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Impact of MLA Animal Health and Welfare Investments (2015–2020)

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Abstract

Meat and Livestock Australia (MLA) implements several research and development (R&D) programs to benefit red meat producers. One such program is the Animal Health and Welfare (AHW) program. We independently estimated expected adoption and impact per unit of adoption of key AHW products to validate MLA estimates of the overall impact of MLAs AHW R&D investments attributable to the 2015–2020 reporting period. This was done in preparation for MLAs statutory funding agreement and performance review in 2020. This review focused on the impact for on-farm profitability and did not include consideration of environmental or social benefits (triple bottom line). A significant impact was estimated for the products *single-shot cattle tick vaccine* (p00372), *novel Johne's disease vaccine for cattle and sheep* (p00402), and *prophylaxis and treatment of Theileria orientalis* (p00444) under the assumption that commercialisation of a product in some form is realised.

Contents

1 Background 4

2 Scope 4

3 Methodology 4

4 Results 5

4.1 Overview of products 5

4.1.1 Cross-reactive footrot vaccine (antigen based) (product code p00461) 5

4.1.2 Novel Johne's disease vaccine for cattle and sheep (p00402) 5

4.1.3 Bacterial rumen detoxification of fluoroacetate plant toxins via supplement (p00182) 5

4.1.4 Prophylaxis and treatment of *Theileria orientalis* (p00444) 6

4.1.5 Pro-TICK probiotic (p00412) 6

4.1.6 Cattle tick vaccine (secreted/excreted antigens) (p00364) 6

4.1.7 Single-shot cattle tick vaccine (Polymer CRC) (p00372) 7

4.1.8 Zone pellucida vaccine (p00427) 7

4.1.9 Numnuts (p00255) 7

4.2 Parameter estimates for model inputs 9

Uncertainties and limitations 12

5 Conclusions/recommendations 12

6 References 12

Appendix: Livestock populations 15

Background 15

Method 15

1 Background

Meat and Livestock Australia (MLA) implements several research and development (R&D) programs to benefit red meat producers. One such program is the Animal Health and Welfare (AHW) program. Expected adoption and impact per unit of adoption of key AHW products is needed to validate MLA estimates of the overall impact of MLAs AHW R&D investments. This is required in preparation for MLAs statutory funding agreement and performance review in 2020.

Names and product codes for products funded fully or partially between 2015–2020 and evaluated were:

- Cross-reactive footrot vaccine (antigen based) (p00461)
- Novel Johne's disease vaccine for cattle and sheep (p00402)
- Bacterial rumen detoxification of fluoroacetate plant toxins via supplement (p00182)
- Pro-TICK probiotic (p00412)
- Prophylaxis and treatment of *Theileria orientalis* (p00444)
- Cattle tick vaccine (secreted/excreted antigens) (p00364)
- Single-shot cattle tick vaccine (Polymer CRC) (p00372)
- Zone pellucida vaccine (p00427)
- Numnuts (p00255).

2 Scope

Our impact review focused on the likely impact of products on on-farm profitability based on increased production and/or cost savings. Other potential benefits, such as social license related to welfare products were not evaluated. Our review was an *ex ante* R&D evaluation, that is, evaluation was of existing R&D investment decisions, but occurred prior to any anticipated benefits being observed.

3 Methodology

Ausvet and MLA representatives attended an initial meeting 4 March 2019 to discuss the required approach and products to be evaluated. Ausvet received an MLA spreadsheet model to input point estimates for the following parameters.

- Adoption start year.
- Units/doses of product adopted per year until 2039/40.
- Annual net benefit per unit/dose (undiscounted by time) based on the productivity impacts of the disease, current cost of managing the disease and cost of the new product.
- Likely attribution or impact to current funding period.
- Percentage cost savings and productivity benefits.
- Ratio of benefit for northern Australia to southern Australia (for regions see the Appendix).

We collected data and calculated point estimates from the scientific literature, project reports and other grey literature, where available. For parameters that relied on livestock population estimates (e.g. units/doses of product adopted) we used data from the Australian Bureau of Statistics (see the Appendix).

Where scant data were available for factors such as disease distribution and prevalence, productivity impacts and likely product efficacy, we sought expert opinion from relevant experts, such as researchers, clinicians and state government veterinarians.

The main MLA spreadsheet model outputs were the estimated first round benefits in 2019-20 dollars at a 5% discount rate and the total first round benefit cost ratio. Based on estimated first round benefits we categorised impact as low (first round net present value (NPV) of $0 to $10 million), medium (>$10 million to 100 million) and high (NPV of >100million).

4 Results

4.1 Overview of products

4.1.1 Cross-reactive footrot vaccine (antigen based) (product code p00461)

Estimated impact: Low

Footrot is a debilitating foot infection of sheep caused by multiple strains of the bacterium *Dichelobacter nodosus.* Product 000461 is a multivalent footrot vaccine, which would be attractive for sheep producers in high rainfall areas, where the infection is typically seen. Potential benefits include reduced treatment costs (antibiotics, footbathing, labour etc), reduced costs associated with flock-level eradication, and reduced productivity losses (e.g. weight loss, culling). The only vaccine currently registered for use in Australia requires farm-level identification of the circulating sero-group which can be costly (Suter). A multi-valent vaccine would not require this level of testing, giving it a commercial advantage. Further research is required to demonstrate field efficacy.

4.1.2 Novel Johne's disease vaccine for cattle and sheep (p00402)

Estimated impact: Medium

Johne's disease (JD) is a contagious chronic granulomatous enteritis characterized by diarrhoea, progressive emaciation and death of ruminants (Sweeney 2011). The causative agent is the bacterium *Mycoplasma* avium subspecies *paratuberculsosis* (Mptb). Gudair®, an effective vaccine for sheep exists, but can cause injection site lesions in sheep and present an occupational health and safety (OHS) risk for humans who may suffer health impacts associated with an accidental needle-stick injury. Product 00402 is a novel vaccine formulation for use in sheep and cattle, which has markedly less injection site tissue reaction in sheep compared to Gudair® and does not present a major occupational health and safety issue for administrators, which is an attractive proposition to producers. A vaccine is available for cattle (Silirium®) but not typically used by beef producers, as the on-farm economic impact of Johne's disease in beef cattle herds is significantly lower than in dairy herds (insidious disease onset, and shorter beef cattle life expectancy). Therefore, most adoption of this product would be for sheep. Early results indicated a protective effect of the novel vaccine candidate antigens in sheep but it was lower than for Gudair® (Whittington *et al.* 2016). Producing effective vaccines for *Mycobacteria* is extremely challenging, both in human and animal medicine (Lloyd *et al.* 2015) and further research is required.

4.1.3 Bacterial rumen detoxification of fluoroacetate plant toxins via supplement (p00182)

Estimated impact: Low

Sodium monofluoroacetate (fluoroacetate)(FA) is a toxic compound found in many native Australian plant species and the commercial poison 1080 (Leong *et al.* 2017). It is highly toxic to many animals,

including grazing livestock, which often eat FA containing plants if nutrition is not optimal. Research is early-stage; however, given the current trajectory of research a final product would be a nutritional supplement for cattle at-risk of FA poisoning, capable of encouraging growth of FA degrading bacteria that can prevent or reduce the toxic effects of ingestion. Ideally this would reduce mortalities and increase the carrying capacity of land where FA plants grow. Although sheep are susceptible to FA poisoning, the bulk of MLA research has been directed at cattle. FA degrading bacteria have not been identified in the rumens of sheep. Further work is needed to evaluate whether nutritional supplements can increase the population of FA degrading bacteria in live cattle, but would require evidence that nutritional supplements could protect against poisoning to gain ethical approval (McSweeney *et al.* 2018). Further research has not been funded.

4.1.4 Prophylaxis and treatment of *Theileria orientalis* (p00444)

Estimated Impact: Medium

Bovine anaemia due to *Theilieria orientalis* group (BATOG), characterised by anaemia, stillbirths, abortion, reduced productivity and mortality started to emerge in cattle in south-east Australia in the mid 2000s (Izzo *et al.* 2010). Clinical disease is mostly seen in southern coastal areas of Australia. Several *T. orientalis* strains exist in Australia, with Ikeda and Chitose strains being most frequently associated with disease (Kamau *et al.* 2011). The bush tick (*Haemaphysalis longicornis*) is a definitive vector (Emery 2016) and clinical disease is associated with the distribution of this vector. There is no vaccine or treatment registered for BATOG in Australia. Product 00444 is a chemical treatment (registered or unregistered) and/or vaccine formulation for the prevention/metaphylactic use and/or treatment of clinical BATOG cases. Efficacy trials are required and, should they demonstrate efficacy, uptake by producers in BATOG affected areas is likely to be strong. The impact of MLA R&D will be higher if a chemical already registered for use in Australia is found to be effective, as costs and time to get to commercialisation (a label change) are far less than a chemical or vaccine that is will require pre-registration testing from scratch.

4.1.5 Pro-TICK probiotic (p00412)

Estimated Impact: Low

Pro-TICK (previously Probio-TICK) is a product currently under development. It is a probiotic (mixture of live microorganisms) intended to be applied to cattle hides to provide protection against cattle ticks (*Rhipicephalus microplus)* and buffalo flies (*Haematobia irritans exigua*) (Anon 2017). Cattle ticks and buffalo flies are the two most economically important cattle disease in northern Australia (Lane *et al.* 2015). The aim of Pro-TICK is to provide an alternative or additional tool to chemical treatments, such as dips, sprays or pour-ons, currently used to control ticks and buffalo flies. Potential benefits include reduced weight loss, hide damage, tick/buffalo fly treatment costs and effects of tick fever. This is a novel approach to tick and buffalo fly control and work is required to demonstrate field efficacy for commercial realisation.

4.1.6 Cattle tick vaccine (secreted/excreted antigens) (p00364)

Estimated impact: Low

Cattle ticks (*Rhipicephalus microplus)* are the most economically important cattle disease in northern Australia (Lane *et al.* 2015). Infestations affect productivity through blood loss, 'tick worry' and transmission of parasites that cause tick fever. A multi-dose vaccine (TickGard) is no longer available because of poor uptake in northern cattle, which are infrequently mustered. Product 00364 is a tick vaccine based on peptides identified by research funded by the Cooperative Research Centre for Beef Genetic Technologies (Beef CRC) (2005–2012). Research to date has not yet demonstrated efficacy to a commercially viable level (Tabor *et al.* 2017). Adoption is likely to be severely hampered unless efficacy can be improved and demonstrated for a prolonged period (1 year or more), so multiple doses are not required.

4.1.7 Single-shot cattle tick vaccine (Polymer CRC) (p00372)

Estimated impact: Medium

Product 00372 is a prototype single-dose vaccine against the tick antigen Bm86. A single-shot tick vaccine that provides protection against tick infestation for a season from one injection would be very attractive to northern cattle for adoption for use at annual mustering. Research is ongoing.

4.1.8 Zone pellucida vaccine (p00427)

Estimated impact: Low

Cull cows and surplus heifers undergo surgical spaying to prevent pregnancies, largely in northern Australia. Spaying is currently the only feasible means of avoiding pregnancy as bulls are maintained with cows year-round, due to the extensive nature of northern beef production. Infertility enables cattle to reach marketable weight ready for turnoff (Petherick *et al.* 2011). Product 00427 is a vaccine zona pellucida vaccine, which may allow replacement of surgical spaying. Ideally, the vaccine will be formulated such that a single shot will induce infertility for more than one year. This would have major welfare benefits (social licence) and would allow improved weight gain and lower mortality compared with spayed cattle. Less than perfect efficacy will be a barrier to adoption as cattle exported overseas (e.g. Indonesia) are required to be non-pregnant. Spayed cattle are unequivocally infertile. In contrast, it will be necessary to pregnancy test all export females to ensure they are not pregnant. Further research is required and commercial realisation is some way off.

4.1.9 Numnuts (p00255)

Estimated impact: None (cost reduction and/or productivity increase)

Castration and tail-docking performed as part of lamb marking are routine procedures for the majority of sheep producers in Australia (Howard and Beattie 2018). Tail docking of male and female lambs and castration of male lambs is performed annually on between 31 and 34 million Australian lambs (Lomax *et al.* 2010). Numnuts is an alternative to traditional ring applicators to deliver local anaesthetic safely at the same time as rings during castration and tail docking. There is little evidence for reduced mortality or improved health due to the use of pain relief for castratio (Paull *et al.* 2009). Research suggests a considerable disparity between consumers' stated intention to pay more for high-welfare products and their actual behaviour at a supermarket (Taylor and Signal 2009; Dawkins 2017). Therefore, there is unlikely to be an increase in on-farm profit related to this

product. Never-the-less there is likely to be some adoption (as there has for other pain relief products) because of welfare and social licence factors.

4.2 Parameter estimates for model inputs

Our key inputs for the MLA spreadsheet model are summarised below in Table 1. Estimated number of units adopted per year until 2039/40 for each product is summarised in Table 2.

Table 1: Data inputs for impact review model of research and development for MLA Animal Health and Welfare products for 2015–2020

Product	**Adoption start year**	**Peak number of units/doses adopted and year of peak adoption**	**Annual net benefit (per unit dose, undiscounted by time)**	**Likelihood of attribution or impact in 2015-2020**	**% Cost savings and productivity increase**	**% Split between north and south**	**Relevant species**
Cross-reactive footrot vaccine (antigen based) (p00461)	2027	Number: 8 204 389 Year: 2032–33	$0.43	56.4%	64.53% cost savings 35.47% productivity increase	100% south	Sheep
Novel Johne's disease vaccine for cattle and sheep (p00402)	2029	Number: 2 792 639 Year: 2034–35	$7.13	69.70%	100% productivity increase	9.31% north 90.69% south	Sheep and cattle
Bacterial rumen detoxification of fluoroacetate plant toxins via	2029	Number: 313 251 Year: 2039–40	$6.33	21.11%	100% productivity increase	100% north	Cattle

supplement (p00182)							
Prophylaxis and treatment of *Theileria orientalis* (p00444)	2021 for a chemical already registered in Australia 2030 for an unregistered chemical or vaccine	Chemical already registered Number: 223 776 Year: 2027–28 Chemical unregistered Number: 223 776 Year: 2032–33	$135	26.40% for chemicals already registered 4.49% for unregistered chemicals and vaccines	100% productivity increase	1.7% north 98.3% south	Cattle
Pro-TICK probiotic (p00412)	2027	Number: 3 000 000 Year: 2033–34	$8.75	5.15%	11.02% cost savings 88.97% productivity gain	94.12% north 5.88% south	Cattle
Cattle tick vaccine (secreted/excreted antigens) (p00364)	2028	Number: 171 492 No peak year	$3.73	37.90%	100% productivity increase	100% north	Cattle
Single-shot cattle tick vaccine (Polymer CRC) (p00372)	2027	Number: 4 287 313 Year: 2034–2035	$7.41	20.64%	100% productivity increase	100% north	Cattle

Zone pellucida vaccine (p00427)	2026	Number: 899 933 Year: 2031–32	$10.11	18.40%	100% productivity increase	100% north	Cattle
Numnuts (p00255)	2020	Number: 3 100 000 Year: 2024–25	$0	51.56%	There are no cost savings or productivity increases associated with this product.	n/a	Sheep

Uncertainties and limitations

A degree of uncertainty exists for many of the input parameters into the MLA spreadsheet model and therefore the model outputs. This is a feature of all *ex ante* evaluations. One common means of dealing with uncertainty is incorporating uncertainty into input parameters and modelling these stochastically so that a credible range of impact could be estimated. However, the MLA spreadsheet model is deterministic, that is, it does not account for uncertainty. Therefore, whilst the impact estimations are useful for estimating the most likely impact of the products, there is some uncertainty in the estimates which is not apparent when presented as a single point estimate.

Our review is restricted to estimates on the likely on-farm profitability impact of adopting each product. Social and environmental benefits were not considered and are likely to be the main drivers for some products, such as Numnuts and the zona pellucida vaccine.

A key assumption for this impact review is that each product is commercialised in some form. In the absence of final efficacy data or product formulations it is not possible to predict confidently which products will make it to this point. We have dealt with this by providing conservative impact estimates and/or adoption estimates for products with limited efficacy data or products that are early in their research timeline. However, it is important to realise that some products may not make it to commercialisation, particularly if future efficacy information is unpromising.

Therefore, the results are useful for estimating the most likely impact and for highlighting knowledge gaps and interpreting impact to assist decision making. Despite this, the results should not be relied upon in isolation of other broader socioeconomic decision-making criteria.

Research is also ongoing for many of the products and our estimates are based on currently available data and information. Results may change as further information, such as efficacy data from field trials, becomes available.

5 Conclusions/recommendations

Several MLA R&D investments for the 2015–2020 reporting period are promising and are estimated to have a significant impact should commercialisation eventuate. The MLA spreadsheet model is useful for highlighting knowledge gaps and inputs can be altered as new information becomes available, particularly regarding efficacy estimates and potential product costs. Future impact assessments may benefit from the addition of stochasticity to incorporate uncertainties for key data points.

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Appendix: Livestock populations

Background

A key requirement of the impact review is to partition benefits to the northern or southern livestock regions and to accurately determine per head benefits. To do this, accurate information on livestock populations and accurate division of populations to north and south is required.

Current MLA data are dated. More specifically, the livestock population data provided by MLA (NorthAndSouth.xlsx) are based on 2015/2016 livestock commodity data (not the most recent)) and based on 2011 Natural Resource Management Regions (NRMR). The more recent version on the MLA website (Cattle numbers as at June 2017) is based on 2016/2017 ABS commodity data, and uses 2016 NRMR boundaries.

The objective of this short appendix was to use the most recent and available Australian Bureau of Statistics (ABS) commodity data to summarise the populations of livestock for use in attribution of benefits.

Method

Data

Livestock data

The most recent ABS livestock commodity data was sourced and downloaded. This was data made available in 2019 from the most recent ABS data collection period (2017/2018). See (Anon. 2019).

The cattle population was represented by the 'Livestock-Meat Cattle-Total (no)' category from the ABS data.

The sheep population was represented by the 'Livestock – Sheep and lambs – Total (no)' category from the ABS data.

Natural resource management regions

The NRMR used by the ABS in the most recent period were sourced as shapefiles. These are estimates of the regions created by ABS in 2016 (Anon. 2016).

- Geographical information systems (GIS) analysis

A GIS (Quantum GIS) was used to match the ABS commodity data with the relevant NRMR.

The NRMR were then divided into north and southern regions based on the previous north and south categorisation as indicated by the 'NorthAndSouth.xlsx' map provided by MLA. Total cattle and sheep numbers were apportioned to north and southern regions based on this geographic categorisation.

Summary tables are presented.

Results

The map of the northern and southern regions remains very similar to previous MLA maps, with some minor changes for updated NRMRs. See Figure 1.

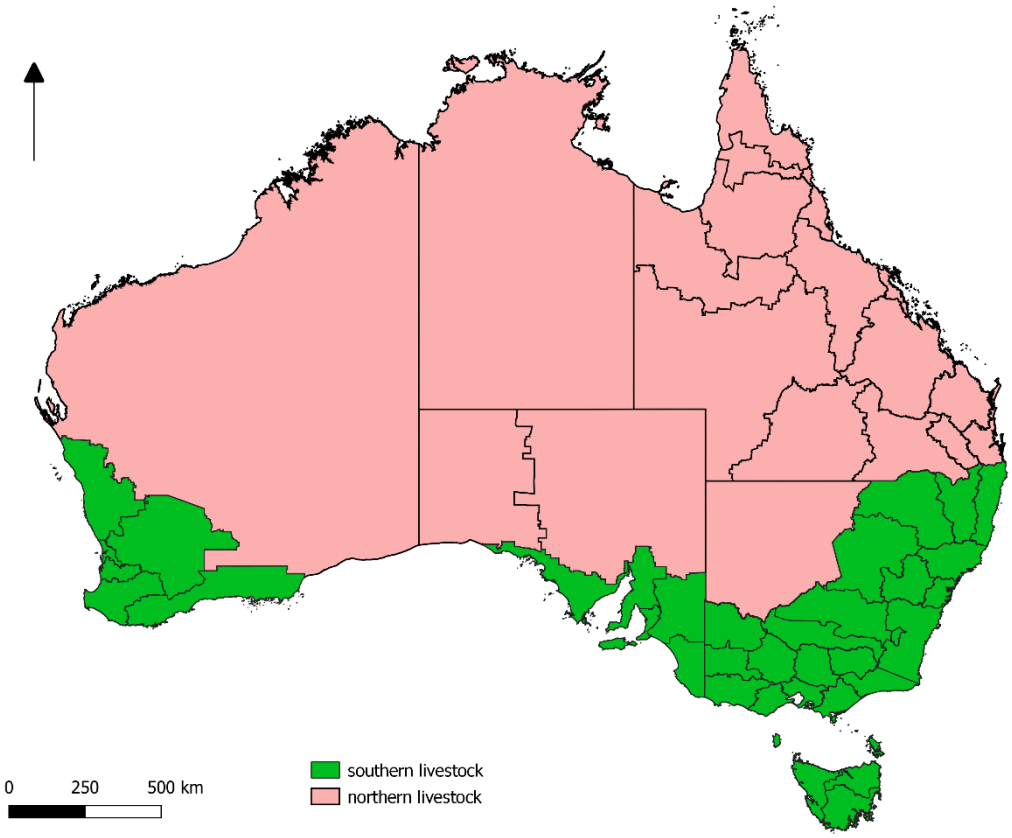

Figure 1: The northern and southern MLA livestock regions based on ABS estimated 2016 NRMR regions

Overall, cattle numbers have declines somewhat between 2016/17 (approximately 26 million) and 2017/2018 (approximately 24 million).

See Table 2 for the numbers of sheep and cattle in the northern and southern MLA regions.

Table 2: The estimated numbers of total meat cattle and sheep in Australia by MLA northern or southern region for 2017/2018 (most recent data).

Region	Cattle	Cattle businesses	Sheep	Sheep businesses
Northern	15 418 074	12 704	5 529 613	1 982
Southern	8 350 308	29 097	64 021 458	29 990
Total	23 768 382	41 801	69 551 071	31 972

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