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Reproductive performance of northern Australia beef herds. 8. Impact of rainfall and wild dog control on percentage fetal and calf loss

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Abstract

Context. Dingoes and hybrid domestic dogs (wild dogs) are lethally managed, principally by large-scale baiting programs, to protect Australia's AU$11.4 billion beef cattle industry from predation. This strategy is promoted by pest management agencies as best practice.

Aim. To investigate the impact of baiting frequency and rainfall on percentage fetal and calf loss.

Methods. Using 64 property-years of data from 31 properties located across Queensland and the Northern Territory, 14 171 mating outcomes were investigated to assess whether annual rainfall, relative to 124-year mean annual rainfall, and the frequency that wild dogs were lethally controlled on each property, influenced predicted fetal and calf loss.

Key results. No effect of baiting frequency on fetal and calf loss in mature cows was observed. Predicted fetal and calf loss was significantly higher in dry and very wet years than in moderate-rainfall years ($P < 0.001$). Losses were observed to be higher in first-lactation cows when baiting was either: not conducted, conducted every 2–5 years or several times per year ($P < 0.05$) when compared with baiting annually, suggesting that factors other than baiting frequency are likely to have a stronger impact on calf loss.

Conclusions. Only limited empirical evidence was found to support lethal control. Further investigations may clarify whether the calves of first-lactation cows experience increased predation risk and whether the effect that dry conditions have on cow nutrition, milk supply and, consequently, the vigour of the cow and calf, may also increase predation risk.

Implications. Lethal control of wild dogs to protect calves is mostly unnecessary.

Keywords: calf loss, *Canis lupus*, dingo, lethal control, predator, rainfall, 1080.

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Introduction

Livestock grazing is the principal land use conducted on 88% of Australia's agricultural land. Beef cattle production is the largest of the livestock industries, returning AU$11.4 billion annually to the Australian economy (ABARES 2018). Since European settlement, dingoes (*Canus lupus dingo*) and domestic dog (*C. l. familiaris*) hybrids (referred to as 'wild dogs' hereafter) have been regarded as serious predators of livestock, principally of sheep but also of beef cattle calves. Wild dogs were first declared as pests under legislation in 1852 (Government NSW 1852) and all states except Tasmania and Northern Territory have legislation making wild dog control compulsory for owners and managers of land. Conventional 'best-practice' control, promoted to be the most efficient method for landholders to comply with the legislation, is to lay 1080-poisoned (fluoroacetate) bait (Fleming *et al*. 2001, 2006).

The perceptions of beef producers towards wild dogs and wild dog control vary greatly (Breckwoldt 1988). Beef producers are often ambivalent and sometimes 'vehemently opposed to compulsory baiting' (Anon 1904). Scientists now recognise that wild dogs can have positive (Johnson *et al*. 2007), neutral (Eldridge *et al*. 2002; Campbell *et al*. 2019), negative (Fleming and Korn 1989) or variable (Allen 2014, 2015) impacts on livestock and the agro-environment. However, typically, community dialogue regarding wild dogs suggests that their impact is mostly negative and substantial. Estimates of economic loss are often subjective, based on landholder surveys (Hewitt 2009) and reflect popular perceptions, or are extrapolations from first-hand accounts of predated cattle (McLeod 2004; Rural Management Partners 2004; Gong *et al*. 2009). In a comprehensive review of reproductive-performance studies examining the cause of calf loss between pregnancy diagnosis and weaning, 40–50% of peri- and post-natal calf losses were attributed to 'unknown causes' (Fordyce *et al*. 2006; Burns *et al*. 2010). The extensive nature of beef cattle properties makes it impossible to monitor cattle daily and verify the cause of death of every calf. The experimental procedures used and the diagnosed causes of calf loss reported may be insensitive to detecting predation, and it is possible that predation loss could be occurring at times but concealed within 'unknown causes'. Nutritional effects, disease, heat stress and dehydration, dystocia, mismothering, misadventure, vitamin and mineral deficiencies, physical traits and abnormalities of the dam or calf, maternal behaviour of the dam and some management practices, all contribute to calf loss (Burns *et al*. 2010). Predation is seldom discovered or reported to be a cause of calf loss in these studies.

Manipulative studies investigating calf loss between pregnancy diagnosis and weaning in cattle pastured in paired areas subjected to annual (or semi-annual) baiting compared with cattle pastured in nil-treatment areas, likewise, show no significant calf-loss differences in most years (Allen 2014; Campbell *et al*. 2019). However, up to 30% greater calf loss attributed to predation was discovered in occasional site-years (Allen 2014). In the study of Allen (2014), a 7% greater mean calf loss was correlated with below-average rainfall years where baiting had occurred. Short-lived and variable efficacy of baiting programs, changes to the age structure and group sizes of wild dogs in baited areas subsequent to baiting and the predicted impact that baiting has on predator–prey relationships are proposed as explanations for variable calf loss (Allen 2015). Alternatively, where elevated calf losses cannot be explained by infectious disease, animal, environmental and management influences are thought to combine to either reduce the milk available for neo-natal calves or reduce the ability of the calf to access milk (Fordyce *et al*. 2015).

The present paper further investigates the hypothesis that control of wild dogs using lethal baits has no impact on fetal and calf loss. The research is reported as part of a series from a large population-based epidemiological study involving 78 commercial beef herds across northern Australia that were monitored between 2007 and 2011 (McGowan *et al*. 2014). Fordyce *et al*. (2020) previously reported major risk factors affecting fetal and calf loss in the present study. This included 5% greater mean calf loss where managers who thought wild dogs caused significant calf loss and controlled them using lethal baits than with those owners who did not think wild dogs were a problem and did nothing to control them. The paper further explores the lethal management of wild dogs on calf loss.

Materials and methods

Ethics

The University of Queensland Animal Ethics Committee approved the conduct of this research per certificates SVS/756/08/MLA and SVS/729/07/MLA.

Environment, cattle and management

McCosker *et al*. (2020) have provided a detailed description. In summary, the research was conducted in environments in which four major country types were distinguished. The fertile soil areas in central and south-eastern Queensland were differentiated into those predominated by eucalypts (Southern Forest) and *Acacia* spp. (Central Forest). In northern and western areas, treeless black-soil grasslands (Northern Downs) were differentiated from forested areas with low-fertility soils (Northern Forest). Most rain falls and grass grows from December through to March; 80% of the region receives less than 600 mm of rainfall annually (Anon 2014; McCosker *et al*. 2020). Annual average evaporation exceeds 2 m and is double this in some situations. In the present study, 80% of cattle were at least 50% *Bos indicus*, with mature cow liveweight in the vicinity of 500 kg (McGowan *et al*. 2014). Low-input ('extensive') management is a feature of beef production in northern Australia. Cattle diets are almost exclusively pasture. Stocking rates are low and in some areas are as low as one cow per 150 ha (Tothill and Gillies 1992). Management groups of 300–1000 cattle are common. The majority of cows are continuously mated, with peak calving occurring late in the calendar year. Seasonal mating is usually between 3 and 7 months where suitable bull-control infrastructure is available; 37% of properties (farms) mate continuously. Cattle handling for husbandry is infrequent and occurs typically twice annually, in April–July and August–September (Bortolussi *et al*. 2005*b*). Mustering using aircraft and on-ground vehicle support is used on 51% of properties.

A subset of 31 properties was selected for the study, located across Queensland and Northern Territory and within known wild dog distributions (Fig. 1). The study covered 64 property-years, 10 294 cattle and 14 171 mating outcomes.

Rainfall

Monthly rainfall totals from January 1889 up until late 2013 for the latitude and longitude location of each property were obtained from www.longpaddock.qld.gov.au (verified 10 January 2014), from which mean monthly rainfall and mean (1 July to 30 June) annual rainfall were calculated. Because most of northern Australia has a defined summer rainfall season and most calves are born in late spring and summer (Bortolussi *et al*. 2005*a*), July–June annual rainfall figures are considered more appropriate than are calendar year rainfall totals. The 124-year annual rainfall totals were ranked into 10 decile groups. The rainfall total for each property-year was assigned its decile rank; for example, a decile rank of '1' was assigned when the annual July to June rainfall for that year and location was in the lowest 10% of historical rainfall records, and a decile ranking of '5' or '6', just below and just above the

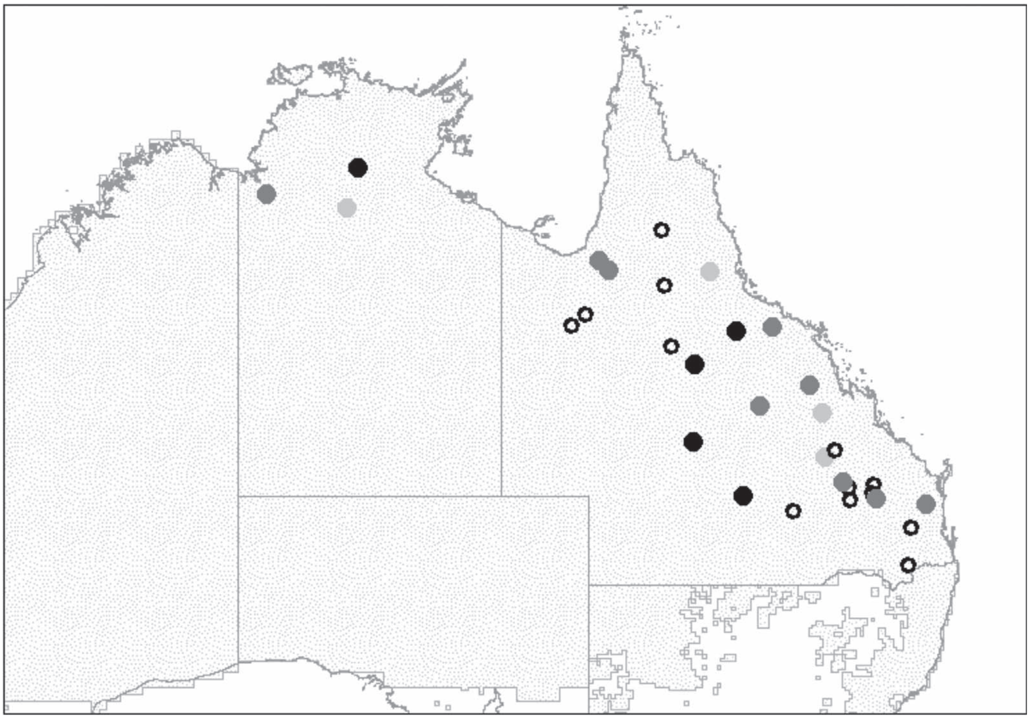

Fig. 1. Location of the 31 study properties relative to the 2012 distribution of wild dogs across northern Australia (from Fleming *et al*. 2014). The frequency of wild dog lethal baiting during the present study is shown: no record of baiting (hollow symbols); bait every 2–5 years (light grey symbols); annual baiting (dark grey symbols); and twice or more annual baiting (black symbols).

Table 1. Frequency distributions of baiting frequency and rainfall decile category for northern Australian beef properties studied between 2008 and 2010

Frequency distribution of baiting frequency is given by number of properties, whereas that for rainfall deciles is given by number of property-years

Risk factor and level	Number of properties/property-years	Number of mating outcomes		
		Total	First lactation	Mature
	Baiting frequency			
No record	13	5774	781	4993
Every 2–5 years	4	1852	52	1800
Annually	9	3495	720	2775
Twice or more annually	5	3050	890	2160
	Rainfall (deciles)			
Dry (1–4)	6	883	139	744
Moderate (5–7)	29	6684	993	5691
Wet (8–9)	15	3484	867	2617
Very wet (10)	14	3120	444	2676

long-term median rainfall total, indicated 'average' rainfall conditions. Because there were few dry years relative to long-term rainfall records between 2008 and 2010 and many very wet years (Table 1), rainfall deciles 1–4 were pooled as 'dry', deciles 5–7 pooled as moderate, 8 and 9 pooled as wet, and 10 as very wet seasonal conditions.

Cow measurements

Cows were individually identified using National Livestock Identification System (NLIS; www.nlis.com.au; verified 18 October 2020) tags. NLIS tags were replaced if the tag was missing or was present but could not be read. In the event of an NLIS tag being replaced, data linkages to previous performance records were often able to be established as study animals were individually identifiable by a separate visual identification tag.

Pregnant animals were identified and fetal age was determined by rectal palpation by persons whose fetal ageing was known to be accurate, including accredited veterinarians (National Pregnancy Diagnosis Scheme, Australian Cattle Veterinarians) in four consecutive years (2008–2011) at or near the last annual weaning muster in June–October. Breed and age were recorded. At each muster for branding, weaning and pregnancy diagnoses in the year following confirmed pregnancy, lactation status and body condition score were assessed. These data were used to derive the mating outcome for each animal for each year. Females were recorded as having experienced fetal and calf loss if they were recorded as not lactating at the first muster after the expected calving date (as calculated from fetal ageing and using a gestation period of 285 days), if this muster occurred more than 1 month after calving and they were not subsequently recorded as lactating. Cows lactating after their expected calving date were recorded as not experiencing fetal and calf loss.

Frequency of lethal bait use

The quantity and type of bait used and the date of each baiting program for the decade until 2008–2009 for each of the cooperating properties was retrieved from a database maintained by the Queensland government. After 2009–2010, authorised bait (1080) distributors, who were required to maintain these records for 3 years within their regions, were individually solicited for the baiting histories of each property. The baiting history of each property was categorised as follows: baits several times per year; baits annually; baits biannually; baits once in 5 years; or, no record of baiting. The Northern Territory government provided baiting histories of three study properties located in that precinct. Because the number of property-years where baiting had occurred once in 5 years or biannually ($n = 6$) was low, these were pooled.

Statistical analyses

A causal diagram was developed linking risk factors for fetal and calf losses identified in previous analyses of data from the large project (Fordyce *et al*. 2020), and the two additional putative risk factors, rainfall and baiting frequency, with each other and the occurrence of fetal and calf loss (Fig. 2). This diagram was used to identify variables to be included in models to appropriately control for confounding to estimate the total effects of rainfall and baiting frequency on fetal and calf loss. Total effect estimates were of primary interest as they represent the expected effect on the outcome if that variable were changed, assuming the relationship is truly causal. One two-way interaction term (cow age class and baiting frequency) was proposed *a priori* by the research team as calves of inexperienced dams could be considered to be more vulnerable to predation. Three separate random-effects logistic regression models were fitted, one for each risk factor and a third that incorporated the interaction term. Property was fitted as the random effect and the unit of analysis was the mating

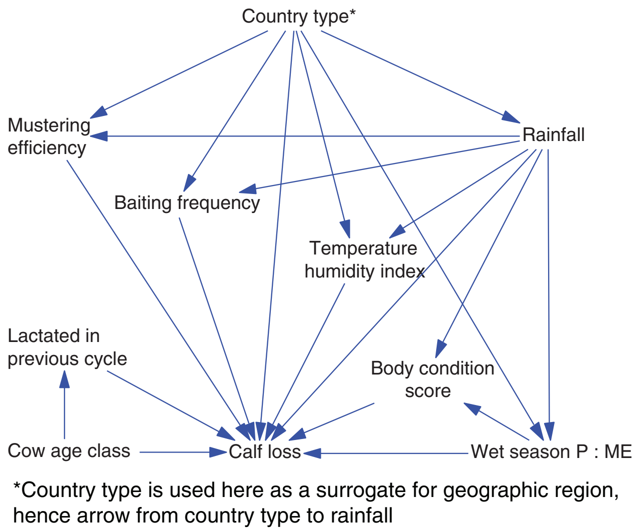

Fig. 2. Causal diagram linking risk factors for reproductive losses identified in previous analyses of data from the large project (Fordyce *et al*. 2020), and the two additional putative risk factors, rainfall and baiting frequency, with each other and the occurrence of reproductive loss. Wet season P : ME, ratio of wet-season faecal phosphorus to dietary metabolisable energy as estimated by near-infrared spectrometry.

outcome (measured once per year per cow). Stata 13 (Stata Statistical Software, Stata Corporation, College Station, TX, USA) was used for data management and statistical analyses.

Results

The overall crude incidence risk of fetal and calf loss was 11.5% (1630/14 171). Seasonal conditions were generally good during the study years, with more than 90% of the 64 property-years having a decile 5 or higher rainfall total (Table 1). Predicted fetal and calf loss was significantly higher in dry and very wet years than in moderate-rainfall years ($P < 0.001$; Table 2).

Sodium fluoroacetate (1080) in 9380 kg of meat and 1036 single-dose Doggone baits were distributed on baited properties in the study, between 2008 and 2010. Thirteen (42%) properties had no record of baiting. Annual baiting was undertaken on nine properties, whereas baiting every 2–5 years, or at least twice annually, was less common (Table 1). Crude incidence risk of fetal and calf loss was lowest on properties with no record of baiting (9.1%) compared with properties that were baited annually or more frequently (10.3% and 12.1% respectively). Greatest losses occurred on properties that had been baited once every 2–5 years (20.4%). There was strong evidence of an interaction between cow age class and baiting frequency. Total-effect estimates, adjusted for confounding by rainfall and country type, suggested that baiting frequency had no effect on mean calf loss in mature cows; however, effect estimates are imprecise, so a definitive conclusion cannot be reached. However, predicted loss was 12% higher from first-lactation cows when baiting was not conducted, 11% higher when conducted twice annually and 32% higher when

Table 2. Estimated odds ratios for the total effects of rainfall, and baiting frequency within cow age class and associated predicted mean reproductive loss percentages

Odds ratios for baiting frequency are presented within cow age class, with no record as the reference group; these odds ratios cannot be compared between age classes. Overall Wald *P*-values are shown in bold, individual Wald *P*-values are not bolded. For rainfall (deciles), covariate is country type. For cow age class, covariates are country type and rainfall

Risk factor and level	Baiting frequency	Odds ratio (95%CI)	*P*-value	Mean loss % (95%CI)
Rainfall (deciles)			**<0.001**	
Dry (1–4)		2.5 (1.8–3.5)	<0.001	17.9 (11.8–24.0)
Moderate (5–7)		Reference		7.9 (5.5–10.4)
Wet (8–9)		1.1 (0.8–1.3)	0.695	8.3 (5.5–11.1)
Very wet (10)		1.4 (1.2–1.6)	<0.001	10.7 (7.4–13.9)
Cow age class			**<0.001**	
First-lactation	No record	Reference		21.7 (12.5–31.0)
	Every 2–5 years	2.6 (0.7–9.5)	0.153	41.8 (13.6–69.9)
	Annually	0.4 (0.2–1.0)	0.046	10.2 (4.0–16.5)
	Twice or more annually	1.0 (0.4–2.7)	0.975	21.4 (7.4–35.5)
Mature	No record	Reference		9.6 (5.2–13.9)
	Every 2–5 years	1.4 (0.5–4.0)	0.580	12.6 (2.3–22.8)
	Annually	0.8 (0.4–1.9)	0.688	8.2 (3.4–13.1)
	Twice or more annually	0.6 (0.2–1.6)	0.286	5.8 (1.2–10.3)

conducted every 2–5 years than with annual baiting ($P < 0.05$; Table 2).

Discussion

In the present study, dry years were associated with greater fetal and calf loss. Rainfall and pasture growth affect prey numbers and the prey species available to wild dogs (Dickman *et al*. 1999; Letnic *et al*. 2005; Letnic and Dickman 2006), which, in turn, appears to influence calf predation (Allen 2014). It is unclear whether the effect reported here was mediated by dog and prey population dynamics, as the earlier report by (Fordyce *et al*. 2020) showed that factors associated with poorer nutrition for cows may mediate higher calf loss through reduced milk delivery to neonates. These alternative explanations are not mutually exclusive. Predators are attuned to recognising signs of weakness and vulnerability in prey and seize on these opportunities (Rankine and Donaldson 1968; Tizard 2008). Calves, weakened by dehydration, malnutrition or disease or calves of inexperienced or weak cows (i.e. conditions consistent with dry seasonal conditions), are more likely to be attacked. Because annual rainfall was generally above average during the study, mean calf loss on this subset of properties (11.5%) might understate the losses otherwise expected, had more dry years occurred.

Higher fetal and calf loss associated with very wet years is more likely to be a function of direct effects on cows and calves rather than an effect on preferred prey populations, in comparison to prey populations in moderate rainfall years; for example, wet weather may cause hypothermia in calves, and may reduce milk yields through disruption of cows grazing.

Adjusted for the effects of rainfall, baiting frequency did not appear to influence the fetal and calf loss in mature cows. Neither did increasing the frequency of baiting consistently reduce the fetal and calf loss in cows in their first lactation. This suggests that factors other than, or in addition to, baiting frequency or predation could be involved. How first-lactation cows are managed, whether they are pastured separately or mixed with mature cattle, may influence the anti-predator behaviour of first-lactation cows in response to wild dogs, especially in the first days and weeks after calving when most losses occur (Bunter *et al*. 2014). Biannual and more frequent baiting has previously been shown to facilitate re-colonisation and be associated with a greater calf loss, with the latter being due to functional differences in predator–prey relationships caused by lethal control (Allen 2015). However, the effect was not substantiated by the results from the present study.

Diet studies into what wild dogs consume (Brook and Kutt 2011; Allen *et al*. 2012) have shown that macropods, introduced pests and feral livestock, that is, animals that compete with cattle for pastures, form a significant proportion of the prey that wild dogs consume. Modelling studies (Wicks and Allen 2012; Choquenot and Forsyth 2013; Prowse *et al*. 2015) evaluating the economic cost–benefits of wild dogs limiting or regulating macropod and pest populations (Newsome *et al*. 1989; Newsome 1990; Pople *et al*. 2000, 2010; Letnic and Crowther 2013), versus preying on beef cattle calves, have indicated that wild dogs are best be left unmanaged in most scenarios. Data from the present large study provided no convincing evidence to the contrary.

There are two important limitations to these analyses. First, baiting frequency was a property-level variable. Results from the main study showed that fetal and calf loss was clustered by property (intra-class correlation coefficient: 0.18; McGowan *et al*. 2014). This means that two mating outcomes within a property are more likely to be similar than two randomly selected mating outcomes from the whole dataset. Consequently, the power of the study, with only 31 properties, to identify property-level risk factors was much lower than power to detect risk factors at lower levels (e.g. at the animal level or mating-outcome level). Where effect estimates are imprecise and the point estimate not close to one, it should be acknowledged that an association may exist, but could not be identified given the constraints of the current study. Furthermore, the small number of mating outcomes for first-lactation cows resulted in imprecise estimates for the effect of baiting frequency on fetal and calf loss for this age class. The second limitation was the partial mismatch between the outcome variable used in the analysis, fetal and calf loss, and the outcome in the hypothesis that would ideally have been tested, calf loss. In the present study, it was not possible to distinguish between prenatal loss and post-natal calf loss. However, it is likely that any possible predation or baiting frequency effect is likely to be greater on post-natal calf loss than on prenatal loss and any effect on the former would then be attenuated by including the latter within the positive outcome category.

The conclusion from the present research is that there remains only limited empirical evidence to support the lethal control of wild dogs to reduce calf loss in beef cattle herds.

Conflicts of interest

The authors declare no conflicts of interest.

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