live export

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Evaluation and cost/benefit analysis of Rhinogard® vaccine in preventing Bovine Respiratory Disease in export cattle

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TABLE OF CONTENTS

REVIEW OF THE LITERATURE 4

1. Bovine respiratory disease 4
1.1 General comments 4
1.2 The cause(s) of Bovine Respiratory Disease 4
1.3 BRD in the live cattle export trade 6

2. Bovine herpesvirus 1 7

3. The Rhinogard® vaccine 7

4. International best-practice in the use of respiratory vaccines 8
4.1 Overview 8
4.2 Underlying principle for best-practice 10
4.3 Using proven vaccines effectively 10
4.3.1 Using proven vaccines 10
4.3.2 Effective vaccine storage, handling and administration 11
4.4 Ensuring animals are capable of producing a protective immune response 11
4.4.1 Pre-arrival management 12
4.4.1.1 Assessing risk 12
4.4.1.2 Managing risk 12
4.4.2 Arrival management 13
4.4.2.1 Processing management 13
4.4.2.2 Feeding management 13
4.4.3 Post-arrival management 14

5. References 15

REVIEW OF THE LITERATURE

This review provides a brief overview of:

- bovine respiratory disease (BRD), including causes of this condition and the impact of this disease in Australia's live cattle export trade;
- bovine herpesvirus 1, an important contributor to BRD, and the virus associated with infectious bovine rhinotracheitis in cattle; and
- Rhinogard®, the first respiratory vaccine of cattle registered for use in Australia

The review also provides a brief summary of lessons learned from international best practice in the use of vaccines for BRD control.

1. Bovine respiratory disease

1.1 General comments

The bovine respiratory disease (BRD) complex is a general term referring to acute[1] respiratory disease of uncertain diagnosis in a group of cattle (Radostits et al., 2000). In the feedlot situation, BRD is most-frequently diagnosed in the first 6 weeks of the feeding period (Sullivan, 2000), and affected animals present with dyspnoea[2], coughing, nasal discharge, varying degrees of depression, inappetence to anorexia[3], fever, evidence of pneumonia, and a variable response to treatment (Radostits et al., 2000). Without treatment, complications can lead to high mortality rates.

In the US, the BRD complex is reportedly the most costly disease of beef cattle, with an annual loss from cattle deaths, treatment costs and loss of performance approaching US$1 billion (Griffin, 1997). Although BRD has traditionally been considered of lesser important in Australia, recent Australian feedlot studies have challenged this view (Dunn et al., 2000). In a study of six feedlots in eastern Australia during 1991-93, BRD was considered the cause of 53% of all feedlot deaths, with most BRD deaths occurring during the first 60 days on feed. Furthermore, fever-on-entry and BRD were the most frequently identified clinical syndromes accounting, respectively, for 24% and 22% of all cases of clinical disease during the period of interest. In a later MLA survey in 2001, bovine respiratory disease was rated by feedlot managers as the most important disease condition of feedlot cattle, particularly in medium and large feedlots (Meat and Livestock Australia, 2001b). Reflecting an increase since an earlier survey in 1991, BRD accounted for 64% of all morbidity and mortality in all surveyed feedlots.

1.2 The cause(s) of Bovine Respiratory Disease

Although the aetiology[4] of BRD is not completely-understood, it is known to be complex and multifactorial[5]. A range of respiratory pathogens, many of which are normal inhabitants of the upper bovine respiratory tract in health animals, play an important role in the development of BRD (Sullivan, 2000). In addition, compromise in the animal's normal defence mechanisms due to environmental, nutritional, physiological and management stresses is also critical

[1] Severe signs, short course. Blood, D. C. & Studdert, V. P. (1988). *Baillière's comprehensive veterinary dictionary*. Baillière Tindall, London.
[2] Laboured or difficult breathing. Ibid.
[3] Reduced or lack of appetite for food. Ibid.
[4] The causes of disease. Ibid.
[5] Arising from the action of many factors. Ibid.

(Sullivan, 2000). These stressors, which can occur prior to, during and following entry to the feedlot, are believed to be cumulative in their effect (Cusack, Sullivan & Nichols, 2001a). Together, these accumulated stresses result in alterations to normal respiratory defence mechanisms, allowing lung access to potential pathogens that normally reside in the upper respiratory tract (Sullivan, 2000).

At this point, it is important to have an understanding of both necessary and sufficient causes of disease. Some factors, particularly several of the microbial agents, are considered necessary causes of BRD, indicating that this disease complex will not occur unless these factors are present. However, these agents *on their own* will not produce BRD, and therefore are not a sufficient cause of disease (Martin, Meek & Willeberg, 1987). Following this logic, BRD develops as the result of the interplay between a range of microbial and non-microbial factors. It is important to note that the specific factors that lead to one outbreak may not be exactly the same as those leading to another. To illustrate, in one outbreak, the primary causes of BRD may include immunosuppression, the presence of *Pasteurella spp.* and environmental stress; whereas in another the causes could include environmental stresses, the presence of *Pasteurella spp.* and the presence of other viral agents (Martin et al., 1987).

A range of microbial agents, including viruses and bacteria, have been linked with BRD in cattle, including:

- *Bovine herpesvirus 1 (BHV-1).* Detailed information about BHV-1 is given below. Through a variety of factors, including compromise of the ciliary clearance of bacteria from the upper respiratory tract, BHV-1 infection can predispose to bacterial overgrowth and bacterial bronchopneumonia (Kapil & Basaraba, 1997). In a study of Australian feedlots (Dunn et al., 2000), BHV-1 infection alone, or in combination with bovine respiratory syncytial virus, was positively associated with illness due to BRD
- *Bovine pestivirus, also known as bovine viral diarrhoea (BVD) virus.* Most clinical disease associated with bovine pestivirus is a consequence of infection *in utero*[6], resulting in foetal death, various malformations, and persistently-infected (PI), specifically immuno-tolerant calves (Potgieter, 1997). As a consequence, in any feedlot situation, there is likely to be a small percentage of PI animals (approximately 1-2% of most young cattle groups) that act as an ongoing source of infection for other animals (Radostits et al., 2000). There is increasing evidence that pestivirus infection in susceptible animals can lead to broad-spectrum immuno-suppression in cattle, affecting both peripheral immunity and pulmonary resistance, and leading to respiratory disease involving other disease agents (Potgieter, 1997). Pestivirus may also play a role as a primary agent of mild respiratory tract disease (Potgieter, 1997). In the Australian study, there was rapid spread of pestivirus to susceptible animals in the study feedlots, with the number of susceptible (that is, not-yet-infected) animals falling from 32% at the time of entry to 10% at 6 weeks and 6% at the time of slaughter (Dunn et al., 2000). In some of the feedlots, there was a significant association between pestivirus infection and respiratory disease.
- *A range of other viral agents, including bovine respiratory syncytial virus, parainfluenza-3 and respiratory coronavirus.* A range of other viral agents, including bovine respiratory syncytial virus (BRSV), parainfluenza-3 (PI-3) and respiratory coronavirus, may also play a role in the development of BRD in cattle. In the US at least, BRSV is considered an important contributor to BRD. In the Australian feedlot study, an average 73% of animals were seronegative to BRSV on entry, falling to 31% and 29% at 6 weeks and slaughter, respectively (Dunn et al., 2000). An understanding of many aspects relating to BRSV, including persistence in cattle populations and the mechanism of disease production, is currently incomplete (Baker, Eliis & Clark, 1997). PI-3 is a frequent viral isolate from BRD cases, and may predispose animals to secondary bacterial pneumonia (Kapil & Basaraba, 1997). In the Australian feedlot study, the presence of antibody to this virus was very variable, with some intakes 100% seropositive, and others 100% seronegative at entry. On average, 22% of animals remained seronegative to PI-3 at 6 weeks and at slaughter. (Dunn et al., 2000). At this stage, the role of the respiratory coronaviruses is poorly understood (Kapil & Basaraba, 1997).

[6] Within the uterus. Ibid.

- *Bacterial pathogens, including* Mannheimia *(*Pasteurella) haemolytica A1, Pasteurella multocida *and* Haemophilus somnus. These organisms are all commensal[7] in clinically-normal feedlot-age cattle, particularly in the upper respiratory tract. Proliferation of these organisms in the lower respiratory tract can occur following viral infection, transportation, temperature extremes, processing, co-mingling, crowding and marketing (Mosier, 1997). In the Australian feedlot study, *Mannheimia/Pasteurella spp.* were isolated from 11% of all animals with clinical signs of BRD, and from 12% of all samples submitted from animals at post-mortem (Dunn et al., 2000).
- A range of factors, in addition to the microbial agents listed above, are also known risk factors for BRD in feedlots (Radostits et al., 2000). These include:
  - Age – with young growing cattle being more susceptible to disease than older cattle because of a lack of sufficient immunity
  - Multiple sources – cattle purchased from various sources and mingled in a feedlot are more likely to develop BRD than cattle from a single source. Co-mingling results in significant psychological stress as well as a source of viruses and bacteria for previously-unexposed animals (Cusack et al., 2001a).
  - Environmental stresses - rapid fluctuations in environmental temperature and humidity frequently precede BRD outbreaks
  - Ventilation - inadequate ventilation is a major predisposing cause of respiratory disease in housed cattle (and presumably also during live export)
  - Other stresses (including temporary deprivation of adequate food and water, rough handling, and long-distance transport) also contribute to the development of BRD

1.3 BRD in the live cattle export trade

Although respiratory disease has long been considered a disease-of-importance in the live cattle export trade, it is only recently that relevant quantitative information has become available. A detailed study, conducted by Richard Norris, Barry Richards and others (R. Norris, personal communications), has recently been completed to establish death rates and the cause of death in cattle exported by sea from Australia. During the period 1995 to 2000, the overall mortality rate in voyages to the Middle East was 0.52%, with the risk of death being three times higher for cattle exported from southern ports of Australia compared to northern ports. In four voyages to the Middle East that were intensively researched between December 1998 and April 2001, respiratory disease was found to be the third most-important cause of death, after heat stress and trauma. There were no deaths from respiratory disease in the first few days following embarkation, which the authors suggest may be because pre-embarkation stresses were minimal. An alternative view is that there is a time factor for accumulated stresses and virus spread before deaths (D. Pitt, personal communication). On these ships, most deaths from respiratory disease occurred towards the end of the voyage, with gross and histological findings typical of infection with *Mannheimia (Pasteurella) haemolytica* or *Pastereulla multocida.*

As discussed in the attached appendices, BRD is a particular problem in long-haul, southern-sourced ships carrying *Bos taurus* animals. Although BRD can occur in northern-sourced ships, it is rarely seen unless climatic conditions are extreme (R. Ainsworth, personal communication). These observations are supported by quantitative evidence, with mortality rates in northern-sourced cattle only one-third of those experienced on ships from southern ports (R. Norris, personal communication).

[7] Living within another organism, and deriving benefit without harming or benefiting the host individual. Ibid.

2. Bovine herpesvirus 1

Bovine herpesvirus 1 is an alphaherpesvirus (Radostits et al., 2000) associated with a diverse range of clinical signs, ranging from subclinical infection to a fulminating respiratory disease in cattle (Smith, Young & Mattick, 1991). The virus has a worldwide distribution, and is frequently found at relatively high prevalence in beef and dairy cattle herds. At six Australian feedlots during 1991-1993, 13% of cattle were seropositive to BHV-1 on entry, increasing to 39% and 76% of all animals by 6 weeks and at slaughter, respectively (Dunn et al., 2000). Based on anecdotal evidence, the percentage of animals seropositive to BHV-1 at time-of-entry to feedlots is higher in northern *Bos indicus* as compared to southern *Bos taurus* animals in Australia (N. Nichols, personal communication). As indicated previously, BHV-1 is an important contributor to the bovine respiratory disease complex in feedlot cattle, both as a primary pathogen (causing bovine infectious rhinotracheitis or IBR) and also as a predisposing factor for subsequent bacterial infection (Mahony et al., 2000).

BHV-1 shows considerable variation in virulence, and several viral subtypes have been identified using serology and restriction endonuclease analysis (Mahony et al., 2000; Smith, Young & Mattick, 1993). BHV-1.1 is the most virulent subtype, and has been associated with severe upper respiratory tract infection and abortion (Mahony et al., 2000), and increased levels of virus shedding (Smith, Young & Reed, 1995). Although the BHV-1.2 subtype can also cause severe respiratory disease, it is not associated with abortion in cattle (Mahony et al., 2000).

Although BHV-1 is internationally recognised as an important cause of respiratory disease in cattle, the geographic distribution of the BHV-1 subgroups is not uniform. In Europe and the US, IBR outbreaks in cattle can be both common and severe, and are generally associated with infection with BHV-1.1 (Smith et al., 1995). Although the UK was believed free of BHV-1.1 prior to 1977, a sudden increase in the incidence and severity of IBR in UK cattle in 1977 was probably associated with the introduction of BHV-1.1 in North American Holsteins (Smith et al., 1995). In contrast, based on detailed research by several groups (Brake & Studdert, 1985; Dunn et al., 2000; Smith et al., 1993; Smith et al., 1995), it is clear that BHV-1.1 is not present in Australia, with all known Australian isolates of BHV-1 belong to the BHV-1.2 subtype. These studies were undertaken using a large number of BHV-1 isolates collected since 1961 in Australia and New Zealand (Brake & Studdert, 1985; Smith et al., 1993), using isolates collected from several Australian feedlots experiencing increased incidence and severity of respiratory disease associated with BHV-1 infection in the early 1990s (Smith et al., 1995), and as part of a study in 1991-93 of diseases affecting cattle at six feedlots in eastern Australia (Dunn et al., 2000). As suggested by Smith and others (1995), import and quarantine restrictions play a critical role in preventing the introduction of BHV-1.1, and the economic consequences that would be concomitant with such an introduction.

3. The Rhinogard® vaccine

The Rhinogard® vaccine is a live, attenuated, intranasal vaccine that is registered with the National Registration Authority for use in cattle in Australia. It was developed on the basis of research conducted by QDPI scientists over a number of years. The seed stock for this vaccine is an Australian BHV-1.2 isolate, V155, which was collected from BHV-1 infected cattle in 1964 (Snowdon, 1965). The vaccine is not a recombinant vaccine (nor genetically modified, nor a GMO, or any other similar terminology vaccine) (P. Young, personal communication).

Extensive studies have shown that Rhinogard® is safe in cattle, including animals that are pregnant. Following vaccination, animals show very mild and transient clinical signs 3-4 days later (N. Nichols, personal communications) and will shed vaccinal virus for no greater than seven days from the time of administration (P. Young, personal communication). During this period, vaccinal virus could theoretically spread to non-vaccinated animals, but only if nose-to-nose contact was possible, or watering sources were shared (P. Young, personal

communications). On the basis of blinded, controlled and randomised trials conducted at commercial feedlot in northern NSW on seven different occasions, feedlot animals vaccinated with Rhinogard® had significantly greater daily weight gain (0.29 kg/day) and improved feed conversion (1.6 kg feed for each kg of weight gained) than placebo animals (Mahony et al., 2000), conferring a A$20 advantage for vaccinated animals compared with the placebos. These trials were conducted for a 30 day period, immediately following entry of cattle (N. Nichols, personal communication).

Several factors contribute to the safety and efficacy of Rhinogard®:

- The vaccine is based on a BHV-1.2 subtype, which is not associated with abortion in cattle. In safety studies involving pregnant cattle, the V155 isolate (and a thymidine kinase (TK) negative virus derived from it) was non-abortigenic and non-pathogenic to the dam (Young et al., 1994). Following intranasal administration, there is no viraemia, and only low levels of viral replication in the upper respiratory tract (P. Young, personal communication)
- Intra-nasal live vaccines give very rapid protection after a single dose. This occurs as a result of induced interferon production in the nasal mucosa and stimulated mucosal immunity (Mahony et al., 2000). In the US, where IBR vaccines are based on BHV-1.1 subtypes, the intranasal route of administration is also used to reduce the risk of abortion

At this stage, it is not known whether Rhinogard® would be protective against challenge with BHV-1.1, and trials to address this issue are likely to be undertaken in Canada during 2002. As a general principle, there is relatively little antigenic variation among closely related herpesviruses, which suggests that cross-protection is likely. For example, there are three recognisable sub-types of Marek's disease virus (another herpesvirus of animals), and there is consistent cross-protection. Also, the post-infection neutralising antibody of BHV-1.1 is indistinguishable from either BHV-1.2 or BHV-5 (previously known as encephalitogenic IBR), even though the restriction endonuclease profile of each is very distinctive (P. Young, personal communication).

Although live BHV-1 vaccines have been available for use in the US for almost 50 years (Smith et al., 1994), they have never been imported for commercial use in Australia. Because the US vaccines are based on the BHV-1.1 subtype, they have a tendency to cause abortion in pregnant cattle. Furthermore, due to virus shedding from vaccinated animals, spread of vaccinal virus to in-contact animals has led to abortion in unvaccinated dams (Smith et al., 1994). For these reasons, vaccine manufacturers in the US rarely recommend the use of live BHV-1 vaccines in this class of animal, or in calves nursing pregnant cows. Several live vaccines have been developed specifically for this class of animals, including TSV-2® which is an intranasally-administered modified-live vaccine for use in pregnant and lactating animals (Pfizer, 2002).

4. International best-practice in the use of respiratory vaccines

4.1 Overview

There has been little experience in the use of respiratory vaccines for cattle in Australia. Rhinogard® was first registered in November 2000, and is the only respiratory vaccine registered for use in cattle in this country. Other vaccines have registration pending or are undergoing detailed evaluation in the field, including vaccines against pestivirus and *Mannheimia haemolytica* (Cusack et al., 2001a). As a consequence, information about international best-practice is best obtained from overseas, and particularly from north America where respiratory vaccines have been available for some time.

As indicated previously, a range of respiratory vaccines are available for use with US cattle, and many are specifically marketed to control BRD in feedlot animals. Examples of US-registered vaccines are presented in Table 1.

Table 1. Examples of US-registered vaccines, produced by Merial (2002), Pfizer (2002) and Fort Dodge (J. Bell, personal communication)

Vaccine (manufacturer)	Disease agents	Type of vaccine	Administration	Manufacturer's comments
RESPISHIELD™ 4 (Merial)	BHV-1 BVDV PI-3 virus BRSV	Inactivated	im/sc, two doses 3-4 weeks apart	Protection for open or pregnant animals in feedlot situations
Triangle 3 (Fort Dodge)[a]	BHV-1 PI-3 virus	Inactivated	im/sc, two doses 2-4 weeks apart	
RELIANT® PLUS BVD-K (Merial)	BHV-1 BVDV PI-3 virus BRSV	Modified-live and killed IBR Modified-live BVD Modified-live PI-3 Inactivated BRSV	im/sc, single dose	Not recommended for use in pregnant animals or calves nursing pregnant cows
Bovi-shield 4 (Pfizer)	BHV-1 BVDV PI-3 virus BRSV	Modified-live	im, two doses 3-4 weeks apart	Not recommended for use in pregnant animals or calves nursing pregnant cows
TSV-2® (Pfizer)	BHV-1 PI-3 virus	Modified-live	Intranasal, at time of arrival	Safe for use in pregnant animals
Resvac® 4/ Somubac® (Pfizer)	BHV-1 BVD PI-3 virus BRSV *Haemophilus somnus*	Modified-live viral agents Inactivated *H. somnus* bacterin	im, two doses 2-4 weeks apart	Recommended for vaccination in healthy, non-pregnant animals

a Triangle 3 vaccine is often imported on demand for use in the Australian live cattle export industry (J. Bell, personal communication)

Although these and other respiratory vaccines available in north America are generally well-characterised under laboratory/experimental conditions, there are very few reports regarding their efficacy (to reduce overall treatment rates and/or increase weight gains) under scientifically-designed field trails (Radostits et al., 2000). Indeed, several highly-respected authors have expressed concern about the lack of rigorous data to support their widespread use in the industry (Martin, 1983; Radostits et al., 2000). Furthermore, several authors have highlighted difficulties (and potential solutions) associated with the design and implementation of trials to evaluate the efficacy of these vaccines, including Perino and Apley (1998) and Radostits and others (2000). A special report in the *Canadian Veterinary Journal* was devoted to this topic (Dohoo & Thomas, 1989; Martin, 1989), including a discussion on why this issue is proving so difficult to address (Wilson, 1989). It is noteworthy that the current efficacy data from the MLA-supported Rhinogard® trials is near-unique, because it provides compelling evidence from a rigorous field-based trial in support of economic benefit following respiratory vaccination (Mahony et al., 2000).

The following recommendations concerning best-practice, whilst widely accepted by feedlot veterinarians and operators in the US, have been devised based on anecdotal evidence of effectiveness. As indicated above, there is little, if any, published evidence, based on controlled field trials, as to whether these recommendations are justifiable (Radostits et al., 2000). Nonetheless, these recommendations have been widely adopted throughout the US, and other parts of north America. Findings from a large baseline study of the feedlot industry (USDA, 2000) have quantified the level of adoption of best-practice within this industry in 1999:

- 84.0% of large operations process all cattle within 24 hours of arrival
- 97.8% of feedlots use respiratory vaccines to control BRD

- 82.1% of large operations use an injectable antimicrobial at entry in 'high-risk' cattle
- 73.9% of large operations revaccinated animals against respiratory diseases within 30 days of entry
- 69.1% of feedlots recorded disease events either always or most of the time
- All large operations and 96.5% of smaller operations used the services of a veterinarian

At this point, it is important to note that the Australian feedlot industry operates under a National Feedlot Accreditation Scheme (NFAS), which is based on the principles of ISO 9000 quality systems management. The NFAS is principally about product integrity, and all accredited feedlots (which currently number over 665) have important compliance responsibilities (R. Sewell, personal communication). Although the industry does not have a specific code of best practice relating to vaccination (or many other routine management practices), experience from the Australian feedlot industry with respect to non-respiratory vaccination will provide important lessons the live cattle export trade with respect to respiratory vaccination.

4.2 Underlying principle for best-practice

Sound immunity is only possible following vaccination if an effective vaccine is used with animals that are capable of producing a protective immune response. For this reason, it is accepted that vaccination can only be effective if part of a broader animal health approach to bovine respiratory disease. The animal health program must include the effective administration of proven vaccines, as well as strategies to reduce immune-suppressing stressors prior to, on-entry and following entry to the feedlot (Cusack et al., 2001a).

4.3 Using proven vaccines effectively

4.3.1 Using proven vaccines

As indicated previously, there is little field-based evidence to support the efficacy of many US-registered vaccines. This issue is now well-recognised by all sectors in north America, and steps are currently being taken to obtain rigorous evidence of vaccine efficacy from field-based studies. It is critical that Australia learn from this experience.

As indicated previously, there remains considerable uncertainty about many aspects of BRD, including the interrelationship and relative importance of the various infectious agents implicated in BRD. Although knowledge of BRD is currently imperfect, there are certain to be advances in this field as a result of ongoing research throughout the world. It is important, at any point in time, that the industry has a sound understanding of current best-international practice regarding BRD prevention.

Implications for industry best-practice in the live cattle export trade:

- *The industry should take the necessary steps to gain and disseminate ongoing and up-to-date information about advances in BRD prevention*
- *The Australian live export industry should only use vaccines with proven efficacy and economic benefit*
- *Trials to assess the efficacy and economic benefit of respiratory vaccines should be conducted in the field using international best-practice. The trials should be undertaken such that the cost-effectiveness of vaccination is assessed against commercially-important outcomes, including weight gain and morbidity (using unambiguous and clearly-defined case definitions) during defined periods following entry to the trade*

4.3.2 Effective vaccine storage, handling and administration

Improper storage and handling will each affect the effectiveness of vaccines (Roth & Perino, 1998), particularly those based on a modified-live agent. For this reason, it is critical that vaccines are stored and handled according to the manufacturer's recommendations. These recommendations will vary depending on the vaccine involved.

Although it is difficult to generalise, given the diversity of vaccines available (at least in the US), when allowed by label instructions parenterally-administered vaccines should generally be given subcutaneously using an 18-gauge needle of no greater than 2.5 cm in length. Needles should be changed when they become dull, barbed or bent, and a clean needle should be used when changing the vaccine bottle to avoid potential contamination. Although a new needle for each animal would prevent the potential transmission of infectious agents, this has proved impractical at most Australian feedlots (R. Sewell, personal communication). Adequate restraint and sanitation both assist in minimising injection site injury and/or reaction. Producers and feedlot operators are certain to be less familiar with intranasally-administered vaccines, and for this reason it is important that the manufacturer's recommendations are studied in detail. Training sessions for key personnel can assist in this regard. With Rhinogard®, vaccine is administered using the Power Doser (Genesis Industries (Aust) Pty, Ltd, Mudgee, Australia), which utilises novel technology to accurately deliver a defined volume into the nose under pressure. The manufacturer's recommendation should also be followed during cleaning of delivery equipment. In general, equipment must be cleaned and rinsed to ensure that disinfection does not come into contact with vaccine (Roth & Perino, 1998).

The timing and frequency of vaccination should also be conducted according to the manufacturer's recommendations. Although recommendations will vary depending on the vaccine involved, it is often recommended that feeder cattle should be vaccinated with respiratory vaccines within 24 hours of arrival in a feedlot (Hartwig & Hauptmeier, 1995). Generally, the choice of vaccine is determined by the class of cattle involved and their perceived level of BRD risk (as discussed below). In many feedlots, as discussed below, animals are assigned to one of three risk management categories at time of entry to a feedlot according to their risk of developing BRD (Lechtenberg, Smith & Stokka, 1998). If a killed vaccine has been used, a second dose of vaccine may be recommended 3-4 weeks later.

Implications for best-practice in the live cattle export trade:

- *Vaccines must be stored, handled and administered according to the recommendations of the manufacturer. If this is not done, the efficacy of the vaccine may be reduced*

4.4 Ensuring animals are capable of producing a protective immune response

As illustrated in Table 2, animals are exposed to a range of 'stressors' prior to entry, on entry and after entry into a feedlot. These 'stressors' are believed to reduce an animal's ability to withstand challenge from a variety of infectious agents (Cusack et al., 2001a), and therefore it is critical that a broad animal health approach to bovine respiratory disease should concentrate on minimising these stressors.

Table 2. Stressors that may affect cattle prior to entry, on entry, and after entry to a feedlot (Cusack et al., 2001a)

Stressors prior to entry into a feedlot	Stressors on entry to a feedlot	Stressors after entry to a feedlot
Weaning	Handling	Pen 'add-ons'
Transport	Co-mingling	Pen movements
Dehydration	Pen density	Changing pen
Co-mingling	Total pen numbers	Mixing already-established cattle
Injury	Competition	Handling for drafting and weighing
Saleyards	Weather extremes (heat and cold)	Ration changes and bunk management
	Dust	
	Injury	
	Adaption to feed and water	
	Dehorning	

Broader animal health approaches to bovine respiratory disease can be considered in terms of pre-arrival, arrival and post-arrival management.

4.4.1 Pre-arrival management

4.4.1.1 Assessing risk

In the international feedlot industry, it is now an accepted practice to accurately assess the likely BRD risk of incoming cattle. Animals are generally assigned to one of three or four risk management categories based on previously-listed risk factors for BRD, including the presentation of the animals on arrival, whether the animals have come directly from the property-of-origin, and whether the animals have been recently-exposed to a stressful event, including weaning (Pfizer, 2002). Differing levels of disease risk are then taken into account when designing processing programs for individual groups of cattle (Lechtenberg et al., 1998).

4.4.1.2 Managing risk

- A number of strategies have been adopted by some sections of the feedlot industry to manage BRD risk posed by 'pre-arrival stressors'. These include:
- *Preconditioning,* which seeks to assist calves to make an easier transition from the property-of-origin to the feedlot. Although a number of principles are involved, the broad approach is that calves are vaccinated and prepared for feedlotting at the property-of-origin for a period of approximately 45 days prior to entry to the feedlot. While theoretically sound, based on data currently available, preconditioning is difficult to justify economically. Further studies are needed to quantify the economic advantages of preconditioning (Radostits, Leslie & Fetrow, 1994)
- *Backgrounding*, where recently-weaned cattle are grown to yearling feeder cattle weight, usually in a smaller feedlot (Radostits et al., 1994). It involves the practices of yard weaning, exposure of cattle to feedbunks and troughs, co-mingling with cattle from different origins to establish social structure, castration and dehorning and treatment with relevant vaccines (George & Cusack, 2001). Backgrounding can be considered a variation of preconditioning. Based on Australian data, backgrounding is justifiable with backgrounded cattle experiencing significant reductions in numbers of cattle pulled for treatment versus freshly weaned and saleyard cattle (George & Cusack, 2001)
- *Avoiding high-risk animals.* Young animals, animals weaned immediately prior to entry to a feedlot, and animals that have come via a saleyard are all known to be at increased risk of developing BRD in feedlots. If commercially achievable, exclusion of these animals will

reduce subsequent BRD problems. In the feedlot industry, a number of operators no longer source animals through saleyards (Cusack et al., 2001a)

- *Minimising stressors during transport.* Prolonged transportation can lead to substantial dehydration of young cattle, and increase risks of injury. For example, 24 hours in a moving truck can result in 8.9% shrinkage (George & Cusack, 2001). Dehydration in association with other stressors of prolonged transport (changing climatic conditions, mixing with unfamiliar cattle) will also adversely affect immune function. Recommendations to minimise stress to animals during transport have been considered in detail by the Standing Committee on Agriculture and Resource Management (Standing Committee on Agriculture and Resource Management, 1999)

Implications for best-practice in the live cattle export trade:

- *A number of strategies are used by the feedlot industry to minimise pre-arrival stressors. Although preconditioning and backgrounding may not neither practical nor economic in the live cattle export trade, opportunities are available during cattle selection and transportation to minimise many of the stressors relating to the pre-arrival period*

4.4.2 Arrival management

Key aspects relating to arrival management include processing and feeding management (Lechtenberg et al., 1998).

4.4.2.1 Processing management

There are a wide variety of vaccines, implants and parasiticides used during processing on-arrival at a feedlot. Consultant veterinarians would make recommendations of an appropriate processing program based on an understanding of the class of cattle, region, season and past history (Lechtenberg et al., 1998). Only key issues will be raised here, because a discussion of all possible combinations would be of limited value.

a. Vaccination

Further to earlier comments, in the US both viral and bacterial respiratory vaccines are used. The four common viral antigens include IBR, PI-3, pestivirus (bovine viral diarrhoea virus, BVD virus) and BRSV. Viral vaccines are available as killed virus, modified-live virus, and a combination of both (Lechtenberg et al., 1998), and can be given as an injectable product or via intranasal administration. In contrast, bacterial vaccination is primarily used in lightweight calves to protect against disease caused by *Mannheimia haemolytica, Pasteurella multocida* and *P. somnus.* These latter vaccines are called whole-cell bacterins, and may include both somatic antigen and a toxoid fraction (Lechtenberg et al., 1998).

Recommendations regarding timing and frequency of vaccination will vary between vaccines, although a common recommendation is that feeder cattle are vaccinated within 24 hours of arrival (Hartwig & Hauptmeier, 1995). If a killed vaccine has been used, a second dose of vaccine may be recommended 3-4 weeks later. The choice of vaccine is determined by the class of cattle involved and their perceived level of risk.

b. Antimicrobial treatment

Mass medication of cattle on-arrival is frequently used to reduce the likelihood of BRD in animals classified as high-risk. Criteria to assess BRD risk on entry have been discussed previously. The route of administration and type of product are dependent on the anticipated severity of respiratory disease (Lechtenberg et al., 1998).

4.4.2.2 Feeding management

On-arrival, most incoming cattle are beginning to lose weight and normal grazing patterns have been substantially disturbed. Therefore, during the early period of feedlotting, the goals of feeding management are to stop weight loss, restore normal intake behaviour, steadily

increase dry matter and energy intake, and develop (high energy) fermentation capacity (George & Cusack, 2001). This is best-achieved by encouraging a steady increase in dry matter intake and gradual feed changes. Expert nutritional input would be required if problems were encountered. George and others (2001) recommend the regular evaluation of faecal texture as a guide to feed management

In the feedlot industry, animals are grouped into lots following initial processing. At this time, co-mingling can result in significant psychological stress for animals, and can also provide a source of viruses and bacteria (Cusack et al., 2001a). If the population subsequently remains stable, the stresses of repeated co-mingling can be largely avoided, and stable eating and drinking behaviour are established. If, however, there is further disruption to the population, particularly early in the feeding period, it can result in further additional stresses. For this reason, 'add-ons' (the addition of newly-introduced animals to an established pen) are avoided where possible.

Implications for best-practice in the live cattle export trade:

- *There is an expanding body of knowledge and literature concerning effective management of feedlots under Australian conditions. For example, a recent MLA publication (Meat and Livestock Australia, 2001a) describes best-practice for animal health in Australian feedlots during the first 40 days on feed. This knowledge is transferable, with some adaption, to the live cattle export trade*

4.4.3 Post-arrival management

Although not directly related to best-practice in vaccine use, the development of processes to recognise and manage animals that develop BRD are critical aspects of an effective health management system in the post-arrival period (Lechtenberg et al., 1998). Key aspects include effective pen-riding and hospital programs. In a feedlot situation, pen riders play a key role in identifying animals with early signs of BRD, thereby allowing effective early treatment. Hospital programs rely on early treatment and non-competitive hospital environments (Cusack et al., 2001a).

Relevant to all phases of feedlotting, the broad animal health program should include a functioning recording system (Lechtenberg et al., 1998). Through the ongoing collection of targeted data, it is possible to calculate defined health indices, as well as information to resolve management and epidemiological questions. Important measures of disease occurrence include morbidity and mortality rates categorised by cause, treatment and re-treatment rates by cause, and rates of disease resulting in salvage. Using these data, it is possible to assess problems and progress (Cusack, Sullivan & Nichols, 2001b; Lechtenberg et al., 1998).

Implications for best-practice in the live cattle export trade:

- *Aspects of best-practice post-arrival management in Australian feedlots will be practical and economic within the live cattle export trade.*
- *As part of the industry's Shipboard Program, there is now a detailed system of reporting and feedback to enable ongoing improvement to the health and welfare of cattle during shipping. This is achieved through daily and overall reports, which are produced by Accredited Stockmen who have received training under the Program (Anon., 2001). With limited changes and additions, the Program could be extended to include pre-embarkation feedlots. With linkages between feedlot and ship, it would be possible to identify feedlot practices that contribute to (or detract from) cattle health and welfare on ship.*
- *The current Shipboard Program offers a vehicle to enable continuous improvement in practices at pre-embarkation feedlots. Based on experience from existing pre-embarkation feedlots and from best-practice in cattle feedlots, it would be possible to design training programs that are appropriate for personnel at pre-embarkation feedlots.*

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