Journal of Mammalogy, 98(1):45–52, 2017
DOI:10.1093/jmammal/gyw156

Cattle mortality on a predator-friendly station in central Australia

Arian D. Wallach,* Daniel Ramp, and Adam J. O'Neill

Centre for Compassionate Conservation, School of Life Sciences, University of Technology Sydney, P.O. Box 123, Broadway, New South Wales 2007, Australia (ADW, DR)
Dingo for Biodiversity Project, P.O. Box 156, Mount Perry, Queensland 4671, Australia (ADW, AJO)
School of Environment, Charles Darwin University, Ellengowan Drive, Casuarina, Northern Territory 0810, Australia (ADW)

* *Correspondent: arian.wallach@uts.edu.au*

Large predators are declining worldwide primarily due to hunting and persecution by humans, driven in large part by the livestock industry. Some ranchers are transitioning to "predator-friendly" farming by adopting nonlethal predator deterrents. On very large rangeland properties, such as the vast stations of the Australian arid zone, ending lethal control may in itself reduce livestock losses by enabling the predator's social structure to stabilize. The dingo (*Canis dingo*), Australia's apex predator, is commonly subjected to eradication campaigns to protect livestock. We analyzed causes of cattle (*Bos taurus*) deaths on Evelyn Downs, a 2,300-km^2 predator-friendly station in central Australia, for 2 years after dingo protection was established. Husbandry-related challenges, associated with deteriorating environmental conditions, were the leading causes of deaths of cattle. Predation by dingoes was minor and declined as the indices of dingo abundance stabilized and social stability increased. Shifting from killing predators to improving husbandry standards is likely to improve livestock survival and welfare.

Key words: 1080, dingo, human–wildlife conflict, livestock, poison-baiting

Improving the environmental and ethical standards of meat production is a major challenge, particularly as meat consumption increases worldwide. Much of the earth's land area is used for livestock grazing, and pastoralists (farmers) frequently come into conflict with wildlife (Machovina et al. 2015). One major change required for the improvement of the pastoral industry is to increase tolerance towards rangeland predators. Poisoning, shooting, and trapping of predators are common industry practices to protect livestock and are significant threats to this imperiled and ecologically important group of species (Ripple et al. 2014). Promoting nonlethal—"predator-friendly"—pastoral practices has the potential to improve both animal welfare and environmental outcomes across large regions of terrestrial landscapes (Johnson and Wallach, in press).

In Australia, dingoes (*Canis dingo*—Crowther et al. 2014) are subjected to intensive culling operations that aim to reduce predation on sheep and calves. Several local, State, and Territory governments encourage killing, by declaring dingoes "pest" species and by offering bounties, collected with scalps that can be worth over AU$100 (about US$70; Fig. 1). In some regions, landholders are legally obligated to control dingoes (New South Wales Government 2015). Dingoes are routinely shot and trapped on pastoral stations, but the main killing method is poison-baiting with sodium fluoroacetate (1080; Fig. 1). The poison is used across the country and is often subsidized for farmers as part of drought relief packages (Department of Agriculture and Fisheries 2015).

Poisoning with 1080 causes severe animal welfare harms (Sherley 2007) and is driving biodiversity declines (Wallach et al. 2010; Colman et al. 2014). As the largest mammalian terrestrial predator in Australia, dingoes perform key ecological functions as apex predators. They limit the densities and affect the behavior of wild herbivores such as kangaroos (*Macropus*) and goats (*Capra hircus*), which enables more productive and diverse vegetation communities, and they also suppress mesopredator populations such as red foxes (*Vulpes vulpes*) and cats (*Felis catus*), thereby reducing predation pressure on smaller prey animals (Wallach et al. 2010; Letnic et al. 2012; Colman et al. 2014). The persecution of dingoes, driven largely by the pastoral industry, is a major cause of Australia's wave of mammalian extinctions (Johnson et al. 2007). The persistence of many of Australia's fauna and flora species depends on the function of dingo populations (Letnic et al. 2009).

Fig. 1.—Dingoes (*Canis dingo*) are persecuted across Australia, primarily with poison-baiting (left panel), and they are also shot and scalped for bounties—and then displayed (right panel). Images from July 2015, highway in Boulia, Queensland. Photos by Arian D. Wallach.

One of the most significant welfare and ecological impacts of killing socially complex species, such as dingoes, is the disruption of their social groups (Haber 1996; Bryan et al. 2015). Dingoes live in extended families led by a single breeding pair. Packs act cooperatively to hold large territories, hunt, and rear offspring. The impact of lethal control extends beyond the individuals directly killed, harming surviving family members, and changing population structure and ecological function (Wallach et al. 2015). Importantly, killing of dingoes is often an ineffective and counterproductive approach to reducing livestock predation (Allen 2014). The breakdown of dingo social groups acts primarily to increase reproductive rates and immigration, due to the loss of reproductive suppression and territorial boundaries (Wallach et al. 2009). Under these conditions, all females can reproduce, primiparity tends to occur earlier, and dingoes can more easily immigrate into vacant territories (Wallach et al. 2015). Lethal control can therefore cause increases in both dingo population density (Wallach et al. 2009) and predation rates on livestock (Allen 2014).

Some Australian pastoralists are transitioning to predator-friendly management by adopting nonlethal deterrents, such as guardian dogs (van Bommel and Johnson 2012). These methods are highly successful in small- to medium-sized properties but are less suitable for very large properties. Seventy percent of the continent is arid and semiarid, and as productivity declines, "farms" and "ranches"—measured in acres and hectares—give way to "stations"—measured in thousands of square kilometers. These large stations have the advantage that they encompass several dingo territories (typically 50–100 km^2—Thomson 1992). Thus, the simple act of ending lethal control can, at this scale, reduce depredation by enabling the establishment of a socially stable population.

Here, we report on the causes of cattle (*Bos taurus*) deaths during the 2 years we (AJO and ADW) managed a large predator-friendly cattle station in central Australia. We hypothesized that protecting dingoes would increase their social stability and would not cause an increase in depredation of cattle. We tested this by recording the causes of cattle deaths and analyzing patterns of mortality in relation to ecological and management variables that were likely to affect dingo predation and cattle condition.

Materials and Methods

Study site.—Evelyn Downs is a 2,300-km^2 cattle station in northern South Australia. Although this is a large landholding, many Australian stations are even larger due to the relative low productivity of the area. This arid region receives on average 150 mm of rainfall annually, but during the study period, rainfall only averaged 9.4 mm/month. Two rainfall peaks occur each year, in summer and in early winter. Temperatures in summer (November–February) sometimes exceed 45°C.

There were 40 main water sources situated approximately 10 km apart across the station. Most were man-made and included semi-permanent rain-filled dams and permanent bores (wells) that were manually pumped with generators into tanks and troughs. Most of the station is a complex of mesas, escarpments, and gibber plains (desert pavement) dominated by chenopod shrublands and tall *Acacia* woodland, with *Eucalyptus* species along ephemeral creeks. The station grazed approximately 1,200 Poll Hereford cattle.

Dingoes were persecuted intensively up until the late 1980s when Evelyn Downs was a sheep station. Killing subsided but continued regularly after the station transitioned to cattle production. The last poison-baiting operation occurred in 2007, when the station acquired organic certification, and killing of dingoes declined significantly from that time but did not end completely. Killing dingoes is an ingrained practice among station workers and can take time and effort to stop, particularly because it can be difficult to patrol human activity across these vast stations. Against station policy, dingoes were killed sporadically until 2012, according to surveys and discussions with station personnel. For example, in 2011, a dingo was found shot, and in 2012, station workers chased a dingo pack and captured a pup which was taken as a pet.

The recovery of dingoes commenced in earnest in October 2012 when we (AJO and ADW) assumed management. During our nearly 2-year tenure (September 2012–August 2014), dingoes were proactively protected in 2 main ways: station visitors and employees were prohibited from killing wildlife and carrying guns (commercial kangaroo shooters were excluded from the station) and we maintained water sources (bores), which were operational even if cattle were not using them, to enable dingoes uninterrupted access to water. During our tenure, we found no evidence to suggest that dingoes were killed or harassed by humans.

Data collection.—Deaths of cows were identified as part of standard station activities, which included extensive daily drives both on and off station tracks (approximately 5 h were travelled daily on average). Carcasses were usually found within days of death, but a small number were found 3–4 weeks after death. We assessed the cause of death and recorded the location and size class of the dead animal as either "calf" (< 9 months old), "adult"—including grown steers (castrated males), heifers (young females), and cows (mature females)—or "bull" (mature intact males). Carcasses were left where they were found.

We grouped all apparent causes of deaths into 4 categories: dingo predation, husbandry, natural, and unknown. Husbandry causes included all cases in which direct or indirect human action led to death, such as drying of dams. Natural causes included a range of circumstances, such as qualitatively assessed heat stress and illness ("poor condition"), as well as fights between bulls. Dingo predation was identifiable by the occurrence of dingo tracks at the remains, as well as conditions of torn and stretched calf hide. Calves eaten by dingoes were recorded as "dingo predation" although some may have died of other causes and been scavenged. The cause of death for orphaned or separated calves was classed together with the cause of death or separation from their mothers.

We measured 7 variables that may have contributed to deaths of cattle: index of dingo abundance, index of dingo social stability, predator-friendly tenure (time since dingo protection commenced), index of abundance of wild prey, rainfall (3-month totals), cattle density at water sources, and vegetation cover. We considered all variables as potentially explaining dingo predation rates, while only the last 3 were included as contributors to deaths due to husbandry or natural causes. The first 3 variables (index of dingo abundance, index of dingo social stability, predator-friendly tenure) reflect conditions and impacts on the dingoes; the 4th variable (wild prey abundance) was included because it could influence dingo prey choice; and the last 3 variables (rainfall, cattle density at water sources, and vegetation cover) affect the condition of the cattle.

Abundance indices of dingoes and wild prey, and measures of vegetation cover, were monitored before and during the period we managed the station: in April 2012, April 2013, November 2013, and April 2014. We established 30 permanent monitoring transects, positioned across the station, > 2 km apart, both on and off road, with a passive track survey method adapted from Wallach et al. (2010). At least 20 of the transects were surveyed at each monitoring session. Each transect was a stretch of earth 500 m long by 1 m wide, cleared of tracks with a metal plate dragged behind a slow-moving quadbike. Each day for 3 days we examined tracks on the transect and counted the number and identified the species of animal crossings, which gave an average abundance index value of number of track crossings along 500 m/day. All wild mammals known to be prey of dingoes (kangaroos; rabbits, *Oryctolagus cuniculus*; donkeys, *Equus asinus*; horses, *E. caballus*; and small mammals such as rodents) were combined into a single prey biomass variable by multiplying the abundance index of each species by its average body mass (obtained from the Encyclopedia of Life website).

Vegetation cover and diversity were measured along ten 10-m plant transects running parallel to and 2 m away from each of the 500-m-long passive animal track transects. We did not measure vegetation > 2 m tall, as it was too high for most browsing animals. Each set of 10 plant transects was averaged for each animal track transect. Plant species were identified, but we used percentage vegetation cover in our analyses because all other variables (e.g., diversity, richness) were strongly correlated with each other and with cover (Wallach et al. 2010).

Dingo social stability was assessed based on scent-marking rates at water sources (Wallach et al. 2009). Dingo scats, urine, and ground rakings are signs of scent-marking and have a wide range of communication purposes, including pack composition and territorial boundaries. In the Australian arid zone, dingoes place scats at distinct focal points such as water sources, animal warrens, and carcasses; but they do this primarily when they are socially stable (Wallach et al. 2009). Scent-marking does not reflect abundance, as dingoes subjected to poison-baiting tend not to leave scats at focal points, even when they are in high abundance. Instead, dingo scat deposits at focal points increase in number the longer an area is allowed to recover from control. Thus, scent-marking rates provide a reliable index of social stability (Wallach et al. 2009). We surveyed dingo scent-marking rates by counting the total number of accumulated dingo scats around water sources approximately every 6 months.

Data on stock composition (calves, adults, and bulls) were taken from the September 2013 muster (roundup) records. Most (probably 75–90%) of the cattle herd were accounted for during the muster. Stocking rates (number of cattle on station) remained relatively constant during the study, but localized density changed as water sources filled and dried up, which could influence mortality rates. We counted the number of cattle at each water source each month. There were no internal fences within Evelyn Downs, apart from 2 holding paddocks, and cattle could move freely between watering sources. However, cattle movement was predictable and groups tended to remain stably concentrated at each watering source, apart from during brief high-rainfall events. We were therefore able to provide a relatively accurate monthly count of cattle numbers at each water source by direct observation.

We compiled monthly records of cattle deaths, cattle density at waters, and rainfall. For variables recorded less frequently (e.g., wild animal abundance measured every 6 months), we generated monthly data by calculating the monthly change between surveys, assuming a linear trend (by dividing the difference between the 2 data points by the number of months between them).

Analysis.—To test the relative strength and direction of each predictive variable on predation, husbandry, and natural deaths, we generated 3 Poisson generalized linear models. The 7 predictive variables were first checked for colinearity, which reduced the number included in the model to 4: dingo social stability, vegetation, rainfall, and cattle density at waters. The variables vegetation, rainfall, and cattle density at waters were included for the models that explained mortality classed as husbandry and natural causes. The model explaining dingo predation was reduced to the variables index of dingo social stability, rainfall, and cattle density at waters. Each variable was standardized to have a mean of 0 and a *SD* of 1. The variables were further reduced using a backwards selection process to select the most parsimonious model with the lowest Akaike Information Criterion. All analyses were conducted in R version 3.1.3 (R Core Team 2015).

Results

During the 2-year study, we recorded 56 deaths of cattle (mean of 2.6 deaths recorded per month). Husbandry problems caused the highest number of deaths ($n = 25$ cases, 45% of all deaths), followed by natural causes ($n = 10$, 18%) and dingo predation ($n = 8$, 14%). The rest ($n = 13$, 23%) were of unknown causes. The most common cause of death ($n = 18$, 32% of total, and 72% of husbandry-caused deaths) was the drying of mud-silted dams (Fig. 2A), causing cattle to get bogged in mud and die of heat stress and dehydration when attempting to access water. One calf killed by dingoes after its mother died in a silted dam was included in the "husbandry" category (orphaned or separated). Most deaths classed as natural causes were of cattle previously observed to be in "poor condition" (including half of all deaths of bulls), followed by calves that were orphaned or abandoned (Fig. 2A).

Most deaths occurred during dry months (Fig. 2B), except for dingo predation, which was concentrated at the beginning of the study (Fig. 2B). Six of the 8 dingo-caused deaths occurred during the first 6 months of the 2-year predator-friendly regime (Fig. 2B), and all were deaths of calves. The 2013 muster records were comprised of 259 calves within a total of 903 cattle mustered. Of these, dingo predation (4 per year averaged) accounted for 1.5% of calves, or 0.4% of the entire herd.

The index of dingo abundance was stable and the index of social stability increased under predator-friendly management (Fig. 3). The decline in dingo predation was best explained by the increasing scent-marking rates (index of dingo social stability), explaining 36% of the variation of predation rates (Table 1). Husbandry deaths were associated primarily with declining rainfall, as well as declining vegetation and increasing cattle densities at water sources, which together explained 45.8% of the variation for this mortality cause. Natural deaths were best explained by cattle densities at water sources, explaining 27.5% of the variation (Table 1).

Discussion

The cessation of dingo persecution on Evelyn Downs did not result in high or increasing predation rates, which is in line with our prediction. Instead, most recorded predation events (6 of 8 calves killed) occurred during the early stages of the dingo's recovery, and subsided after 6 months, as the index of dingo social stability increased. The index of dingo abundance was stable during the study and did not explain predation rates. The main cause of deaths of cattle during the study was the drying of silted dams (Fig. 4). Husbandry-related deaths were concentrated in dry times, were 3 times more common than recorded predation by dingoes, and affected all size classes including valuable breeding cows and a stud bull. Deaths classed as "natural" were not unrelated to husbandry and were best explained by cattle densities at water sources. Half of the recorded deaths of stud bulls were caused by "poor condition." The bulls may have been less resilient to this environment because, unlike the rest of the herd, they were born and raised in milder climates and selected primarily for reproductive and growth rates.

Dingoes were known to kill only calves. Calf carcasses may have been less visible to us than those of adults and bulls because of their smaller size and the ability of dingoes to consume more of the carcass. It is therefore possible that we under-recorded predation compared to husbandry and natural deaths. However, this is unlikely to be a significant bias in our data, because most recorded deaths of calves were caused by problems unrelated to dingoes, and because we were able to detect relatively high predation rates at the onset of the study. Therefore, we conclude that while opportunistic sightings of dead cattle of different causes and sizes are not fully comparable, the patterns are informative. In addition, this is the type of information available to most cattle producers and will be the basis for informing their perceptions of mortality.

Our results are in line with other studies around the world that show that killing predators for livestock protection is generally unnecessary and counterproductive. For example, McManus et al. (2014) found a 70% decline in predation rates and operating costs per sheep during 2 years of predator-friendly farming in South Africa, regardless of the nonlethal method adopted. In North America, wolf depredation on cattle and sheep increased by 4–6% the year following

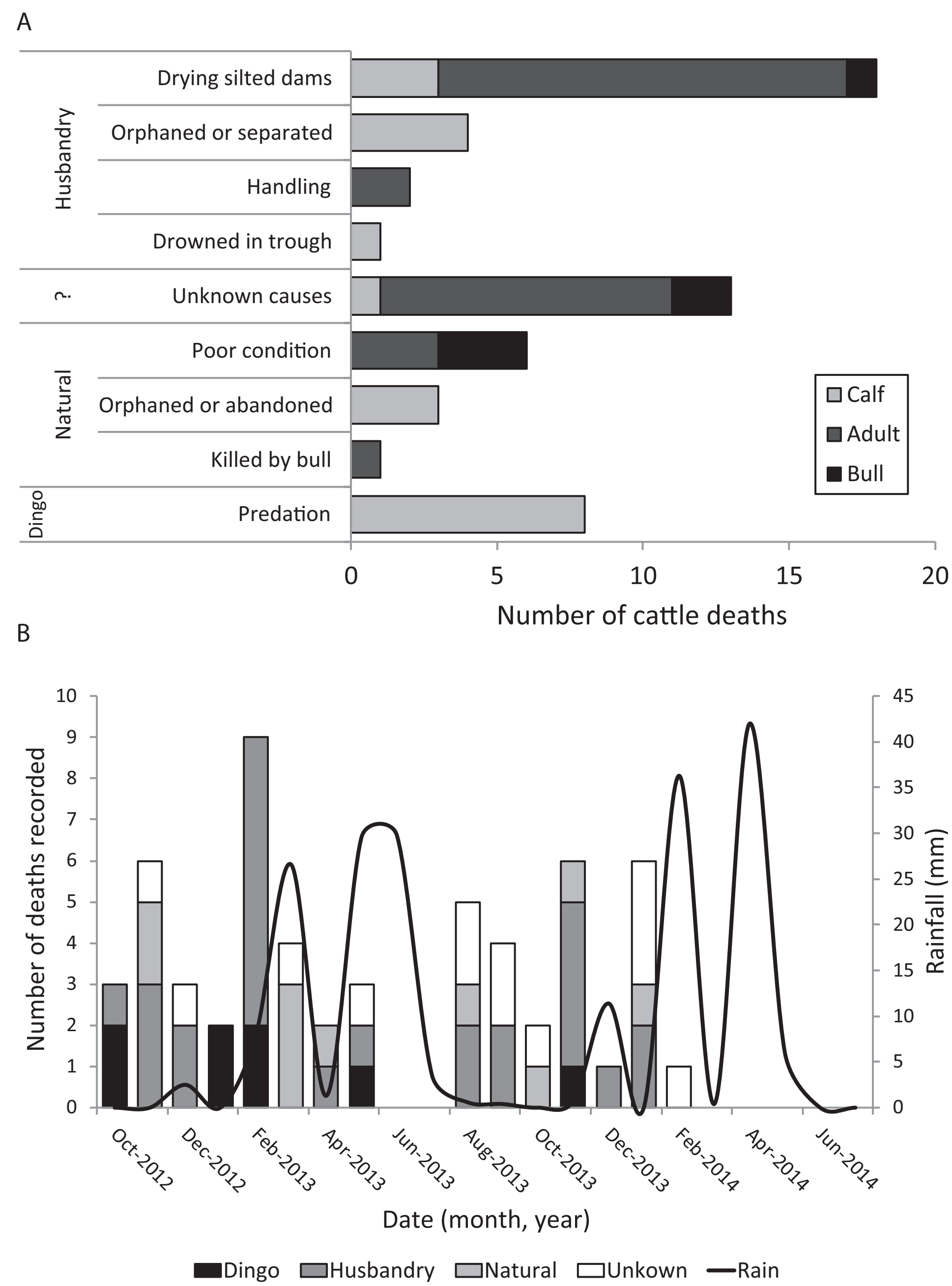

Fig. 2.—Causes of cattle deaths during 22 months of predator-friendly (nonlethal) management on a cattle station in South Australia. A) Cattle deaths recorded for each size class revealed that husbandry problems were the most common causes, particularly drying of mud-silted dams. B) Cattle deaths tended to occur during months of low rainfall (black line), while predation by dingoes (*Canis dingo*) was concentrated at the early stage of the study.

predator control operations according to one study (Wielgus and Peebles 2014), and in another study, application of nonlethal deterrents was significantly more effective than predator control at reducing wolf depredation on sheep (Stone et al., this issue). While we cannot compare predation rates with and without predator control, our case study suggests that husbandry practices, not dingoes, are often the primary cause of preventable deaths for cattle. Similarly, in North America, the growth rate of calves is related mainly to husbandry practices and climatic conditions, rather than to wolf activity (Ramler et al. 2014).

Transitioning from killing dingoes to improving husbandry practices is likely to increase survival and welfare of cattle significantly, as well as improve economic outcomes on large stations. Maintaining dams and bores in good condition, handling cattle humanely during muster, designing yards to reduce stress for cattle, ensuring sustainable stocking rates, and choosing breeds suited to the environment they will be bred in, are likely to result in significantly fewer deaths and lower costs. Government assistance and subsidies to farmers during times of drought and financial difficulty would best focus on improving station infrastructure. For example, subsidies for dam maintenance,

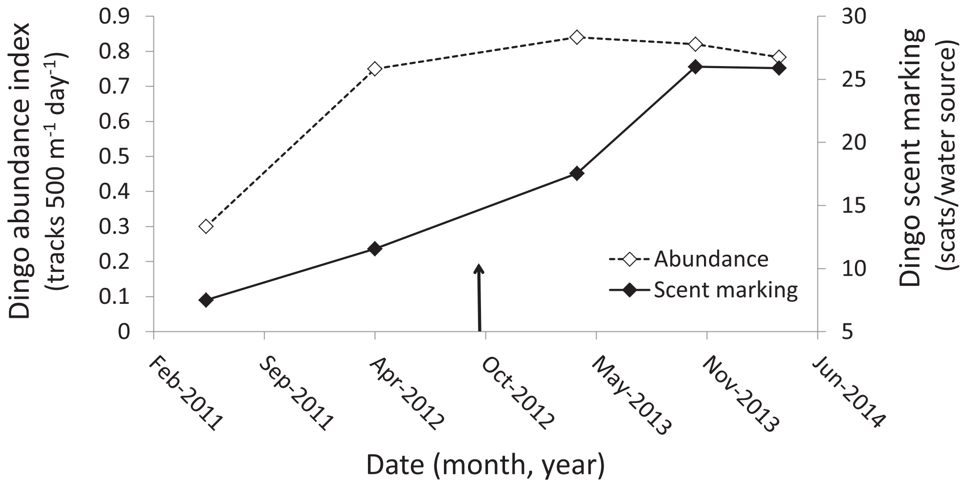

Fig. 3.—Abundance of dingoes (*Canis dingo*) and dingo scent-marking, before and after predator-friendly management began (indicated by arrow) on a cattle station in South Australia. Index of dingo abundance was stable and scent-marking rates (number of scats per water source) increased under predator-friendly management.

Table 1.—Causes of deaths of cattle (*Bos taurus*) on a predator-friendly station in South Australia, as shown by results of generalized linear models. Husbandry deaths were associated primarily with low rainfall as well as with low vegetation cover and high density of cattle at water sources. Natural deaths were mainly associated with high density of cattle at water sources. Predation by dingoes (*Canis dingo*) was best explained by low values of our index of dingo social stability. "Rainfall" is total monthly rainfall, "vegetation" is percentage vegetation cover, "cattle per water source" is the mean number of cattle at water sources, and "index of dingo social stability" is based on the mean number of dingo scats per water source. Asterisks (*) highlight statistically significant coefficients ($P < 0.05$).

Cause of death	Predictive variables	Coefficient estimate	*P*-value	Deviance explained
Husbandry				
	Rainfall	−1.16	0.005*	
	Vegetation	−0.53	0.10	
	Cattle per water source	0.37	0.13	45.8%
Natural				
	Cattle per water source	0.84	0.01*	27.5%
Predation				
	Index of dingo social stability	−1.49	0.02*	36%

Fig. 4.—Dingoes (*Canis dingo*) were not the main cause of death for cattle on Evelyn Downs station, South Australia. Left, cow (*Bos taurus*) keeps a watchful eye on a young dingo at Evelyn Downs. Right, cows becoming bogged in a drying mud-silted dam at Evelyn Downs was the main cause of death. Apart from the 18 cows that died in silted dams, 4 wild donkeys (*Equus asinus*) were also killed. However, 9 cows (including those in the image), 2 wild donkeys, and 1 wild horse (*E. caballus*) were rescued (some more than once). Photos by Gerrit Schuirmann (left) and Arian D. Wallach (right).

transitioning from manual generators to solar-operated bore pumps, and installation of remote satellite monitoring cameras at critical and remote water sources could significantly improve production and reduce stress for farmers, particularly during dry times.

There is a significant need for transition to evidence-based and ethically defensible management in livestock production that could be delivered through increasing collaboration between farmers, academics, and policy makers (Johnson and Wallach, in press). Our study provides an inside view of the workings of a single cattle station during a 2-year period, using an observation method that could be readily adopted by farmers. Much would be gained by establishing similar studies on a broader scale with replication and controls. The effectiveness of different management strategies, or of changes in management, could be tested by regular monitoring and reporting to assess cost effectiveness and animal welfare.

Transitioning to predator-friendly farming is also necessitated by a growing social demand for improved transparency and ethical conduct in farming practices (Johnson and Wallach, in press; Slagle et al., this issue). Clearly, there remains a large gap between social expectations and practices. For example, poison-baiting remains the most common and intensively used approach to protecting livestock from dingoes and other predators, despite it being perceived by the public as unacceptably inhumane (Fitzgerald 2009; Slagle et al., this issue). Vucetich et al. (this issue) argue that policies that enable the killing of predators are inconsistent with expectations that wildlife management practices will be guided by science, democracy, and legitimacy. As human population continues to grow and expand, the need for enabling peaceful coexistence and tolerance of wildlife outside of protected areas is becoming ever more apparent. Developing "coexistence skills" will be demanded of farmers in particular, as they sit on the frontline of the human–wildlife interface.

Acknowledgments

We are grateful to J. Knight and C. Thomas for hosting our study and for establishing one of Australia's 1st large-scale predator-friendly cattle stations. We thank B. Bergstrom for convening this Special Feature on mammalian predator control and for helpful comments on earlier drafts. Helpful reviews by C. Johnson and 2 anonymous reviewers improved this work.

Literature Cited

Allen, L. R. 2014. Wild dog control impacts on calf wastage in extensive beef cattle enterprises. Animal Production Science 54:214–220.

Bryan, H. M., J. E. Smits, L. Koren, P. C. Paquet, K. E. Wynne-Edwards, and M. Musiani. 2015. Heavily hunted wolves have higher stress and reproductive steroids than wolves with lower hunting pressure. Functional Ecology 29:347–356.

Colman, N. J., C. E. Gordon, M. S. Crowther, and M. Letnic. 2014. Lethal control of an apex predator has unintended cascading effects on forest mammal assemblages. Proceedings of the Royal Society of London B: Biological Sciences 281:20133094.

Crowther, M., S. M. Fillios, N. J. Colman, and M. Letnic. 2014. An updated description of the Australian dingo (*Canis dingo* Meyer, 1793). Journal of Zoology 293:192–203.

Department of Agriculture and Fisheries (DAF). 2015. Department of Agriculture and Fisheries. Queensland Government. https://www.daf.qld.gov.au/environment/drought/assistance/new-package/new-feral-animal-assistance-package. Accessed October 2015.

Encyclopedia of Life. http://www.eol.org. Accessed September 2015.

Fitzgerald, G. 2009. Public attitudes to current and proposed forms of pest animal control. Invasive Animals Cooperative Research Centre, Canberra, Australia.

Haber, G. C. 1996. Biological, conservation, and ethical implications of exploiting and controlling wolves. Conservation Biology 10:1068–1081.

Johnson, C. N., J. L. Isaac, and D. O. Fisher. 2007. Rarity of a top predator triggers continent-wide collapse of mammal prey: dingoes and marsupials in Australia. Proceedings of the Royal Society of London B: Biological Sciences 274:341–346.

Johnson, C. N., and A. D. Wallach. In press. The virtuous circle: predator friendly farming and ecological restoration in Australia. Restoration Ecology.

Letnic, M., F. Koch, C. Gordon, M. S. Crowther, and C. R. Dickman. 2009. Keystone effects of an alien top-predator stem extinctions of native mammals. Proceedings of the Royal Society of London B: Biological Sciences 276:3249–3256.

Letnic, M., E. G. Ritchie, and C. R. Dickman. 2012. Top predators as biodiversity regulators: the dingo *Canis lupus dingo* as a case study. Biological Reviews 87:390–413.

Machovina, B., K. J. Feeley, and W. J. Ripple. 2015. Biodiversity conservation: the key is reducing meat consumption. Science of the Total Environment 536:419–431.

McManus, J. S., A. J. Dickman, D. Gaynor, B. H. Smuts, and D. W. Macdonald. 2014. Dead or alive? Comparing costs and benefits of lethal and non-lethal human–wildlife conflict mitigation on livestock farms. Oryx 49:687–695.

New South Wales Government. 2015. NSW Government Gazette No. 62. Primary Industry Notices. Animal Diseases and Animal Pests (Emergency Outbreaks) Act 1991.

Ramler, J. P., M. Hebblewhite, D. Kellenberg, and C. Sime. 2014. Crying wolf? A spatial analysis of wolf location and depredations on calf weight. American Journal of Agricultural Economics 96:631–656.

R Core Team. 2015. R: a language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. http://www.R-project.org/. Accessed September 2015.

Ripple, W. J., et al. 2014. Status and ecological effects of the world's largest carnivores. Science 343:1241484.

Sherley, M. 2007. Is sodium fluoroacetate (1080) a humane poison? Animal Welfare 16:449.

Slagle, K., J. T. Bruskotter, A. S. Singh, and R. H. Schmidt. This issue. Attitudes toward predator control in the United States: 1995 and 2014. Journal of Mammalogy.

Stone, S. A., et al. Adaptive use of nonlethal strategies for reducing wolf-sheep conflict in Idaho. This issue. Journal of Mammalogy.

Thomson, P. C. 1992. The behavioural ecology of dingoes in north-western Australia. IV. Social and spatial organization. Wildlife Research 19:543–563.

van Bommel, L., and C. N. Johnson. 2012. Good dog! Using livestock guardian dogs to protect livestock from predators in Australia's extensive grazing systems. Wildlife Research 39:220–229.

Vucetich, J. A., J. T. Bruskotter, M. P. Nelson, R. O. Peterson, and J. K. Bump. This issue. The principles of wildlife management and wolf harvesting in Michigan. Journal of Mammalogy.

Wallach, A. D., I. Izhaki, J. D. Toms, W. J. Ripple, and U. Shanas. 2015. What is an apex predator? Oikos 124:1453–1461.

Wallach, A. D., C. N. Johnson, E. G. Ritchie, and A. J. O'Neill. 2010. Predator control promotes invasive dominated ecological states. Ecology Letters 13:1008–1018.

Wallach, A. D., E. G. Ritchie, J. Read, and A. J. O'Neill. 2009. More than mere numbers: the impact of lethal control on the social stability of a top-order predator. PLoS ONE 4:e6861.

Wielgus, R. B., and K. A. Peebles. 2014. Effects of wolf mortality on livestock depredations. PLoS ONE 9:e113505.

Special Feature Editor was Barbara H. Blake.