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Prepared by: Matt Playford
Strategic Bovine Services

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Review of research needs for cattle tick control - Phases I and II

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Abstract

This review examines measures to control cattle ticks and evaluates possible control programs using a literature review, a quantitative survey of experts, public submissions, economic modelling and interviews with beef producers and tick control experts. The cost of ticks for the northern beef industry is difficult to quantify, but is estimated at A$170–200m. Southern cattle producers appear to have a greater concern for cattle tick control, probably due to the higher use of *Bos taurus* cattle. The economic model shows that any strategies used for tick control would have on average five times higher returns for *B taurus* than *B indicus* cattle. The use of tick-resistant breeds of cattle is the most valuable means of controlling ticks. Crossbreeding and other methods for the genetic improvement of tropical and temperate breeds, including gene markers, should be used to maximise productivity. The model shows that the eradication of ticks would have the highest Net Present Value of any strategy, but this is not practical due to lack of support from the majority of the industry. Extension materials should be made available to advisers, to assist beef and dairy producers in controlling ticks in the face of decreased government involvement. Acaricide resistance management, while useful for limited application as in the Northern Territory, has low estimated economic returns, and would require extensive regulatory input to be implemented in Queensland. The formation of a peak body for tick control would encourage regular contact between producer groups and governments; this would also assist with the coordination of extension, research and regulatory efforts.

Executive summary

MLA commissioned Strategic Bovine Services (SBS) to conduct this review in order to examine current measures for cattle tick control, threats to the continued success of these measures, research needs for maintaining control of cattle ticks, and the relative economic benefits to be gained from pursuing some of these strategies. Published reports put the overall cost between A$85–290m in 2004. We believe the most accurate estimate is close to A$175–200m.

A literature review was conducted, supplemented by submissions from the public. Australia's leading authorities on tick control were interviewed, and the overall opinion was that the most practical strategy for controlling ticks in the future was crossbreeding. Other favoured strategies were Integrated Pest Management (IPM), and introduction of chemicals from overseas. Gene markers were supported with caveats relating to the unproved status of this technology. Government control programs, such as eradication and controlling resistant ticks, were not well supported. Using an economic model we estimated the Net Present Value (NPV) of various strategies. All had higher projected returns for *Bos taurus* than for *Bos indicus* herds. The mean NPV was five times higher for *Bos taurus* cattle. Eradication was projected to have the highest NPV, while crossbreeding, IPM, introducing products from overseas and gene markers all ranked highly across different breeds. The lowest economic returns were predicted for strategies that involved acaricide resistance management.

Pastoral company representatives concurred that the use of resistant cattle and crossbreeding are the most important means of tick control in northern Australia. Improving fertility and meat quality would offset tick-related risks to the northern cattle industry due to loss of markets, low productivity and concern over the welfare of cattle. Gene markers potentially allow selection for tick resistance within a herd or within a breed, a technique that has long been possible but has not been widely adopted due to practical difficulties. The Beef Cooperative Research Centre addresses major issues affecting the profitability of northern beef enterprises without a specific emphasis on ticks.

Regulatory controls, assisted by natural climatic barriers, have been successful in confining ticks to a defined geographical area of Western Australia, the Northern Territory and Queensland, and for eradicating ticks from most areas of New South Wales. However, the future of regulatory controls is under threat due to resistance to chemicals. The NT government has implemented a program to eradicate synthetic-pyrethroid resistant ticks. State government policy in QLD and NSW is to shift the burden of responsibility for tick control to cattle producers. Due to the high incidence of resistant ticks, restrictions on the movement of cattle with resistant ticks in Queensland would be unlikely to provide extensive economic benefits, and would be difficult to enforce.

In the past tick control has suffered from the absence of a united national approach, but the recent development of Standard Definitions and Rules has facilitated cooperation between states. However, there is still a need for a coordinated advisory body to consider policies for the management of ticks and a meeting in Queensland to establish such a coordinating body, CTMQ, was well supported by the industry and researchers. Follow up meetings have since been held, sponsored by QDPI&F.

Northern pastoralists ranked the tick vaccine very high in terms of a desirable tool for tick control. Due to its low efficacy and short duration of immunity the current tick vaccine is not widely used. An improved vaccine is unlikely to be developed within the next five years with more work needing to be done to extend the immunity duration to twelve months, and improve efficacy to 90%. This would make the tick vaccine a viable tool for use in beef cattle. The tick fever vaccine is generally very effective but there are problems with biosecurity risk, convenience and side effects. Research on non-live vaccines for tick fever is proceeding. The *Anaplasma* vaccine project has made interesting progress in recent years, but the real need in Australia is for a vaccine against *Babesia*, which causes the majority of tick fever cases.

To date chemical treatments have been a cheap and effective control tool, but the average time from introduction of a new acaricide until it develops resistance or is taken off the market, is only about eight years. Resistance to common chemical classes is widespread in Queensland. Macrocyclic Lactones (MLs) and Fluazuron are widely used in the beef industry without any reported resistance. Researchers anticipate the onset of resistance to MLs within the next 30 years. A DNA-based test for acaricide resistance could assist producers to ensure farm biosecurity, which would probably have commercial application both in Australia and overseas. However, pharmaceutical companies show a trend away from the development of new chemicals. New formulations already registered overseas would likely be readily adopted in Australia, but the APVMA registration requirements are onerous and expensive. The APVMA do not see the cost of registration as being an issue they need to address.

Fungal biopesticides show promise as an alternative measure for the treatment of both ticks and buffalo fly, but are still unproven in the field and require seed money to complete product development. According to the economic model, the introduction of IPM measures, including environmental management of ticks and buffalo flies, would give reasonably high economic returns and is supported by authorities involved in tick control. Both strategies promise to decrease risk of residues in animal products.

As government investment in tick control decreases, cattle producers are being increasingly held responsible for this. We recommend that MLA invest in tick research to help provide northern beef producers with the tools needed to offset the risks posed to markets, welfare and productivity caused by ticks. The greatest returns could be achieved by MLA giving assistance to:

- Research into crossbreeding and gene markers through the Beef CRC programs;
- Support for the peak body (Cattle Tick Management Queensland) that would decide tick control policy and prioritise research and extension needs;
- Extension tools being provided for consultants to advise farmers on control of ticks and buffalo fly;
- Research on a diagnostic test for acaricide resistance;
- The monitoring of tick vaccine research. This would take top priority for funding if a vaccine with 12-month duration of immunity and 90% efficacy could be delivered.

An ancillary recommendation is that MLA facilitates the reporting of reliable statistics on breed trends in the national beef herd. These are needed to provide a sound database on which to assess potential benefits from interventions in the beef industry, to promote trade, to assess risk of disease and to study possible trends in meat quality and other production parameters.

Contents

List of acronyms

AACo	Australian Agricultural Company
ABARE	Australian Bureau of Agricultural and Resource Economics
ACIAR	Australian Centre for International Agricultural Research
AFS	Australian Friesian Sahiwal
AIT	Adult Immersion Test
ALFA	Australian Lot Feeders Association
AMZ	Australian Milking Zebu
ARCBA	Australian Registered Cattle Breeders Association
ARI	Animal Research Institute, Yeerongpilly
Avcare	National Association for Crop Production and Animal Health
CRC	Cooperative Research Centre
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CTMQ	Cattle Tick Management Queensland
DA	Dairy Australia – formerly DRDC (Dairy Research and Development Corporation)
ILRI	International Livestock Research Institute (Nairobi)
IPM	Integrated Pest Management
FAO	Food and Agricultural Organisation (of the United Nations)
LPT	Larval Packet Test
ML	Macrocyclic Lactone
MLA	Meat and Livestock Australia
MRL	Maximum Residue Limit
MSA	Meat Standards Australia
NAPCo	North Australian Pastoral Company
NLIS	National Livestock Identification Scheme
QA	Quality Assurance
QBAC	Queensland Biosecurity Advisory Council
QDPI&F	Queensland Department of Primary Industries and Fisheries
SBS	Strategic Bovine Services
SUSDP	Standard for the Uniform Scheduling of Drugs and Poisons
TBC	Tropical Breed Content
TIGR	The Institute for Genomic Research
TFC	Tick Fever Centre of the QDPI&F, Wacol
USDA	United States Department of Agriculture
UQ	University of Queensland

1 Background

Tick fever (*Babesiosis, Anaplasmosis* and *Theileriosis*) and tick infestation (*Boophilus microplus*) cause economic loss in cattle in northern Australia, through death, weight loss, fertility decline, hide damage, treatment and regulatory costs. Various control options are used including chemicals to kill ticks, resistant cattle genotypes, regional tick eradication programs and movement controls, vaccination for ticks and tick fever, and grazing (pasture) management. These are promoted in integrated programs, although adoption rates of these programs are not documented. Current control relies heavily on the inherent resistance of *Bos indicus* cattle to ticks and some tick fevers and the integrity of the tick line (preventing movement of cattle from infested endemic areas to "clean" areas). Threats to control include acaricide resistance, failure of amitraz to be effective in clearing dips for control across the tick line, privatisation of the tick line activity and use of part *Bos taurus* genotypes to improve meat quality in northern herds. The significance of these threats in the longer term is uncertain. A survey of acaricide resistance is being conducted and will include a questionnaire about control practices to define current practices.

This review will:

- define the research directions that may be taken and
- prioritise those identified in the context of the needs of the industry and
- evaluate the potential economic impact of failure to control ticks.

This review will also address the potential for technical and commercial success of different strategies.

2 Project outline

2.1 Objectives of Phase I of the project

1. Provide a brief assessment of the current costs of tick and tick fever control and the relative importance of these diseases relative to other animal health problems in northern Australia.
2. Describe current control practices for ticks and tick fever in brief and assess the success or otherwise of these options.
3. Assess the future threats and opportunities to improve the control options and for increasing the adoption of current solutions.
4. Describe and evaluate new opportunities for control, the potential for technical success, the relative value of such solutions compared to existing options and their likely commercialisation and/ or adoption.
5. Indicate the research that is currently being conducted, the likely outcomes and successes of these approaches.
6. Recommendations for new activity are prioritised and include increased adoption of current solutions, grazing management, biocontrol (biopesticides), enhancements to tick and tick fever vaccines, enhanced genotype resistance through gene markers or other means and support for new chemical discovery such as new target identification in ticks. The solutions that are applicable to dairy cattle are identified. The recommendations for research to be conducted include an estimate of the cost-benefit of each strategy and the net present value of the benefit calculated over at least 30 years, the time frame for research and adoption of some of the longer-term solutions.
7. The implications for research solutions on tick control include hide damage associated with tick infestations.

2.2 Objectives of Phase II of the project

Phase II of the review was commissioned in order to broaden the scope of the initial report. The aims were to:

1. Identify appropriate producers, researchers and regulators in North Queensland, Northern Territory and Western Australia;
2. Interview a cohort of northern region stakeholders, and work through their responses to the questionnaire used in Phase I of the project;
3. Re-calculate the NPV of the proposed projects based on the information gleaned from the northern stakeholders;
4. Include comments and observations from northern stakeholders in the report;
5. Investigate the epidemiological features of the tick problem, including aspects such as breed change, live export markets, stock movements, climate;
6. Study the practical aspects of tick eradication, including the role of feral animals;
7. Make the recommendations more specific, to reflect the fact that some measures will only have limited scope while others will be applicable across the northern beef industry;
8. Give greater details of the proposed extension program for IPM strategies; outline the economic and non-economic benefits, and the infrastructure already in place that would enhance the adoption of the program. Show how this program could succeed despite the low adoption of a previous tick control extension program (TickCON);
9. Meet with APVMA to discuss regulatory barriers to acaricide registration.

2.3 Methods

A combination of quantitative and qualitative review techniques was used to explore the topic. Because much information relating to tick control research is not published, we have attempted to cover areas of emerging concern or those with little published data by requesting submissions from interested parties, and interviewing beef producers, regulators, consultants and researchers involved in the field. An attempt has been made in the review to attribute the remarks of interview subjects, and these should be read as the opinion of that person. We recognise that these opinions represent the interests of the interviewee or submitter, and have attempted to evaluate opinions using other sources.

2.3.1 Literature review

A review of published literature was carried out to assess the history of tick control, current measures being used and research being conducted to provide new methods of control.

2.3.2 Interviews

Leading researchers, regulators, pharmaceutical company representatives and consultants were identified and interviews conducted. The objective of these face-to-face meetings was to glean information regarding tick control measures not presented in the published literature. In Phase II of the review representatives of northern producers, regulators and industry groups were interviewed.

2.3.3 Survey

A survey form, asking participants for their opinions and estimates, was circulated to 30 researchers, regulators and consultants. Producer representatives were also asked to participate. This survey explored various strategies for tick control, their chance of being adopted in the beef industry and their potential for success (see Appendix Nine). In Phase II of the project a further fifteen survey forms were received from a cross section of stakeholders in the northern beef industry.

2.3.4 Model

A Microsoft Excel-based computer model (the Rabiee model) using research conducted at Massey University (New Zealand) and the University of Queensland was constructed and used as a ranking tool to assess the relative economic benefits of the various proposed strategies. For details see Chapter Nine. The model could further be applied to sensitivity analysis or scenario analysis in the future.

2.3.5 Call for public submissions

Advertisements were placed in the newspapers “Queensland Country Life” and “The Northern Register” during the weeks commencing 17 and 24 May 2004 (see Appendix One) calling for submissions from any member of the public. Submissions were collated and are presented in Appendix Two.

2.3.6 Requests for submissions from interested parties

A copy of the newspaper advertisement was sent via email directly to over thirty researchers, regulators, consultants, producer groups and pharmaceutical companies. Each was followed up with a telephone call and a request to make a submission to the review.

2.4 Personnel

Matthew Playford
Technical Manager, Strategic Bovine Services

Ahmad Rabiee
Research Director, Bovine Research Australia

Ian Lean
Managing Director, Strategic Bovine Services

Melinda Ritchie
Research Assistant, Strategic Bovine Services

3 Recommendations

3.1 Industry statistics

In this study, industry estimates of the financial impact of tick disease were made difficult because there is insufficient information on the breed composition of cattle in Australia. We recommend that MLA ensure that reports such as “Australian Beef Industry 2004” provide up-to-date information on breeds and production parameters. This will provide substantial benefits to epidemiologists, extension officers, consultants, policy makers and farm advisers, not just for ticks, but for other important disease and production issues, and allow decision making for research and policy directions to be based on hard figures, rather than rough estimates.

3.2 Support coordination of regulation and research

Tick control research and policy-making has been hampered in the past by the lack of communication and coordination between stakeholders. In the light of predictions of climate change over the next 30 years making conditions in Australia even more suitable for the survival of ticks, high level cooperation is essential to set policy.

We recommend that MLA, as the major industry body, supports the establishment of Cattle Tick Management Queensland as the country’s peak advisory body on cattle ticks. This would initially involve interaction with the CTMQ steering committee. Further involvement could be determined by the MLA after the structural arrangements for CTMQ have been finalised.

Recognition should be acknowledged that cattle tick control is a national problem with ramifications for market access, trade, animal welfare and overall industry viability that go beyond parochial interests. Representatives of the New South Wales Board of Tick Control, the Northern Territory and Western Australia, as well as researchers, chemical manufacturers and rural retailers should be possible participants in this peak body.

The dairy industry in Queensland relies entirely on susceptible *Bos taurus* breeds of cattle, the majority of which are located in the tick-endemic areas. These have a disproportionate impact on tick numbers and acaricide usage.

MLA, along with state and federal governments, should consider co-funding peak body activities, so that the body is adequately resourced to provide guidance for extension, regulatory and research programs, in order to maximise the impact of the pool of funds available for tick control.

3.3 Tick Control Extension Program

State governments to date have provided huge amounts of funding for tick control programs and extension. The major beneficiaries of these programs have been the producers living outside tick-endemic areas. In recent years state governments have scaled back their funding of activities such as dipping, testing and extension, in order to apply “user-pays” principles. This has created a potential gap where producers must assume individual responsibility for their own tick control programs. At the same time, due to market demands, producers wish to learn more about means of producing livestock with reduced reliance on chemicals. This leads to the danger of a “knowledge deficit” due to producers not having sufficient experience or concern about ticks and associated diseases. This could result in outbreaks of tick fever, production losses and welfare problems due to tick infestation, and in times of suitable weather conditions, expansion of tick distribution.

We recommend that MLA fund the creation of extension tools, in cooperation with state and federal governments and other interested parties, such as Dairy Australia. The major purpose would be to allow the dissemination of practical information on cattle tick control, including biosecurity and Integrated Pest Management, to advisers and consultants who service cattle producers in northern Australia. Due to the welfare and economic importance of buffalo fly and the potential for co-control, this should be included in the program.

We propose that a small project team would develop a manual detailing the practical means of implementing tick control on individual properties and for regions. IPM principles and use of tick-resistant breeds should be included to allow for options that reduce chemical use. The program should be made available to rural advisers and consultants (government and private) to use as part of their farm management and animal health advisory services for beef and dairy producers. The advisers would then be able to recommend the appropriate tick control methods for the type of enterprise and location, and coordinate with other management practices, hence ensuring maximum efficiency of treatments.

A precedent for this type of extension program can be found in the 'More Beef from Pastures' program, which has already been rolled out across southern Australia.

The major difference between this type of extension program and the conventional extension programs used in the past is the emphasis on delivering information to 'information providers' in the rural industries, rather than directing information at farmers. The need for farmers to master the skills required for modern livestock production has seen them inundated with information, not just on traditional farming practices such as livestock management and agronomy, but also with Occupational Health and Safety, Chemical Use, Quality Assurance Programs and Information Technology. As a result, farmers in the twenty-first century are overwhelmed with information, and more likely to refer to advisers or consultants to provide knowledge on specialist issues.

By targeting advisers and consultants rather than farmers, MLA and the other stakeholders can avoid the waste of resources that accompanies widespread campaigns. At the same time they can ensure that their key responsibility, of providing farmers with the tools necessary to avoid the economic and welfare disasters that are possible from inadequate tick control, is performed.

Advisers can be state government extension officers, district veterinary officers, animal health officers, dairy company extension officers, veterinary practitioners, veterinary consultants, pastoral company staff and other stakeholders in the cattle industries. Promotion of the 'adviser training courses' can be targeted at the advisers themselves, while a promotional campaign to promote general awareness of the program in the producer community would be a relatively low-cost exercise using print media or direct mail.

3.4 Crossbreeding and genetic research

This study has identified the use of tick-resistant cattle as the single most important factor in controlling cattle ticks in Australia. Much progress has already been made in selection and crossbreeding to improve the productivity of tick resistant breeds.
MLA is already providing funding for the Beef Cooperative Research Centre, along with the universities, CSIRO, the Commonwealth and state governments, other industry bodies and commercial partners. Projects included in the CRC promise to add substantial value to the beef industry. Productivity may be further enhanced by less proven strategies such as use of gene markers for tick resistance and meat quality, as well as implementing post-slaughter methods for improving meat quality.

Most of the larger pastoral companies operating in northern Australia have highly-qualified and experienced staff who are able to review the scientific literature, run trials and determine the most economically rewarding strategies for production, including crossbreeding. However, these resources are not available to smaller producers.

The decision-support tool, Hotcross, developed by CSIRO Livestock Industries, Rockhampton, needs to be properly validated and made available as a web-based tool for northern beef producers. This would allow it to be continually updated and improved. Hotcross should include an economic analysis of breeding decisions.

3.5 Immunobiological methods of tick and tick fever control

Vaccines are an accepted and easily implemented part of livestock management across Australia. The live tick fever vaccine has gained wide acceptance and is used on approximately one third of cattle born in the tick-endemic areas each year. Nonetheless, many cattle remain susceptible due to the lack of predictability of *Babesia* and *Anaplasma* endemicity and misinformation about natural exposure. Moreover, tick fever outbreaks are frequently not reported by producers, due to economic penalties caused by lack of access to markets, and social stigma.

We recommend that MLA should support and promote the use of the live tick fever vaccine given at the time of weaning, in order to not only prevent productivity losses but also to decrease the risk of producers losing access to markets and to promote animal welfare. The Ramsay model, developed at TFC for predicting the benefits of vaccination in areas of low challenge, should be promoted as a decision-making tool. These practices should be included in any extension programs involving tick control.

The long-held promise of a practical vaccine against ticks themselves has not been realised, despite extensive and costly research. The available tick vaccine has low efficacy (approx. 70%) and short duration of immunity, resulting in low uptake. Despite this, a tick vaccine remains a potentially extremely useful tool that is highly desired by producers and regulators alike.

Northern beef producers have indicated that a vaccine would only be practical if the duration of immunity was at least twelve months, and efficacy was approximately 90%. Further research on the tick vaccine should be monitored, both in Australia and overseas. Immunological research is proceeding rapidly, with developments of the existing vaccine being conducted in Latin America, together with some totally novel approaches to vaccines. However, there is no evidence to show a practical tick vaccine can be delivered at this stage.

Due to the enormous potential benefits of a tick vaccine, if researchers provide new evidence that a vaccine with 90% efficacy and requiring a single annual vaccination can be delivered, we recommend that this should be given top priority and its development assisted by MLA.

3.6 Chemical methods of tick control

The current regulatory arrangements for the movement of cattle across the tick line, requires the use of a knock-down acaricide. If resistance to amitraz, the most widely used knock-down acaricide, continues as forecast, then alternative arrangements will need to be made, with disruption of trade. In order to monitor and control the problem of acaricide resistance, no tool would be more useful than a rapid diagnostic test.

Despite not having a high, predicted Net Present Value when assessed on an industry wide basis, the diagnosis of acaricide resistance using molecular techniques could justify MLA funding from a regulatory benefit viewpoint. This would also provide individual property owners with a tool to allow them to prevent the importation of resistant ticks, especially in south-east Queensland where resistant ticks are most prevalent. It is considered that a market exists for this technology both domestically and overseas.

3.7 Eradication of ticks

Many producers, especially those in south-east Queensland, support the eradication of ticks on a regional or national basis. Eradication is still the official policy of Queensland, the Northern Territory and Western Australia outside the tick line, as well as for the whole of New South Wales. No change in this strategy is foreseeable.

However due to the endemic nature of cattle ticks across northern Australia, the presence of feral deer that act as natural vectors, the already high levels of resistance to available knock-down acaricides, the difficulty of mustering cattle in extensive areas for treatment, and the low efficacy and short duration of immunity of the current tick vaccine, the right conditions for national eradication are not present, nor could they be constructed without massive investment. Beef producers, especially those in tropical areas, have largely become accustomed to living with ticks by using resistant genotypes of cattle, and complying with regulatory requirements to clear cattle of ticks before transport into tick-free areas. Opinions expressed by regulators and beef producers in tropical Australia show that there is little political will for eradication.

Regional eradication is possible but requires the cooperation of all landowners in a district, together with strict movement controls, to ensure that ticks do not re-infest areas suitable for their development. Moreover, all the cattle in recently cleaned areas are susceptible to tick fever and require vaccination with the tick fever vaccine to prevent the possibility of outbreaks.

MLA should not support any programs aimed at the eradication of cattle ticks unless novel technologies provide the tools to facilitate this end. Instead, MLA should encourage cattle producers in the tick-endemic areas of northern Australia to follow a policy of harm minimisation using the practical methods outlined in this report to ensure maximal animal productivity and welfare.

4 History of cattle ticks in Australia

4.1 Introduction of ticks and tick fever to Australia

Cattle ticks and the accompanying intracellular parasites that cause tick fever were introduced into northern Australia along with their host stock, probably as early as 1829. An excellent historic account of the spread of these parasites is given by Beverly Angus[1].

This account details the introduction of cattle into the Northern Territory region between 1829 and 1849 from Timor and possibly Bali, where the parasites were enzootic. The author surmises that this probably led to the establishment of these parasites in the top end, and their survival was enhanced by the introduction of susceptible British breeds of cattle into the Darwin area from 1866.

Disease caused by tick fever or ’redwater’ was first recorded around Darwin in 1870, in working bullocks transported to Darwin by sea from NSW. The construction of the overland telegraph line from this time, relying on the use of bullocks for transport, helped distribute ticks and tick fever further afield. Redwater was noted as affecting cattle brought into the Roper River area of the Northern Territory by the Duracks in 1885. Angus provides further anecdotal evidence of redwater outbreaks in northern herds as early as 1845.

Outbreaks of redwater were recorded in mobs of cattle being droved from the Wave Hill region of the Northern Territory to the Kimberley region of Western Australia in 1885, following the discovery of gold at Halls Creek and the need to supply miners with beef. Large movements of naïve cattle from Queensland into the Roper River district saw mortalities as high as 24%.

4.2 Spread of ticks and tick fever

From the 1880s ticks and their accompanying disease spread backwards along the stock routes from the Northern Territory into western Queensland. Seddon[2] described the ensuing rapid spread of ticks and tick fever from the initial focus in the Northern Territory, across the country adjoining the Gulf of Carpentaria by 1892, to Cape York by 1894, and to the east coast towns of Cairns and Townsville by 1895. The Queensland government responded by commissioning research by Sidney J. Hunt, which confirmed the causative link between redwater and the cattle tick *Boophilus microplus.* Hunt and another researcher, C. J. Pound, began separate experiments to inoculate naïve cattle with blood from infected stock, both showing remarkable success. Pound went on to develop a method for the collection of blood from immune donors, and inoculation into susceptible cattle. His work was well publicised and adopted widely.

Quarantine lines were hastily established to prevent the introduction of ticks into southern and eastern Queensland, which had large cattle populations. The lack of success of these lines was apparent however, in the need to drastically re-draw them from the original 1892 and 1894 lines, boxing in the northwest corner of Queensland, to the 1895 line which divided north and south Queensland with a line drawn parallel with Mackay, to the 1896 line drawn below Rockhampton. By 1898 zones were established to protect southern and southeast Queensland, the parasites and accompanying disease having spread as far south as Bundaberg.

Herds of cattle were decimated in the face of the parasites. Reports from the Gin Gin area in 1898 note 60% to 70% mortality in newly infected cattle. In contrast, cattle inoculated along the lines of Pound’s recommendations suffered losses of only 3–5%.

The NSW government closed the NSW–Queensland border to cattle imports in order to prevent the introduction of cattle tick to the state. Cattle ticks were noted on the Queensland side of the border in 1902, and despite the best efforts of stock inspectors, including double fencing, inspection and dips, had spread into NSW by 1906. Distribution was enhanced by bullock teams travelling in the northeast corner of the state, and had spread to Kyogle by 1909, and as far south as Coffs Harbour by 1932.

The distribution of ticks has changed little since then, except for the control of ticks in NSW. In fact, the current distribution of cattle ticks (2005) closely resembles the distribution in 1906. This would indicate that the rapid spread of cattle ticks between 1880 and 1905 across the tropical north coast of Australia and down the warm humid east coast of Queensland into NSW, closely follows the limits of the natural habitat of the tick.

Distribution 1829 *Distribution 1895* *Distribution 1906*

Plate 1: Maps of Australia illustrating spread of cattle tick *Boophilus microplus* on a time-course scale. (Modified from drawings supplied by Tick Fever Research Centre, Wacol, Queensland)

4.3 Tick fever research

There have been three distinct periods of research activity on tick fever in Australia[3]. These are summarised in Table 4.1 (below).

Table 4.1: (from Mahoney DF 1994, *Australian Veterinary Journal*, vol. 71, no. 9, pp. 283–289)

The chronology of key discoveries on which the control of tick fever in Australia has largely been based, showing three distinct periods of research activity		
Period	**Key discoveries**	**Year**
1. 1893–1930	Transmission by ticks	1895
	Identification of *B. bigemina*	1896
	Immunisation	1897
2. 1930–1960	Identification of *A. marginale*	1933
	Immunisation against *A. marginale*	1934
	Identification of *B. bovis*	1935
	Bivalent vaccine for Babesiosis	1939
3. 1960–present	Advances in diagnosis	1961 et seq
	Life cycle of *Babesia* in ticks	1964,1966

	New vaccine for *B. bovis*	1964
	Duration of immunity to *Babesia*	1969
	Chemosterilisation/prophylaxis	1970
	Epidemiological model	1972
	Vaccine failure	1976,1990
	B. bigemina culture vaccine	1987
	Cloning of *B. bovis* protective antigens	1987–89

The predecessor of MLA, the Australian Cattle and Beef Research Committee, later the Australian Meat Research Council, was established in 1961 at the beginning of the third phase of progress in tick fever research. It was seen as a valuable supporter of tick fever research in the 1960s and 1970s, and for some programs this continued into the 1980s. The ACBRC is recorded as contributing $1.4m to the Queensland Department of Primary Industries between 1962 and 1983 for tick control projects at Yeerongpilly, Wacol and Oonoonba laboratories, as well as generously supporting the CSIRO Division of Animal Genetics in Rockhampton and the Division of Entomology at Long Pocket. However, according to Mahoney "The AMRC was replaced by the Australian Meat and Livestock Research and Development Corporation in 1985 and support for tick fever research was reduced by the new authority"[3].

In the years since 1989 the *B. bovis* protective antigens that were noted as a milestone achievement (see Table 4.1 above), have been successfully developed into a commercial vaccine, the world's first recombinant vaccine directed at an ectoparasite. The vaccine, TickGARD, and its improved version, TickGARD Plus, have been available for cattle producers since 1995.

Since 1995, despite continued high-level research into both ticks and tick fever, there have been no further discoveries that could be called milestones. Producers continue to rely on the live vaccine developed back in the 1960s, and diagnosis is largely based on thin smears of peripheral blood, a technique developed in the early twentieth century. The use of antibody-based diagnostic techniques is currently restricted to epidemiological studies.

QDPI&F researchers are using ELISA tests for serology to better understand the distribution of tick fever organisms in Kenya, Zimbabwe and the Philippines[4]. Apart from the study above, there is little application of this technology in Australia.

Research on protective recombinant antigens against tick fever organisms has been progressing since 1982 at the CSIRO laboratories at Long Pocket and St. Lucia, but to date has not produced any commercial vaccines.

The current situation includes a highly effective live vaccine available from the Tick Fever Centre at Wacol together with non-susceptible genotypes of cattle used throughout the high-risk areas of northern Australia. This means that there are few major outbreaks of tick fever, and thus little economic motivation for continued research into the disease. This could change with the introduction of different genotypes of cattle or with changes in *Anaplasma* distribution as *Bos indicus* cattle are highly susceptible.

4.4 Research into acaricides

Baths to "disinfect" cattle from ticks were proposed as early as the 1890s, and practical application was attempted by many stockowners throughout that decade. Some, such as carbolic acid adapted from a sheep dip, showed low efficacy and caused irritation to the cattle. Various oils were tested in the USA for the same purpose, and some were trialled in Queensland. C.J. Pound tested three hundred different combinations of chemicals in order to establish a safe and efficacious means of freeing cattle from tick burdens.

Public dips were quickly established in many towns in Queensland in order to stop the spread of ticks. By 1898 there were nine dips in place, each with caretakers, and government-sponsored chemicals were supplied for the use of pastoralists. However, there was a great deal of dissatisfaction with the efficacy of the available dips.

In 1898 Mark Christian, of Willangie near St. Lawrence, is credited with developing the “Queensland Dip” for use on his cattle. This was a combination of arsenic, tar and soda ash. Despite initial opposition to the use of arsenic on the basis of its toxicity to cattle (especially from Pound) the dip gained popularity, even as far away as South Africa and the United States. Further development of the formula led to an acceptable combination of efficacy and safety, and the use of this dip was standardised and adopted by the Queensland government in 1907.

The arsenic dip faced problems with toxicity, environmental contamination and from 1937, resistant ticks, but it was used in Queensland right up until 1986[5]. By this time many other classes of acaricide had been applied in tick control, among them chlorinated hydrocarbons, organophosphates, carbamates, amidines and synthetic pyrethroids. Resistance has since emerged to all of these chemical classes, on average within ten years of the release of a new chemical.

The biology of the tick suggests that it may even become resistant to newly released chemicals, such as ivermectin and other macrocyclic lactones, and those used overseas for cattle ticks: fipronil and spinosad.

Mechanisms for tick resistance were researched extensively by James Nolan, Peter Green and others at the Yeerongpilly laboratory in the 1970s. Attempts were made by the Queensland government to contain some strains of resistant ticks with an aim to wiping them out, but these proved unsuccessful, largely due to lack of compliance.

Commercial research into dips, led initially by Coopers, Imperial Chemical Industries and Timbrol, has focused to date largely on identifying chemicals that will kill ticks without causing problems with safety, residues or environmental damage. More chemicals were screened by CSIRO at the Yeerongpilly laboratory. In recent years developments in molecular biology have seen more work focused on targeting specific enzymes, pathways or molecules within the tick so that ’designer drugs’ or biologicals could be developed that attack ticks without harming other species.

One notable achievement of recent years has been the registration and commercial launch by Novartis of fluazuron, the first chemical acaricide to target the enzyme chitin synthase, and so prevent the development of larval ticks. Its mode of action is described as a “Tick Development Inhibitor”, much like the “Insect Growth Regulators” used against flies and lice in animal health, and against many insect pests in cropping and horticulture. The long-acting nature of this chemical means that cattle can be treated once and enjoy protection from re-infestation for up to nine weeks post-application, overcoming earlier problems with short-acting chemicals requiring re-application every three to four weeks. This overcomes the problem of the cost of mustering outweighing the benefit of tick control on many extensive properties.

Few researchers have looked at the practical aspects of preventing the onset of acaricide resistance. Extension programs have been based on scant evidence, largely focusing on the need to use acaricides according to label recommendations (as the abuse of dips in the past is thought to have sped up resistance onset) and decreasing the frequency of dipping. This is seen as a means of reducing selection pressure for the resistant gene in tick populations.

4.5 Research into the biology of ticks and epidemiology of tick-related disease

Ticks and tick fever spread from the initial site of distribution in the Northern Territory in 1881, through to North Queensland by 1887, and then down the Queensland coast, reaching the New South Wales border by 1902. Ticks then spread into NSW by 1906 and gained a foothold on the northeast corner of the state.

The Queensland Stock Institute was the scene of many of the early investigations under the direction of Patrick Gordon. Gordon pursued collaborations with overseas researchers, particularly in South Africa and the United States. This allowed Australian researchers to characterise the nature of tick fever organisms for the first time. The first dedicated laboratory for the study of diseases of livestock was established in Yeerongpilly, Brisbane, in 1910 by Sydney Dodd, who identified a second causative agent for tick fever and introduced trypan blue as the first effective chemotherapy for the disease[1].

Prof. John Sprent established the Department of Parasitology at the University of Queensland in the early 1950s. Through his own research and the work of his students, he was able to establish a laboratory model for *Babesia* and describe the life cycle, pathogenesis and epidemiology of the parasite in detail.

Ron Glanville of the Queensland Department of Primary Industries summarised the biology and epidemiological features of cattle ticks in 1985, and predicted the potential distribution of ticks in Queensland[6]. He found that large areas of the Darling Downs (a tick free area) were suitable for tick survival, and reported a large number of property quarantine cases in the 1970s and 1980s, due to favourable climatic conditions. In the remainder of Queensland, the location of the tick line reasonably defined the biological limit of survival of the tick due to temperature and humidity limitations for survival and reproduction. Glanville warned that precautions against tick fever should be maintained because of the danger of the rapid incursion of ticks into a previously free area.

Computer models, devised by Sutherst in 1979 and then by Elder in 1983, were used to calculate optimum treatment programs, and predict economic returns from cattle of various genotypes (Zebu type, British and crossbred)[7].

Russel Bock of the Tick Fever Centre at Wacol conducted a serological study of northern Australian cattle herds in the mid-1990s in order to determine the prevalence of the three important tick fever parasites. A total of over 7000 blood samples were tested for antibodies to *Babesia bovis, B. bigemina and Anaplasma.* The results showed very low levels of natural exposure to these organisms except in a few shires[8], indicating an "endemically unstable situation in the region".

In 2003, Sserugga and co-workers used serological testing of dairy calves to challenge accepted customs, such as the practice of allowing calves to carry a tick burden in order to act as a natural method of preventing tick fever outbreaks[9]. This practice was shown to be false, and the authors recommended that all dairy calves were routinely given live tick fever vaccine, as it is the only way of ensuring freedom from tick fever in the endemic areas.

Since Glanville's work of the mid-1980s there has been very little epidemiological research on the range of the cattle tick, and there is little documented evidence to show the effect of recent trends such as the development of live export markets, movement of cattle across the northern region, and changes in breed composition of the northern beef herd.

4.6 Research into eradication and regulatory control

After J. A. Gilruth had travelled to the United States in 1919 and observed the success of the cattle tick eradication program there, a similar scheme was mooted for Australia. Only NSW attempted eradication. After a false start in the Tweed Valley in 1921, quarantine and enforced dipping began in earnest in 1923 under a new Act giving the Tick Control Board of NSW statutory powers. Compulsory dipping, inspection and improved fencing to eliminate stray cattle were instituted. In 1927 the Cattle Tick Control Commission was established to further this work, with cooperation from the Queensland government and co-funding from the Commonwealth government. Problems with dip efficacy, compliance and the geography of the area meant that by 1940 an admission was made that eradication measures to date had failed. By 1946 the core Tick Quarantine Area was re-infested, and a new scheme mooted. Due to lack of finance this scheme was not launched until 1956.

By the 1950s, Queensland government policy was to prevent the spread of the tick using inspection and dipping to prevent stock from the tick-endemic area transporting ticks to the tick-free area. The Northern Territory and Western Australian governments also adopted similar approaches, with the underlying view that management of the economic effects of cattle ticks was a better policy than eradication. NSW however has maintained that eradication is possible and desirable, and has pursued this policy now for over one hundred years.

In 1956 eradication efforts began with renewed vigour, aided by 750 personnel, 1100 State-owned dips, fourteen-day inspections and dips, clearing of stock in unmusterable areas, and the use of DDT in cattle dips. This program managed to clear cattle ticks from about half of the Tick Quarantine Area, but failed overall. Evaluation of the program by a committee established to examine the causes for failure indicated that eradication was impracticable with the current state of knowledge. The Cattle Tick Research Station at Wollongbar was established in 1961 to provide a research base for eradication. Government extension officers were appointed to educate stock-owners. In 1983 State-owned dips and overall responsibility for dipping was handed back to private cattle owners.

4.7 Research into tick-resistant cattle

Indications that tropically-adapted cattle were well-suited to the Australian environment came as early as 1896, when it was found that six Bantu cows and one bull that had been brought from the Cape of Good Hope had subsequently escaped from the colony of Sydney and multiplied. By 1808 their descendants numbered 5,000 head, in herds roaming the Cowpastures area southwest of Camden[1]

It was nearly a century later that government and private efforts were made to introduce breeding stock from Asia and Africa, motivated by their tick-resistant qualities. In 1908 Queensland dairy farmer, G.W. Munro-Hull, reported that British breed (Jersey) cattle could be selected for tick resistance, although this finding caused great controversy among researchers at the time.

C.J. Pound was unwilling to accept Munro-Hull's findings, instead favouring the introduction of Brahman cattle. Another advocate for the introduction of Zebu breeds was John Gilruth. However, it was not until after noted South African researcher Sir Arnold Theiler's visit to Australia in 1928 that support for the tropical breeds grew among commercial cattle producers. In 1931, Ralph Kelley travelled extensively through the United States and the UK to study the most suitable cattle types, commenting favourably on the Santa Gertrudis and Brahman breeds developed in Texas.

Despite strong opposition to the introduction of Zebu cattle by many pastoralists, CSIRO established a program in 1933 to further genetic gains in cattle through crossbreeding, and chose to import cattle from the United States due to the decreased risk of infectious disease compared to cattle from Asia or Africa. Three pastoral companies, Australian Estates and Mortgage, Queensland Stations Ltd, and Winter-Irving and Allison, contributed sufficient money to import Brahman bulls and establish a stud.

The Zebu-crossbreeding program showed remarkable success, not only due to tick-resistance but also due to their suitability to the northern climate. Advances in breeding were made by pioneer Brahman studs such as the Atkinson family of central Queensland. Hybrid breeds with 50% *Bos indicus* blood such as the Droughtmaster, developed in Queensland with a stud established at the University of Queensland in 1962, paved the way for cattle producers to quickly establish tropically-adapted, tick-resistant breeds in commercial operations.

“Belmont” station in Rockhampton was bought by the CSIRO (with funding from the Australian Meat Board) in 1952 with the specific aim of providing scientific backup to the crossbreeding and genetic efforts of stud and commercial breeders in northern Australia. Over the next two decades George Seiffert, James Rendel and colleagues collaborated with CSIRO researchers from Long Pocket laboratories under the direction of R. H. Wharton to study the role played by tropical breeds of cattle in tick control. Several hybrid breeds were developed, including the “Belmont Red” as well as tropically adapted dairy cattle. The latter, however, have never found acceptance in the Queensland dairy industry.

5 Survey of researchers on tick control strategies

5.1 Background

A survey questionnaire was created by Strategic Bovine Services, and evaluated by several tick researchers and beef producers before implementation. A modified form was circulated to a total of 30 tick researchers, beef industry consultants, regulators active in tick policy planning and implementation, and beef producers. The thirteen strategies posed were derived from existing projects, or had been proposed by researchers, regulators or producers during the public consultation phase of this review.

The intention of the survey was to ascertain the opinions of leaders in the field of tick control regarding strategies for future tick control, and obtain estimates of economic parameters relating to tick research projects. People active in the field of tick research were chosen as those most likely to be able to compare the strategies available for tick control.

Participants were provided with background material on the reported costs associated with ticks and tick fever, and a briefing on the aims of the current review on tick control research.

The complete tables including standard deviations are presented in Appendix Nine. Abbreviated tables showing means only are presented below.

Figures derived from the survey were used to create the assumptions used in the model to evaluate costs and benefits of tick control strategies presented in Chapter 9.

5.2 Results

Completed forms were received from thirteen people in the target group. Several responses showed pooled results, so in total the opinions of fifteen people are represented. The mean scores of the figures estimated by respondents, plus standard deviation, are shown in this summary. Several survey forms were filled out incompletely, in that ranges of numbers over the 30-year time span of the survey were indicated by a figure in the first and last columns and a line to indicate a link. In these cases we estimated the figures in the intervening cells.

A number of other survey forms showed estimates for the early years but not the latter years. Where the intention of the subject was not clear these cells were left out of the final reckoning. Two completed survey forms arrived too late for processing. The tables below indicate the mean values given for each of the strategies.

5.2.1 Adoption rate

Adoption rate was seen as a key issue for any tick control strategy. The MLA brief asked us to quantify the relative cost-benefits of these approaches over a 30-year time span. History shows that the beef industry is relatively conservative, and that new approaches to tick control have a slow rate of uptake.

Table 5.1: Estimated adoption rate of various strategies for tick control

	Mean						
Adoption rate (%)	Year 1	Year 5	Year 10	Year 15	Year 20	Year 25	Year 30
Crossbreeding	15%	22%	31%	38%	45%	52%	58%
Improve tick fever vaccine	11%	26%	41%	47%	51%	51%	52%

Improve resistance diagnosis	4%	13%	28%	36%	41%	42%	44%
Introduce products from overseas	1%	27%	38%	41%	42%	44%	44%
Develop novel chemicals	0%	16%	23%	33%	37%	41%	43%
Introduce IPM measures	9%	12%	21%	29%	36%	39%	43%
Gene markers	1%	10%	16%	25%	32%	37%	40%
Eradication of ticks	2%	13%	25%	30%	35%	38%	39%
Slow acaricide resistance	3%	9%	17%	25%	32%	36%	36%
Compulsory vaccination	9%	20%	24%	28%	32%	35%	35%
Control resistant ticks	1%	11%	25%	29%	31%	35%	35%
Improve tick vaccine	10%	16%	24%	25%	29%	29%	30%
Biopesticides	0%	2%	12%	18%	25%	26%	28%

The project with the highest projected initial adoption rate (Year 1) was crossbreeding, which is understandable given that it is an established strategy. It was also given the highest estimated adoption after 30 years (58%).

Some researchers were equivocal about the benefits of crossbreeding however, with one comment that the strategy "will need to develop strains, extension to convince growers of the benefits, extension to assist adoption. Difficult to see any new breed achieving more than 30% industry adoption."

The strategy with highest adoption at 5 and 10 years was 'introduce product from overseas', which reflects participants' confidence that registration of the commercial formulations could be achieved fairly rapidly. The strategy with the second highest estimated adoption after 30 years was an improved tick fever vaccine (52%). The lowest estimate for adoption, both initially and after 30 years, was biopesticides, probably reflecting the early stages of this project and the general lack of knowledge of its effects.

5.2.2 Cost of implementing

Participants were asked to estimate the cost of developing and implementing the various strategies.

Table 5.2: Estimated cost of implementation of various strategies for tick control (not in order)

	Mean	(A$ m)					
Cost of implementing ($)	Year 1	Year 5	Year 10	Year 15	Year 20	Year 25	Year 30
Crossbreeding	$0.34	$1.77	$4.10	$6.56	$7.02	$7.85	$7.85
Gene markers	$0.67	$2.96	$2.95	$5.74	$5.37	$5.37	$5.37
Eradication of ticks	$4.50	$47.00	$70.00	$71.17	$73.83	$77.83	$94.00
Compulsory vaccination	$2.23	$16.45	$31.38	$46.48	$64.92	$76.68	$93.45
Control resistant ticks	$1.93	$6.60	$11.90	$17.80	$22.80	$27.80	$32.80
Slow acaricide resistance	$0.87	$3.77	$7.77	$7.93	$7.93	$7.93	$7.93
Improve resistance diagnosis	$0.59	$3.17	$3.57	$3.94	$4.14	$4.14	$4.14
Introduce products from overseas	$0.83	$7.00	$10.00	$10.00	$10.00	$10.00	$10.00
Develop novel chemicals	$2.50	$12.50	$40.00	$160.00	$160.00	$160.00	$160.00
Biopesticides	$0.34	$2.52	$16.94	$20.94	$20.94	$20.94	$20.94
Improve tick vaccine	$1.08	$2.88	$12.88	$15.38	$15.38	$15.38	$15.38
Improve tick fever vaccine	$0.38	$1.45	$5.25	$5.25	$5.25	$5.25	$5.25
Introduce IPM measures	$0.54	$2.38	$3.98	$5.65	$7.32	$8.98	$10.65

Several participants felt unqualified to answer and skipped this entire section, or made qualitative remarks such as "Low", "Moderate" or "High". The highest estimates were for the eradication of ticks, compulsory vaccination, and developing new chemicals.

One comment directed at ’eradication’ was “impossibly high and unwarranted”. Another was, “potentially very expensive”. The lowest estimated cumulative cost over 30 years was for ’improving resistance diagnosis’ This was followed by ’improve tick fever vaccine’, ’gene markers’ and ’crossbreeding’.

5.2.3 Benefits

’Eradication of ticks’ was set as the index at 100%. Participants were asked to estimate the relative benefits of each of the strategies to the beef industry.

Table 5.3: Estimated benefits of various strategies for tick control, compared to an index of 100 for ’Eradication of ticks’

Benefits (%)	**Mean**	**SD**	**Min**	**Max**
Eradication of ticks	100%	0.00%	100%	100%
Crossbreeding	55%	25.05%	20%	100%
Improve tick vaccine	50%	27.34%	20%	100%
Introduce IPM measures	50%	27.16%	17%	100%
Gene markers	49%	30.67%	10%	100%
Compulsory vaccination	48%	21.57%	15%	90%
Develop novel chemicals	48%	23.19%	10%	80%
Introduce products from overseas	43%	23.58%	5%	80%
Biopesticides	38%	24.72%	5%	80%
Slow acaricide resistance	31%	18.81%	5%	60%
Improve tick fever vaccine	27%	19.40%	5%	60%
Control resistant ticks	23%	15.74%	5%	60%
Improve resistance diagnosis	22%	13.05%	5%	50%

Again the highest ranked strategy was ’crossbreeding’, with a mean value of 55%. Some comments reflected the enthusiasm for crossbreeding. One researcher gave the benefit at 110% of eradication, with the comment “if it could be successfully implemented, (crossbreeding) would have additional animal welfare benefits and trade-related benefits not available to chemically-induced eradication.”

’Improved tick vaccine’ and ’IPM measures’ were next highest ranked as far as projected benefits, closely followed by ’gene markers’ and ’develop novel chemicals’. One consultant remarked that the benefits of new chemicals would depend on their features, such as the efficacy, or application techniques that did not require mustering.

A pharmaceutical industry representative commented that IPM measures were a necessary framework for all tick control, and were therefore essential. This comment was echoed by a researcher who said “development of well-thought out, practical and property-specific IPM programs is critical to achieving maximum effectiveness of just about all of the strategies above… This is the overarching strategy and use of most of the approaches above should be considered in the context of an IPM approach rather than stand-alone technologies.”

The lowest-ranked strategies were ’improve resistance diagnosis’ at 22%, ’control resistant ticks’ at 23%, ’improve tick fever vaccine’ at 27% and ’slow acaricide resistance’ at 31%.

5.2.4 Efficacy rate

Table 5.4: Estimated efficacy of various strategies for tick control

	Mean						
Efficacy rate (%)	Year 1	Year 5	Year 10	Year 15	Year 20	Year 25	Year 30
Eradication of ticks	28%	35%	51%	59%	67%	74%	78%
Crossbreeding	26%	22%	43%	48%	61%	63%	63%

Introduce IPM measures	41%	43%	51%	55%	58%	59%	61%
Gene markers	12%	14%	42%	48%	54%	56%	59%
Compulsory vaccination	28%	31%	36%	36%	49%	52%	50%
Introduce products from overseas	24%	31%	47%	49%	49%	49%	50%
Biopesticides	22%	17%	27%	34%	40%	44%	46%
Improve tick vaccine	20%	18%	22%	32%	43%	45%	46%
Develop novel chemicals	27%	29%	43%	47%	48%	48%	44%
Improve tick fever vaccine	13%	13%	29%	33%	35%	35%	35%
Slow acaricide resistance	12%	12%	19%	24%	31%	34%	33%
Improve resistance diagnosis	12%	15%	20%	24%	31%	33%	31%
Control resistant ticks	11%	8%	11%	16%	22%	26%	25%

Participants were asked to estimate the efficacy of each project "if the strategy could be fully-funded and implemented. (This means) to estimate the effectiveness of the strategy in removing ticks or tick fever from infested properties, or reducing the infestation to a tolerable level (a level at which there are no welfare, production, trade or animal health effects)".

Eradication was given the highest mean score, with an overall 78% chance of achieving the stated ends. The next highest scores were given to crossbreeding, IPM and gene markers. IPM especially was scored very highly (41%) from the first year, and ranked highest or equal highest up to year ten. This probably indicates that the necessary technology is already available to implement the program.

The lowest estimates were given to controlling resistant ticks, improving diagnosis of resistance and slowing the development of acaricide resistance.

5.2.5 Overall ranking

Survey participants were asked to rank their opinion of the overall chance of success of each project, and their reason for allocating that ranking. The rankings were transformed using a formula that assigned a value of "1" to rankings of 1, a value of "2" to rankings of 2, and so on up to a score of "13" for rankings of 13. The values were tallied and the scores compared. The overall rankings (below) show a fairly tight cluster of scores with values lower than 70, making up the top 6 ranked projects.

Table 5.5: Overall ranking of the various strategies for tick control

Strategy	Score	rank
Crossbreeding	44.00	1
Introduce products from overseas	52.00	2
Gene markers	55.00	3
Introduce IPM measures	59.00	4
Slow acaricide resistance	62.00	5
Improve tick fever vaccine	65.00	6
Improve resistance diagnosis	70.00	7
Improve tick vaccine	77.00	8
Biopesticides	87.00	9
Develop novel chemicals	98.00	10
Control resistant ticks	101.00	11
Compulsory vaccination	121.00	12
Eradication of ticks	148.00	13

The highest ranking was achieved by crossbreeding. Reasons given included “cheap and effective”, “established, popular and done elsewhere” and “easy-fix solution to wider industry”.

Introducing products from overseas was ranked next highest (2), with positive comments such as “cheap and easy to do – if regulatory environment was easier”, “regulatory hurdles are an obstacle for new acaricide – why are spinosad and fipronil not registered?” and “effort would best be spent lobbying for removal of any unrealistic registration requirements”. However, one survey participant noted that, “chemicals still generate residue problems and consumer perception difficulties”. The fourth-highest ranked project was “Introduction of IPM”. Comments given include “relatively easy-fix solution”, “essential and practical”, and “definitely good but idealistic – farmers make their own decisions, lots of input gets low uptake but general gradual improvement”. The other three projects ranked in the top six were gene markers (3), improved tick fever vaccine (6) and slow acaricide resistance (5).

The lowest ranked project was eradication (13), with eight of the survey participants putting it in last place. Comments given were “not feasible”, “lack of political will to get the job done”, and “too expensive”. Compulsory vaccination was ranked the next lowest (12), with comments such as “wouldn’t be accepted”, “mustering costs too high” and “not feasible”.

’Develop novel chemicals’ ranked tenth, with comments such as “pie in the sky!” and others suggesting that the market size does not warrant the expense. ’Control resistant ticks’ was ranked eleventh. One reason for the low rank was “far too aggressive and cost-benefit not justifiable” and “regulatory control pivotal for compulsory programs – political will?”

5.3 Discussion

Crossbreeding ranked well across all areas, reflecting the established status of this strategy. Many favourable comments from researchers are detailed above. Gene markers were ranked high across most areas, and the overall ranking was third. It was backed by comments such as “quicker than crossbreeding to implement and advantage that producer can apply to his/her breed or herd”. Also, “can be implemented without measuring animals” – (indicating an advantage over selection as a tool). However, some researchers expressed reservations towards gene markers such as “doubt if it is feasible” and “will need to find suitable markers, demonstrate benefits of their use, develop practical breeding schemes which incorporate gene markers in systems with all other economic traits, and get adoption of these schemes”. One researcher commented that it had “limited use”, while another remarked on the “unknown number of genes involved”. Another said it was “a long, slow and high risk project”.

IPM was also ranked highly in the overall rankings (4), with a reasonably low estimated cost of implementation, high estimated benefits and high estimated efficacy. Most researchers commented favourably on IPM, with remarks such as “necessary for a clear and workable tick program for producers”.

Strategies that required government intervention were unpopular across all areas investigated. Strategies such as eradication, controlling resistant ticks and compulsory vaccination, all ranked poorly in the overall ranking, and low for adoption rate.

Introducing products from overseas was supported in the overall rankings (second) and ranked highly in other areas. One industry representative commented “best short-term band aid”. However several researchers commented on the registration requirements for new products, indicating that they were too onerous, and acted as a disincentive for chemical manufacturers (see above).

Developing novel chemicals was generally regarded as too expensive and unlikely to achieve great benefits. It ranked highest for estimated cost of implementation, and had a slow estimated adoption rate.

5.4 Summary

The survey of leading researchers, regulators and industry representatives revealed a high level of enthusiasm for crossbreeding as the major means of controlling ticks in the northern beef industry. Other favoured projects were IPM and introducing chemicals from overseas. Gene markers received support from many researchers, but many qualified their support with caveats relating to the as yet unproved status of this strategy. All strategies that involved government control programs, such as eradication and controlling resistant ticks, were poorly supported.

6 Survey of northern pastoralists, veterinarians, regulators and industry representatives

During the first phase of this review, the survey results were based on the opinions of researchers and regulators who were mainly based in the subtropical areas. As a means of getting a more balanced input, MLA requested we approach selected producers, regulators and veterinarians in tropical Australia and survey them to see if their opinions differed. The results presented below represent the views of a cohort of representatives of pastoral companies, state government regulators and private veterinarians.

Interviews with the northern stakeholders showed that they were not in a position to estimate the costs of implementing control programs. The survey and interviews conducted with northern stakeholders focuses on the practicality of cattle tick control programs.

Table 6.1: Representatives of the northern beef industry and regulators interviewed for Phase II of the review

Contacts for MLA AHW.054 Phase II				
	Name	**Position**	**Organisation**	**Location**
1	Garry Hodgen	Stock Inspector	WA Department of Agriculture	South Perth
2	Peter Buckman	Chief Veterinary Officer	WA Department of Agriculture	South Perth
3	Chris Mayberry	Project Manager, Stock Movements	WA Department of Agriculture	South Perth
4	Bob Vassallo	District Veterinary Officer	WA Department of Agriculture	Kununurra
5	Ben Madin	District Veterinary Officer	WA Department of Agriculture	Broome
6	Ruth Webb-Smith	Chief Executive Officer	WA Pastoralists and Graziers Association	Kimberleys
7	Edgar Richardson	Policy Officer	WA Pastoralists and Graziers Assoc	Perth
8	Greg Brown	Chairman, Agforce Cattle	Agforce, QLD	Brisbane
9	Amanda Parker	Policy Officer	Agforce, QLD	Brisbane
10	Grant Maudsley	Cattle Tick Management representative	Agforce, QLD	Mitchell
11	Peter Hall	Cattle Tick Management representative	Agforce, QLD	Cloncurry
12	Steve Millard	General Manager Breeding and Genetics	North Australian Pastoral Co	Brisbane
13	Geoff Wagstaff	General Manager Breeding	Australian Agricultural Co	Brisbane

14	Mark Perkins	General Manager Livestock and Marketing	Colonial Agricultural Co.	Brisbane
15	Jay Simms	Chairman, Beef producer	Western Queensland Regional Beef Research Committee	Hughenden
16	Lach McKinnon	Chief Executive Officer	NT Live Exporters Assoc	Darwin
17	Stuart Kenny	Executive Director	NT Cattlemen's Assoc	Darwin
18	Stephen Tapsall	Researcher	Trop Sav CRC	Darwin
19	Steve Petty	Research and Development Manager	Heytesbury Pastoral Co.	Darwin
20	Kel Small	District Veterinary Officer	NT Dept of Business Industry and Resource Development	Darwin
21	Tom Stockwell	Chairman	North Australian Beef Research Committee	Sunday Creek, NT
22	Geoff Warriner	Operations Manager	Consolidated Pastoral Co	Kununurra
23	Peter Morecombe	Technical Manager	Animal Health Australia	Canberra
24	Ross Ainsworth	AQIS-accredited Veterinarian	Australasian Livestock Services	Darwin
25	Michael Hartman	Deputy Director	Cattle Council of Australia	Canberra
26	Malcolm Reid	Beef cattle producer	Board of Tick Control, NSW	Woodenbong NNSW
27	Elizabeth Milbourne	Senior Product Evaluator	APVMA	Canberra
28	Judith Platt	Product Evaluator	APVMA	Canberra
29	Cheryl Javro	Senior Evaluator	APVMA	Canberra
30	Judith Bourne	Veterinary Policy Officer	Biosecurity Australia	Canberra

Of the list above, each person was contacted by telephone and asked to contribute to the review. A selection were interviewed by telephone, others were interviewed at face-to-face meetings. Producer representatives, selected veterinarians and regulators were asked to complete survey forms. A total of fourteen completed survey forms were collated. These represented the collective opinions of twenty of the people named in the list above (Table 6.1), as well as many others who contributed to the responses.

6.1.1 Adoption rate

Table 6.1: Estimated adoption rates (%) for the next 30 years, provided by northern stakeholders involved in cattle industry

Strategies for tick control	Adoption rate (%)						
	Year 1	Year 5	Year 10	Year 15	Year 20	Year 25	Year 30
1.Improve tick vaccine	24	45	43	54	62	67	74
2. Introduce products from overseas	22	54	44	54	59	60	64
3. Eradication of ticks	7	33	43	44	48	50	58
4. Biopesticides	5	24	34	50	49	52	55
5. Improve resistance diagnosis	17	24	35	31	35	42	54
6. Develop novel chemicals	4	30	43	52	46	49	50
7. Improve tick fever vaccine	30	60	38	38	43	43	48
8. Crossbreeding	23	26	30	34	39	44	48
9. Control resistant ticks	9	17	35	41	54	46	47
10. Gene markers	0	5	14	22	34	39	43
11. Slow acaricide resistance	13	28	32	40	37	38	39
12. Introduce IPM measures	11	25	30	38	50	55	38
13. Compulsory vaccination	3	16	31	29	29	30	30

The highest estimated adoption rate was for the improved tick vaccine (74% after 30 years). This probably reflects the fact that most producers in tropical Australia are already using an annual vaccine against Botulism, and see an annual tick vaccine as an easily implemented means of control. Several producers made comments backing up this opinion. Second highest ranked was ’introducing products from overseas’, which had an estimated adoption rate of 64% after 30 years.

Compulsory vaccination had the lowest estimated adoption rate, with only 30% estimated acceptance after 30 years, while measures to slow acaricide resistance was also rated low (39% after 30 years).

6.1.2 Benefit of implementing

Table 6.1.2: Estimated benefits (%) of different strategies for the next 30 years, provided by northern stakeholders involved in cattle industry

Strategies for tick control	Benefit of implementing (% of eradication)	SD	Minimum	Maximum
	Mean			
1. Crossbreeding	59	23	20	80
2.Improve tick vaccine	54	31	10	100
3. Biopesticides	49	35	5	80
4. Develop novel chemicals	44	16	25	70
5. Introduce IPM measures	43	28	15	80
6. Improve resistance diagnosis	43	25	5	80
7. Improve tick fever vaccine	42	26	0	70
8. Introduce products from overseas	42	22	5	70
9. Gene markers	41	32	5	80
10. Slow acaricide resistance	39	26	5	80
11. Control resistant ticks	32	22	5	60
12. Compulsory vaccination	21	14	0	35
13. Eradication of ticks	100	(index)	-	-

Crossbreeding was seen to give the greatest benefit over 30 years, with a mean score of 59% of the perceived benefit provided by tick eradication. This was followed by ’improved tick vaccine’, which gained an overall score of 54%. No other strategy gained more than a 50% rating, but ’biopesticides’ was rated at 49%. Comments from producers reflected a belief that a biopesticide that provided tick control without residues would be preferable to chemical acaricides.

The lowest perceived benefit was from compulsory vaccination, which was rated as only 21% of the benefit of eradication, while ’controlling resistant ticks’ (32%) and ’slow acaricide resistance’ (39%) also rated low.

6.1.3 Estimated efficacy

Table 6.1.3: Estimated efficacy rates (%) of different strategies for the next 30 years, provided by northern stakeholders involved in cattle industry

Strategies for tick control	**Efficacy rate (%)**						
	Year 1	**Year 5**	**Year 10**	**Year 15**	**Year 20**	**Year 25**	**Year 30**
1. Crossbreeding	26	31	41	51	50	56	60
2.Improve tick vaccine	10	20	23	33	38	40	54
3. Eradication of ticks	3	23	30	23	25	28	44
4. Introduce IPM measures	6	13	16	19	20	24	38
5. Biopesticides	17	19	24	27	30	33	37
6. Develop novel chemicals	19	24	28	28	35	34	34
7. Gene markers	3	7	13	21	28	28	33
8. Improve resistance diagnosis	6	11	15	19	23	25	28
9. Improve tick fever vaccine	18	26	26	29	27	27	28
10. Slow acaricide resistance	15	21	24	25	26	26	24
11. Introduce products from overseas	12	19	26	30	23	21	20
12. Control resistant ticks	4	13	16	10	11	13	13
13. Compulsory vaccination	0	12	12	13	3	5	5

The northern beef producers gave the highest score to crossbreeding as the highest predicted efficacy of the strategies for controlling ticks, with a mean score of 60% after 30 years. This was also the highest scoring after one, five, ten, fifteen and subsequent years, indicating that many producers believe the use of crossbreeding is already an established means of tick control. The next highest estimate was for ’improved tick vaccine’ with 54%. This probably indicates the experience of producers with vaccines, and their faith in researchers to deliver a vaccine with good efficacy.

The lowest ranking strategy was ’compulsory vaccination’ (5% after 30 years) with most producers believing there would be little chance of this strategy succeeding in tick control on cattle. ’Controlling resistant ticks’ also ranked very low (13% after 30 years). ’Introducing products from overseas’ was estimated as only having a 20% success rate after 30 years, reflecting the comments from several producers that new chemicals are rapidly made ineffective by the onset of acaricide resistance. However, strategies to slow acaricide resistance and improve resistance diagnosis also achieved low mean scores (24 and 28% respectively after 30 years).

6.1.4 Overall ranking of the various strategies

Table 6.1.4: Overall scores and order of the strategies, ranked by northern stakeholders

Strategies for tick control	Scores	Order
Crossbreeding	22.00	1
Improve tick vaccine	34.00	2
Gene markers	49.00	3
Biopesticides	52.00	4
Develop novel chemicals	60.00	5
Introduce products from overseas	62.00	6
Introduce IPM measures	66.00	7
Control resistance ticks	67.00	8
Improve tick fever vaccine	68.00	9
Slow acaricide resistance	72.00	10
Improve resistance diagnosis	77.00	11
Eradication of ticks	85.00	12
Compulsory vaccination	105.00	13

As for the previous survey of researchers, regulators and producers (see section 5.2 above), crossbreeding was the top-ranked strategy for cattle tick control for northern beef producers, regulators and veterinarians. However, the second ranked strategy for the northern group was ’improved tick vaccine’, which only ranked sixth in the previous survey. Gene markers were also ranked high (3), followed by biopesticides (4) and developing and introducing new chemicals (5 and 6 respectively).

The lowest ranking strategy was ’compulsory vaccination’ (13), reflecting the fact that the northern group allocated low scores to this strategy for adoption rate and efficacy. The second lowest overall ranking was for ’eradication of ticks’ (12), followed by ’improve resistance diagnosis’ and ’slow acaricide resistance’ (11 and 10 respectively).

6.2 Discussion

The northern group of survey respondents had similar responses to the group initially surveyed in Phase I. For adoption rate, crossbreeding was rated highest in both groups, due to the already established position of crossbreeding in the control of ticks. A major difference in the response from the northern group was the estimation that an improved tick vaccine would have the second highest adoption rate (74% at 30 years), compared to the initial survey group only estimating a 30% adoption rate for this strategy at 30 years. This possibly reflects the greater familiarity of the southern group with the existing tick vaccine, which requires frequent (every 2–3 months) boosters and is deemed impractical. The northern producers were largely unaware of the existing tick vaccine, and probably framed their responses based on their experience with other vaccines, such as Botulism, that are in common use in the north.

The lowest estimated adoption rate in both groups was the regulatory approaches (compulsory vaccination, controlling resistant ticks).

The highest ranked strategies for both groups for estimated benefit was crossbreeding, again reflecting the fact that this strategy is already being implemented, while the second highest ranked for both groups was the improved tick vaccine. For estimates of efficacy, the northern group again scored crossbreeding and improved tick vaccine top, while the subtropical group ranked eradication ahead of crossbreeding, followed by Integrated Pest Management and gene markers.

The overall ranking in the northern group again favoured crossbreeding and improved tick vaccine, followed by gene markers and biopesticides. The original survey group also gave crossbreeding top ranking, but gave novel chemicals the second highest ranking, followed by gene markers and Integrated Pest Management.

Looking at the potential strategies that drew low marks, the least favoured were clearly those that required regulatory intervention. Compulsory vaccination had low appeal across all areas for northern producers, while research to slow resistance onset also scored low. The original survey group saw least appeal in controlling resistant ticks, research to improve resistance diagnosis, and gave a low rank for the improved tick fever vaccine. This may indicate that there is low general support for the continued use of acaricides in the control of cattle ticks. It also indicates that there is not a great deal of support for improving the current tick fever vaccine as a solution to losses from ticks.

6.3 Comments from northern producers, regulators and veterinarians

Cattle tick related disease and production loss appears to have changed in the last 30 years. However, it is clear from the comments (below) of stakeholders in the tropical regions that ticks are still a major cause for concern.

6.3.1 Eradication

Darwin-based veterinarian, Ross Ainsworth, commented: “I would love to see eradication because ticks are a major nuisance but this requires a new discovery. Having been involved in the BTEC from start to finish I strongly recommend no formal eradication plans be undertaken until appropriate technologies are in place and the industry is in full agreement”. He also stated that: “the status quo is acceptable without major changes”.

Mark Perkins, Colonial, “Eradication – unlikely in Queensland due to the entrenched culture.”

Malcolm Reid of Woodenbong, NSW, ranked the ’eradication of ticks’” the highest in the list of potential strategies for cattle tick control. This is consistent with responses received from other producers in subtropical areas in Phase I of the review.

Jay Simms, Hughenden said “I am always cautious when using words like 'eradication'... (is it possible, is it cost-effective, and what are the down stream consequences?) I think we can achieve better control over ticks, and probably start moving the tick line back into the endemic tick areas with the use of several of the proposed strategies. There is a real opportunity to replace management dipping using chemical acaricides in heavy tick areas with a vaccination against ticks which has the 'magic' one year (13 months) protection period. Many properties within the endemic zone do not have suitable management of their stock to ensure any degree of control by government regulation, and this would ultimately provide a large, nasty, expensive, compliance issue. Bigger than BTEC! There will be a case for a tick line and for clearing dips (using acaricides) for a long time to come... Let’s just hope we can keep pushing that line well back into the endemic zone.”

6.3.2 Breeds and meat quality

Geoff Wagstaff, General Manager of Breeding, of the Australian Agricultural Company, commented that "AACo has a large number of purebred Brahman cattle, e.g. in Wrotham Park on Cape York, which has very high average temperature and rainfall unsuited to crossbred cattle. Ticks aren't the only reason why there are no European or British breed cattle in the Gulf or Cape York."

"The Brahman breed has made a lot of progress in last 10 years, and now have better beef characteristics. Genestar has contributed to this and will be used. AACo Brahmans have done well in shortfed domestic market."

"Supermarket buyers use hump height as a gauge and accept cattle up to 50% *Bos indicus* content."

"However AACo's premium "1824" Brand beef is set using MSA standards and is usually derived from Santa Gertrudis X Angus cattle from Headingly, or Santa Gertrudis X Charolais cattle from Austral."

"Purebred Angus and Charolais bulls do poorly in the far north in their first year, and have a very slightly higher (0.5%) mortality rate than Santa Gertrudis bulls. After they have adapted they do well. AACo do plan to put European sires as far north as Lawn Hill (Barkly Tableland) to improve carcase quality of cattle turned off. "Genetics is the key to having efficient beef production in the north."

Steve Petty, Research and Development Manager of Heytesbury, commented "Cattle for domestic trade are bred in the Kimberly properties and the Barkly Tableland. Charolais and Charbray bulls are used to upgrade the Brahman females. They are still aiming at >50% Brahman content in these areas.

Victoria River area properties require 75% *Bos indicus* content due to the higher rainfall and humidity encountered. They therefore use a Charbray bull over the Brahman cows there."

"Specifications for cattle for live export are that they are tick-resistant breeds of cattle, tropically adapted, lean, no intramuscular fat, 300kg carcase at slaughter, perform well in tropical feedlot, robust, able to withstand the stresses of shipping and transport, white colour and high hump preferred as they resemble the Mongol type of cattle that are favoured in Indonesia and The Philippines.

Previous to 1980s the breeding herd were Shorthorns, and have been progressively upgraded to Brahmans over the last two decades. The breeders are now 7/8 to 15/16 Brahman."
Genestar is not used in their bull selection.

Heytesbury's long-term strategy is to maintain high *Bos indicus* content in breeding females while increasing *Bos taurus* content in the offspring to improve marketability.

They are not interested in developing composites, as these do not have the flexibility to change with changing markets. Crossbreeding is a better strategy, so they will continue to crossbreed using Charolais. Bull survival is quite good, although pure Charolais bulls don't survive as well as tropical breed bulls. To support the European bulls and crossbreds they give extra supplements to paddocks of cattle lower *Bos indicus* content."

Steve Millard, General Manager of Breeding and Genetics of NAPCo, ranks "crossbreeding" as the top strategy for controlling ticks in the future, and made the following comments:

"Composite cattle – Alexandria composite used for female herd, (50% *Bos indicus)*. Given tick fever vaccine before being sent into Gulf country. Only dipped if brought in for other management practices (i.e. once or twice a year). Tuli X cattle are used in far northern Gulf property Boomarra.

The advantage of African breed cattle over Brahmans is that the hump height is lower and situated further forward, yet they are tropically adapted, can handle hot humid conditions and are tick-resistant. Aim to get higher *Bos taurus* content into heifers for future breeding.

Composites are probably the best option for big companies, but crossbreeding probably more useful for smaller properties. Hotcross should be used on a demonstration farm and producers invited to come along and view the results of crossbreeding.
F1 cattle are generally strongest, best growing cattle but difficult to keep up supply, which is why NAPCo breed composites.

Hotcross – has great potential for beef producers especially along Queensland coast. More money should be put into developing it as a useful tool. It is a simple way to adapt to market demands and improve hybrid vigour.

EBVs – are very important but poorly appreciated by many producers.

Genestar – has great potential. Genetic Solutions, the company that made Genestar commercially available are assisting NAPCo with EBVs for composite animals.

Brahman breed – much potential to use genetic markers for tenderness and other meat quality characteristics, and increase market potential and flexibility. If meat can be packaged and aged then meat quality is fine, and ACC and Coles don't mind buying it.

Tuli Breed – undersold in Australia. NAPCo realised their potential and ability to do well in feedlots. They are tropically adapted but have better meat quality than Brahmans (according to research done at Clay Research Centre). Smaller than Brahmans but much more fertile."

Mark Perkins, General Manager of Livestock and Marketing of Colonial Agricultural Company, commented:
"Genetics – inside tick line all cattle are 100% *Bos indicus*. These are still turned off in feedlots. Live exports only account for a small portion of their turnoff, as there is more money to be made from getting cattle into the value adding chain.

Genestar – not a viable productivity tool yet as too many potential competing loci. Key indicator of performance is weight gain not meat quality."

MSA – initially this was punitive towards *Bos indicus* cattle, and this drives breeding policy to a degree. However it does open up pathways to improve meat quality of Brahmans e.g. aging, tenderstretch.

Colonial prefer to use crossbreeding for genetic gain rather than composites because it is simpler and allows more flexibility.

Bulls – Colonial breed their own Santa Gertrudis bulls, buy Charbray and Brahman bulls. They aim to breed towards fleshy beefy Brahmans. They pay the same price for Charbray bulls that give them more profit than Brahman bulls. Heifers 75% *Bos indicus* content are kept as breeders. They aim to get weight gain at a young age so they can turn cattle off quickly.

Trends – Uneasy about seeing *Bos taurus* cattle above tick line as it creates a susceptible population there that could lead to outbreaks of tick fever. Better to select for improved *Bos indicus* cattle."

Michael Hartman, from the Cattle Council of Australia made the following comments:
Cattle breeds – ABS census no longer includes breed information due to poor support for this information about five years ago. However Cattle Council believes this information is very important, especially for the issues of disease control and also for commercial reasons.

Gene markers – Cattle Council sees this as an important potential tool for both tick control and improving meat quality and strongly supported the Beef CRC.

Breedplan – it is a challenge for producers to provide the required data to validate Estimated Breeding Values for Breedplan, but some traits are very reliable and it is worth the effort.

Hotcross – a very good idea for small property owners, but as for other tools such as Breedplan it will initially be taken up by elite breeders and then later filter down to commercial users. It may need five years to get good uptake. It would be useful to apply in extension services.

Jay Simms, WQBRC, added – "Many beef producers in Queensland choose to stay outside the tick-endemic zone, and pass up opportunities to extend their interests east or north because they don't want to run cattle in tick country. This is because they want to use susceptible breeds of cattle and don't want the hassle of dealing with ticks. These people strongly support the government-backed tick line."

This observation is backed up by findings in the report by Greg Bortolussi, CSIRO Livestock Industries, Rockhampton, (see Section 8.1.5).

6.3.3 Regulatory issues

Darwin-based Northern Territory government veterinarian, Kel Small, commented on the industry in the Top End as follows: "the major problems for cattle producers in the endemic tick area are the regulatory issues associated with market access. This includes the requirement to be free of ticks to meet export certification and the need to be free of ticks to travel through tick free zones. The treatments carried out to meet regulatory requirements then create potential issues of residue problems".

Stuart Kenny, Executive Director of the Northern Territory Cattlemen's Association, made the following remarks about government involvement in tick control –

- Elliot yards and dip were intended to be the clearing dip for cattle crossing the tick line. Now that the tick line has shifted cattle need to travel 200km through clean country before they can be dipped, creating a biosecurity hazard in the case of escaped cattle.
- NTCA maintained the yards for the last ten years but have handed back control to the NT government because NTCA members feel that it is government responsibility to maintain the tick line.
- Support government regulations on controlling ticks on properties identified with Parkhurst strain.

Mark Perkins of Colonial Agricultural Co., commented: "Tick line – State government (Queensland) policies have improved, with privatisation of inspection points the service has become more flexible and businesslike. Colonial are not concerned about the quality of inspection as they are monitored. Most graziers (90%) do the right thing and support tick line. If there was an effective tick vaccine it wouldn't matter if the tick line was lifted."

Ben Madin, District Veterinary Inspector, Broome, Western Australia, commented: "there had been a tick outbreak outside of the tick line in the Karratha region several years ago. This had probably been due to the transport of uninspected cattle across the tick line. Due to fairly dry conditions in this area the properties involved were cleared of tick within a couple of seasons."

Ben also reported that there are frequently small outbreaks of tick fever on northern properties, but that these are not officially reported or diagnosed due to the fact that an outbreak disqualifies a property from live export of cattle for a period of twelve months. He hears about the outbreaks "on the grapevine", even though there is no official notification.

This observation is consistent with anecdotal reports from the Northern Territory that there are frequent small (and occasional large) outbreaks of tick fever in Top End properties, these are not reported due to the repercussions for live export.

It has been reported that there is often a social stigma attached to properties that have suffered an outbreak of tick fever[10].

Ruth Webb-Smith, Executive Officer of the Western Australian Pastoralists and Graziers Association, and the Kimberleys' regional representative of the Association, commented: "The tick problem in WA is generally seen to be "under control". The major issue is regulatory control of the tick line, to ensure that ticky cattle are not brought south below the tick-endemic area."

Edgar Richardson, Policy Officer of the WAPGA, stated: "Producers do not generally treat cattle for ticks, except to allow for tick free cattle to be exported. Tick fever vaccine is given to cattle as they are prepared for boarding the ship for live export."

Chris Mayberry, Senior Veterinary Officer in Western Australia, commented: "In Western Australia, tick control in endemic areas is not high on the list of priorities for cattle owners. Thus, the Department has very little input in to the area and does not have reliable data to use to answer the questions.

We have to assume that the options are funded and implemented by industry. Cattle tick control per se in Western Australia fails the test of public good investment."

Steve Millard, NAPCO: "Regulation – Need auditors to check the work of private (3rd party) tick inspectors as they could become lax."

Jay Simms, Chairman of the Western Queensland Regional Beef Research Committee, "Producers are not confident about the use of third party inspectors, we felt better when the QDPI ran all inspections. The new inspection system should be audited and results made public to build up faith in the system."

6.3.3.1 Northern Territory resistant tick control strategy

The officers of the Northern Territory government's Department of Business Industry and Resource Development (DBIRD) are involved in enforcing the quarantine and treatment of ticks on cattle from affected properties in the Darwin region. This maintains free movement of cattle to WA because the WA government know the problem is being controlled within the NT.

Parkhurst ticks introduced from Qld in 1997, spread to about 12 properties in the Darwin area. The survival times of larvae on the ground are very extended due to the moist, lush conditions. Affected properties were identified using a DBIRD survey of ticks (see the report in Appendix 15) and a permit had to be obtained for stock, which then had to have a supervised dip, after being presented to the weighbridge.

It is thought that live exporters using Bayticol PO exacerbated the Parkhurst tick problem, but the recent re-introduction of Bayticol PO for live export cattle will not affect Australian ticks. Most producers who previously used Bayticl PO are now plunge dipping their stock with Amitraz. If Ulam or Ultimo ticks are introduced further problems may be anticipated.

6.3.4 Extension

Mark Perkins of Colonial, commented about extension: "(we) prefer extension to be done by industry or private consultants not by government as govt. extension can hinder progress."

Michael Hartman, Cattle Council, said: "Extension programs –

- Should focus on issues of acaricide resistance and provide information that farmers can use to protect themselves against economic loss.
- Farmers who pay for a consultant value the advice more than that given free by a government extension officer
- However many farmers still expect extension advice to be provided free
- The approach by MLA's "More Beef from Pastures", where advisers and consultants are targeted first and encouraged to then relay the information to farmers is a good development.
- Farmers are already overwhelmed by the need to educate themselves in many different topics including OH&S, management, financial matters, environmental concerns, animal welfare, QA programs, agronomy etc."

6.3.5 Chemicals

Peter Hall, beef producer of Hughenden, and Agforce representative on Cattle Tick Management Queensland Steering Committee, comments: "(I) can't see any real benefits in controlling resistant ticks. Resistance to tickicides is brought about by misuse of chemicals or ignorance about how to use chemicals properly. This could be alleviated by better education of producers, or producing alternatives to chemicals so that exposure to chemicals is reduced. It is important to listen to consumers, who are saying that chemical use should be reduced to minimise potential risk from residues. "

Kel Small, Regional Veterinary Officer in Darwin, commented: "In NT most dipping is done on an opportunity basis due to large herd size. Producers still use traditional dips rather than Acatak or MLs. However some properties on edge of tick area have attempted eradication using Acatak and paddock rotation, which was not successful."

Mark Perkins, Colonial, referred to chemicals: "Dips used in the Gulf country to treat cattle twice before they leave the property. This enables them to be expedited through the tick check.
Dectomax injectable is used to treat weaners, this gives them protection against internal parasites as well."
They use injectable product instead of pour on for OH&S reasons.

6.3.6 Tick fever vaccine

Geoff Wagstaff of AACo, commented on the use of vaccine: "frozen vaccine used exclusively on AACo properties. It is more convenient to store and flexible to use."

Steve Millard, NAPCo, said of tick fever vaccine: "NAPCo only use TF vaccine on three northern properties, Mittiebah, Boomarra and Coolullah. Cattle from Gulf Country (Boomarra and Coolullah) are cleared of ticks at Cloncurry before proceeding to grower properties in Western Queensland."

Mark Perkins, Colonial, commented on their policy towards tick fever vaccine: "Colonial only have one property on the boundary of the ticky area. All cattle going onto ticky country are blooded (given TF vaccine before moving). Use frozen vaccine, not worried about biosecurity."

6.3.7 Tick vaccine

Steve Millard of NAPCo comments: "If a tick vaccine were available then a two–three-year persistence would be preferred. They would definitely use an effective tick vaccine even if it were high-priced. Will not use any vaccine such as TickGARD Plus which has frequent vaccination intervals."

Mark Perkins of Colonial, commented on tick vaccine: "If there was an effective vaccine with an annual booster this would be very attractive. If there was an effective tick vaccine it wouldn't matter if the tick line was lifted."

Jay Simms added: “An effective tick vaccine with an annual booster would be the ultimate answer. Anything that requires more frequent musters wouldn’t work in Northern Australia.”

6.3.8 Integrated Pest Management

Ben Madin of WA Dept. of Agriculture, in Broome, passed on comments from a beef producer on the Fitzroy River, who observed a noticeable decline in tick populations on cattle as the stocking rate was decreased. They commented that this could have been due to the animal’s body condition and would welcome research to be done on this topic. This producer ranked IPM measures as a high priority for research, along with gene markers, biopesticides and tick vaccine. Regulatory programs such as eradication, compulsory vaccination, notification and control of resistant ticks were ranked lowest.

6.4 Discussion

The northern producers, regulators and veterinarians surveyed in Phase II of this study had slightly different priorities to the regulators and researchers interviewed in Phase I, as revealed by their responses to the survey questions and comments in interviews. However, both groups showed broad support for crossbreeding and were interested in research into vaccination against ticks, indicating that they felt both these measures would be easily implemented and efficacious, and would probably have the greatest benefit to producers.

The least favoured strategies of northern stakeholders were those requiring regulatory intervention, such as compulsory vaccination and eradication, while measures to prolong the lifespan of existing acaricides, such as research to slow acaricide resistance and controlling resistant ticks, also scored low.

There appears to be a lower level of concern about ticks among northern producers compared to beef producers in the southern part of Queensland and in northern NSW. This is probably largely due to the adoption of tick resistant breeds of cattle in the north, and the fact that the tropically-adapted cattle perform better in the high rainfall and temperatures of the tropical regions.

7 Interviews with regulators and industry bodies

7.1 Australian Pesticides and Veterinary Medicines Authority

The Australian Pesticides and Veterinary Medicines Authority (APVMA) is a government-controlled authority funded through levies paid by veterinary and agricultural product manufacturers. The role of the APVMA is to oversee the registration of all products intended for therapeutic or production use for plants or animals.

On 23 February 2005 a meeting was held in Canberra between Matt Playford and Ahmad Rabiee representing Strategic Bovine Services, and Elizabeth Milbourne, Judith Platt and Cheryl Javro of APVMA to discuss the regulatory barriers for the registration of new acaricides, and the possibility of new acaricide registration requirements being reviewed. Jonathan Taylor, manager of the Parasiticides Section, had initially committed to conduct the meeting but was unable to attend due to conflicting appointments.

Summary

- Registration requirements for efficacy and residue trials for acaricides are set by the APVMA with consideration of local conditions and trade requirements. The current guidelines for *Boophilus microplus* treatment were established in 1996 after extensive industry consultation. The guidelines are loosely based on pre-existing international guidelines.
- As of 2001, new regulations were put in place requiring all efficacy and safety trials to be conducted to GCP standards, and residues trials to be performed to GLP standards.
- This means that the cost of trials is much higher today than it was in 1996, when these guidelines were set out.
- Veterinary pharmaceutical manufacturers need to assess the cost of performing trials and other costs of registration, and weigh them against the potential sales of a new product. APVMA are not concerned with the cost of registration or products.

7.2 Animal Health Australia

Animal Health Australia is a member-funded non-government organisation which acts to coordinate plans to prepare for Emergency Animal Disease. All state governments and most industry producer bodies are members. It was suggested by MLA that AHA may be a suitable forum for coordinating policy and setting research priorities for cattle tick control.

Matt Playford interviewed Dr. Peter Morecombe, technical manager of AHA by telephone.

Major points

1) Animal Health Australia wants to restrict its activities to Emergency Animal Disease preparedness. The only exception to this is the coordination of Johnes Disease control, which was initially intended to be an eradication program.
2) Endemic diseases such as cattle ticks and tick fever are left to state governments.
3) If states wanted AHA involvement in ticks they could make a formal submission.
4) The aims, objectives and funding would need to be determined before AHA could proceed.
5) The four jurisdictions involved would need to agree that AHA coordinate a national management plan.
6) Initially, present plan to the cattle industry and see if there is a favourable response. If requested then AHA board would consider the proposal.
7) State governments would still have legislative power and responsibilities.
8) While there is potential for AHA to coordinate regulation and advice on a national basis, it is unlikely at this stage.

Summary
There are potential benefits in co-opting the expertise of Animal Health Australia in coordinating plans for tick control in northern Australia. Implementation would require formal submission from the four state and territory governments, and funding from the cattle industry. None of these bodies has expressed such an interest previously. If this matter is to be pursued MLA will need to make a proposal to the four state and territory governments and to the industry bodies concerned, then approach AHA after a favourable response has been gained.

7.3 Biosecurity Australia

Biosecurity Australia is a division of the Australian Quarantine and Inspection Service (AQIS), which in turn is a division of the Federal Department of Agricultural, Fisheries and Forestry. BA is responsible for ensuring that requirements stipulated by importing countries are followed.

Dr. Judith Bourne of Biosecurity Australia in Canberra was interviewed by telephone on 18 February 2005, to ascertain AQIS' current policies on ticks for animals being exported live.

Until 2005 it was mandatory for all cattle shipped live into Indonesia to be vaccinated with Tick Fever vaccine. This was often performed just before the animals were boarded.

On 18 January 2005, the Indonesian Director General of Livestock issued a statement permitting cattle that had not been vaccinated with tick fever vaccine to be imported into Indonesia. This was not immediately implemented, and as of 18 February 2005 the policy had not been posted on the Indonesian government's website.

Biosecurity Australia was committed to working with the Indonesian government to trial shipments of cattle that had not been vaccinated with tick fever vaccine. The object of the trial is to see if unvaccinated cattle destined for feedlotting in Indonesia could perform as well as vaccinated cattle. Cattle would be monitored and any incidence of tick fever reported. These trials are ongoing.

8 Tick control strategies

8.1 Genetic approachers

The introduction of tick-resistant breeds, crossbreeding, and selecting for tick resistance within a breed have been used to great effect in the northern beef industry over the last fifty years[11]. More recently, the identification of genetic markers may allow breeders greater options to select for desired traits, such as marbling within tick-resistant breeds, or for tick-resistance in *Bos taurus* breeds.

8.1.1 Breeds

Tick-resistant breeds of cattle were the subjects of experiments by Australian beef producers as early as the late 19th century. However, little progress was made until federal government funding and CSIRO research led to trials by a syndicate of private beef properties in Queensland. Ralph Kelley travelled to the United States during the 1930s to investigate and procure suitable breeding stock[83].
Due to its inherent resistance to ticks and tolerance of tropical temperatures, the Brahman has become the dominant breed of cattle in Northern Australia[12]. However, pure *Bos indicus* breeds such as the Brahman have lower reproductive efficiency[13], flighty temperament, and lower meat quality than traditional British breeds used in the southern beef industry[13].

Because of this, substantial effort has been directed towards crossbreeding, and selection of *Bos taurus* strains for tropical conditions. The Belmont crossbreeding project undertaken on behalf of the MLA (Project CS183a) examined performance indices involving growth traits, adaptive traits and temperament, fertility and survival traits, and carcase quality traits. A total of 31 genotypes were examined, derived from tropically adapted British, Sanga, Zebu cross, Zebu and Continental breed groups[14].

In trials conducted between 1991 and 1997, purebred ZebuXcrossbred Zebu animals had the lowest mean tick counts (9.5), followed by BritishXSangaXZebu (9.9) and ZebuxZebu with 10.3. Meanwhile Zebu ContinentalXSangar animals had the highest recorded counts (34.7), followed by the tropically adapted *Bos taurus*, Belmont Adaptaur (HerefordXShorthorn) with 29.1. In general, as the Zebu proportion in the cross increased, ticks decreased, while in F1 backcrosses, lowest tick counts were seen in animals with Zebu content >75%.

This report also noted that even in resistant genotypes, at least 20% of animals can be categorised as lowly resistant or susceptible, so that tick resistance gains can be made within a genotype by identifying and culling these individuals and selecting highly resistant males as sires of the next generation.

Markets – A trend driving breed selection in the northern beef industry is the requirement for most organisations importing Australian live cattle for 50% *Bos indicus* content. This means that apart from the domestic market requirements, producers aiming to export live cattle need to continue using high levels of *Bos indicus* genetics[15].

Breed loyalties – Introduction of the Brahman breed to northern Australia, was very slow due to concern about the “mongrelisation” of British cattle breeds[83]. This is despite the use of tick-resistant cattle in the United States since 1849. Uptake of *Bos indicus* in Australia’s north was slow, and required convincing trials conducted by CSIRO at Rendel, Belmont, and other research stations. Widespread acceptance of *Bos indicus* cattle did not occur until the 1970s. Commenting on a report conducted in Queensland in 1977–78, Elder notes that “Zebu” cattle had been introduced widely into the extensive grazing country of Northern and Central Queensland, but that “In south-eastern Queensland acceptance of tick-resistant cattle has been slower because producers believe they are more difficult to manage than European cattle”. [16]

This breed loyalty is even stronger in the dairy industry. During the 1960s and 1970s the Queensland Department of Primary Industries and CSIRO cooperated in developing tick-resistant dairy cattle. However, in Queensland the use of these tropically adapted breeds such as the Australian Milking Zebu (AMZ) and the Australian Friesian Sahiwal (AFS) is almost negligible. Some semen for AFS is available and programs to buy calves from farmers willing to rear them in order to export them to Southeast Asian countries have been implemented.

The higher production of Holstein-Friesian, red breeds and Jersey cattle commonly used in the Queensland dairy industry has precluded adoption of crossbreeds. Producers were also concerned about the poor temperament of these animals (see Appendix Four).

Economic return – The infusion of *Bos indicus* genes into the northern Australian cattle herd over the last 30 years has been extremely economically beneficial[17]. Farquharson reports the investment of A$340m in beef genetic improvement over this time, with a net benefit of A$11bn, 90% of which he attributes to the infusion of *Bos indicus* cattle[18].

8.1.2 Meat quality

Research in Australia and the USA focused on the benefits of using *Bos indicus* cattle to achieve effective tick control without the use of chemicals, and Brahmans and their crosses became the dominant breed in northern Australia by the 1980s[83]. Meat researchers agree that meat quality suffers due to *Bos indicus* content[19]; "As *Bos indicus* content increases, palatability decreases"[19]. Further, "Most reports from the USA on meat quality of *Bos indicus* cattle show increasing proportion of *Bos indicus* content to be associated with decreased tenderness and increased variability"[21]. However, these studies rarely used effective electrical stimulation, or tenderstretch methods, to control cold shortening. When appropriate post-slaughter processing was used, sensory palatability was similar for *Bos taurus* and *Bos indicus* cattle and their crosses[20].

Meat standards Australia – Means of offsetting the breed effect of *Bos indicus* on meat quality have undergone considerable research in Australia[21]. In recent years, Meat Standards Australia included *Bos indicus* content in their grading system, so that other factors being equal, cattle with higher hump height indicating *Bos indicus* content are downgraded[22]. Guidelines are provided for producers to assess cattle for percentage *Bos indicus* content or "Tropical Breed Content (TBC)"[23].
As a result, many northern beef producers are contemplating whether to decrease the *Bos indicus* content of their cattle, or manipulate carcase composition in other ways to gain premium prices for beef quality.

Gene markers – Markers for the marbling potential of beef have been identified and commercialised. Many bulls available for sale or which have semen available in Queensland have their GeneSTAR score clearly displayed[24]. Dr. Bill Barendse of CSIRO Livestock Industries St Lucia provided the following information about the patent status of these markers:

Barendse, W. 1997. Assessing lipid metabolism. Patent WO9923248 Patent US6383751 (Patent Application PCT/AU98/00882). <http://ep.espacenet.com/>

Barendse, W. 2001. DNA markers for meat tenderness. Patent WO02064820 (Patent Application PCT/AU02/00122). <http://ep.espacenet.com/>

These references are available on the Internet. A technical publication in the *Australian Journal of Experimental Agriculture* on the gene marker, TG5 – i.e. GeneSTAR marbling will appear shortly.

Cost of testing – Christian Duff, Technical Officer at Tropical Cattle Technology Services, Rockhampton, said that the cost of the test to the farmer is about $90/head for individuals, or about $66/head if done through a breed society. The benefits for producers purchasing bulls or semen are not quantifiable at present, but producers or stud breeders do not want to run the risk of buying bloodstock or semen with a zero score.

Christian stated that the post-slaughter methods of improving meat quality have had a high uptake in northern Australia, with Tenderstretch and ageing being used to counter the perceived negative influences of *Bos indicus* content (hump height) and the use of Hormonal Growth Promotant implants.

Feedlot specifications – Companies managing feedlots specify the breed characteristics of the cattle being fattened in the feedlot. An example is the requirements for cattle specified by Elders for intake in their feedlots (see Table 5.1 below). It is clear that more opportunities exist for British and crossbred cattle to be finished in feedlots than for *Bos indicus* breeds. Figures kept by ALFA indicate that approximately half of the cattle in Australian feedlots are destined for the Japanese export market, while about 40% go for domestic consumption.[25]

Table 8.1: Elders' specifications for feedlotting cattle, including breed requirements. Taken from http://livestock.elders.com.au/custom_feed.asp#spec

Market	Time on Feed	Breed	Induction weight	Sex	Frame
Domestic	70 days	British and British X	300–350kg	Mixed	Medium
Taiwan	70–100 days	British and British X	300–350kg	Mixed	Medium
Korean	100 days	British and British x *Bos indicus*	420–500kg	Steers	Large
Japanese	100–120 days	British and British x *Bos indicus*	420–500kg	Steers	Large
Japanese	150–180 days	British, British x *Bos indicus*	420–500kg	Steers	Large
Japanese	220–300 days	Angus, Murray Grey, Wagyu	380–470kg	Steers	Large

8.1.3 Genetic markers for resistance and meat quality

Visible markers, such as the hump of the *Bos indicus* cattle, have long been used as markers for tick resistance, as well as for heat tolerance and ability to survive on poor tropical pastures. However, more recent genomic work identified genes that can be used to select bloodstock for improving resistance to ticks. Some physical features, such as thermotolerance and grooming ability due to dexterity, are thought to confer tick resistance in *Bos indicus* cattle. These features may not be amenable to be transferred to other breeds[26].

Dr. Bill Barendse of CSIRO Livestock Industries St Lucia has been funded by Dairy Australia to identify resistant genes. He has collaborated with Lex Turner of QDPI and F Mutdapilly, who has been responsible for monitoring tick numbers on cattle in field trials. Three gene regions have been identified that correspond to tick resistance, two from Brahman and one from Tickmaster. These are currently being trialled in over 5,000 head of cattle, at Belmont Research Station, Rockhampton, in the northern beef herd, and in 1,500 head of dairy cattle in southeast Queensland.

8.1.3.1 Aim of using genetic markers

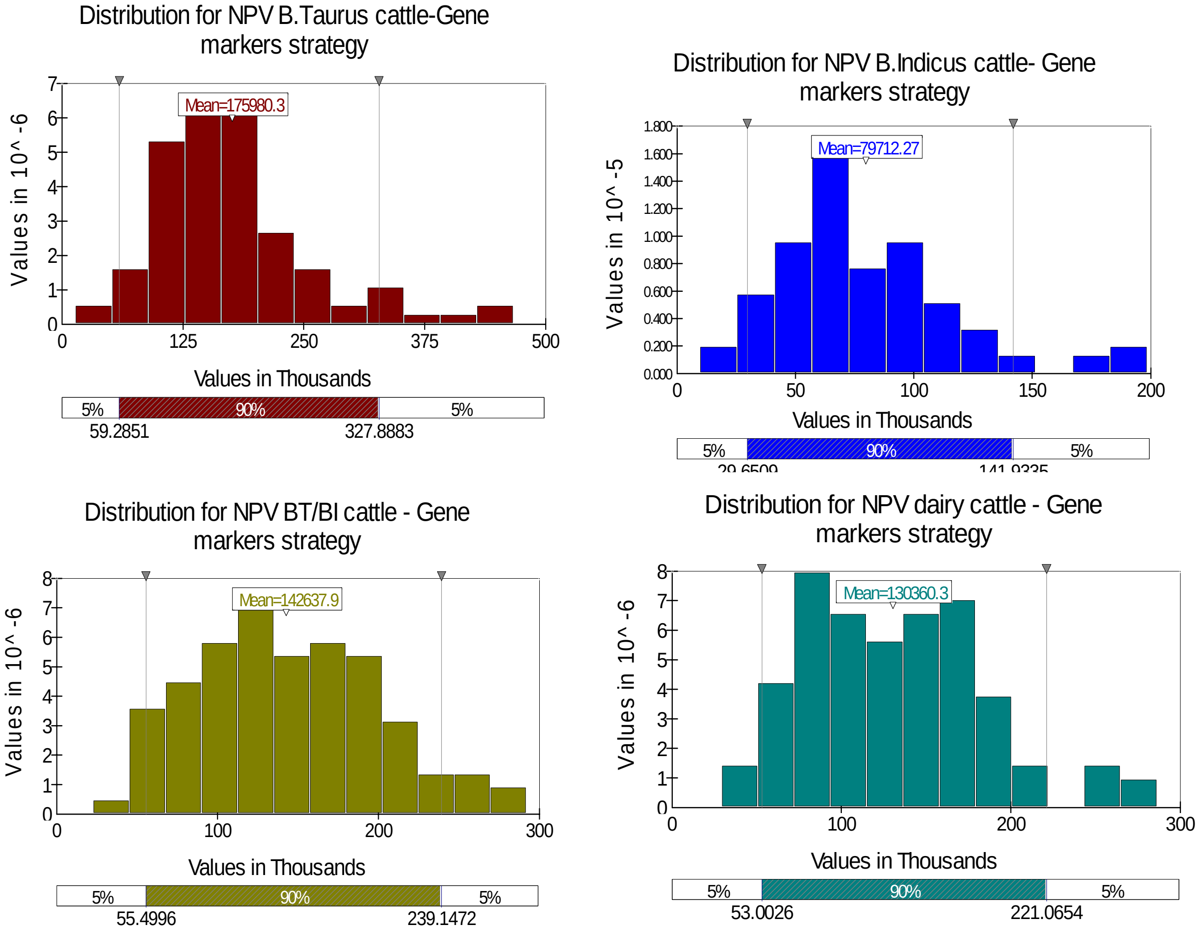
The research is designed to establish a diagnostic test for Single Nucleotide Polymorphisms (SNIPs). Ultimately, farmers would take a hair sample from the tail of cattle and send it to the laboratory for testing. The test would establish whether cattle had high, medium or low resistance status. Validation of these markers is necessary to ensure that these confer higher resistance to ticks, and are not negatively correlated with other important traits for production and disease.

Dr. Barendse's estimates are that 75% of the benefits would apply to the beef herd and 25% to dairy. He reports that tick resistance has a moderate to high heritability (0.4–0.6). In future, sellers of semen or bulls for use in northern Australia may be able to use a grading system to show the tick resistance status of the animal, similar to that for marbling (see above, GeneSTAR).

8.1.3.2 Economic modelling of gene marker benefits

Strategy outline – **"**Develop genetic markers to identify tick resistant traits, use to develop lines of commercial cattle with superior carcase characteristics, commercialise for producers"

Figure 8.2: Net Present Value of gene markers in four classes of cattle



Gene markers ranked second highest of the thirteen strategies assessed by the economic model for *Bos indicus* cattle, fourth for crossbred cattle, sixth for *Bos taurus* and seventh for dairy. The mean value for NPV was similar across all breeds. For details of the economic model see Chapter Nine.

8.1.4 Breed trends

As discussed above, *Bos indicus* animals have become the dominant breed in northern Australia. Glanville (2003) estimates that in Queensland 80% of beef cattle are *Bos indicus* or *Bos indicus* cross[43]. However the desire for higher meat quality may promote a trend towards *B taurus*, motivated by the MSA grading system which downgrades animals with a higher hump.

Observations – Sandi Jephcott, consultant of Fernvale, QLD, reported that northern beef producers such as AACo and NAPCo are no longer relying on purebred *Bos indicus* cattle. Santa Gertrudis cattle (5/8 *Bos taurus*) are being crossed back to composites. The remaining properties belonging to Stanbroke Pastoral Co. are using crossbreeding to maximise heterosis and improve carcase quality. They are infusing European genetics into their herds by buying Charbray bulls. *Bos indicus* content of these animals varies from 50% to 30%. Other northern beef producers, such as Heytesbury and Consolidated, still use Brahman cattle. Kidman use Shorthorn cattle, except for at the Victoria River Downs station in the Northern Territory, where they use Brahman. Colonial use crossbreds but still have a high *Bos indicus* content. Smaller properties in the northern regions are still using mainly *Bos indicus* content. Sandi remarked that MSA grading is the main driver of breed change in northern Australia.

Reliable figures – on the makeup of the northern beef herd are not available, but breed society, ABARE, bull sales, ARCBA figures and an academic study (see below) can give some insight into current trends.

For details of the breeding programs of northern Australian beef cattle producers see Section 6.3.

8.1.4.1 Angus Society

The Angus Society of Australia publishes a summary of sales of bulls in the eleven major breeds (see Appendix Six). Sales of bulls nationally over the last three years show that of the bulls sold in 2002 and 2003, 17% were tropical breeds, whilst in 2004 (to 23 August) only 9% were tropical breeds. The 2004 figures do not indicate a trend towards higher sales of British and European bulls[27].

8.1.4.2 ABARE

The following table was published in the "ABARE Australian Beef Industry" report in 2001[28].

Table 8.3: Percentage composition of the Australian beef herd by major breed at 30 June

Breed	1990 (%)	1994 (%)	1997 (%)	2000[p] (%)	Relative S.E.
Hereford	26.7	22.1	19.7	11.2	(9)
Angus	4.2	5.7	9.0	9.1	(16)
Other British breeds	11.2	6.8	6.5	5.8	(22)
European breeds	3.1	1.3	0.6	2.1	(23)
Brahman	8.8	13.4	17.4	13.2	(13)
Santa Gertrudis	2.8	3.8	5.2	5.0	(20)
Other tropical crosses	6.3	4.0	4.6	6.2	(19)
British/European cross	7.4	5.2	4.2	5.5	(11)
Indicus/taurus cross	22.8	19.2	14.6	26.4	(26)
Other[a]	5.5	8.9	7.1	4.6	(22)

a Includes dairy breeds used for beef production and dairy-beef cross cattle
p Preliminary estimate

This table shows that *Bos indicus* breeds, including crossbreds, increased from 40.7% of the national herd in 1990 to 50.8% of the national herd in 2000.

8.1.4.3 Australian Registered Cattle Breeders' Association

ARCBA publishes a report to members detailing the number of registered cattle in each of the breeds of member societies. Note that only a small percentage of the national herd is registered (stud) cattle.

Table 10.1 (see Appendix Seven) details trends in the numbers of registered cattle in each of the breeds between the years 1992–2003. These figures indicate that tropical breeds made up 25.8% of the registered national herd in 1992, remaining at 24.8% in 2000, then declined to 23.3% by 2003. British breeds made up 57.1% of registered cattle in 1992, peaked at 63.8% in 2001, and in 2003 represented 61.6% of the registered herd. European breeds peaked at 18.1% in 1995, and have since declined to 13.8% of the registered herd.

8.1.4.4 Bull sales records in 'Queensland Country Life' newspaper –

No clear trends can be detected from records of bull sales in Queensland for 2003 provided by the Queensland Country Life newspaper. In fact, reports indicate that bull sales for tropical breeds have continued to be extremely healthy, as evidenced by the report (below), from the Queensland Country Life newspaper, 4 December, 2003.

> "**$26.5m from stud bull sales in Qld**
> Thursday, 4 December 2003
>
> A strong commercial market for store and prime cattle has helped offset the effects of drought in Queensland to deliver another solid result for the 2003 bull selling season.
>
> When the hammer dropped on the final Brahman sale of the year at Charters Towers on Friday, more than 9000 registered and herd bulls had changed hands through the auction system.
>
> The big breed winner for the year, based on average prices paid at sales in Queensland, was Santa Gertrudis, selling 1431 bulls for an average price of $4330.
>
> Santas were the only breed to record a significant rise on last year's results, up about $250.
>
> The six largest breeds were analysed by "Queensland Country Life".
>
> When combined, they represented total sales of 6947 bulls and these six breeds reaped a $26.5 million reward from auction sales of bulls in 2003, down a little from $29m last year.
>
> Clearance rates at many sales this year were up, with substantial breeds like Droughtmasters and Santa Gertrudis recording clearances of 86pc and 88pc respectively.
>
> In terms of sheer numbers of bulls sold, Brahmans continue to dominate the Queensland landscape, selling 2632 bulls this year – close to double the next largest breeds, Santa Gertrudis (1431) and Droughtmasters (1240)"

8.1.5 Academic study

In a report on the northern Australian beef industry, Greg Bortolussi of CSIRO Livestock Industries, Rockhampton, examines the breed composition of northern herds over a five-year period in the mid-1990s[29]. Three hundred and seventy five producers in eight regions were surveyed. The author comments that beef producers in Queensland, the Northern Territory and Western Australia used breeds that met their market aspirations. British breeds and *Bos indicus* cross were much more common in the tick-free areas of Queensland (unweighted average of two tick-free areas 23.5% versus 10.8% in six tick-endemic areas), while pure *Bos indicus* cattle dominated in the six tick-endemic areas (unweighted average 54.5% versus 16.5% in the two tick-free areas). Climatic conditions, such as rainfall and humidity, may account for some of this variation. However, the fact that beef producers chose lower *Bos indicus* content in the absence of ticks probably reflects greater market flexibility for British breeds or their crosses compared to pure *Bos indicus* cattle.

8.1.6 Selection versus crossbreeding

Use of crossbreeding to obtain optimal performance from beef cattle in terms of production, welfare and economic return, has been addressed by many Australian researchers[30]. Selection within a herd can be used to obtain tick-resistant animals, as studies have found that 1% of *Bos taurus* cattle, 45–60% of crossbreds and 95% of Brahman cattle are highly resistant[12]. It was this principle that allowed the development of the Belmont Adaptaur line of *Bos taurus* cattle.

However, due to the relative ease of introduction of new genetic material compared to selection within a herd, as well as the cost of co-selecting for uneconomic traits, crossbreeding has been widely embraced by Australian beef producers wishing to improve tick resistance in their herds[1]. Seiffert (1984) detailed the process of selection for tick resistance within a breed, but commented, "Although the technologies for selecting cattle for increased resistance to the cattle tick have existed for some time and their effectiveness demonstrated under research station management, they have not yet been widely adopted."[11]

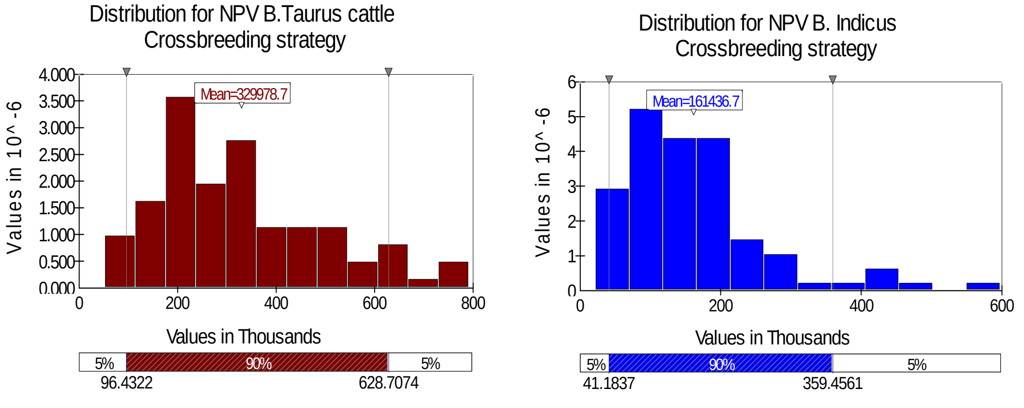
There is little selection for tick resistance in the field because cattle need an average tick burden of 100 ticks per side in order to see a difference between cattle. Because these conditions are rare in the field due to seasonal variation, practical difficulty of counting, and variation in counts between individuals counting, the chance of success is low.

An outcome of the Meat Quality CRC in 1997 was the production of a decision support software package called "Hotcross". Different combinations of cattle genotypes can be compared based on the individual circumstances of the property with regard to parasites including ticks, and climate[31]. This addressed the fundamental issues involved in crossbreeding, but had some limitations. These are being addressed in a new version of the software currently being developed[32].

8.1.7 Economic modelling for crossbreeding

Strategy outline – **"**Develop tick resistant cattle breeding programs to produce stock with carcase characteristics and reproductive indices similar to British breeds, and make these breeds available to commercial producers. Develop and promote software to help with critical breeding decisions."

Figure 8.4: Net Present Value for crossbreeding strategies used in *Bos taurus* and *Bos indicus* herds



This figure shows the Net Present Value of crossbreeding strategies when applied to both *Bos taurus* and *Bos indicus* herds. Crossbreeding represents the most economically beneficial of the thirteen strategies assessed by the model for *Bos indicus*, and ranked third for *Bos taurus.* However, the mean value of a crossbreeding strategy was twice as high for *Bos taurus* (A$329,979) as for *Bos indicus* herds (A$161,437). The results of crossbreeding for dairy cattle are not presented here, but if milk production could be maintained, the economic model projects that this would give an economic return of A$221,649, making it the top ranked strategy for dairy. For details of the economic model see Chapter Nine.

8.1.8 Discussion

Bos indicus breeds have been adopted in northern Australia due to their tick resistance and general hardiness in tropical climates. It is estimated that up to 80% of the northern beef herd now contains *Bos indicus* genetics[43]. This adoption has led to substantial gains in productivity and boosted the Australian economy by billions of dollars[18].

However, as the domestic market for beef becomes more sophisticated, and overseas markets continue to gain importance, disadvantages in carcase value and fertility compared to temperate breeds become more important. The introduction of temperate breeds to tropical and subtropical Australia is hazardous, as cost of acquiring quality bulls or females is high, while the survival and fertility of these animals in tropical conditions are low[32]. This illustrates the limitations of simple crossbreeding methods.

Research to improve meat quality in northern Australian cattle will therefore need to focus on tropically adapted cattle with improved carcase traits. Work from previous research at the Beef CRC suggests that a high grade composite is the solution offering the greatest benefits[14].

Despite the fact that many sources have commented on the increasing trend towards *Bos taurus* breeds in the northern beef industry, the evidence presented above shows that there is no clear trend either way. Statistics provided by MLA, ABARE, State governments and ABS currently do not include breed composition.

Trends in world trade indicate that Brazil will increase beef exports, but will supply mostly low-grade meat derived from *Bos indicus* cattle[33]. There will continue to be demand for live export of *Bos indicus* cattle to Southeast Asia and the Middle East[34]. The key markets for high value beef (where traits such as marbling and tenderness are required) will be Korea and Japan. These are especially important as half of these countries' beef imports in the past decade have been supplied by the USA, which is currently unable to supply export beef due to the discovery of Bovine Spongiform Encephalopathy in that country. Even if exports resume, demand for high-grade Australian beef in these countries will continue.

It is essential, therefore that northern Australian beef producers have access to the results of genetic research that will maximise meat quality and carcase value. Research should also focus on improving fertility in *Bos indicus* breeds and their crosses, and improving the safety of workers handling them.

Dr. Bob Sutherst commented that since the presence or absence of a single gene is only an indirect indicator for resistance, and since genes selected may be linked to deleterious traits, gene markers may not be a useful means of improving tick resistance status of cattle.

While there is clear merit in using *Bos indicus* cattle and their crosses for tick control, failure to address meat quality and productivity issues will result in exposure to several risks.

1. Markets – increased competition from other countries such as Brazil, threats to the live export market due to welfare or political concerns, and re-entry of the USA as a beef exporter will result in pressure on prices of low-grade *Bos indicus* beef. Detection of tick fever in exporting herds could block access to live export markets. Producers of high-grade crossbreds and composites will have greater options for marketing, including finishing in feedlots.

2. Animal welfare – introduction of temperate breeds in tick-endemic zones by producers seeking to improve meat quality could lead to unacceptable losses from tick damage, buffalo fly and tick fever, if these animals are not acclimatised and managed correctly. Adverse public opinion could lead to restrictions on management practices or result in loss of markets (see below).

3. Productivity – despite productivity gains over recent years, low branding percentages and high death rates are prevalent in northern beef production, with branding rates up to 20% lower than southern Australia, and average death rates over 10% being recorded[35]. Other potential problems with using single breeds are low growth rates of calves and low fertility of females[13]. Minimising these losses should be an aim of crossbreeding programs, and programs to maximise heterosis would greatly assist producers make breeding decisions to improve productivity.

8.1.9 Summary

The use of resistant cattle and crossbreeding are the most important means of tick control in northern Australia. Recent comments that *Bos taurus* content of the northern beef herd was increasing were backed by comments from representatives of the northern pastoral companies. However, risks exist to the northern cattle industry due to loss of markets, low productivity and concern over the welfare of cattle. Gene markers show promise to allow selection for tick resistance within a herd or within a breed, a technique that has long been possible but has not been widely adopted due to practical difficulties.

The Beef CRC, with multiple points of investigation including heterosis, meat quality, temperament and adaptation to environment, addresses many major issues influencing the profitability of northern beef enterprises.

8.2 Regulatory approaches

8.2.1 Regulatory controls

Both federal and state laws are used in various ways to control registration of chemicals, use of chemicals, movement of cattle and inspection of cattle.

The major regulatory input into tick control is restriction on the movement of cattle depending on their place of origin. Cattle moving from the tick-endemic zone to the tick-free zone are dipped, inspected and, if found to carry ticks, held and re-treated until declared free of ticks. Only then are they permitted to travel into the tick-free areas. Dips and gates are located along the Tick Line, a line dividing the ecological and epidemiological extent of the tick's habitat, which roughly tracks several hundred kilometres parallel to the coast of Queensland, before turning west to run along the Townsville–Mt Isa railway line, across the middle of the Northern Territory, and the top corner of the Kimberley region (see Appendix Five).

8.2.2 Registration of acaricides

The registration of veterinary chemicals in Australia is administered by the Australian Pesticides and Veterinary Medicines Authority (APVMA). The APVMA's guidelines for registration of new tick products are comprehensive and were agreed upon after consultation with the research and producer communities. However, they have been widely criticised as being too onerous. To wit, "..the financial incentives to find a new cattle acaricide are relatively minor and the regulatory costs can be a significant hurdle.[36]"

Current guidelines – Until recently the APVMA guidelines required "98–100% tick control short-term efficacy trials (22 days post-treatment)[37]." This was based on older immersion chemicals and was not appropriate to the newer generation treatments, such as Macrocyclic Lactones (MLs) and Fluazuron. In more recent guidelines (see Appendix One) this issue is recognised, and a product with lower than 98% efficacy can be registered, "as long as a satisfactory and stable tick management program can be demonstrated". There has also been some reluctance to allow combination chemicals for tick control as they have been mooted to lead to increased rate of resistance, but this should also be reviewed in the light of newer developments[37]. Examples are co-formulation of TickGARD vaccine and injectable acaricides (registered as CattleGARD but not marketed), or potentially biopesticides, such as fungal spore formulations with pour-on acaricides. The vaccine or biocontrol methods may only have 50–80% efficacy but will decrease the required frequency of acaricide application, the major driver of onset of resistance[73].

Proposed guidelines – The draft guidelines prepared on behalf of the World Association for the Advancement of Parasitology recommend a 95% efficacy requirement for tick knockdown products. For products such as Insect Growth Regulators (Tick Development Inhibitors), the length of time that ticks are controlled by 95% is the preferred measurement, in order to allow for some time delay for these products to achieve therapeutic effect[38].

8.2.3 Eradication

Pegram outlined the eradication programs conducted against *Boophilus annulatus* in Texas, the USA. National programs implemented by a federal regulator were the prerequisite for the successful elimination of ticks from continental USA[41]. Eradication efforts were started in 1906, and it was estimated to have cost US$46m by the time eradication was completed in 1943. An economic analysis reported a benefit-cost ratio of 140:1[114].

Requirements – According to Powell and Reid (1982)[39], the conditions required for the eradication of ticks and tick fever did not exist in Queensland. The right conditions are specified as:

1. The ability to muster all favourable hosts for treatment at 14 day intervals or to de-stock country which cannot be mustered;
2. Adequate facilities for treating cattle;
3. Justification of the programme by cost-benefit analysis;
4. Effective industry cooperation;
5. Reasonable prospects of protection from re-infestation;
6. Availability of efficient chemicals;
7. Adequate finance to ensure uninterrupted progression of the programme.

The presence in the tick-endemic area of large numbers of susceptible *Bos taurus* cattle, which act as multipliers of tick numbers, can be seen as the single largest barrier to tick eradication[40]. Added to this is the problem of resistance to available knock-down acaricides, which is much greater in 2004 than it was in 1982. Pegram cites this as a reason for Queensland's failure to consider eradication – "inefficient cattle owners, known as "weekend farmers" with little knowledge of ticks ..(makes) any eradication program logistically impossible because they are largely responsible for the for the extensive acaricide resistance in southern Queensland.[41]"

Regional eradication programs against *B. microplus* have failed in Puerto Rico and other islands in the West Indies[41]. Other countries with endemic tick populations have opted for control programs. These have also met with various levels of success, with some in Africa deemed failures, and only Zimbabwe in the pre-civil war period hailed as a success.

8.2.3.1 New South Wales

In the past decades hundreds of millions of dollars have been spent on tick eradication in NSW[42]. Government supplied dips, chemicals and contract musterers, to allow farmers to dip their cattle on a regular basis. Current expenditure is in the region of A$5m (see Appendix Four). This program has been so successful that today only a small band of northern NSW around Kyogle (about 200 farms) still has regular reports of ticks, with about 39–53 infestations per year reported over the last four years. Producers in this area have a low commitment to control ticks as they have become accustomed to living with them.

The NSW Agriculture Tick Control Manager, Peter McGregor, said that despite the fact that NSW has a zero tolerance policy towards ticks in the State and supports eradication within NSW, they would not support a scheme to eradicate ticks from the rest of Australia.

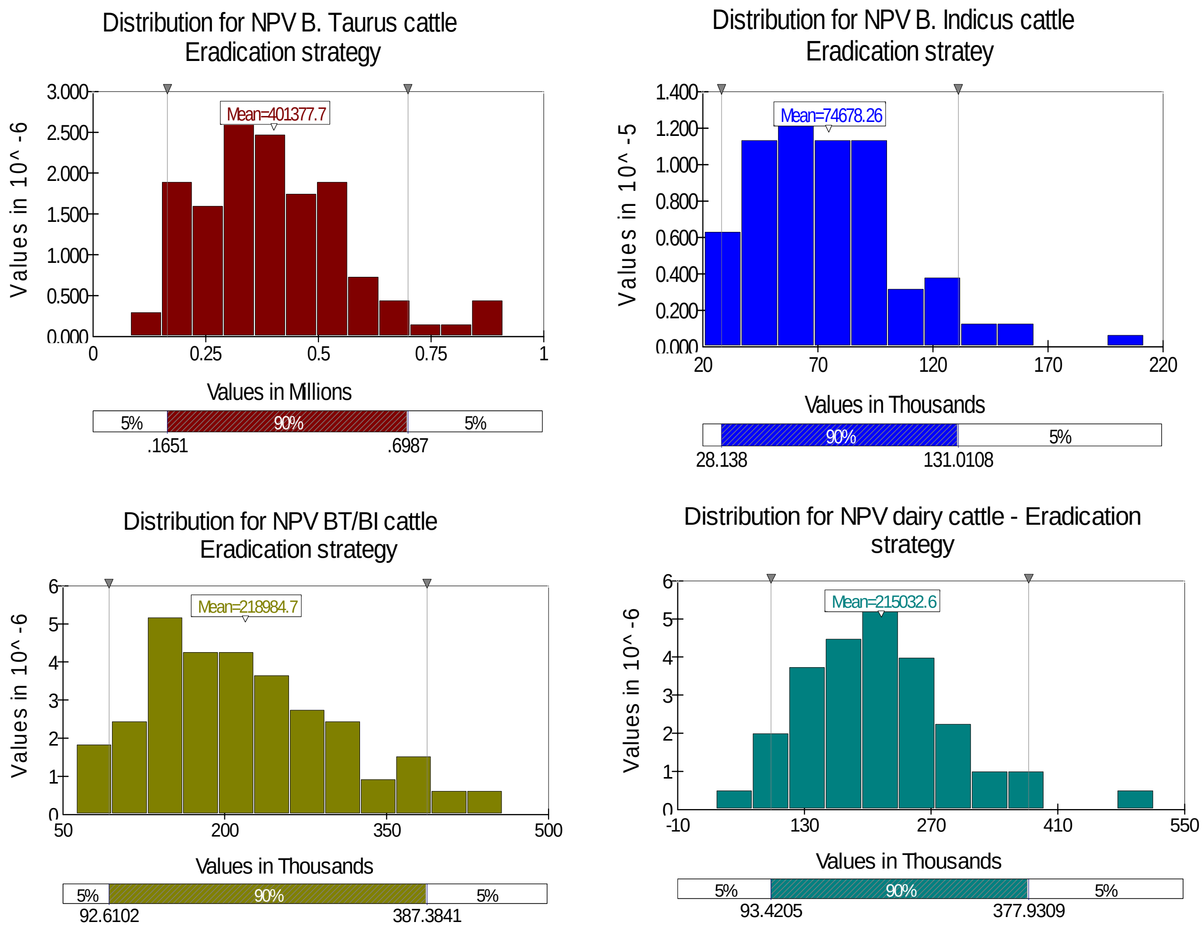
8.2.3.2 Queensland

The State government has assisted industry groups in voluntary eradication programs over the past twenty years. The trend now is towards decreased government spending on tick eradication, and more emphasis on individual farmer responsibility. Local eradication is only supported by the Queensland government if the producers involved have looked at the potential benefits and costs, using the Davis model[43]. It is generally believed that moving the tick line from its current position would include areas that are more suitable for the ecology of the tick, making eradication technically unfeasible.

8.2.3.3 Economic modelling for eradication

Strategy outline – **"**Eradicate cattle tick from Australia by a program of regulatory controls on stock movements, de-stocking of certain areas, compulsory treatments and inspections, gradual shifting of the tick line"

Figure 8.5: Net Present Value for eradication of ticks across four classes of cattle



NPV of tick eradication, according to the model, were high in all classes of cattle. This strategy ranked highest of all strategies for dairy and crossbred herds, second for *Bos taurus* and third for *Bos indicus* herds.

8.2.4 Control of movement

New South Wales – Like areas of Queensland outside the tick line, NSW protects the tick-free status of its farms by movement controls on stock entering the State from tick-endemic areas in other states. For cattle marketed at saleyards in north-eastern NSW, detection of ticks at sale will result in a letter of breach, followed by a fine or a prosecution, depending on the level of the breach. Cattle in this region are dipped after sale. Infested cattle are traced back to the property of origin and neighbours asked to comply with inspection and if necessary treatment regimes.

Government programs in NSW routinely use Cydectin Pour On for the treatment of infested cattle in these traceback exercises, due to efficacy against resistant ticks and ease of use.

NSW currently has a "no-risk" policy towards the introduction of ticks. This will be changed to a "risk management" policy in the future. The practical implications of this mainly relate to the provision of border controls. Automated systems using electronic surveillance to identify livestock transport vehicles will largely replace manned checkpoints in the future. This will save a large part of the $2 million currently spent on checkpoints.

8.2.4.1 Queensland

Researchers at ARI suggested that no cattle should be sold at public saleyards, if carrying ticks. This would reflect similar practices in other states where sheep carrying lice are not allowed to be sold at public saleyards. Stock inspectors monitor sheep for lice. If lice are detected the sheep are sent back to the property of origin.

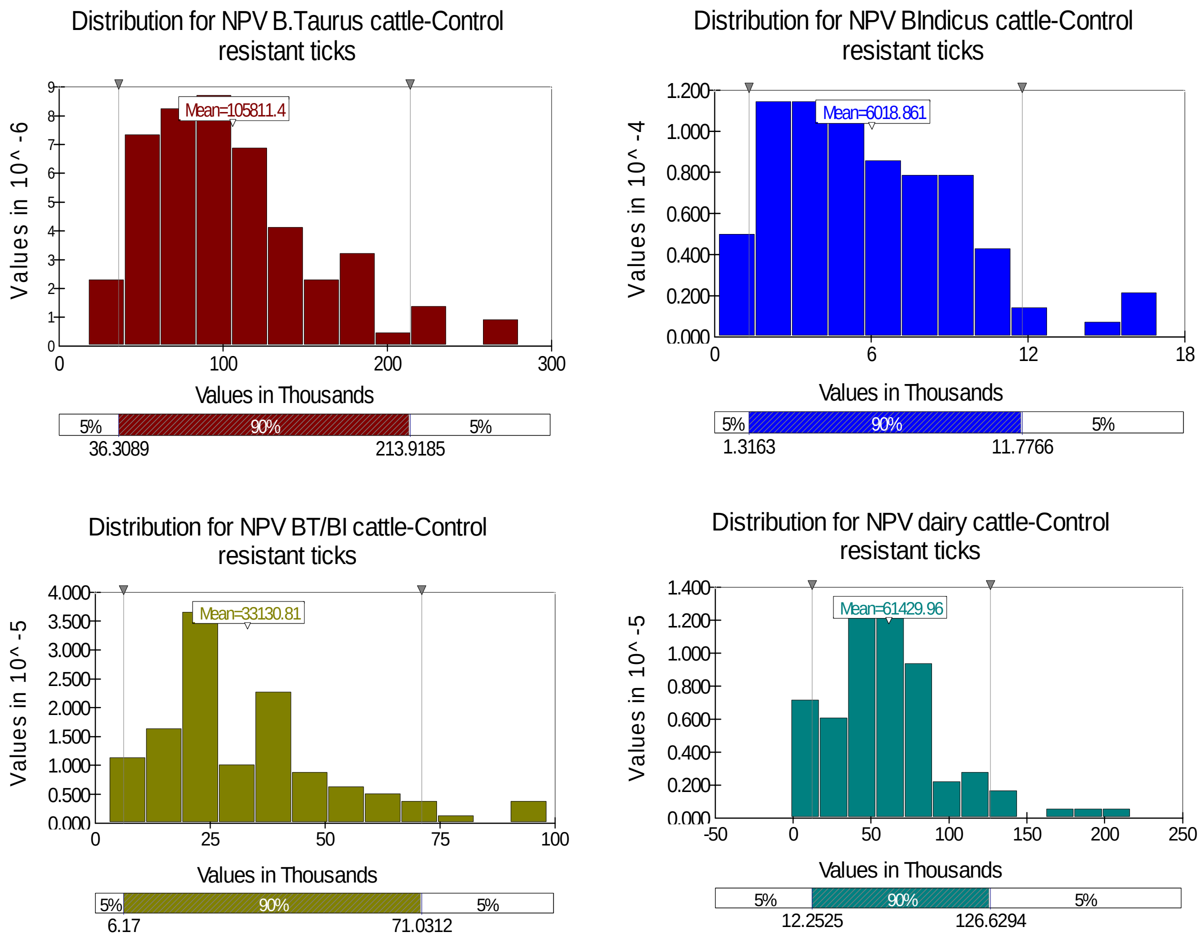
In Queensland there are currently no restrictions on presenting tick-infested animals to saleyards within the tick-endemic zone. Ron Glanville and Malcolm McLeod of QDPI remarked during their interview that this could be contributing to the spread of resistant ticks, but that buyers (producers) should be responsible for farm biosecurity. They did concede that a Vendor Declaration relating to the use of acaricides could help, but that there was insufficient demand from the industry to introduce it at this stage. They also remarked that the State government's duty of care to prevent the spread of resistant ticks was met by the provision of programs to prevent introduction of resistant ticks to properties (see remarks from Kevin Duff, "Buyer beware principle", below).

Queensland employs random surveillance of livestock transport vehicles. Temporary tick monitoring gates are set up at strategic locations on the tick line, and cattle checked as they move through.

8.2.4.2 Economic modelling for controlling resistant ticks

Strategy outline – "Control and eradication of amitraz-resistant ticks from farms. Monitoring program boosted, with increased lab capacity to identify resistance, field officers to ensure compliance. De-stocking of affected farms, with compensation provided to affected farmers."

Figure 8.6: Net Present Value for controlling resistant ticks across four classes of cattle



This figure shows the NPV gained from controlling movements of cattle to prevent the spread of resistant ticks, according to the economic model. The predicted NPV over 30 years are the lowest of all the thirteen strategies examined in the model.

Details of the Northern Territory government program to identify and quarantine properties with resistant ticks, is provided in Appendix fifteen.

8.2.5 The tick line

Queensland's "tick line", maintained by regulated inspection and treatment of stock, is the implementation of State government policy to prevent the spread of ticks and tick fever from northern and eastern regions into the State's interior[43].

QDPI&F staff remarked during the interview for this review that maintaining the tick line was a political and social issue that is difficult to change. Regulators from NSW and QLD agreed that if ticks were suddenly to appear as a novel infestation in Australia today, there would be no political will to establish movement controls, and free movement of cattle would be allowed. The major beneficiaries of the tick line are producers living outside the tick area, as they are free to keep the most profitable breeds of animals, and do not have to spend money on treatment programs.

The Queensland government currently spends $3.3 million per year on maintaining the tick line. Moves to outsource and privatise testing and dipping will result in savings of $1.5 million.

Clearing dips – The major issue concerning the tick line at present is that the dips that are used to clear cattle are charged with amitraz. The most dangerous type of tick from a producer's point of view is the amitraz-resistant Ulam and Ultimo tick. The extent is as yet unquantified but these ticks are possibly present on up to 15% of properties in the tick-endemic area[44]. Therefore the chances of amitraz-resistant ticks surviving the tick line dip, and escaping detection are relatively high. This may be exacerbated by the use of non-government inspectors and privatised dips, a program which is currently being implemented.

An alternative to chemicals at the tick gates could be the use of feedlots to clear ticks, as suggested by David Kemp. Cattle placed in feedlots for a period of a month could be tested by stock inspectors and allowed to proceed after being cleared. This would decrease chemical use (in line with government principles outlined in the state and federal department's working party[79]), and also decrease the chance of amitraz-resistant ticks being selectively allowed through the tick line.

The likelihood of the extension of ticks from the endemic area to the tick-free area is also high due to the natural movement of stock across fences and boundaries. Recent trials with radio-tracking collars show that individual animals can move as far as 40 km within a short space of time, especially during the wet season (Sandi Jephcott, pers. comm.). Animals carrying ticks and moving to adjacent farms during the wet season when fences may be damaged could spread ticks and cause outbreaks of tick fever.

The spread of ticks is not a major concern, as normal seasonal conditions practically exclude ticks from establishing in areas outside the tick line[45] in Queensland. Movements south to New South Wales however, could result in costly clean up programs as conditions favour endemicity in the north-eastern part of the State. The real threat to animal welfare, productivity and farm economics is the potential for outbreaks of tick fever in cattle outside the tick line that are suddenly exposed to ticks carried by newly-introduced cattle. In the early days of the spread of ticks, explosive outbreaks in susceptible herds could lead to high losses, with 20% or more of a mob affected, and high mortality ensuing[1].

Routine vaccination against tick fever could become an important part of risk minimisation for cattle producers living outside of the tick zone.

8.2.5.1 Privatisation

The Queensland government has decided to initiate Third Party Provider (TPP) services to inspect cattle to be cleared for the tick line[46]. This is largely due to a policy to expand services provided by QDPI&F stock inspectors to enable greater attention to emergency diseases and biosecurity, and also to move the burden of control from the government to the individual stockowner.

8.2.6 Cattle tick management Queensland (CTMQ)

The State Government of Queensland convened a workshop in December 2003, with participants from all parts of the cattle and associated industries. Representatives from governments or organisations outside of Queensland did not attend. Tick control was discussed, and recommendations considered for ongoing government involvement. It was resolved at this meeting to form a body to manage the tick control program in Queensland, to be known as Cattle Tick Management Queensland. A Steering Committee for this group would report to the Queensland Biosecurity Advisory Council. The purpose of this committee would be to form policy for tick control, and provide advice on extension and research priorities.

- The CTMQ's mission is: "To improve the management of ticks in Queensland and minimise their impact on livestock industries."

The follow up to the meeting has not resulted due to the overwhelming priority of disease eradication programs, such as citrus blight, and the need to implement the National Livestock Identification Scheme. The body also lacks a convenor who could coordinate the attendance of representatives from government, industry and commercial interests[47].

8.2.7 The role of deer in maintaining endemicity of ticks

Several studies have shown that feral deer, particularly red deer, *Cervus elaphus*, were natural hosts of cattle ticks in Queensland[48]. It was noted that deer had some natural resistance to ticks but lost this when they suffered stress due to poor nutrition or lactation. Observed burdens of ticks were so high as to cause the death of farmed deer[49]. The range of red deer in Queensland covers nearly 1.5 million hectares, and overlaps some of the State's least accessible country to the north and west of Brisbane. It is estimated that this area has a population of between 10–15,000 head of deer. Much of the area is mountainous and set aside for State Forest[50].

Details of the range of wild red deer can be seen in Appendix sixteen.

Due to the large population of wild deer in an inaccessible area of the state, and the fact that these deer harbour natural infestations of cattle tick, it is considered unlikely that any cattle tick eradication program would be successful without first eliminating the feral deer. This would likely cause opposition from interest groups such as recreational shooters, the safari hunting industry and animal welfare activists.

8.2.8 Discussion

The tick-line, the major regulatory barrier preventing the spread of ticks from tick-endemic to tick-free zones, depends on an effective knock-down acaricide. Maintenance of this fundamental means of tick control in northern Australia is at threat due to amitraz resistance (see section 8.4.1). This matter is urgent from a regulatory viewpoint as there is a risk that the spread of amitraz resistance could progress quickly, and movement controls would need to be reconsidered.

The economic model showed that eradication would be the most beneficial strategy for crossbred and dairy cattle, and ranked high for *Bos taurus* and *Bos indicus herds.* Australian regulators throughout the course of this review showed very little enthusiasm for eradication, an opinion that was supported by the majority of researchers interviewed. These attitudes contrast with the opinion of many producers, particularly dairy farmers and beef producers who keep *Bos taurus* cattle. In submissions to this report received from the public (MLA levy payers), many expressed support for eradication and all supported the continuation of tick line controls.

Producers appear to be aware of the dangers facing the tick line due to resistant ticks and privatisation. An example is Len Carlson, Chairman of the Gympie Beef Liaison Group, who argued that the producers he represents would like the tick line moved eastwards, but warns that increasing costs may encourage farmers to move stock illegally, with a corresponding risk of outbreaks.

State governments may require novel approaches to maintain the tick line, including on-farm testing, quarantining cattle in feedlots or tick-free pastures before reaching the tick line, or other approaches not yet defined. These are State government responsibilities that should be funded by the State government, but require support from the beef industry, especially producer bodies such as Agforce, to ensure their success.

The potential economic gains from the eradication of ticks are extremely high across all classes of cattle, as determined by the economic model. However the gains from controlling the spread of resistant ticks via movement restriction, shows a very low economic return. Feral deer populations in south-east Queensland pose a major impediment to any attempt to establish local or total eradication of ticks.

8.2.9 Summary

APVMA requirements for the registration of acaricides have been criticised for being too demanding. Regulatory controls have been successful in confining ticks to a defined geographical area of Queensland, and for eradicating ticks from most areas of New South Wales. However, the future of regulatory controls, such as the tick line, is under threat due to amitraz resistance, and the lack of new knockdown acaricides to replace it. State government policy in QLD and NSW is to shift the burden of responsibility for tick control to cattle producers. Restrictions on the movement of cattle with resistant ticks would not provide economic gains, and would be difficult to enforce. There is a need for an advisory body to consider policies for the management of ticks. A meeting in Queensland to establish a coordinating body, CTMQ, was well supported by the industry and researchers. A steering committee has subsequently met to drive policies in tick control.

8.3 Biological approaches

8.3.1 Tick vaccine

8.3.1.1 Tick vaccine availability

The TickGARD vaccine directed against gut antigens of *Boophilus microplus* was introduced in 1995. It was anticipated that the vaccine would be widely applied throughout the tick-endemic areas to decrease reliance on chemical acaricides. However, estimated peak sales of the vaccine only approached 4% of sales of chemicals for ticks[51]. TickGARD vaccine sales were so low during the late 1990s that when the manufacturing site of the vaccine was closed, the company holding the marketing licence, Intervet, allowed production of the vaccine to lapse. From 2000 producers were unable to procure the vaccine for a period of approximately two years. The vaccine was re-introduced in 2002, but the cost of the vaccine was high and sales continued at a low level, mainly to south-east Queensland dairy producers. In 2004 Intervet launched a collaborative initiative with the Queensland Dairyfarmers' Organisation to drop the price of TickGARD Plus to approximately $2.05 per injection, if farmers commit to a contract for two year's supply of vaccine[51].

8.3.1.2 Tick vaccine efficacy

The effect of using the TickGARD vaccine in beef cattle was evaluated across 18 beef-producing properties in south east and central Queensland. The number of acaricide treatments used per year to control ticks was calculated from historical data, and compared with the number of treatments required when cattle were vaccinated and boosted with the tick vaccine. The total number of acaricide treatments 'saved' for each booster vaccination was between 1 and 4, with a mean value of 2.4 across all sites. Breed and class (especially lactation status) had a non-significant trend to alter the number of treatments saved, with non-lactating *Bos indicus* cattle performing best, and lactating *Bos taurus* cattle requiring the most treatments[52].

Jonsson[71] found that in lactating *Bos taurus* (Holstein Friesian) cattle, tick counts were reduced by 56%, and the number of eggs laid by each engorging female was reduced by 53%. Egg hatchability was also reduced, resulting in an overall efficacy of 72%.

Cuban studies with the local version of TickGARD Plus, known as Gavac, show that the uptake of vaccination was much greater in that country when accompanied by regulatory inducements. It is claimed that the frequency of acaricidal treatments was reduced by 60% in a field trial conducted on 260,000 head of dairy cattle in five Cuban provinces[53]. However, the details of how this figure was deduced are not provided, and since the frequency of acaricide treatment before vaccine seems unreasonably high (down to ten days between treatments) some doubts exist as to the validity of this claim.

8.3.1.3 Promoting usage of the tick vaccine

Hoechst, and later Intervet, invested substantial funds in marketing the vaccine, with newspaper advertisements, promotional leaflets, and testimonials from users. At the time of the launch of the tick vaccine in Queensland, a 'Tick Advice Centre' was established in Brisbane, with three full-time staff to support the use of the vaccine in tick control programs. The tick vaccine was, and still is, recommended and promoted by the QDPI&F for use as a means of decreasing the number of chemical treatments required per year. Despite continued availability of extension, technical advice, support, on-farm demonstrations and trouble-shooting, sales of the vaccine never exceeded 250,000 doses/year, and are currently well below this figure[51].

Intervet believe that the TickGARD Plus vaccine was used mainly in the dairy industry, with very little uptake in the beef industry[51]. The benefits of using the vaccine (less tick larvae on pasture, decreased threat of acaricide resistance, decreased chance of residues violations in milk) are not apparent to the individual farmer. However, the costs of treatment (cost of buying vaccine, mustering every 12 weeks, lumps on cattle, protein test dropping, difficulty in vaccinating cattle often in poor weather and with poor restraint mechanisms) are all too apparent.

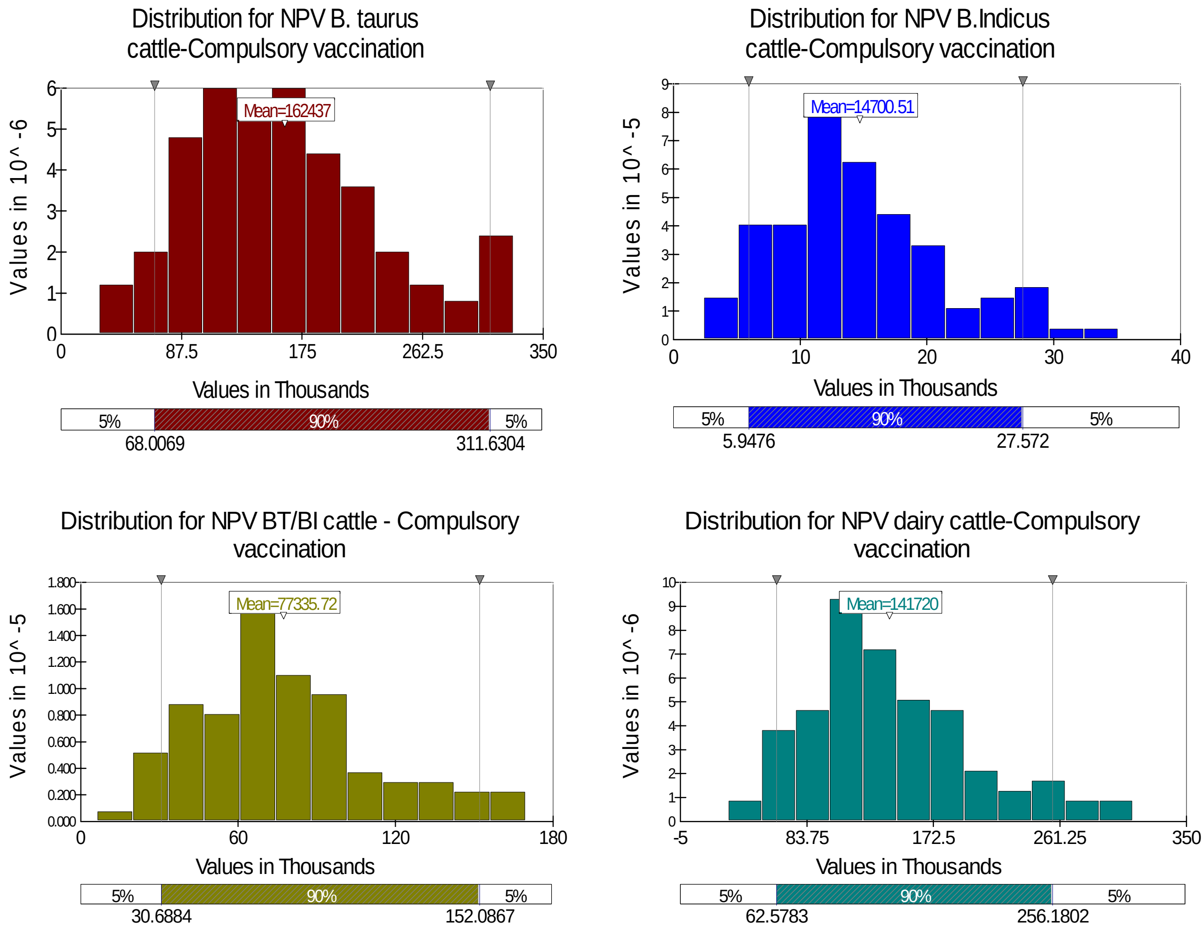
Because of this, beneficiaries of the less tangible benefits of vaccine use (less chance of milk and meat residues, lower frequency of chemical use leading to less chance of acaricide resistance developing) could provide incentives for the farmer to use more vaccine. The main beneficiaries of this would be the milk factories, meat processors or retailers, and state governments.

One suggestion discussed with CSIRO Livestock Industries at St Lucia was a quality bonus, similar to that provided to dairy producers for low somatic cell count in milk. Milk factories or beef buyers could provide the cash bonus to producers who choose to use the vaccine instead of chemical treatments. Andrew Taylor of Parmalat, a major processor of milk in Queensland, believes that TickGARD vaccine is “a safe and sensible means of managing tick burdens” (see Appendix Four).

8.3.1.4 Economic analysis of compulsory vaccination strategy

Strategy outline – “All cattle in the tick endemic area and control zone to be vaccinated for tick fever once at weaning, and all >5/8 *Bos Taurus* cattle with tick vaccine four times annually. Government and industry inducements to stock owners to comply, plus penalties or market exclusion for vaccine non-use or excessive chemical use.”

Figure 8.7: Net Present Value of compulsory vaccination programs across four classes of cattle

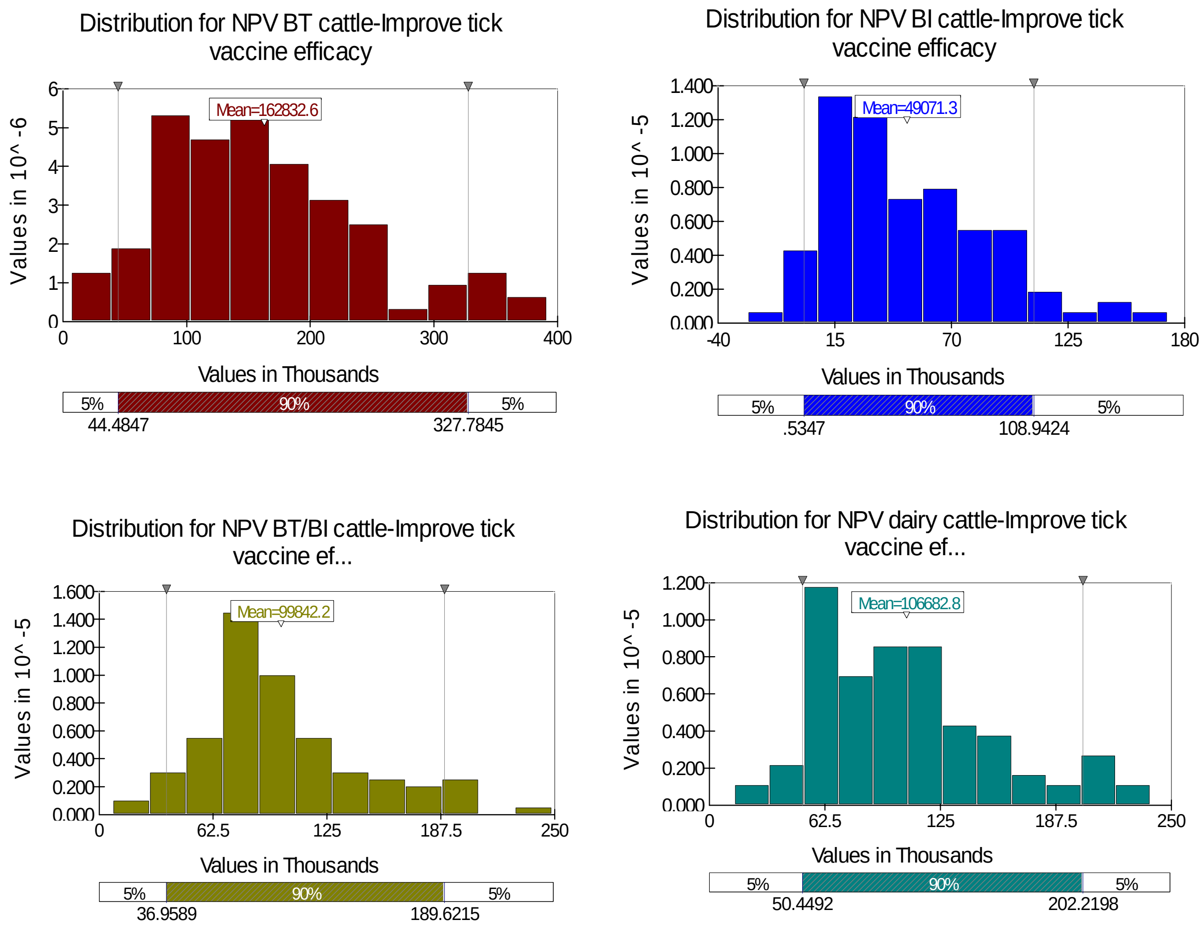


The figure above shows the NPV of a strategy that utilises compulsory vaccination for ticks and tick fever, as proposed by the producers. This strategy ranked sixth for dairy, seventh for crossbred and eighth for both *Bos taurus* and *Bos indicus* herds.

8.3.1.5 Economic analysis of a strategy to improve the tick vaccine

Strategy outline – "Bring to market a *Boophilus microplus* vaccine with 90% tickicidal efficacy, annual booster, no lumps."

Figure 8.8: Net Present Value of a strategy to improve the tick vaccine



The strategy to improve the tick vaccine was ranked medium to low across the four classes of cattle. The highest ranking was in crossbred and *Bos indicus* herds (5), while in *Bos taurus* herds it ranked seventh, and in dairy herds ranked eighth. For details of the economic model see Chapter Nine.

8.3.1.6 Discussion

The licence holder for TickGARD Plus vaccine, Intervet, have indicated that due to low sales they have no plans for the further development of this vaccine. Peter Willadsen and David Kemp of CSIRO believe that there is potential for improving the efficacy of the vaccine, with the use of other antigens derived from *B. microplus*. This issue has also been pursued by Cuban researchers, who identified the Bm95 antigen, which is derived from Argentinian isolates of tick gut moieties, as a worthy candidate[54].

The concept of a more efficacious vaccine is supported by many of the researchers, consultants and regulators interviewed during the course of this review. Officials of the QDPIand Fisheries believe that "an efficient vaccine against cattle ticks could mean that both eradication and tick line maintenance could no longer be justified as industry will be able to efficiently control ticks in an endemic situation." [43]

Ron Glanville and Malcolm McLeod of QDPI&F suggested that if the tick vaccine were 90% effective and could be used once a year, then it would be a definite success. They predicted that if such a vaccine were made available it would enable the functional disbandment of the tick tine, and would also allow producers in extensive northern properties to introduce highly susceptible *Bos taurus* animals into their breeding program.

Bm86 vaccine has been trialled against ticks other than *Boophilus microplus*[55]. Peter Willadsen reported that the efficacy of Bm86 vaccine against *Boophilus annulatus* had now been replicated in three laboratories, and that these results will probably help stimulate further research into the vaccine. He and David Kemp are confident that the current vaccine could be improved, saying that the original registration should have been delayed to allow for inclusion of other antigens into the formulation. This probably would have brought efficacy up to the critical 80–90% level that producers seem to require. Once the vaccine was registered and commercialised no further funds were available to improve it.

Other vaccines – Overseas researchers have developed putative vaccines against other ticks such as *Amblyomma* and *Haemaphysalis* (Peter Willadsen, pers. comm.). These may have potential to be adapted for action against *Boophilus.*

8.3.2 Tick fever vaccine

8.3.2.1 Cost of tick fever

The cost of tick fever to the northern cattle industry is estimated at $34m per year[56]. *Anaplasma* and *Babesia* infections were reported in 1997 to cost Australian cattle farmers US$15.9m (A$27m adjusted to 2004)[57]. Sales of the vaccine are reported at 870,000 doses[58] per year at a cost to the farmer of approximately A$2–3/dose[59], a total of approximately A$2.4m. Deaths, loss of productivity, cost of chemicals and other treatments to control ticks and prevent tick fever, account for the remaining A$24.6m.

8.3.2.2 Efficacy of the tick fever vaccine

About 870,000 doses per year of tick fever vaccine are administered to the approximately 8 million cattle living in the endemic regions of Australia. The vaccines against *Babesia bovis* and *B. bigemina* are reported to provide sound, long-lasting (lifelong) protection against these two parasites, while the *Anaplasma centrale* vaccine used to protect against infection with *A. marginale* gives adequate protection against Australian isolates, but not the diverse strains found overseas[59].

There are widespread fears of side effects associated with the tick fever vaccination. However, investigations into cases of tick fever temporarily associated with inoculation and assumed to be side effects determined by Polymerase Chain Reaction testing of isolates concluded that most were not related[60]. Only one case out of five was found to be related to the vaccine strain, while the others were deduced to be wild strains.

8.3.2.3 Problems with the tick fever vaccine

The following shortcomings of the currently available live vaccine have been identified:

1) Biosecurity issues relating to the vaccine being derived from the blood of splenectomised calves carrying live *Babesia* and *Anaplasma* organisms.

2) Logistical problems resulting from the short shelf life (four days) and need for refrigeration. The frozen vaccine with six-month shelf life needs to be kept in liquid nitrogen, limiting portability, especially on extensive properties in the northern and western regions of Australia.

3) Side effects experienced in a portion of a herd inoculated. These range from transient fever to death.

4) High cost of production, resulting from the need to maintain the infection on live splenectomised calves.

8.3.2.4 Usage of the tick fever vaccine

A survey of beef producers in Queensland showed however, that the major requirements for the vaccine were long-lasting protection from a single vaccination, and low cost. The relative importance of other features such as shelf life and convenient storage system were low[61]. The same survey reported that ticks were second on the list of animal health concerns for Queensland beef producers in the tick-endemic area after buffalo fly, and tick fever ranked sixth. It was estimated that only 33% of beef producers in the endemic region used the tick fever vaccine. This collates well with the figures of 870,000 doses per year provided by TFC, as cattle are generally only given a single vaccination to protect them for life. One hundred percent adoption would mean that all weaner cattle were vaccinated, with close to three million doses required.

Since the vaccine only requires a single administration at the time of weaning (six to nine months of age) to give life-long protection, the cost of the vaccine (approx. $3/head) is cheap compared to other potential control methods for tick fever. The cost and inconvenience of mustering were cited as other reasons for the relatively low adoption rate. The natural exposure of young calves to the parasites while still immune (up to about nine months of age) in endemic areas allows development of immunity without the vaccine[62].

The producer survey found that 52% of producers who didn't use tick fever vaccine cited their use of acaricides to prevent tick infestations as a reason for this. This practice is counter-productive as it could interfere with the natural acquisition of immunity by cattle due to exposure to ticks and tick fever parasites. Moreover, it contributes to acaricide resistance through extra treatments.

Live export – Russel Bock of the Tick Fever Centre (TFC) reported that since many of the live export protocols require vaccination of animals before they board the ship, vaccination is commonly carried out during the dockside acclimatisation period. This is likely to lead to morbidity and possibly mortality on the boat as animals may develop reactions and experience high body temperatures, loss of appetite, weight loss and ensuing health setbacks in the few weeks following vaccination. TFC strongly recommends vaccinating all animals at weaning if they are destined for live export.

Production costs – The use of the chilled vaccine results in high costs because the shelf life is only four days. There is a large amount of wastage as many doses harvested from the donor animals go unused within the shelf life. Costs could be reduced if producers used frozen vaccine. This would entail liquid nitrogen containers being used, the same as for semen transport.

Animal welfare – On properties that currently do not vaccinate, some cite lack of observation of tick fever as the main reason[28]. This is possibly because losses of 4% or even more are regarded as background levels on extensive properties and not worth intervening to improve upon. If the true incidence of tick fever in extensive areas could be quantified, it could act as a motivator for producers to increase vaccine use in order to prevent unseen losses[62].

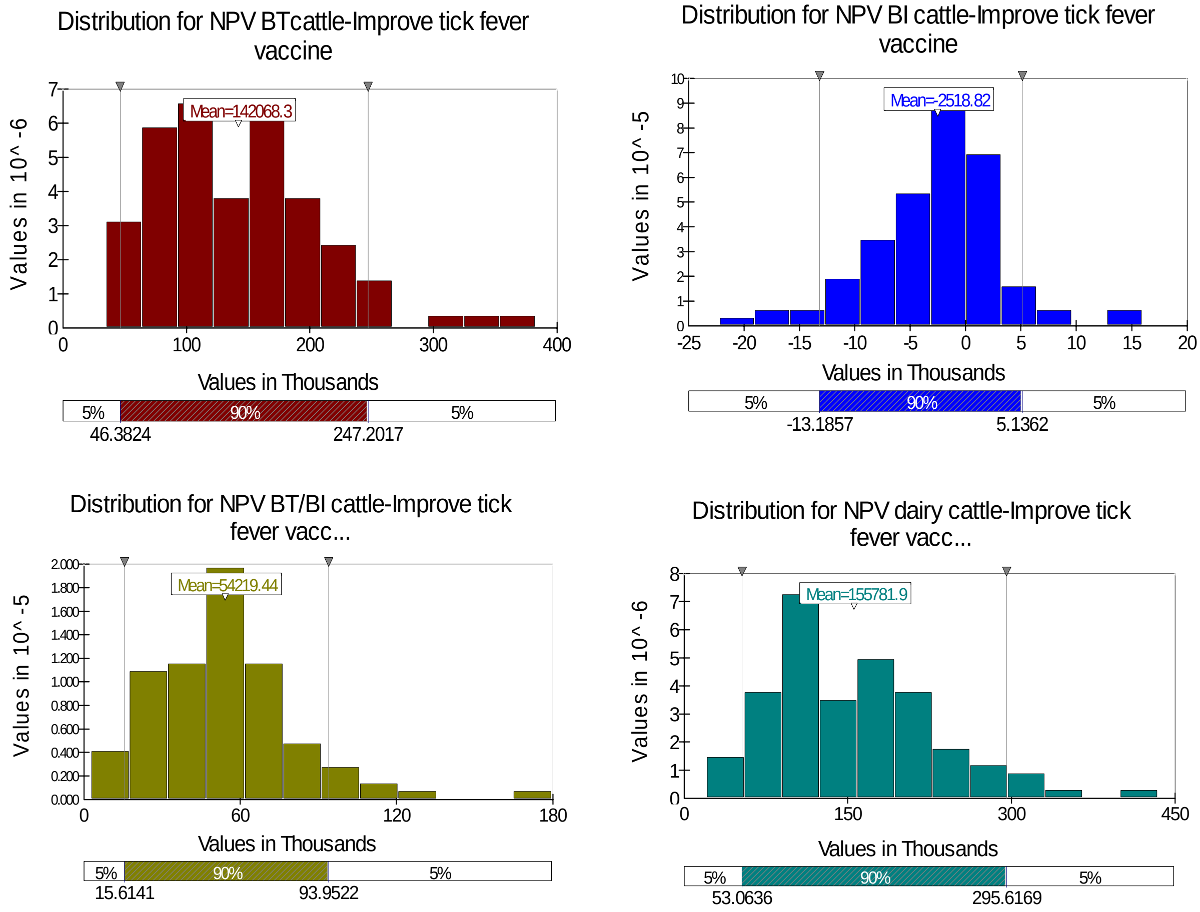
8.3.2.5 Eradication of tick-borne diseases

If all cattle in an area were vaccinated with the TFC vaccine there is the potential to eradicate *Anaplasma* infection. However, due to the nature of the *Babesia* vaccine, i.e. live attenuated strains of the naturally occurring pathogenic organisms, it does not prevent infection with the wild strains. There is therefore no possibility of eradicating tick fever using the existing live vaccines.

8.3.2.6 Economic analysis of a strategy to improve the tick fever vaccine

Strategy outline – **"**Bring to market Babesia and Anaplasma vaccine with six-month refrigerated shelf-life, no contaminants, A$1/shot, no major side effects"

Figure 8.9: Net present value of a strategy to improve the tick fever vaccine



Economic analysis of the strategy to improve the tick fever vaccine shows that for all classes of beef cattle the return is low. In *Bos indicus* cattle the NPV is the lowest of all thirteen strategies, while in *Bos taurus* cattle and crossbred herds it ranked ninth. In dairy cattle the mean return is high, at A$155,782, which ranked third out of the thirteen projects.

8.3.2.7 Discussion

The tick fever vaccine's current usage rate with 33% of beef producers seems to be low given the risk of tick fever to the industry. Greater awareness of the presence of tick fever could increase the penetration of tick fever vaccine use in Queensland. Compulsory notification of cases would contribute to this, as would extension aimed at implementing Queensland Department of Primary Industries recommendations[63], and to raise awareness of the benefits of vaccination over chemical treatment.

The decision on whether it is necessary to vaccinate for tick fever in low-prevalence areas, such as northwest Queensland, can be made based on the serological prevalence of the parasites in a herd and a support tool such as the Ramsay model[62].

The use of the tick fever vaccine in beef cattle in the tick-endemic area at the time of weaning can be supported in almost all cases on production benefits alone, even in areas of low prevalence. Animal welfare and market access grounds further support vaccination at weaning of all cattle in the tick-endemic and protected areas.

The adoption of the National Livestock Identification Scheme in northern Australia should facilitate quality assurance for cattle entering the live export trade, and provide for identification of cattle vaccinated for tick fever at weaning.

It has been suggested within QDPI&F that the Tick Fever Centre should be sold off, in order to cut costs. Other suggestions have been to make the TFC operate on a full cost-recovery basis. This would result in an increase in the cost of the tick fever vaccine, and possibly lower use of the vaccine.

Improvements in the live vaccine are possible, but unlikely given the current rate of funding. At present the researchers at TFC are busy fine-tuning the vaccine by investigating strain differences, and checking reported breakdowns or vaccination reactions.

Research on a subunit vaccine for *Anaplasma* has been performed at CSIRO Livestock Industries, the progress of which can be found on the Vaccine Technology website[64]. Wayne Jorgensen of ARI, Yeerongpilly, stated his belief that the live vaccine currently used posed a risk for biosecurity, and that research on a recombinant vaccine should proceed as a matter of urgency. TFC acknowledges the biosecurity risk in using the live vaccine, but maintains that a risk management approach and rigorous quality control, as evidenced by their compliance with Good Manufacturing Practice, limits their exposure.

8.3.3 Alternative strategies, not yet commercialised

8.3.3.1 Pheromones, tail tag decoy system and neck bands

Pheromones derived from secretory/excretory products can be used to give chemical signals to ticks in order to modify their behaviour. The principle is to attract ticks to acaricides, lure them to traps, prevent them from mating or otherwise decrease their reproductive potential. A summary of potential methods is provided by Chris Moore[65].

8.3.4 Biopesticides

Entomopathogenic nematodes (EPNs) – Samish (2003)[66] reported that *Boophilus annulatus* ticks were highly susceptible to the predation of EPNs such as *Heterorhabditis* sp. Ticks were killed in under five days. These nematodes are capable of killing adult ticks, but are not so effective while on the host, and it is recommended that on-ground stages be targeted. It is suggested that *B. microplus* ticks may be resistant to predation by nematodes. These measures are being considered by Peter James and his team at ARI Yeerongpilly, but no work has commenced as yet.

Entomopathogenic fungi – Colombian studies using ten fungal isolates against *B. microplus* showed moderate efficacy (68–85%)[67] *in vitro*. Further research was recommended to discover how application methods, activators and other fungal species could be used to improve acaricidal effect. The process of using fungal biopesticides has previously been investigated by Dairy Australia[70].

Research is being conducted into practical application of fungi at the Animal Research Institute, Yeerongpilly, and DPI Mutdapilly, initially funded by Dairy Australia. This project is currently unfunded and is therefore carried out in the spare time of researchers Lex Turner and Dianna Eamon. Discussions with commercial partners have not yet led to any contracts.

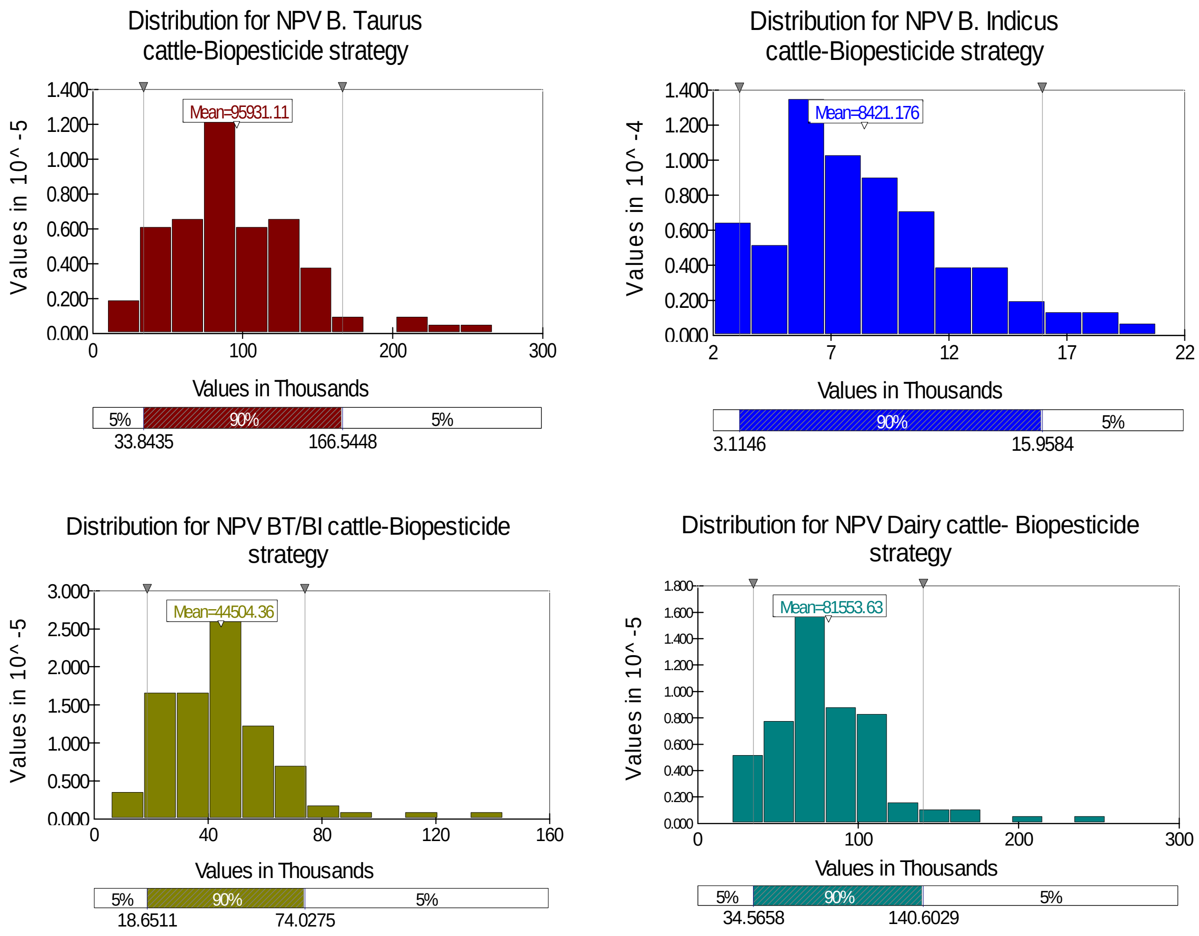
The fungus chosen, *Metarhyzium anisopliae,* is available as a treatment for agricultural pests (Biogreen and Biocane granules, registered by Bio-care against red headed cockchafer, greyback can grub), and also has a degree of efficacy against buffalo flies[69]. Published literature is available for the mammalian toxicity studies, and the APVMA does not regard it as requiring special safety precautions. The products are not scheduled as poisons according to the Standard for the Uniform Scheduling of Drugs and Poisons (SUSDP)[68].

According to Lex Turner and Dianna Eamon of QDPI&F, basic efficacy studies show that when fungal spores are applied to dairy heifers there is an 80% reduction in ticks. Previous trials where fungi were applied to pasture were not effective, and in future, fungi must be applied to the coat of the animal[69]. Egg counts in surviving females are also reduced and hatchability is halved. Fundamental work on dose titration, formulation and application methods is required, but collaboration with an organic chemist to assist in these areas could rapidly progress this project.

8.3.4.1 Economic analysis of a strategy to develop biopesticides

Strategy outline – **"**Develop, trial and register a novel control strategy based on biopesticides. Use extension services to demonstrate benefits to producers."

Figure 8.10: Net Present Value of a strategy to develop biopesticides for four classes of cattle



The figure above shows that NPV for biopesticides varies from A$8,421 in *Bos indicus* herds (ranked twelfth) to A$95,931 in *Bos taurus* herds (ranked tenth). This strategy ranks eleventh out of twelve in crossbred herds and tenth out of twelve in dairy herds.

8.3.4.2 Environmental measures

Environmental measures such as pasture spelling and feedlotting to control ticks are already practised to a degree in the Queensland cattle industries. Uptake by producers is restricted by a lack of research, no firm guidelines available for extension, and the fact that some options can limit production from pasture. In 1980, Elder noted "Pasture spelling appears to be quite common especially in the coastal north (of Queensland); it is being carried out for pasture management rather than as a tick control measure. Producers in central and couth-eastern Queensland, who do not spell pastures, feel that it reduces carrying capacity". [16]

However, these measures limit chemical usage, and may improve the appeal of animal products to the consumer indicating a possible role in future tick control.

Some of the strategies include[70]:

- Burning pasture – widely practised in Africa.
- Use of feedlots – although this can have deleterious effects on tick numbers if tick survival is high after dropping, as it is easier for larvae to find hosts.[71]
- Use of pasture species such as fodder crops.
- Intensive grazing such as high density strip grazing on improved pasture cultivars. This also contributes to higher levels of nutrition and better host resistance.
- Strategic cultivation – ploughing soil buries ticks, and removing plant material affects the larval tick's ability to develop.
- Vacuum methods – Running a mob of resistant cattle across a pasture before putting dairy cattle in may lessen the number of larvae able to attach to the dairy cows.
- Night paddock management – ticks are reported to drop in the few hours before or after dawn. This knowledge has been used to corral animals in pens so that they drop ticks in an environment that is not conducive to egg development and survival.
- Pasture rotation and spelling – this method has been used practically in Queensland, when hosts were removed for five months. Models have been constructed to simulate the effects of spelling in the dry and wet season.
- Elimination of wildlife hosts – this is important in southeast Queensland, as feral deer species are capable of carrying and spreading *B. microplus.*

8.3.5 Demonstration farms

Several researchers mooted the possibility of establishing demonstration farms as a means of research for environmental measures of tick control and extension vehicles. Peter James of ARI Yeerongpilly stated that the Australian Wool Innovation program to set up 22 demonstration farms is a good example of what could be achieved. The aim of this project is to establish Integrated Pest Management systems for external parasites. These have been placed under the responsibility of local consultants and coordinated centrally by AWI.

Several farms for both dairy and beef could be established in central regions, so that a Discussion Group of local farmers could meet regularly at each farm. Field days could also be held on them, and farmers from outlying regions brought in to observe first hand the control measures in place. Buffalo fly control would be included as a target pest, and new measures such as biopesticides applied.

QDPI&F staff mentioned that another benefit of environmental measures of tick control is that they are suitable for organic producers, which they believe will become a more important market force in the future. They currently see about three cases per year of organic beef producers with uncontrollable tick problems.

8.3.6 Integrated Pest Management

The aim of Integrated Pest Management (IPM) is to decrease the amount of chemicals used to control pests by applying strategic treatments designed to kill as many pest species as possible at the same time, and to implement non-chemical means of control, such as vaccination and the environmental measures mentioned above. An example would be to use treatments that kill buffalo fly and ticks at the same time, and to apply strategically at the time of year when the treatment will decrease subsequent challenge. Monitoring for pests is emphasised so that treatments only take place when a threshold level of pests are present.

IPM measures have been successfully applied to the cotton and other agronomic industries[72]. Similarly, the principles of refugia have been applied to cotton to enhance the long-term efficacy of genetically modified insect-resistant strains[72].

8.3.7 Extension needs for IPM and environmental measures

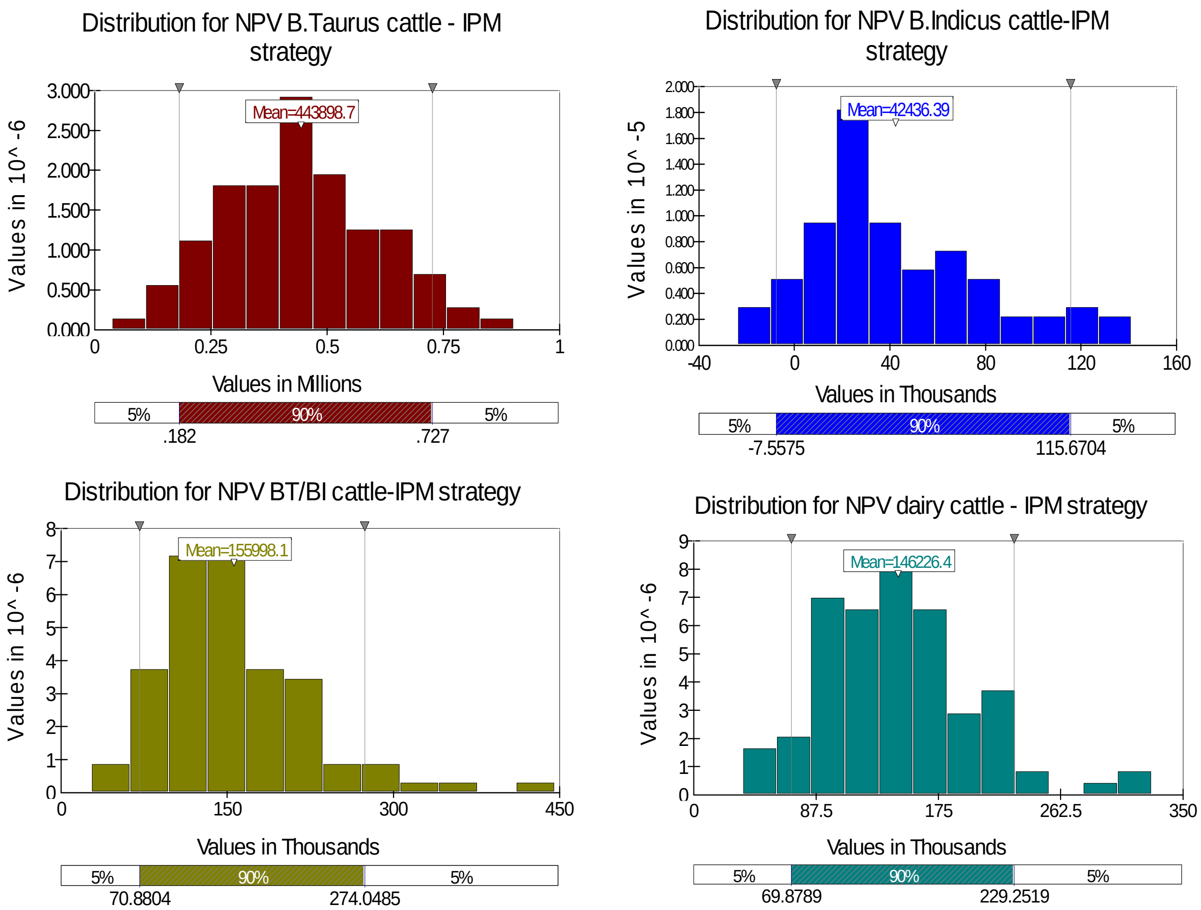
Most producers of cattle do practice IPM to some extent. However, the complexity of Environmental or Integrated Pest Management programs means that a large-scale extension program would be required to ensure effective practices are adopted, ideally combined with demonstration farms to be used as test vehicles to prove the long-term cost-effectiveness of the programs. Research would be needed to validate that IPM measures were cost-effective and did not compromise welfare or market requirements before they could be widely adopted.

Peter Willadsen mentioned that IPM strategies have to be farm-specific. Each producer must be able to utilise measures that reflect their own priorities on their property. Buffalo fly control must be included, as crossbreeding and gene markers for ticks will not overcome this parasite.

8.3.8 Economic analysis of a strategy to develop IPM measures

Strategy outline – **"**Decrease chemical acaricide use by 50% by adopting environmental and combination measures. Establish model feedlot dairies and beef production facilities to demonstrate chemical-free production methods."

Figure 8.11: Net Present Value of a strategy to develop Integrated Pest Management measures for four classes of cattle



IPM measures showed the highest NPV of any of the thirteen strategies for *Bos taurus* herds, with a mean NPV of A$443,898. This strategy also ranked high (2) for crossbred cattle, with a projected NPV of A$155,998. Rankings for *Bos indicus* herds (6) and dairy herds (5) were medium.

8.3.9 Discussion

One advantage of biological approaches to tick control is to decrease the frequency of chemical acaricide application and therefore decrease selection pressure for resistant ticks. This also results in less risk of residue violations for milk and meat. Other benefits are less exposure of farm workers to chemicals, lower risk of inducing acaricide resistance and the potential for decreased mustering costs.

The tick vaccine (TickGARD Plus) is useful for dairy cattle, but commercially it is a marginally viable product given the current cost, rate of efficacy, short duration of immunity and side effects (occasional swelling at injection site). Beef producers have not used it to any great extent and are unlikely to increase usage given the aforementioned shortcomings. There is a reasonably high risk that it will be withdrawn from the market within a few years if sales do not improve, as production costs are high. Given the arguments that the vaccine is useful for promoting chemical-free cattle production in the tick-endemic areas, interested parties (meat processors, milk factories, organic produce marketers, regulators) should consider incentive schemes to encourage use. Further development of the vaccine to improve the efficacy and duration of immunity is seen as highly desirable but is unlikely, given the high cost of development.

The currently available vaccine against tick-borne diseases is a valuable tool for preventing losses due to tick fever. Vaccination is cheap, but biosecurity risks are real and the short shelf life of the fresh product and inconvenience of using the frozen product mean that many producers see it as ‘too much trouble’. Use of the vaccine will continue to be seen as essential for producers with high value cattle, or those who cannot accept the occasional losses due to tick fever that are the norm on properties that rely on natural exposure for protection. The risk of losing market access, or suffering losses due to live export cattle being unvaccinated or vaccinated immediately before export are important, and could be countered by producers vaccinating all calves at weaning.

Application of Integrated Pest Management on cattle properties in northern Australia would rely largely on extension programs[73]. Since none of the individual measures mentioned above have very high efficacy, these would still need to be combined with other measures, such as traditional chemicals for treatment of animals in times of high tick challenge, or to treat buffalo fly. Extension programs to control ticks have proven to be difficult to implement in the past (see section 4.4.1.2 above). Future programs could target farms with amitraz-resistant ticks, and use demonstration farms so that discussion groups could observe and copy the programs.

Fungal biopesticides could be useful means of controlling both ticks and buffalo fly in a manner that has little impact on the environment, food residues or occupational health and safety. Moreover, these would fit in well with environmental and IPM approaches to external parasite control. However, efficacy for the treatment has not yet been established fully, and research to optimise the application method and demonstrate efficacy in pen trials needs to be completed before the concept can be successfully commercialised.

8.3.10 Summary

The tick vaccine is useful for dairies and small farms with low mustering costs; overall use is extremely low due to short duration of immunity and low efficacy. An improved vaccine with higher efficacy and annual booster would be welcomed by producers and regulators but is unlikely given the current state of research. Tick fever vaccine is safe and effective but does have problems with biosecurity risk, convenience and side effects. There is little chance of this vaccine being improved, but research on non-live vaccines for tick fever is proceeding. Introduction of IPM measures including environmental management of ticks would give very high economic returns according to the model. Fungal biopesticides could provide an alternative measure for treatment of both ticks and buffalo fly but will not proceed unless funding becomes available.

8.4 Chemical approaches

8.4.1 Acaricides

A variety of acaricides have been used by northern Australian beef producers in the past, and currently-registered products for ticks include organophosphates, synthetic pyrethroids, amitraz, Macrocyclic Lactones and Fluazuron. The QDPI&F encourages beef producers to treat even tick-resistant cattle for ticks prior to marketing, due to the belief that “Considerable advantages can occur when cattle are presented to market free of ticks.”[74]

8.4.1.1 Acaricide resistance

Australia is noted as having “the worst record in history of acaricide resistance and its management.[41]”

Acaricide resistance has been a feature of the chemical treatment of ticks since ticks were found to have acquired resistance to arsenic, the first effective chemical treatment, just forty years after its introduction in 1896[75]. Subsequently, DDT, organophosphates, and an array of synthetic pyrethroids, and amidines have been used against ticks, and all have developed resistance within the space of a few decades[76]. The average time from introduction to resistance being detected, or the chemical being withdrawn from the market is just 7.5 years[76]. Recent findings have shown that the distribution of amitraz-resistant ticks is spreading, and the extent of this resistance will be quantified by surveys currently underway[44].

In 2004 the only tickicides with 100% efficacy are the Macrocyclic Lactones and Fluazuron, both classes being unable to clear cattle as “knock-down” acaricides. Despite this, Fluazuron particularly has been well accepted in the field as it provides effective long-term control of ticks from a minimal intervention (one to three backline applications per year). Macrocyclic Lactones are widely used for tick control, and are the last resort for dairy farmers with multiple-resistant (“Ultimo”) ticks. Resistance to the MLs has been reported overseas[77], and it is feared that the current popularity of the MLs for tick control, combined with a knowledge of the long-term effects of selection for resistance on other parasite species, notably nematodes in sheep[78], will lead to the onset of resistance to this class in ticks in the near future.

Concentration – of acaricide may speed or slow selection for resistance. For example, high amitraz concentration allows survival of moderately resistant heterozygote ticks, increasing the chance of heterozygote resistant ticks emerging. At lower concentrations this does not occur due to the survival of more susceptible ticks which then pass on susceptible genes to the next generation (DH Kemp, pers. comm.).

Non-chemical control – A working party set up by state and federal departments in 2000 outlined the following principle regarding the use of chemicals to control ticks. “A further consideration has been the increasing concerns over the use of chemical controls with their associated environmental, workplace health and safety, and chemical residue concerns. A general principle that has been adopted is that at all times the use of chemical controls will be minimised where this is consistent with the ability to control cattle ticks.[79]” This general principle indicates that at a government level, means of tick control that do not rely on acaricides will be given greater priority in years to come.

This principle is not consistent with the current reliance on acaricides to clear cattle for movement across the tick line. State governments rely on knockdown dips, currently amitraz, to clear cattle for movement to tick-free areas. However, it was emphasised during the interview with regulators that the long-term future for tick control will rely on non-chemical methods.

Risk factors for acaricide resistance – Jonsson (2001) studied the risk factors associated with acaricide resistance in a case control study within a survey of 199 dairy farmers[80]. Consistent factors associated with acaricide resistance were location of farm (region) and number of applications of acaricide per year. The highest levels of resistance to synthetic pyrethroids and amitraz were found on dairy farms that treated cattle 5 or more times per year, and were located in Central Queensland. Resistance was also related to the use of spray races or hand sprays (rather than plunge dipping).

Resistant farms survey – Langstaff and Jonsson later followed up 100 farms that had been identified with multi-resistant (Ultimo) ticks to record their current treatment practices. Seventy one per cent were dairy farms and the remainder beef farms. Surprisingly, the majority of these farmers were still using amitraz dips for tick control, and increasing the frequency of treatment to try to keep tick numbers low[81].

Field resistance – Jonsson remarked that field evidence of amitraz resistance was only evident at <90% efficacy, at which point the frequency of the resistant gene was close to 0.1 in the tick population. Modelling shows that the increase in the expression of the resistance gene is exponential after an incidence of 0.1 is reached, so it is likely to increase rapidly, to almost total expression within 4–5 generations of field resistance first being noticed. The critical point of detecting resistance is then not when field resistance is noticed, as it is already too late, but at an earlier point when the gene expression is less than say, 0.05. At this stage interventions could prevent the onset of clinically evident field resistance[80].

Fitness – David Kemp stated that there is evidence that the fitness of amitraz-resistant ticks is lower than susceptible ticks. There is therefore hope that if amitraz were removed from the environment, ticks would revert to susceptibility within a few generations.

QDPI&F/MLA survey – A survey to accurately quantify the level of resistance of ticks to acaricides is currently being undertaken by QDPI&F, supported by MLA. The aim is to be able to map the incidence of resistant ticks, and identify the areas where the problem is greatest. It may also help to explain whether new reports of resistant ticks are due to *de novo* expression of resistance, or to the spread of resistant ticks that have arisen elsewhere.

Buyer-beware principle – Kevin Duff, QDPI&F Stock Inspector from Beaudesert, stated that the recommendations for avoiding the purchase of resistant ticks have been available from the QDPI&F for over ten years, and there has been a very consistent extension message for farmers to quarantine bought-in cattle and treat with a Macrocyclic Lactone to prevent the spread of resistant ticks. Despite this, Kevin believes that the uptake of this message has been extremely low, and that there is little awareness or concern for the issue among farmers, potentially leading to the unchecked spread of resistant ticks.

Regulatory restrictions on farms carrying resistant ticks – A submission to this review, representing members of the Queensland Dairyfarmers' Organisation, proposed that properties with resistant ticks be identified and restrictions placed on the movement of animals. This proposal was put to the researchers interviewed during this review. Although most agreed that this would potentially prevent the spread of resistant ticks, all of them argued that it would be impractical to apply in the current climate of decreasing regulatory controls. QDPI&F representatives did not consider this a practical option.

Ron Glanville and Greg Gates of QDPI&F noted that movement restrictions had been used in an attempt to contain Biarra ticks during the 1980s. This had been unsuccessful either due to illegal movements of stock, or simply due to the fact that by the time field resistance to organophosphates was detected the level of resistance genes in the tick population was already very high, leading to *de novo* resistance occurring in other areas.

Litigation – Greg Gates of QDPI&F mentioned the possibility of legal action being taken between producers if the actions of one producer led to economic loss due to ticks being inflicted on a neighbour or producer in another area. Precedents have already been set in Queensland with the successful pursuit of claims in court. Prosecution is also possible if it can be determined that illegal movement of stock is responsible for losses.

8.4.1.2 Discussion on extension programs

Jonsson[82] shows that even a well-researched and deftly communicated program, such as TickCON, was only properly implemented by about 6% of target properties. His evaluation surveyed 199 dairy farmers throughout Queensland, who had been the subject of the broadly backed TickCON extension program to reduce the economic impact of ticks and eradicate them from some properties during 1994–1996[82]. Despite 85% of respondents believing that this program was useful for the industry in general, the low uptake of its principles shows a low level of immediate concern.

Many of the researchers, consultants and regulators interviewed during the course of this review remarked that if an extension program like TickCON was so unsuccessful in impacting the most susceptible part of the industry, i.e. dairy farms, then there is little likelihood of achieving success in changing the practices of the beef producers. David Kemp reported that it is technically possible to slow the onset of resistance to MLs by simply devising programs that restrict usage and rotate the use of acaricides. However, if left to the individual stockowner it would be very difficult to achieve a high level of uptake of this type of program.

Greg Gates of the QDPI&F in particular remarked that apart from several local areas, beef producers' concern about ticks was too low for an extension program solely based on tick control to be successful. This is highlighted by submissions from beef producers in the Crows Nest area of the Darling Downs to be classified back into the tick-infested zone, rather than the protected zone status they now have. He reports that they would rather live with endemic ticks than be forced to comply with movement and treatment regulations imposed by the State government.

Mr. Gates further commented that market pressure, in particular specifications regarding residues and breed content from buyers such as Woolworths and Coles, is a more powerful driver of change in the industry than government regulations or extension programs.

8.4.2 Chemical use patterns

Prolonging the lifespan of amitraz, an important chemical in the current system to maintain the tick line is an achievable option, according to Jonsson and Kemp. Research would focus on alternating the use of chemicals to avoid amitraz, and note the reversion to susceptibility of amitraz-resistant ticks over time. It is anticipated that with judicious use of chemicals ticks, will revert to susceptibility within a few years. This could provide a means of prolonging the lifespan of the current generation of chemicals. However, it may only be practical if the use of amitraz were controlled or restricted to clearing dips for a period until the reversion to susceptibility of the field strains of ticks.

It is not known if this approach would also be applicable to Macrocyclic Lactones. Some evidence is available to show that resistance of ticks to the MLs is related to Dieldrin resistance, already present in field strains of ticks in Australia[44]. If this is confirmed, it may indicate that once detected field resistance to the MLs will progress rapidly. Resistance to Dieldrin (related to resistance to BHC) was noted only 2 years after its introduction to Queensland[83].

8.4.2.1 Refugia

It has been suggested that allowing a percentage of ticks to survive in the environment (“refugia”), either by not treating all animals in a herd, or by purposely using an acaricide that does not have 100% efficacy, is a means to slowing or preventing the onset of acaricide resistance[84]. These principles have already been applied to slowing anthelmintic resistance in sheep with some success[85]. The application of “refugia” principles to tick control in Australia has not yet been attempted but is worthy of consideration.

A simple method of applying refugia principles would be to select a number (e.g. 5%) of the most robust cattle in a herd and not treat them at all when other cattle are treated. This may involve running a small number of resistant cattle (*Bos indicus*) with a herd of susceptible *Bos taurus* cattle, such as lactating dairy cows, which would all require treatment. The ticks dropping from untreated animals would re-infest the pasture and dilute the resistant genes. Note that this strategy contrasts markedly with advice previously given, which encouraged clean musters and total annihilation of ticks on all the animals in a herd[39].

8.4.3 Macrocyclic Lactones

Macrocyclic Lactones (MLs) are currently used as a way of treating cattle ticks, not only in northern Australia, but also in Asia, Africa and South America. Their role is particularly important in south-east Queensland as they are the only products with a nil meat or milk withholding period effective against multiple-resistant ticks such as Ultimo, which are becoming increasingly prevalent.

They are currently used in northern NSW to treat cattle traced back from saleyard monitoring for ticks. MLs are frequently used in Queensland as:
a) a quarantine treatment for new cattle coming onto a property
b) for cattle being cleared of ticks for sale or transport across the tick line
c) as a convenient means of reducing tick burdens without the need for sprays or dips
d) as a way of treating resistant ticks particularly on dairy cattle.

Sales – Because of the nature of MLs these are effective at treating both endo- and ectoparasites. Due to this, the amount used for treating ticks is unknown, and is likely to be underestimated. In previous estimates presented on the value of tickicides used in Australia each year, the MLs were not represented, as these are placed in a separate section from acaricides in the Avcare industry audit report[93].

Parasite resistance – Resistance of ticks to the MLs has not yet been reported in Australia but has been noted in Brazil[77].

A submission received from Dr. Anthony Preshaw of Fort Dodge, Australia, outlines studies performed to assess the potency of the available MLs against ticks (see Appendix Two). Dr. Preshaw cites the case of resistance to *Haemonchus* spp. in sheep[86] as an example of how greater potency of an ML can determine the rate of onset of resistance[87]. In one study, *Haemonchus* exposed to ivermectin, developed resistance more rapidly than those exposed to moxidectin, despite evidence that the mechanism for resistance is the same for both molecules[88]. Dr. Preshaw argues that since moxidectin is more potent against cattle ticks than the other ML products[89], it is likely to cause less resistance than other products if used in the field. Development of resistance to one ML is likely to result in resistance to other MLs[90].

8.4.4 Fluazuron

A backline pour-on formulation based on the Tick Development Inhibitor, Fluazuron, was introduced into the Australian market in 1994, but withdrawn from sale after approximately two years, due to the active ingredient not having a Maximum Residue Limit (MRL) standard in overseas markets. It was re-introduced in 1998 after regulatory conditions were satisfied. The product Acatak, developed and marketed by Novartis Animal Health, Australasia, is registered for beef cattle, with a meat withholding period of 42 days. Use in dairy cattle is prohibited due to the selective excretion of the chemical into milk[91].

Field trials in southeast and central Queensland showed that Acatak is effective in reducing tick numbers on cattle to close to zero, and that due to the chemical's persistence, the acaricidal effects last for up to three months[92]. It is claimed that due to the chitin-inhibiting nature of the chemical, larval development and egg-hatching is suppressed, resulting in Fluazuron-treated cattle being able to "vacuum" tick larvae from paddocks, lowering the source of subsequent infestation for cattle held in that paddock[91].

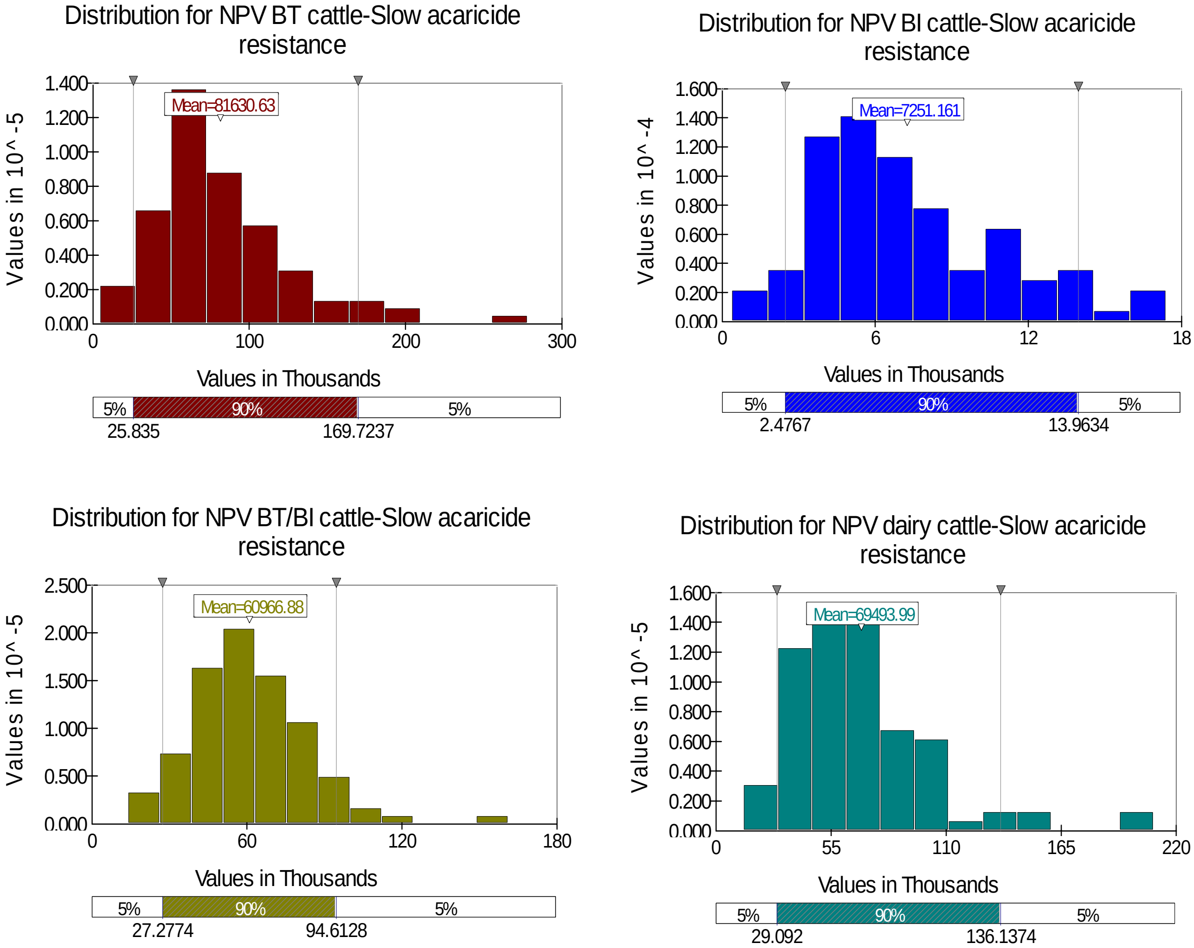
Fluazuron is claimed to be effective against strains of ticks that are resistant to all other acaricides, and no resistance to the chemical has yet been detected[93]. For the above reasons, Fluazuron has become an extremely popular chemical in northern Australia, outselling all other classes of acaricides throughout Australia[93].

Due to the mode of action of fluazuron, tick numbers drop slowly after application, and may not reach zero at any stage. Acatak is not recommended as a clearing treatment, but may be incorporated as a preliminary treatment to decrease tick numbers if used at least 28 days before presentation for clearing inspection. Novartis studies have shown that due to the fact that ticks still attach to Acatak-treated cattle, natural immunity to *Babesia bovis* is not affected[91].

8.4.4.1 Economic analysis of a strategy to slow or prevent onset of acaricide resistance

Strategy outline – **"**Retain use of amitraz at 95% efficacy, and MLs at 100% efficacy. Use of Insect Growth Regulators or Tick Development Inhibitors such as Fluazuron will be included in rotation. Promote program to producers."

Figure 8.12: Net Present Value of a strategy to prevent onset of acaricide resistance



This strategy ranked lowest of the proposed projects for *Bos taurus* herds. It also ranked low for *Bos indicus* (11), crossbreds (8) and dairy (11).

8.4.4.2 Opinions on acaricide management

Dr. David Kemp has performed research on the discriminating dose of various MLs againt ticks, and expressed concern about the potential onset of resistance to the MLs in the CSIRO Livestock Industries submission (see Appendix Three). Nick Jonsson also expressed concern, warning that since Macrocyclic Lactones were already being used at relatively high frequency to treat buffalo flies and internal parasites, adding tick treatments in tick-endemic areas meant that ticks were potentially being exposed to these compounds at extremely short intervals.

Malcolm McLeod of QDPI suggested that if a policy to prolong the lifespan of MLs were implemented, then Pour-On formulations of Macrocyclic Lactones would need to be withdrawn from the market due to the unreliability of dosing, and the increased chance of under-dosing, contributing to the onset of resistance.

Peter McGregor of NSW Agriculture remarked that in NSW Pour-On formulations of moxidectin were used in eradication programs. He argued that since the cattle were treated until ticks were eliminated, the problem of resistance in surviving ticks was also eliminated.

Peter James of ARI Yeerongpilly stated that it would be very difficult to regulate control of the use of MLs against ticks, as these could be purchased for other target pests such as buffalo flies and internal parasites. Moreover, extension would be unlikely to make an impact. Even if 50% of the farmers were to adopt the recommended use of MLs, the remaining 50% would probably be sufficient to cause resistance if misuse was common. The resistant ticks would then be spread to other farms.

Lex Turner reports that it is difficult to convince dairy farmers of the need for long-term strategies, such as preventing the onset of resistance, due to a “siege mentality” currently in place in the QLD dairy industry, caused by major adjustments relating to the deregulation of the market. Those dairy farmers forced to give up the use of cheap dips due to the presence of resistant ticks would be likely to use the cheapest strategy possible when selecting an ML.

8.4.5 New pharmaceutical formulations available overseas

8.4.5.1 Fipronil (Merial)

This chemical is highly efficacious against cattle ticks (99.7% quoted[95]) at 1% active. It is formulated as a Pour-On with a 1 mL/10kg application rate[94]. Due to residue fears it is not registered for use in dairy cattle, but anecdotal reports suggest that there is considerable use in South American dairy cattle nevertheless. Persistence of effect is quite extended, at >95% efficacy for six weeks after application[95]. It is registered in Latin American countries as Ectoline, and is also used for horn fly (buffalo fly) treatment. Rumours of resistance are associated with the misuse of agricultural formulations in cattle, but no official reports of Fipronil-resistant ticks yet exist. The active ingredient is registered in Australia for fleas in dogs, and against agricultural pests[96].

8.4.5.2 Spinosad (Elanco)

Spinosad (Elector) has been on the market in Brazil and the USA since 2003. It is applied to cattle as a spray, at 250ppm, for treatment of ticks[94]. It is more effective against immature stages than engorged females, so clearance of ticks from treated cattle takes three to four days. Acute efficacy was determined to be around 85–90%, and there does not appear to be any residual effect[97]. It is therefore recommended to use it in a rotation strategy. The active ingredient is registered in Australia for flies and lice in sheep, where it has a nil withholding period for meat, wool and milk. It is also unclassified by the SUSDP for poisons, indicating that it has an extremely safe toxicity profile. No resistance has yet been reported.

8.4.5.3 Long-acting Ivermectin formulations – Ivomec Gold and Intraruminal bolus (Merial)

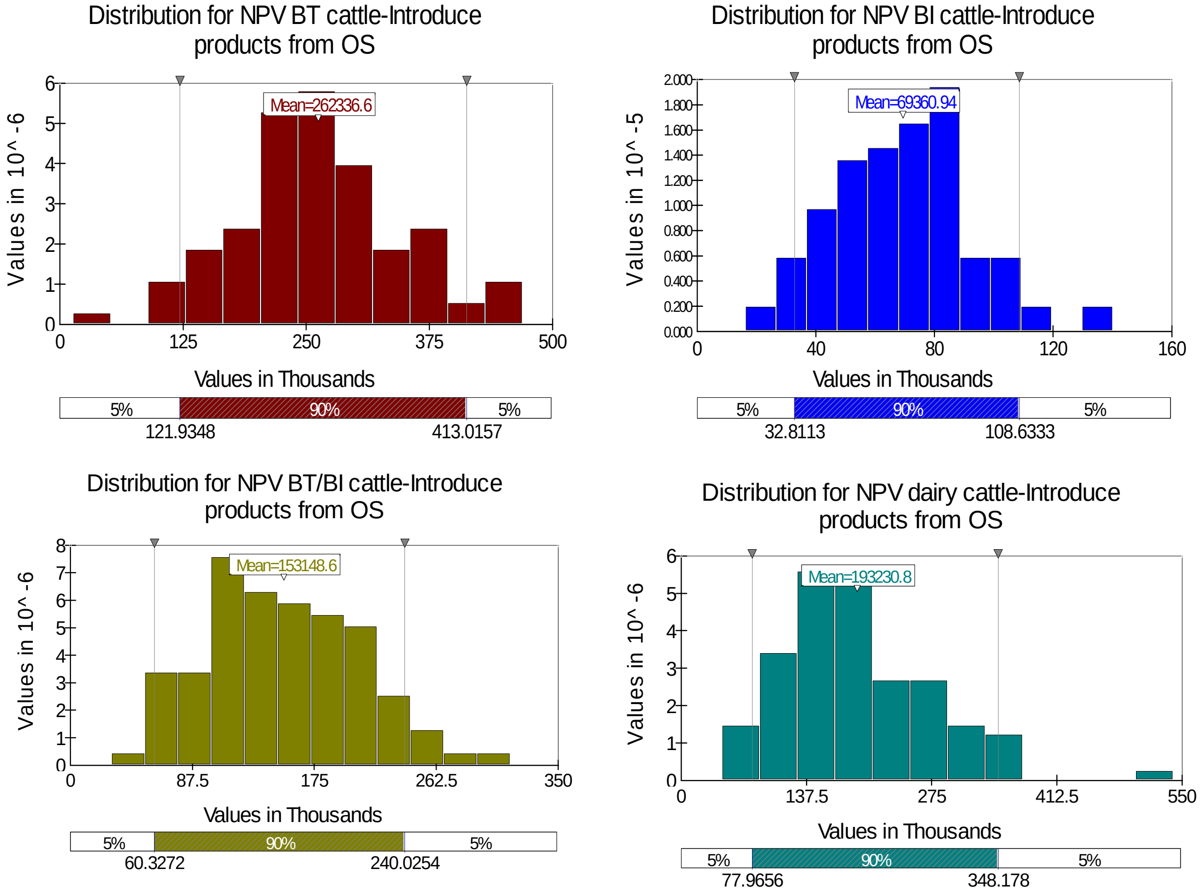
Ivomec Gold is a long-lasting injection of Ivermectin, with reported persistence for 60–70 days[94]. The bolus pays out 12mg ivermectin per day for 135 days, dose rates which are claimed to give >99% efficacy against ticks. Problems with both these formulations are their potential effect on dung beetles in Australia, lack of eradication effect, and meat and milk withholding periods.

An injectable microsphere-based formulation of Ivermectin was found to control *B. annulatus* ticks for 16 weeks under experimental conditions[98]. Potential issues for registration of this type of preparation in Australia are the long meat withholding periods and injection site damage or residues.

8.4.5.4 Economic analysis of a strategy to introduce new formulations of acaricides from overseas

Strategy outline – **“**Compile an APVMA submission and register products that are already in use in other markets, through local efficacy, safety, residues trials. Market to producers.”

Figure 8.13: Net Present Value of introduction of overseas formulations on four classes of cattle



This strategy shows relatively high returns in all classes of cattle. The ranking is highest in dairy cattle (2) with a mean NPV of A$193,230 per farm. The ranking in crossbred herds is 3 out of 12, while in *Bos taurus* and *Bos indicus* herds it ranked fourth.

8.4.6 New active ingredients to treat ticks

Due to the relatively small size of the market for acaricides world wide, little applied research is devoted to the discovery of new target sites or effector molecules for ticks. Most of the advances in potential new active ingredients are spill overs from the agricultural chemical industry[36]. Moreover, increasingly stringent regulatory requirements mean that companies are unwilling to invest the large amounts of money required for efficacy, safety and residues testing in order to commercialise a product for the animal health market. Coupled to this is the limited intellectual property protection available once new products are commercialised. History also has shown that cattle ticks have the capacity to develop resistance to new acaricides very rapidly. It may be necessary to introduce regulatory measures to ensure that any new chemicals introduced to the Australian market are used according to label specifications, and measures to slow resistance onset are complied with.

Rothwell (2003) identified new active ingredients introduced during the 1990s, and noted that only a limited number of target sites for acaricides have been identified (see Table 5.3)[36]. Research based on molecular genetics for selecting target sites capable of providing approaches for novel acaricides would be rewarding, if it were coupled with high-throughput acaricide screening[99].

Table 8.14: Active ingredients and mechanism of action of various pesticides (from Rothwell 2003)

Of the Top 13 New Insecticides Introduced in 1990s, 10 are from New Mechanistic Classes

ELANCO ANIMAL HEALTH

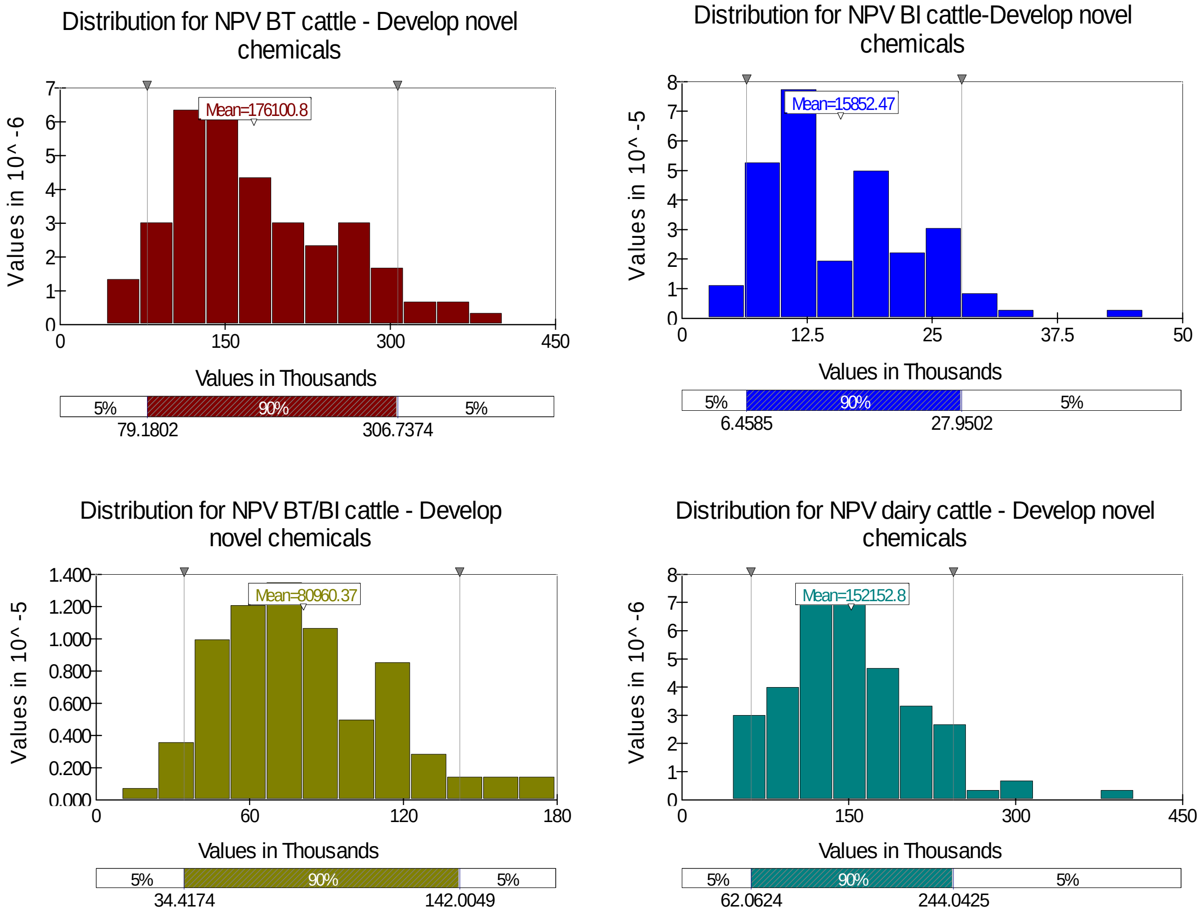
Compound	Year Introduced	Company	Mechanism (Target)
Imidacloprid	94	Bayer Crop Sci	nAchR
Fipronil	93	Bayer Crop Sci	GABA Cl
Spinosad	97	Dow AgroSci	nAchR
Acetamiprid	96	Nippon Soda	nAchR
Chlorfenapyr	96	BASF	Uncoupler Oxi. Phos.
Pyridaben	90	Nissan / BASF	Elec Trans Inhib
Thiamethoxam	97	Syngenta	nAchR
Diafenthiuron	93	Syngenta	Mitochon Resp Inhib
Indoxacarb	98	DuPont	Na Channel
Tebufenozide	95	Dow AgroSci	EcdyR Agonist
Lufenuron	94	Syngenta	Chitin Synth Inhib
Flufenoxuron	93	BASF	Chitin Synth Inhib
Betacyfluthrin	91	Bayer Crop Sci	Na Channel

Several of these have been developed for the animal health ectoparasiticide market →

8.4.6.1 Economic analysis of a strategy to develop novel acaricides

Strategy outline – "Develop novel products by identifying target molecules, screening molecules, compiling complete drug files, performing animal trials and registering product with APVMA. Market to producers."

Figure 8.15: Net Present Value of a strategy to develop new acaricides in four classes of cattle



This strategy showed moderately high NPV in all classes. The highest ranking was in dairy herds (4), while it ranked fifth in *Bos taurus,* sixth in crossbred, and seventh in *Bos indicus* herds.

8.4.7 Discussion

The prospects for new chemicals to be introduced to the Australian market are not good. This is due to several factors: the relatively small size of the market; the substantial cost of developing new chemical products; and low expected returns on investment for companies seeking to trial and register a new acaricide in this country. The economic model projects that the returns from a strategy to develop novel acaricides would be moderate compared to other strategies.

New active ingredients based on existing formulations available overseas would act as a short-term rotation option for dairy producers and small landholders wishing to use chemical treatments, but are unlikely to have a major impact on the wider beef industry. This is because the expense of mustering outweighs the benefits of using chemical treatments on a routine basis, and producers are more likely to opt for resistant genotypes of cattle that do not require frequent treatment. The economic model of introducing overseas chemicals indicates that the NPV would be highest for dairy cattle and crossbreds, and would rank fourth for *Bos indicus* and *Bos taurus* herds.

Fluazuron is, and will continue to be, widely used in the northern beef industry, because of its effect of reducing tick numbers from only one or three applications per year. There is potential to include Fluazuron-treated cattle as “vacuums” in IPM programs, as they could take up larvae on pasture and render the pasture “clean” for untreated cattle to graze subsequently.

Market research to accurately determine the level of ML usage in cattle in the tick-endemic areas of Australia is not available. Because of the strategic importance of MLs in treating multiple resistant ticks and clearing cattle for the tick line, quantifying the relative risk of particular MLs to the onset of resistance, as well as routine monitoring for resistance are important.

Research to model refugia programs and to prove that the concept needs to be completed before strong recommendations or extension projects involving refugia proceed, could be widely promoted. Peter James proposed cooperation with Bob Sutherst to develop a model that could be used as a base for programs. These concepts could be incorporated into extension programs for IPM.

Research to slow the onset of amitraz resistance is feasible due to the lack of biological competitiveness of amitraz-resistant ticks. Economic analysis of the strategy to slow acaricide resistance shows that it would likely have a low return, ranking close to the bottom in all classes of cattle. The major benefits of the strategy would be regulators as it could allow the maintenance of movement controls such as the tick line, and *Bos taurus* producers who require frequent low-cost acaricidal treatments.

8.4.8 Summary

Chemical treatments have been used historically in Australia to prevent production losses due to ticks. Dips have been cheap and effective, but are rapidly losing efficacy due to the onset of acaricide resistance. The average time from the introduction of a new acaricide until it develops resistance or is taken off the market is only 7.5 years. Effective chemicals are still present for the treatment of ticks on cattle. In particular, MLs and Fluazuron are widely used in the beef industry, and have no resistance recorded in Australia. The onset of resistance to MLs is anticipated by researchers within the next 30 years, due to the pattern of use and examples of resistance in other areas and in other parasite species. Programs to slow acaricide resistance are possible but would require excessive regulation and the economic returns of these strategies are probably low. The main benefit of these strategies would be to uphold regulatory movement controls of cattle.

Formulations already registered overseas would likely be readily adopted in Australia, but the registration procedure is onerous and discourages pharmaceutical companies from investing in new active ingredients. The projected economic benefit of this strategy is high. Developing novel acaricides is very costly and is unlikely given the small size of the market. Moderate returns are projected from developing new acaricides.

8.5 Other approaches

8.5.1 New methods for diagnosis of acaricide resistance

Routine diagnosis – Testing for acaricide resistance relies heavily on the use of the Larval Packet Test (LPT). This test is time-consuming (six weeks) and unreliable for the detection of amitraz resistance, as confirmed by parasitologist, Glenn Anderson, of the QDPI Animal Research Institute at Yeerongpilly. This is seen as one of the most serious issues in tick control, because amitraz is a cheap and widely used acaricide that is also used by the QDPI in their clearing dips. In attempting to improve the accuracy of the LPT for amitraz, four different discriminating doses are used compared to only one for other acaricides. The Food and Agriculture Organisation of the United Nations is sponsoring a project to standardise the LPT for world-wide use.

Monitoring – No routine monitoring is currently being performed in Queensland for ML resistance[44].

Adult immersion tests – Trials on adult immersion tests are continuing. It is hoped that these can provide some benefits in accuracy compared with the LPT, as well as being faster. However, early trials show poor consistency in results[100]. Work on a modification of the LPT using an acetate packet is also being conducted at ARI[44].

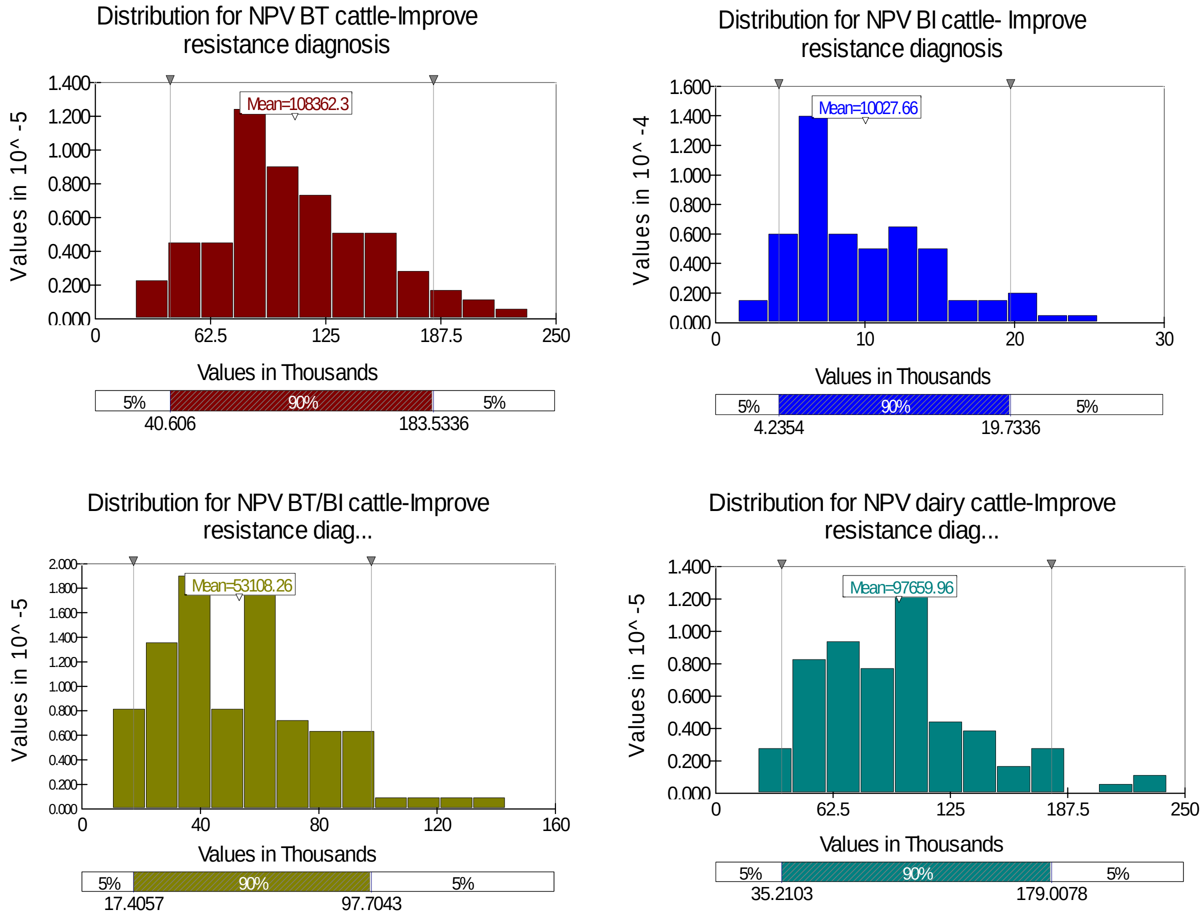
DNA tests – Several researchers have expressed interest in developing DNA-based tests for rapid diagnosis of acaricide resistance in ticks. David Kemp of CSIRO Livestock Industries stated that advances in diagnosis already achieved by the United States Dept. of Agriculture could be used as a foundation for diagnostic tests in Australia[101]. The advantage of DNA-based tests is that these would offer a 24 hour test, meaning that farmers, veterinarians or advisers in the field could submit ticks by courier, and have the results faxed or emailed to them within a few days.

MLA project – Funding has been provided to ARI to test samples of ticks in order to determine the level of resistance to the commonly-used acaricides, including MLs and Fluazuron, and map the occurrence throughout the State. Frozen samples are being put aside to be used for the validation of DNA testing at a later date.

8.5.1.1 Economic evaluation of a strategy to improve diagnosis of acaricide resistance

Strategy outline – **"**Establish DNA tests that can identify resistance genes in ticks by overnight tests."

Figure 8.16: Net Present Value of a strategy to develop a novel diagnostic test for acaricide resistance



The economic model shows that the benefits from an improved diagnostic test for acaricide resistance were uniformly low. This strategy ranked ninth or tenth in all classes of cattle. For more details on the economic model see Chapter Nine.

8.5.2 Other approaches to tick control

Ala Lew, of ARI Yeerongpilly, has identified several projects with potential for future tick control. A tick cell line has been established at ARI by Wayne Jorgensen after visiting collaborators in Oklahoma, which could provide a tool to model the effects of new active ingredients or immunological effectors on target sites in tick cells.

RNA interference – RNA interference techniques for *Babesia* and *Boophilus*.

Forestry by-products – Oils derived from the processing of pine trees have potential for yielding acaricides.

Tick genome research – Projects to sequence the entire tick genome are underway, supported by International Livestock Research Institute (ILRI, Nairobi), the United States Department of Agriculture (USDA) and The Institute for Genomic Research (TIGR). This is seen by some tick researchers as being a significant step forward, as it would help identify targets for pharmaceuticals and vaccines.

Viruses – Entomopathogenic fungi have their virulence enhanced by certain viruses. Using them in combination may help improve the efficacy of the fungi project.

Tick egg receptors – Ian Sutherland and Sharon Bishop-Hurley of CSIRO Livestock Industries, Rockhampton, are working on a phage peptide that could block receptors on the egg surface and prevent the tick from hatching.

8.5.3 Discussion

The project to develop a rapid DNA-based diagnostic test is supported by Glenn Anderson of the Animal Research Institute, Yeerongpilly, Nick Jonsson of the University of Queensland, Shelly Hope of CSIRO, St Lucia, and Ian Sutherland of CSIRO Livestock Industries, Rockhampton. All of these researchers rate the potential to develop DNA tests highly, and have the capability to contribute to a successful test, but none have specific funding to pursue the project, so small measures are being taken on a piecemeal basis.

The successful development of a DNA-based test would allow people purchasing cattle to test ticks before the cattle were able to drop them onto their property. This would give producers a means of ensuring their own property's biosecurity. Applying the benefits of a DNA-based test for acaricide resistance would require substantial cooperation from extension and regulatory authorities if the exercise were to be useful. It would also assist regulatory control of the spread of ticks.

Other projects such as tree extracts and RNA interference are still in early stages, and will require substantial time and laboratory-level research before field trials can be attempted.

8.5.4 Summary

Many projects in pharmacology, immunology, biochemistry and genetics show potential for application in tick control. However, the only project of immediate interest is the development of a DNA-based test for acaricide resistance, which would enable producers to ensure farm biosecurity, and probably have commercial application both in Australia and overseas.

9 Current research

9.1 CSIRO Livestock Industries, St Lucia

Pictured below (left to right)
Dr. Peter Willadsen, Dr. Bill Barendse and Dr. David Kemp

a) Funded by Beef CRC and DA – Bill Barendse, leading a gene marker project for identification of resistant genes in beef and dairy cattle, and developing a cost-effective test for their identification. Collaborating with QDPI&F.

b) Funded by Vaccine Technology, CRC – Peter Willadsen, leading a project to develop a novel vaccine against *Anaplasma marginale* using recombinant antigens. Also involved are Robin Anders, LTU, George Riding, CSIRO, Moira Menzies, CSIRO, Shelly Hope, CSIRO and Anne Kelso, CRC-VT. A patent application was filed in 2002, and papers on the project were presented at an international conference.

c) Funded by CSIRO, David Kemp active in collaborating with other projects run by QDPI&F, UQ (see below).

9.2 QDPI&F Tick Fever Centre, Wacol

Pictured below (left to right)
Dr. Bert DeVos and Dr. Russel Bock

9.2.1 Current projects

QDPI&F-funded ongoing research relating to tick fever vaccine, concentrating on trouble-shooting manufacturing issues and investigating strain differences that would influence the efficacy of the vaccines. Note that recent changes to QDPI&F policy, has removed responsibility for pure research from TFC to other areas of QDP&F. This has also resulted in a name change from the Tick Fever Research Centre to Tick Fever Centre.

9.3 QDPI&F Animal Research Institute, Yeerongpilly

**Pictured below (left to right), Dr. Lex Turner, Dr. Glenn Anderson,
Dr. Peter James, Dr. Wayne Jorgensen, Ms. Diana Eamon, Dr. Ala Lew**

9.3.1 Current projects

1) Biotechnology projects (Emerging technologies)

a) Funding from QDPI&F and ACIAR, collaborating with the governments of the Philippines, Kenya and Zimbabwe, as well as ILRI and USDA – Wayne Jorgensen, heading four projects aimed at:
(i) improving the diagnostic capability of tick-borne disease with validated ELISA tests
(ii) determining the distribution of tick fever in northern Australia and breed susceptibility
(iii) improving quality control of the live tick fever vaccine
(iv) improving protection of the live tick fever vaccine.
b) Funding from MLA – Glenn Anderson heading the project with David Waltisbuhl, informal associations with UQ and CSIRO. Tracking the incidence of acaricide-resistant ticks in Australia. This involves testing ticks submitted from the field plus survey work. Also working with John Molloy to develop more accurate tests for diagnosing resistant ticks.
c) Funding from FAO – Glenn Anderson, to standardise the LPT for use overseas.
d) Funding from Beef CRC – Ala Lew working on new technologies, such as RNA interference, immunological target sites in both ticks and tick fever organisms.

2) Integrated Pest Management

Funded by QDPI&F and Dairy Australia (DA, formerly Dairy Research and Development Corporation) – Peter James, Diana Eamon and Lex Turner. Working on the practical application of new technologies such as biopesticides (see below) and refugia, in combining them with existing environmental and chemical control methods for ticks.

3) Biopesticides

Funded by DA and QDPI&F – Lex Turner and Diana Eamon using the fungus, Metarhyzium anisophilae, in trials on ticks and buffalo fly. Looking for a commercial partner at present.

4) Gene markers

Funded by Beef CRC and DA – Lex Turner, working in association with CSIRO Livestock Industries St Lucia (see above).

5) Pharmaceuticals

Funded by private companies – Actest facility, run by David Waltisbuhl, provides contract research for the testing of pharmaceuticals.

9.4 CSIRO Entomology, Long Pocket

Dr. Bob Sutherst (pictured below)

9.4.1 Current projects

Funded by CRC for Tropical Pest Management, the National Greenhouse Advisory Committee of the Commonwealth Department of Environment, Sports and Territories. This Models the distribution and economic effects of ticks and buffalo fly, in line with projected climate changes.

9.5 CSIRO Livestock Industries, Rockhampton

Dr. Ian Sutherland (pictured below)

Dr. Heather Burrow (pictured below)

Nick Corbet
(pictured below, at Belmont Research Station)

Belmont Research Station (pictured below)

9.5.1 Current projects

a) Funded by CSIRO – Dr Ian Sutherland, Sarah Shaw, Dr Juliet Sutherland, Tanya Robinson, Dr Sharon Bishop-Hurley, Kelly McNicol – to identify breed differences relating to tick control. Focusing on the immunological and biochemical differences between breeds. The major application is for gene expression markers, which promise to have greater potential than the gene markers themselves.
b) Funded by CSIRO – Ian Sutherland and Sharon Bishop-Hurley – examining tick egg receptors and the application of phage peptides. This is fundamental research aiming at identifying new potential targets for vaccination and the biological control of ticks.
c) Funded by Beef CRC – Heather Burrow, K.C. Prayaga – using molecular genetics to identify helpful traits such as meat quality genes in tick-resistant species. An example is the thyroglobulin gene that is related to marbling. A crush-side test could be developed as a practical application of this research. A full description of Beef CRC projects is available at http://www.beef.crc.org.au/
d) Funded by Beef CRC – Heather Burrow, K.C. Prayaga – decision-making software, known as Hotcross, which provide predictions to beef breeders on the most economically rewarding breeding strategies.
e) Funded by private companies – contract research to evaluate pharmaceuticals.
f) Funded by MLA – K. C. Prayaga – the Belmont Crossbreeding Project (CS183a), recently completed

9.6 School of Veterinary Science, University of Queensland

Pictured below (left to right), Dr. Nick Jonsson and Dr. John Morton

9.6.1 Current projects

a) Funded by FAO – a review of Integrated Pest Management and its application to control tick species throughout the world.

b) Funded by DA – a series of projects (DAQ151), now completed, that examined the state of tick control in the northern dairy industry, extension projects explaining tick control to dairy farmers, the efficacy of the tick vaccine, TickGARD Plus, economic consequences of tick and buffalo fly infestation, resistance of Holstein-Friesian cows to cattle tick infestation.

c) Funded by private companies – contract research to test pharmaceutical formulations.

d) Funded by UQ – collaboration with CSIRO Livestock Industries to develop tools to diagnose acaricide resistance, and to develop strategies to slow the onset of acaricide resistance.

e) Funded by UQ – collaboration with Shelly Hope of CSIRO Livestock Industries to develop a *Babesia* transmission-blocking vaccine.

f) Funded by UQ – collaboration with USDA to perform research into the Adult Immersion Test for acaricide resistance.

9.7 Discussion

Australia has been well served in the past by a wealth of research into ticks and tick-borne disease. This has resulted in such breakthroughs as the introduction of tick-resistant cattle into northern Australia, crossbreeding and genetic advances to maximise the benefits of different genotypes, the world's first commercial vaccine for external parasites (TickGARD), a safe and effective commercial vaccine against tick-borne parasites, and the local registration of a wide range of chemical acaricides, from the arsenic-based “Queensland dip” of the late 1890s, to Fluazuron in the 1990s.

Research into ticks is dominated by CSIRO, the Queensland State government and the University of Queensland. International pharmaceutical companies are less active locally than in the past, with the closure of Bayer’s tick research facilities at Beenleigh, QLD, in 2001. There have been no new active ingredients registered in Australia since Fluazuron was first launched more than ten years ago, despite the registration of dozens of generic copies or minor formulation changes to existing actives. Several researchers and pharmaceutical company representatives commented that the requirements for registration of new acaricides are too stringent, and the pharmaceutical companies are now focused on regulatory trials for generic actives. The majority of this work is commercial-in-confidence and cannot be publicised.

The direction of research has correspondingly moved away from the development of new chemicals to immunological and biochemical techniques, including molecular genetics. However, the problem of acaricide resistance is being addressed with strategies to slow the onset of amitraz resistance, and several projects aimed at improving the diagnosis of acaricide resistance. Some of the projects, such as the ’Emerging Technologies’ program at ARI are directed at overseas problems, while others, such as the work of the Beef CRC, focus on improving the productivity of the Australian beef herd.

Apart from the ARI Actest facility at Yeerongpilly, other facilities currently conducting contract acaricide efficacy trials are at UQ Pinjarra Hills, CSIRO Livestock Industries, Rockhampton, and Agrisearch, Innisfail. There is a moderate degree of collaboration between public laboratories, but this could be improved with a coordinating body that would allow regular sharing of information, including the priorities of government control programs. An impediment to collaboration could be the intense competition for limited research funding for ticks.

9.8 Summary

Tick research in Australia has been responsible for many breakthroughs. Current research activities in pharmaceutical companies show a trend away from the development of new chemicals towards the development of formulations from existing active ingredients. Public laboratories are working on a wide variety of strategies including genetics, immunology, vaccines, diagnostic tests, biopesticides and IPM.

10 Vulnerability of the industry

Apart from the direct effect of the ticks and tick-borne diseases on cattle, several aspects of ticks and tick control have the potential to impact on the viability of the cattle industry.

10.1 Welfare

The effect of ticks on the welfare of cattle in northern Australia has not been addressed directly. During the interviews conducted for this review, the issue of welfare was discussed, with consensus that welfare was a major aspect of tick control. As an example, it was reported that some dairy farmers in the tick zone tend to treat cattle as soon as ticks are detected[82]. Since they are able to observe cows twice daily, dairy farmers can monitor the presence of ticks quite closely and treat when they feel the cows are suffering as a result of ticks. This practice of over-treatment leads to the increased cost of treatments, mustering, and could lead to a higher rate of onset of acaricide resistance. However, it is frequently practised due to stock-handler's concern for the welfare of their animals. Similarly, buffalo fly tend to be treated as much for animal welfare reasons as for straight economic reasons[102].

The economics of welfare have been considered by several authors[103]. One aspect that could be relevant to this situation is that "consumers may feel cognitive dissonance associated with their consumption of livestock products because of animal welfare concerns over the way in which those products are produced."[104] Other organisations have shown initiatives to link retail and consumer buying practices with animal welfare[105]. It should be noted that consumer perception of the humaneness of production systems can affect the retail choices of products of a livestock industry. An example is the availability on supermarket shelves of "dolphin-friendly" tuna, or "free-range" eggs and poultry meat products. Surveys showed that a large percentage of consumers answered that they were prepared to pay more for a product if it involved improved the welfare of the animals[106]. Evidence to show that this is a major trend in consumer behaviour is, however, lacking.

10.2 Residues

Increased consumer awareness of residues was cited by some respondents in our survey as a reason for promoting biological or IPM measures (Peter James, ARI, see Appendix Three). Moreover, awareness of residues from tick treatments has led to loss of markets. An example is Acatak, which was withdrawn from sale soon after its initial launch in 1997, due to the fact that the United States had not decided on an MRL for the active ingredient, Fluazuron. The product was only released back onto the market after these technical and regulatory obstacles had been overcome[93].
Similarly, Bayticol, a very popular acaricide based on the active ingredient Flumethrin, was withdrawn from sale for domestic use in 2002, due to the restrictions on residues in certain export markets. The product may become available again in the future, but only for treating animals at the point of departure for live export markets[107].

10.3 Market access

1. Properties with a record of a tick fever outbreak in the preceding twelve months are not eligible to send animals for live export to certain markets. This restricts the options available for producers to market cattle and can have serious economic consequences[108].
2. *Bos taurus* and *Bos taurus* cross cattle have more acceptance in feedlots, and so have greater options for being marketed (see Section 4.1.2, above).
3. Cattle destined for the live export trade are generally required to have 50% *Bos indicus* genetics[15].

10.4 Productivity

As noted above, low branding percentages and high death rates have long been a feature of northern beef production, with branding rates up to 20% lower than in southern Australia, and average death rates of over

10% being recorded[109]. Frisch (2000) notes "Brahman cattle are inherently less productive than F1 (Brahman x *taurus)* crossbreeds." Over-reliance on tropical breeds to provide tick resistance has been reported to cause disadvantages in the form of lower meat quality, reproductive potential and temperament[12].

10.5 Spread of ticks

There is a danger of the spread of ticks to areas outside the current endemic ones, as predicted in the study by White *et al.* that projected tick population dynamics with climate modelling[117]. This danger is exacerbated by the spread of acaricide resistance, and possibly by the trend towards lowered government input into tick control programs. Even given current climatic conditions, ticks would survive on the Darling Downs and coastal New South Wales, probably as far south as Newcastle[45]. If ticks were to spread, cattle producers in these areas would be exposed to loss from tick fever outbreaks, tick worry, and treatment and control measures.

10.6 Discussion

Welfare risks posed to the northern beef industry by ticks are probably moderate compared to other practices that have been highlighted, such as live export, firebranding, lotfeeding and dehorning[110]. Residue in meat is an ongoing concern that has already caused the rejection of shipments of meat to major trading partners, and must be ranked high. Previous cases of the occurrence of tick fever in live export cattle, and the lack of eligibility to the export of farms with a history of tick fever also emphasise the risk to trade posed by ticks.

Trade benefits are to be found in having a range of genotypes of cattle available for different markets, in order to give stability to the industry. Highly tick-resistant cattle are preferred in some markets, such as live export to Southeast Asia, but not in high value markets such as lofted beef for domestic consumption or export to Japan. Cattle with a high content of *Bos indicus* have shown lower fertility than crossbreds or *Bos taurus* cattle, which can result in lower productivity. This is offset by good foraging ability and survival in extensive conditions.

10.7 Summary

The northern beef industry is moderately exposed to risks due to ticks and tick fever that aren't related directly to the effect of the parasites on cattle. These include public perception of animal welfare due to tick worry and tick fever, potential for chemical residues in meat and milk, spread of ticks to new geographical areas, market access problems and low productivity related to breed selection.

11 Economic costs of ticks and tick fever

11.1 Economic value of the Australian beef industry

The beef industry makes a very important contribution to Australia's economy. In FY2002-03 9.3 million head of cattle were slaughtered in Australia, and 968 thousand head of live cattle were exported. Most of the live export cattle originated from the northern tick-endemic areas of the country[111]. The combined value of slaughtered and live export cattle was A$6.4bn[112].

11.2 Costs of ticks and tick fever

Beef cattle in northern Australia are subject to disease and production loss from ticks and tick-borne parasites. Losses due to cattle ticks can be attributed to:

a) decrease in liveweight gain
b) decrease in milk production
c) hide damage
d) morbidity and mortality due to tick fever
e) labour cost of mustering and treatment
f) capital cost of facilities for treatment
g) cost of chemicals for treatment
h) veterinary costs to treat sick animals
i) cost of maintaining regulatory controls
j) costs of research and policy-making
k) welfare costs
l) trade-related or fertility losses due to inability to use the most desirable breeds.

11.2.1 Chemical costs

Sales of tickicides are included under "Parasiticides – Large Animal, External" in the APVMA's 2002 annual sales report. The total value of this sector is A$52.1m. It is estimated that in 2003 the sales of tickicides, including Macrocyclic Lactones to control tick costs, was approximately A$16.8m. This takes into account the value of tickicides such as dips and sprays containing amitraz, synthetic pyrethroids and organophosphates, as well as the pour-on Insect Growth Regulator Fluazuron[93]. An estimate is made for the value of Macrocyclic Lactones, such as Ivermectin and Moxidectin, used in tick control.

11.2.2 Cost of tick fever

Anaplasma and *Babesia* infection were reported in 1997 to cost Australian cattle farmers US$15.9 million (A$27m adjusted to 2004)[113]. Sales of the vaccine are reported at 870,000 doses per year at a cost to the farmer of approximately A$3/dose[59], a total of approximately A$2.4m.

11.2.3Hide damage

No accurate and up to date reports on hide damage associated with ticks were available. In order to provide some data, we interviewed several people involved in hide processing over the telephone.

Warren Low, who markets hides for Murgon Lea tannery of Murgon, commented that the average hide value is approximately $70. This can be reduced by 25–30% if there is tick damage, and up to 50% in extreme cases. This is due to the fact that pocked hides require filling, and can not be then used for high-quality applications, such as for shoes. Damaged hides are imprinted with a press before use to cover over defects. Tanneries will try to selectively source cattle from non-tick areas. If buying cattle that have been finished in a feedlot, they are less concerned about the origin as the three months in a tick-free environment will allow tick lesions to heal. Buffalo flies are the next most important cause of loss.

Greg Daley of Michelle Leather, Gunnedah, confirmed the estimates above. Greg said that up to 60% of the hides sourced from abattoirs in south-east Queensland were tick-damaged, with an average of 20% overall. Hides from feedlot cattle can still have substantial tick damage, depending on their origin. Ticks are a bigger issue than buffalo fly, followed by brands, scratches and knife cuts.

One of the reasons given why producers were often unwilling to treat to prevent tick damage to hides is that the hide component of the price paid for the cattle includes an average amount for the hide. Hides presented to the abattoir in perfect condition can still be damaged by accidental scratching or cuts during processing, so prices paid by the hide buyer are insulated from the producer. The reverse is also true. Benefits of presenting cattle with clean hides to sale are not passed on to the producer.

11.2.4 Overall cost estimates

Tisdell (1999) summarised the cost of ticks and tick fever in various regions, and found a wide variation in the estimates provided. Studies cited in their review estimated annual losses in Australia of between A$60m up to A$250m (1999 prices)[114].

Other published estimates of the overall costs of ticks and tick fever are summarised below (see Table 8.1). Davis (1998) reported various estimates of the components of the cost of ticks, with treatment accounting for 11%, additional labour 35%, production losses and animal deaths 32%. It is estimated that the overall cost of ticks to the northern beef industry may have decreased in recent years due to the widespread infusion of *Bos indicus* cattle, but this effect has not been quantified[114].

Table 11.1: Estimates of the cost of ticks to the Australian cattle industry

Estimate (cost/year)	Author	2004 values (assuming an annual inflation rate of 3%)
A$33m 1973	Cattle Tick Commission, 1973	A$85
A$132m 1995	McLeod (1995)	A$172
>A$100 1997	Willadsen (1997)	>A$122
A$87m 1973, A$184m 1995	Davis (1998)	A$240
A$134m 1995	Davis (1998)	A$175
A$250m 1999	Tisdell (1999)	A$290

11.3 Other diseases of importance to the northern beef industry

A mail survey of 448 beef producers conducted in 1995 by researchers at the Tick Fever Centre, Wacol, examined the cost of factors reducing production in Queensland beef herds[28]. Producers ranked their personal assessment of various pests and disease. Buffalo fly was the top-ranked pest, with cattle tick ranking second across the three regions. Ephemeral fever was seen as the third biggest problem, with plant poisoning, botulism and tick fever following.

11.3.1 Buffalo fly

Sales of buffalo fly treatments are included under “Parasiticides – Large Animal, External” in the APVMA’s 2002 annual sales report. The total value of this sector is A$52.1m, of which buffalo fly treatments are estimated to account for approximately A$5.2m. Add to this the amount of Macrocyclic Lactones used against buffalo fly, estimated to be approximately 5–10% of the total value of sales of MLs in northern

Australia, or approximately A$0.67 to A$1.35m. Total buffalo fly chemical costs can be calculated then as approximately A$6.55m. The most common chemical treatment used today is the application of eartags impregnated with organophosphates or synthetic pyrethroids.

Hide damage due to buffalo fly is also an economic cost, as cattle that are hypersensitive to buffalo fly bites develop proud lesions on their skin that need to be trimmed or processed.
Buffalo fly can also be treated with the installation of fly-traps. These are popular in Queensland dairies. Application of these traps in extensive situations is possible if they are located in a chute leading to the water source or mineral licks, and cattle are trained to pass through them. The traps cost about $3,800 each to install[115].

It has been estimated that buffalo fly can cost producers up to A$30 per head if not properly treated, and the overall cost to the industry is "at least A$20–30m per year[115]" (2001 figures).

11.3.2 Botulism

The incidence of botulism relates to the wide problem of phosphorous-deficient soils in northern Australia. Supplementation of cattle with phosphorous in the form of lick blocks or other supplements ameliorates the level of pica and decreases the incidence of clinical botulism. Both CSL and Fort Dodge market bivalent (C and D toxin) vaccines for use against botulism in cattle. Single dose administration and annual boosters mean that producers have access to cheap and effective protection against this problem.

11.3.3 Plant poisoning

The occurrence of plant poisonings in northern Australia is sporadic and difficult to quantify.

11.3.4 Bovine Ephemeral Fever

A live vaccine is available for the prevention of Bovine Ephemeral Fever (Fort Dodge, Australia), otherwise known as Three Day Sickness.

11.3.5 Discussion

Major diseases other than ticks rated highly in the problem stakes by northern Australian cattle producers are buffalo fly, ephemeral fever, botulism and plant poisoning. Two of these, botulism and ephemeral fever, are amenable to prevention with effective and convenient annual vaccines. The rate of adoption of Bovine Ephemeral Fever vaccine is reported to be limited by the need for two injections in the first year. Another disease, plant poisoning, is a sporadic condition that occurs inevitably in extensive grazing situations, despite proper nutrition of cattle and attention to weed management.

Cattle tick and buffalo fly are the two major production-limiting diseases of cattle in northern Australia that are most amenable to intervention. The amount of production losses and other costs due to ticks alone could be estimated at $A175m per year (see above), with buffalo fly causing losses of up to A$30m per year[115]. The problem of buffalo fly was rated higher than ticks in a 1995 survey of northern beef producers, possibly due to the greater visibility of buffalo fly and nuisance value of the fly when cattle are yarded.

Due to the nature of infestations, integrated control of ticks and buffalo fly has been practised widely in the past. Cattle dipped in synthetic pyrethroids or organophosphate dips were protected from buffalo fly for a certain period of time (two to four weeks). However, these dips are rarely used now for tick control due to acquired resistance of ticks, and resistance to synthetic pyrethroids is becoming common in buffalo fly. Currently, producers use pour-on MLs if they wish to treat ticks and buffalo fly concurrently. This is an expensive option compared to the dips used previously, with pour-on MLs costing about ten times as much per head as the older dips[42]. Some savings are made in the cost of facilities as pour-ons can be administered in a race, whilst dips require expenditure on a 10–15,000 L dipping vat with a roof. These cost approximately A$20,000[116].

The likelihood of gaining a return from money spent on research to prevent disease is highest if the money is directed towards preventing tick infestation, the costliest of these diseases and the one most likely to threaten markets. Including buffalo fly treatment in an integrated program will give added benefits, especially in regard to animal welfare and the prevention of hide damage.

11.3.6 Summary

Ticks and tick fever are the biggest disease causes of production loss to the northern beef industry, with losses estimated at A$175. Together with buffalo fly, these diseases cause approximately A$200m of losses to the industry. Dips to control both ticks and buffalo fly have been widely used in the past but are less efficacious today due to acaricide resistance. Pour-on MLs are used today for the same purpose. Future control programs to decrease production losses from ticks would also benefit from focusing on buffalo fly.

12 Model to evaluate economic benefits

White *et al.* (2003)[117] modelled the economic impact of ticks on the Australian cattle industries in the face of climate change. They surmised that global warming could lead to conditions more favourable to the spread and survival of ticks outside the current tick-endemic areas.
Issues that arose in their modelling led to the following comments.

"A major objective of the current study was to test the highest level of a hierarchy of approaches designed for use in impact assessments of pests under climate change (Sutherst *et al.*, 1996), that is process-based modelling linked to a spatial data platform and an econometric model. The study is believed to be the first to vertically integrate all levels of information from climate through biological systems and agricultural production systems into a national level, socio-economic analysis of a pest species. It required collaboration between modelling disciplines and the integration of an ecological and econometric model, with a GIS. The case study raised a number of technical issues in addition to the specific findings related to cattle ticks in Australia."

White's model predicts that the number of ticks will increase over the next 30 years due to climate change, but he does not factor in the effect of acaricide resistance, assuming that as acaricides cannot be used they will be replaced by new acaricides at equivalent cost. The comment is made however "In extreme cases, such as when production from *B. taurus* cattle is targeted at a specific market and there is severe resistance in the ticks to acaricides, beef and dairy production may cease altogether or require zero grazing."

- Jonsson[118] estimated the cost of cattle ticks to the Queensland dairy industry using empirical data obtained from field trials to calculate production losses, added to the cost of control practices. Three related models based on Microsoft Excel spreadsheets were used in this study.

- The major difficulty in assessing the costs and benefits arises from the many less tangible benefits of tick control that arise from issues such as improved market access, freedom to use favoured breeds of cattle and welfare benefits.

- Davis[119] attempted an overview of the economics of cattle tick control in his PhD studies at the University of Queensland in 1996, giving the following caveat. "..valuing of uncertain and intangible values prevents cost-benefit analysis from being an effective technique for evaluating alternative pest-control policies and can even be 'more dangerous than helpful."

- Bearing the experiences of previous researchers in mind, we have constructed a model that attempts not to give a 'cost-benefit' analysis of strategies used in tick control, but a 'ranking tool', which can be used to compare strategies. In order to validate assumptions used in the model we surveyed leaders in the field and asked them to give estimates of aspects of control strategies, such as efficacy, cost of implementation, potential adoption, and benefit compared to total eradication of ticks. Each of the strategies has been compared to a baseline 'null' or 'no research' scenario.

12.1 "No research" scenario

In the event that no further progress is made in research on issues relating to tick control in northern Australia, the following scenario could be envisaged over the next 30 years. This hypothesis is based on information and opinions collated in this review.

1. Resistance to amitraz would continue to spread or arise *de novo*, reaching levels close to saturation within twenty years.

The effect on the model would be a steady rise in tick numbers as the resistant gene reached 0.1, then an exponential increase followed by a gradual increase until an asymptote is reached at twenty years, when the resistant gene reaches full penetration.

2. Difficulty in maintaining the tick line in the absence of an effective knock-down acaricide and decreased direct regulatory input would lead to major changes of the tick line within ten years[120]. Cattle will need to be treated with Macrocyclic Lactones on property, then inspected and held at the tick gate for up to 14 days and inspected twice[121]. The resultant costs will see fewer cattle moved.
The model would show increased total tick numbers due to higher cost and lower frequency of treatment, and reflect the increased risk of cattle outside the tick line suffering outbreaks of tick fever.

3. Fluazuron would continue to be an effective agent for tick control on beef properties. However, it cannot be used in dairies, which will only be able to use existing control methods. Little TickGARD vaccine will be used on beef properties due to the short duration of immunity and low efficacy. Dairies would most likely not have access to the TickGARD vaccine in the medium to long-term, as due to current low sales and high production costs the vaccine could be withdrawn from the market. Improved technology for residue detection and increasing market sensitivity to residues will most likely see milk withholding periods set for all Macrocyclic Lactones.
The effect on the model would be for an increased spread of resistant ticks due to the lack of options for managers of dairy cattle and beef producers with resistant ticks. Their continued use of chemicals in the face of resistance increases selection pressure for the resistant genes.

4. Macrocyclic Lactone use against ticks and buffalo fly would continue at an increased rate in the short-term, especially for properties clearing cattle crossing the tick line, live export, sales and on dairies. This would probably lead to resistance developing within fifteen years, approaching saturation within 30 years.
The model would be influenced by a lack of control options for both routine use and for clearance, showing similar characteristics to that of amitraz resistance above.

5. Selecting within breeds will not be widely used as a tool for tick control despite the moderately high heritability of resistance (H^2=0.4 to 0.5) due to the unreliability of suitable conditions for determining selection. Beef producers would continue to use high levels of *Bos indicus* cattle, whilst crossbreeding to improve meat quality, fertility and temperament.
This is not expected to greatly influence tick numbers overall.

6. Animal welfare considerations, productivity traits and the increased cost of chemical treatments will lead to less use of pure *Bos taurus* cattle in the tick-endemic zone. Within twenty years most cattle in the tick zone will have tick resistant genes, mostly as a result of crossing *Bos indicus* cattle with *Bos taurus*.
The model would reflect increased use of resistant breeds by showing lower numbers of ticks.

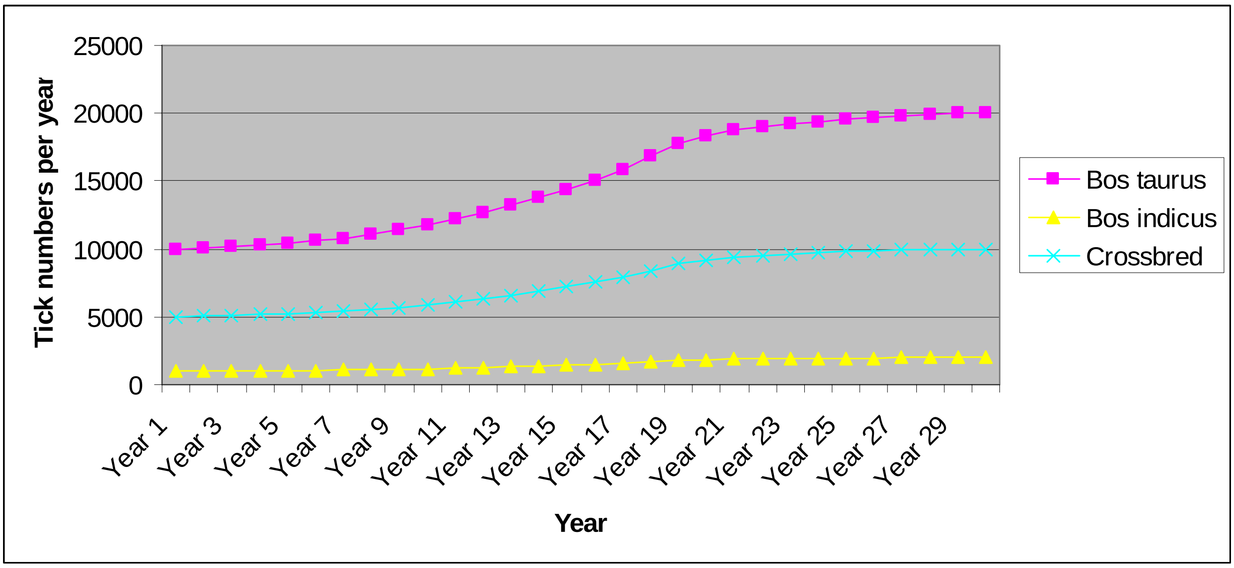
7. Occasional outbreaks of tick-borne disease would cause serious economic and animal welfare consequences on a local scale, particularly on the fringes of the tick-endemic zone.
This would show as an increased loss from tick fever overall.

8. There will be little change in the rate of use of the tick fever vaccines, in the short-term. It is likely that the State government could disinvest the Tick Fever Centre, putting the vaccine at the mercy of market forces. The risk remains that an infectious disease could be spread in the vaccine and propagated throughout northern Australia before it is detected. This could result in the live vaccine being taken off the market, and producers would need to devise a means of naturally exposing animals to infection within the first nine months of life to prevent disease.
This risk will be reflected in the model by an increased danger of tick fever and associated losses.

Economic losses relating to ticks in this scenario would stem from opportunity costs from not using the most productive breeds, loss of markets due to ticks or tick fever, inability to maintain a dairy industry in Queensland, inability to control tick fever losses in the event of the vaccine being lost, inability to bring cattle from tick-free country to fatten on the coast, increased cost of holding and clearing cattle for transport.

12.1.1 Estimate of tick numbers

Figure 12.1: Changes in average tick numbers over 30 years, in the event that no further research is conducted



The combined effects of acaricide resistance, movement controls, use of more resistant breeds, potential loss of TickGARD vaccine, climate change and other factors predicted in the future scenario are illustrated in Figure 12.1 (above). In the model, tick numbers in all breeds of cattle will double over the next 30 years.

12.1.2 Estimates of tick numbers for other strategies

Using the model, the number of ticks on cattle can be predicted if the other various strategies of tick control were implemented.

A partial budget was developed for each strategy to evaluate the financial benefits of new strategies for controlling cattle tick in northern Australia. In these partial budgets, losses due to cattle tick under current control measures were compared with the losses with the newly developed strategies in this protocol for a period of 30 years. Partial budgets were developed for individual breeds based on a list of assumptions presented in Table 12.2 (below). Some market estimates on the costs of specific new treatments were also considered in the budgets.

Where there were extra benefits and expenses with the new strategies, these were also included in the partial budgets. Each partial budget for this protocol contained three parts (four parts for dairy cattle) (Table 12.2):

1. Weight losses
2. Milk losses (dairy cows only)
3. Losses due to variable factors
4. Losses due to fixed factors.

The results of our survey, thereby reflecting expert opinion, were used to calculate the efficacy and adoption rates of new strategies for controlling cattle tick. The efficacy rates were utilised to assess the number of ticks following the implementation of a new strategy. The adoption rates were used to analyse the overall benefits of individual strategies to the cattle industry.

12.1.3 Calculation of Net Present Value

Net present value (NPV), which expresses the difference between the total present value of benefits and costs, was used to estimate the financial benefits of new strategies for the next 30 years with an average of 5% inflation rate. The formula for NPV that was used is shown below:

$$\sum_{n=1}^{n} \frac{Values_n}{(1+r)^n}$$

Values are the cash flows received over the years,
n is the number of cash flows in the list of values,
r is the inflation rate over the years.

12.1.4 Calculation of confidence intervals using @RISK

Following the development of partial budgets for each strategy, appropriate distributions were created for each variable (e.g. mean and SD for body weights) using @RISK v 4.5.3. (Palisade Corporation, USA). Latin Hypercube sampling was used to re-create the probability distributions for each variable. Latin Hypercube is a recent development in sampling technology designed to accurately recreate the input distribution through sampling in fewer iterations. To conduct the sampling procedure, the distribution function was set for 100 iterations with 3 simulations. The mean NPV and 95% confidence intervals of the strategies were calculated separately for each breed.

Table 12.2: List of assumptions for the partial budgets (Figures in this table are rounded)

Assumptions	***B. taurus***	***B. indicus***	**Cross-bred**	**Dairy**
Herd size (N)	1,300	1,300	1,300	175
Proportion of herd adult (%)	50%	50%	50%	80%
Proportion of herd young stock (%)	50%	50%	50%	20%
Total number of adults (N)	650	650	650	140
Total number of young stock (N)	650	650	650	35
Proportion of herd tick infested (%)	98%	98%	98%	98%
Average ticks per beast per year (N)	10,000	1,000	5,000	10,000
Liveweight loss (kg/tick/day)	0.001	0.001	0.001	0.001
Milk loss (L/tick/day)	-	-	-	0.009
Lactation period (days/hd/year)	-	-	-	300
Proportion of herd milking (%)	-	-	-	85%
Bodyweight adult animal (kg)	550	550	550	650
Bodyweight young animal (kg)	160	160	160	350
Value of adult animal ($/head)	$800	$800	$800	$800
Value of young animal ($/head)	$500	$500	$500	$500
Price paid per kg meat ($)	$1.80	$1.60	$1.70	$1.50
Price paid per litre milk ($)	-	-	-	$0.30
Fertility loss	10%	2%	5%	10%
Mustering cost ($/hd)	$15	$15	$15	$2
Average number of mustering/year	4	2	3	5
Inflation rates over 30 years	3.0–7.0%	3.0–7.0%	3.0–7.0%	3.0–7.0%

Table 12.3: Details of the partial budget developed for a beef herd size of 1300 (± 400) and dairy herd size of 175 (± 20) for different strategies

Budget items	*B. taurus*	*B. indicus*	Cross-bred	Dairy
A. Estimated losses due to weight loss				
Number of ticks on individual stock per day	27	3	14	27
Weight loss of individual stock per day (kg)	0.027	0.003	0.013	0.027
Weight loss of individual stock per year (kg)	10	1	5	10
Number of stock (N)	1,268	1,268	1,268	171
Total weight loss per year (kg)	12,473	1,247	6,237	1,678
Total value of weight loss ($ per year)	**$22,452**	**$1,996**	**$10,602**	**$3,020**
B. Estimated losses due to milk loss				
Number of ticks on individual dairy stock per day				27.4
Milk loss of individual dairy stock per day (kg)				0.251
Milk loss of individual dairy stock per year (kg)				75.34
Number of lactating dairy stock (N)				116
Total dairy milk loss per year (L)				8,742
Total value of dairy milk loss ($ per year)				**$2,622.48**
C. Estimated losses due to other variable factors				
Physical loss of adults ($ per year)	$10,416	$5,208	$7,812	$2,240
Physical loss of young stock ($ per year)	$6,510	$3,255	$4,883	$350
Hide loss adults ($ per year)	$814	$651	$1,302	$175
Hide loss young stock ($ per year)	$5,208	$2,604	$3,906	$280
Fertility losses loss ($ per year)	$12,685	$2,537	$6,342	$10,067
Welfare dividend	$13,010	$1,301	$6,505	$1,750
Total variables losses ($ per year)	**$41,401**	**$13,962**	**$29,981**	**$12,729**
D. Estimated losses due to fixed factors				
Environmental costs ($ per year)	$1,301	$1,301	$1,301	$175
Market access ($ per year)	$1,3010	$26,020	$19,515	$26,020
Tick line ($ per year)	$1,301	$1,301	$1,301	$175
Productivity penalty ($ per year)	$0.00	$6,342	$0.00	$0.00
Total fixed losses ($ per year)	**$15,612**	**$34,964**	**$22,117**	**$36,370**
Estimated total losses per year ($)	**$79,465**	**$50,922**	**$62,700**	**$44,741**

12.2 Net Present Value calculations for different breeds

The model was used to calculate NPV for the four different breeds of cattle, based on the above assumptions. Results are presented in the five tables below.

Table 12.4: Net Present Value (NPV) of different strategies for *Bos taurus* cattle

Strategies for tick control	**NPV for an average *B. taurus* herd size (1300 ± 400)**		
	Mean ($)	**95% Confidence Interval**	**Ranks**
1. Crossbreeding	329,979	(96,432 – 628,707)	3
2. Gene markers	175,980	(59,285 – 327,888)	6
3. Eradication of ticks	401,378	(165,083 – 698,721)	2
4. Compulsory vaccination	162,437	(68,007 – 311,630)	8
5. Control resistant ticks	105,811	(36,309 – 213,918)	11
6. Slow acaricide resistance	81,631	(25,835 – 169,724)	13
7. Improve resistance diagnosis	108,362	(40,606 – 183,534)	10
8. Introduce products from overseas	262,337	(121,935 – 413,016)	4
9. Develop novel chemicals	176,101	(79,180 – 306,737)	5
10. Biopesticides	95,931	(33,844 – 166,545)	12
11.Improve tick vaccine	162,833	(44,485 – 327,785)	7
12. Improve tick fever vaccine	142,068	(46,382 – 247,202)	9
13. Introduce IPM measures	443,899	(182,033 – 727,038)	1

Table 12.5: Net Present Value (NPV) of different strategies for *Bos indicus* cattle

Strategies for tick control	**NPV for an average *B. indicus* herd size (1300 ± 400)**		
	Mean ($)	**95% Confidence Interval**	**Ranks**
1. Crossbreeding	161,437	(41,184 – 359,456)	1
2. Gene markers	79,712	(29,651 – 141,934)	2
3. Eradication of ticks	74,678	(28,138 – 131,011)	3
4. Compulsory vaccination	14,701	(5,948 – 27,572)	8
5. Control resistant ticks	6,019	(1,316 – 11,777)	12
6. Slow acaricide resistance	7,251	(2,477 – 13,963)	11
7. Improve resistance diagnosis	10,028	(4,235 – 19,734)	9
8. Introduce products from overseas	69,361	(32,811 – 108,633)	4
9. Develop novel chemicals	15,853	(6,459 – 27,950)	7
10. Biopesticides	8,421	(3,115 – 15,958)	10
11.Improve tick vaccine	49,071	(535 – 108,942)	5
12. Improve tick fever vaccine	-2,519	(-13,186 – 5,136)	13
13. Introduce IPM measures	42,436	(-7,558 – 115,670)	6

Table 12.6: Net Present Value (NPV) of different strategies for crossbred cattle

Strategies for tick control	**NPV for an average crossbred herd size (1300 ± 400)**		
	Mean ($)	**95% Confidence Interval**	**Ranks**
1. Crossbreeding	**-**	**-**	**-**
2. Gene markers	142,638	(55,499 – 239,147)	4
3. Eradication of ticks	218,985	(92,610 – 387,384)	1
4. Compulsory vaccination	77,336	(30,688 – 152,087)	7
5. Control resistant ticks	33,131	(6,170 – 71,031)	12
6. Slow acaricide resistance	60,967	(27,277 – 94,613)	8
7. Improve resistance diagnosis	53,108	(17,406 – 97,704)	10
8. Introduce products from overseas	153,149	(60,327 – 240,025)	3
9. Develop novel chemicals	80,960	(34,417 – 142,005)	6
10. Biopesticides	44,504	(18,651 – 74,028)	11
11.Improve tick vaccine	99,842	(36,959 – 189,622)	5
12. Improve tick fever vaccine	54,219	(15,614 – 93,952)	9
13. Introduce IPM measures	155,998	(70,880 – 274,049)	2

Table 12.7: Net Present Value (NPV) of different strategies for dairy cattle

Strategies for tick control	**NPV for an average dairy herd size (175 ± 20)**		
	Mean	**95% Confidence Interval**	**Ranks**
1. Crossbreeding	-	-	-
2. Gene markers	130,360	(53,003–221,065)	7
3. Eradication of ticks	215,032	(93,420–377,931)	1
4. Compulsory vaccination	141,720	(62,578–256,180)	6
5. Control resistant ticks	61,430	(12,253–126,629)	12
6. Slow acaricide resistance	69,494	(29,092–136,137)	11
7. Improve resistance diagnosis	97,660	(35,210–179,008)	9
8. Introduce products from overseas	193,231	(77,966–348,178)	2
9. Develop novel chemicals	152,153	(62,062–244,043)	4
10. Biopesticides	81,554	(34,566–140,603)	10
11.Improve tick vaccine	106,683	(50,450–202,220)	8
12. Improve tick fever vaccine	155,782	(53,064–295,617)	3
13. Introduce IPM measures	146,226	(69,879–229,252)	5

Table 12.8: Summary of strategies ranking of four breeds

Strategies for tick control	Ranking orders			
	B. taurus	***B. indicus***	**Cross-bred**	**Dairy**
1. Crossbreeding	3	1	-	-
2. Gene markers	6	2	4	7
3. Eradication of ticks	2	3	1	1
4. Compulsory vaccination	8	8	7	6
5. Control resistant ticks	11	12	12	12
6. Slow acaricide resistance	13	11	8	11
7. Improve resistance diagnosis	10	9	10	9
8. Introduce products from overseas	4	4	3	2
9. Develop novel chemicals	5	7	6	4
10. Biopesticides	12	10	11	10
11.Improve tick vaccine	7	5	5	8
12. Improve tick fever vaccine	9	13	9	3
13. Introduce IPM measures	1	6	2	5

12.3 Discussion

Economic modelling shows that all of the tick control strategies over 30 years give greater returns to *Bos taurus* than *Bos indicus* herds. The top-ranking strategy for *Bos taurus* was IPM measures, which returned a mean of A$443,899 per farm. This compares with the top strategy for *Bos indicus,* crossbreeding, which returned only A$161,437. The lowest ranked strategy for *Bos taurus* (slow acaricide resistance) still returned A$81,631, while the lowest ranked strategy for *Bos indicus* (improve tick fever vaccine) had a negative return (A$2,519). The overall mean NPV for all programs for *Bos taurus* was A$203,749, while the mean NPV for *Bos indicus* was only A$41,265.
The model therefore predicts that overall NPV of these tick control strategies are five times greater for *Bos taurus* than for *Bos indicus* herds.

For crossbred herds and dairy herds, the top strategy was tick eradication, returning A$218,985 and A$215,032 per farm respectively. Eradication of ticks showed considerable economic benefits in all herds, being second highest ranked in *Bos taurus* and third highest ranked in *Bos indicus* herds. Again the NPVs were greatest for *Bos taurus,* with a mean return of A$401,378, as against *Bos indicus* gaining only a A$74,678 benefit from tick eradication. Whilst the NPV of tick eradication is easily recognised, the estimated cost of the eradication program may have been underestimated by the experts due to the difficulty of prognostication.

IPM ranked reasonably high across all breeds, being first in *Bos taurus,* second in crossbreds, but only sixth in *Bos indicus* and fifth in dairy. Gene markers showed relatively high economic returns in all breeds, having the second highest rank in *Bos indicus* herds and fourth highest in crossbred herds. Introducing products from overseas showed high returns (three or four) in all breeds and was second highest in dairy.

The lowest-placed strategies in this model all related to management of acaricide resistance. Lowest of all was control resistant ticks, which placed close to last across all breeds. Slow acaricide resistance and improve resistance diagnosis also showed low economic benefits. This would indicate that regardless of the breed used, the issue of acaricide resistance is not anticipated to have a high economic impact on northern beef producers. Biopesticides also showed a low economic return across all breeds.

12.4 Summary

The economic model used in this review estimated the NPV of various strategies for tick control across a range of classes of cattle. All strategies had higher projected returns for *Bos taurus* than for *Bos indicus* herds, with the average return five times higher for *Bos taurus* cattle. Eradication of ticks was projected to have the highest economic return of any strategy, whilst crossbreeding, IPM, introducing products from overseas and gene markers all ranked high across different breeds. The lowest economic returns were predicted for those strategies that involved acaricide resistance management. The estimates given by the model are largely validated by qualitative evidence obtained from interviews with tick researchers (see Chapter Eight) indicating good consistency between the economic assessment and pooled expert opinion.

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Disclaimer

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Appendix Two

MLA Tick control review 2004- summary of producer submissions

Name	Organisation	Comments
Brian Tessman	**Queensland Dairyfarmers Organisation**	Tick Line must be maintained within Queensland Protected areas should be declared "tick free" More research on and education for horse owners and hobby farmers to prevent spread Examine role of feral animals in spreading ticks Re-examine low-efficacy tickicides Examine use of Acatak in dairy cattle Encourage use of TickGARD in beef as well as dairy cattle Costs – Average Daily Gain, milk, labour, chemicals Lack of coordination in genetics research (DPI, CSIRO) Dairy industry supporting gene marker research Concern over increasing British genetics in beef industry Lack of cooperation between dairy & beef industry on ticks Research on non-chemical control Ask if sufficient extension of research findings Ticks seriously threaten viability of Qld dairy industry
Graeme Wicks	**Kingaroy, Wondai, Proston Tick Eradication Committee (1,200 producers)**	Statewide program to eradicate ticks strongly encouraged whilst chemicals can still be used Resistant cattle easy to control ticks Animal welfare issues mustn't be ignored
Di Gresham	**Gympie Branch Queensland Dairyfarmers Organisation**	Production and welfare both important issues for individual animals Unwilling to use AFS cattle because of poor temperament, OH&S concerns Significant investment for farmers to control ticks More emphasis required on non-chemical control TickGARD useful but needs including efficacy, less side effects Demonstration farms to show benefits of paddock rotation, feedlotting, spelling

Matthew Arkinstall	**Beef producer, Rathdowney**	Inrease boundaries of tick line, decrease infested area, eradicate TickGARD vaccine good except for lumps Don't want to use Ivomec because of dung beetles Tick Fever vaccine- costly, restricts sales of cattle outside QLD Costs- hide damage (e.g. show cows), mustering, dipping, inspecting Variation in tick resistance within breeds, marker would be a benefit Look at neem oil, pine oil, sulphur, natural treatments Look at efficacy of tick fever vaccine as breakdowns occur Eradication at 2 - 10 km/year would eventually stop all ticks and fever
Lindsay Brown	**Beef producer, Murwillumbah**	Must maintain tick gates or risk further spread of ticks to NSW Buying hay from tick country is a risk Cattle at M'bah saleyards tested and traced back to property of origin, may be too late to stop spread
Michelle Anderson	**Wolvi via Gympie dairy farmer coordinator of area Discussion Group**	Local farmers reporting tick resistance problems, either spraying or dipping with Amitraz (Taktic). Pour-Ons not seen to be an economical alternative TickGARD vaccine considered to be too expensive to use (estimate $14/head). If it were cheaper they would definitely use it. Crossing the Tick Line with cattle is a major hassle, cattle waiting 5 weeks at Tick Gate before clearance (Dan Sullivan, stock agent) *Bos indicus* cross cattle, temperament too unpredictable for routine handling, cites OH&S issues
Carl Grice	**dairy farmer, Rockhampton QDO commissioner 07 4938-7233**	TickGARD injection every 8 weeks makes cows needle-shy Resistant ticks being transported a major problem as it spreads resistance Should be individual farm monitoring and restriction on moving cattle if they have resistant ticks Farmers reluctant to test because they don't want to be blacklisted Definite link between dairy and beef resistant ticks, dairies may be the source of resistance Farmers possibly using Acatak in dairy cattle, fears that residues may occur in milk Retail outlets – how to stop them selling Acatak to dairy producers
Andrew	**Parmalat**	Respresents 390 dairy suppliers, 280 of whom are in the tick endemic area

Taylor written submission	**Brisbane**	Major Issues- farmers exiting industry due to tick problems, and potential residues caused by treatments Tick Line must be maintained as government or user-pay system Cydectin widely used but expensive and resistance bound to develop TickGARD a safe and sensible means of reducing tick burdens Strongly support non-chemical control e.g. biological, environmental, quarantine Research funding should come from commercial firms i.e. pharmaceutical manufacturers
Len Carlson	**Chairman** **Gympie Beef Liaison Group** 07 5483 4725	Doesn't want any relaxation of regulatory aspects of tick control, concern over 3rd party providers 30-40% resistance noted to Amitraz, Acatak long WHP, other tickicides no good e.g Barricade TickGARD vaccine 60% effective so good if used with a tickicide, use should be encouraged Tick fever vaccines underutilised (5%?), despite excellent research- grazier adoption should be encouraged through more extension Finding the right genetic mix difficult- pressure from MSA for carcase characteristics, European breeds don't finish well, need to use modern Bos indicus genetics

Appendix Three

MLA Tick control review 2004- summary of submissions from government institutions

Name	Organisation	Comments
Peter James	**Animal IPM Group**	Acaricide resistance increasing- only two groups still 100% effective, MLs have resistance overseas
	ARI Yeerongpilly	Consumer awareness of meat and milk residues, ecological issues, EMS
	QDPI&F	Organic beef can give 30% price premium, growing markets especially overseas. Barrier to production.is parasites
		OH&S issues for people working to control or test for ticks
		Environmental impact of dip sites, waste dip disposal
		IPM approach addresses above issues with non-chemical control methods e.g. Biopesticides
		Integrating tick and buffalo fly control to reduce chemical exposure, resistance and residues
		Improve efficiency of chemical use by pheromones, new applications
		Fungal bio-pesticides- commercial backing for this needed with QDPI project
		Low chemical IPM- research and extension project mooted
		Pheromone strategies (potential strategy)- e.g. attract ticks to insecticide bands
		Repellents/deterrents (potential strategy)- e.g. on legs of cattle prevent tick uptake
Lex Turner	**Animal Research Institute**	Current research being conducted on a) Biopesticides
	Yeerongpilly	b) Genetic markers
	QDPI&F	c) Essential oils
	Confidential submission	
Peter McGregor	**Program Leader**	NSW policy of surveillance, containment (quarantine) and eradication
	Cattle Ticks	Only 200 properties near border (Kyogle) still in tick quarantine area, remainder tick-free
	NSW Agriculture	Sale yards surveillance from Grafton north detects and treat ticks after trace back

		Over last 4 years 39-53 cases/year, this year 35 cases so far
		Movement restrictions on infested & adjacent properties prevents spread
		Budget about A$5m/year, well down on previous years due to majority of state tick-free
		A$2.2m to maintain border controls, $0.6m to maintain dips
		Infested herd owners pay for mustering & management costs plus 25% of acaricide
		Acaricide subsidy will be gradually reduced, costs vary $0.30-40 (dip) to $4-5 (pour-on)
		Vaccine not favoured as NSW policy aims for eradication not reduction in numbers
		Threat to tick line if contact acaricides no longer effective, much of North of NSW could be affected
David Kemp	**CSIRO Livestock Industries**	QDO program makes TickGARD vaccine more affordable, vaccine alone good for low prevalence areas
	St Lucia	Improvements required are speed of kill (new antigens) and short duration of immunity, both need research
		Need to manage amitraz resistance as it is an important clearing acaricide, delay resistance to other chemicals.
		Improve speed of resistance testing using DNA techniques, inc. monitoring for ML resistance, act to delay onset
		Use management-acaricide together to improve longevity of amitraz, e.g. rotation
		Identify QTLs for resistance in composite animals, identify DNA markers in resistant cattle
		Early prediction of new chemical resistance onset- manage and avoid resistance onset
		Encourage pharmaceutical companies to do high-throughput screening, using ACTEST QDPI facilities

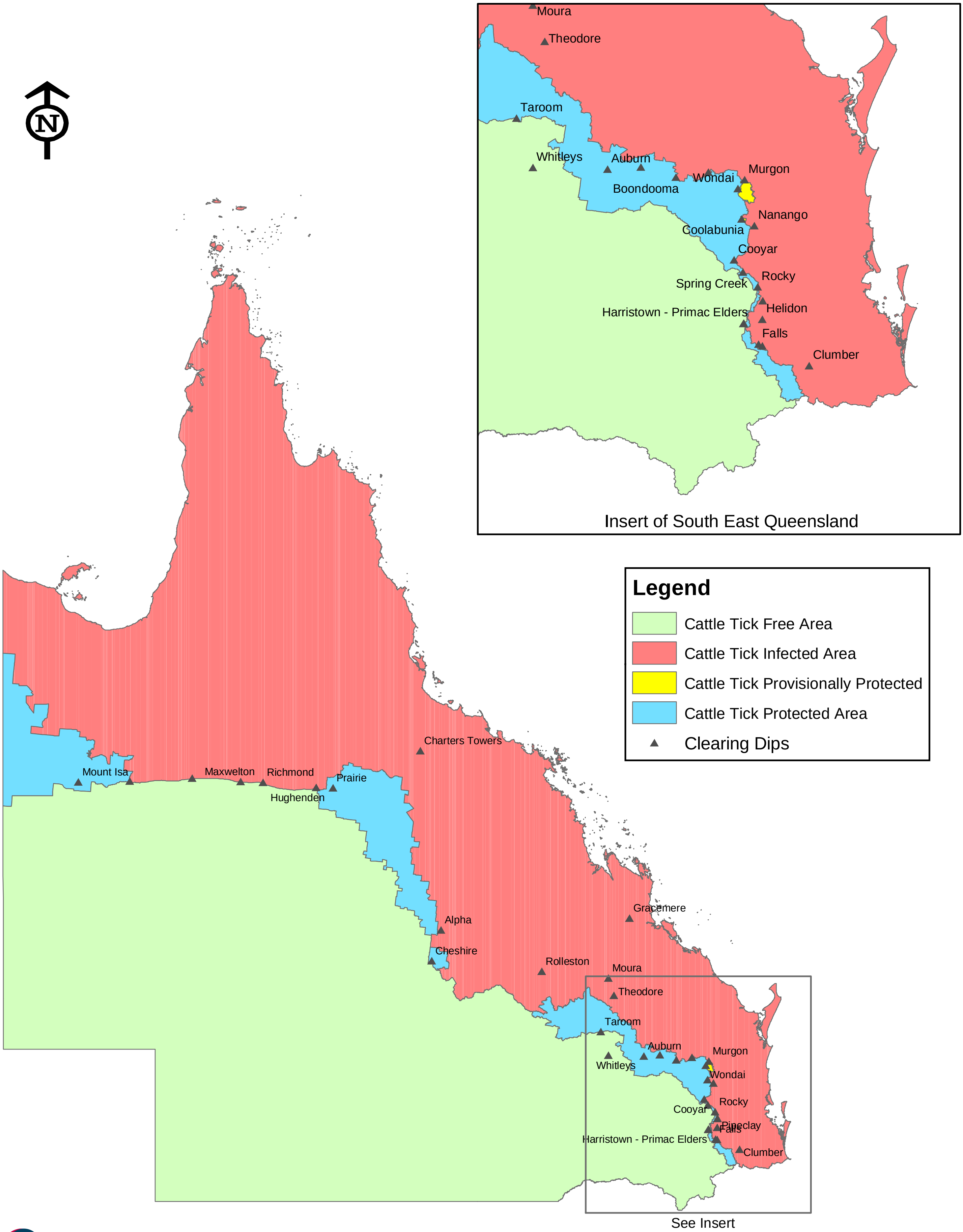
Appendix Four

MLA Tick control review 2004- summary of meetings with companies

Name	Organisation	Comments
Anthony Preshaw written submission	**Fort Dodge**	Effect of different MLs on selection pressure varies with active Need monitoring for ML resistance in ticks Genetics of resistance, and effects of MLs on resistant strains Recommendations on use of MLs to decrease resistance
Jim Rothwell meeting Sydney 31.05.04	**Elanco**	Ref. presentation in 2002 MLA Tick review on registration barriers APVMA requires 3 local field trials, 2 residue trials- excessive- see new WAAVP guidelines Cost of registration over A$600K Overseas pen trials should be accepted by APVMA if conducted to GCP standards 98% efficacy is unrealistic Spinosad is <98% effective, takes 4 days for knockdown, used as spray Tick line difficult to maintain now, need on-farm monitoring In South America.- increasing use of *Bos taurus* in Argentina & Mexico, not Brazil Tick Fever vaccine not widely used so tick control vital especially for dairies In Colombia pasture mgt/animal movements used for control
Ron Gogolewski **Peter Scott** meeting Sydney 31.05.04	**Merial**	Ivomec capsule- long term control from single application Ivomec Pour-On has short residual effects Ectoline (Fipronil) has reported 60d. efficacy from single backline application Takes 6 days for knockdown Investment to register would be based on potential market IP protection also needed as disincentive to invest if generic copies flood the market

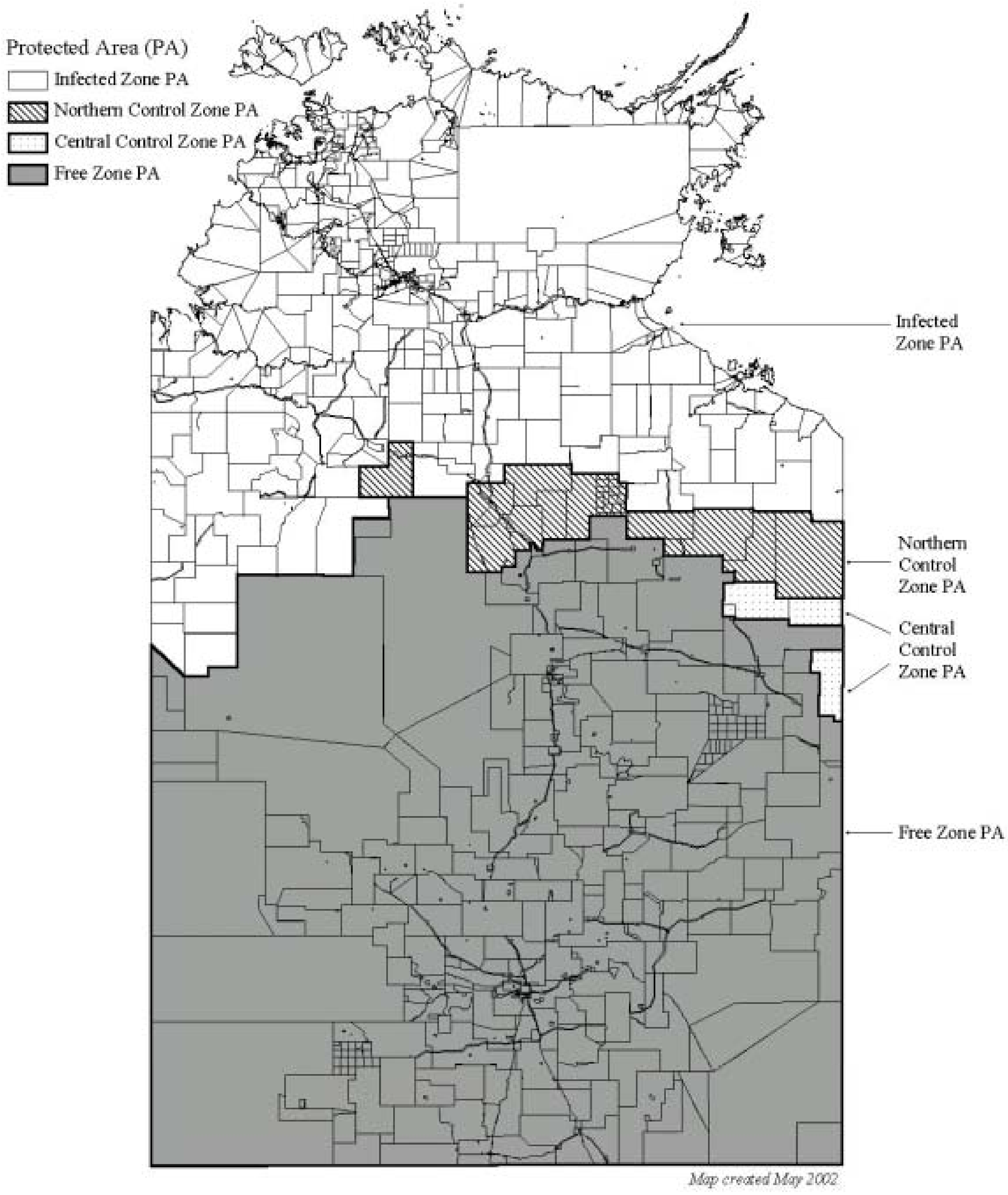
		Ivomec Gold- gives 70d protection
Stephen Gibson **David Butchart** meeting Sydney 31.05.04 written submission	**Novartis**	Potential for including Acatak in on-farm protocol for crossing tick line No confirmed cases of Fluazuron resistance yet reported David Waltisbuhl (QDPI) has done some Larval Packet Testing Fluazuron active loses patent protection very soon, expect generics on market New registrations for Fluazuron have been completed to allow sales in different markets IGR (Acatak) should be encouraged on properties intending to take cattle across tick line to decrease tick burden IGR potential use to decrease pastoral tick populations as IPM approach, decrease chemical use and decrease selection pressure Possible to increase *Bos taurus* content of cattle with good IPM using IGR Should evaluate effect of treating *Bos indicus* animals warrant productivity benefit over cost of Treatment
Darryl Barlow	**THG** **07 3839-1388**	Interested in supplying chemicals for tick control programs
Tony Cooley	**Intervet**	Scheme in conjunction with QDO to provide cut-price TickGARD vaccine to dairy farmers Can't anticipate any new developments to the vaccine to improve efficacy or reduce side effects TickGARD now more affordable, potential for this scheme to be extended to beef farmers

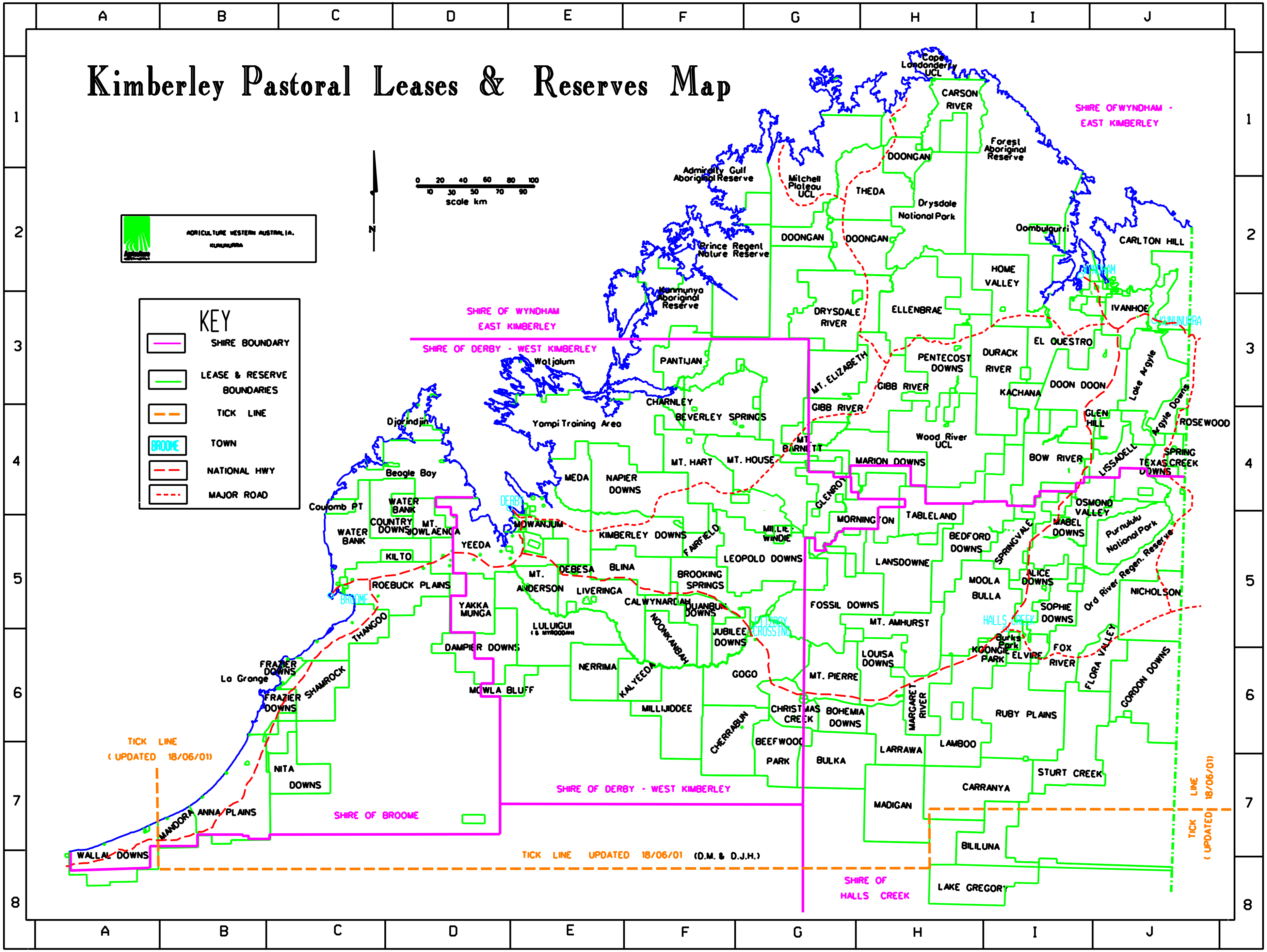
QUEENSLAND CATTLE TICK AREAS
(Current as at February 2003)



Queensland Government
Department of Primary Industries
Animal and Plant Health Service

NORTHERN TERRITORY CATTLE TICK PROTECTED AREAS





Kimberley Pastoral Leases & Reserves Map
A
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0 20 40 60 80 100
10 30 50 70 90
scale km
N
AGRICULTURE WESTERN AUSTRALIA,
KUNUNURRA
KEY
SHIRE BOUNDARY
LEASE & RESERVE BOUNDARIES
TICK LINE
BROOME
TOWN
NATIONAL HWY
MAJOR ROAD
SHIRE OF WYNDHAM - EAST KIMBERLEY
SHIRE OF WYNDHAM
EAST KIMBERLEY
SHIRE OF DERBY - WEST KIMBERLEY
SHIRE OF BROOME
SHIRE OF HALLS CREEK
TICK LINE
(UPDATED 18/06/01)
TICK LINE UPDATED 18/06/01 (D.M. & D.J.H.)
Cape Londonderry UCL
CARSON RIVER
Forest Aboriginal Reserve
DOONGAN
Admiralty Gulf Aboriginal Reserve
Mitchell Plateau UCL
THEDA
Drysdale National Park
Oombulgurri
DOONGAN
DOONGAN
CARLTON HILL
Prince Regent Nature Reserve
HOME VALLEY
WYNDHAM
Kunmunya Aboriginal Reserve
DRYSDALE RIVER
ELLENBRAE
IVANHOE
KUNUNURRA
PANTIJAN
Wotjalum
MT. ELIZABETH
PENTECOST DOWNS
DURACK RIVER
EL QUESTRO
Lake Argyle
CHARNLEY
GIBB RIVER
GIBB RIVER
KACHANA
DOON DOON
Argyle Downs
ROSEWOOD
Djarindjin
Yampi Training Area
BEVERLEY SPRINGS
GLEN HILL
MT. BARNETT
Wood River UCL
SPRING CREEK
MT. HART
MT. HOUSE
MARION DOWNS
BOW RIVER
LISSADELL
TEXAS DOWNS
Beagle Bay
MEDA
NAPIER DOWNS
GLENROY
OSMOND VALLEY
Coulomb PT
WATER BANK
DERBY
MORNINGTON
TABLELAND
MABEL DOWNS
COUNTRY DOWNS
MT. JOWLAENGA
MOWANJUM
MILLIE WINDIE
Purnululu National Park
WATER BANK
KIMBERLEY DOWNS
BEDFORD DOWNS
SPRINGVALE
YEEDA
FAIRFIELD
KILTO
LEOPOLD DOWNS
LANSDOWNE
Ord River Regen. Reserve
MT. ANDERSON
DEBESA
BLINA
BROOKING SPRINGS
ALICE DOWNS
MOOLA BULLA
BROOME
ROEBUCK PLAINS
LIVERINGA
CALWYNARDAH
NICHOLSON
YAKKA MUNGA
FOSSIL DOWNS
SOPHIE DOWNS
QUANBUN DOWNS
HALLS CREEK
THANGOO
LULUIGUI
NOONKANBAH
MT. AMHURST
FITZROY CROSSING
JUBILEE DOWNS
Bungle Park
DAMPIER DOWNS
KOONGIE PARK
ELVIRE
FOX RIVER
LOUISA DOWNS
FLORA VALLEY
FRAZIER DOWNS
NERRIMA
KALYEEDA
GOGO
MT. PIERRE
GORDON DOWNS
La Grange
MOWLA BLUFF
MARGARET RIVER
FRAZIER DOWNS
SHAMROCK
MILLIJIDDEE
CHRISTMAS CREEK
BOHEMIA DOWNS
RUBY PLAINS
CHERRABUN
BEEFWOOD PARK
LARRAWA
LAMBOO
BULKA
NITA DOWNS
STURT CREEK
CARRANYA
MADIGAN
ANNA PLAINS
MANDORA
BILILUNA
WALLAL DOWNS
LAKE GREGORY

Appendix Six

National Summary 2004
Bulls Sold at Auction
(The 11 Major breeds in alphabetical order)

BREED	NO. OF SALES	% OF SALES	NO. OF BULLS SOLD	% OF BULLS SOLD	TOP PRICE $	GROSS $	% OF GROSS	AVERAGE $
ANGUS	93	41%	3,597	42%	30,000	13,929,835	42%	3,873
BRAHMAN	6	3%	1,178	14%	40,000	4,486,650	14%	3,809
CHAROLAIS	13	6%	332	4%	10,000	1,102,590	3%	3,321
DROUGHTMASTER	5	2%	290	3%	18,000	936,850	3%	3,231
HEREFORD	26	11%	824	10%	60,000	3,353,100	10%	4,069
LIMOUSIN	11	5%	219	3%	20,000	871,450	3%	3,979
MURRAY GREY	18	8%	390	5%	22,500	1,608,800	5%	4,125
POLL HEREFORD	24	11%	720	8%	52,000	2,823,600	9%	3,922
SANTA GERTRUDIS	8	4%	351	4%	37,500	1,327,050	4%	3,781
SHORTHORNS	8	4%	350	4%	48,000	1,572,450	5%	4,493
SIMMENTALS	15	7%	315	4%	12,200	1,145,050	3%	3,635
TOTALS	**227**	**100%**	**8,566**	**100%**	**$60,000**	**33,157,425**	**100%**	**3,871**

National Summary 2003
Bulls Sold at Auction
(The 11 Major breeds in alphabetical order)

BREED	NO. OF SALES	% OF SALES	NO. OF BULLS SOLD	% OF BULLS SOLD	TOP PRICE $	GROSS $	% OF GROSS	AVERAGE $
ANGUS	146	35%	5,448	31%	41,000	19,678,185	30%	3,612
BRAHMAN	13	3%	2,354	13%	47,500	9,666,730	15%	4,107
CHAROLAIS	31	7%	1,254	7%	16,000	4,863,390	7%	3,878
DROUGHTMASTER	17	4%	1,474	8%	70,000	5,450,100	8%	3,697
HEREFORD	53	13%	1,893	11%	30,000	7,215,420	11%	3,812
LIMOUSIN	16	4%	359	2%	12,000	1,255,980	2%	3,499
MURRAY GREY	19	5%	414	2%	13,800	1,456,500	2%	3,518
POLL HEREFORD	44	11%	1,322	8%	85,000	5,012,500	8%	3,792
SANTA GERTRUDIS	41	10%	1,923	11%	26,000	7,660,180	12%	3,983
SHORTHORNS	17	4%	658	4%	35,000	2,662,975	4%	4,047
SIMMENTALS	18	4%	448	3%	20,000	1,530,950	2%	3,417
TOTALS	**415**	**100%**	**17,547**	**100%**	**$85,000**	**66,452,910**	**100%**	**3,787**

National Summary 2002
Bulls Sold at Auction
(The 11 Major breeds in alphabetical order)

BREED	NO. OF SALES	% OF SALES	NO. OF BULLS SOLD	% OF BULLS SOLD	TOP PRICE $	GROSS $	% OF GROSS	AVERAGE $
ANGUS	140	34%	5,484	29%	26,000	23,122,445	30%	4,216
BRAHMAN	19	5%	3,153	16%	55,000	13,353,150	17%	4,235
CHAROLAIS	26	6%	1,075	6%	61,000	4,084,650	5%	3,800
DROUGHTMASTER	22	5%	1,561	8%	60,000	5,401,817	7%	3,460
HEREFORD	53	13%	2,098	11%	52,000	8,737,970	11%	4,165
LIMOUSIN	12	3%	316	2%	10,000	1,040,815	1%	3,294
MURRAY GREY	25	6%	591	3%	17,000	2,410,600	3%	4,079
POLL HEREFORD	48	12%	1,635	9%	55,000	6,834,689	9%	4,180
SANTA GERTRUDIS	31	7%	2,003	10%	42,500	7,978,060	10%	3,983
SHORTHORNS	21	5%	879	5%	40,000	3,760,461	5%	4,278
SIMMENTALS	17	4%	438	2%	13,800	1,635,250	2%	3,733
TOTALS	**414**	**100%**	**19,233**	**100%**	**$61,000**	**78,359,907**	**100%**	**4,074**

National Summary 2004
Bulls Sold at Auction to 23 August
(The 11 Major breeds in alphabetical order)

BREED	NO. OF SALES	% OF SALES	NO. OF BULLS SOLD	% OF BULLS SOLD	TOP PRICE $	GROSS $	% OF GROSS	AVERAGE $
ANGUS	116	40%	4,735	42%	30,000	19,452,660	43%	4,108
BRAHMAN	9	3%	1,296	11%	40,000	4,761,800	11%	3,674
CHAROLAIS	21	7%	613	5%	17,500	2,265,390	5%	3,696
DROUGHTMASTER	6	2%	360	3%	18,000	1,148,050	3%	3,189
HEREFORD	33	11%	1,221	11%	60,000	5,271,100	12%	4,317
LIMOUSIN	14	5%	325	3%	20,000	1,337,200	3%	4,114
MURRAY GREY	18	6%	390	3%	22,500	1,608,800	4%	4,125
POLL HEREFORD	34	12%	1,051	9%	52,000	4,350,475	10%	4,139
SANTA GERTRUDIS	12	4%	586	5%	37,500	2,027,200	4%	3,459
SHORTHORNS	10	3%	404	4%	55,000	1,737,200	4%	4,300
SIMMENTALS	17	6%	351	3%	12,200	1,239,900	3%	3,532
TOTALS	**290**	**100%**	**11,332**	**100%**	**$60,000**	**45,199,775**	**100%**	**3,989**

Appendix Seven

Australian Registered Cattle Breeders Association (ARCBA)
Changes in registrations by breed groups 1992-2003

Breed group	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
British breeds												
No. of registrations	95859	97004	93000	91611	89964	81393	78623	80137	81744	84090	83866	78077
%	57.1	59.6	59.2	60.1	59.7	60.2	61	62.4	62.5	63.8	63.5	61.6
Tropical breeds												
No. of registrations	43218	36371	35130	32588	34247	32116	31722	30711	32410	30381	32940	29583
%	25.8	22.4	22.4	21.4	22.7	23.7	24.5	23.9	24.8	23.1	24.9	23.3
European breeds												
No. of registrations	28329	28791	28317	27503	26176	20795	17803	16485	15269	16511	14571	17501
%	16.9	17.1	18.1	18.1	17.4	15.4	13.8	12.9	11.7	12.5	11	13.8

Appendix Eight

Names of researchers, regulators and consultants interviewed for this study

12 July 2004

Researchers

David Kemp, CSIRO Livestock Industries, St Lucia

Peter Willadsen, CSIRO Livestock Industries, St Lucia

Bill Barendse, CSIRO Livestock Industries, St Lucia

Russel Bock, QDPI&F Tick Fever Centre, Wacol

Bert De Vos, QDPI&F Tick Fever Centre, Wacol

13 July 2004

Researchers

Wayne Jorgensen, QDPI Animal Research Institute, Yeerongpilly

Glenn Anderson, QDPI Animal Research Institute, Yeerongpilly

Ala Lew, QDPI Animal Research Institute, Yeerongpilly

Peter James, QDPI Animal Research Institute, Yeerongpilly

Dianna Eamon, QDPI Animal Research Institute, Yeerongpilly

Lex Turner, QDPI Mutdapilly

Regulators

Ron Glanville, QDPI Animal and Plant Health

Malcolm McLeod, QDPI Animal and Plant Health

Greg Gates, QDPI Animal and Plant Health

Kevin Duff, QDPI Animal and Plant Health

Peter McGregor, NSW Agriculture

14 July 2004

Consultants

Andrew & Janet von Berky, von Berky Veterinary Services, Woody Point, QLD

Sandi Jephcott, Fernvale

Industry

Wayne Hall, Meat & Livestock Australia, Brisbane

Researcher

Bob Sutherst, CSIRO Entomology, Long Pocket

15 July 2004

Researchers

Ian Sutherland, CSIRO Livestock Industries, Rockhampton

Heather Burrow, CSIRO Livestock Industries, Rockhampton

Nick Corbet, CSIRO Livestock Industries, Rockhampton

Toured facilities at Belmont Research Station, Rockhampton

Industry

Christian Duff, Technical Officer, Tropical Beef Research Services, Rockhampton

16 July

Researchers

Nick Jonsson, School of Veterinary Science, University of Queensland

John Morton, School of Veterinary Science, University of Queensland

CATTLE TICK CONTROL REVIEW 2004

TICK CONTROL STRATEGIES SURVEY.

STRATEGIC BOVINE SERVICES

ABN: 94 050 042 754
2 Broughton Street
PO Box 660 Camden 2570,
NSW, Australia
Phone: 02 46 558532
Fax: 02 46 558501
Website: www.dairydocs.com.au
Globaldairy: www.globaldairy.net
Email: mattp@dairydocs.com.au

CONTENTS

TICK CONTROL STRATEGIES SURVEY

1. Executive summary

1.1. Background

Australia currently has a population of approximately 26 million beef cattle, nearly eight million of which live in the tick-endemic areas of Queensland, the Northern Territory, and Western Australia. These cattle are quarantined from cattle in adjacent areas by a regulatory “Tick Line” and movement controls. In addition, nearly one million cattle in the northern regions of New South Wales are subject to movement controls and monitoring to ensure the spread of ticks and tick fever in NSW is minimised. It is estimated that without effective controls, ticks could spread down the NSW coast as far south as Newcastle. Control of ticks is necessary to limit the economic and welfare impact of disease and production losses caused by ticks.

1.2. Economic cost of cattle ticks

In financial year 2002-03 around 9.3 million head of cattle were slaughtered in Australia, and 968 thousand head of live cattle were exported. Most of the live export cattle originated from the northern tick-endemic areas of the country. The combined value of slaughtered and live export cattle was A$6.4 billion[1].

Beef cattle in northern Australia are subject to disease and production loss from ticks and tick-borne parasites. Losses due to cattle ticks can be attributed to:

a) decrease in liveweight gain

b) decrease in milk production

c) hide damage

d) morbidity and mortality due to tick fever

e) labour cost of mustering & treatment

f) capital cost of facilities for treatment

g) cost of chemicals for treatment

h) veterinary costs to treat sick animals

i) cost of maintaining regulatory controls

j) costs of research and policy-making

k) welfare costs

l) trade-related losses due to inability to use the most desirable breeds, or access markets due to chemical withholding periods or presence of tick fever parasites

Overall cost estimates of ticks and tick fever are summarised in Table 1. Davis (1998) reported various estimates of the components of the cost of ticks, with treatment accounting for 11%, additional labour 35%, and production losses and animal deaths 32%. It is estimated that in 2003 the sales of tickicides, including Macrocyclic Lactones to control ticks costs is in the region of A$16.8m[2].

Table 1: Estimates of the cost of ticks to the Australian cattle industry

Estimates A$ (cost/year)	2004 values (A$)- assuming an annual inflation rate of 3.0% since 1995	Reference
33m (1973)	239m	Cattle Tick Commission, (1973)
132m (1995)	172m	McLeod (1995)
> 100m (1997)	>122m	Willadsen (1997)
87m (1973)	217.5m	Davis (1998)
134m (1995)	175m	Canyon et al (2002)

1.3. Trends

Tick control is becoming more difficult for producers in northern Australia due to-

- Acaricide resistance making control more expensive for farmers
- Tick Line- threatened by lack of efficacy of knockdown chemicals
- Meat Quality issues leading to decreasing Bos Indicus content
- Low uptake of TickGARD & Tick Fever Vaccines, as well as other methods of tick control such as Integrated Pest Management (IPM) & environmental measures

Meat & Livestock Australia (MLA) are looking at the strategies for controlling ticks and prioritising these for funding of projects.

1.4. Your importance to this project

This survey is extremely important to the review of tick control strategies currently being undertaken, and subsequently for ongoing support of research into ticks and tick fever. You have been chosen as one of twenty leaders in this field who can provide an expert opinion on features of tick control. You are asked to read the following questions and make estimates of the costs, benefits, and other features of various strategies, in order to validate a model for ranking projects. Note that the current review focuses solely on *Boophilus microplus,* and associated intra-erythrocytic parasites and their effects on the beef industry.

2. Project strategies

The following table lists thirteen tick control strategies, in no particular order. These projects have been proposed by producers, regulators and researchers based on existing and future technologies.

Table 2: List of selected strategies for cattle tick control

Strategies for tick control	Category	Aim
1. Crossbreeding using Bos Indicus and resistant Bos Taurus genetics to develop naturally tick resistant strains and crosses of cattle with high quality carcass characteristics. Use extension services to promote these strains to the beef industry.	Genetics Extension	Develop tick resistant cattle breeding programs to produce stock with carcass characteristics & reproductive indices similar to British breeds, and make these breeds available to commercial producers. Develop & promote software to help with critical breeding decisions.
2. Gene markers identifying markers for genes that confer tick resistance and using these for gene insertion or selection techniques. Use extension services to publicise	Genetics Extension	Develop genetic markers to identify tick resistant traits, use to develop lines of commercial cattle with superior carcass characteristics, commercialise for producers
3. Eradication of ticks federal program to reduce tick numbers by controlling stock movements, then compulsory treatments to eradicate regionally and eventually nationally	Regulatory Extension	Eradicate cattle tick from Australia by a program of regulatory controls on stock movements, de-stocking of certain areas, compulsory treatments and inspections, gradual shifting of the Tick Line.
4. Compulsory and assisted Tick & Tick Fever vaccination government and industry-sponsored programs to decrease chemical use and incidence of ticks and tick fever by increasing resistance using the available vaccines. Live export market access is assured by vaccinating all animals in endemic zones with *Anaplasma*, and both *Babesia*.	Regulatory Vaccine	All cattle in the tick endemic area and control zone to be vaccinated for tick fever once at weaning, and all >5/8 Bos Taurus cattle with tick vaccine four times annually. Government and industry inducements to stock owners to comply, plus penalties or market exclusion for vaccine non-use or excessive chemical use.
5. Notification and control of Ulam & Ultimo resistant ticks government-sponsored programs to extend movement controls to include farms with amitraz or multi-resistant ticks. Will require de-stocking of some farms or areas, and re-stocking later with resistant breeds.	Regulatory Chemical	Control and eradication of amitraz-resistant ticks from farms. Monitoring program boosted, with increased lab capacity to identify resistance, field officers to ensure compliance. De-stocking of affected farms, with compensation provided to affected farmers.
6. Research to slow resistance of existing Acaricides research on means of slowing or reversing acaricide (esp. Macrocyclic Lactones & amitraz) resistance by rotation of chemicals, application of principles of refugia, recommendations for type of ML and use patterns etc.	Chemical Pharmaceutical Extension	Retain use of amitraz at 95% efficacy, and MLs at 100% efficacy. Use of Insect Growth Regulators or Tick Development Inhibitors such as Fluazuron will be included in rotation. Promote program to producers.

7. Acaricide resistance diagnosis & monitoring lab-based research to develop methods of speeding up resistance diagnosis with genetic techniques, monitoring spread of resistance to back up regulatory controls	Chemical Genetics	Establish DNA tests that can identify resistance genes in ticks by overnight tests.
8. Introduce formulations that are in use overseas (Fipronil, Spinosad, Ivomec Gold) register and market new active ingredients or formulations already registered overseas with APVMA	Regulatory Marketing	Compile an APVMA submission and register products that are already in use in other markets, through local efficacy, safety, residues trials. Market to producers.
9. Develop novel chemicals develop new acaricides, vaccines, IGRs or repellents from existing actives, or new actives against existing or novel targets	Pharmaceutical Regulatory Marketing	Develop novel products by identifying target molecules, screening molecules, compiling complete drug files, performing animal trials and registering product with APVMA. Market to producers.
10. Biopesticides- e.g. neem oils, fungus, pheromones, tick egg-eating nematodes develop new bio-controls that can safely be applied to cattle or environment to decrease ticks	Biopesticides Pharmaceutical Extension	Develop, trial and register a novel control strategy based on biopesticides. Use extension services to demonstrate benefits to producers.
11. Increasing Tick vaccine efficacy research to improve tickicidal and ovicidal effects of vaccine and extend duration of efficacy, decrease side effects	Vaccine Immunological	Bring to market a *Boophilus microplus* vaccine with 90% tickicidal efficacy, annual booster, no lumps
12. Increasing Tick Fever vaccine convenience development of vaccine that overcomes shelf life, biosecurity, cost, side effects	Vaccine Immunological	Bring to market Babesia & Anaplasma vaccine with 6-month refrigerated shelf-life, no contaminants, A$1/shot, no major side effects
13. Develop & introduce Integrated Pest Management measures strategic plan for each farm to control ticks and other parasites by combining chemical treatments, using non-chemical treatments, including environmental approaches- de-stock pastures over summer, cultivate, use feedlots, cut & carry, pasture rotation	Extension Environmental	Decrease chemical acaricide use by 50% by adopting environmental and combination measures. Establish model feedlot dairies and beef production facilities to demonstrate chemical-free production methods.

3. Rate of adoption

Assume that the strategy is funded and implemented. Estimate the adoption rate (%) of this measure in the northern beef industry over the timeframes indicated. The estimate should include the time required to develop the strategy to the stage that it can be implemented.

Table 3: Estimated adoption rate for the strategies

Strategies for tick control	**Adoption rate (%)**						
	1 yr	**5 yrs**	**10 yrs**	**15 yrs**	**20 yrs**	**25 yrs**	**30 yrs**
1. Crossbreeding							
2. Gene markers							
3. Eradication of ticks							
4. Compulsory vaccination							
5. Control resistant ticks							
6. Slow acaricide resistance							
7. Improve resistance diagnosis							
8. Introduce products from overseas							
9. Develop novel chemicals							
10. Biopesticides							
11.Improve Tick vaccine							
12. Improve Tick Fever vaccine							
13. Introduce IPM measures							

Comments:

4. Cost of implementing

Estimate the cost of developing & implementing each of the various strategies, in order to achieve the stated aim in the northern beef industry. Take into account the current state of knowledge, need for extension services and producer education, new technologies required, industry assistance and regulatory measures required

Table 4: Cost of implementing strategies for tick control

Strategies for tick control	**Cost of implementing (A$'000)**						
	1 yr	**5 yrs**	**10 yrs**	**15 yrs**	**20 yrs**	**25 yrs**	**30 yrs**
1. Crossbreeding							
2. Gene markers							
3. Eradication of ticks							
4. Compulsory vaccination							
5. Control resistant ticks							
6. Slow acaricide resistance							
7. Improve resistance diagnosis							
8. Introduce products from overseas							
9. Develop novel chemicals							
10. Biopesticides							
11.Improve Tick vaccine							
12. Improve Tick Fever vaccine							
13. Introduce IPM measures							

Comments:

5. Benefits

Consider the benefits to the beef industry if it were feasible to eradicate cattle tick. Estimate as a percent of the benefit of eradication (using the factors listed below) the benefit of each other tick control measure if was successfully implemented.

a) production benefits including hide damage,
b) labour cost of mustering & treatment
c) capital cost of facilities for treatment
d) cost of chemicals for treatment
e) morbidity and mortality due to tick fever plus veterinary costs to treat sick animals
f) cost of maintaining regulatory controls
g) costs of research and policy-making
h) animal welfare benefits
i) trade-related benefits
j) other (please comment)

Table 5: Benefits of the strategies for tick control

Strategies for tick control	**Benefit of implementing (% of eradication)**	**Comments**
1. Crossbreeding		
2. Gene markers		
3. Eradication of ticks	100%	Index value
4. Compulsory vaccination		
5. Control resistant ticks		
6. Slow acaricide resistance		
7. Improve resistance diagnosis		
8. Introduce products from overseas		
9. Develop novel chemicals		
10. Biopesticides		
11.Improve Tick vaccine		
12. Improve Tick Fever vaccine		
13. Introduce IPM measures		

Additional comments:

6. Efficacy rate

Assume the control strategy could be fully-funded and implemented. The definition of efficacy will be slightly different for each project. The guiding concept is to estimate the effectiveness of this strategy in **removing ticks or tick fever from infested properties, or reducing the infestation to a tolerable level** (a level at which there are no welfare, production, trade or animal health effects on cattle due to ticks).

Table 6: Efficacy rate of the strategies for tick control

Strategies for tick control	**Efficacy rate (%)**						
	1 yr	**5 yrs**	**10 yrs**	**15 yrs**	**20 yrs**	**25 yrs**	**30 yrs**
1. Crossbreeding							
2. Gene markers							
3. Eradication of ticks							
4. Compulsory vaccination							
5. Control resistant ticks							
6. Slow acaricide resistance							
7. Improve resistance diagnosis							
8. Introduce products from overseas							
9. Develop novel chemicals							
10. Biopesticides							
11.Improve Tick vaccine							
12. Improve Tick Fever vaccine							
13. Introduce IPM measures							

Comments:

7. Ranking

How would you rank the overall chance of success of each project? Take into account the level of current knowledge, technology required for implementation, fit with current management practices, level of investment required and return on that investment in benefits to the industry. Rank projects from one to thirteen.

Table 7: Ranking of strategies for tick control

Strategies for tick control	Rank	Reason
1. Crossbreeding		
2. Gene markers		
3. Eradication of ticks		
4. Compulsory vaccination		
5. Notification and control of resistant ticks		
6. Research to slow resistance of existing Acaricides		
7. Acaricide resistance diagnosis & monitoring		
8. Introduce existing chemicals from overseas		
9. Develop & register novel chemicals		
10. Biopesticides		
11. Increasing Tick vaccine efficacy		
12. Increasing Tick Fever vaccine convenience		
13. Introduce IPM measures		

8. Key features for successful implementation

List or discuss any regulatory issues, industry features, trade issues, extension needs or scientific issues that could impact on successful implementation of any of these strategies.

9. References

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[1] Dept. of Agriculture, Fisheries & Forestry, Australian Food Statistics 2004, Interim Report ISSN 1444-0458

[2] Dalgleish R (2004) pers. comm..

Appendix Ten

Detailed results of survey of Australian tick control experts

Table 4.6: Estimated adoption rates (%) for the next 30 years provided by survey participants

Strategies for tick control	Adoption rate (%) Mean ± SD (Range)						
	1 yr	**5 yrs**	**10 yrs**	**15 yrs**	**20 yrs**	**25 yrs**	**30 yrs**
1. Crossbreeding	15±25 (0.0 – 70)	22±26 (0.0 –70)	31±31 (0.0 – 90)	38±30 (0.0 - 90)	45±28 (10 – 90)	52±27 (15 – 90)	58±29 (15 – 95)
2. Gene markers	1±3 (0.0 –10)	10±15 (0.0 – 50)	16±16 (1 – 50)	25±19 (5 – 60)	32±23 (5.0 – 60)	37±24 (5 – 70)	40±25 (5 – 80)
3. Eradication of ticks	2±4 (0.0 – 10)	13±31 (0.0 – 90)	25±38 (0.0 100)	30±43 (0.0 –100)	35±44 (0.0-100)	38±47 (0.0 – 100)	39±46 (0.0 – 100)
4. Compulsory vaccination	9±26 (0.0 – 80)	20±26 (0.0 – 80)	24±27 (0.0 – 80)	29±32 (0.0 – 80)	32±32 (0.0 – 80)	35±35 (0.0 – 80)	35±35 (0.0- 80)
5. Control resistant ticks	1±1 (0.0 – 3)	11±16 (0.0 – 50)	25±29 (0.0 – 80)	29±34 (0.0 – 100)	31±36 (0.0 –100)	35±39 (0.0 – 100)	35±39 (0.0 –100)
6. Slow acaricide resistance	3±5 (0.0 –15)	9±9 (0.0 – 30)	17±7 (10 – 30)	25±10 (10 – 40)	32±14 (15 – 50)	36±20 (15 – 80)	36±22 (10 – 80)
7. Improve resistance diagnosis	4±7 (0.0 – 20)	13±15 (0.0 – 50)	28±31 (0 – 90)	36±34 (0.0 – 100)	41±33 (0.0 – 100)	42±33 (0.0 – 100)	44±32 (0 – 100)
8. Introduce products from overseas	1±2 (0.0 – 5)	27±23 (2 – 70)	38±22 (10 – 80)	41±21 (15 – 80)	42±20 (15 – 80)	44±20 (15 – 80)	44±20 (15 – 80)
9. Develop novel chemicals	0±0 (0.0 – 0)	16±25 (0.0 – 70)	23±30 (0 – 80)	33±26 (4 – 80)	37±29 (5 – 80)	41±26 (10 – 80)	43±25 (10 – 80)
10. Biopesticides	0±1 (0.0 – 2)	2±3 (0.0 – 5)	12±15 (1 – 50)	18±20 (2.5 – 70)	25±25 (5 – 80)	26±25 (5 – 80)	28±25 (5 – 80)
11.Improve Tick vaccine	10±26 (0.0 – 75)	16±23 (0.0 – 75)	24±23 (0 – 80)	25±22 (0.0 – 80)	29±24 (0.0 – 80)	29±24 (0.0 –80)	30±23 (0.0 – 80)
12. Improve Tick Fever vaccine	11±26 (1.0 – 75)	26±24 (0.0 – 75)	41±32 (1 – 100)	47±31 (2.5 – 100)	51±31 (5 – 100)	51±31 (7.5 –100)	52±30 (10 – 100)
13. Introduce IPM measures	5±5 (0.00 – 15)	12±8 (0.0 – 25)	21±15 (5 – 50)	29±18 (5 – 50)	36±23 (5 – 80)	39±24 (5 – 80)	43±26 (5 – 80)

Table 4.7: Estimated cost ($) of implementing different strategies for the next 30 years provided by survey participants

Strategies for tick control	Cost of implementing (A$m) Mean ± SD (Range)						
	1 yr	**5 yrs**	**10 yrs**	**15 yrs**	**20 yrs**	**25 yrs**	**30 yrs**
1. Crossbreeding	0.43±0.43 (0.10-1.0)	1.77±1.98 (0.0-5.0)	4.10±4.68 (0.10-10.0)	6.56±8.68 (0.10-20.0)	7.02±10.07 (0.00-20.0)	7.85±11.47 (0.00-25.0)	7.85±11.47 (0.00-25.0)
2. Gene markers	0.84±0.87 (0.10-2.0)	2.96±3.92 (0.00-10.0)	2.95±4.12 (0.0-10.0)	5.74±7.90 (0.20-20.0)	5.37±8.11 (0.0-20.0)	5.37±8.11 (0.00-20.0)	5.37±8.11 (0.00-20.0)
3. Eradication of ticks	5.63±5.09 (0.50-10.0)	47±44.16 (2.00-100.0)	70.00±78.23 (10.0-200.0)	71.17±87.91 (2.00-220.0)	73.83±91.76 (1.00-230.0)	77.83±98.77 (1.00-250.0)	94.00±102.13 (0.00-250.0)
4. Compulsory vaccination	2.79±4.82 (0.05-10.0)	16.45±22.44 (0.10-50.0)	31.38±45.89 (0.10-100.0)	46.48±69.25 (0.10-150.0)	64.92±97.12 (0.10-200.0)	76.68±115.99 (0.10-250.0)	93.45±141.53 (0.10-300.0)
5. Control resistant ticks	2.57±2.40 (0.20 -5.0)	6.60±10.31 (1.00-25.0)	11.90±21.37 (0.50-50.0)	17.80±32.21 (0.00-75.0)	22.80±43.33 (0.01-100.0)	27.80±54.48 (0.00-125.0)	32.80±65.63 (0.00-150.0)
6. Slow acaricide resistance	1.09±1.33 (0.10 - 3.0)	3.77±5.64 (0.10-15.0)	7.77±15.85 (0.10-40.0)	7.93±15.81 (0.10-40.0)	7.93±15.81 (0.10-40.0)	7.93±15.81 (0.10-40.0)	7.93±15.81 (0.10-40.0)
7. Improve resistance diagnosis	0.78±1.06 (0.10 - 2.0)	3.17±4.33 (0.10-10.0)	3.57±4.63 (0.10-10.0)	3.94±5.10 (0.10-10.0)	4.14±5.35 (0.10-10.0)	4.14±5.35 (0.10-10.0)	4.14±5.35 (0.10-10.0)
8. Introduce products from overseas	1.25±1.06 (0.50 - 2.0)	7.00±5.20 (1.00-10.0)	10.00±10.0 (0.01-20.0)	10.00±10.0 (0.01-20.0)	10.00±10.00 (0.01-20.0)	10.00±10.0 (0.01-20.0)	10.00±10.0 (0.01-20.0)
9. Develop novel chemicals	5.00± (5.00-5.0)	12.50±17.68 (0.00-25.0)	40.00±56.57 (0.00-80.0)	160.00±5657 (120.0-200.0)	160.00±56.57 (120.0-200.0)	160.00±56.57 (120.0-200.0)	160.00±56.57 (120.00-200.0)
10. Biopesticides	0.45±0.49 (0.05-1.0)	2.52±4.23 (0.00-10.0)	16.94±35.27 (0.20-80.0)	20.94±44.21 (0.20-100.0)	20.94±44.21 (0.20-100.0)	20.94±44.21 (0.20-100.0)	20.94±44.21 (0.20-100.0)
11.Improve Tick vaccine	1.63±1.94 (0.25-3.0)	2.88±4.77 (0.00-10.0)	12.88±18.60 (0.50-40.0)	15.38±23.49 (0.50-50.0)	15.38±23.49 (0.50-50.0)	15.38±23.49 (0.5-50.0)	15.38±23.49 (0.50-50.0)
12. Improve Tick Fever vaccine	0.58±0.60 (0.15-1.0)	1.45±2.38 (0.00-5.0)	5.25±6.84 (0.50-15.0)	5.25±6.84 (0.50-15.0)	5.25±6.84 (0.50-15.0)	5.25±6.84 (0.5-15.0)	5.25±6.84 (0.50-15.0)
13. Introduce IPM measures	0.68±0.90 (0.10-2.0)	2.38±3.90 (0.00-10.0)	3.98±7.88 (0.10-20.0)	5.65±11.95 (0.10-30.0)	7.32±16.03 (0.10-40.0)	8.98±20.11 (0.10-50.0)	10.65±24.19 (0.10-60.0)

Table 4.8: Estimated benefits (%) of different strategies for the next 30 years provided by survey participants.

Strategies for tick control	**Benefit of implementing (% of eradication)**
	Mean ± SD (Range)
1. Crossbreeding	55±25.05 (20 – 100)
2. Gene markers	49±30.67 (10 – 100)
3. Eradication of ticks	100±0.00 (100 – 100)
4. Compulsory vaccination	48±21.57 15(90)
5. Control resistant ticks	23±15.74 (5 – 60)
6. Slow acaricide resistance	31±18.81 (5 – 60)
7. Improve resistance diagnosis	22±13.05 (5 – 50)
8. Introduce products from overseas	43±23.58 (5 – 80)
9. Develop novel chemicals	48±23.19 (10 – 80)
10. Biopesticides	38±24.72 (5 – 80)
11.Improve Tick vaccine	50±27.34 (20 – 100)
12. Improve Tick Fever vaccine	27±19.40 (5 – 60)
13. Introduce IPM measures	50±27.16 (17 – 100)

Table 4.9: Estimated efficacy rates (%) of different strategies for the next 30 years provided by survey participants

Strategies for tick control	Efficacy rate (%) Mean ± SD (Range)						
	1 yr	**5 yrs**	**10 yrs**	**15 yrs**	**20 yrs**	**25 yrs**	**30 yrs**
1. Crossbreeding	26±40 (0 – 100)	22±33 (0 – 100)	43±37 (0 – 100)	48±34 (0 – 100)	61±27 (15 –100)	63±26 (15 –100)	63±26 (15 – 100)
2. Gene markers	12±31 (0 – 95)	14±33 (0 –100)	42±40 (0 – 100)	48±35 (5 – 100)	54±33 (10 – 100)	56±32 (10 –100)	59±31 (10 – 100)
3. Eradication of ticks	28±41 (0 – 100)	35±41 (0 – 100)	51±43 (0 – 100)	59±43 (0 – 100)	67±42 (0 – 100)	74±41 (0 – 100)	78±40 (0 - 100)
4. Compulsory vaccination	28±34 (0 – 90)	31±32 (0 – 85)	36±32 (0 – 90)	36±29 (0 – 80)	49±31 (5 – 90)	52±33 (5 – 90)	50±32 (5 – 90)
5. Control resistant ticks	11±28 (0 – 90)	8±6 (0 – 20)	11±7 (0 – 20)	16±15 0(50	22±26 (0 – 80)	26±32 0(80	25±30 (0 – 80)
6. Slow acaricide resistance	12±28 (0 – 90)	12±9 (0 – 25)	19±11 (0 – 35)	24±15 (0 – 50)	31±24 (0 – 80)	34±28 (0 – 80)	33±27 (0 – 80)
7. Improve resistance diagnosis	12±29 (0 – 90)	15±15 (0 – 50)	20±14 (10 – 50)	24±13 (10 – 50)	31±16 (10 – 50)	33±18 (10 – 50)	31±17 (10 – 50)
8. Introduce products from overseas	24±37 (0 – 95)	31±27 (0 – 90)	47±24 (10 –100)	49±22 (10 –100)	49±25 (10 – 100)	49±29 (10 – 100)	50±31 (10 – 100)
9. Develop novel chemicals	27±43 (0 – 100)	29±36 (0 – 100)	43±33 (0 –100)	47±26 (10 –100)	49±23 (12 – 100)	48±26 (15 – 100)	44±33 (20 – 100)
10. Biopesticides	22±40 (0 – 100)	17±32 (0 – 100)	27±30 (1 –100)	34±30 (5 – 100)	40±31 (5 – 100)	44±33 (5 – 100)	46±34 (5 – 100)
11.Improve Tick vaccine	20±35 (0 – 90)	18±25 (0 – 80)	22±24 (0 – 80)	32±29 (0 – 80)	43±32 (10 – 90)	45±33 (10 – 90)	46±32 (10 – 90)
12. Improve Tick Fever vaccine	13±31 (0 – 90)	13±10 (0 – 25)	29±28 (5 – 90)	33±28 (5 – 90)	35±30 (5 – 90)	35±30 (5 – 90)	35±30 (5 – 90)
13. Introduce IPM measures	41±42 (0 – 90)	43±36 (0 – 90)	51±31 (10 – 90)	55±30 (10 – 90)	58±30 (10 – 90)	59±31 (10 – 90)	61±29 (10 – 100)

Table 4.10: Rankings orders of strategies for the next 30 years predicted by survey participants

Strategies for tick control	Ranking by survey participants											
	ARI	**NJ**	**BS**	**DK**	**LT**	**PH**	**HT**	**RG**	**SJ**	**AB**	**AP**	**HB**
1. Crossbreeding	5	8	9	1	1		6	1	1	3	5	2
2. Gene markers	7	9	10	2	5		7	4	2	2	4	1
3. Eradication of ticks	13	13	12	13	13		13	13	9	11	13	12
4. Compulsory vaccination	12	12	4	11	12		5	12	5	12	11	13
5. Control resistant ticks	1	11	5	10	11		9	11	6	9	12	10
6. Slow acaricide resistance	1	2	2	6	9		12	2	6	5	3	9
7. Improve resistance diagnosis	1	6	6	5	3		10	9	6	4	2	11
8. Introduce products from overseas	4	1	1	9	2		1	3	6	8	1	8
9. Develop novel chemicals	8	7	13	12	7		11	7	6	10	9	7
10. Biopesticides	6	3	11	8	8		4	8	7	6	10	5
11.Improve Tick vaccine	2	10	8	3	10		2	6	4	13	6	4
12. Improve Tick Fever vaccine	0	5	7	4	6		7	10	3	1	7	6
13. Introduce IPM measures	3	4	3	7	4		3	5	8	7	8	3

ARI= Peter James, ARI Yeerongpilly, QLD
NJ= Nick Jonsson, University of QLD
BS= Bob Sutherst, CSIRO Entomology, Long Pocket
DK= David Kemp, CSIRO Livestock Industries, St Lucia
LT= Lex Turner, QDPI&F Mutdapilly
PH= Peter Holdsworth, Avcare
HT= Andrew Taylor, Parmalat Nambour
RG= Ron Glanville, QDPI&F Plant & Animal Health Service
SJ= Sandi Jephcott, Consultant, Brisbane
AB= Andrew von Berky, Consultant, Brisbane
AP= Anthony Preshaw, Technical Services Manager, Fort Dodge
HB= Heather Burrow, CSIRO Livestock Industries, Rockhampton

Table 4.11: Summary of ranking orders for different strategies

Strategies for tick control	Ranking order												
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
1. Crossbreeding	**4**	2	1	0	**2**	1	0	1	1	0	0	0	0
2. Gene markers	1	**4**	0	2	1	0	2	0	1	1	0	0	0
3. Eradication of ticks	0	0	0	0	0	0	0	0	1	0	1	2	**8**
4. Compulsory vaccination	0	0	0	1	**2**	0	0	0	0	0	2	**6**	1
5. Control resistant ticks	1	0	0	0	1	2	0	0	**2**	**2**	**3**	1	0
6. Slow acaricide resistance	1	**3**	1	0	2	2	0	0	**2**	0	0	1	0
7. Improve resistance diagnosis	1	1	1	1	1	**3**	1	0	1	1	1	0	0
8. Introduce products from overseas	**4**	1	1	1	0	1	0	**3**	1	0	0	0	0
9. Develop novel chemicals	1	0	0	0	0	1	**4**	1	1	1	1	1	1
10. Biopesticides	0	0	1	1	1	2	1	**3**	0	1	2	0	0
11.Improve Tick vaccine	0	2	1	2	0	2	0	1	1	**2**	0	0	1
12. Improve Tick Fever vaccine	1	0	1	1	1	2	3	0	1	1	0	0	0
13. Introduce IPM measures	0	0	**4**	**3**	1	0	2	2	0	0	0	0	0

BIOTECHNOLOGY – TICK FEVER

4 scientists and 4 technical staff

CURRENT ACTIVITY SYNOPSIS

OBJECTIVES	OUTCOMES	BENEFITS
Improved diagnostic capability	*internationally validated ELISA's for tick fever:* *Babesia bovis* *Babesia bigemina* *Anaplasma marginale* *Anaplasma centrale* **Exotic disease awareness**	**Improved advice on disease distribution and outbreak risk** **More accurate and cost effective strategic surveillance for international markets** **Staff training on exotic diseases**
Determine distribution of tick fever in Northern Australia	**Survey of distribution of tick fever.** **Studies on susceptibility of X and full breed *Bos Indicus***	**Improved advice on vaccination strategy** **Levels of protection required for national and international stock movements – vaccine cost benefit studies**
Improved vaccine quality control	**Strain markers** **Species identification tests** **Assays for contaminants** **Virulence markers**	**Understanding vaccine breakthrough – tools for improved investigation capability** **Sensitive & specific assays for monitoring vaccine quality and for contaminants**
Improved vaccine protection	**Vaccine production using tissue culture technology & improved frozen vaccines** **Develop virulence markers** **Improved understanding of bovine immune responses to tick fever**	**Safer vaccines** **Cost effective production and development of replacement vaccine strains** **Improved protection - lay ground work for next generation vaccines** **Food safety - more protective vaccines – minimise drug & acaricide residues resulting in expanded export markets**

Appendix Twelve

15 February 2004

Telephone interview with Dr. Peter Morecombe, Technical Manager, Animal Health Australia, Canberra

Background

During the telephone hookup with Matt Playford, Joan Lloyd and Geoff Niethe in November 2004, it was suggested by Geoff Niethe that Animal Health Australia be approached to coordinate the overall strategies for the regulation of tick control in Australia. This interview aims to address this issue.

Major points

1) Animal Health Australia wants to restrict its activities to Emergency Animal Disease preparedness. The only exception to this is the coordination of Johnes Disease control, which was initially intended to be an eradication program.
2) Endemic diseases such as cattle ticks and tick fever are left to state governments.
3) If states wanted AHA involvement in ticks they could make a formal submission.
4) The aims, objectives and funding would need to be determined before AHA could proceed.
5) The four jurisdictions involved would need to agree that AHA coordinate a national management plan.
6) Initially present plan to the cattle industry and see if there is a favourable response. If requested then AHA board would consider the proposal.
7) State governments would still have legislative power and responsibilities.
8) While there is potential for AHA to coordinate regulation and advice on a national basis, it is unlikely at this stage.

Summary

There are potential benefits in coopting the expertise of Animal Health Australia in coordinating plans for tick control in northern Australia. Implementation would require formal submission from the four state and territory governments, and funding from the cattle industry. None of these bodies has expressed such an interest previously. If this matter is to be pursued MLA will need to make a proposal to the four state and territory governments and to the industry bodies concerned, and approach AHA after a favourable response has been gained.

Appendix Thirteen

Interview with Australian Pesticides & Veterinary Medicines Authority (APVMA)
Brisbane Ave, Canberra
23 February 2005

Matt Playford & Ahmad Rabiee (SBS)
Elizabeth Milbourne, Cheryl Javro & Judith Platt (APVMA)
(Jonathan Taylor sent apologies)

MP gave a background to the meeting including a description of the review being undertaken for MLA (AHW.054), and the response from many people both with pharmaceutical companies and the producer community that APVMA regulations make it too difficult to register new acaricides for use in cattle in Australia. The guidelines set out requirements for pen trials, and then stipulate that for field trials two locations in each of three geographical areas be used for trials over two tick seasons. In practical terms this means that twelve field trials need to be conducted for inclusion in the regulatory dossier. Half of the trials should include a positive control group for comparison with the trial product. All trials need to be conducted to GCP standards.

EM The current guidelines for registration of acaricides for *Boophilus microplus* were written in 1996 after extensive consultation between the (then) NRA, state government departments and researchers. At the time it was decided to include three geographical locations for efficacy trials to reflect different management, climatic and tick conditions.

MP Some of the pharmaceutical companies maintain that the requirement for trials in three different locations is excessive given that some of the products registered overseas have already been extensively trialled.

EM Overseas data produced to GCP standards can be used as supporting data in a dossier. However GCP standard Australian efficacy trials are absolutely required before dossier submission. State departments review the submission and expect there to be local trials. The guidelines are only an outline. APVMA may be flexible with the actual content. e.g if there were convincing overseas data it may be possible to reduce the number of local trials required.

APVMA allows companies to make appointments for meetings to discuss their plans for trialling products for registration. These are not actively encouraged, as they take up APVMA staff's time. A preferred option is for companies to submit a Category 50 application outlining their intentions. This is reviewed by the states who can then comment on the likelihood of the strategy succeeding.

CJ Residues implications are very important for trade. Any new formulation, especially pour-ons, needs to be investigated as they can have widely varying effects depending on the concentration and nature of the excipients. Since APVMA now sets the Export Slaughter Interval (ESI) as well as the Withholding Period (WHP) they need to be sure that all potential export markets are covered as well as Australia's residue requirements.

Small changes in formulation for Pour-On and long-acting injectables can have profound effects so all new formulations require a full residues package.

If an existing active ingredient is being used in a new application e.g. a spray-on chemical applied to eartags then it is possible that a reduced residues package could be submitted.

MP Since the guidelines were set out in 1996 there has been an increase in the cost of performing trials due to the need for companies to comply with GCP for efficacy trials and GLP for residues trials. This means that the cost of performing all of the trials set out in the requirements has greatly increased. Some companies are saying that this makes it impractical to attempt registration of new formulations in Australia.

EM The economics of registration are not a concern of the APVMA. If a company decides not to attempt registration due to the small market size then that is their own internal business.

CJ It may be possible to decrease for example the cost of residue testing if there was a data package from overseas that provided convincing evidence. It may be then possible to modify the number of data points, for example.

MP Is the APVMA looking to change its approach to setting residues testing requirements?

CJ APVMA will probably, in future, bring their approach for setting residues in line with the EU approach.

<u>Summary</u>

- Registration requirements for efficacy and residue trials for acaricides are set by the APVMA with consideration of local conditions and trade requirements.
- Trials need to be conducted to GCP standards (efficacy) or GLP standards (residues) as of 2001.
- This means that the cost of trials is much higher today than it was in 1996 when these guidelines were set out.
- Veterinary pharmaceutical manufacturers need to assess the cost of performing trials and other costs of registration, and weigh them against the potential sales of a new product.

Appendix Fourteen

Interview with Cattle Council 23 February 2005
NFF House, Brisbane Ave, Barton ACT

Michael Hartmann, Deputy Director

Matt Playford, Ahmad Rabiee (SBS)

Michael was formerly Chief Executive Officer of the Brangus Society and has experience with cattle producers who are trying to control cattle ticks.

Extension programs-

- Should focus on issues of acaricide resistance and provide information that farmers can use to protect themselves against economic loss.
- Farmers who pay for a consultant value the advice more than that given free by a government extension officer
- However many farmers still expect extension advice to be provided free
- The approach by MLA's "More Beef from Pastures", where advisers and consultants are targeted rather first and encouraged to then relay the information to farmers is a good development.
- Farmers are already overwhelmed by the need to educate themselves in many different topics including OH&S, management, financial matters, environmental concerns, animal welfare, QA programs, agronomy etc.

Cattle breeds- ABS census no longer includes breed information due to poor support for this information about five years ago. However Cattle Council believes this information is very important, especially for the issues of disease control and also for commercial reasons.

Gene markers- Cattle Council sees this as an important potential tool for both tick control and improving meat quality and strongly supported the Beef CRC.

Breedplan- it is a challenge for producers to provide the required data to validate Estimated Breeding Values for Breedplan, but some traits are very reliable and it is worth the effort.

Hotcross- a very good idea for small property owners, but as for other tools such as Breedplan it will initially be taken up by elite breeders and then later filter down to commercial users. It may need five years to get good uptake. It would be useful to apply in extension services.

Michael recommended that we approach Malcolm Reid, a member of Cattle Council and producer from northern NSW, who has been on the NSW Tick Control Board since 1988.
Address: Grahams Creek, Woodenbong, NSW 2476
Phone (02) 6635-1340
reidmal@bigpond.com

We conducted a telephone interview with Malcolm and he also completed a tick control survey form.

Malcolm breeds Hereford cattle close to the NSW-QLD border. He expressed a concern that decreased government involvement in cattle tick regulation would lead to breakdowns in tick control and could lead to outbreaks in NSW. He thinks that individual farmers do not have sufficient knowledge of ticks nor the tools to enact their own tick control programs. This would be different if there were an effective tick vaccine, however. He also ranked continued access to effective acaricides as being important.

PROJECT:	**Monitoring and Eradication of Cattle Tick Strains Resistant to Chemicals**
Project Officers:	**K. Small, D. Russell and I. Doddrell**
Location:	NT Wide

Objectives:

Locate chemically resistant strains of cattle ticks on NT properties and prevent their spread.

Advise industry on the chemical control of any detected resistant strains of cattle ticks.

Prior to April 1999 there were no known cattle tick strains resistant to synthetic pyrethroids or amitraz in the NT. Previously some resistant strains to organic phosphates were detected during the 1970s and 1980s. Organic phosphates as acaracides were banned in 1987.

There are strains of cattle ticks resistant to one or more acaracides in Queensland. All cattle from the tick-infected areas of Queensland require a clean inspection followed by plunge dip to enter the NT. Despite this control, there is a low level of activity to monitor for resistant ticks as there may be illegal movements or inspectors in Queensland may not detect ticks. Although there is little cattle tick control in the NT to improve production, the widespread establishment of resistant ticks would have a significant effect on achieving tick-free cattle for export overseas and interstate.

Fully engorged female cattle ticks are collected in the field and sent to the Animal Research Institute, QDPI, for processing and larval packet testing against a number of tickicides. Collectors and station owners/managers are given the results and appropriately advised. The program targets properties that report poor tick kill and properties on which pour-on synthetic pyrethroids are used for cattle tick or buffalo fly control.

Parkhurst strain resistant ticks (resistant to synthetic pyrethroids e.g. cypermethrin and flumethrin as in *Bayticol*®, *Barricade 'S'*® and *Blockade-S*®) were found on two properties in the Mary River area in April 1999.

Situation in 2002-03

Parkhurst strain cattle ticks have been eradicated from one property. There are nine properties infected with Parkhurst ticks. Movement controls are in place to reduce the threat of further spread of these ticks.

An active surveillance program commenced to determine the extent of spread of Parkhurst ticks in the Darwin area.

The establishment of plunge dips charged with amitraz at the Darwin export yard and the Noonamah export yard has facilitated the movement of cattle from infected properties to export under a permit system. Amitraz plunge dips are also available at Opium Creek and Twin Hills.

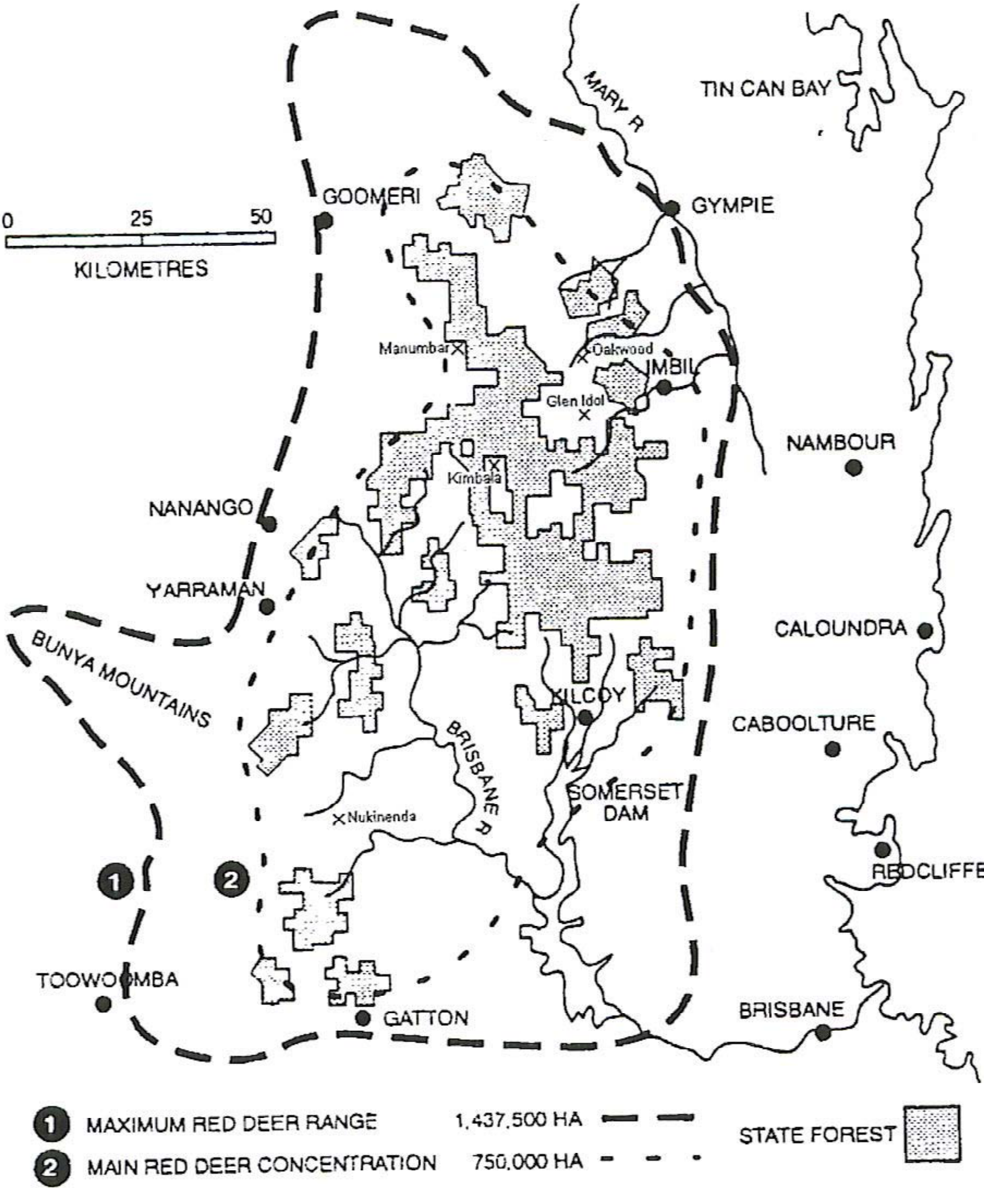

Figure 3.1. Map of estimated wild red deer range in Queensland showing the five properties that deer were harvested from in this study. Reproduced from McGhie and Watson (1995).