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Decisions to manage endemic ectoparasites: the case of ticks and tick-borne diseases in northern Australia

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Summary

Control of ticks and tick-borne diseases in northern Australia is considered economically important, but is complicated due to the physical and production environment. Various approaches to analysis have been applied to evaluate decisions to control tick-borne diseases but have been used in research rather than as direct support for producer decisions. To be effective, the results from economic analysis need to be applied by decision-makers. The application of the results from economic analysis requires decision-makers and analysts to incorporate effective communication within their relationship. Taking a learning approach to enhance communication in economic advisory services has potential to overcome misalignment between the advice provided and producers' approaches to decision-making. In this approach, we need to understand the processes a livestock producer would use to evaluate their experiences and develop new understanding and knowledge over time as a result of these experiences. This paper explores the nature of private decisions in relation to tick-borne disease control then considers the use of a learning approach to enable effective learning to take place between producers and their advisors.

Key words

Animal health economics – Australia – Communication – Decision – Decision support – Learning – Tick-borne disease.

Introduction

The control of ticks and tick-borne diseases in northern Australia is complicated. The physical conditions are unpredictable, the biological variation in the parasites is large and the host response to the parasites is variable. In addition, the production systems present in northern Australia consist of large, often inaccessible properties with a variety of management systems. In 2015, Meat & Livestock Australia (a research and development body of the red meat and livestock industry) produced an estimate of the costs of cattle diseases in Australia, together with a priority ranking (1). In that study, control of ticks was stated to be a high priority for the cattle industry in Australia, with tick-borne diseases considered a lower priority. The study was based on producer opinion and researchers consider there are gains to be made in both production and financial performance from enhanced control of tick-borne diseases.

Economic analysis needs to align with the processes producers use to allocate resources; if it does not, the predictive capacity of the analysis will generally be poor. In addition, where the analysis is being used to guide decision-making and it is not aligned, it may not be accepted by farmers and therefore ignored. The application of the results from economic analysis therefore requires decision-makers and analysts to incorporate effective communication within their relationship. Approaches to carrying out economic analysis for animal health have continued to develop, but development of the approach to communicating outcomes has been limited. This paper first examines private decisions and their application to animal health decisions. It then examines the specific situation for tick and tick-borne disease control in northern Australia, followed by suggestions for further development of decision support through a learning approach.

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Supporting decision-makers in animal health

Decisions are a human process made within a social context. They involve multiple elements, including reasoned (cognitive) and affective (emotional) elements. Decisions and the processes by which they are made are not well understood and the decision-maker is often unable to describe the process by which a decision has been made. In part, this inability is due to the fact that many decisions are intuitive rather than analytical (2). Various disciplines, including economics, have worked to understand decision processes and have investigated how decisions are taken in situations of risk and uncertainty and how information sources are used (3, 4, 5). In the case of agricultural producers it has been demonstrated that decisions are made on the basis of the values and priorities of the producer and those values and priorities can vary between producers and between members of the same family (6). Those decisions are generally made by producers on the basis of their subjective beliefs, with those beliefs heavily weighted by their own experience (7). Economic and financial analysis provides advice to decision-makers. In an economic framework, the analyst provides a structured approach to decision-making that encourages decision-makers to *i)* establish a clear picture of exactly what outcome the decision is designed to achieve, and *ii)* develop a model that builds links between the decision and the desired outcome.

In the veterinary literature, animal health decisions are often analysed as though they function outside the rest of the production system. The analysis tends to take the form of a justification for a decision rather than as a means to determine the most appropriate action. Several authors have stated that animal health is an economic issue with veterinary implications rather than a veterinary problem with economic implications (8, 9). From an economic perspective, maximising economic benefits is the aim of most economic analysis. Benefit–cost analysis can be used to determine optimal economic choices, and economically optimal control of livestock disease can be considered to occur where the net benefits, less costs, are maximised (10).

Many of the approaches applied to assist decision-making by producers, including the economic approach, work from the assumption that the decision will be enhanced if a logical process is put in place to substitute for the normal human decision-making processes. That is, the analyst produces a model of how a 'rational person' should act in a situation. However, supporting decision-makers involves having an understanding of the issues they face and the outcomes they desire. Studies in Australia have highlighted the need for advisors of primary producers to operate as an integrated team that considers the production unit as an interconnected system (6). Animal health professionals provide decision support, but that support is generally provided from a single perspective rather than the perspective of the system as a whole. As supporters of decision-makers, animal health professionals can benefit from having an understanding of the processes, aims and priorities of livestock producers as well as the broader context in which they operate and can take an approach that enables producers to learn more about the potential impacts of decisions in their particular context.

Ticks and tick-borne diseases in Australia

Ticks and the diseases they transmit pose particular challenges for managers of livestock. Ticks and tick-borne diseases are distributed in relation to the physical environment and are found in the sub-tropical and tropical parts of the country. Climate variability can be extreme in the Australian context, resulting in large, difficult-to-predict variations in the population and distribution of ticks and in the transmission of tick-borne disease agents both within and between years.

In Australia, *Rhipicephalis microplus* is the main tick species impacting on cattle. The tick transmits *Babesia bovis, Anaplasma marginale* and *B. bigemina*, the main organisms involved in tick-borne disease. All three organisms have strains that vary in their virulence and therefore the impact they have on infected hosts. The diseases caused by these organisms are often considered a single complex rather than individual diseases, and control activities are carried out to control the complex rather than the individual diseases. In addition to these more established diseases, there is emerging disease caused by new types of *Theileria orientalis* (11).

Cattle vary both in their susceptibility to infestation with the tick and in their susceptibility to disease following infection with the various disease-causing organisms. That susceptibility is breed related. *Bos taurus* are most susceptible to infection and *B. indicus* least susceptible. The susceptibility of crossbred animals usually lies somewhere in the middle, but this is not the case for infection with *A. marginale*, as all breeds and crossbred cattle appear to be equally susceptible to disease caused by this organism (12). There is a continuum in relation to the host's resistance to disease for other disease-causing organisms (13). There is also a continuum of resistance to *R. microplus*, with *B. taurus* most susceptible and *B. indicus* least susceptible. In all breeds of cattle, natural exposure to ticks and tick-borne disease agents can induce immunity without disease if that exposure takes place during the first 12 months of life. The level of natural exposure in the first year of life and

its ability to protect animals from disease is the basis for the concept of enzootic stability (14).

Control of ticks and tick-borne diseases in an African context is more complex than in Australia because of the additional diseases, their pathology, the multiple tick species involved and the ecology and life cycles of the various tick species. In addition, the vaccines available are less reliable and more complex to use. An example is the control of East Coast fever (ECF) (15, 16), where vaccination involves infection and treatment rather than simply infection, and control of ticks is for a multi-host tick species rather than a single-host species.

The decision environment in northern Australian cattle production systems

Ticks and tick-borne diseases occur in the northern Australian production zone where there are large seasonal and year-to-year variations in weather, especially rainfall. Access to stock is restricted during wet periods and managers have limited herd performance and disease data.

Cattle properties in the tick-affected areas in northern Australia vary considerably in size, number of cattle and management structure. The properties are often large and inaccessible. Producers generally use a low-input system and cattle are difficult to access, except in the dry season when the annual muster is carried out and husbandry procedures are performed. Despite the low-input approach, mortality rates in this region are generally low. The cattle population tends to be clustered on the larger properties and 41% of cattle in northern Australia are found on the 350 properties with more than 5,400 head (17). The 5,300 smaller properties with fewer than 800 head comprised approximately 13% of the region's total cattle population. The cattle properties in what is known as the live export zone have considerably larger herd sizes than other northern properties (approximately 3.8 times bigger) (17). The management structure of these properties also varies considerably: some are owned by indigenous communities and many of the larger cattle properties are owned by corporations, with some corporations owning multiple properties. The southern part of the tick-affected area contrasts with the north, because the properties are smaller and each carries fewer cattle. Dairy farms are present in the southern tick-affected area and on those properties the milking herd is observed daily.

The structure for decision-making on northern cattle properties varies depending on the management structure, which, in turn, varies according to ownership. Some ownership and management structures include: *i)* an owner who is also a hands-on manager who works on the property; *ii)* a manager who reports directly and frequently to the owner (the owner may be an individual or organisation, which could be a company or a traditional community); *iii)* an owner who is not directly involved in day-to-day operations but still makes most decisions; and *iv)* property-owning families or communities (which may be single or multiple generations of the same family or community) who own, manage and operate the production unit.

There is limited infrastructure in northern areas of Australia and the industry has been developed to service the needs of specific markets. International markets for live cattle are important. Production of cattle for specific live export markets has a long lead time and producers need to minimise the risk of being excluded from a market.

On-farm control of ticks and tick-borne disease in Australia

The control options available to manage both ticks and tick-borne diseases in Australia relate to the areas of host, organism and environment. On-farm control options are not all or nothing but can involve the use of multiple approaches. The interactions and flow-on effects from the control activities, in association with variable climatic and market conditions, make the decisions complex.

A producer may consider the use of tick control to reduce the direct effects of ticks on animals. Several options are available for tick control, including the application of chemical acaricides and the use of tick-resistant breeds of cattle as a form of biological control. Both options have flow-on effects. Chemical control needs to be performed strategically to have greatest impact, and appropriate timing for control does not align with other husbandry activities. Chemical control has the potential to produce chemical residues in treated animals and ticks may become resistant to the acaricides. The breed of cattle used impacts on the markets that can be accessed and, consequently, on the price for the animals. Effective tick control reduces the production and welfare impacts associated with tick worry. Tick control through breed selection and use of acaricides can also reduce the population of ticks and the transmission rate of the parasites that cause tick-borne diseases. The reduction in parasite transmission can either reduce or increase the incidence of tick-borne diseases, depending on other factors, such as the breed of animals involved and the initial transmission rates.

Vaccination is commonly used for control of disease caused by *B. bovis*, *A. marginale* and *B. bigemina* in Australia. Vaccination can be used to achieve several objectives, including to:

– protect animals on a property from diseases

– protect animals from a property where the diseases do not occur (or transmission rates are very low) that are being moved to a property where the diseases do occur (or transmission rates are higher)

– protect live cattle export markets by ensuring animals exported meet import requirements and are protected from the diseases on arrival at their destination.

The last two examples do not impact on disease control on the home property but could be considered to form part of the marketing of the product. The main impact of vaccination is a reduction in mortality due to the diseases, with impacts on growth rates and reproduction being relatively minor. Two vaccines are available, namely a bivalent vaccine that is effective against *A. marginale* and *B. bovis* and a trivalent vaccine that is effective against all three parasites. Bivalent vaccine is usually recommended for *B. indicus* and crossbred cattle and trivalent for *B. taurus*.

The selection of which breeds of cattle to include on properties is important because of the variation in the levels of resistance of various breeds of cattle to both tick infestation and tick-borne diseases. Selecting breeds that are resistant to infestation helps reduce disease transmission rates by reducing the number of ticks on individual animals, thereby reducing the number of ticks on the whole property; selecting breeds that are resistant to disease reduces disease incidence if disease-causing organisms are transmitted. In addition, as there is international demand for resistant breeds, such as Brahman (*B. indicus*) or crossbred types, stocking these animals opens up additional export markets.

Disease control options and decision support for producers

In the Australian context, decision support to livestock producers in relation to the control of tick-borne diseases has generally taken the form of advice to vaccinate their animals. It is difficult to comment on the sources of information used by producers in northern Australia to assist them in their decision-making in relation to tick-borne disease, because the published reports are nearly 20 years old (18, 19). With the advent of the Internet and its increasing availability in rural areas in Australia, it is expected that the World Wide Web will become an important source. Surveys carried out in the late 1990s, before access to the Web was widespread, suggested that producers in the Australian tick-infested zone did not actively seek information to support their decisions on controlling tick-borne diseases. Where they did seek information, the primary source of advice was veterinary practitioners. In the case of beef producers, a rural newspaper was a secondary source. Most dairy producers surveyed in a 1998 study believed cattle ticks were not important in their own production system but were a problem for the dairy industry as a whole. Similar issues in relation to the perception of cattle producers of the individual and industry impacts of bovine virus diarrhoea have been found in Europe (20). Information provided to producers by animal health advisors, such as veterinary practitioners, has been more sophisticated, but generally without a specific economic component.

In terms of what has been achieved so far in relation to tick and tick-borne disease control in Australia, one of the main advances has been the development of vaccines, which developed from crude beginnings in the late 1800s to become more sophisticated in the mid to late 1900s (21). Today, they are extremely reliable and are available to producers in Australia through the government-owned Tick Fever Centre, which is based in Queensland.

Another of the key changes affecting the control of ticks and tick-borne disease has been the development of the biological concept of enzootic stability, which is used as a tool to estimate when vaccination may or may not be needed (14). It denotes a state in which the relationship between the host, agent, vector and environment is such that clinical disease occurs rarely or not at all. The concept has been applied to evaluate the susceptibility of a herd of cattle to tick-borne disease in Australia. The usefulness of endemic stability for supporting decisions on disease control has been challenged and it has been suggested that, in each system, empirical data are required on the occurrence of clinical disease, the genotype of the hosts and the specific pathogen under consideration (22).

Resistant cattle breeds, as referred to previously, are another important factor in the control of tick-borne disease, and they have become an integral part of the Australian northern cattle industry. Whether resistant to infestation or resistant to infection, these breeds have an important role to play in the control of tick-borne diseases, and their use has reduced the number of areas now affected by these diseases.

Finally, a bio-economic simulation model developed by Ramsay (23) and applied by Bock (24) has also contributed to control efforts by providing decision support for producers, but it has limitations and is not widely employed. The model was mostly used as suggested by McCown (25), where Bock acted as the intermediary and provided various scenarios and outcomes to the decision-makers. The

scenarios included biological and financial predictions for various disease and control scenarios, including estimates of the number of cases of disease (including deaths), the severity of those cases and a discounted cash flow. The simulation model allowed the resistance of cattle to disease to be varied and the incidence of transmission to be varied from year to year. The model was limited in that it only worked with one tick-borne disease at a time and not all three simultaneously. It was suggested by Bock (24) that decision support using the model outcomes to evaluate scenarios be provided to cattle producers as a paid service as part of the overall services provided by the Tick Fever Centre. While there was interest from some of the large-scale corporate producers, that interest was insufficient to maintain and update the model as needed.

Where to next for economics and tick-borne disease control in Australia?

The application of economics to animal health is assumed to provide support for producers' decisions. However, livestock producers do not always take account of economic analyses as they have other approaches they apply to enable them to make decisions; the approaches include 'rules of thumb' and heuristics, i.e. an approach based on learning from past experiences to improve the decisions made. As decisions become more complex and information to support the decision is limited, it is possible that producers' decisions are more likely to be based on their own judgement and be intuitive.

In animal health economics, analysis is often presented as an addition to or substitute for the producers' usual decision processes. However, the economic analysis of researchers and the intuitive approach of the producers are not aligned, resulting in the analysis not being used by the producer to inform their decisions. This situation has been referred to as the 'problem of implementation', with the lack of alignment referred to as the 'problematic socio-technical relationship between scientific models built to guide practice and actual practice' (26).

One approach to integrate the elements of a decision has been the development of computerised decision support systems (DSS). In work on the use of these systems by producers, it was found that many decisions made by producers are intuitive and that decision-makers have made limited use of computerised DSS (7, 27). However, benefits from this technology have been gained when the system is used to assist decision-makers to learn more about the potential outcomes of their decisions, as this enhances their intuitive decision-making capabilities (27). Others have found that DSS are difficult to target at producers and suggested they be focused on technical advisors who work with producers (28). The process used to engage and facilitate the learning of a decision-maker is different from that used to provide a substitute for the decision-maker's decision processes, but it is a way to produce alignment.

Taking a learning approach to enhance communication in economic advisory services has potential to overcome barriers between the advice provided and the producers' approaches to decision-making. In this approach, we need to understand the processes a livestock producer would use to evaluate their experiences and develop new understanding and knowledge over time as a result of these experiences. There is an extensive and diverse literature on experience and learning. This body of work can assist and, at times, confuse the reader seeking to understand the processes involved. In a simple form, learning has cognitive, emotional and social elements and how a person uses these three elements impacts on the learning that takes place (29). All three factors need to be considered in the provision of learning for livestock producers. For example, it is possible that presentation of a complex economic evaluation of a decision could provoke a negative emotional reaction in a producer, reducing the potential learning from the experience and application of the analysis. It is also possible that an activity with a positive social impact could stimulate learning from the experience.

Some developers of DSS have moved to the approach of working with producers to develop a collaborative learning approach as a form of action research (26, 30, 31). This is a multidirectional learning approach that enables producers to build on their knowledge to support their decisions. In this way, the producer controls the knowledge development so that it is aligned with their normal approach and the advisor does not need to have an exhaustive understanding of the producer's knowledge or learning processes. Consequently, the models and analysis produced provide an opportunity for the producer, in association with the advisor, to test scenarios and build their intuitive knowledge. It is important to have an approach in which both the producer and researcher are engaged in the development of knowledge. The approach has areas of commonality with Vickers' conception of appreciative systems, a formalised approach that links to intuitive decision processes (32, 33). In this context, the analytical process of economic analysis is important because it can provide experiences that can be used to assist producers to gain learning and expand their intuitive decision process. Other approaches that have been applied to establish communication and share information between analysts and producers include behavioural economics (34) and innovation systems (35), with social network analysis providing a means to assess the impacts (36). ■

Décisions relatives à la gestion des ectoparasites endémiques : le cas des tiques et des maladies transmises par les tiques dans le nord de l'Australie

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Résumé
Le contrôle des tiques et des maladies transmises par les tiques dans le nord de l'Australie est considéré comme une priorité économique, mais sa réussite est rendue difficile par les contraintes physiques et de production. Les décisions en matière de lutte contre les maladies transmises par les tiques ont été évaluées en recourant à diverses méthodes d'analyse, mais davantage dans le cadre de la recherche que pour soutenir directement les décisions des producteurs. Or, pour être efficaces, les conclusions d'une analyse économique doivent être appliquées par les décideurs. Pour ce faire, il faut que les décideurs et les analystes intègrent les principes d'une communication efficace dans leurs relations de travail. La mise en œuvre d'une démarche apprenante pour améliorer la communication dans le cadre des prestations de conseils économiques permet de résoudre les problèmes d'inadéquation entre le conseil fourni et les méthodes de prise de décision suivies par les éleveurs. Dans cette démarche, il s'agit de comprendre les processus suivis par un éleveur pour évaluer son expérience et pour élaborer une nouvelle vision et acquérir de nouvelles connaissances à la faveur de cette expérience. L'auteur examine la nature des décisions privées concernant la lutte contre les maladies transmises par les tiques ainsi que l'importance d'une approche apprenante pour qu'un véritable apprentissage ait lieu entre les éleveurs et leurs conseillers.

Mots-clés
Apprentissage – Australie – Communication – Décision – Économie de la santé animale – Maladie transmise par les tiques – Soutien à la décision.

Decisiones de control de ectoparásitos endémicos: el caso de las garrapatas y las enfermedades que transmiten en Australia septentrional

G.C. Ramsay

Resumen
Aunque se considera económicamente importante, la lucha contra las garrapatas y las enfermedades transmitidas por ellas en el septentrión australiano se ve complicada por las condiciones de producción y el entorno físico. Para evaluar las decisiones encaminadas a combatir esas enfermedades se han utilizado distintos métodos de análisis, pero más bien con fines de investigación que como elemento de apoyo directo a la adopción de decisiones sobre producción. Para que los resultados del análisis económico sean eficaces, es preciso que quienes toman decisiones los apliquen,

lo que a su vez exige que tanto quienes deciden como los analistas integren una comunicación eficaz como parte de su relación. El hecho de abordar la cuestión pensando en aprender cómo mejorar la comunicación que se establece en los servicios de asesoramiento económico abre la posibilidad de superar el desfase entre el asesoramiento ofrecido y la forma en que los productores adoptan decisiones. Para ello es menester los procesos que seguirá un productor ganadero para evaluar su experiencia y a partir de ahí, con el tiempo, ir ganando en comprensión y conocimiento. Tras estudiar la naturaleza de las decisiones privadas en todo lo tocante a la lucha contra las enfermedades transmitidas por garrapatas, el autor examina el uso de métodos de aprendizaje para lograr que entre los productores y sus asesores se genere una dinámica eficaz de aprendizaje.

Palabras clave
Apoyo a las decisiones – Aprendizaje – Australia – Comunicación – Decisión – Economía de la sanidad animal – Enfermedad transmitida por garrapatas.

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