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INCREASING UPTAKE OF GENETIC TECHNOLOGIES ACROSS THE BEEF VALUE CHAIN

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SUMMARY

This paper reviews the agricultural extension literature to identify strategies that could increase the use of genetic technologies across all sectors of the Australian beef industry. An ideal strategy would be creation of a value-based marketing system that rewards suppliers who use genetic technologies to better comply with market specifications. Interventions to support such a strategy could focus on overcoming factors that inhibit adoption, including methods to overcome the perceived complexity of genetics and their lack of trialability and observability. Successful interventions would also need to directly address social factors that limit use of genetic technologies. The aim would be to implement a practical management strategy with appropriate performance metrics that increase efficiencies, coordination and communication across the entire beef value chain, along the lines recommended by Bryceson and Slaughter (2009).

INTRODUCTION

The Cooperative Research Centre for Beef Genetic Technologies (Beef CRC) completes its current funding term in 2012 and is exploring opportunities for a 5-year extension. In addition to a genomics research program, the CRC recognises an urgent need to significantly increase the use of genetic technologies across all sectors of the Australian beef industry. Hence a separate program is being designed to identify and create novel mechanisms to generate 'pull-through' incentives to encourage all sectors of the beef value chain to use genetic improvement to improve their productivity and increase compliance with beef market specifications. This paper reviews the literature to identify strategies that should be considered for inclusion in that program.

CURRENT STATUS OF BEEF GENETIC TECHNOLOGIES

Genetic improvement is an important source of continual increase in profitability for beef businesses across all sectors of the industry. Although there are some excellent examples of Australian beef businesses achieving strong genetic improvement, in general the Australian beef industry could generate much larger gains than it does at present and for a broader range of economically important traits. There are two main areas where improvement could be achieved: i) in the seedstock sector, where rates of genetic gain could be significantly increased; and ii) across all commercial sectors of the value chain, where the potential role of improved genetics in overcoming production inefficiencies and failure to meet market specifications is largely not recognised by most beef businesses in the production, feedlotting and processing sectors.

There are many reasons for the sub-optimal rates of genetic gain in the seedstock sector and the generally poor use of genetic technologies across commercial sectors of the beef industry. Those reasons are not unique to Australia, occurring in the beef industries of countries worldwide. They include poor recognition by producers of the value of genetic improvement due to weak market signals; short-term industry investment timeframes requiring short-term returns outside genetic improvement timeframes; and long time lags between decisions to adopt (e.g. purchase of a genetically superior bull) and receipt of market rewards (e.g. sale of progeny 3-4 years after purchase). Social factors associated with beef producers themselves are also likely to play a role in the lack of uptake. A number of other factors identified by Rogers (1995) also impact on adoption, including the difficulty of trialing and observing genetic technologies before full implementation; the difficulty of selecting between genetic and other options; the complexity of the technologies due to the difficulty and expense of measuring large numbers of animals and the poor understanding of genetic improvement processes; and the perceived lack of compatibility of genetic improvement with other on-farm management practices.

These factors were summarised by Moreland and Hyland (2010) in an examination of 'innovation fit' (i.e. characteristics that influence adoption) of the key technological innovations developed for the Australian beef industry between 1992 and 2007. The initial 13 innovations identified by 25 respondents were subsequently reduced to three 'key technological innovations': two genetic technologies (BREEDPLAN and DNA markers) and Meat Standards Australia (MSA), Australia's unique meat grading scheme that guarantees the palatability of beef based on consumer preferences (Thompson *et al.* 2008). The general characteristics used to determine the 'innovation fit' of each of the technologies are shown in Table 1.

Table 1. General innovation characteristics of key technical innovations developed for the Australian beef industry between 1992 and 2007 (source: Moreland and Hyland, 2010).

Technology	Relative advantage	Complexity	Trialability	Observability	Compatibility	Innovation Fit
BREEDPLAN	Yes (positive)	Yes (negative)	No (negative)	No (negative)	Unclear	Low
DNA markers	Yes (positive)	Yes (negative)	No (negative)	No (negative)	Yes (positive)	Low
MSA	Yes (positive)	No (positive)	Unclear	Unclear	Yes (positive)	Moderate

It is possible useful lessons can be learned by comparing the adoption of genetic technologies in other livestock industries where strong rates of genetic gain have been achieved, and also with MSA, which may be regarded as a highly complex, 'black-box' technology (similar to BREEDPLAN). Those comparisons are undertaken in following sections of this paper. When examining options to achieve desired levels of genetic improvement across the Australian beef herd, it will be necessary to do so at the two levels identified above, i.e.:

1. *the beef seedstock sector*, which generally operates through cattle breed societies. The aim would be to increase the $index value most applicable to the breed, recognising that any gains in this sector will also be reflected in commercial sectors through sales of breeding cattle; and
2. *commercial value chain sectors* where current market signals offer few incentives for genetic improvement. The aim of improvement in these sectors would be to: i) increase throughput (beef yield per carcase or calf numbers by improved reproductive rates); ii) reduce costs of production (reflecting improved feed efficiency, adaptation to environmental stressors or reduced methane emissions); and iii) improve compliance with beef market specifications.

LEVELS OF INTERVENTION

A modified version of Bennett's hierarchy (Crisp 2010) can be used to help identify the most effective interventions that, if implemented, would achieve the planned outcomes. Table 2 summarises the levels of change required and activities that could be used to achieve the desired change. In this program, a Level 4 change (i.e. improved environmental, economic and social conditions) is required, suggesting activities must be implemented at each of Levels 1, 2 and 3 as well as undertaking the essential monitoring and evaluation required to achieve Level 4 change.

Table 2. Activities to achieve levels of change identified in Bennett's hierarchy (Crisp, 2010).

Level	Level of change	Activities to achieve desired level of change
1	Change in awareness	Communication, PR, marketing campaigns using mass media, internet, newsletter circulars, field days etc.
2	Change in generic knowledge, understanding and skills	Workshops, training courses, seminars, some field days, networks, expert or peer demonstrations of relevant case studies to allow in-depth information exchange, clarification and discussion between the target audience members and those recognised as holding key knowledge and understanding.
3	Change in practice or behaviour (small or large scale)	To achieve this level of change, target audiences need the confidence and motivation to initiate change, access to situation-specific knowledge and skills and the necessary physical resources to act. Activities include small-scale trialing; offering financial incentives; a series/sequence of workshops, technical modules or other activities that support a cycle of workplace action and review between the modules; peer networks that support technical learning, action and reflection; working as a group or part of a team to provide peer support and greater sense of commitment and responsibility; personalised technical support (current and ongoing). At this level, the key is for individuals to develop ownership of the change.
4	Improved social, environmental and economic conditions	Outcomes at Level 4 will result from achieving change at levels 1, 2 and 3. The focus at Level 4 is therefore on continual monitoring and evaluation of expected change and implementation of corrective actions if required.

LESSONS FROM GENETIC IMPROVEMENT IN OTHER LIVESTOCK INDUSTRIES

Lindsay (1998) examined the major livestock industries in Australia and suggested their vastly different social and economic structures had influenced their use of genetic improvement. Spectacular improvements had been achieved in the average genetic merit of animals in some industries but not others (Table 3). Industries that had not improved measurably had generally not applied quantitative techniques to their breeding programs, with reasons for the failure being historical, economic and social. All reasons were determined to be very powerful, but had little to do with the quality of genetic theory or its potential to accelerate improvement, suggesting a need to directly address the historical, economic and social reasons if change is to be achieved.

An important reason for the lack of uptake of genetic technologies was a perception by practitioners in the extensive livestock industries that they were competent animal breeders in their own right (Lindsay 1998). The author contrasted this with grain-growers who perceived plant-breeding to be too complex to self-manage, even though it was less complex than animal breeding. Lindsay argues this perception, and the social and economic overtones derived from it, have resulted in a wide variability in the rate of genetic progress in the extensive livestock industries. He supports this contention by a comparison of the ratio of prices for elite and commercial animals across industries (Table 3) and suggests the high ratios seen in the extensive livestock industries established those studs producing the elite animals in a unique and powerful social position in their industry. Since they had been placed there by traditional (non-quantitative) methods of breeding and selection, there was a high and justifiable economic incentive to protect the traditional methods and very little incentive to experiment with quantitative breeding technologies.

By way of contrast, the more intensive livestock industries (pork, poultry, dairy) have substantially different structures, with specialist animal breeding companies primarily responsible for most production-oriented genetic improvement programs world-wide. These companies make extensive use of reproductive technologies, effectively transferring genetic decision-making from individual livestock producers to artificial insemination and bull-breeding centres. This suggests a need to closely examine the structure of the Australian beef industry to determine whether interventions designed to modify the structure and/or improve information flow and collaboration across sectors of the value chain would increase the use of genetic technologies.

Table 3. Ratios of prices for elite and commercial animals in Australian livestock industries and their relationship to genetic gain and use of quantitative genetics (Lindsay, 1998).

Species	Price ratio elite/commercial*	Estimated rate of genetic gain (1960-1990)	Acceptance by industry of quantitative genetic techniques
Merino (wool) sheep	3000: 1	*	Low
Beef cattle	350: 1	**	Low-medium
Meat sheep	50: 1	**	Low-medium
Dairy cattle	35: 1	****	Very high
Pigs	30: 1	****	Very high

**Ratio of mean auction prices paid for top 10 stud males to the mean price of young commercial females based on 1960 prices (in 1998 the ratio was deemed to be very similar)*

LESSONS FROM MEAT STANDARDS AUSTRALIA (MSA)

A clear message from the agricultural economics literature (Pannell 1999*a, b*; Marsh and Pannell 2000; Pannell *et al*. 2006; Marsh *et al*. 2008) is that new technologies will only be adopted if sufficient incentives are provided. Pannell *et al*. (1999*a*) and Marsh *et al*. (2008) emphasise the final level of uptake of any technology primarily depends on economic factors, even for innovations oriented towards resource conservation. In spite of the well-documented returns on investment possible from use of beef genetic technologies, there are currently few economic incentives in the Australian beef industry to directly encourage their uptake. In the seedstock sector, it is still common to see the highest prices paid for animals that have no genetic performance information available, in line with Lindsay's (1988) report. Most commercial bull buyers still have little or no understanding of genetic improvement and therefore do not pressure the seedstock sector to undertake performance recording. And whilst the feedlotting and processing sectors recognise the need for differentiated products that best meet market requirements, most are still largely governed by the need for throughput and have implemented practices based on averaging (i.e. average quality and/or compliance with market specifications), leading to manageable inefficiencies in their systems. However as pressure increases on value chain partners to move away from commodity production (where price averaging is important) to focus more on meeting the tight specifications of differentiated markets (where value-based marketing is required), there will be a need for entirely new approaches to better align beef producers with value chain partners, to ensure market signals across all sectors are transparent and provide the economic incentives needed for adoption to occur.

The MSA scheme created price incentives from scratch for beef palatability. It is now estimated that around 60% of eligible carcases in Australia's domestic beef market are MSA-graded, representing an extraordinary adoption rate since 1999. It would therefore be useful for the proposed new program to examine how the MSA incentives were created and implemented to achieve such success. MSA and the beef value chain could readily be perceived as an example of a complex social-ecological system, comprising multiple subsystems and internal variables within the subsystems at multiple levels, such as those described by Ostrom (2009). Both Ostrom (2009) and Bryceson and Slaughter (2009) provide novel frameworks that could be used to examine and analyse the MSA system, as they have done to examine the loss of natural resources (fisheries, forests and water) and agrifood supply chain performance respectively. Both frameworks appropriately recognise the fact that different enterprises and organisations operating within a complex system such as MSA often have substantially different goals and drivers of success, resulting in a lack of integration, coordination, communication and thus cooperation.

One option that has been proposed is to simply integrate genetic technologies into MSA. MSA currently focuses only on beef eating quality. If warranted, it could be expanded to include additional commercial traits (carcass weight, fatness traits, retail yield). However it is highly improbable that MSA could be expanded to include on-farm traits (e.g. liveweight, feed efficiency, reproduction, adaptation), all of which are essential for genetic improvement programs. And nor could the MSA system be readily adapted to accommodate breeding values that change over time as occurs in genetic improvement programs. Hence, the aim of examining MSA and the beef value chain, using systems frameworks as proposed, would be to develop a practical management strategy that increases use of genetic technologies through improved efficiencies and coordination across the entire value chain, along the lines recommended by Bryceson and Slaughter (2009).

LESSONS FROM THE AGRICULTURAL EXTENSION LITERATURE

Earlier studies discussed herein have examined factors impacting on adoption and uptake of technologies such as improved crop varieties and use of farming systems or natural resource management practices. There are though, very few studies that focus on adoption of extensive livestock management and/or genetic improvement programs. This review therefore examines the published agricultural extension literature to determine whether methods used to successfully achieve uptake of other technologies could be adapted to increase the use of beef genetic technologies by industry. It focuses largely on interventions designed to achieve practice change (Level 3) rather than those designed to achieve change at Levels 1 and 2 (Bennett's hierarchy).

The need for designed partnerships. As indicated by Martin *et al.* (2010), engagement and partnership creates dependencies on all sides, introducing variables not controlled by a single organisation or group of organisations. Hence any initiative to create new incentives for use of genetic improvement should be designed as a co-creation of all those involved in the outcomes. It also needs to recognise that conflict is likely to be an inherent component, meaning the design process should be based on the theories of negotiation and conflict management (Leeuwis 2000). Appropriate partnerships should be specifically designed from the outset, based on a set of agreed principles and strategies intended to ensure the relationship platform for the initiative is robust and principled (Martin *et al*. 2010). Such an approach would emphasise the need to manage the social processes at least as much as the technical processes, with participation, engagement and interpersonal interaction recognised as fundamental for success.

Trialing and observing beef genetic technologies. Guerin and Guerin (1994) suggest the major constraints to adoption of innovations include the extent to which a business finds the new technology complex and difficult to comprehend; the degree of observability of the outcomes from use of a technology; the financial cost of use of a technology; the user's beliefs and opinions towards the technology; the user's level of motivation; the user's perception of the relevance of the new technology; and the user's attitudes towards risk and change. Pannell *et al*. (2006) indicate that non-adoption or low adoption can readily be explained in terms of a range of difficulties in trialing new technologies. Pannell (1999*a*) suggested the trial phase could perhaps be the most important in determining final adoption or 'disadoption' (i.e. trialing but choosing not to adopt) of a technology. Hence, if small scale trials are not possible (as is the case with quantitative genetic improvement), the chances of widespread adoption are greatly diminished due to the risk that the innovation will prove a failure. This risk of failure is part of the cost of gaining high quality information about the innovation. Clearly the larger the scale of the trial that is required, the greater the cost of this information and the less likely the business is to make the investment in trialing. According to Pannell (1999*a*), highly credible information sources (e.g. respected individuals or research results) will help promote trialing, but their advice will almost never be accepted as a substitute for a trial. This is supported by the authors' past experience where, for example, beef producers have generally not accepted evidence from long-term research station selection experiments or producer demonstration sites using sires from those selection experiments in on-farm trials, unless the trials occurred on their own properties. And as Rogers (1995) indicated, even where trials are undertaken, the results are often much more difficult to observe than traditional farming practices. The proposed CRC program could help overcome the difficulties of trialing beef genetic technologies by supporting trials, particularly at feedlot and processor levels if this would assist those sectors to create incentives for producers' use of the technologies.

A further requirement for a trial to be worthwhile is for the results to be observable (Pannell 1999*b*). This is usually not a problem for direct, saleable output from a system. But if a significant benefit arises indirectly (e.g. a reduction in methane emissions that cannot readily be measured), observability can be critical. Factors such as variability over time and space in climatic conditions, pests and diseases and other management practices due to changing economic circumstances can further erode the observability of a technology.

Decreasing complexity and lag-time to adoption. Attributes of beef genetic technologies that result in poor 'adoptability' include complexity of the technology and the long lead-time before results of adoption can be measured. A simple examination of the MSA system suggests it is a highly complex, 'black-box' technology that has nevertheless achieved excellent uptake in industry. However as indicated by Moreland and Hyland (2010), although '*... the science that informs the MSA grading system is complicated ... there was no indication this complexity concerned the end user.'* The main differences between BREEDPLAN and DNA markers and MSA in end-user perception of complexity appear to be related to the timeframes that apply to genetic improvement ('*selection is so slow – two, three, four years down the track')* and the financial incentives and clear guidelines offered in the MSA scheme that encourage producers to overcome the complexity *('there are some pretty clear guidelines for farmers with MSA'*; Moreland and Hyland 2010). This finding suggests that if incentives can be created for producers for use of genetic technologies, end-users may identify ways of implementing them as occurred with MSA. The likelihood of uptake may be significantly increased if it was also possible to simplify the 'marketing' of the complex quantitative genetic platform, particularly to commercial sectors of the value chain, without compromising the scientific credibility of the technologies.

Marketing approaches and market segmentation. An approach that should be investigated is whether a targeted marketing campaign would be useful, particularly in support of a value-based incentive program if that was created. Keys and Orchard (2000) used a marketing approach to promote the Prime Pasture program in NSW, similar to the launch of a new commercial product. Similarly, Kaine *et al.* (2005) undertook market research to develop an extension program targeting the specific irrigation management needs of growers in the stone and pome fruit industry. They viewed adoption of complex new practices as a form of 'high involvement purchasing'. If using a marketing approach to increase adoption, the market should be segmented to better define the target audience. Kaine and Lees (1994) suggested research and development market segmentation and Kaine *et al*. (2005) proposed the same idea for extension. But both papers indicated that market segmentation may be less straightforward in agricultural RD&E than in retailing, where variables such as age, education and income are valuable. The most useful variables in differentiating market segments among landholders were psychological rather than demographic and hence were more difficult to observe. To overcome this problem, Kaine *et al*. (2005) focused on the farm context and the fit of the innovation within that context.

An alternative to a traditional segmented marketing approach could be use of more traditional extension approaches, but targeting those approaches specifically at perceptions that are important in the adoption decision (Llewellyn *et al.* 2003). Once influential perceptions are identified, there is potential for a marketing approach to influence adoption by changing the perceptions.

Waters *et al.* (2009) describe a tool designed to segment target markets in the dairy industry. The Derived Attitudinal Farmer Segmentation (DAFS) approach segments farmers on their perceptions of a wide range of situational and individual characteristics. The tool has explained patterns in a wide range of behaviours across industries and geographic locations. Attitudinal characteristics include business orientation, aversion to risk, sustainable improvement, knowledge and self-reliance, intergenerational orientation, the 'dairy way of life', financial pressure and farming tradition. As the Australian beef industry moves towards an increasingly specialised and differentiated market where the role of genetic improvement will become increasingly more important, a marketing approach could potentially be very useful.

Capacity building and mentoring. Abadi Ghadim and Pannell (1999) indicate that adoption is a learning process with two distinct aspects: i) collection, integration and evaluation of new information to allow better decisions about the innovation; and ii) end-user improvement in the business' skills to apply the innovation to their own situation. With regard to beef genetic technologies, both aspects need to be improved, not only at end-user level, but importantly also at the level of the end-user service providers (e.g. consultants, extension specialists, technical specialists). Nettle *et al.* (2010) describe a project known as *'On the Fast Track'* which aimed to improve the use of research outputs in the Australian dairy industry. Mentoring was shown to be an important process in increasing confidence of participants, exposing more people to capacity building research and supporting people to turn increased confidence into action. Although mentoring may be viewed as one tool amongst many for increasing confidence in capacity building, the authors argue that simply characterising mentoring in that way diminishes the value of mentoring to achievement of their outcomes.

'Beef Profit Partnerships'. Beef CRC developed and implemented a novel systems approach known as 'Beef Profit Partnerships' (BPPs) that have demonstrably achieved uptake of practices, tools and technologies with subsequent significant improvements in profitability of commercial beef producers in Australia and New Zealand (AFBM, 2008). However to date, few BPP businesses have chosen to focus on genetic technologies to improve their profitability. Reasons for this primarily relate to the perceived lack of financial incentives for use of the technologies, but also include all the factors associated with poor 'adoptability' of genetic technologies identified in this paper as well as social factors. In addition, the BPPs deliberately focused initially on short- and medium-term interventions rather than longer-term options such as genetic improvement, to achieve 'proof of concept' of the process. This means that no real attempt has been made to interest BPP members in the use of genetic technologies. It is possible that if financial incentives could be created for the use of genetic technologies, the BPPs offer a Level 3-4 strategy to increase use of genetic improvement.

THE ROLE OF GOVERNMENT OR INDUSTRY-LEVEL ACTIONS

This review indicates a wide range of economic and social reasons impact on the adoption of beef genetic technologies, resulting in a form of market failure. The French government has addressed such market failure directly by meeting the genetic investment costs, including recording, in return for control of the sire selection process. In Australia, neither the government nor the beef industry would likely support such an approach. Based on this review, such an approach would not be warranted, as it is clear a number of new and alternative strategies are available and should be tested with the aim of increasing the rates of genetic gain in the beef seedstock sector and utilising genetic technologies to increase throughput and compliance with beef market specifications across all sectors of the beef value chain.

CONCLUSION

Assuming the proposed CRC program is able to develop interventions that generate pull-through incentives to encourage greater use of genetic technologies, it will be critical to determine in advance how success will be measured. Across the seedstock sector, actual rates of genetic gain ($index value) would apply. Across commercial production, feedlotting and processing sectors, an integrated measure of success (e.g. compliance with market specifications, adoption of a value-based incentive program or such) would be more appropriate.

To start the process of creating financial incentives for use of genetic technologies, Beef CRC is now undertaking a preliminary study of the beef value chain to identify: i) locations in the value chain where genetic technologies could potentially value-add; ii) which, if any, genetic technologies are already being used; iii) gaps where genetic technologies could be used and/or any blockages to their use; and iv) the people who make the critical decisions about technology uptake at different locations in the chain and what influences their decision-making. Results from the preliminary study will be used to guide further development of the proposed CRC program (and will be presented at the AAABG conference).

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