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Management of wild canids in human-dominated landscapes

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Contents

Introduction

Whereas some canid species are declining globally under the pressure of habitat degradation and fragmentation, disease and persecution, other have managed to survive and even thrive in human-dominated landscapes. This overlap with people results in competition for resources, which is at the heart of the conflict between many wild canids and man.

Canids prey upon a range of livestock, game stock, and threatened wildlife, and a few of the larger species may also attack, and on rare occasions, fatally injure humans. As a result of this and innate human prejudice, canids have frequently been vilified by people, classed as vermin and actively sought out and killed. Control may be occasional and opportunistic, such as when a farmer shoots a fox attacking his chickens, or targeted and systematic, such as with control programmes to reduce or eradicate problematic species.

Harassment notwithstanding, canids have survived in many areas where other carnivores have gone extinct. Their resilience is principally due to their relatively high reproductive rate (i.e., large litter sizes and early sexual maturity), which compensates for increased human-inflicted mortality rates, and their adaptability to new environments. Canids can often quickly recover from population decreases and range contraction, and rates of re-colonization are often high due to high levels of dispersal (Gittleman 1989).

This chapter examines the reasons why canids frequently find themselves in conflict with humans, and the ways in which conservation biologists and managers have tried to solve these problems. Data for this essay are derived from original research, literature reviews, and from a preliminary analysis of the information provided in the species accounts of Part I of this action plan. This paper borrows several ideas first developed by Sillero-Zubiri and Laurenson (2001) for carnivores in general. For additional information on managing conflict in canids, see Sillero-Zubiri *et al*. (2004).

Why do canids come into conflict with humans?

Given the long tradition of canid persecution, it is pertinent to ask what the reasons are behind human-canid conflict. Although in recent times public perception of canids has improved, historically, the majority of people have held negative views towards wild canids, with these views being handed down through the generations, and then carried with them as they migrate. These views have often been generated by an ingrained fear of the larger species, and by the recurrent issue of wild canids predating on livestock and valuable game species. Europeans, for instance, took their intolerance of carnivores with them when they colonized other regions of the world, notably Africa and America. In North America, grey wolves (*Canis lupus*) and coyotes (*Canis latrans*) were actively hunted by the colonists upon their arrival, and by the 1930s wolves had been extirpated from most of the USA, with only Minnesota and Alaska harbouring viable populations (Mech 1970). Elsewhere, Europeans were responsible in 1876 for the last known canid extinction, namely that of the Falklands wolf or Malvinas fox (*Dusicyon australis*) (Macdonald and Sillero-Zubiri 2004). Similarly, African wild dogs (*Lycaon pictus*) were considered vermin by European farmers and deliberately killed on farmland and protected areas (Woodroffe *et al*. 1997).

Intriguingly, Africans' perceptions may differ from those of Europeans; for example, wild dog kills are considered a useful source of meat by the Shona in Zimbabwe (G. Rasmussen pers. comm.), and the Maasai people of East Africa regard them as an asset as they prey on wildebeest (*Connochaetes taurinus*), which they regard as competition for grazing with their cattle (Fuller and Kat 1990).

Attacks on humans

The larger canids are often considered a direct threat to human life. Grey wolves and wild dogs, and to a lesser extent dholes (*Cuon alpinus*) are portrayed as villains in the myths and folklore of

many cultures (Landau 1993). Attacks on humans are quite rare though, and deaths are even less frequent (Linnell *et al*. 2000), yet many people still hold a deep-rooted fear of wild canids and this contributes to the overall negative view held in many societies. For instance, attacks by wolves are still feared by people in the USA, even though, in contrast to other predators like bears and mountain lions, there have been no verified attacks in the last century (Mech 1970; Kellert *et al*. 1996). African wild dogs are often described as 'ruthless killers' (e.g., Bere 1955), although attacks on humans rarely, if ever, occur (Creel and Creel 2002). In situations where canids do attack people it is often due to an individual rabid animal in 'furious' phase, attacking people repeatedly over the short time period they survive (Linnell *et al*. 2000). With the eradication or reduction of rabies in many parts of the wolf's range, the incidence of wolf attacks has dropped dramatically, but cases are still reported from Asia and the Middle East.

The majority of present-day predatory (non-rabies) wolf attacks seem to occur in highly modified environments, with little or no natural prey, with wolves habituated to people presence and relying heavily on human refuse and livestock as an alternative source of food. As many as 273 children have been reported killed by wolves in the last 20 years in northern India, where wolves come into close contact with shepherd children due to their dependence on villages for food (Jhala and Sharma 1997). Wolf attacks may result from habituation, with wolves loosing their fear of humans and increasing the likelihood of encounters. Furthermore, attacks may also result from provocation when wolves are cornered, trapped or a den with pups is breached.

Although attacks are very rare, when they occur they attract a disproportionately large amount of sensationalist media coverage, and have the potential to be very damaging to canid conservation efforts. For example, the recent killing of a young boy by a dingo (*Canis lupus dingo*) on Australia's Fraser Island has led to calls for a dingo cull, even though this population is considered one of the most genetically pure dingo populations remaining (Queensland Parks and Wildlife Service 2001). Thankfully, it appears that the efforts of conservation groups are proving increasingly successful at overturning this inherent human fear of canids, and conservation support for wild canids is gaining in popularity.

Competition for resources

Ever since our ancestors began herding livestock, many carnivore species have been persecuted for their role as predators of domestic animals. Throughout Europe there were, and in some instances still are, deliberate policies to reduce the numbers of predatory species to safeguard livestock and poultry, and also to promote human safety and to benefit game species. Certain canid species have experienced a long history of organized persecution; for example, in 6th century BC Greece, the city of Athens issued state bounties for the killing of wolves in an attempt to protect livestock from predation (Reynolds and Tapper 1996). Grey wolves were also deliberately exterminated from the islands of Japan, except Sahkalin, even though other large mammalian carnivores were allowed to remain extant (Dobson 1994). In some areas predator reduction was so effective that canids survived only in very low numbers or were completely extirpated. For example, in Britain grey wolves, brown bears (*Ursus arctos)* and lynx (*Felis lynx*) were all extinct by the middle of the 19th century (Harris 1989).

Unlike the exaggerated problem of attacks on humans, canid predation on livestock and game is a harsh reality difficult to deal with. In many countries large-scale control policies have traditionally been deployed to reduce livestock predation, and are often written into state law, and rewarded by bounty schemes (Childes 1988). Yet, the resources and expense invested in control campaigns have often been disproportionate with the damage perpetrated. For example, in South Africa £400,000 (currency of the period) was spent between 1915 and 1925 to extirpate predators (Pringle 1977).

More recently, conservationists have led a re-examination of the costs to farmers, hunters and society as a whole, of preserving viable carnivore populations (e.g., Clark *et al*. 2001; Sillero-Zubiri and Laurenson 2001). Although the general public is no longer willing to see wild canid populations reduced simply because they come into conflict with certain sectors, this change is not necessarily taking place among people living near wild carnivores. As a result,

canids still face substantial persecution, particularly in those areas where they spill-over from the edges of protected areas (Woodroffe and Ginsberg 1998). Meanwhile, conflict has not been a problem for many decades in agricultural landscapes where carnivores have been extirpated, but this situation is changing as many carnivore populations, especially wolves and coyotes, have been increasing and reclaiming some of their historical ranges (Mladenoff *et al*. 1995).

Predation on livestock

Every domestic species, from chickens to cattle, is affected by canid predation. Indeed, livestock predation was the most frequently cited reason for problems between humans and canids in part 1 of this volume. Due to selective breeding and protection, domestic animals exhibit little effective anti-predator behaviour, making them particularly vulnerable to predators (Kruuk 2002), with domestication effectively breeding out the "wildness" of these animals. Changes in livestock husbandry and a decrease in the manpower employed in livestock production, most rapid and advanced in the developed world, have resulted in animals rarely herded (e.g., Rasmussen 1999) or guarded by dogs and thus more vulnerable to predation. In addition, livestock compete with wild herbivores for resources and, subsequently, they can either reduce the abundance or alter the distribution or behaviour of wild prey, thus changing the pattern of predation to include more livestock (Yalden 1996). Although farmers consistently express the most negative attitudes toward large canids, such as grey wolves and African wild dogs, they often constitute a minor problem compared with smaller canids such as jackals, coyotes, and feral dogs (e.g., Ciucci and Boitani 1998).

Livestock losses can be significant. Estimates of sheep losses to wild canids in the USA, for example, ranged from US$19-150 million between 1977 and 1999, and cattle losses represented US$52 million in 2000 (Knowlton *et al*. 1999). Although these losses represent only a fraction of the total income generated by the USA livestock industry, often they are not spread out evenly over the farmer community but rather are borne by a few individual farmers who endure the majority of the damage. In developing countries high livestock losses can have a serious impact on farmers' livelihoods. In India's Spiti Region losses to predators averaged US$128 per family per year in three villages, which equates to half the average annual per capita income (Mishra 1997).

Predation on game species

Throughout history, canids have been seen as competitors for prey and this remains the second most significant cause of human-canid conflict today. In Europe, gamekeepers target red foxes and other predators in an attempt to increase the population of partridges, pheasants, and grouse that are available for hunters to shoot (e.g., Macdonald *et al*. 2000). In North America, carnivore populations have traditionally been controlled in order to increase game species, in particular wild ungulates. This strategy was prevalent even amongst conservationists, and predator removal was the National Parks' policy until the latter half of the 20th century (Clark *et al*. 1999). Although carnivores are increasingly valued as an integral part of the ecosystem, and in spite of the fact that canids mostly target the sick and infirm animals that are not sought after by hunters, there is still great pressure from the hunting lobby to reduce their numbers. In Alaska, for example, grey wolves are blamed by hunters for declining moose and caribou populations and the resulting reduction in hunting quotas (Gasaway *et al*. 1992).

Predation on threatened wildlife

Wild canids can also have a detrimental effect on other wildlife, particularly where they have been introduced to isolated islands, where ground-nesting seabirds have often not developed any defence mechanisms to avoid predation. Arctic foxes (*Alopex lagopus*), for instance, have been responsible for large reductions on several Arctic seabird colonies, due to either being introduced by man (Bailey 1993) or where they have naturally invaded islands (Birkhead and Nettleship 1995). See Courchamp et al. (2003) for a review of mammal invaders on islands.

In a few exceptional circumstances, there may be a novel conservation dilemma when a threatened canid species has had a significant impact on another threatened species. In the Alas Purwo National Park, Java, Indonesia, dholes were deemed responsible for the decline in the Endangered banteng (*Bos javanicus*) (Indrawan et al. 1996), and consequently a reduction in their numbers was recommended. Asian

wolves (*Canis lupes pallipes*) in Velavadar National Park, India, may play a part in limiting the population size of the Vulnerable blackbuck antelope (*Antilope cervicapra*) (Jhala 1994). While these conflicting situations might only pose a localized threat, they do create a conservation quandary when ecosystem conservation, practical management and animal welfare must all be balanced with existing land-use.

In a reversal of the above scenario, threatened canid populations can also be under threat from other species, such as African wild dogs facing competitive exclusion from spotted hyenas (*Crocuta crocuta*) and lions (*Panthera leo*) in some protected areas (Creel and Creel 1996). Canid populations can also be threatened through intra-guild competition, such as with coyotes preying heavily on sympatric swift foxes (*Vulpes velox*) (e.g., Carbyn et al. 1995).

Solving problems: approaches to canid-human conflict

The traditional way to deal with conflict between humans and wild canids was to attempt to remove the threat simply through extermination. This approach of blanket predator control has traditionally been the backbone of canid management, with farmers and wildlife managers trapping or poisoning canids wholesale. However, the outcome of indiscriminate control is not always straightforward, both in technical terms and due to widespread resistance amongst the general public.

Widespread killing seldom delivers effective long-term predation reduction and the preferred approach is now one that focuses on changing the behaviour of the individuals directly involved in damage, and also addresses the behaviour of the people that are facing the problem. Non-lethal methods are increasingly favoured to prevent, or at least reduce, the incidence of predation, and the management goal is slowly shifting to minimise impact on innocent individuals, while minimising human-canid conflict (Treves and Karanth 2003). Indeed, in some instances the predation problem can be exacerbated where culling allows the immigration of problem animals into vacant territories (Sacks et al. 1999). Consequently, removing culprit individuals from a canid population may be more efficient than attempting population control (Conner et al. 1998; Blejwas et al. 2002).

In the next section, various lethal and non-lethal methods are examined, followed by a review of approaches that attempt to reduce or eliminate human-canid conflict by increasing human tolerance towards wild canids.

Predation control and reduction

Trapping

Trapping is perhaps the oldest method used to reduce predator numbers and a wide variety of cage, box, leg-hold traps and snares have been used, either killing the malefactor directly or holding it until it can be destroyed by a returning hunter. Traps are often unselective and may kill non-target species (see Conover 2002). Traps have been made illegal in many parts of the world due to concerns over the high level of stress, pain and suffering on the animals that are caught. Notwithstanding this, trapping is still a major method for canid reduction, most notably in the control of coyotes in the USA and Patagonian foxes. Most countries where commercial trapping for furbearers still occurs, e.g., Canada, the European Union and the Russian Federation, have regulated open and closed seasons and restrictions on methods of capture, under an agreement on international trapping standards signed in 1997. Recently, an ISO standard was developed for mammal trap testing (ISO 1999), and there are efforts to research and disseminate best trapping practices (e.g., IAFWA 2003).

Shooting

Perhaps the most widely used method to kill canids, shooting is labour intensive but species-specific. For certain species, e.g., red fox, shooting with a rifle is usually regarded as offering the best combination of efficiency and humaneness, and is often carried out at night with a spotlight and vehicle (Reynolds and Tapper 1996). Shooting on a large scale has been used in North America to control canid populations, including aerial hunting from helicopters; this technique is commonly used by agriculture

agencies in the western USA to reduce coyote predation on sheep (Wagner and Conover 1999). Used in combination with expert tracking, or stalking at a kill site, shooting becomes a good method for targeting problem animals, although it requires experienced personnel.

Denning

Farmers often resort to trapping canids in their dens, digging them out and euthanizing them, or fumigating the den and asphyxiating the occupants. Although still legal as a means to control pest species in the USA and elsewhere, both methods are considered inhumane and their use is strongly discouraged.

Poison baiting

Baits containing poison are often used in schemes to eradicate canids from a large area, and were one of the chief methods by which wolves were exterminated from large parts of Europe and North America (e.g., wolf poison campaigns to increase wild ungulate populations in Alberta, Canada in the 1950s and 1960s; Gunson 1992). Among population culling techniques, poisoning exemplifies a necessary trade-off between utility (cost-efficiency), conservation (target-specificity) and humaneness, with no one method satisfying all criteria (see Sillero-Zubiri et al. 2004).

In addition to widespread opposition on welfare grounds, there are serious concerns about the effects of toxins on other wildlife and livestock, since poison baits are not discriminatory. This is of particular concern to conservationists where the intended target species is sympatric with populations of a threatened species. In order to circumvent the specificity shortfall, coyotes in the USA have been targeted by a spring-powered device called M-44 that delivers a lethal dose, and that is selective by using bait designed only to attract canids (Beasom 1974).

Livestock protection collars

This collar consists of a sachet of poison attached to the neck of the domestic animal needing protection. It operates on the premise that many canids kill by a neck bite, and they would thus puncture the sachet, release and swallow the deadly poison. These collars are particularly effective as they target only the individual canids that are responsible for killing livestock, sparing those that do not engage on livestock predation, and take individuals that have evaded other capture methods (Burns et al. 1996). One study in California showed a halving of lamb losses to coyotes from 15.8 % to 7% of the flock (Timm 1999).

The main advantages of this method are its high specificity, its potential application on other livestock including cattle and goats, and protection against a number of predator species. Unfortunately, the need to equip most of the herd or flock with collars renders it impractical and expensive. Additionally, there has been objection over the use of the compound 1080 (sodium fluoroacetate) in the collars and the effect it may have on non-target species, as collars may accidentally fall off and subsequently come in contact with other wildlife.

Sport hunting

Hunting canids for sport remains a traditional pastime in Europe, Asia, North America, Patagonia and Australia. It may include hunting with firearms, bows or crossbows, or large organised hunts using horses and packs of dogs. From a management perspective, sport hunting can be used to offset livestock losses or dispose of known 'problem' animals, while it may also be useful in conserving populations of canids since it can increase their value. For example, some foxhunts in Britain have actually invested in management policies that conserve a certain population level of red foxes, such as habitat creation, artificial den sites, and artificial feeding, in order that there is sufficient quarry to hunt (Reynolds and Tapper 1996). Notwithstanding this, it is unlikely that sport hunting would deliver a viable alternative for mitigating human-canid conflict, as most canid species are not sought after by sports hunters.

Non-lethal alternatives

The search for non-lethal alternatives to manage canid conflict has intensified over the last few decades due to increasing conservation and welfare concerns. Non-lethal approaches

should not be thought of as a completely novel area, as many such methods (for example, suitable husbandry, guarding dogs and barriers) were traditionally used to reduce canid predation on livestock and game. Unfortunately, the traditional methods declined in use with the intensification of agriculture, but there is now a move back towards some of these traditional techniques and also a search for new non-lethal techniques. The most important aspect to realise with the development of these alternatives is that there is no one method that would be applicable in all situations, and often several may be needed in combination to significantly reduce conflict.

Use of fencing as a barrier for predation

Fencing can be employed either to keep predators out of a particular pasture, field or enclosure containing valuable stock, or to keep them confined within a particular area, such as a wildlife reserve. In Africa there is widespread use of traditional bomas or kraals, small enclosures built from dense thickets of Acacia bush (Acacia spp.), to protect livestock from predators when they are most vulnerable (e.g., at night or during calving). Kruuk (2002) showed that a simple thorn-bush boma could make a large difference to subsistence shepherds in northern Kenya, where 90% of all losses to predators took place outside enclosures. In Europe and Asia, livestock has traditionally been fenced in by hedges, stone-walls, wooden fences and more recently, barbed wire. Although these barriers are effective in preventing animals from straying, they offer little protection from predation, as they are permeable to discerning carnivores.

Small predator-proof fences have been used to protect ground-nesting birds (Bailey 1993), and have successfully excluded Arctic foxes from the nests of Alaskan pectoral sandpipers (*Calidris melanotos*) (Estelle et al. 1996). Installation costs and maintenance of predator-proof fences tend to be prohibitive at a large scale, and fencing would be impractical to prevent canid predation on sheep production systems in the western USA and Argentine Patagonia (Knowlton et al. 1999). In Australia, however, a 5,614km fence excludes dingoes from sheep farming lands in South Australia, Queensland, and New South Wales (Reynolds and Tapper 1996), and it is deemed that sheep farming would not be viable without this fence.

Electric fences provide a promising non-lethal predation avoidance/ protection system that also protects the carnivores involved, and can be cost-effective for some species in some situations (Balharry and Macdonald 1999). In the Rumanian Carpathos, tests of mobile night corrals were successful at significantly reducing losses to wolves and bears (Mertens et al 2002). As a cheaper alternative to wire fences, Musiani and Visalberghi (2001) propose "fladry", a line of red flags hanging from ropes traditionally used to hunt wolves in eastern Europe, which in tests showed captive wolves avoiding the flags even when the daily food ration was placed on the other side.

Fencing reserves and their wildlife has been used as a way of reducing conflict with the surrounding communities. Although this is an outdated conservation approach and antagonised with modern 'open' conservation systems, in many places it has proved very effective. Several public and private areas in South Africa are prime examples, such as Kruger or Pilanesberg National Parks. Unfortunately, permanent fence construction and upkeep are costly, thus precluding their use in poorer countries. More importantly fencing effectively cuts wildlife movement and may result in catastrophes during droughts or bushfires, and the small size of many fenced reserves means that populations of canids with a small genetic pool will require active management.

Improving livestock husbandry

Predation risk tends to increase with herd size, distance from people and buildings, proximity to thick cover, and carcasses left in the open (e.g., Mech et al. 2000; Kruuk 2002); many of these attributes are brought about by the extensification of livestock farming.

Diligent husbandry is essential to prevent unnecessary losses, such as improved vigilance, preventing livestock from straying and returning herds to enclosures at night (e.g., Kruuk 2002). It has also been argued that in certain economies, utilising additional manpower is justified because it has economic benefits beyond those accrued simply through reduced predation. Most of these are resultant from improved stock tractability and herder vigilance, and include reduced stock theft, increased weaning weights because calves spend more time with their dams, and sick animals or cows with calving difficulties are

noticed earlier. In addition, as cattle become more manageable with the continual handling there is a reduction in losses to physical injuries from breakouts and they benefit from fewer stress-related problems (Rasmussen 1999).

Specific husbandry practices, however, must be developed for the particular situation of each producer's group, and evaluated accordingly, to prevent the use of practices that may only delay predation or have undesirable side effects (Knowlton et al. 1999). At a larger land-use scale, diversification has been proposed to reduce conflict (Johnson et al. 2001), such as shifting from sheep to cattle husbandry (e.g., Patagonia).

Livestock guarding animals

Livestock guarding dogs (LGDs) have been used by shepherds to guard their flocks from predator attacks in Europe and Asia as early as the 6th century (Rigg 2001). With the foregoing of traditional livestock techniques, the use of LGDs had been in decline in much of Europe, and flocks were left unprotected in many areas. However, the recovery of predator populations in many areas has lead to a re-awakening of interest in using LGDs to protect livestock. For instance, the reintroduction of LGDs is currently underway in several southern and Eastern European countries to prevent wolf predation. LGDs have also been extensively trialed in the USA and are now in use in a number of western states to help reduce coyote predation on sheep.

A good LGD is usually large, independent, intelligent, attentive and gentle towards livestock, but aggressive towards predators (Knowlton et al. 1999). The dogs are placed with a flock or herd of animals from an early age and bond with them, effectively becoming part of the herd. They remain with the herd at all times, even when humans are absent, alerting the flock and shepherds to the presence of predators and will themselves attempt to drive predators away from the flocks. Overall, the economics of using LGDs is dependent on a number of factors including the annual rate of predation, the ability and longevity of the dog, and the costs of purchase and maintenance (Green et al. 1984). To be effective LGDs must be able to see predators approaching easily, and, therefore, it is best to use them in flocks of 100-200 sheep in large open pastures, or instead in small fenced areas (Rigg 2001).

Although the most frequently used, dogs are not the only animals that can be used for livestock guarding. Llamas have proved to be effective livestock guards in certain situations and since the early 1980s have been increasingly used in the USA to defend against predation on sheep by wolves and coyotes (Meadows and Knowlton 2000). Llamas have an inherent dislike of canids, and when pastured away from other llamas will bond with sheep becoming part of the flock. They have several advantages over LGDs, namely they live longer, require less training, have a faster acquisition of guardian status, have fewer special management considerations such as food and maintenance, and are more compatible with other depredation techniques (Meadows and Knowlton 2000). However, their ability to guard the sheep depends on the ability to see the whole pasture and the sheep within it, and, therefore, it may be better for them to be used in relatively small, flat, open pastures (Timm 1999). They can also cause trouble if dogs are used to herd the sheep, as they will often behave aggressively towards these dogs (Timm 1999).

Donkeys were often used to defend livestock from predators in Namibia when European-owned farms developed there a century ago, and are now making a comeback (Rigg 2001). In Switzerland, donkeys have been used to guard sheep since 1995. Donkeys are capable of providing a high level of protection at a relatively low cost and level of maintenance (Rigg 2001), and their use could be very beneficial in developing countries where the cost of maintaining LGDs may be too high to be economically viable for most farmers.

Translocation of problem animals

Translocation has been used in North America to manage individual grey wolves involved in livestock depredation. It has also had limited application with African wild dogs, involving the relocation of whole packs from problem farmland areas. In Zimbabwe such translocations have showed high survival of the new founder stock (90% survival), followed by successful reproduction in the new area. This experience has showed promise for similar translocations in the future, as it delivers a face saving excuse to farmers that otherwise would have illegally killed the dogs. Even though new dogs have slowly filled the artificial vacuum created by the trans-

location, the latter has assisted to maintain an 'entente cordiale' with landowners (G. Rasmussen pers. comm.).

There are concerns that the survival of translocated animals may be poor, particularly in an ecosystem with a high density of conspecifics where a translocated animal could get an opportunity to fit into the social system (Linnell et al. 1997). For example, of 107 wolves translocated in northern Minnesota following depredation or harassment of livestock, 17% were shot, or recaptured at least once, for re-offending (Fritts et al. 1984) Although the mortality of translocated wolves was not higher than that of resident wolves, pack mates failed to stay together and travelled long distances with some animals returning home. It would appear that unless there are large areas available with a low density of conspecifics and where conflict potential is low, this strategy is unlikely to work (Linnell et al. 1997) (see Chapter 15 for a more detailed discussion of canid translocations).

Conditioned taste aversion

The principle of conditioned taste aversion (CTA) relies on taste and olfactory agents that cause a deep and lasting aversion to associated tastes and create a negative association between eating a particular food and sickness. Gustavson et al. (1976) first suggested that lacing lithium chloride on baits could be a useful management tool for problem predators and extensive trials have been conducted since, but because of poor experimental design, results have been equivocal and, therefore, controversial (Reynolds 1999). Unfortunately, CTA does not seem to be viable as a canid deterrent (Andelt et al. 1999; Linnell 2001); predators do not seem to associate the illness with killing behaviour, and, therefore, they often continue to kill livestock. Furthermore, there are practical problems with CTA application, in that it requires the predator to be treated several times, and as new individuals are recruited into the population treatment would need to be repeated regularly.

Direct, generalised aversion to foul-tasting substances, such as BitrexTM, has an advantage over CTA in that because the experience of foul taste on sampling is immediate it involves no ambiguity as to which prey is associated with the negative experience, and it may, therefore, effectively confer protection upon untreated prey. This has been shown with a family of captive red foxes successfully conditioned to avoid untreated milk after drinking treated milk (Macdonald and Baker 2004), and may hold some potential as a predation deterrent.

Aversion and disruptive stimuli

Undesirable stimuli such as sonic and light deterrents have been tested to scare canids away from livestock and game. These can include strobes, sirens or pyrotechnics that aim to startle or frighten a predator, forcing them to retreat from an area of livestock or disrupting their predatory attempts (Shivik and Martin 2001; Shivik et al. 2003). Sounds are alleged to repel animals by several mechanisms including, pain, fear, communication jamming, and disorientation (Bomford and O'Brien 1990). Explosive bangs deliver sound loud enough to cause pain, but often are a nuisance to humans and the use of pain for animal control tends to draw animal welfare objections. Another disadvantage to these sound repellents is that animals quickly become habituated to them, rendering them ineffective in the long-term.

A more advanced and novel use of disruptive stimuli is to coordinate the activation of the stimuli with the actual predation behaviour. Disruptive stimuli could be triggered by collars worn by individual canids, so that the stimuli are activated on the approach of the predator toward a certain area, i.e., a pasture containing livestock (Shivik et al. 2003). Collars can also be fitted that will give a canid an electric shock if they attempt to attack livestock, causing pain and discomfort and hence repelling the individual (Shivik et al. 2002). These collars could be placed on target animals by using automated collaring devices (Rasmussen 1997; Shivik et al. 2000), and by placing these collaring devices in the vicinity of livestock herds it may be possible to target collaring to those animals which are most likely to attack livestock. The potential for this approach is somewhat limited due to high costs of equipment and the level of expertise needed to set up the systems. However, they may prove useful in areas where the conservation of a threatened predator is paramount, thereby justifying the high cost.

Fertility control

In theory, canid populations could be manipulated by controlling their reproductive capacity, and fertility control via immunocontraception

and chemosterilants have been proposed for such population control (Asa 1992). In Australia, immunocontraception of red foxes has been tested to deliver protection from predation to marsupials (Newsome 1995). This approach could prove useful for many common canid species involved in conflict, but current technology has the disadvantage that a high 'hit rate' is required to achieve population control, as well as the need of handling, and the ensuing high cost and effort. Baiting with birth control chemicals may become a viable option in the future, pending the development of easy to use, reliable and safe birth control compounds.

Approaches to increase tolerance of canids

The traditional approach to dealing with troublesome predators is giving way to a more compassionate one that also focuses on changing human perceptions and behaviour in an attempt to reduce conflict while coexisting with wild species. For this to happen, a greater awareness of the views of all the relevant stakeholders (e.g., livestock producers, wildlife managers, hunters, conservationists, the public at large), and a willingness to work together toward solutions is essential if we are to be successful at reducing conflict. By changing the attitudes of those affected and increasing the threshold of what people are prepared to tolerate, an otherwise insurmountable conflict may become manageable. In addition, economic benefits may be accrued from conserving canids and other wildlife, such as from tourism and employment, or the broader society may bear a share of the costs, through compensation and insurance schemes.

Recognising the problem

One of the first steps in reducing human-canid conflict is to acknowledge that there is a problem and to view it with objectivity (Sillero-Zubiri and Laurenson 2001). The negative impact of canids on a local economy tends to affect well-defined communities, be it small-scale shepherds in Africa or the Carpathian mountains, gamekeepers on the British moorlands, Argentine and Australian sheep farmers or Rocky Mountains cattle ranchers. Often these groups feel they are marginalized or ignored by government officials, particularly conservationists. As in many walks of life, simply listening to a grievance and recognising a community's problem can alleviate the problem through reducing underlying tension.

Community participation and sharing revenue

Novel ideas for the co-management of habitat and wildlife with local communities are increasingly seen as the way forward for conservation, particularly outside protected areas. These frequently involve improving the economic benefits the community may derive from wildlife. Community participation in wildlife management might involve the design and management of a protected area, such as the Afroalpine grasslands of Menz that afford protection to Ethiopian wolves (*Canis simensis*) (Malcolm and Ashenafi 1997), or the actual transfer of land and resource rights to local communities. In Canada's Western Arctic, polar bears (*Ursus maritimus*) have benefited from a co-operative wildlife management process established by the Inuvialuit Land Claim, which indirectly reflects on wolf and Arctic fox conservation (Bailey et al. 1995). An interesting by-product of this initiative is that it overcame the mutual distrust existing between government biologists and the Inuvialuit.

There are a number of ways in which programmes have endeavoured to transfer economic benefits to local communities, particularly through ecotourism, hunting, employment and compensation for any livestock losses. Clearly, where economic benefits are substantial, this is one of the most powerful ways of reducing negative perceptions of wild carnivores and wildlife in general. The philosophy that local communities should directly benefit financially from conservation underpins many of the recent strategies for community-based conservation, although it is not without its critics.

One example of community conservation that indirectly benefited African wild dogs in a few areas is the Communal Areas Management Programme for Indigenous Resources (CAMPFIRE) in Zimbabwe. This programme was set up to promote conservation of wildlife through utilisation by allowing communal landholders to receive direct income generated by hunting fees, game-viewing and curio sales (Child 1996). Large predators, previously persecuted for livestock losses, now have enhanced value for the local people as they command

substantial hunting fees. Probably of greater value, however, are conservation projects that become significant employers in the local community (e.g., the Ethiopian Wolf Conservation Programme), and may also provide additional social benefits such as supporting schools and providing healthcare.

Compensation and other cost-sharing schemes

The cost of tolerating wild canids tends to be unevenly spread, and there is a case for the broader society to share the burden with the few afflicted individuals through public funding. Compensation schemes are one such mechanism, but they have faced many limitations and may soon give way to better alternatives.

Direct compensation for livestock losses has proven to be a relatively widespread and sometimes inexpensive, but not always effective, means for relaxing opposition to canid conservation. In Italy, for example, the local government compensates 100% of the value of livestock killed by wolves, bears and even feral dogs (Cozza et al. 1996). This amounted to a modest 0.4-2.8% of total livestock subsidies in the region. It is vital that the criteria for compensation are clearly laid out, to avoid abuses in the claim system. For example, a few farmers may take advantage of the situation to gain other subsidies. In Italy, farmers sometimes keep old or infirm sheep for headage payments, but these are more likely to be killed by predators (Cozza et al. 1996). The opposite of compensation is a bounty scheme, such as that in place with a group of Argentine sheep producers, the majority of whom get 5-10 fox bounties every year, effectively subsidising some of their losses (Novaro et al. 2004).

Although compensation schemes may alleviate direct losses to farmers, they do nothing to alleviate the problem, rarely deal with full costs, are open to corruption, can involve expensive bureaucracy, and tend to encourage a state of constant conflict. Furthermore, they often do not identify and improve situations where only a few farmers suffer the vast majority of losses, nor do they encourage the improvement of management systems (though these shortfalls may be alleviated if compensation criteria are modified). Crucial components of a successful compensation scheme include quick and accurate verification of damage, prompt and fair payment, sufficient and sustainable funds, and measures of success (Nyhus et al. 2003). As compensation schemes are costly to administer and are open to corruption, a scheme could be considered whereby rather than paying owners for each kill, they are paid a lump sum to tolerate predators. This approach would positively benefit those that have good husbandry practices and hopefully promote others to follow suit.

Some of the difficulties inherent in compensation may be circumvented by community-based insurance schemes, where the community has a vested interest in the transparency of the system and legitimacy of claims, and where producers sustaining least losses may derive some benefit analogous to a "no-claim" bonus. Commercial livestock growers may insure valuable stock against predation, particularly with pedigree herds, using established commercial insurance brokers. Premiums could then be reflected by parameters such as management strategies and risk of predation due to proximity to the wildlife area. As a result, rather than 'managing the predator', in order to meet regulations set by insurers, such a system would encourage ranchers to adopt an active herd management strategy (e.g., Rasmussen 1999).

In the USA, Defenders of Wildlife has created an innovative programme called the Proactive Carnivore Conservation Fund with the objectives of reducing conflicts between predators and humans, keeping predators from being unnecessarily killed by agencies in response to human conflicts, and increasing general tolerance for carnivores across the landscape. They cost-share with ranchers actions to prevent livestock depredation from occurring, such as buying livestock guardian dogs, erecting electric fencing to keep wolves away from sheep, hiring "wolf guardians" to monitor wolves in sheep territory by radio telemetry, and chasing them away when they get close to livestock (N. Fascione pers. comm.). Defenders of Wildlife has also paid more than US$ 250,000 in compensation to ranchers for losses due to wolf attacks since 1995.

Other alternatives include providing tax incentives to landowners and transferring user fees from recreation to landowners. A novel way of sharing the cost of living with carnivores is to add a premium price to goods labelled and marketed as produced by "predator-friendly" farms (e.g., Cheetah Conservation Fund; L. Marker pers. comm.), and "wolf-friendly" and "wild dog-

friendly" beef would be the next natural step for this approach.

Recreational use

Ecotourism has been a major growth industry over the last 20 years and there is no doubt that some canid species are becoming an attraction for tourists planning a traditional wildlife safari. Traditionally, tourism has been a source of revenue for established conservation areas, with parts of Africa, India and the Rocky Mountains abounding with examples where safari tourism has become a major source of income. In southern Africa, commercial farmers, whose precarious income from cattle farming has always been susceptible to drought, are increasingly turning to tourism as well as consumptive trophy hunting as an alternative source of income (Lambrechts 1995).

Although ecotourism appears to be a potent tool for canid conservation, it is perhaps only the high profile and visible canid species (e.g., African wild dogs, grey wolves, Ethiopian wolves, dholes and maned wolves) that may draw tourists, and hence may be partially capable of supporting a sustainable tourist trade. This approach may be unsuitable to other more secretive species or those extremely sensitive to human pressure. However, it is not necessarily seeing the animal that is important, as many visitors to areas renowned for their predators are attracted by the knowledge of the presence of these animals, even if the chance of sightings may be minimal. But expectations may surpass reality and tourists and experienced naturalists alike may become disappointed if they do not see the elusive focus of their interest during their visit.

However, a note of caution is needed as the economic rewards of ecotourism may be low or not reach the expectations of the local community. For example, in the Bale Mountains in Ethiopia, where income from tourism is often given as a justification to the local community for the presence of a park, the number of tourists visiting each year is numbered only in the hundreds, many visitors hire vehicles rather than local horses or guides to see the area, and the amount of money that goes into the local community is relatively small. Tourism may also be susceptible to changes in the global economy or political stability of a given country. This was dramatically displayed by the recent crash in Zimbabwe's substantial tourism trade (with African wild dogs a significant attraction), due to ongoing political instability. Thus, it would be unwise to hinge carnivore conservation purely on the economic benefits accrued from tourism, particularly as only a proportion of these benefits may go to local communities. It is also salient to point out that many regions do not necessarily lend themselves to ecotourism, and, furthermore, many rural communities may not welcome the intrusion of paying visitors.

Conservation education

In many situations it is impossible to provide sufficient economic benefit to local communities to compensate for the resources that are lost to wildlife. In these circumstances the most important way that public support can be gained for large canids and their conservation is through educational programmes, so that local people can relate positively to the species or habitats in question. Perceptions of predator problems often exaggerate the reality (e.g., Rasmussen 1999), and education programmes can target this by delivering accurate information and increase people's tolerance and appreciation for wildlife (Conover 2002).

Recommendations to involve the local community include targeting key groups with education campaigns, building support through the use of spokespeople within the target groups, integrating human and ecological concerns and, if possible, designing species-specific education initiatives using the species as a flagship for other conservation concerns. Some canid species can act as such flagships to gain public support for habitat conservation - grey and Ethiopian wolves being good examples, with comparable potential for African wild dogs, dholes and perhaps even Darwin's or island foxes. Conservation projects may engender a local pride so that the community see the target species as "their" animal, and this is more often than not the root of the problem.

In the recent past educational activities have been seen as the first step in outreach programmes around protected areas, and indeed are increasingly becoming an integral part of the activities of conservation agencies, but their success is still open to question and not often evaluated. In a few cases involving canids that we reviewed, however, there was an obvious improvement in the situation. For example, in

northern Kenya the killing of wild dog pups at dens stopped (K. Doherty pers. comm.) and in Canada an education programme made farmers aware of the presence and conservation importance of swift foxes and the farmers became involved in monitoring foxes (A. Moehrenschlager pers. comm.). For education programmes to reach their full potential as formal undertakings, it is imperative that adequate funding, resources, and trained personnel are available, as opposed to being additions "tagged" onto existing research programmes.

Conclusions

Increasingly, farmers are re-examining traditional anti-predation methods and, with the use of new technology, adapting and developing them to fit into modern livestock production systems. Simple husbandry practices, such as keeping livestock in pens at night, extra surveillance by herdsmen and shepherds, the provision of alternative pastures away from canid dens, the proper disposal of livestock carcasses, and the use of livestock guarding dogs (particularly breeds with more developed anti-predator instincts), may all help to reduce livestock losses.

In some cases, it may be difficult to change livestock husbandry, either because farmers are resistant to change or because management options are too difficult or expensive to put into practice. There may also simply be little incentive for farmers to change, if losses are relatively low, or else farmers may not be keen to take on perceived extra work. Thus, it is important that the local community is involved by any process seeking to address human-canid conflict through the various conservation approaches reviewed, in the

hope of reverting traditionally, deeply based, negative views of wild canids in younger generations. Community involvement, however, requires strong partnerships, shared goals for both wildlife and human communities, and shared responsibility.

Realistically, in human-dominated landscapes where canids and people coexist there will only be, at best, an uneasy tolerance. Thus, to conserve wild canids, conservation policy must encompass a mixture of strategies, including protectionism, conservation education, public relations, community involvement and revenue sharing. While some of the examples in this review have illustrated how steps have been taken along this path, future conservation efforts must expand the use and variety of innovative and imaginative solutions to canid-human conflicts.

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