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Associations between animal characteristic and environmental risk factors and bovine respiratory disease in Australian feedlot cattle

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ABSTRACT

A prospective longitudinal study was conducted in a population of Australian feedlot cattle to assess associations between animal characteristic and environmental risk factors and risk of bovine respiratory disease (BRD). Animal characteristics were recorded at induction, when animals were individually identified and enrolled into study cohorts (comprising animals in a feedlot pen). Environmental risk factors included the year and season of induction, source region and feedlot region and summary variables describing weather during the first week of follow-up. In total, 35,131 animals inducted into 170 cohorts within 14 feedlots were included in statistical analyses. Causal diagrams were used to inform model building and multilevel mixed effects logistic regression models were fitted within the Bayesian framework.

Breed, induction weight and season of induction were significantly and strongly associated with risk of BRD. Compared to Angus cattle, Herefords were at markedly increased risk (OR: 2.0, 95% credible interval: 1.5–2.6) and tropically adapted breeds and their crosses were at markedly reduced risk (OR: 0.5, 95% credible interval: 0.3–0.7) of developing BRD. Risk of BRD declined with increased induction weight, with cattle in the heaviest weight category (≥480 kg) at moderately reduced risk compared to cattle weighing <400 kg at induction (OR: 0.6, 95% credible interval: 0.5–0.7). Animals inducted into feedlots during summer (OR: 2.4, 95% credible interval: 1.4–3.8) and autumn (OR: 2.1, 95% credible interval: 1.2–3.2) were at markedly increased risk compared to animals inducted during spring. Knowledge of these risk factors may be useful in predicting BRD risk for incoming groups of cattle in Australian feedlots. This would then provide the opportunity for feedlot managers to tailor management strategies for specific subsets of animals according to predicted BRD risk.

1. Introduction

Bovine respiratory disease (BRD) comprises a complex of diseases affecting the respiratory system of cattle and is the the major cause of clinical disease and death in Australian feedlot cattle (Sackett et al., 2006). BRD has a multifactorial aetiology, with component proximal causes consisting of a combination of respiratory pathogens, physiological stress and immunologically susceptible animals. Animal characteristic and environmental risk factors may directly or indirectly impact these proximal causes of BRD to influence risk of BRD.

Several animal characteristics have been associated with increased risk of BRD, including breed, with the Hereford breed consistently associated with increased risk (Cusack et al., 2007; Hägglund et al., 2007; Snowder et al., 2006a), sex, typically with higher risk in steers (Alexander et al., 1989; Cernicchiaro et al., 2012a; Cernicchiaro et al., 2012b; Sanderson et al., 2008; Snowder et al., 2006b), and bodyweight, with lighter animals being at higher risk (Cernicchiaro et al., 2012a; Reinhardt et al., 2009; Sanderson et al., 2008; Snowder et al., 2006b). The influence of age was assessed in a bull testing facility population; younger age at arrival was associated with fever (used as a proxy for BRD) after adjusting for weight (Townsend et al., 1989). Dentition may be used as

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a proxy for age, but is of limited value in some feedlot cattle populations because the majority of animals do not have permanent incisors at feedlot entry. In one Australian study, dentition was not associated with BRD risk (Dunn et al., 1995).

Environmental risk factors have also been associated with risk of BRD. Source region and feedlot region have been linked to BRD incidence (Cernicchiaro et al., 2012b). Variation in BRD incidence with the year and season of feedlot entry have been described in several studies (Cernicchiaro et al., 2012a, 2012b; Martin et al., 1988; Snowder et al., 2006b). Increased risk of BRD in the autumn and summer has been reported in large North American studies (Cernicchiaro et al., 2012b, 2012c), but univariable associations between arrival quarter and cohort-level BRD incidence did not persist in multivariable models in another study (Sanderson et al., 2008). A nationwide stratified random sample of French cattle herds found that herd-level BRD incidence was highest during winter (Gay and Barnouin, 2009). Anecdotally reports from feedlot managers and consulting veterinarians have suggested a seasonal association with BRD incidence in Australia, although this association was not supported by one published study (Dunn et al., 1995). 'Season' is likely to be a proxy for several undefined risk factors which may vary in different locations, such as weather conditions. Associations between weather variables and BRD have been reported. In one Australian study, a moderate correlation between minimum daily temperature and occurrence of BRD was noted after accounting for serial correlation of temperature between days (Cusack et al., 2007). In a large North American study, the lagged effects of several weather variables were significantly associated with BRD risk and a number of interactions between weather variables and between weather variables and demographic variables were reported (Cernicchiaro et al., 2012a).

Limitations in the published research assessing animal characteristic and environmental risk factors for BRD may arise from using single feedlot populations, narrow weight or age ranges, limited duration of feedlot entry or limited geographical areas. For example, the intake of younger and lighter weight cattle typically peaks in autumn (fall) in North American feedlots (Taylor et al., 2010). Hence, studies investigating the effects of season may be confounded by animal characteristics in some populations. Findings about environmental risk factors may not be generalisable to populations in other geographical locations. Whilst studies utilising large datasets are useful in assessing the effects of exposures at the pen or cohort level, the use of aggregated data may also result in limitations such as ecological fallacy.

In Australia, cattle of differing breeds sourced from a wide geographical area enter feedlots with varying environmental conditions, year round and at a range of weights and ages (Gaughin and Sullivan, 2014). In capturing animal-level data from this heterogeneous population, the National Bovine Respiratory Disease Initiative (NBRDI) was well placed to address many of the limitations of previous research (Hay et al., 2014). The project aimed to identify and quantify the effects of putative risk factors on the occurrence of BRD in Australian feedlot cattle. The current study aims to investigate the roles of animal characteristic and environmental risk factors in the occurrence of BRD in the NBRDI project population.

2. Materials and methods

2.1. Study procedure, study population and case definition

The NBRDI study design and study population have been described elsewhere (Hay et al., 2014). Induction refers to processing or preparing the animal for placement 'on feed' (i.e., being fed a full feedlot ration in a feedlot pen) at the feedlot. At induction, each study animal was identified and detailed data were recorded, including identification numbers, induction date, sex, breed, dentition (i.e., number of permanent incisors) and induction weight. Other data were recorded for groups or cohorts (i.e., pens) of cattle (e.g., 'intended days on feed'). Data were supplied as electronic files.

Each animal's induction date was defined as 'day 0'. Data detailing animal-level lifetime movement history were obtained from the National Livestock Identification System (NLIS) database and used to derive variables describing group structure at time points of interest prior to day 0 (Hay et al., 2014). Thus, the group that an animal was part of 13 days prior to induction ('group-13') was determined from the property (i.e., farm) identification code (PIC) recorded in the NLIS data, where animals in the same group-13 later joined the same study cohort. Similarly, group-28 defined the group an animal was part of 28 days before induction where animals in the same group-28 later joined the same cohort.

In total, 35,160 cattle were enrolled into study cohorts from March 2009 to December 2011, of which 35,131 animals, those with sufficient data for inclusion in the analyses, comprised the project population. The project population had a nested hierarchical structure with animals clustered within 1077 group-13s clustered within 170 cohorts clustered within 14 feedlots.

Each animal was monitored from induction until it left the study cohort for any reason (i.e., removal to the hospital pen or another pen separate from the cohort, death or feedlot exit). Further data were supplied for animals that were hospitalised or died during the observation period; data from hospitalised animals were used to derive the case definition as described elsewhere (Hay et al., 2014). Briefly, all animals with diagnoses indicating respiratory system involvement at first examination in the hospital crush (i.e., "pneumonia", "respiratory", "BRD" and "IBR" (infectious bovine rhinotracheitis)) were classified as BRD cases and the outcome of interest was the development of BRD during the animal's first 50 days following induction. Animals that were initially diagnosed with another condition and subsequently developed BRD were retained in the study but not classified as having developed BRD as their management following the initial diagnosis differed from the management of those remaining in the study cohorts; the stress from being moved to a hospital pen, and exposure to diseased animals from other pens in the hospital pen may have markedly increased their risk of acquiring BRD. The unit of analysis was the individual animal.

2.2. Exposure variables

Animal-level data recorded at induction were used to derive categorical variables describing animal characteristics, with definitions of categories based on prior hypotheses and distributions of the data. 'Breed category' consisted of seven categories. Breeds with sufficient numbers adequately distributed across feedlots were retained as separate categories (e.g., "Hereford"), but those with more limited distributions were combined. Tropically adapted breeds or crosses were those with a *Bos taurus indicus* or a *Bos taurus africanus* component breed, animals classified as European/European crosses mainly comprised Charolais and Charolais crosses, but also Simmental and other European breeds or crosses. British breed crosses comprised only crosses between British breeds. 'Sex' comprised two categories (steer/heifer); there were no bulls in the population. 'Dentition', comprising three categories ('0', '2', '4 or 6' permanent incisors),was used as a crude estimate of age in the full project population because the ages of cattle at induction were unknown.

Continuous predictors were categorised to avoid incorrectly assuming linearity of associations with the logit of BRD by day 50. Thus, 'Induction weight' (body weight at induction), was described

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