Breeding Focus 2016 – Improving Welfare

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Published by

Animal Genetics and Breeding Unit

University of New England

Armidale, NSW, Australia

Animal Genetics and Breeding Unit

University of New England

Armidale NSW 2351

Australia

http://agbu.une.edu.au

ISBN: 978-1-921-597-69-5

Cover design by Susan Joyal

Book design by Kathy Dobos

First published, 2016

Contents

Preface

The inaugural ‘Breeding Focus’ workshop was held in 2014 to outline and discuss avenues for genetic improvement of resilience. The Breeding Focus workshop was developed to provide a forum for exchange between industry and research across livestock and aquaculture industries. The objective of Breeding Focus is to cross-foster ideas and to encourage discussion between representatives from different industries because the challenges faced by individual breeding organisations are similar across species. This book accompanies the Breeding Focus 2016 workshop. The topic of this workshop is ‘Breeding Focus 2016 - Improving welfare’.

> *“Animal welfare means how an animal is coping with the conditions in which it lives. An animal is in a good state of welfare if (as indicated by scientific evidence) it is healthy, comfortable, well nourished, safe, able to express innate behaviour, and if it is not suffering from unpleasant states such as pain, fear, and distress. Good animal welfare requires disease prevention and veterinary treatment, appropriate shelter, management, nutrition, humane handling and humane slaughter/killing. Animal welfare refers to the state of the animal; the treatment that an animal receives is covered by other terms such as animal care, animal husbandry, and humane treatment.”* (World Organisation for Animal Health 2008).

Animal breeding offers opportunities to improve the state of animals. Existing methodologies and technologies used in animal breeding can be used to improve welfare of animals on farm while maintaining productivity. Welfare and productivity are not necessarily in opposition because several welfare measures are genetically independent from productivity traits. Further, it is often economically beneficial to improve welfare traits. These aspects provide ample opportunities to improve both welfare and productivity through selective breeding.

The chapters of this book describe existing frameworks to define welfare of animals and outline examples of genetic improvement of welfare of farm animals. A reflection on ethical issues of animal breeding and welfare is presented and further avenues for genetic improvement of welfare are discussed.

We thank all authors for their contributions to this book and their presentations at the Breeding Focus 2016 workshop in Armidale. Each manuscript was subject to peer review by two referees. We thank all reviewers who generously gave their time to referee each book chapter. A special thank you goes to Kathy Dobos for looking after all details of organising this workshop and for her meticulous work on putting this book together.

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Armidale, September 2016.

Breeding sows better suited to group housing

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Abstract

The re-introduction of group housing for gestating sows in Australia, and elsewhere, has implications for both sow welfare and performance through enabling interactions (both positive and negative) between sows. Several strategies were investigated to identify selection criteria which might facilitate selection of sows better suited to group housing. These include: 1) estimation of social genetic effects; 2) use of proximity loggers for recording contacts between animals in groups; and 3) evaluation of flight time and fight lesion scores as potential selection criteria. Using strategy 1, significant social genetic effects were evident for litter size outcomes of group-housed sows. This implies that interactions between sows in groups have an impact on their reproductive performance, and this could be accommodated by appropriate models to estimate breeding values simultaneously for social genetic and additive genetic effects. Using strategy 2, proximity loggers provided opportunities to record all contacts between individual sows in group settings, but on animal implementation with off-the-shelf collars and modified (with harness) loggers failed in the age class of interest (gilts). Using strategy 3, both flight time and fight lesion scores were moderately heritable, but only fight lesion scores recorded 24 hours post-mixing in gilts had any association with other important sow characteristics. Preliminary parameter estimates suggest that under current housing and selection in maternal lines, post-mixing fight lesions recorded gilts would be expected to reduce, favouring improvement in some welfare related traits. Additional direct selection against fighting behaviour is also possible, and would be expected to reduce early culling of gilts. Overall, while developing meaningful selection criteria based on behavioural attributes which are practical to implement in commercial breeding programs is difficult, some opportunities to improve sow welfare and performance in group housing were identified in our studies.

Introduction

Since 2012, a significant change to sow management in Australia (and globally) has been the re-introduction of group housing for gestating sows, largely replacing common practice over the last 30 to 40 years of individual confinement during gestation. Group housing is intended to improve the overall welfare of sows by providing more space for exercise and movement (Marchant-Forde and Broom 1994), and by better enabling between-animal interactions. However, both positive and negative interactions between sows occur. Therefore, there is also the possibility of reduced welfare and detrimental effects on production performance, particularly due to the effects of aggression. Appropriate housing design, feeding, mixing and management strategies assist in limiting the potential for negative interactions between animals (Karlen *et al.* 2007; Li and Johnson 2009; Li *et al.* 2012). However, selection strategies could also be used to improve the management ease, performance and welfare for sows in these new confinement free systems, given identification of suitable selection criteria. That is, it is presumed that sows which better tolerate group housing, and which are less aggressive towards each other over the gestation period, can be identified for selection purposes.

Currently, many potential indicators of behaviour (e.g. resident-intruder test, social ranking and other descriptors of aggressive behaviours derived from video images), which are frequently used in behavioural research, are not useful as selection criteria for applied breeding programs. The utility of these types of traits is largely hindered by data recording issues, such as an inability to record large numbers of individual animals in groups concurrently, or the relevance of individual behavioural measurements recorded in isolation to behaviour in group settings. Therefore, in this chapter we discuss practical criteria which could potentially be implemented in commercial breeding programs to produce sow lines targeted for confinement-free production systems. Three strategies were investigated (Bunter 2015): 1) the influence of "competitive" or "social genetic" effects for sow performance, assessed using data on reproductive outcomes for sows housed in known groups; 2) proximity logging networks as a practical and effective alternative form of behavioural data on group housed sows, and 3) novel behavioural traits, such as flight time and fight lesion scores recorded on gilts, as an indication of their later attributes as sows.

Evaluating behavioural traits from on-farm data

Social genetic effects

Social effects are essentially the impact of an animal on the performance of its pen mates, and social genetic effects are the heritable component of these (Bijma *et al.* 2007). One of the potential results from the presence of adverse social genetic effects (also called competitive or indirect effects) is the failure to obtain the expected response to selection in group settings (Muir 2001; Muir 1996b; 2005). This is because animals with superior performance in groups might achieve this through detrimental effects on their contemporaries, thereby lowering the overall improvement in group settings. This phenomenon has been well illustrated in poultry and aquaculture (Khaw *et al.* 2016), and motivated testing of groups rather than individuals for selection purposes (Muir 1996b). However, testing and selection of groups is not feasible for larger, less prolific livestock species. Therefore, analytical strategies within a BLUP framework have also been developed to estimate social genetic effects from performance data collected in group settings (Muir 2005). Significant estimates of social genetic effects have subsequently been reported for growing pigs (Arango *et al.* 2005; Bergsma *et al.* 2008; Bijma *et al.* 2007). In addition to having an impact on performance in groups, there is independent evidence of welfare benefits for hens and pigs differing in estimates of merit for social genetic effects. These include changes in behaviour (Camerlink *et al.* 2013) and reductions in feather pecking and mortality in poultry (Muir 1996a) or ear and tail biting (Camerlink *et al.* 2015) in groups of grower pigs representing improved merit for social genetic effects. Unfortunately, it has not yet been illustrated that selection for improved social genetic effects alone will also improve overall performance of growing pigs (Camerlink *et al.* 2010; Camerlink *et al.* 2014), although behavioural (Cassady 2007) and group characteristics (Bergsma *et al.* 2008; Jones *et al.* 2011) are known to be important for growth generally.

Individual housing of sows essentially eliminates the possibility for detrimental social effects on sow reproductive performance. Moreover, the long history of individual housing during gestation means that sows have been selected for their reproductive performance in the absence of between-animal interactions. If social and/or competitive effects also exist for sows housed in groups, the questions are then: are social genetic effects important for the performance outcomes for groups of gestating sows, are they meaningful for welfare or performance outcomes, and can we estimate them from existing data on individual sows recorded in known groups? Since sows are generally not fed *ad libitum* throughout gestation, this is almost certainly a situation which facilitates ongoing competition between sows for food and other resources (including access to feeders, water and space) throughout the gestation period. However, sow grouping strategies (e.g. grouping occurring only after early-pregnancy, grouping similar sized or parity animals together) might reduce the magnitude of the effect or the extent of competition and therefore estimates of social genetic effects from this data (Li and Johnson 2009; Li *et al.* 2012). In addition, while some grouping systems might be static (groups are formed and not changed until after farrowing), there may also be changes in group dynamics as sows are removed from or added to gestating groups as their reproductive status alters (dynamic groups). Gestating sow group sizes also potentially vary widely both within and across farms. In other studies on growing animals, group size has been demonstrated to have an impact on estimates of social genetic effects (Bijma 2010).

Prior to our studies, social genetic and competitive effects models had not been considered for gestating sows because of lack of suitable data. Preliminary analyses of data for sows mixed into small groups around day 30 of gestation demonstrated small but significant heritable social genetic effects affecting litter size traits (Bunter *et al.* 2014). In addition, the models estimating both additive genetic and social genetic effects revealed more genetic variation controlling reproductive performance for group-housed sows than was evident in simple additive models. It is thought, but unproven, that these estimates of social genetic effects reflected interactions between animals, such that animals with aggressive behaviours towards other sows would have detrimental estimates of social genetic effects. Nevertheless, group performance was more accurately predicted from breeding values using analytical models expanded to accommodate social genetic effects, implying some benefits would be gained in the accuracy of selection for reproductive performance under group housing with this type of model. More recent analyses (Bunter *et al.* 2015) using more data also supported the concept that group housed sows with more space (>1.49m^2 in this study) were more likely to have improved reproductive performance, possibly due to a reduction in the extent of negative social interactions, as was also observed experimentally in other studies (Hemsworth *et al.* 2013).

With appropriate parameterisation and data structure, social genetic effects for sow reproductive performance can be estimated in a BLUP framework, resulting in breeding values estimated simultaneously for both additive genetic and social genetic effects. Disadvantages of models used to estimate social genetic effects are that the data structure required is very difficult to generate for sows housed in groups, because gestation groups can be static or dynamic in nature. There are no studies yet supporting the estimation of social genetic effects using data from dynamic groups. In addition, appropriate recording systems are required to avoid data censoring when sows are removed from groups, or the impact of social effects will be underestimated. Practical implementation might also be hindered by some technical questions relating to variable group size, and the analytical models are both demanding computationally and might be difficult to implement in certain situations (e.g. concurrent with genomic analyses). Finally, the most appropriate indicator trait to provide data for estimating social genetic effects is not clear (e.g. litter size, birth weight, sow condition pre-farrowing). From a welfare perspective, the mechanisms behind estimated social effects for reproductive performance in group housed sows have yet to be confirmed, so the implications for sow welfare remain elusive. It seems likely that these effects are related to aggression, such that the estimates of social genetic effects actually represent genetic contributions from non-reproductive traits (Trubenova and Hagar 2012). Therefore, while there is some information to be gained from these more sophisticated models which might improve accuracy of selection for performance in group settings, further work is recommended prior to routine implementation of this approach in animal breeding applications. In particular, it should be demonstrated that models which produce estimates of social effect breeding values do predict daughter performance more accurately in group settings and that social genetic effects ultimately create some welfare, and not just production, benefits to sows housed in groups.

Proximity logging networks for recording behaviour in groups

Proximity logging networks use radio technology (spatial proximity loggers) to automate the recording of data which represent the network of contacts between animals. The frequency and duration of contacts between multiple animals can be recorded simultaneously, and the distance between animals before a contact is recorded can be specified. Proximity loggers could potentially overcome data collection deficiencies for behavioural traits as they are able to record objective data continuously in groups with no observer present and no requirement for video image analyses. This technology has previously been used to identify maternal-offspring links in sheep and cattle (Handcock *et al.* 2009), wildlife disease transmission routes (Hamede *et al.* 2009), and the development of social hierarchies (Patison *et al.* 2010), mostly in open-air settings. Proximity logging networks (or other similar technology based strategies) can therefore potentially provide an effective and efficient way to routinely collect an alternative form of individual behavioural data on group-housed sows. For example, patterns of behaviour consistent with aggressive interactions between sows can be recorded. These patterns of behaviour have welfare implications.

In our study, a trial was designed to pair automated logger data with video image analysis (VIA) to identify new traits derived from logger data which could be used to describe observed behaviours in groups. Proximity loggers were calibrated off the animal first, essentially to adjust for the inter-logger variation in performance (Boyland *et al.* 2013). In addition, pen construction was modified to reduce the possibility of interference to logger signals resulting from the metal surfaces typically present in pig pens. Preliminary testing demonstrated that proximity loggers successfully recorded contacts between specific sows concurrently within groups housed inside, and the duration of these contacts, in groups of up to 10 sows. In addition, aggressive interactions between pairs of sows were generally logged by both sow collars simultaneously (see Figure 1). However, contact information alone is imprecise in the sense that both aggressive and neutral behaviours contribute to electronically recorded contacts. Subsequently, traits representing differential patterns of contacts amongst sows were derived from logger data using software to process the pairwise raw data into more meaningful traits: for example, the count and duration of contacts with individual sows or the group of sows and the pattern of contacts between sows over time (Table 1). Additional phenotypes are also feasible, such as counts of multiple animal interactions, for example. While it was clear that variation existed amongst sows in their pattern and duration of contacts for these derived traits, the preliminary trial was not large enough to establish how these patterns were related to later welfare and performance outcomes.

Figure 1a. Red and yellow fighting – contacts recorded; 1b: all calm – no contacts recorded

A larger trial was subsequently conducted using gilts (about 24 weeks old) recorded after selection. Relative to the older sows used in the first trial, gilts are an age group of more interest from a selection perspective. These individual gilts were fitted with collars and remixed into a new pen containing 10 gilts after selection. Based on both VIA and observation, young gilts were relatively less aggressive than the weaned, remixed sows used in the preliminary trial. This is beneficial from a welfare perspective, but somewhat limiting from the perspective of proving a concept. Moreover, the neck conformation typical of young gilts, along with their behaviour towards novel objects (i.e. the logger collars), meant that it was extremely difficult to obtain data from the proximity loggers over a complete 24-hour time period for all gilts within groups, mostly due to between-animal interference resulting in collars becoming detached. A lost collar also interferes with data collected by other collars until it is found and moved out of signal range.

Table 1. Calculated values from proximity logger trial data

Sow	Total contacts	Total duration (seconds)	Av. duration (seconds)	Number sows contacted
A (red)	18	469	26.1	5
B (yellow)	30	419	14.0	5
C (green)	10	173	17.3	5
D (blue)	3 (collar lost)	118	39.3	3
E (white)	13	206	15.8	4
F (black)	20	389	19.5	4

Simultaneous collection of video images, to compare with proximity logger data, was also problematical in the piggery environment, highlighting the technical difficulties of obtaining such data in commercial (rather than research) settings which are more typical of nucleus herds recorded by breeding companies. Therefore, the implementation of proximity loggers in our trial did not overcome the limitations typical of many behavioural traits, which in the first instance include a limited ability to measure large number of individual animals accurately in a group setting. While this approach appeared to provide some opportunities for data recording, overcoming on animal implementation issues (e.g. miniaturisation of loggers into multi-function low cost tags) will be a key step before considering use of this or similar technologies again for recording individual behaviours in groups of gilts.

Flight time and fight lesion scoring in gilts

Flight time is a behavioural trait previously examined in cattle and pigs (Hansson *et al.* 2005; Jones *et al.* 2009) which essentially reflects an animal's response to being released from restraint, by measuring the time taken to pass between two fixed sensors. Flight time has not been previously measured in maternal lines of pigs, which are the relevant genotype for the majority of gestating sows. Fight lesion scoring represents the extent to which individuals have engaged in fighting when mixed into groups. Fight lesion counts have mostly been assessed in young growing pigs and can be related to individual behaviour (D'Eath 2004; D'Eath *et al.* 2009; Turner *et al.* 2009). The positioning and extent of the lesions is thought to provide some evidence towards whether an animal's behavioural type is relatively aggressive or submissive. However, recording actual lesions counts are not feasible in large scale operations. Therefore, we categorised approximate counts into scores to increase the speed with which animals were assessed and recorded.

In our study, both flight time and lesion score traits assessed in gilts were both lowly to moderately heritable behavioural measures. Flight time and fight lesion scores were also largely uncorrelated with each other, suggesting that they also represented very different aspects of behaviour. Flight time recorded in gilts was less heritable than previously observed in some other studies (Jones *et al.* 2009). Moreover, flight time was also uncorrelated with any other performance measures indicative of sow longevity or reproductive performance. Therefore, without clear associations between flight time and behavioural attributes or handling characteristics, this trait would appear to have little value as a potential selection criterion to improve their welfare in maternal lines of pigs.

In contrast to the relatively unpromising results for flight time, scoring of fight lesions 24 hours post-mixing was practical, heritable (h^2: 0.12 to 0.15) and related to later outcomes for sows. The majority of gilts (94.5%) had engaged in some degree of fighting post-mixing. However, the extent of lesions from fighting ranged between 5.5% of gilts with no lesions, 40.9% of gilts with up to 20 lesions, 44.5% with between 20-40 lesions, and 9.1% with more than 40 lesions recorded over the whole body. Nearing the end of gestation, results were quite different. Prior to farrowing, 28.7% of sows had no evidence of fight lesions, and the remaining sows had relatively few lesions (Table 2). This supports a dramatic reduction in the number of sows involved in aggressive interactions during gestation in stable groups, and also demonstrates that the aggression displayed occurred at a much lower level. Results from lesion scoring generally supported other studies demonstrating a decline in aggression and/or lesion scores observed within stable groups (e.g. Turner at al., 2009). However, since there were still some sows with fight lesions, not all detrimental interactions were removed by sow familiarity and a stable grouping throughout gestation.

Table 2. Comparison of lesion counts recorded post-mixing and pre-farrowing in grouped-housed sows

Gilts post-mixing		End of gestation/before farrowing				
Lesion count	%	Lesion count	%	=>	Lesion count	%
None	5.5	None	28.7		None	28.7
<20	40.9	<5	54.2		<20	71.3
20-40	44.5	5-10	13.9		20-40	0
>40	9.1	>10	3.2		>40	0

Our results also demonstrated that although individual ranking for fight lesion scores changed between the two time points of selection and gestation (Bunter and Boardman 2015), scoring for fight lesions at both time points was informative for different reasons. Selected gilts with high anterior lesion scores post-mixing (considered aggressive gilts: 15%) had a 4.9% (p=0.03) higher wastage and were more likely to leave the herd without farrowing, and wastage was also elevated by 2.8% in the larger percentage of gilts (54% of all gilts) with moderate to high anterior scores. Genetic correlations were also unfavourable in direction (0.09 and 0.26) between fighting post mixing as gilts and wastage. The extent of engagement in fighting post mixing also affected group level gilt wastage.

Aggressive gilts which entered the herd and went on to farrow tended to produce litters which also had slightly poorer birth weights, 21–day litter weights and elevated piglet losses, but these effects were generally not large enough to be statistically significant. On the other hand, gilts which avoided posterior fight lesions post mixing had heavier piglets at birth (41-44g/piglet heavier, p≤0.02), higher litter weight at 21 days (up to +2.08kg, p=0.03) and less piglet mortality in the first litter. Accompanying genetic correlations were also favourable: 0.24 to 0.33 for average birthweight (p<0.05), 0.15 to 0.34 for 21-day litter weight and (-0.20 and -0.41 for piglet mortality. Moreover, elevated fight lesion scores recorded at 5 weeks of gestation were accompanied by poorer locomotion (Lumby *et al.* 2015). Therefore, there is good evidence to suggest that how gilts respond behaviourally to mixing post selection in particular had implications for both their welfare in groups and later performance characteristics. Moreover, evidence for ongoing fight lesions in stable gestation groups was potentially associated with poor locomotion, which is a common contributor to sow culling.

In current dam lines of pigs, which are subjected to ongoing selection for longevity and maternal attributes in a group-housed setting, the estimates of genetic correlations obtained in our study suggest that there would be slight downward pressure on fighting post mixing, which should improve both welfare and reproductive performance of group housed sows indirectly. However, more data are required to obtain accurate estimates of these genetic correlations. In addition, estimates of heritability suggest that it should also be possible to select against fighting behaviour directly, while management to reduce fighting amongst gilts at mixing could reduce gilt wastage and improve reproductive performance in commercial herds.

Summary

Our studies demonstrated that while there is some scope to identify traits which are behavioural in origin and which show heritable differences among individuals, developing meaningful selection criteria based on behavioural attributes which are practical to implement specifically in commercial breeding programs remains difficult. The most promising results in this context were obtained from lesion scoring 24 hours post mixing of gilts. Moreover, estimates of genetic parameters suggest that the selection emphasis in maternal lines is not antagonistic for their welfare, when considering lesion scoring in groups as an indicator trait for welfare. Generating data structures to estimate social genetic effects in nucleus herds is also an opportunity which could be progressed in herds with static grouping strategies for sows during gestation.

Acknowledgements

This project would not have been possible without the collaboration and assistance of staff at PIC US (Corey Hart and Marney Jobin), Dr David Swain and Don Menzies (CQU, Australia), Dr Jean-Loup Rault and Maxine Rice (University of Melbourne) and staff at Rivalea Australia (Dr Cherie Collins, Kristy Tickle, Kate Boardman, Jemma Lumby).

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