Breeding Focus 2016 – Improving Welfare

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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.

Livestock breeding and welfare – reflections on ethical issues

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Abstract

Animal breeding has been an effective way to shape companion and production animals to our needs. However, as the technologies used in animal breeding are becoming more advanced and effective, and as people's views on the use of animals for human benefit change, ethical questions in relation to animal breeding of companion and production animals have been raised. I will explore why the ethical debate relating to the use of animals is complex. I propose the use of an Ethical Matrix to encourage structured discussions relating to the ethics of livestock breeding. The Ethical Matrix may assist animal geneticists and breeders to gain greater awareness about the complexity of the ethical issues relating to livestock breeding. Reflection on these issues and more informed engagement with other stakeholders can facilitate the development of transparent and more broadly accepted decisions relating to animal breeding and is likely to encourage the development of more balanced animal breeding programs with a greater focus on animal welfare and sustainability.

A brief introduction to animal breeding

Starting with the domestication of animals, humankind has modified the genetic make-up of animals via conscious selective breeding and unintentional selection. Selective breeding was initially based on selection on an animal's phenotype by giving reproductive preference to animals that display desirable traits. This practice exploits naturally occurring genetic variation in animal populations and ultimately led to the development of various breeds (groups of animals that share certain phenotypes), that have been shaped by humans applying differential preference on different observable traits.

The efficiency of selective breeding in production animals has increased dramatically since the beginning of the 20th century due to an improved understanding of genetics. This started with the re-discovery of Mendelian genetics, followed by the use of statistical methods to estimate animals' genetic merit for traits of interest in the mid-20th century. Breed societies and animal breeders establish breeding objectives, calculate estimated breeding values (EBVs) (based on animals' pedigree relationships and measured performance for specific traits in related animals),

and mate animals with favourable EBVs to create new generations of animals with improved genetic merit. This shift from selection on phenotype to selection on genotype has been very effective in improving average performance for traits under selection. It is important to note that this process is value driven: people value certain traits over others, assume that certain scientific technologies or methodologies are more or less appropriate to use, and that we have a right to use scientific knowledge to shape future generations of animals (Banks 1992). As a consequence, animal breeding is used with different aims by different animal industries and is undergoing constant change: Breeding objectives are modified, methods to estimate breeding values are improved and reproductive technologies (e.g. artificial insemination, multiple ovulation and embryo transfer) are used to accelerate breeding and provide easier access to elite animals across geographic boundaries. More recent developments in both molecular genetics and 'big data' analyses have resulted in further changes due to opportunities for 'genomic selection', where the use of molecular genetic markers allows more accurate selection for traditionally difficult-to-select traits (Jonas and de Koning 2015).

In addition to selective breeding, which exploits naturally occurring genetic variation in animal populations, methods have been developed to create new genetic variants. Genetic engineering (GE) also referred to as genetic modification is used to change genomes (including the transfer of genes within and across species boundaries), and now includes the very new method of CRISPR/Cas9 genome editing, a process where site-specific mutations can be introduced relatively easily into animal genomes (Menchaca *et al* 2016). In contrast to plant breeding, genetic engineering has not been widely applied to animals used for human consumption. So far, only genetically modified salmon (i.e. AquAdvantage Salmon) has been approved for human consumption by the U.S. Food and Drug Administration (U.S. Food and Drug Administration 2015). However, GE animals are widely used in biomedical research and biopharming, and the new CRISPR/Cas9 genome editing technology could result in wider use of genome engineering in livestock.

A number of issues in animal breeding have raised concerns among animal breeders and the wider community. These include the increase in efficiency of animal breeding technologies, the focus of selection on only a few production traits to sometimes extreme levels, decreases in genetic diversity and especially the ability to change the genomes of animals beyond the species barrier (e.g. Gamborg and Sandøe 2003, Olsson *et al* 2006, Fischer and Mellor 2008, Sandøe *et al* 2008). It has been suggested that with these increased efficiencies and 'interferences' comes an increased responsibility or duty towards the animals involved and a higher degree of accountability to society (Sandøe *et al* 2008). A wide discussion is needed on how such a responsibility or duty to the animals is shared by farmers, breed societies, regulatory bodies and the wider society. For example, breeding objectives are described in economic terms and the setting of breeding objectives is market-driven. It could be argued that consumers and society are at least partially responsible for the focus on increasing animal production due to a constant prize squeeze. Furthermore, on a global level, animal breeding practices need to be assessed in the context of the need to feed an increasing world population with decreasing resources and increasing concerns about environmental impacts.

In the following, I will first explore why the ethical debate relating to the use of animals is complex and often heated, and then start a discussion to refine ethical concerns relating to livestock breeding using an Ethical Matrix. I suggest that the use of the Ethical Matrix can assist in future decision making processes for more balanced and sustainable breeding programs. I acknowledge that my family background in livestock breeding, my veterinary training and research experience in animal genetics, as well as my recent interest in bioethics, will inform this discussion.

Ethics and the use of animals – why is the debate often heated?

Ethics is by definition a branch of philosophy that deals with values relating to human conduct, with respect to the rightness and wrongness of actions and to the goodness and badness of the motives and ends of such actions; or in other words, ethics is concerned about how we ought to live our lives in relation to others. One of the reasons for disagreements in ethical debate is the fact that over time, different ethical frameworks, perspectives or theories have evolved and are co-existing. They may use different approaches to assess rightness and wrongness (e.g. assessing outcomes versus intentions; aiming to maximise human and animal well-being versus protection of intrinsic rights) and thus at times do not come to the same conclusion. Furthermore, some situations are complex and require multiple stakeholders. This can result in so called ethical or moral dilemmas, where we are confronted with a choice between different actions but any of the possible actions will bring a negative result.

With regards to the use of animals, discussions are often further complicated due to lack of agreement on how or even whether animals should be considered within these ethical frameworks, i.e. disagreement on the moral status of animals. It is important to note that most people's views on animal ethics are informed by more than one ethical framework and I recommend the 'Animal ethics dilemma' website (http://www.aedilemma.net/) to readers to explore and reflect on their own views about animal ethics.

The brief summary below is modified from a previous paper on the use of animals in research (Tammen 2012) and aims to explore how different ethical frameworks (i.e. utilitarianism, rights perspective and principlism) consider animals and how differing opinions about the moral status of animals can expand this discussion.

Moral status of animals

One can argue that there are three major positions in relation to the debate on the moral status of animals. There are the two extreme positions: animals either do not have a moral status at all (and thus can be used for any purpose), or they are considered to have a moral status equivalent to that of humans (and thus cannot be used as a mere 'means to an end'). In between these extreme positions is a third position that comprises a continuum of viewpoints held by representatives of various philosophical frameworks (and apparently the majority of the population): that animals have some moral status although of a lesser degree than the moral status of humans, which

consequently allows the use of animals with varying levels of limitations. This continuum of viewpoints reflects differences in philosophical standpoints, as well as differences in cultural, socio-economic and religious backgrounds (Legood 2000; Gilbert *et al* 2005). Even within a single philosophical framework, views on the moral status of animals often differ. Furthermore, the perceived moral status of animals often depends on the species concerned. This perception can be based on scientific (e.g. phylogenetic relationship to humans, complexity of nervous system or level of sentience) or 'emotional' considerations, which are often associated with the role that different animals are perceived to have in our society (e.g. companion animals versus livestock versus pest animals versus wildlife).

Examples of ethical frameworks

Utilitarianism

Utilitarianism assesses outcomes of actions, considers that sentient animals have moral status and accepts a balancing of the costs (or harm) to one individual versus benefits to another individual. A moderate utilitarian viewpoint, in which the moral status of animals is not treated as equal to that of humans, has been adopted to underpin animal welfare legislation and regulation in many countries. Under this view, the use of animals for the benefit of humans (e.g. food resources, labour, research, companionship) can be permissible, but there is an explicit need to minimise suffering (and maximise welfare) in the animals. A key criticism of utilitarianism is that what sounds to be a simple calculus, is in reality a difficult or impossible task. Specifically, there is uncertainty around how to accurately define and measure the suffering or the welfare of animals, and how to weigh suffering and benefits between individuals of different species. It thus often remains difficult to come to an agreed position on where to draw the line between what is ethically acceptable and what is not in relation to the use of animals. Even if the difficulties of the utilitarian calculus could be overcome, those who use animals for any purpose are still faced with the need to defend their position against those disagreeing with the moderate utilitarian approach.

Rights-based perspective

One of the ethical frameworks opposing utilitarianism is the rights-based perspective, which argues that humans and animals have intrinsic rights that place limits on how they can be treated. Thus a benefit to one individual can't be used in a defence of breaching another individual's rights. However, the debate is ongoing about what these rights are in both the human and animal rights context. Some argue that animals have the same rights as humans. Many people argue that the 'Five Freedoms' (freedom from hunger and thirst; from discomfort; from pain, injury or disease; from fear and distress; and freedom to express normal behaviour) proposed in 1979 (Farm Animal Welfare Council 2009) can be considered as minimal rights for farm animals.

Principlism

The principlist approach (Beauchamp and Childress 2001) might be more useful to guide moral action in relation to the assessment of ethical dilemmas concerning animals. Due to the failure of most ethical frameworks in relation to ethical dilemmas in a biomedical context, Beauchamp and Childress (2001) suggested that a process of 'shared moral reflection', with the aim of balancing the four principles of respect for autonomy, non-maleficence, beneficence and justice, can guide moral action in situations of difficult-to-resolve ethical dilemmas. In contrast to utilitarianism, some norms cannot be balanced, and disagreement is a tolerable component of this approach due to the acceptance of validity of pluralistic views. Disagreement about the moral status of animals and lack of exact measures for suffering of animals and benefits of their use to others are thus not limitations for this method.

Mepham (1996) has applied principlism in an animal context by developing the Ethical Matrix, which allows for the additional complexity when individuals beyond humans need to be considered. He combined non-maleficence and beneficence to wellbeing and exchanged justice with fairness. The Ethical Matrix has since been considered by others (e.g. Kaiser and Fosberg 2001, Jensen *et al* 2011) as a useful decision-making tool in relation to issues concerning animals, humans and the environment, as it provides structure in participatory interdisciplinary approaches without pre-empting content or evaluation or ignoring pluralism. An example of a generic Ethical Matrix is shown in Table 1. Details about the specifics of the interest groups (e.g. individual animal versus breed or population, stud breeder versus producer, citizens in the developed world versus global citizens) can be adjusted according to the specifics of the ethical dilemma under discussion.

Table 1. Generic Ethical Matrix (modified from Mepham (1996) and Jensen et al (2011))

Interest group	Respect for		
	Wellbeing	*Autonomy (Choice)*	*Fairness (Justice)*
Animal	Animal welfare	Behavioural freedom	Telos/Intrinsic value
Producers	Satisfactory income & working conditions	Managerial freedom	Equitable trading & market systems
Citizens	Food safety & quality of life	Informed choice	Affordability & access to food
Environment	Conservation & protection	Maintenance of biodiversity	Sustainability

When assessing an action (e.g. impact of a new technology) ethical issues relating to each cell in the matrix are explored either by research and reflection and/or by stakeholder workshops. Once the issues are identified users should attempt to reach some agreement on how to weigh the relative importance of the issues identified and develop action-guides that reflect these weightings. However, consensus or an acceptable compromise for all stakeholders is not always possible. The key strength of this method is therefore that it creates greater awareness about the complexity of the ethical issues relating to the action under investigation. Reflection on these issues and more informed engagement with all stakeholders can facilitate the development of transparent and more broadly accepted decisions.

Ethical dilemmas in relation to livestock breeding and animal welfare

I will start with the assumption that the use of animals can be ethically permissible under certain circumstances or with certain restrictions. This appears to be the view held by the majority of people, despite substantial disagreement of what circumstances or what restrictions ought to apply. Due to the coexistence of often opposing ethical frameworks and the inability to come to an agreed position on the moral status of different animal species, I do not aim to present compelling statements about either the use of livestock in general or whether it is right or not to breed animals. Instead, I will use the Ethical Matrix (Table 1) to encourage reflection and debate about animal welfare in livestock breeding. I present personal reflections and will only briefly touch on selected issues relating to animals, producers and consumers. Animal breeding practices also impact on the environment (e.g. breeding for improved feed efficiency and reduced greenhouse gas emission, impact on biodiversity), but due to the focus on welfare in this paper, environmental impacts have been omitted here.

It is important to note that most ethical frameworks that consider the use of animals as permissible in specific circumstances pay specific attention to animal welfare, e.g. in the utilitarian calculus increased animal welfare can be used to counterbalance harms; from a rights perspective welfare standards can be considered as minimum rights for farm animals; and in Kantian duty based ethics (an ethical framework that is also referred to as deontology) the use of animals results in a duty to create good animal welfare. The following definition highlights that welfare is a rather complex construct that is difficult to measure and quantify.

> *"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)

Livestock breeding and welfare - Reflections on selected cells in the Ethical Matrix.

Animals

Wellbeing (Animal welfare): Traditionally, livestock breeding programs have prioritised the selection of a few production traits with breeding objectives that are often described in economic terms. Substantial improvement in performance can be achieved in relation to these traits under selection, but to achieve optimal performance animals need to be in a state of good animal welfare. It is clearly not the intention of a livestock breeding program to compromise animal welfare for individual animals or on population level. Nevertheless, a strong focus on selection for a few production traits can result in unintended effects on the well-being of animals (e.g. selection for rapid growth and weight gain in broiler chickens has been associated with decreased leg health, selection for lactation traits in dairy cattle has been associated with increased susceptibility to mastitis, increased incidences of metabolic diseases and decreases in fertility), or known negative impacts on welfare are tolerated to achieve a net economic gain due to increased production (e.g. dystocia due to double muscling). It is important to note that once unintended effects are identified, animal breeding can be used to counter balance negative impacts on animal welfare. This may be done via a change to the breeding objective, a change to how this trait is defined and measured (e.g. moving from number of piglets born to number of piglets weaned), or the consideration of inclusion of additional traits into a selection index. However, improved reproductive and genetic technologies have accelerated the rate at which genetic gain can be achieved. This can increase the risk that breeding for a specific form of production is pushed too far, and unintended effects are spread widely before they are noticed, making it potentially more difficult to reverse them. In addition, modern reproductive technologies and strong reliance on elite ranking using EBVs or genomic EBVs (gEBVs) for a few traits or a single index, have the potential to result in the intensive use of a few elite animals or lines of animals, possibly leading to increases in inbreeding. This can lead to inbreeding depression and an increased risk for animals to be born that suffer from inherited recessive diseases.

If breeding for production traits has been largely very effective in creating the desired genetic change and animals need to be healthy and well to perform at optimal levels, why hasn't there be a stronger focus on breeding for health and welfare traits? Did farmers only care about economic gains with no intention to improve animal welfare? It is important to acknowledge that the focus on selection for production traits in the past can at least partially be attributed to the fact that production traits tend to have much higher heritabilities, and are easier and more cost-effective to measure in large numbers of animals when compared to welfare and health traits. Thus production traits are easier to influence via breeding and the benefits of the genetic change can be observed more immediate by producers. Furthermore, considering the definition of animal welfare by the World Organisation for Animal Health (2008), improvements in animal welfare and health can be achieved more reliably and efficiently by improving animal husbandry, nutrition and veterinary services. Only the relatively recent improvements in animal

breeding technologies have created opportunities to consider breeding for welfare more broadly (Jonas & de Koning 2015; Rauw 2016). It is encouraging to see that more recently health and welfare traits have been included in breeding programs (Rauw 2016) but further incentives may be needed to accelerate the uptake.

Autonomy (Behavioural freedom): With regard to livestock breeding, specific concerns relating to an animal's behavioural freedoms relate to loss of reproductive choices. Some might consider this as interferences with an animal right. Artificial reproductive technologies such as artificial insemination are commonly used and even if natural matings occur, animals are not allowed to choose who they reproduce with.

Fairness (Telos/Intrinsic value): The assumption that it is permissible for humans to change the genetic make-up of future generations of animals interferes with animals' intrinsic value. In the past, selection has been a slow process that gave preference to specific naturally occurring genetic variants and resulted in the loss of other genetic variants. However, over time, domestication and animal breeding have resulted in substantial biological changes to large populations of animals and created many different breeds. More recently, intensification and globalisation of animal breeding with a focus on a few breeds that perform well for specific production traits has resulted in other breeds becoming endangered or extinct. Attempts to maintain rare livestock breeds as insurance populations can be costly but are often justified because the breeds are perceived to have intrinsic value, often have cultural significance, are believed to be better adapted to local environments, and might have favourable genes for traits that are currently not under artificial selection.

Concerns about intrinsic value appear to have greater weight when it comes to creating substantial changes to what an animal is (e.g. creation of featherless chicken via traditional breeding to improve welfare in hot climates has raised concern about interference with their intrinsic value) and to genetically engineering animals, especially if genetic material is introduced from a different species or a different taxonomic kingdom. Another issue relating to fairness towards animals in the context of breeding could be the real or perceived differences in the standards of animal welfare that animals receive based on the value that is given to them by humans, e.g. is it fair that elite breeding stock often experience higher welfare compared to animals in commercial production herds.

Producers[1]

Wellbeing (Satisfactory income & working conditions): Ultimately, breeding livestock is a business that generates income to support the livelihood of people. Thus, the setting of breeding objectives is largely market-driven and aims to increase the net economic output of

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[1]   The stakeholder group of producers should ideally be subdivided further for this exercise to better reflect the different positions of breed societies, stud breeders, multipliers and commercial farms in different livestock industries.

the business. It is clearly of interest for the economic and mental wellbeing of those involved in breeding livestock to be financially viable and to make profit. However, I would argue that breeding animals is for many people not just about financial outcomes. In most agricultural societies, living and working closely with animals, and being ultimately dependent on their wellbeing, has created a relational view: farmers do care about animals (Bock *et al* 2007). For many breeds, breeding of animals has a history going back centuries and for many farmers the animals on their farm are the result of breeding that has occurred within their family over several generations. There is enormous pride and happiness associated with breeding animals well, which cannot be measured in economic terms but most certainly impacts on producers' wellbeing.

Autonomy (Managerial freedom): Different players within this stakeholder group and different livestock industries vary with regard to the level of managerial freedom that individual players have in relation to animal breeding. In intensive animal industries (e.g. pigs and poultry) most of the breeding decisions are made by a few employees in a small number of companies. Extensive animal industries (e.g. sheep and cattle) tend to provide more managerial freedoms with regard to breeding choices, and the underlying breed societies tend to have a more inclusive structure.

Ultimately, farmers can choose between different breeds, between purebred or cross-breeding systems, or even consider creating their own breed. Managerial freedoms are often restricted by government regulatory frameworks, which appear to be limited in most countries when it comes to the specifics of animal breeding. However, animal welfare can be a very emotive topic. Consumer demand has in the past driven change in livestock industries (largely in the context of animal husbandry practices), and consideration of consumer concerns are expected to increasingly influence how we breed animals.

Fairness (Equitable trading & market systems): Farmers are increasingly operating in a global market, where famers in different countries operate under different social and regulatory systems and in different environments, resulting in many inequities. In Australia, jurisdiction of animal welfare and wellbeing is the responsibility of state and territory governments. Thus even within Australia, different regulatory requirements exist. However, these inequities are common to all business operations, not just specific to animal breeding.

The issues relating to animal breeding and fairness for producers that I would like to raise here are the inequities in regards to access to expertise and advanced breeding technologies as well as the issue of fair pricing. In multinational pig and poultry breeding companies and a selected group of breed societies for the dominant cattle and sheep breeds, staff with relevant training in animal breeding are employed to develop and oversee breeding programs. Substantial investments can be made into research and development and have resulted in breed-specific advanced breeding technologies (e.g. EBVs, genomic selection). However, small breed societies and especially breeders of livestock in developing countries are less likely to have access to specialized animal geneticists and cannot afford to adapt some of the advanced breed-specific breeding technologies (e.g. progeny testing, genomic selection). In regards to fair

pricing, it needs to be acknowledged that the current market system not only puts farmers under rising, and at times unsustainable, pressure due to a constantly increasing prize squeeze; it also provides very limited opportunities to financially reward those, who aim to breed animals to improve animal welfare or reduce environmental impacts.

Citizens

Wellbeing (Food safety and quality of life): Humans evolved as omnivores. A large proportion of humans consider the regular consumption of animal products as a component of quality of life. However, as attitudes towards the use of animals are changing, the need to use animals to benefit humans is often morally justified by requesting that these animals have a 'good life'.

Autonomy (Informed choice): Consumers should have choices in regards to their nutrition and these choices should be informed by knowledge on how food is produced. It is likely that within a society, different consumers have different preferences in regards to how food is produced and this might require differential pricing to fairly recompense producers.

Fairness (Affordability and access to food): A key reason for the focus in livestock breeding on improving production traits has been the need to produce food and fibre for a rapidly growing population using decreasing resources. Despite substantial improvements in food production, food insecurity still affects a large proportion of humanity and it is has been estimated that global agricultural production must grow by at least 60 percent above the level of 2005-07 to meet the projected demand in the year 2050 (Food and Agriculture Organization of the United Nation 2009).

Conclusion

 "*...moral reality is less tidy and more complex than many theories portray*" (Li 2002, p. 589)

In relation to ethical questions, the coexistence of well-informed divergent views, which are based on different philosophical, cultural, social and/or religious frameworks, is the norm. It is only through respectful, considerate and open-minded discussion of these divergent views that society can develop approaches to deal with underlying ethical dilemmas. The continuum of views in relation to the moral status of animals further complicates any discussion about the use of animals. Inherent in the 'middle way' view of the moral status of animals is the acceptance that in some situations animal use can be morally justified. However, it is often seen as a requirement or a moral duty of those responsible for the use of animals to minimise suffering and maximise welfare.

In regards to different ethical frameworks, the calculus of the moderate utilitarian approach to the use of animals appears unattractive. Principlism presents as an interesting alternative. It is widely accepted as a practical approach for ethical decision-making in the medical context and

principles in case-specific context, acceptance of validity of pluralistic views and the emphasis on identification of ethical dilemmas for various stakeholders in the system.

I have highlighted ethical dilemmas relating to animal breeding using the Ethical Matrix. Similar concerns have been identified by others (e.g. Gamborg and Sandøe 2003, Olsson *et al* 2006, Fisher and Mellor 2008, Sandøe *et al* 2008, Rauw 2016), and relate to the need for improved productivity in livestock to feed a growing global population and simultaneously improve animal welfare and reduce environmental impacts. As with most ethical dilemmas, there is no easy answer on how to balance conflicting needs. However, it is obvious that improving animal welfare is in the interest of all stakeholders. Some more specific questions for ongoing discussions in this context include:

- Is genetic engineering (e.g. genetic editing) in livestock acceptable if it is used to improve animal welfare?

- How can we define balanced and sustainable breeding objectives that support increase in production without impacting negatively on welfare (e.g. Oleson *et al* 2000)?

- How can we 'value' non-economic traits (animal welfare and sustainability) in current breeding systems that are based on net economic gain?

- How can the financial burden to improve long-term societal goals be shared fairly between producers and consumers?

- How can we avoid unintended harm in animal breeding (possible strategies include progeny testing for new traits, linking progeny testing to existing veterinary data sources, monitoring of inbreeding, and systematic surveillance for emerging inherited diseases)?

- Is it cost effective to improve animal welfare via breeding compared to improved veterinary care and husbandry?

- How can animal breeding be improved ethically in developing countries?

- How can we better utilise breeds that are well adapted to challenging environments?

- Who should drive the required change? What is the role of breed societies in this process?

- Does livestock breeding require more regulation (e.g. self-regulation – see Code-EFABAR http://www.responsiblebreeding.eu/ in Europe)?

I have presented personal reflections relating to the use of the Ethical Matrix in relation to animal breeding and raised some questions for future discussion. Broad input from all stakeholder groups is required to fully utilise this tool, and breed societies could play an important role in driving such discussions in workshops with stakeholders from animal welfare organisations, farmers and consumers to create awareness of the underlying complexities so that more widely

supported outcomes can be achieved. New technologies in animal genetics and reproduction have the potential to further change how we utilise livestock but we need to invest in animal breeders and scientists who have the scientific knowledge and the ethical understanding to apply these technologies wisely.

Acknowledgements

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