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ADVANCING LIVESTOCK WELL-BEING – THE ROLE OF GENETIC IMPROVEMENT

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SUMMARY

Livestock well-being can be defined as a wicked problem. It is difficult to approach and ever evolving due to its multifaceted characteristics and multiple stakeholders of influence. Well-being consists of two areas: health and welfare. This review outline some of the areas that contribute to health and welfare research and explores the role of genetic improvement in advancing livestock well-being as an overarching concept. It is concluded that due to the complex qualities of the problem, an interdisciplinary approach is required to create lasting change.

INTRODUCTION

A variety of definitions exist for animal welfare, health, and well-being (Lerner 2008). In a research context, health and welfare have evolved as separate streams of science. Welfare research explores the effects of the environment and husbandry procedures on an animal's' physical and mental well-being. Animal health research is concerned about functional mechanisms that contribute to disease resilience and the effect of disease on animals' physical well-being. Here animal well-being is defined as the term that encompasses animal health and welfare.

The ethical treatment of livestock is increasingly the focus of animal welfare groups, advocacy ranging from requesting alternatives to animal husbandry practices to elimination. Such scrutiny could pose a threat to the social licence of livestock farming (Martin and Shepheard 2011), potentially threatening livestock producer's livelihood. The red meat industry is taking a pro-active approach with "world class animal health, welfare, biosecurity and production practices" being one of the six priorities in Red Meat 2030, which sets the direction for the red meat industries for the next decade (Red Meat Advisory Council 2019). However, the improvement of livestock well-being is a "wicked" problem (Rittel and Webber 1973). A wicked problem has ten inherent characteristics: 1) it is difficult to define; 2) it is hard to measure success; 3) it can only be improved rather than solved; 4) approaches have to be made up; 5) multiple explanations exists, all stemming from individual opinions; 6) it is interconnected and a symptom of another problem; 7) mitigation strategies do not have a ultimate test of success; 8) it has little scope for learning through trial and error; 9) every wicked problem is unique and; 10) planners are liable for their consequences. Approaching a wicked problem requires an understanding of the complexity, interconnectedness and of the multiplicity of stake holders involved. Selective breeding, adapting the animal, is an integral part of the approach, next to management interventions, adapting the environment, to move towards improved livestock well-being. This review is exploring the role of genetic improvement in advancing mitigation strategies to the wicked problem of livestock well-being.

ASSESSMENT OF ANIMAL WELL-BEING

The traditional definition of animal well-being, based on the framework of The Five Freedoms (Table 1), was adopted into RSPCA Australia policy in 1993. It outlines key aspects of animal well-being, including physical and mental requirements of animals. Whilst it is relatively easy to assess the vigour and health of an animal, it is exceedingly difficult to assess the mental state which is a subjective perception by the animal and the assessor.

Grandin and Johnson (2009) argue that the concept of freedom is difficult, and it is necessary to understand the underlying emotions. They give the example that it might be assumed that chickens that are kept in predator safe barns are free of fear. Chickens have evolved to be only free of fear when they can hide to lay their eggs and it is irrelevant if that is indoors or outdoors. To understand emotions in animals research has been conducted into "affective state" (Boissy and Lee 2014). Affective state has two dimensions 1) the extent to which the state is negative or positive 2) the level of arousal which can be high or low (Mendl *et al.* 2010). Methodology to assess affective state provides a useful model for experimental validation of the mental state of animals (Graunke *et al.* 2013; Monk *et al.* 2018). However, currently methods do not exist that can provide such an assessment at a scale necessary for inclusion in a breeding program.

Table 1. The Five Freedoms

Principle	Implementation
Freedom from hunger and thirst	by ready access to fresh water and a diet to maintain full health and vigour
Freedom from discomfort	by providing an appropriate environment including shelter and a comfortable resting area
Freedom from pain, injury and disease	by prevention through rapid diagnosis and treatment
Freedom to express normal behaviour	by providing sufficient space, proper facilities and company of the animal's own kind
Freedom from fear and distress	by ensuring conditions and treatment which avoid mental suffering

Although it is obvious that several commercial husbandry procedures (e.g. castration, tail docking), are associated with pain, the level and duration of pain that an animal experiences following such procedures is difficult to assess objectively. Pain models based on physiological and behavioural responses have been developed (Landa 2012). Objective measures (e.g. cortisol levels) are difficult to obtain, because they are influenced by multiple factors and are expensive, while observation of behaviour is also species specific, with some species not expressing pain very overtly (Landa 2012). However, models exist and have underpinned the successful development of advanced pain relief options for sheep (Smith *et al.* 2017; Colditz *et al.* 2019).

Remote animal sensing technology provide opportunities not just for precision farm management, but also for the collection of animal behaviour data at high frequency at the level of the individual animal (Handcock *et al.* 2009), which can be used for novel trait development of welfare traits and possibly assist in disentangling social interaction effects (Pérez-Enciso and Steibel 2021). Biosensors and wearable technology can be used to collect data for animal health related traits, such as stress, heat load and disease occurrence which can inform management and could also be used as phenotypes for genetic improvement (Neethirajan 2017)

ADAPTING THE ANIMAL TO THE ENVIRONMENT

Whilst management strategies to improve livestock well-being, such as pain relief and appropriate husbandry systems, adapt the environment to the animal, genetic improvement provides the parallel mechanism to adapt the animal to the environment. It has been demonstrated that selection for production traits with little consideration to well-being traits can lead to unfavourable correlated responses in trait complexes related to animal well-being, such as reproduction, metabolism and health traits (Rauw *et al.* 1998). The challenge for genetic improvement strategies of livestock well-being is the integration of often novel and difficult to measure traits into existing breeding programs. Fundamental research is required on trait measurements, the establishment of genetic and phenotypic relationships with other traits and determining an economic value for welfare traits, because it is difficult to attach a monetary value.

Genetic and genomic strategies have been developed to improve livestock well-being and will continue to have significant impact, as highlighted by the following examples in sheep and cattle. Australian Wool Innovation Limited collaborated with the CSIRO and the Western Australia Department of Agriculture and Food to explore the genetic background of breech strike resistance to provide tools to industry to cease the practice of mulesing for breech flystrike control (Smith *et al.* 2009; Greeff *et al.* 2014). The research projects identified dag, breech wrinkle and breech cover as suitable indirect selection criteria for breech flystrike and since 2009 estimated breeding values for these traits have been reported by Sheep Genetics, the Australian sheep performance recording system (http://www.sheepgenetics.org.au/Home). Direct selection on breech flystrike is feasible in the future through genomic selection (Dominik *et al.* 2021).

Single genes for five recessive conditions in Angus cattle have been identified and genetic tests provide information on the carrier status of bulls for informed purchasing decisions (https://www.angusaustralia.com.au/registrations/dna/genetic-conditions/). Rather than promoting the eradication of the recessive alleles, Angus Australia developed a policy for the use of carrier bulls, which has seen a drop in allele frequency from 7% to 2% whilst minimising the effect on the genetic gain for production traits (Teseling and Parnell 2013).

Angus Australia has also been fostering the improvement of general disease resistance, termed immune competence, in the Angus breed (Angus Australia 2019). Immune competence is moderately heritable and yields accurate genomic breeding values that can be used as a long-term strategy to improve livestock well-being. The approach will see fewer animals affected by disease which reduces the reliance on antibiotics in the Angus industry (Hine *et al.* 2019).

Genetic improvement in cattle well-being related traits, such as temperament, calving ease and structural soundness, have been advanced through the inclusion of these traits in BREEDPLAN the Australian beef cattle genetic evaluation system. Selection for temperament was introduced to into BREEDPLAN Version 4.2 in 2002 in form of a docility breeding value. The phenotype and genetic background of the trait can be objectively assessed using flight speed and crush score (Fordyce *et al*. 1982). In sheep, a clear linkages exist between the temperament and mothering behaviour in sheep that can be exploited for genetic improvement (Brown *et al.* 2016).

Next to selection on breeding values, genomic selection, marker assisted selection, also simple mass selection is often still applied to welfare related traits. For traits that affect longevity, breeding values might not be available. In sheep this could include traits such as leg conformation, shoulder confirmation, fleece rot and flystrike amongst others. Genetic gains can still be achieved if these traits are moderately heritable, but the practice compromises genetic gain towards the overall breeding objective because these cannot be balanced as part of the selection index. At the other end of the spectrum of selection strategies, precise gene editing (PGE) holds great promise for the improvement of livestock well-being, but its application is still debated. Great impact on animal well-being has been achieved in the cattle industry with genetic dehorning which alleviates the need for surgical procedures. The genetic test has been refined over the last 12 years to increase its effectiveness for prediction of the poll status (Randhawa *et al.* 2020), but PGE would be an even more effective strategy to reduce the frequency of the poll allele in a population (Mueller *et al.* 2019). Other applications of PGE have been demonstrated e.g. resistance to porcine reproductive and respiratory syndrome in pigs (Chen *et al.* 2019) and foetal sexing of layer chicks to avoid euthanasia of male chicks after birth (Doran *et al.* 2017).

CONCLUSIONS

Traditionally selection has furthered improvement in a number of trait complexes that are related to livestock well-being. Building on existing genetic and genomic tools a multidisciplinary effort is required to take advantage of behavioural and biological data from sensors to work towards a solution of the ever-evolving challenge of improving livestock well-being. Gene editing may provide novel opportunities to improve livestock well-being, but it also increases the level of complexity of the wicked problem.

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