WILD DOGS AND THEIR MANIPULATION TO PREVENT LIVESTOCK PREDATION IN AUSTRALIA

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ABSTRACT: Dingoes and other wild dogs cause substantial damage and control expense in many Australian environments. The main methods of control are exclusion fencing, poisoning with 1080, and trapping. Strategies to mitigate livestock predation by wild dogs include; enterprise substitution, the reduction of wild dog populations, and baited buffer zones between wild dog country and sheep country. Damage functions show significant positive relationships between density indices and the losses caused by predation for both sheep and cattle enterprises. However, descriptive and explanatory models fitted the data poorly. A strategic approach to the management of wild dogs that aims to reduce predation on livestock while allowing the conservation of wild living dingoes is also outlined.

KEY WORDS: wild dogs, dingoes, predation, sheep, cattle, 1080 poisoning, exclusion fencing, trapping, damage functions, vertebrate pests

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INTRODUCTION

In Australia, dingoes and other wild dogs (*Canis lupus dingo*, *C. l. familiaris*, and hybrids) are simultaneously considered pests of agriculture (particularly in sheep areas), tolerated in some other areas (usually unoccupied lands and extensive cattle country), and actively conserved in parts of their range. This paper briefly defines and describes wild dogs; mentions their origins and distribution in Australia; discusses livestock predation, damage functions, past and current management, and dingo conservation; and outlines a strategic approach to the management of wild dogs that aims to reduce predation on livestock while allowing the conservation of wild living dingoes.

DINGOES AND OTHER WILD DOGS: NOMENCLATURE, DESCRIPTION, ORIGINS, AND DISTRIBUTION

In this paper, I use the following terms:

Wild dogs: all wild-living dogs (including dingoes, feral dogs, and hybrids).

Dingoes: native dogs of the type present in Australia before domestic dogs came.

Domestic dogs: dog breeds selected by humans and living in association with humans. Feral dogs: wild-living domestic dogs.

Hybrids: dogs resulting from crossbreeding of a dingo and a domestic or feral dog, and the descendants of crossbred progeny.

The name "dingo" is probably a European corruption of the word "tingo," used by Aboriginal people at Port Jackson (Sydney Harbor) to describe camp dingoes (Breckwoldt 1988). Dogs and dingoes can interbreed and produce fertile hybrid young when they do. Newsome et al. (1980) discriminated between dingoes, domestic dogs, and hybrids using skull morphology and this was correlated with coat color (Newsome and Corbett 1985). In dingoes, ginger is the most common color, although, black, black and tan, and white dingoes occur (Newsome and Corbett 1985). Most dingoes have white points. Feral dogs and hybrids may be similarly colored but sable, brindle, patched, spotted, and brown forms also occur (Korn and Fleming 1989; Jones 1990). These colors do not occur in pure dingoes (Newsome and Corbett 1985). Pure dingoes are distinct from similar-looking domestic dogs and hybrids because they breed once a year and have some different skull characteristics. Where all wild dogs communicate by scent marking and howling, dingoes usually do not bark; whereas, most hybrids and feral dogs do. Microsatelite DNA analysis is being developed to distinguish between dingoes and other wild dogs (Wilton et al. 1999).

Feral dogs in Australia may weigh up to 60 kilograms (Korn and Fleming 1989) but are usually 11 to 24 kilograms (males), and 10 to 22 kilograms (females) (Jones 1990). The average adult dingo weighs approximately 16 kilograms and males are larger and heavier than females (Thomson 1992a; Corbett 1995). Dingoes are largest in northern and northwestern Australia.

Wild dogs live in small packs in territories where the home ranges of individuals vary between 10 and 300 square kilometers, depending on where they occur. Home ranges are larger in the more arid regions of southern central Australia and smaller in the more productive areas in southeastern Australia. Packs are usually stable but under certain conditions some wild dogs, usually young males, will disperse (Thomson et al. 1992).

Dingoes were first introduced to Australia from Asia about 4,000 years ago (Milham and Thompson 1976). The dispersal of dingoes throughout Australia was aided by Aboriginal people who used dingoes for food, companions, hunting-aids, and bed-warmers (Corbett 1995). The most recent introductions were by Macassan trepangers who traded with Aboriginal people in north of Australia (90 to 350 years ago; Macknight 1976). The dingo has never been present in Tasmania and is regarded as an exotic animal in Tasmanian legislation.

Feral dogs have been present as escapees or purposeful releases since domestic dogs were brought

from England with the First Fleet in 1788. Free-living dogs of specific breeds have been seen or captured in remote areas (Jones 1990; Newsome and Corbett 1985; Corbett 1995; Fleming 1996a).

Wild dogs are widespread throughout Australia (Figure 1), their distribution being determined by suitable prey, permanent water, and past control activities. Despite the reduction in range imposed by agricultural practices (particularly land clearing) and population manipulation, wild dog numbers have increased since 1788, probably because of the construction of artesian and other artificial water sources in the more arid areas.

IMPACTS OF WILD DOGS

Predation of Livestock by Wild Dogs

Wild dogs eat a diverse range of foods, from insects to feral water buffalo (*Bubalus bubalis*), but prefer medium and large vertebrates (Corbett 1995). Part of their success and occurrence in such diverse habitats is because they can change hunting tactics. Larger groups of wild dogs are more successful when hunting large kangaroos and cattle (Corbett 1995), and solitary animals are more successful when hunting rabbits and small macropods (Thomson 1992b). Single wild dogs can easily pull down sheep, although groups of dogs will cooperate in kills (Thomson 1984a).

The threat of predation of livestock by wild dogs has largely determined the distribution of sheep and cattle in Australia (Figure 1) (Newsome and Coman 1989). Damage by wild dogs is most likely wherever their ranges overlap those of sheep. Sheep are the most commonly attacked livestock, followed by cattle and goats (Fleming and Korn 1989). Damage is largely independent of the age and condition of sheep or goats, seasonal conditions, and availability of alternative food for wild dogs. Surplus killing, where more sheep are killed than are needed for food, means that losses can be high even when wild dogs are at low densities.

In a study in the Pilbara region of Western Australia (Thomson 1984a), 26 radio-collared dingoes in sheep paddocks were observed from the air and their interactions with sheep were confirmed on the ground and at shearing time. Some dingoes caused far more damage than others did. The presence of a dingo changed the distribution and feeding behavior of the sheep, even if the dingo did not actively harass them. All dingoes chased sheep, sometimes maiming without killing outright, and all but one attacked sheep. When dingoes killed sheep, they often left carcasses uneaten (this seems to be a characteristic of predation of sheep by wild dogs throughout their range, e.g., Fleming 1996a). Individual dingoes that frequently killed sheep often ate native prey such as kangaroos.

A study of affected sheep graziers in the northeast of New South Wales in 1962 showed annual losses of 1.3% per property, and 39.5 person hours per annum were spent in wild dog control activities (NERDA undated, c. 1966). Schaefer (1981) surveyed a sample of graziers in the same area and reported average sheep losses of 0.9% per annum. This was similar to Fleming and Korn's (1989) study in 1984-85 which estimated losses of 0.7% per annum. Backholer (1986) in a mailed questionnaire of 809 properties in eastern Victoria, reported mean losses per property of between $400 and $4,230 per annum, which was 0.1% to 24.9% of the total value of the enterprises.

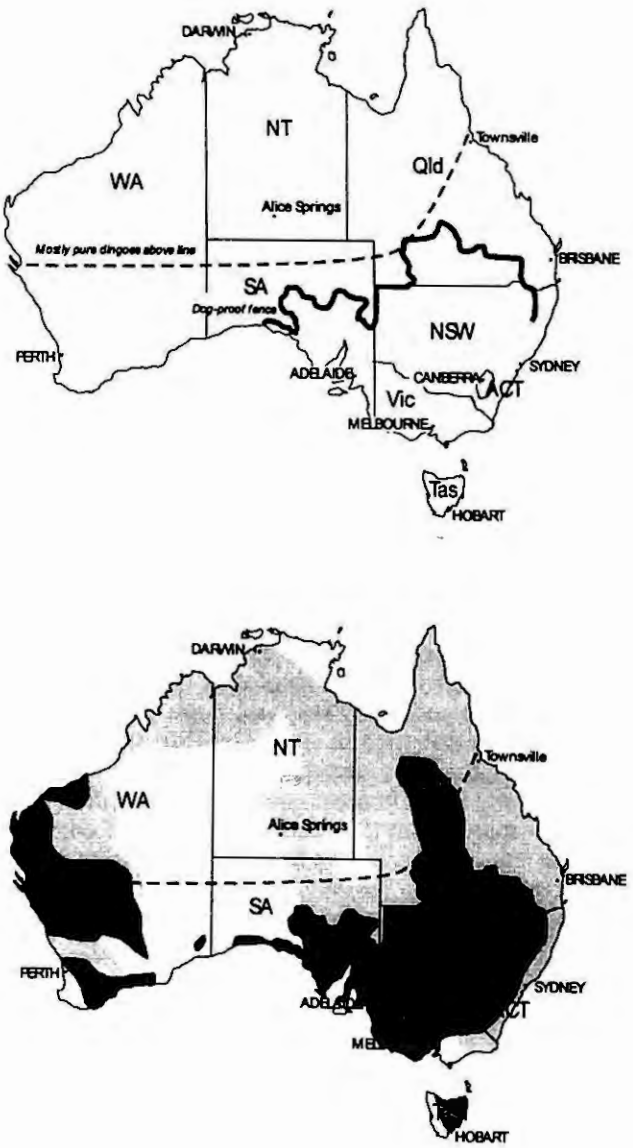

Figure 1. The distribution of wild dogs (top) and livestock (bottom) in Australia. Wild dogs above the dashed line are mostly pure dingoes. The solid line is the "dog fence", the longest man-made structure in the world. Wild dogs present at varying densities from naturally sparse to common. Top map, wild dogs mostly absent. Sheep, cereals, and cattle production. Cattle predominant. Bottom map, livestock absent. WA=Western Australia, NT=Northern Territory, SA=South Australia, Qld=Queensland, NSW=New South Wales, CT=Australian Capital Territory, Vic=Victoria and Tas.=Tasmania.

The impact of wild dogs on cattle production in Australia is more variable. Attacks on young calves are the major cause of wild dog losses to cattle, but weaners

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and older cattle are sometimes killed or injured by packs of wild dogs. Estimates of predation losses of calves and weaners in normal conditions in rangeland grazing areas are in the range of 0% to 29.4% per annum (Rankine and Donaldson 1968). Predation is greater when alternative food is scarce (Corbett 1995; Allen and Gonzalez 1998). Studies of reproductive failure in cattle herds undertaken in Queensland have suggested up to 30% loss of calves caused by predation by wild dogs (Allen and Gonzalez 1998). A 1995 questionnaire survey of approximately 67% of cattle graziers in the Northern Territory estimated annual calf losses attributable to predation by wild dogs between 1.6% and 7.1% (Eldridge and Bryan 1995). In southeastern Australia, where both sheep and cattle are grazed in wild dog-inhabited areas, predation of cattle is rare (Fleming and Korn 1989).

Fleming and Nicol (unpubl. data, in preparation) have investigated damage functions for wild dog predation of livestock. They found that, while accumulated ANOVAs showed that there was a very strong relationship between wild dog density indices and reported damage (all P values <0.001), there was no predictive value in either linear and exponential functions for cattle or sheep enterprises (all R^2 values <0.2). This apparent contradiction was probably because of surplus killing of sheep (i.e., one wild dog could be responsible for many kills) and packing behavior during cattle predation (i.e., more than one wild dog responsible for one kill). The consequence of this finding is that break-even points for control effort cannot be calculated because the amount of damage expected for a given density of wild dogs is highly variable. However, the presence of wild dogs in sheep country will inevitably result in predation (Fleming et al., In Press).

The presence of wild dogs has costs to agricultural production that are additional to predation. There is considerable expenditure on control (e.g., Table 1).

In Australia, the prevalence of hydatidosis (causal agent *Echinococcus granulosus*) in humans is often linked to sylvatic cycles in wild dogs and wildlife (e.g., Coman 1972a; Thompson et al. 1988). Incidence in humans is relatively low, but is more common in southeastern Australia where the densities of wild dogs are highest (Jenkins and Power 1996). However, the sylvatic cycle of hydatids is also linked to the condemnation of offal in sheep and cattle from wild dog-inhabited areas. The economic cost of this has not been assessed, but hydatidosis leads to the condemnation of offal from up to 90% of slaughtered cattle from endemic areas (D. Jenkins, unpubl. data).

Value of Wild Dogs

On the other side of the ledger, pure dingoes are iconic and are attractive for tourists and, therefore, have existence value and monetary value. The ecological role of dingoes and other wild dogs is uncertain; however, as the top predator in the ecosystems where they occur unmolested, they probably have influence over the abundance of their prey, particularly macropods. Some foresters regard wild dogs as an asset because they believe wild dog predation on macropods reduces damage to pine plantations during establishment. The value of these roles as an environmental service requires evaluation.

DINGO CONSERVATION

In Australia, dingoes are both a significant vertebrate pest and a significant resource. People in agricultural regions often view dingoes as a pest to be removed from the environment; aboriginal communities, urban people, and conservationists may view dingoes as an iconic (or totemic) native Australian mammal. There is some public expectation that dingoes be conserved, and dingoes are legally protected in parts of some States and Territories. Wild dogs are top order predators ("Top Dog") in Australian wildlife communities, and as such probably have a major influence on the abundance of the species they compete with or prey on. They co-occur with the introduced European red fox (*Vulpes vulpes*), feral cats (*Felis cattus*), and quolls (*Dasyurus* spp.), but interactions between wild dogs and these species are not well understood. Nevertheless, dingoes require conserving in some situations, and Australian Federal and State legislation and policy facilitate this.

Table 1. The effort expended for the control of wild dogs by graziers in northeastern New South Wales. Data were collected from members of Wild Dog Control Associations or equivalent organizations (from Fleming et al., In Press).

Year	Primary Method of Control	Control Effort (Hours/Property/Year)	Source
1962	Dog-proof fencing, hunting, trapping	39.3	NERDA, undated c. (1966)
1981	Aerial baiting (fixed-wing aircraft), dog-proof fencing	15.9	Schaefer (1981)
1985	Aerial baiting (fixed-wing aircraft), dog-proof fencing	12.5	Saunders and Fleming (1988)
1988	Aerial baiting (helicopter), dog-proof fencing	11.6	Thompson and Fleming (1991)

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The greatest threat to the survival of dingoes as a subspecies is hybridization with domestic and feral dogs (Corbett 1995). In the more settled coastal areas of Australia and increasingly in outback Australia, hybridization is becoming more common and the dingo gene pool is being diluted. In southeastern Australia, more than half the wild dogs are hybrids (Jones 1990; Corbett 1995). Corbett (1995) predicts that, at the present rate of hybridization, there will be no pure dingoes on mainland Australia by 2100. The main hope for conservation is to manage pure dingoes on large offshore islands such as Fraser Island off Queensland. A coordinated genetic survey of wild dogs using DNA analysis is beginning in southeastern Australia. It may well identify "islands" of pure dingoes where dingo social behavior and management practices have isolated dingo populations from feral dogs. Such areas might also serve as centers for dingo conservation.

MANIPULATION AND MANAGEMENT OF WILD DOGS

During the 1800s and early 1900s, the combination of habitat modification (clearing for farming and livestock grazing), exclusion fencing, poisoning, and trapping resulted in the dingo becoming extinct over much of its previous range in southern Queensland, New South Wales, Victoria, and South Australia. By 1890, all mainland States and Territories had enacted legislation to facilitate and administer the control of wild dogs.

Before the extensive fencing of pastoral runs to manage the movements of sheep, the first method used to reduce predation by wild dogs was shepherding of flocks by paid shepherds. Shepherds were often sent into isolated areas where they had to protect their stock from human and wild dog predation. Shepherding to prevent predation by wild dogs is now only practiced as a last resort because of the expense and time constraints (Fleming et al., In Press).

As fencing materials became more sophisticated and more readily available, the use of exclusion fences as barriers to wild dog movements into sheep country became feasible. Often a continuous fence resulting from adjoining landholders fencing around their own properties, protected groups of properties. For example, about 1,000 kilometers of barrier fencing was erected by landholders on the New England tablelands in New South Wales in the 1920s and 1930s (NERDA undated c. 1966) (Figure 1). Governments also erected exclusion fences including, for example, 5,000 kilometers in South Australia between 1896 and 1908 (Holden 1991).

Initially, management of wild dogs in Australia relied heavily on labor-intensive population-manipulation techniques, such as trapping, shooting, and ground baiting using strychnine, with bounty payments being offered as an incentive to kill dogs. However, as elsewhere, bounty payments have not been successful in reducing predation by wild dogs and are subject to abuse (Smith 1990). Much of the control work was reactive, dealing with problems after they had arisen. Nevertheless, some strategic, preventative control was carried out, including the construction of exclusion fences.

Today, most States and Territories have a legal requirement to destroy wild dogs in sheep and cattle grazing zones. Poisoning programs form the basis of lethal population manipulation efforts, although trapping and occasionally shooting are important. Current management strategies focus on the objective of minimizing the impact of wild dog predation on livestock, not solely on killing wild dogs. Aerial baiting with 1080 baits forms a major part of most management programs and is primarily targeted at limited zones adjacent to livestock grazing areas. Large coordinated campaigns have generally been adopted, being more cost-efficient and effective than small localized efforts. Ground baiting programs conducted by groups are also becoming more common. Many concerns about non-target risks have been allayed by research on the toxicity of 1080 to Australian fauna (e.g., McIlroy 1981). In some States and Territories, reductions in loadings of 1080 in baits, better bait placement, and a reduction in the number of baits used have resulted in a theoretically negligible risk to non-target species (Fleming 1996b). Trapping is still used for wild dog removal and will probably always be needed to target particular dogs that cannot be removed by other means.

Techniques used in North America, such as livestock-guarding dogs, M-44s devices, and toxic collars have been suggested as alternatives to current methods in Australia (L. Allen, pers. comm.; F. Gigliotti, pers. comm.). Sheep-guarding dogs have not been experimentally tested in Australian conditions, but two breeds of stock-guarding dogs, Anatolian karabash and maremma, have been used to protect sheep and goat flocks from predation by wild dogs and foxes. In an area of Victoria, maremmas have been used to reduce stock losses from 10% per annum to 3% per annum over the eight years since their first use (Balderstone, 1992).

MANAGEMENT STRATEGIES

Exclusion Fencing

The erection of exclusion fences for wild dogs began in the 1880s with the erection of 1.8 meter high fences of 13 plain wires laced with vertical wires at about 15 cm intervals (Harden, unpubl. data). Exclusion fences became more widespread after the introduction of prefabricated wire netting at the turn of the century. Fence designs vary, but usually fences are 1.8 meters high and constructed of wire netting or mesh. Advances in electric fencing technology have resulted in the widespread use of electrified wires either in the body of new fences (P. Bird pers. comm.) or as offsets to existing exclusion fences.

Initially, governments and local wild dog control organizations wholly funded or subsidized the erection and maintenance of long fences to prevent the incursion of wild dogs into sheep country. The long, government-erected fences linked along state borders and became known as the "dog fence" or "barrier fence," which extends 5,614 kilometers from near Dalby in southeastern Queensland to Fowlers Bay on the Great Australian Bight in South Australia (Figure 1) (Fleming et al., In Press). Prior to shortening of the Queensland section of this fence in 1989, the dog fence was 8,614 kilometers long

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(Breckwoldt 1988). The dog fence is extended into northern New South Wales by a series of linked, privately erected and maintained fences.

The Queensland–New South Wales dog fence (359 kilometers) was originally built as a (failed) rabbit-exclusion fence, and the fence between South Australia and New South Wales was converted from a rabbit-proof fence to a dog-proof fence in 1917. Responsibility for maintenance of the dog fence lies with the State governments involved and boards comprising private and government land managers. Other exclusion fences in eastern New South Wales and Victoria, Queensland, and Western Australia were usually erected and maintained by private landholders and groups of landholders. However, there has been a recent trend for government contributions where a fence is on the boundary of agricultural land and national estate.

Pre-emptive Population Reduction

From the early 1800s, when strychnine was first used for poisoning wild dogs, control programs were instigated at the property level or cooperatively. Cooperation between landholders was necessary because strychnine was expensive and could only be imported in quantities too large for individual landholders (Fleming et al., In Press).

Aerial baiting began with experimental drops of brisket-fat baits containing strychnine in Western Australia and Queensland in 1946 (Tomlinson 1954). Since the mid-1960s, 1080 has largely replaced strychnine in baits. 1080 meat baits were first aerially distributed in the Northern Tablelands of New South Wales in 1964 and had replaced strychnine baits in aerial baiting programs in most areas by the late 1960s (Fleming et al., In Press). Fixed-wing aircraft were used until 1986, when helicopters became mandatory for aerial baiting in the east of New South Wales because baits could be placed with more accuracy (Thompson et al. 1990). Aerial baiting is now generally accepted as a cost-effective, safe method for the extensive strategic management of wild dogs (Thomson 1986; Thompson and Fleming 1991), and is used in Queensland, New South Wales, Western Australia, and the Northern Territory.

Buffers and Baited Zones

Thomson (1984b) first suggested and tested the use of dingo-free buffer zones to prevent predation of sheep in Western Australia. Buffer zones were created by aerially baiting a zone of approximately two dingo home range widths adjacent to sheep country. It took two years for dingoes to fill the sink created in the buffer and livestock predation was effectively eliminated in the sheep country for two years. The buffer zone forms the basis of wild dog control in Western Australia, and a similar strategy is used in northeastern New South Wales. There, annual aerial baiting reduces the wild dog population in a strip 4 to 12 kilometers wide adjacent to the sheep country (Fleming 1996a). Because the baited zone is not as wide as the Western Australian buffer, the sink is filled sooner and annual baiting is required to minimize damage (Fleming 1996a).

In eastern Australia, cattle are grazed in paddocks close to timbered wild dog refuges and sheep are run in the paddocks further away. Similarly in South Australia, sheep graziers often run cattle in paddocks adjacent to the dingo fence where risks of predation are greatest (P. Bird, pers. comm.).

Doggers and Trapping

The employment of professional doggers by government agencies, wild dog control organizations, and sometimes by groups of landholders, has been an important strategy for wild dog control. In some areas (e.g., southeast New South Wales, Victoria, the Australian Capital Territory, and some parts of Western Australia) doggers are still an integral part of pre-emptive reduction of wild dog populations. Doggers rely primarily on trapping to reduce wild dog populations and to remove troublesome individual wild dogs.

STRATEGIC APPROACH TO MANAGEMENT

In Australia, better management of all aspects of agriculture, including vertebrate pest control, is required. A strategic approach (Braysher 1993) to wild dog management is being developed (e.g., Fleming et al., In Press) and fostered at the government level, and is being adopted in more regions. The strategic approach allows improvements at both the local and regional scale.

The strategic approach to vertebrate pest management has four components: defining the problem; developing a management plan that includes strategies similar to those outlined previously; implementing the plan; and monitoring and evaluating progress and outcomes (Braysher 1993). Defining the problem involves the identification of who has a wild dog problem; what harm the wild dogs cause; where, when, and why damage occurs; and how much it costs. A management plan has set objectives including interim and long-term goals for dingo conservation, mitigation of livestock predation; strategies (see above) and actions for managing wild dog predation; a time frame for performing actions and achieving goals; and indicators for measuring performance. Monitoring and evaluation occur at different levels throughout the implementation of the plan and, on completion of actions, allow revision and progress. By adopting this strategic approach, predation by wild dogs should be minimized while the conservation of the dingo proportion of the wild dog population will be enhanced. Limited resources will be better allocated and the scale of management will be more aligned to the scale of wild dog problems.

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