have a detrimental impact on animal welfare (Rauw *et al.* 1998; Turner *et al.* 2018). To balance high performance and welfare, emphasis on welfare traits has increased, resulting in additional challenges for breeders. Welfare traits are difficult or expensive to measure, hard to assign economic values to (Olesen *et al.* 2000), and in some instances unfavourably genetically correlated with production traits (Kanis *et al.* 2005; Nielsen *et al.* 2011). Therefore, there can be a perception that more emphasis on welfare traits could result in slower overall genetic improvement. From a purely economic point of view, breeders could decide to dismiss welfare traits, and focus on short-term gain. However, although breeders are not necessarily paid for the enhanced welfare, the ethical value should not be neglected (Nielsen *et al.* 2011). The aim of this study was to quantify expected responses in individual production and welfare traits, and index changes depending on different selection criteria recorded, using recent knowledge of welfare traits and genetic correlations with production outcomes (Vargovic *et al.* 2019).

## MATERIALS AND METHODS

An appropriate breeding goal including both production and welfare-related traits has already been derived elsewhere for the Australian pig industry and was adapted here (Amer *et al.* 2014). The traits that are commonly available were average daily gain (ADG), backfat thickness (BF), number of piglets born alive (NBA), feed conversion ratio (FCR), proportion of piglets surviving at farrowing (FS), and from farrowing until weaning (PWS), weaning to conception interval between first and second parity (WCI), weight of sow when reaching maturity (MWT) and the number of parities a sow achieves during her lifetime (LONG). Two additional traits, currently not routinely recorded, were considered as selection criteria: feed refusal before farrowing (FRBF), defined as the proportion of days when sows refused more than half of their allocated feed from entry to the farrowing shed until farrowing, and caliper score (CAL), representing body condition of sows upon transfer to the farrowing shed (~ 7 days before farrowing). These traits were correlated with positive lactation outcomes (e.g. more piglets weaned) for breeding sows, implying improved welfare of both sow and piglets (Vargovic *et al.* 2019).

A consensus of assumed genetic parameters (Table 1) adapted from several Australian studies (Tholen *et al.* 1996; Hermesch *et al.* 2008; Bunter *et al.* 2010; Hermesch *et al.* 2015; Vargovic *et al.* 2019) was obtained. Since some of the traits (e.g. CAL or FRBF) were novel, correlations were assumed consistent with those previously reported for similar traits. Economic weights were expressed in $/gilt (Table 1). Repeatabilities for NBA (0.18), MWT (0.30), and CAL (0.25) were assumed to accommodate repeated records, and common litter effects were included for ADG (0.13), BF (0.05) and FCR (0.05). For other traits it was assumed that repeatabilities equalled heritabilities.

**Table 1: Economic weights (EW, $/gilt), genetic standard deviations (GSD), heritabilities (diagonal, bold), consensus genetic (below diagonal) and phenotypic (above diagonal) correlations**

| | ADG | BF | FCR | NBA | FS | PWS | WCI | LONG | MWT | CAL | FRBF |
|---|---|---|---|---|---|---|---|---|---|---|---|
| EW | 1.49 | -28.61 | -462.62 | 91.93 | 107.17 | 1092.88 | -3.60 | 86.90 | -4.17 | 0.00 | 0.00 |
| GSD | 31.7 | 1.15 | 0.25 | 0.83 | 0.08 | 0.03 | 2.54 | 0.69 | 9.02 | 1.42 | 0.41 |
| ADG | **0.21** | 0.11 | -0.20 | -0.04 | -0.01 | 0.03 | 0.02 | -0.05 | 0.32 | 0.05 | -0.16 |
| BF | 0.02 | **0.38** | 0.06 | 0.02 | 0.05 | 0.03 | -0.02 | 0.10 | -0.01 | 0.32 | 0.00 |
| FCR | -0.37 | 0.10 | **0.25** | -0.01 | -0.02 | -0.03 | 0.01 | 0.03 | -0.10 | 0.04 | 0.02 |
| NBA | -0.19 | -0.02 | -0.07 | **0.09** | 0.07 | 0.07 | -0.02 | 0.22 | 0.00 | 0.01 | -0.04 |
| FS | -0.01 | 0.00 | 0.05 | 0.13 | **0.13** | 0.06 | -0.15 | 0.12 | 0.18 | -0.01 | -0.12 |
| PWS | 0.27 | 0.07 | -0.02 | -0.19 | 0.28 | **0.05** | -0.21 | 0.00 | 0.16 | 0.02 | -0.10 |
| WCI | -0.09 | -0.24 | -0.15 | -0.20 | 0.09 | -0.15 | **0.08** | -0.05 | 0.00 | -0.02 | -0.01 |
| LONG | -0.28 | 0.35 | -0.02 | 0.30 | -0.25 | 0.18 | -0.22 | **0.14** | -0.03 | 0.09 | 0.00 |
| MWT | 0.30 | -0.12 | -0.15 | -0.21 | 0.09 | -0.22 | 0.00 | 0.10 | **0.18** | 0.26 | 0.03 |
| CAL | 0.28 | 0.32 | 0.18 | -0.07 | 0.19 | 0.21 | -0.14 | 0.33 | 0.15 | **0.34** | 0.01 |
| FRBF | -0.21 | 0.02 | -0.07 | 0.30 | 0.00 | -0.32 | -0.36 | -0.21 | -0.27 | -0.13 | **0.21** |

Abbreviations: ADG: average daily gain (g/day); BF: backfat thickness (mm); FCR: feed conversion ratio (kg feed/kg gain); NBA: number of born alive piglets (piglets/litter); FS: farrowing survival (proportion); PWS: pre-weaning survival (proportion); WCI: wean to conception interval between first and second parity (days); LONG: longevity (number of parities); MWT: sow mature weight (kg); CAL: number of increments on caliper; FRBF: proportion of days where sows refused more than half of their daily allocation (proportion)

Index calculations (Hazel 1943) were performed using the MTIndex program (https://jvanderw.une.edu.au/) to obtain relative responses for trait and index combinations. These predicted responses are for a single generation of selection with a selection intensity of one. It was assumed that ADG and BF were available for the selection candidate, dam, sire, six full sibs and 40 half-sibs. For FCR, data was available for sire, one full sib and five half-sibs. Data for NBA, FS, PWS, WCI, CAL and FRBF were available for the dam (two records, except WCI, one record) and three half-sibs. For LONG and MWT, the information was available for a dam only. The study investigated how response in individual traits and the index changed depending on what selection criteria are recorded, for a simple production breeding objective (Scenario 1) or a breeding objective including FCR and welfare traits (Scenario 2 or higher). Six different scenarios were compared: Scenario 1: economic weights and recording for ADG, BF and NBA only, without welfare traits; 2) Scenario 2 (Base): Breeding objective with welfare traits + recording of economic traits ADG, BF and NBA only; 3) Scenario 3: Scenario 2 (Base) + recording of welfare traits FS + PWS + WCI and LONG; 4) Scenario 4: Scenario 3 + recording of MWT; 5) Scenario 5: Scenario 4 + recording of CAL and FRBF; and 6) Scenario 6: Scenario 4 +recording of FCR.

## RESULTS AND DISCUSSION

The full breeding objective with welfare traits values FCR and some welfare-related traits (FS, PWS, WCI, LONG and MWT). When the breeding objective ignores the importance of welfare traits (Scenario 1), selection for production traits resulted in reduced (e.g. PWS) or undesirable (e.g. WCI, LONG, MWT) responses, but a desirable response in FCR. Applying the same selection criteria with the full breeding objective (Scenario 2) increased desirable responses across all welfare traits and increased index response from $36.28 to $43.17. At the same time, favourable responses in production traits were retained, but with different emphasis (e.g. increased ADG, reduced response in BF).

**Table 2: Predicted genetic changes under different scenarios with overall selection response (ΔG in $/gilt), accuracy of index (Acc) and response relative (RR) to Scenario 2 after one generation assuming a selection intensity of one**

| | Trait | Scenario 1 | Scenario 2 | Scenario 3 | Scenario 4 | Scenario 5 | Scenario 6 |
|---|---|---|---|---|---|---|---|
| | | BO 1 | BO 2 | | | | |
| Productivity and efficiency | ADG | *10.8* | *14.7* | *14.1* | *13.9* | *13.5* | *10.6* |
| | BF | *-0.584* | *-0.249* | *-0.233* | *-0.227* | *-0.223* | *-0.162* |
| | FCR | -0.05 | -0.05 | -0.05 | -0.05 | -0.05 | *-0.09* |
| | NBA | *0.037* | *0.035* | *0.034* | *0.038* | *0.052* | *0.053* |
| Welfare | FS | 0.0008 | 0.0010 | *-0.0008* | *-0.0005* | *0.0000* | *-0.0014* |
| | PWS | 0.0011 | 0.0023 | *0.0029* | *0.0033* | *0.0029* | *0.0020* |
| | WCI | 0.18 | -0.04 | *-0.09* | *-0.09* | *-0.14* | *0.04* |
| | LONG | -0.17 | -0.12 | *-0.09* | *-0.09* | *-0.10* | *-0.04* |
| | MWT | 1.36 | 1.33 | 1.29 | *0.93* | *0.75* | *0.78* |
| Selection criteria | CAL | -0.10 | 0.08 | 0.10 | 0.09 | *0.08* | -0.02 |
| (additional welfare traits) | FRBF | -0.02 | -0.03 | -0.03 | -0.03 | *-0.004* | -0.007 |
| | ΔG ($) | **36.28** | **43.17** | **44.94** | **45.75** | **46.62** | **63.69** |
| | Acc | **0.414** | **0.244** | **0.254** | **0.258** | **0.263** | **0.359** |
| | RR | **84.03** | **100.00** | **104.11** | **105.99** | **107.99** | **147.54** |

For trait abbreviations see Table 1. BO1: breeding objective without welfare traits, BO2: breeding objective with welfare traits. Italicized traits are recorded within the scenario.

As additional selection criteria were used (Scenarios 3 to 6) overall index response increased. When information that is readily available from herd recording systems (FS, PWS, WCI, LONG and MWT) was added in Scenario 3, the undesirable responses observed in the breeding objective traits PWS, WCI, LONG and MWT were reduced, and the index response was higher ($44.94, +4.11%). At the same time, there were marginal changes in production trait responses, which does not support the general perception that including welfare traits into breeding programs will result in slower overall genetic improvement. When all of the production and reproductive traits were available, additional selection criteria such as MWT were more effective at maximising the overall response (Scenario 4), relative to Scenarios 2 and 3. Adding CAL and FRBF records (Scenario 5), which were not part of the breeding objective, additionally increased overall response (relative to Scenario 4) by 2.00%. The largest differences in individual trait responses were for MWT, WCI and NBA, whereas changes for other traits were small. In the present study, both CAL and FRBF are relatively inexpensive to implement, considering that the information is typically recorded in the farrowing shed for management purposes, but the resulting data may not be stored.

Feed conversion ratio is not routinely recorded in maternal lines, but is of economic importance. If FCR is recorded, the overall response will be higher ($60.78/gilt) in a simple production breeding objective (BO1 with FCR included). However, correlated responses for welfare traits had undesirable directions (not shown). The trait FCR is costly to record, and has negative consequences that are not properly valued. In an attempt to combat these detrimental responses, Scenario 6 included recording for both FCR and welfare traits. This resulted in the largest overall response in comparison to the other scenarios (47.5% increase and a response of $63.69). However, the strong emphasis on feed efficiency resulted in undesirable (PWS, WCI, CAL) or lower response (ADG) for other traits, despite their contribution to the index. In general, if there is a need for a change in the overall response, a trait with high economic emphasis should be recorded. However, recording patterns are driven by both biological and cost constraints, and outcomes depend on the assumed economic weight, parameters and recording patterns. This could suggest reinvestigation of the calculations for assumed trait economic weights, if welfare traits are to be maintained.

## CONCLUSIONS

Extending pig breeding programs with welfare traits that are correlated with performance outcomes results in long-term genetic gain. The overall economic value per pig increased, making these traits attractive for incorporating into breeding programs. However, larger data sets with welfare traits recorded may be required to obtain more accurate estimates of genetic correlations between traits, to ensure these index calculations are representative of likely outcomes.

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