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Perspectives on Animal Biosciences

New skills, networks and challenges: the changing face of animal production science in Australia

Dianne Mayberry[A,E,F], *Sue Hatcher*[B,C,E] *and Frances Cowley*[D,E]

[A]CSIRO Agriculture and Food, Queensland Bioscience Precinct, 306 Carmody Road, St Lucia, Qld 4067, Australia.
[B]Makin Outcomes, PO Box 8358, Orange East, NSW 2800, Australia.
[C]Graham Centre for Agricultural Innovation, Charles Sturt University, Boorooma Street, North Wagga Wagga, NSW 2678, Australia.
[D]School of Environmental and Rural Science, University of New England, Elm Avenue, Armidale, NSW 2351, Australia.
[E]All authors contributed equally to this publication.
[F]Corresponding author. Email: dianne.mayberry@csiro.au

Abstract. Livestock producers are facing increasing pressure to reduce the environmental and animal-welfare impacts of production, while also managing the challenge of an increasingly variable climate and diminishing resources. This perspective paper highlights the role for animal scientists to contribute to the sustainability of future livestock systems. We argue the need for a broader, more inclusive and more integrated concept of animal science, better connections among scientists, producers, consumers and policy makers, and more support for the next generation of animal scientists. Animal scientists have an important role to play in providing the evidence to support the social licence of livestock production and inform decisions made by policy makers and consumers regarding the production and consumption of livestock products. Animal scientists can also assist producers to adapt to social, environmental and political challenges that affect their livelihoods and the way they farm. Traditionally, animal science has focussed on species- and discipline-specific areas of research such as ruminant nutrition, genetics or reproductive physiology. While this fundamental research remains essential to understand the underlying biology of livestock production and improve production efficiency, it needs to be better integrated into research applied at and beyond the herd or flock level. Systems thinkers who can apply this knowledge across farm, regional and national scales also have an important role in providing information to key decision makers, from farmers to national government. Better engagement with the social and economic sciences can inform how animal scientists and extension services interact with producers to understand constraints to production as well as adoption of new technology and co-develop evidence-based solutions. Underlying this, the demographics of those who study and work in animal science are changing. Australian animal industries require the best and brightest minds to overcome future challenges and engaging these students as the new face of Australian animal science is an essential step towards sustainable future livestock systems.

Additional keywords: consultants, farming systems, graduates, multi-disciplinary.

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Introduction

Changing climates, consumer preferences and regulatory pressures are creating momentum to change livestock production systems. Global demand for livestock products is increasing, but they need to be produced more efficiently, with reduced impacts on the environment and enhanced animal well being. These changes to farming systems are not insignificant, and the complexity of problems faced by producers requires an interdisciplinary and multi-scale approach, based on a sound understanding of animal science and production practices combined with a broader understanding of the environmental, economic and social aspects of sustainability. Sustainable future livestock systems in Australia will be contingent on our ability to attract and retain the best and brightest minds into the animal sciences, to conduct research that addresses long-term and emerging industry challenges, not just those we face today.

Australian livestock production systems span a diverse range of agroclimatic zones, covering an area of 341 million hectares (Australian Bureau of Statistics 2018). While there are local nuances to future climate projections for the Australian agricultural sector, generally, primary producers can expect to experience warmer average temperatures, greater frequency of hot days, and changes to the timing of rainfall events (Reisinger *et al*. 2014). The sector is also predicted to experience more frequent and severe extreme climate events, including drought and flooding, and the combination of extended droughts and high temperatures may lead to increased frequency and severity of fire events. These changes may affect the productivity, profitability and risk profile of livestock production through impacts on forage and feed production, water availability, and direct impacts on animals through heat stress and disease (Porter *et al*. 2014; Rojas-Downing *et al*. 2017; Ghahramani *et al*. 2019). It may also affect the distribution of livestock, as ruminants can be farmed in areas where production of broadacre crops or horticulture is no longer possible or profitable. In mixed farming systems, livestock help farmers mitigate risk by diversifying their sources of income and providing flexibility in their response to economic and environmental conditions (Bell *et al*. 2014). As a result, the past 20 years has seen the value of Australian livestock production (slaughtering, live export and livestock products) increase significantly relative to crops and horticulture, more than doubling from AU$12.7 million in 1998–1999 to AU$31.9 million 2017–2018 (ABARES 2019).

Animal industries are also challenged with increased societal expectations from increasingly educated, affluent, connected and urbanised consumers, who are often both geographically and socially disconnected from the process of livestock production (National Committee for Agriculture Fisheries and Food 2017). Lawrence *et al*. (2019) reported a reduction in the number of people eating meat and a shift towards vegetarian and flexitarian diets ('part time' vegetarianism) due to health, environmental and animal-welfare concerns (Malek *et al*. 2019; Admassu *et al*. 2020). These concerns have prompted a shift in supply and consumption towards more animal and environmentally friendly options such as free-range eggs, sow-stall-free pork, grass-fed beef and non-mulesed wool, and in 2019, Five Founders (North Australian Pastoral Co.) became the first certified carbon-neutral beef to hit Australian shelves. While these products sometimes attract price premiums in exchange for improvements in animal welfare and sustainability, they rely on changes to farming systems that may increase the cost and complexity of how food and fibre are produced. There are also challenges and costs associated with traceability and certifying these changes to on-farm management.

Consumer research has also highlighted a shift towards alternative protein sources including plant-sourced (grains, pulses, nuts, fruit, vegetables) and non-traditional (insects, algae, seaweed, cultured meats) foods (Admassu *et al*. 2020). In Australia, the largest market for alternative protein is dairy milk analogues (e.g. soy, almond, rice), which now represent 9.2% of the dairy sector (Admassu *et al*. 2020). While the global market for alternative proteins remains small compared with animal-origin protein (AU$2.2 billion vs AU$1.7 trillion in 2019, Bashi *et al*. 2019), the sector is rapidly expanding (Lawrence *et al*. 2019; Admassu *et al*. 2020). These trends are reflected in moves of major Australian food retailers including supermarkets (Woolworths, Coles) and fast-food business (Hungry Jacks, McDonald's) to increasingly promote plant-sourced meat analogues to mainstream consumers. While alternative proteins are often perceived as a threat to the market for animal-sourced foods, it is likely that the demand for protein is large enough to sustain both industries, provided livestock producers can respond to consumer demand for ethical and sustainable food production.

A broader role for animal science

There is a role for animal scientists to develop solutions to these challenges, and to also provide evidence to support decisions made by consumers and policy makers. Animal science research and teaching has traditionally been based around specific disciplines such as nutrition, physiology, genetics, reproduction, health and welfare (Bell 2019), but as the issues facing animal production become more complex, there is a need to broaden our definition of animal science beyond the farm gate, and for different disciplines to work together, to solve the new challenges of livestock production (Fig. 1). In this context, the concept of multi-disciplinary livestock systems, perhaps most influentially articulated in Australia by G. L. McClymont as a holistic approach to problem solving (Bryden 2012), has a renewed importance. Whereas McClymont conceived the 'agricultural ecosystem' revolving around the axis of plant–soil–animal science, linking biological efficiency to economic efficiency; the new face of animal science also integrates mathematical modellers, computer scientists, data scientists, physicists, climate scientists, economists and social scientists (just to name a few) into multidisciplinary teams to address the broader requirement for economic, environmental and societal sustainability. There is also a need for systems thinkers with the ability to integrate these different areas of research, but it is critical that larger-scale analyses, which often influence policy decisions, have links back to the underpinning animal science and local context.

The Cooperative Research Centre (CRC) for Plant-based Management of Dryland Salinity provides a good example of

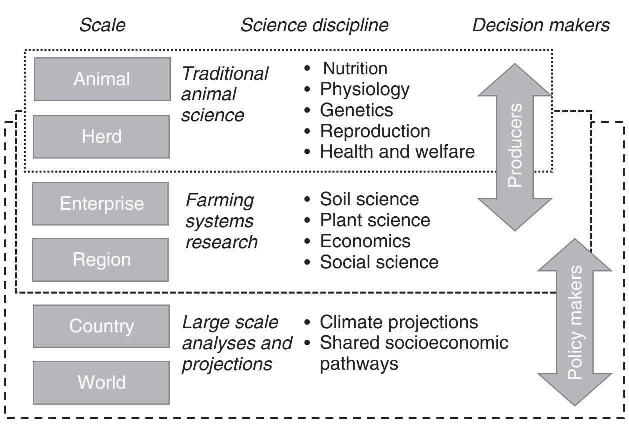

Fig. 1. Animal science must operate beyond the farm gate to deliver innovation, new technologies and approaches. While traditional animal science disciplines address animal and herd-level issues, most decisions regarding the management of livestock production occur at larger scales.

a multidisciplinary and landscape-scale response to an agricultural and environmental problem. A combination of land clearing and sustained use of annual crops and pastures in southern dryland farming systems resulted in a rise in saline water tables, which, in turn, reduced both the yields and profitability of crop and livestock production. The CRC combined animal science, plant science, soil science, hydrology, economics, social science and other disciplines to develop and evaluate farming systems based on perennial crop and pasture species that could either tolerate or reduce waterlogging and saline soils (e.g. Friend *et al*. 2007). Animal science was a key component of this research program and grazing of salt-tolerant shrubs and pasture species emerged as one of the most profitable and sustainable farming solutions (Masters *et al*. 2006). Importantly, the application of these systems was based on a detailed understanding of how consumption of salt-accumulating plants could affect animal growth and reproduction, with several PhD projects evaluating animal-level responses to high-salt diets (e.g. Digby *et al*. 2008; Chadwick *et al*. 2009; Mayberry *et al*. 2010).

More recently, the integration of computational and data science and machine learning with traditional animal science disciplines has improved our ability to characterise and predict complex livestock systems, such as in the Ag360 (previously ASKBILL) decision-support system (Kahn *et al*. 2017), and has opened up new frontiers in the use of remote sensors and other wearable technologies for livestock production (Rahman *et al*. 2018). Used appropriately, these technologies have the potential to transform livestock production through concurrent reductions in labour and increased access to detailed real-time information in extensive production systems. For example, virtual fencing and herding technology can be used to exclude livestock from ecologically sensitive areas and improve pasture utilisation, reducing the need for manual labour in constructing fences and physically herding livestock (Anderson *et al*. 2014; French *et al*. 2015; Campbell *et al*. 2018). Despite the exciting opportunities these disciplines offer, maximising their value requires integration with on-ground and animal-level researchers and practitioners to determine what information and controls are required. One problem that must be avoided is the temptation for disciplines more remote from applied animal science to use a *post hoc* approach that seeks out animal production ‘problems’ for retro-fitting new technologies. A ground-up approach that involves animal scientists and practitioners from the very start of the technology-development process will better serve the needs of producers.

Achieving long-term change by livestock producers is difficult. In the future, animal science will need to work much more closely with social scientists to connect animal scientists, implementers, the livestock industry, consumers and community. Already, many large livestock and farming-systems research projects in Australia now contain a social research dimension (e.g. Grain and Graze project (McGuckian and Rickards 2011), and the Virtual Herding project (Dairy Australia 2020)). The integration of social scientists into livestock research projects is used at both ends of the research and development pathway, including to explore and address community perceptions of livestock production systems and technologies, as well as farmer decisions to adopt these. Wells *et al*. (2011), for example, explored the motivations behind Australian wool producers’ intentions regarding mulesing, and concluded that farmers’ intentions to stop or continue mulesing was affected by their perception of social pressure to discontinue mulesing and their ability to implement effective alternatives. In this scenario, the role of the traditional animal scientist addresses only one part of the farmers’ decision to change their mulesing practices (i.e. the availability of effective alternatives).

The face of animal science research funding has also changed in recent decades. Agriculture is more commonly now seen as a private, rather than a public, good, and state governments are conducting less applied research for the livestock industry (National Committee for Agriculture Fisheries and Food 2017). In their place, universities and the CSIRO are competing for funds to conduct applied, rather than fundamental research. The Australian Research and Development corporations (RDCs) are a major funder of livestock research in Australia, with their research priorities increasingly driven by producer consultative committees and based on short-term funding cycles. This reduced pool of livestock researchers, and constrained focus on applied research and adoption tends to deliver short-term incremental changes in productivity, rather than the step changes required to overcome the limitations imposed by a given set of genetic and environmental resources. While applied-research solutions tailored to local production systems are essential to stimulate producer adoption of new technologies, it is critically important that the applied research is complemented with a fundamental research component. Longer-term research investments and permission for scientists to test new ideas, with the possibility of failure, are vitally important to develop the step changes required to improve livestock production. As an example, breeding sheep that are naturally resistant to flystrike and cattle that emit less methane takes decades of research investment to achieve, but has huge potential to improve the environmental and animal-welfare credentials of these industries.

Training the next generation of animal scientists

In the past decades, there has been an evolution in the tertiary education of animal scientists and in enrolment in animal science degrees. In previous generations, animal science and agriculture students were predominantly male and came from a rural, Australian background. Today, we see much more diversity in enrolments, with larger numbers of women, international students (Fig. 2) and students from a non-farming background. These changing enrolment statistics reflect the increasing importance that the next generation of graduates place on sustainable and ethical production of food and fibre, and the conservation and protection of non-livestock species, but also challenges educators to provide meaningful connections to industry and an appreciation for the day-to-day operations of animal agriculture.

In the second half of the 20th century, most non-veterinarian animal scientists graduated from generic agricultural science degrees, perhaps with a livestock major.

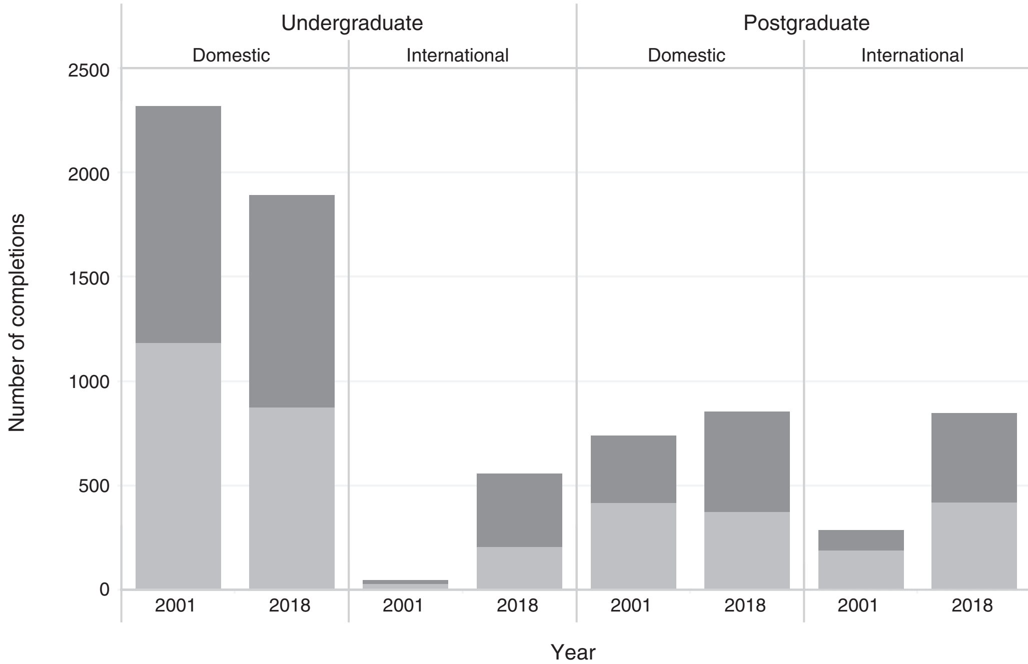

Fig. 2. Completion count of undergraduate bachelors and postgraduate degree students from domestic and international enrolments in combined agriculture, environmental and related studies field of education in 2001 and 2018 (dark shading, female graduates; light shading, male graduates). Source: uCube – Higher Education Data Cube (Department of Education and Training 2016).

Table 1. Undergraduate degree courses and course majors in animal science or livestock production offered by Australian universities, and distribution of minimum Australian tertiary entrance ranking (ATAR) thresholds for school-leaver entry in 2019

Source: University Admissions Centre 2018 data, www.uac.edu.au [verified 12 August 2020] and individual universities. ATAR, Australian tertiary entrance ranking from 30 (low) to 99.95 (high), or equivalence from overall-position score. A higher score indicates a higher ranking, with an ATAR of 80 indicating that a student is in the top 20% of the group. VET, vocational education and training

Category of degree	Course duration (years)	Count	Mean ATAR	Min. ATAR	Max. ATAR
Bachelor of Animal Science	4	2	66.1	59.0	73.3
Bachelor of Agricultural Science	4	3	69.0	62.4	81.3
Bachelor of Agriculture	3	7	63.5	49.1	82.5
Bachelor of Science (Wildlife/Zoology major)	3	7	61.0	40.8	69.5
Bachelor of Science (Animal Science major)	3	5	64.6	55.8	75.1
Bachelor of Science (Animal Behaviour major)	3	2	51.7	50.9	52.6
Equine Science (Bachelor or major)	3 or 4 years	3	71.6	66.4	75.0
Bachelor of Animal and Veterinary Biosciences	3	4	66.8	52.0	79.0
Combination VET and university degrees	3	3	n.a.	n.a.	n.a.

In recent decades, there has been a narrowing of many tertiary offerings into specific animal science degrees, albeit with a broadening of the focus from livestock alone to companion animals and wild fauna, so that Pratley (2012) estimated that fewer than half of Animal Science graduates are interested in livestock production. Concurrent with an increasing demand for and establishment of additional veterinary science degrees from the early 2000s, began the establishment of dedicated animal science degrees (Table 1) to meet high demand, and, in many cases, to capitalise on the overflow of students unsuccessfully gaining admission into veterinary science (Pratley 2012). The two current Bachelor of Animal Science degrees are both 4-year degrees focusing on livestock production. Three-year animal and veterinary bioscience degrees are a new offering, and many enrolments in these degrees are made with the view to post-graduate enrolment in veterinary science degrees, although a substantial proportion does not continue this path. There has been a large increase in offerings of and enrolments in degrees with an equine, wildlife or zoology focus. Meanwhile, job opportunities specific to these degrees and majors are limited, even though these graduates have broad-based skills that could be adapted to other animal science roles. Although only a few universities are currently offering agriculture degrees with technology majors, most agricultural and animal science degrees now have some focus on building skills in using new technologies, giving animal scientists the knowledge and vocabulary to enable them to work together with data and computational scientists.

Increasingly, young primary producers are now degree holders, and have been trained in the science, rather than just the practice, of livestock production. This trend has been linked to increased innovation and adoption of new technologies (National Committee for Agriculture Fisheries and Food 2017) and is driven by several factors. First, the closure of the majority of agricultural training colleges in most states has moved formal education of primary producers out of the vocational (VET) sector and into the university sector. As a result, some universities recognise VET certificate-level qualifications as part of some 3-year degrees to fill this gap. Secondary to this, animal production in Australia is becoming increasingly corporatised. This is nearly completely the case in the poultry and pork industries, and increasingly so in grazing and grain-finished beef sectors. These corporate-owned farms are more likely to recruit staff externally, and university qualifications are highly valued by recruiters.

While the number of animal science degrees available could be considered a reflection of demand, the published mean minimum Australian tertiary admission rank thresholds (Table 1) indicate that these degrees do not attract the highest-calibre students. The increasing complexity of challenges facing livestock production in Australia means that we need to engage with the best and brightest young minds; so, the challenge is to convince students to invest their time and university fees in animal sciences. Awareness is the first step, and state education departments are starting to incorporate agriculture into mainstream curriculums, with agriculture now being a compulsory unit for Years 7 and 8 in New South Wales public high schools. Teachers need support to implement these units, and the RDCs have followed with development of resources for primary and secondary schools such as programs *All About Eggs* by Australian Eggs, *Chicken Farming in the Living World* by Australian Chicken Meat Federation (ACMF) and *Learn about Wool* by Australian Wool Innovation (AWI) and *Wool4School*. Broader initiatives such as the *Good Meat* program of the Meat & Livestock Australia (MLA) build community trust in the integrity and ethics of livestock production, which is key in attracting students from non-farming backgrounds. In addition to this, we need better promotion of the range of science roles that underpin future livestock systems, and of the opportunities available to students who are looking for a rewarding career in diverse scientific disciplines, as well as those with a specific interest in agriculture.

On-going support for a career in animal science

An animal science degree provides graduates with a starting point for their careers and an opportunity to select a pathway from a wide range of research, education, extension, regulatory, policy or livestock-production roles. The graduates of today are likely to be highly mobile and work in many different jobs during their career, a prospect that is exciting to some, but difficult for others to manage. Common to all sciences, and often publicised in the academic media, is the attrition of dedicated early and mid-career scientists in research positions due to lack of career stability, long-term contracts and work–life balance (e.g. Science Connect 2017; Cech and Blair-Loy 2019). This provides a challenge for employers and the broader animal science community to provide on-going support for the development of young scientists and professionals for the benefit of future livestock industries.

Historically, mentoring and training programs would have been provided primarily by employers as part of a career-development program for employees, the majority of whom were hired on permanent contracts. These programs have largely disappeared due to an increasing dependence on external funding sources and short-term funding cycles. These problems are broader than just the animal sciences, and it is outside the scope of this perspective to provide solutions. However, we note the importance of professional networks and associations such as the Australian Association of Animal Sciences (previously the Australian Society of Animal Production), the Australian Rural Leadership Foundation and Nuffield Australia in providing networking, training and mentoring opportunities for those working to improve livestock production in Australia. Many of these societies are run by volunteers, and we suggest that employers could invest in the development of their staff by allowing them time to participate in these networks, particularly in committee roles, which require moderate investments in time, but provide substantial rewards in the form of expanded networks, new collaborations and capacity building. Similarly, Bell (2019) highlighted the role for scientific conferences to promote networks and collaborations among animal scientists. Currently, most societies and conferences within Australia are species or discipline specific, leading to deeper learnings in specific fields of research, but presenting a missed opportunity for the wider collaboration and learning that can encourage new innovations and transformational change. Limited time and funding for researchers to attend these fora make it difficult to prioritise general meetings over those specific to a field of research, but the benefits of these wider interactions cannot be understated.

Changes in the balance between government and private research and extension services have also created challenges for the development of young professionals. Private livestock consulting is a growing sector in Australia. However, most established private livestock consultants began their careers in government research or extension services as part of a state-wide network, with the support of experienced colleagues and formal mentoring programs. New entrants to the sector are now seeking to establish their consulting businesses as sole traders, most often without any on-the-job training or support. Many of these businesses begin by providing services related to implementing on-farm data-collection systems based on electronic identification and data-management and -analysis services to producers engaged with national genetic-improvement programs (i.e. LambPlan or MerinoSelect). Few new livestock consultants have the necessary on-going links with the research and development sector of the research, development and extension continuum to both identify and translate scientific advances to their clients. This poses an increasing challenge for the two-way transfer of knowledge from science to and from producers. In response to this, MLA has begun a livestock-consulting internship program to '*address the decline in extension services offered by public agencies by supporting private consulting businesses overcome the substantial financial costs and time required to upskill graduates and*, *as a result*, *boost the number of new entrants to the livestock consultancy field*'. AWI has funded the development and delivery of national sheep extension programs that have included a train-the-trainer component for private consultants, but there is no formal on-going technical-support network for private livestock consultants. The same can be said for animal scientists who work in the private sector for companies engaged in nutrition, animal health, artificial breeding, animal multiplication (pigs or poultry) or processing (abattoirs). There are few continuing professional development (CPD) programs for animal scientists in Australia. Ag Institute Australia (AIA) offers a Chartered Agriculturalist (CAg) and a Certified Practising Agriculturalist (CPAag) accreditation schemes for the agricultural sector. While discipline-specific societies such as the Australian Association of Ruminant Nutrition (AARN) offer specific CPD programs for their members.

Learning is a social process, and the increased use of social media and online networking platforms such as LinkedIn, Twitter and ResearchGate provides opportunities for the creation of informal learning networks. Peer-to-peer learning is important for producers, consultants and scientists, and these online tools provide an opportunity to expand existing peer networks, share knowledge and experiences, and engage with experts. The use of these tools and networks has increased during the COVID-19 pandemic, with workshops, conferences and even field days moving online, and becoming available to a wider audience who may not usually have been able to participate. However, particularly with social media and in the absence of a formal peer-review process, it is up to individuals to critically assess the quality of the information provided.

Finally, we would like to highlight the importance of international collaboration and global networks. Australia cannot conduct science in isolation. Fundamental science is increasingly being undertaken at a global level wherever the necessary critical mass of researchers exists. International collaborative genome-sequencing projects for major livestock species including beef, sheep, pigs and poultry are examples of fundamental science that have delivered major advantages for Australian livestock production. Genomic breeding values are now commonly used in dairy breeding programs and are currently being implemented in national beef and sheep genetic-improvement programs. Participation in international research for development projects funded by government and philanthropic organisations provide Australian animal scientists with the opportunity to apply their expertise in developing countries. These interactions bring significant benefits back to Australia through a broadening of the skills base of researchers, the ability to maintain an increased overall scientific capacity, and increased interest in animal science careers (National Committee for Agriculture Fisheries and Food 2017).

Conclusions

Australian livestock production systems need to adapt and evolve to meet the challenges of a changing climate and societal expectations, while remaining economically viable. Addressing these issues requires multi-disciplinary and multi-scale approaches, but these must be based on high-quality, discipline-specific science. As such, we suggest that future livestock industries would be better served by graduates familiar with both the science and the context in which livestock are produced. This could be achieved through mixed or double degrees combining animal science with other disciplines (e.g. computer science, natural resource management), or a return to broader agricultural degrees with the opportunity to major in animal science.

It is important that we attract the brightest students from both rural and urban backgrounds into agriculture and animal science careers. This requires that those currently working in animal science actively advocate for the important role and varied career paths of livestock production in Australia and overseas, and it is critical that this information reaches secondary students and their advisors. The RDCs have started to provide resources for schools, and this could be supported by increased engagement of animal scientists and practitioners in programs such as the Superstars of STEM (Science and Technology Australia) and STEM Professionals in Schools (CSIRO), particularly in urban areas.

Impactful science will require better connections between animal science and primary producers to facilitate a deeper understanding of current and future industry needs. This could be achieved through industry internships, mentoring or an agricultural enterprise engagement program, as recommended in the Decadal Plan for Australian Agricultural Sciences (National Committee for Agriculture Fisheries and Food 2017). While the Decadal Plan specifically focuses on building industry relationships for early career researchers, this supported engagement is essential throughout a career in animal science as many of us will work across different species, systems and regions over time.

Conflicts of interest

The authors declare no conflicts of interest.

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