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Livestock guarding dogs: their current use world wide

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Robin Rigg

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Forward

The use of livestock guarding dogs in carnivore conservation

While most large carnivore species are threatened, there are some carnivore populations which are recovering, notably in North America and Central and Eastern Europe, where large carnivores are returning to areas where they had vanished long ago. Combined with a relaxation of responsible livestock guarding in many areas where carnivores had been eradicated, modern farmers no longer know how to protect their animals against attacks from wolves, coyotes, bears, pumas, lynx and others. Livestock losses often lead to increased antagonism towards wild carnivores and any associated conservation project, with the overall negative impact on conservation activities often exceeding the actual financial cost of predation.

It is therefore important that this increasing conflict is addressed, not only through education and alleviation schemes but also by taking active steps to reduce livestock losses to predators. There is much to be learnt from the herding traditions of regions where large carnivores have survived, such as the use of livestock guarding dogs in the Italian highlands and sheep herding techniques in Eastern Europe.

A better understanding of the various approaches and techniques tried and tested across a wide range of countries and projects may provide appropriate preventative measures for other areas. This is relevant to the current research WildCRU and the Born Free Foundation are undertaking on Human Wildlife Conflict Resolution and, more specifically, in the field testing of anti-predator strategies in Slovakia.

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Cover photograph: An eight week old Slovenský èuvaè undergoing socialisation with lambs as part of the project Protection of Livestock and Conservation of Large Carnivores in Slovakia. R. Rigg, 2nd July 2000.

Introduction

Aims

This report aims to outline the basic concepts of using dogs to protect livestock from predators, to describe some of the breeds involved, to give brief advice on acquiring and raising dogs to be successful livestock guardians and to provide some indication of how to solve common problems. Its main purpose, however, is to compile a detailed review of current practices in the use of livestock guarding dogs throughout the world and to discuss these in relation to livestock depredation by predators. The annexes list known users and experts on livestock guarding dogs as well as sources of further information available in the scientific literature and on the internet.

Target audience

Wildlife managers, potential sponsors of livestock guarding dog and human-wildlife conflict resolution projects, researchers as well as livestock breeders.

Sources

The majority of material presented here was obtained from literature searches of scientific journals along with presentations from the 2nd International Wildlife Management Congress in Gödöllõ, Hungary from the 28th June to 2nd July 1999 and the Beyond 2000: Realities of Global Wolf Restoration symposium in Duluth, Minnesota from the 23rd to 26th February 2000 as well as the author's own experience of fieldwork in Slovakia in 1996-2001 and a brief study visit to Romania and Bulgaria from 9th to 24th August 2001. Consultations with various colleagues have been held as opportunity has allowed. As a great deal of work with livestock guarding dogs is not of a scientific nature, particularly outside the USA, additional material available on the internet between October 2000 and October 2001 has been included. For convenience, website addresses for articles posted on the internet have been included in the Annex II reference section and useful website addresses have also been provided in the early sections of the report (references to websites given within the body of text quote the year in which the site was visited).

Limitations

Although the intention has been to provide case studies from as many countries using livestock guarding dogs as possible, there was a shortage of information among the sources reviewed for some regions, particularly Asia and South and Central America, as well as some European states. ¼. Remeta (pers. comm. 2001) described groups of Caucasian Shepherd dogs being left for days at a time in sole charge of large herds (thousands) of livestock in Dagestan, Black and Green (1985 citing Orbigny 1826) mentioned working dogs in Uruguay and Darwin (1845 in Coppinger *et al* 1985) also observed dogs socialised to and guarding livestock in Banda Oriental; Arons (1980) mentioned and Coppinger *et al* (1985) discussed livestock guarding dogs in Mexico, the early Southwest US and South America. The latter authors also postulated reasons for the demise of the Castillian mastiff. Landry (1999*b*) has briefly reviewed observations from Bosnia, the Sharplanina region of Macedonia, Kosovo and Albania as well as the Caucasus (Georgia); Coppinger and Coppinger (1995) and Lorenz and Coppinger (1986) included captioned photographs of Shar Planinetz in Yugoslavia; whilst husbandry practices associated with livestock guarding dog use in these European countries do not seem to diverge greatly, as far as the evidence suggests, from those described for other European countries included in this report, practices in Latin America and Asia may be quite different.

Basics

Definitions: What is a livestock guarding dog?

Dogs have been used by people in Europe and Asia for millennia to guard domesticated animals against wild predators, stray or feral dogs and human thieves. Over the centuries, a distinct set of dogs has been developed throughout Eurasia from Portugal to Tibet. These are known as livestock guarding dogs or flock guards.

Livestock guarding dogs (LGDs), rather than helping herdsmen move their stock as do typical herding dogs such as collies, protect the animals from external threats. They are usually large (often 70 cm at the withers and >45 kg), independent, stubborn and intelligent. They are less energetic than herding dogs, with calm dispositions. Most breeds have a large head and pendant, rather than pricked, ears.

Like other dogs, LGDs are social animals: they have a great need to stay in a group, especially with individuals that they have known since their early years. This feature has been inherited from wolves, the immediate ancestors of domestic dogs and has been used to socialise LGDs with livestock at an early age. In adulthood the dogs then follow and protect the flock as if they were part of it. The coat colour of LGD breeds has been adapted to the appearance of the animals that they have to guard: white dogs with white sheep, coloured (brown or grey) dogs with coloured sheep, goats or yaks. This increases the likelihood of livestock accepting the dogs among them and possibly helps shepherds to distinguish dogs from predators and/or gives the LGDs an element of surprise in confronting predators.

The typical LGD temperament (described by the UKC for the Sarplaninac), is: "highly intelligent and independent, devoted to family members and wary of strangers, calm and steady but fearless and quick to react to perceived threats."

Livestock Guarding Dog Association
http://www.lgd.org

Flock & Family Guardian Network
Livestock and family guardian dog comprehensive resource gateway
http://www.flockguard.org

Dog Owner's Guide: Livestock guard dogs
http://www.canismajor.com/dog/livestck.html

Guardian dogs. The United Kennel Club (UKC)
http://www.ukcdogs.com/GuardianDogs/GuardianDogs.html

Working Dog Web
http://www.workingdogweb.com/wdbreeds.htm

Guarding dogs versus herding dogs

Livestock guarding dogs work by being attentive to livestock and driving away intruders (McGrew and Blakesley 1982). Coppinger and Coppinger (1987) were sceptical that serious physical combat took place more than rarely, although there are claims that LGD-predator encounters often involve fights, such as in Sedefchev (2000) writing about the Karakatchan in Bulgaria (see USA LGD evaluation for speculation on how guarding dogs might reduce predation on livestock). Coppinger *et al* (1988 citing Coppinger *et al* 1987) suggested that LGDs display arrested development (neoteny) of predatory motor sequences and retain juvenile characteristics throughout their lives (Coppinger *et al* 1983). This, they argued, also blurs species-specific recognition, allowing dogs to bond with livestock such as sheep. Herding dogs, by contrast, retain predatory sequences which can be seen in their eye-stalk-chase approach to livestock (Coppinger *et al* 1985 citing Holmes 1966 and Vines 1981), although these sequences are incomplete or inhibited (collies do not usually catch and kill livestock). In short, LGDs behave towards livestock as if they were siblings whereas herding dogs behave as though they were stalking prey.

Historical origins

The origins of livestock guarding dogs can be traced back nearly 6000 years, possibly to the upland region of present-day Turkey, Iraq and Syria (de la Cruz 1995). Sheep and goats seem to have first been domesticated around 7000-8000 years BC in the area of present day Iran and Iraq. These early animals were black, grey or brown and the first guard dogs were similarly coloured, as is e.g. the Sharplaninatz (de la Cruz 1995). Large dogs are present in 13th BC illustrations recovered from the ruins of Babylon or Nineveh in ancient Assyria (reviewed in Landry 1999*b* and Taylor 2000). Domestic dogs and sheep first appear together in archaeological sites dated 3585 BC The first ancestors of guarding dogs probably arrived in Europe with nomadic shepherds from the Caucasus in the 6th century BC.

White wool was favoured in Roman times and consequently dogs were selected for white colour, leading to breeds such as the Kuvasz and Pyrenean Mountain Dog, typically of 35-65 kg (de la Cruz 1995). Lucius Junius Moderatus Columella in *res Rustica* (65 CE) and Macius Terentius Varro in *Res rusticae* (36 BCE) wrote that white dogs were preferred as they could be distinguished from wolves and other predators; modern authors have suggested that coloured dogs pre-dated the ability to wash white wool and dye it in various colours. There is evidence, though, that livestock themselves may have been at least partially involved in selecting the dogs

that guarded them, as they were seen to be more comfortable with the dogs that most resembled them in appearance (reviewed in Taylor 2000).

Until very recently dogs were selected by herders to be livestock guardians on the basis of their physical attributes and behaviour as pups, their working traits and possibly also according to superstitions (as in Greece, Hubbard 1947 and Bulgaria, M. Stoeva pers. comm. 2001). People used what was locally available ("the founder effect") and adapted dogs to the required task, creating a set of animals variable in appearance but fairly consistent in function, termed a "land-race". Gradually they were then standardised by selective breeding (Sponenberg 2000). The concept of "pure breeds" with Standards only emerged from English views of animal husbandry in the 19th century (de la Cruz 1995). Since then the International Canine Federation and other registry bodies have recognised many breeds of livestock guarding dogs and fixed or accepted Standards for them. This, together with changing use of dogs, has sometimes resulted in breeding for traits other than would be desirable in working livestock guarding dogs. D. and J. Nelson (quoted in Sponenberg 2000) called the process of standardising breeds away from their original niche "gentrification". Significant physical changes in some livestock guarding dog breeds have been observed in recent decades (e.g. Landry 1999*b* citing M. Nussbaumer pers. comm.) and show or pet dogs may be smaller than their working counterparts (Hubbard 1947; Pedro 1996-2000*a*).

On the other hand, the advantage of having breeds is that they represent predictable genetic packages: two pure-bred livestock guarding dogs will have pure-bred pups which can reasonably be expected to have similar behaviour to their parents, i.e. guard rather than herd livestock. This predictability greatly facilitates raising different dogs for different purposes in a variety of situations (Sponenberg 2000). Taylor (2000) noted that, as for related wild animal species (including wolves), body mass is generally greater for breeds from cold climates, typically "mountain dogs" or mastiffs e.g. the Turkish Kangal, and less for those from warmer climates, the "desert dogs" derived from gazehounds or greyhounds e.g. the Turkish Akbash.

Advantages: Why use livestock guarding dogs?

Ginsberg and Macdonald (1990) believed that livestock guarding dogs continued to represent "perhaps the most cost effective method of non-lethal predator control".

Based on the results of a great deal of research on numerous dogs and livestock operations, the United States Department of Agriculture (USDA 1998) found the main advantages of LGDs to be:-

- reduction of predation on livestock;

- reduction of labour (lessening the need for night corralling);
- alerting owners to disturbances in the flock;
- protecting the owner's family and property;
- allowing more efficient use of pastures and potential expansion of the flock.

Several US studies have noted that guard dogs can greatly reduce livestock depredation by carnivores (see USA LGD evaluation). Green *et al* (1984) reported the greatest benefit of LGDs was in reducing predation, but 87% of producers also felt greater peace of mind with their dogs present, 53% said they reduced reliance on other forms of predator control and 47% said they eliminated the need for night confinement. These authors concluded that there are few limitations to the type of conditions under which a good dog can be a benefit.

The use of LGDs also has a role in carnivore conservation. In Europe, Boitani (pers. comm. to Ginsberg and Macdonald 1990) argued strongly that the traditional use of LGDs by Italian shepherds was pivotal to the historical coexistence of wolves and sheep. A number of on-going carnivore conservation projects include the use of LGDs. Coppinger and Coppinger (1987) recommended placing LGDs *in advance* of anticipated predator recovery or reintroduction so that they become established as residents and hence will be likely to defend their territories – and flocks – better against in-coming carnivores, especially in the case of canids such as wolves, which are treated as con-specifics (Coppinger and Coppinger 1995).

Practicalities

How to choose pups

The Livestock Guarding Dog Association (in Lit.) recommend choosing a pup from a reputable breeder after seeing at least the mother, if not both parents. The surroundings should appear clean and the pup healthy, happy and outgoing (not shy), rounded and firm (not emaciated) and with no discharge from eyes or nose. It should stand on strong legs and feet, receive a registration certificate, pedigree and inoculations/medications.

Andelt (1999*a*) provided the following guidelines for choosing pups:

> *"Buy a pup between 6 and 8 weeks old, or an older dog that was raised with sheep. Examine the pup, and parents if possible. Adults should have sound shoulders, legs and feet and be certified or guaranteed free of hip dysplasia. Be sure that neither parent exhibits excessive aggressiveness or shyness. These traits are likely to show up later in the pup. Look for*

> *sound muscle and bone structure in the pups, including well-shaped heads, jaws and teeth. The teeth should meet, or preferably overlap in a scissors bite. Check eyes and ears for discharges. The pup should be confident, outgoing and friendly. Avoid a pup that seems overly shy, or one that dominates all its litter mates – it may later try to dominate you."*

Lorenz (1985) emphasised that the bloodline must be considered, ideally choosing a pup from good working parents rather than relying on the reputation of a particular breed because differences in temperament between dogs of the same breed may be greater than those between LGDs of different breeds.

How to choose a puppy
http://lgd.org/choosepup.html

Raising and training

The traditional practice of raising livestock guarding dogs employed by shepherds may be somewhat loose and informal, though with quite severe punishments metered out to badly behaved dogs, as among the Native American Navajo (Black and Green 1985), and/or depend largely on experienced adult dogs being available to teach pups, as in Romania (Mertens and Promberger 2000*b*). Ancient herders probably selected the original livestock guardians from among their general camp dogs which were most similar in size and colour to sheep and showed the weakest chase behaviour. As the Navajo still do, they may have allowed such dogs to whelp and raise pups among the herd, which the pups then grew to regard as their pack, preferring to remain with it and guard it in adult life (Miller unpub. reviewed in de la Cruz 1995). Examples of pups suckled by ewes have been reported (e.g. Darwin 1839 reviewed in Arons 1980) though Arons (1980) found that this was not essential for the development of LGDs nor, necessarily, resulted in better dogs.

A more formal system has been developed in the USA and refined through long-term research that provides a methodology for socialising pups with livestock without necessarily using adult LGDs as teachers. This has become widely accepted as the method of choice for establishing new LGD programmes, variations of which have been used by LGD/carnivore conservation projects in Slovakia (Bloch 1995; Rigg and Finï o 2000), Poland (Nowak and Mys³ajek 1999*a*; Œmietana 2000), Switzerland (Landry 1999*b*), Namibia (Marker 2000*a*,*c*) and elsewhere, to many of which R. and L. Coppinger have been consultants. The basis of the method is in selecting key elements of traditional practice and combining them with the analysis of LGD ontogeny and behaviour.

Coppinger and Coppinger (1978) reported that LGD behaviour was separated into three basic components: trustworthy, attentive and protective. The development of these three behaviours is considered critical for good livestock guarding dogs (Marker 2000*c* citing Coppinger and Coppinger 1980). Lorenz and Coppinger (1986) described these three traits as follows:

> ***"Trustworthy.*** *The absence of predatory behaviour is the basis of trustworthiness. Livestock-guarding dogs are selected to display investigatory and submissive behaviours that do not threaten sheep or other livestock. Approaching sheep with ears back and squinted eyes, avoiding direct eye contact and lying on the back are called submissive behaviours. Sniffing around the head or anal areas is called investigatory behaviour. Both are desirable behaviours, signs that your dog has the right instincts and is working properly.*
>
> ***Attentive.*** *The attraction of a guarding dog to a home-site and to surrogate littermates is the basis of attentiveness. Flock guardians are selected for their ability to follow other animals. Following a moving flock and sleeping and loafing among the sheep are signs of attentiveness to sheep. A dog that retreats to the flock at the approach of a stranger is showing another good sign of a sheep-attentive dog. Researchers have shown a direct correlation between attentiveness to livestock and a reduction in predation. Therefore, success depends on training your pup to follow sheep.*
>
> ***Protective.*** *The basis of protectiveness is your dog's ability to react to deviations from the routine. Consequently, flock guardians are selected for their ability to bark at new or strange activities. Typically, a young pup will respond to a new or strange situation by rushing out and barking with tail raised over its back. It will retreat to the sheep or home-site, if challenged, with tail between its legs. This is called approach-withdrawal behaviour. A predator, let's say a coyote, usually avoids the threatening approach-withdrawal behaviour of a guarding dog. Attacking a predator, which is generally unnecessary, rarely occurs. Interactions with potential predators often involve complex behaviours that are difficult to interpret. Approach-withdrawal behaviour may quickly shift to an aggressive display of dominance or a hasty retreat to the sheep. It might be coupled with defence of food or maternal-like defence of a young lamb. The distance of the approach toward strange activity increases as the dog matures. The distance a dog travels varies with individuals but rarely extends beyond the boundaries of the*

> *property. Because protective behaviour develops as a result of good trustworthy and attentive behaviours, it doesn't require specific training."*

In order to achieve a good adult LGD showing these three behavioural traits, a dog should be kept with, brought up with, socialised with and bonded with the stock it is going to protect (Coppinger 1992 quoted in Marker 2000*c*) – "If the dog isn't with the sheep it isn't where it's supposed to be." (Lorenz 1985). The critical period for dogs to form social attachments is roughly between 3 and 12 weeks of age (Landry 1999*b* citing Freedman *et al* 1961, Scott 1962, 1968 and Scott and Fuller 1965). This process is distinct from imprinting as described by Lorenz (1937 reviewed in Landry 1999*b*), which occurs when the pup first opens its eyes at about two weeks old. Social attachment becomes difficult after 16 weeks and so it is essential to begin the training of LGDs as pups; there are examples in the literature of unsuccessful attempts to introduce adult dogs to livestock in Namibia (Marker 2000*c*) and among the Navajo (Black and Green 1984). However, pups should not be separated from their mother and other dogs too early as they may later show fear of dogs (Landry 1999*b* citing Scott and Fuller 1965). The ideal age to begin training LGDs is around eight weeks old.

The Navajo's successful use of mongrels emphasises the importance of raising and training LGDs from pups, rather than relying on in-born traits alone. Both, however, are important: according to Coppinger *et al* (1988),.dogs not reared properly cannot be retrained to be successful guardians and dogs which do not have the right genes will not train regardless of management.

Assimilating all these issues, the USDA (1998) listed "Key points in successfully rearing a guarding dog":-

- Select a suitable breed and reputable breeder;
- Rear pups singly from 8 weeks of age with sheep, minimising human contact (probably the most critical ingredient for success);
- Monitor the dog and correct undesirable behaviours;
- Encourage the dog to remain with or near the livestock;
- Ensure the dog's health and safety;
- Manage the livestock in accordance with the dog's age and experience (e.g. use smaller pastures while the dog is young and inexperienced);
- Be patient and allow plenty of time to train your dog. Remember that a guarding dog may take 2 years or more to mature.

A modified system of raising LGDs has been described which may be more suitable for smallholdings (see Australia LGD training).

LGDs can usually be expected to begin work when around one year old. Dogs usually live for 10-12 years, barring accidents or illness (Lorenz 1985) so will provide up to 10 years of productive service (Green *et al* 1984) as it may take more than a year for LGDs to develop enough confidence to attack predators, especially other domestic dogs (Arons 1980). See USA LGD evaluation for percentage mortality at different ages and causes of death.

R. Coppinger (pers. comm. to Cluff and Murray 1995) noted that two years are required for a LGD programme to be in place once a need has been identified, although Coppinger and Coppinger (1987) pointed out that the process of incorporating LGDs into existing livestock operations can be greatly speeded up by people with expertise and dogs of known quality.

Common problems

Dogs often act playfully as puppies in the period from 6 months to 1 year and may make mistakes, but corrective measures and patience while the dog matures will remove these undesirable behaviours in most cases (Arons 1980).

Green *et al* (1984) reported that producers mentioned the following difficulties with adult or juvenile LGDs: caused problems when sheep were worked (84%); farmer worried about the dog's safety (22%); had unwanted breeding (9%); pups were too playful with sheep (69%; for 64% this had not been a serious problem while 32% said it had demanded considerable time and training); dog roamed (4%); sometimes bit people (7 of 137 dogs or 7%); or chased wildlife (3%). However, 52% reported that their LGDs caused no extra worry. The USDA (1998) recommended posting signs to alert passers by to the presence of LGDs and escorting visitors when near the flock.

Lorenz and Coppinger (1986) noted that most problems can be related to one of the three basic LGD behaviours:-

Not trustworthy. Nearly half of all dogs from 4 litters observed by Arons (1980) seriously injured a sheep during their first year, although they were more trustworthy with adult sheep and large lambs, which were less likely to initiate a chase by running. Obnoxious behaviours included chasing, biting, mounting and pulling wool. This is usually play but must be corrected as it can become a serious problem if sheep respond fearfully and/or run (Lorenz and Coppinger 1986). A stick attached to a chain on the dog's collar and hanging 8-10 cm above the ground

inhibits play chasing. Play can also be reduced by lowering calorie intake (but not quantity of food), such as with a 2 week diet of cooked oats. Sick, old or odd sheep may be attacked by otherwise trustworthy LGDs. If stalking-type behaviour is observed, the dog should be replaced.

Not attentive. Very few dogs are 100% attentive and most sleep during the day (Lorenz and Coppinger 1986). Not all dogs observed by Arons (1980) stayed with the sheep at all times, although they were more attentive at night. Lack of shelter against bad weather, mosquitoes, heat and humidity all seem to affect attentiveness. Summer heat may reduce attentiveness; brushing out under-fur, shearing long-haired dogs and giving plenty of water can help. Basic needs must be provided to allow LGDs to do their job (Coppinger and Coppinger 1987). In Romania, for example, dogs leave their flocks to seek food (Mertens and Promberger 2000b). Leaving the flock can also be associated with sexual activity so neutering may decrease wandering (Lorenz and Coppinger 1986; Andelt 1999*a* citing Green and Woodruff 1988). The most common problem is, however, dogs returning to areas of human activity (Lorenz and Coppinger 1986). Seriously inattentive dogs tend to be those treated as pets or allowed to develop social relations with pet dogs (Coppinger and Coppinger 1987). Nevertheless, even dogs attentive to people can be useful in some situations, such as where a shepherd is always present, within an electric fence, where pastures surround a house or barn (Lorenz and Coppinger 1986) or where other LGDs are present (Coppinger and Coppinger 1987).

Not protective. Most protectiveness problems are associated with poor attentiveness. Protectiveness also depends on aggressiveness (in turn a function of age, sex and individual dog), density of predators, flocking behaviour of sheep, etc.. More than one dog may be needed to protect widely scattered sheep (Lorenz and Coppinger 1986) and this will also reduce the impact of a deficient animal. Having the company of other dogs tends to lower the threshold of protective behaviour categories (Coppinger and Coppinger 1987), i.e. gives LGDs the courage to be more protective. In addition, anxiety in novel surroundings is reduced (Coppinger and Coppinger 1995).

Green *et al* (1984) noted that the extra time involved in raising LGDs was often overlooked, although this varied with the type of livestock operation. For small flocks kept close to the normal work area extra time was minimal, whereas those with sheep in large pastures away from their house spent more time making special checks and visits. Ranchers reported spending around 50 hours per month supervising, training and feeding pups, but this dropped to 9-11 hours per month after the first year. Moving livestock to a new location can upset LGDs so extra time may need to be spent familiarising them with the new situation (McGrew and

Blakesley 1982). Conversely, dogs over 9 months old may save producers more time in sheep management than they require to feed and work with (Andelt 1992).

Any other predation-control methods used concurrently must be compatible with dog presence: poisons, traps and snares can all kill LGDs as well as predators (USDA 1998), although LGDs can be taught to avoid them if necessary (Lorenz and Coppinger 1986).

Finally, it should be noted that even the best dogs may not completely eliminate predation (Linhart *et al* 1979; McGrew and Blakesley 1982). Expectations of LGD performance must be realistic. Dogs are most effective in certain situations: their efficacy is increased in smaller herds and in the presence of a shepherd (Ginsberg and Macdonald 1990), although they have been found to work well in many other kinds of livestock operations (see the case studies in this report). Low levels of predation (e.g. <5 lambs per year) may render dogs not economically practical (Green *et al* 1984), although this is often a question of individual choice: where predation is episodic one farmer may feel that having a dog continuously on duty is worthwhile insurance while another decides the initial cost and effort are not worth the potential benefits.

General training tips and tricks
http://lgd.org/tips.html

Frequently asked questions
http://lgd.org/trainfaqs.html

Livestock Guard Dog Basics for working dogs
http://www.c-c-farms.com/lgd_basics.html

LGD breeds

In addition to the breeds recognised by the major kennel clubs and registry bodies, some races have been described but not officially recognised. There are also sometimes differences in opinion on classification as well as, more frequently, the spelling of breed names between different authors and organisations (Landry 1999*b*). Some eastern European and Asian races considered to be the same breed in the West have a different name in each of the countries in which they are native.

Table 1 presents a summary of LGD breeds recognised by the International Canine Federation (ICF) as well as others mentioned in the literature. A selection of breeds is then listed in alphabetical order with notes on their origin, physical description, use, advantages, possible problems and website addresses for further information (see also, where included, the relevant case study of the breed's native country).

Table 1. LGD breeds (Hubbard 1947, Green and Woodruff 1990, Adams 1998, Kubyn 1998-2000, Landry 1999*b*, Fogle 2000, LGD Association website, United Kennel Club website).

Country/region of origin	Breed
Afghanistan	Sage Koochi
Bulgaria	Barachesto ovcharsko kuche (Barachesto) Karakachansko kuche (Karakatchan)
Caucasus	Kavkaskaya ovcharka (Caucasian Shepherd Dog, with Georgian, Armenian, Azerbaydjan and Dagestan varieties)
Croatia	Tornjak, Croatian Guard Dog
France	Patou des Pyrénées (Great Pyrenees) Briard, Alpine Shepherd Dog
Greece	Elinikos Pimenikos (Greek Shepherd Dog)
Hungary	Komondor Kuvasz
Iran	Sage Mazandarani
Italy	Maremmano-Abruzzese (Maremma) Bergamo Shepherd Dog
Kirgizia	Kirgizkaya ovcharka (Kirgizian Shepherd Dog)
Mongolia	Buryato (Mongolian Livestock Guarding Dog)

Morocco	Aidi (Atlas Guard Dog or Chien de l'Atlas)
Nepal and northern India	Bhotia (Himalayan Mastiff)
Poland	Owczarek Podhalañski (Tatra Mountain Dog or Goral)
Portugal	Cão de Castro Laboreiro Cão da Serra da Estrela Rafeiro do Alentejo
Romania	Ciobanese romanesc Carpatin (Romanian Shepherd Dog) Ciobanesc romanesc Mioritic (Mioritic Shepherd Dog)
Russia	South Russian Ovtcharka Stredneaziatskaya Ovcharka (Central Asian Shepherd) Iounjnorousskaia Ovcharka (Central Asian Shepherd)
Slovakia	Slovenský èuvaè (Slovak Chuvatch, Liptok)
Slovenia	Krasky Ovcar (Kras, Karst or Istrian Shepherd)
Spain	Pyrenean or Navarre Mastiff Mastin Espagnol (Spanish Mastiff) Perro de Pastor Mallorquin
Switzerland	Great Swiss or Swiss Grand Bouvier Bernese Mountain Dog or Bouvier St. Bernard (?)
Tadjikistan	Dahmarda (Tadjikian Mastiff)
Tibet	Do-Khy (Tibetan Mastiff) Tibetan Kyi-Apso
Turkey	Akbash Kangal Kopegi, Sivas Kangal or Karabash (Anatolian Mastiff or Shepherd Dog) Kars Dog Kurd Steppe Dog
Turkmenistan	Alabay Koyunchi, Chokcha (Turkmenian Shepherd)
Uzbekistan	Torkuz Sarkangik
former Yugoslavia, Macedonia	Sharplaninatz (Yugoslavian Shepherd Dog)

Akbash, Anatolian Shepherd, Kangal, Karabash and Kars

The Akbash is a white dog from west central Turkey, south and west of Ankara. Imported to the USA in 1978 and used for livestock protection as well as a companion dog, by 1986 it was one of the most successful LGD breeds in the USDA LGD Project. It is now recommended by the USDA Animal Damage Control as one of the best three breeds, less aggressive to people than many other LGD breeds but very aggressive to wild predators and intruding dogs. It is more heat tolerant than heavier, more massive breeds (Taylor 1998*b*) and shows signs of greyhound or gazehound influence in its long-legged build and fleetness of foot. Its white coat is accepted by sheep and distinguished at night by shepherds from dark coloured predators (Taylor 1998*a*,*b*). None of 6 sheep producers in a Colorado study (Andelt 1992) said their Akbash dogs were aggressive to people. Andelt (1999*b*) concluded that in the US the Akbash might be the breed of choice in fenced pastures and on rangelands.

Taylor (1998*b*) wrote that the United Kennel Club in the USA provided a registry for pure Akbash dogs, whereas other registry bodies outside Turkey – including the ICF, the British Kennel Club and the American Kennel Club – did not and, instead, registered all Turkish dogs as Anatolian Shepherds.

The Karabash has been referred to as the black-masked form of Anatolian Mastiff (Taylor 1998*b*) or Anatolian Shepherd Dog (LGDA 1988) – with the Akbash being the white form – and as another name for the Kangal (Landry 1999*b*; Dog Owner's Guide online magazine). Its dun coloured coat is difficult to see against the dusty soil in its native land (Turcoman Int' 2000*b*). In 1998 all exports of Anatolian Mastiffs were banned by the Turkish Agriculture Ministry amid fears that foreigners taking the best dogs abroad and breeding of the remaining animals with wild dogs were threatening the breed with extinction in Turkey (Turcoman Int' 2000*b*). The dark masked, fawn coloured Kangal from east central Turkey is heavier than the Akbash, has a blunt muzzle, pendant ears, powerful chest, broad skull (Taylor 1998*a*) and slightly shortened muzzle, showing the influence of the early mastiff. It was first reported in western literature by D. and J. Nelson in 1983 (Taylor 1998*b*) and is now on a list of endangered native breeds whose export from Turkey is strictly limited (Taylor 1997).

The Kars is a multi-coloured, heavy-coated dog from the far northeast of Turkey, first described in detail by Nelson (1996).

Marker (2000*c*) reviewed the literature to provide the following profile of the Anatolian Shepherd: It has a history of over 6000 years in the arid Anatolian Plateau region of Turkey and Asia Minor. Medium length coat and coarse, usually light coloured hair allowing for effective cooling of the body while still insulating.

Males normally 60+ cm at the shoulder and 70-75 kg. Can reach speeds of 75 km/h and go days with minimal water and food. Good eyesight, sharp hearing and excellent sense of smell. Have been found to be capable of deterring foxes *Vulpes vulpes*, coyotes *Canis latrans*, wolves *Canis lupus*, bears *Ursus* spp. and cougers *Felis concolor* in both rangeland and pasture situations.

The Akbash Home Page
http://www.whitelands.com/akbash

The ancient origins of the Akbash Dog
http://www.people.unt.edu/~tlt0002/adogs2.htm

The native dogs of Turkey
http://www.people.unt.edu/~tlt0002/newad.htm

The Kangal Dog: An Introduction
http://www.people.unt.edu/~tlt0002/kdhome.htm

Anatolian Shepherd Livestock Guarding Dog Program in Namibia
http://www.cheetah.org/anatolian.htm

Anatolian Mastiff/Karabas
http://www.turcoman.btinternet.co.uk/anatolian-karabas.htm

Anatolian Shepherds
http://www.anatolianshepherds.com

Anatolian Shepherd Dogs Inc.
http://www.geocities.com/~anatolian

Castro Laboreiro

A native Portuguese breed recognised by the Club Português de Canicultura (the Portuguese Kennel Club) and the ICF. Can be brown to light coloured, dark or mosaic, but "mountain colour", meaning greyish with more or less deep tones tending to black/brown/reddish hairs, is favoured by local people for good camouflage in wolf environment. Always attentive and with a penetrating gaze, it is a middle-large breed, 57-71 cm at the shoulder and 30-45 kg. Portuguese Kennel Club standards are smaller – males 55-60 cm and females 52-57 cm – reflecting out-dated measuring and/or a trend towards kennel and city dogs. Some dogs have double dew-claws, which are not recommended for livestock work (Pedro 1996-2000*a*). The Castro Laboreiro shows devotion to its owner – "a one master dog" – and is docile and playful, unlike other LGDs such as the Serra da Estrela. It is very suspicious of strangers but has a great capacity for learning, is versatile and well balanced (Pedro 1996-2000*b*).

Castro Laboreiro Livestock Guardian Web Site
http://www.geocities.com/mop07231/castro_laboreiro_web_site.htm

Caucasian Shepherd

Known variously as Kavkazskaya Ovcharka, Kauasischen Owtscharka and Nagazi in the Caucasus, where it originates. Historically it was a livestock guard, home guardian and fighting dog. Indigenous to the mountain regions of Georgia, Armenia and Azerbaydjan, Kabardino-Balkar, Dagestan and Kalmyk and the steppe of the northern Caucasus and Astrakhan. Tolerant of different temperatures and climates. Males at least 65 cm (69-85) and females 62 (65-75) at the shoulders, medium to long double coat often with abundant ruff and fringing. Males can weigh 90 kg.

Type varies through the range – more massive in the Transcaucasus, more rangy and leggy in the steppe. Range of shades from dark to light grey, reddish to fawn, white markings and usually distinctive dark facial mask. Massive wedge-shaped head. Shepherds crop ears shortly after birth to prevent biting by wolves or other dogs. Strong minded, well-balanced and even-tempered. Territorial and suspicious of strangers. Fast to protect flock from danger. Good judgement in assessing level of threat. Slow to mature. Very intelligent. Can be very head-strong, especially in first two and a half years. Good hearing. Usually vigorously healthy. Screen for hip and elbow dysplasia. Life expectancy 12 years or more. There has been extensive crossbreeding in Europe and the former USSR with, for example, St. Bernard, Great Dane, Tibetan Mastiff and Sar Planina (Kubyn 1995).

Caucasian Mountain Dogs
http://www.k9web.com/dog-faqs/breeds/caucasians.html

Central Asian Ovcharka

One of the oldest breeds, which has been left virtually untouched by modern selection due to the relative isolation of its region of origin in central Asia, although political and cultural changes in the 20th century led to its use, for example, as a military guard dog at penal labour camps during Communism and more recently as a pet and show dog. Originally, each area had a different name for the dog which has led to different names for the breed (e.g. Alabai, Tobet and Kooche) in the present-day republics of Iran, Afghanistan, Turkmenistan, Uzbekistan, Kazakhstan, Tajikistan, Kyrghyzstan and Russia.

The first CAOs arrived in the USA in 1998, where the breed became a flock guardian. Many dogs exported from their countries of origin for breeding have been of questionable quality so caution is needed in choosing and buying dogs. In 1999 the Central (or Mid) Asian Ovcharka was accepted by the United Kennel Club as a working breed under the name Central Asian Shepherd (FoxFire Farms website 2000). It is also known as the Mid or Middle Asian Ovtcharka, Mid-Asiatic

Sheepdog or Stredneaziastskaya Ovcharka/Owtcharka (Turcoman Int' 2000*a*). Landry (1999*b*) lists the Stredneaziastskaya ovcharka and Iounjnorousskaia ovcharka in Russia. Skalicky (1999) has reviewed the work of I. Sehner on the origins of the Mid-Asian Ovcharka, briefly discussed some of its relatives – the Tibetan Mastiff, Mongolian Livestock Guardian Dog and Kirgiz Guardian Dog – and also included the Caucasian Ovcharka as a form of Mid-Asian Ovcharka, though he wrote that the Turkmenian Alabai is closer to the original type of livestock guarding dogs.

History of the Central Asian Shepherd
http://circlezfarms.org/v_skalicky_article-history_of_central_asian_shepherd.htm

FoxFire Farms, USA
http://www.centralasianshepherd.com/history.html

Alabai. The national dog of Turkmenistan
http://www.turcoman.btinternet.co.uk/alabay-turkmenistan.htm

Great Pyrenees

Native to the Pyrenees mountains of France and Spain. Massive skull, deep stop, pennant ears – characteristics of the mastiff family. Tan or grey markings on head are common (Taylor 2000). The Great Pyrenees has low aggression to humans (Hansen and Bakken 1999). No incidents of biting people were reported by US producers in Green *et al* (1984) and none of 3 sheep producers in a Colorado study (Andelt 1992) indicated that their Great Pyrenees were aggressive to people. Green and Woodruff (1988) found that significantly fewer Great Pyrenees than Komondors, Akbash and Anatolians injured livestock.

Great Pyrenees Club of California
http://www.sonic.net/~cdlcruz/GPCC/index.htm

Pyrs of the Realm
http://www.pyrealm.com

Greek Sheepdog

All-white, though can have biscuit/lemon/fawn colour on head or flanks; about 65 cm in height. Used by shepherds in the Balkan mountains, Albania, Epirus, Macedonia, southern Greece and the Parnassus Ranges. Have been true bred for centuries, with non-white pups eliminated due to superstition and the advantage of being able to see white dogs better. Shepherds quite often crop the right ear (never the left) in the belief that hearing will be improved. Ferocious – strangers walk with

cudgels. Shepherds use crooks and stones or a log or length of iron attached to the collar (Hubbard 1947).

Greek SheepDog (excerpt from Hubbard 1947)
http://www.flockguard.org/greek.htm

Karakatchan

Has probably been bred in the area of present-day Bulgaria for 5000 years and is derived from local guarding dogs mixed with other races descended from the Tibetan mastiff which arrived later with herders from Asia (M. Stoeva pers. comm. 2001).

It is large (65-75 cm at the shoulders for males and 60-68 cm for females), with long (8-27 cm), straight fur and a strong, rugged constitution. The head is compact and monumental and the neck is short and strong. Long body fur and rich hairs on the legs and tail are typical. The fur consists of two colours: large, dark (black, grey, brown or yellow) patches clearly distinguishable on a white base. These colours have practical values: it is easy to see the dog even from a long distance and in case of night attack the shepherd can distinguish the dogs from predators.

Karakatchans are independent with a calm and adamant character. They are able to take decisions themselves when the situation calls for action and react only to serious irritants. They have inherited a strong instinct for guarding a herd.

Although not a registered breed, the Karakatchan has been included in the National Biodiversity Conservation Strategy of Bulgaria as an authentic, local race in danger of becoming extinct.

The Karakatchan Sheep Project
http://www.artesweb.com/niccer/karasheep.htm

Karst Shepherd

Cheerful and less aggressive than other LGDs (Flock & Family Guardian Network website 2000). From Istria in the northeast corner of the Adriatic. Closely related to Sparta, Romanian and eastern Balkan sheepdogs. Has the short muzzle and heavy bones of the ancient Mollosus. Short, dense and quite harsh coat. Darker shades of grey, sometimes black and tan. 60-64 cm and 36-41 kg (Hubbard 1947).

Krasky Ovcar/Karst/Istrian Sheepdog (excerpt from Hubbard 1947)
http://www.flockguard.org/kraskyovcar.htm

Komondor

This is an ancient breed, a descendent of the Owtcharka which was brought to the Hungarian Puszta by invading Magyars. It is named in documents from the 16th century, though large sheepdogs were described in Hungary before that. It was almost wiped out during the Second World War; around 1000 were registered in Hungary in 1960. Importing to the USA resumed after 1962 and 50 litters were born annually in the 1980s. The Komondor's dense white cords protect it from the weather and predators. Males average 80 cm tall and females 70 cm, weights 50-61 kg and 36-50 kg respectively. Nevertheless they are fast, agile and light on their feet. Many dogs are not fully mature until 3 years old. The Komondor has few genetically-linked problems, although hip dysplasia as well as entropian eye disorders and bloat (gastric dilation-torsion syndrome) are possible. External parasites can be problematic due to the heavy coat. The ears should be kept hair-free and the feet pads checked regularly (KCA 2000; KC UK website 2001).

McGrew and Blakesley (1982) described the breed as very conservative and listed its traits as: intelligence, stubbornness, aggressiveness, shyness, strong habit formation and a low inclination to chase. Five of 6 sheep producers in a Colorado study (Andelt 1992) said that their Komondors were aggressive to people and both this study and Green and Woodruff (1988) found them to be more aggressive towards people than Akbash, Great Pyrenees or Anatolians. It was concluded that Komondors might be considered for remote areas or where livestock theft is a concern but are not suitable for public lands and other areas where encounters with humans are likely. McGrew and Blakesley (1982) suggested that aggression towards people might be alleviated by early social experience with a variety of people. They also reported that none of the nine 26 month old Komondorok (*sic.*) they tested was observed harassing sheep. However, they pointed out that Komondors may be less adaptable than other LGD breeds because of their strong site fidelity. These authors considered a 6- to 10-month old dog ideal, rather than a young puppy, for beginning socialisation training and recommended the following procedures in training a new Komondor of any age:

1. *Place the dog with sheep immediately upon arrival at the farm or ranch and leave it there. The area should be large enough for the dog to move freely, but secure enough to prevent escape. It should include a sheltered place where the dog can retire from the sheep.*
2. *Choose the sheep to complete the dog's personality. We have found that yearling ram lambs do well with large, aggressive dogs, while bummer lambs are more suitable for small or shy dogs.*

3. *Supervise early contacts with sheep very carefully. Do not leave the dog unattended for long periods of time until it is clearly adjusted to the situation. Concentrate on building confidence by praising and rewarding desirable behaviour.*
4. *Ignore (not punish) undesirable behaviour unless it threatens the sheep. Chasing especially must be curbed since it can carry over into adulthood if learned as a puppy. Chewing ears and pulling wool are other traits which cannot be tolerated.*
5. *Give the dog at least basic obedience training. For the safety of sheep and humans the owner must have control over the dog. Obedience training also provides an opportunity for development of an affectionate dog-human bond. Work with the dog on a regular basis in the pasture with the sheep so that training becomes associated with the pleasure of the owner's company and with sheep.*
6. *As the dog matures and becomes accustomed to being with sheep, move it to situations which provide progressively more freedoms and opportunities for independent action. Continue to monitor it carefully, encouraging good behaviour and showing displeasure at bad behaviour.*

About the Komondor
http://clubs.akc.org/kca/aboutthe.htm

Kuvasz

A traditional LGD from Hungary.

Kuvasz Fanciers of America
members.aol.com/kfa4kuvasz

Maremma

The Maremma is originally from Italy, where it is still used within the traditional pastoral system. It has been extensively exported, is one of the LGD breeds most commonly used in the USA and has also protected livestock in Israel, Australia and elsewhere. The Kennel Club UK (website 2001) describes it as large, majestic, strongly built, lithe and able to move easily over rough ground and turn quickly, intelligent and courageous but not aggressive. According to the KC UK Standard, dogs are ideally 65-73 cm and 35-45 kg, bitches 60-68 cm and 30-40 kg. The coat is all white (or sometimes with a little shading of ivory or pale fawn) with black pigmentation of the lips, nose and eye rims.

Circolo del Pastore Maremmano Abruzzese, Italy
http://www.cpma.it/index.htm

Amarcord Kennels Maremmano Abruzzese
http://www.maremmano.com

Selladore Maremmas, United Kingdom
http://www.selladore.u-net.com

Podhalañski Owczarek or Tatra Mountain Dog

White dogs, ancestors of today's Owczarek Podhalañski, came to the Podhale area of Poland along the Carpathian mountains together with sheep and cattle herders in the 14th and 15th centuries. These dogs are related to the Slovak Chuvatch, Hungarian Kuvasz, Pyrenean Sheepdog and Italian Maremmano-Abruzzese. In their native Poland, well-trained Owczarek Podhalañski dogs, although not herding sheep alone, can run them on meadows, from one place to another, gather them together, return them to pastures as well as drive them into pens where milking takes place (Dereziński 1999).

Tatra Mountain Sheepdog
http://www.prodogs.com/breed/BreedPages/Tatra_Mountain_Sheepdog.html

Sharplaninatz

An ancient breed from the mountain region of southeastern Yugoslavia, known as Ilyria in Roman times. Most common in the Sharplanina mountain range and is believed to be descended from the ancient Molossian dogs of Greece and the Turkish LGDs. Still widely used to protect flocks from predators in its homeland. It was first recognised by the ICF in 1939 as the Illyrian Shepherd Dog but its name was changed to the Yugoslavian Shepherd Dog Sharplanina in 1957. The Sarplaninac was recognised by the United Kennel Club in 1995. A medium-sized dog and, although slightly smaller than many LGD breeds (males 61 cm, 35-45 kg and females 57 cm, 30-40 kg), has large teeth and great strength. It is double-coated, the outer coat being long and straight, most often iron grey (UKC Breed Standard website 2000). No incidents of biting people were reported by US producers in Green *et al* (1984).

Official United Kennel Club Breed Standard
http://rarebreed.com/breeds/sarplaninac_ukc/std.html

Slovenský èuvaè

See Slovakia case study.

International Canine Federation Standard
http://www.arba.org/Slovensky-Cuvac-Standard.htm

South Russian Ovcharka

The South Russian Ovcharka (SRO) is independent, intelligent, stubborn, dominant and loyal. Affectionate in its own time. Little will to please, independent, distrustful of strangers. A leader, with dominance established in the first 16 weeks of life, perhaps with another peak at 9 months (Sari 2000). Landry (1999*b*) referred to the Caucasian Shepherd dog as mountain-type and Southern Russian Shepherd dog as steppe-type in Russia.

Working dogs in Russia
http://www.wdogs.com/eng/index.htm

Ovcharka Dog Breeds Discussion Forum
http://www.ovcharka.org/discus/messages/board-topics.html

Tibetan mastiff

The Tibetan Mastiff has several characteristics which are unique in the dog world. It is still a primitive breed, as marked by the fact that bitches have a single oestrus per year, normally in autumn (Tibetan Mastiffs website 2001). Described as powerful, heavy, well-built, solemn and aloof but of kindly appearance, the Tibetan Mastiff is slow to mature, reaching its best at 2-3 years in females and at least 4 years in males. The head is fairly broad, heavy and strong and the skull massive. Males carry noticeably more coat than females, mainly fairly long and thick, with heavy undercoat in cold weather. Colours are rich black, black and tan, brown, various shades of gold, grey and blue; grey and blue and tan. Tan ranges from a very rich shade, through to a lighter colour. Dogs are at least 66 cm and bitches 61 cm (KC UK website 2001). Tibetan Mastiffs have exceptional memories.

Tibetan Mastiffs
http://www.tibetanmastiffs.com

Comparison of breeds

Lorenz (1985) has noted that differences in temperament between dogs of the same breed may be greater than those between LGDs of different breeds. Green and Woodruff (1988) comparing breeds and characteristics of LGD use across the USA found no significant difference in success rate in protecting livestock between Great Pyrenees, Komondors, Akbash, Anatolian Shepherds, Maremma and hybrids, between males and females or between intact and neutered dogs. Andelt (1999*b* citing Green and Woodruff 1989) reported that Akbash and Great Pyrenees both deterred black bear predation on sheep. Nevertheless, the results of 10 years of research by Coppinger *et al* (1988) indicated that variations in the basic LGD behaviours (trustworthy, attentive and protective) were breed-specific for the Anatolian Shepherds, Maremmas, Shar Planinetz, Anatolian/Shars and Maremma/Shars they studied. Other US researchers have also found differences.

Effectiveness. Andelt (1999*b*) found that for producers in Colorado using a single breed of LGD (Akbash, Great Pyrenees or Komondor) the estimates given for ewe and lamb mortalities to most predators in most types of sheep operations, value of sheep saved from predators and ratings of effectiveness did not vary among breeds. However, producers using more than one breed (also including Anatolians) rated Akbash as more effective than Great Pyrenees in deterring predation. More producers also rated Akbash as more effective than Komondors in deterring predation by all predators combined and by coyotes. Overall, the Akbash was also rated as more aggressive, attentive, trustworthy, active and faster than Komondors. Anatolians were rated as faster than Great Pyrenees, which were rated as less active than Komondors. Most producers considered aggressiveness to predators, great attentiveness to sheep and great trustworthiness to be the most important attributes. Green and Woodruff (1983) reported that Great Pyrenees were significantly more successful than Komondors and Akbash to deter predation on rangelands and pastures. Green and Woodruff (1990) reported that Great Pyrenees were more effective than Anatolians.

Trustworthy and attentive. Green and Woodruff (1988) reported that more Komondors than Great Pyrenees, Akbash, and Anatolians bit people and significantly fewer Great Pyrenees than Komondors, Akbash and Anatolians injured livestock. Green and Woodruff (1990) reported that a greater proportion of Anatolians injured and killed livestock than did Great Pyrenees. Coppinger *et al* (1983, 1988) reported that Maremmas were significantly more attentive and more trustworthy than Anatolians.

Age of maturity. Some Akbash and Great Pyrenees may begin working as guardians at 6 months of age whereas Komondors usually start later (Andelt 1999*a*), reaching a degree of behavioural maturity at 18 to 30 months (many do not reach maturity until 3 years according to KCA 2000), as do Anatolian Shepherds (Green and Woodruff 1990).

Cost. The difference in cost for pups or adults of different breeds can be quite substantial (see USA LGD evaluation).

Mongrels

Mongrels are used extensively as livestock guarding dogs by the Navajo. Black and Green (1985) pointed out that their method is a cheap, low labour intensity and readily accessible form of livestock protection which could be employed by other ranchers. Coppinger *et al* (1985) have emphasised that no evidence was provided that any type of dog can make a good LGD given sufficient training and postulated that mongrels are likely to make better LGDs than most pure breeds – except for Old World (Eurasian) dogs bred specifically for the purpose – because hybridisation disrupts eco-specific behaviours such as hunting sequences which are undesirable in livestock guardians. However, a six year study in Bulgaria concluded that hybrids of the native LGD Karakatchan with other traditional LGD breeds (Caucasian Shepherd) as well as St. Bernard and Newfoundland did not have the ability to guard livestock (Tsingarska *et al* 1998).

Black and Green (1985) mentioned a few other observations of mongrels used as LGDs: a large, 34 kg mongrel dog working with a flock in Turkey (R. Coppinger pers. comm. to Black); Orbigny (1826) observed a large dog that both herded and defended members of the flock from large avian predators and human intruders in Uruguay; Bendure (1948) also described the value of a mongrel dog in predator control. During visits in August 2001 four mongrels were seen in use as LGDs in a flock of sheep herded in Retezat National Park, Romania and several mongrels (together with Karakatchans) were seen guarding sheep and goat flocks in the Eastern Rhodopes of Bulgaria (R. Rigg pers. obs. 2001). Landry (1999*b* citing V. Guberti pers. comm.) mentioned the use of mongrels in Italy.

Case studies

This section contains an analysis of livestock-carnivore conflicts and attempts to reduce losses using livestock guarding dogs in a number of countries in Africa, the Americas, Asia, Australasia, Europe and the Middle East. The information is presented on a country by country basis and further broken down into the following sub-headings:-

Landscape

A brief description of the livestock raising area, whether summer mountain grazing, fenced farmland, etc.

Livestock

The main species grazed/subject to depredation.

Husbandry

The prevalent practice(s), whether animals are fenced, with or without a shepherd present, if the herd is brought in at night or not; summer grazing or permanent, etc.

Predator species and attacks

The main livestock depredators with estimates of numbers. Descriptions of the patterns of attacks including frequency, seasonality, time of day and numbers of victims as well as any apparent preference for livestock breeds, age classes, etc.

Losses

Estimates in terms of head of livestock and financial costs.

LGD breeds and status

The dog breed(s) used and whether traditional, introduced or re-introduced. Where known, the number of head of livestock per dog and/or number of dogs per herd.

LGD training

The regime used for raising and training dogs and, where applicable, the criteria employed for selecting potential owners.

LGD evaluation

The reported or apparent effectiveness of using LGDs.

Other measures

For directly or indirectly protecting livestock from carnivores.

AFRICA

Namibia

Landscape

Twenty-eight percent of Namibia is arid, receiving less than 150 mm of rainfall annually. Another 69% is semi-arid, with 150-600 mm of rainfall per year (reviewed in Marker 2000*c*).

Livestock

Cattle, goats and sheep, small stock (Marker 2000*b*).

Husbandry

Cattle are managed in an open range system on commercial livestock farms averaging 10,000 ha. The 53,000 ha Schneider-Waterberg ranch, for example, employs herders with all stock, corrals lambs at camp until they are strong enough to follow the flock for a full day and usually corrals livestock at night. Over 70% of Namibia's game species are also present on the livestock farms. Communal lands make up 40% of the country. Communal farmers are primarily subsistence farmers; their herds are usually not separated (Marker 2000*b*).

Predator species and attacks

Cheetah *Acinonyx jubatas*: 2000-3000 (90% primarily on commercial livestock farmlands). In a 1991-93 survey by the Cheetah Conservation Fund (CCF), larger farms (>15,000 ha) reported more cheetah problems, primarily due to less intensive farm practices. Farms that reported problems with cheetahs had a lower game:cattle ratio than farms with no such problems. At least 25% of farmers were affected by a perceived or actual problem. Fifty-one percent of calves killed by cheetahs were under 3 months old, 29% were under 8 weeks old. Cheetahs were known to kill small stock and calves up to six months old but were blamed for far more losses than actually occurred (Marker 2000*a,c*).

Leopard *Panthera pardus*, black-backed jackal *Canis mesomelas*, brown hyena *Haena brunnea*, caracal *Felis caracal* and baboons (Marker 2000*c*).

Estimated losses

Cheetah: Viewed as a pest and described by many farmers as the biggest threat to livestock (Marker 2000*c* citing Marker-Kraus *et al* 1996), although other predators were reported by farmers as more of a problem (Marker 2000*c* citing Marker in

press). A survey of farmers indicated losses of 3% of cattle and 9% of small stock annually. Many farmers accept losing one or two calves a year, while others (e.g. subsistence farmers) find any loss an economic hardship (Marker 2000*a*).

LGD breeds and status

Anatolian Shepherd imported from Turkey on the initiation of the CCF's Livestock Guarding Dog Programme. Dogs were originally placed on the Schneider-Waterberg ranch, which has separate herds of small stock. Some farmers were using dogs before the Programme, but their dogs were smaller than the cheetah (15-25 kg) and were not specifically bred for guarding abilities, even exhibiting herding tendencies. Anatolian Shepherds were chosen for the Programme due to their effectiveness in working in extensive areas, ability to think independently of humans and large size (Marker 2000*c*).

The LGD Programme imported 10 Anatolian Shepherds from Birinci Anatolians and the Livestock Guarding Dog Association in the USA. In January 1994 one adult male, one male pup, one adult female and one female pup, all of different lineage, were imported followed – in June 1994 – by a further six pups, 2-4 months old and from five separate litters (two dogs were from separate lineages). Breeding from these original dogs began in March 1995; by 2000 over 120 dogs were in place on more than 75 farms (Marker 2000*a*,*c*).

LGD training

The Schneider-Waterberg ranch was selected for the first trials of Anatolian Shepherds due to its existing non-lethal anti-predator measures, the support of this ranch for other CCF activities and the family's local influence. Subsequently, farmers must agree to follow a strict set of guidelines before puppies are placed with their stock. A "Potential LGD Owners Questionnaire" has been developed, in addition to the CCF's "Annual Farmers Questionnaire", to help place puppies where they are most needed. The CCF researches geographic areas, suitable people to approach and the timetable for the LGD Programme. Pups are weaned from their mother and placed with herds at 7-8 weeks of age (up to 16 weeks maximum). They go out with their herds immediately to habituate them to the behaviour of the livestock and wild animals. Human interactions are kept to a minimum to avoid pups bonding with people, but pups are carefully supervised and introduced slowly to their job and its dangers, with daily checks for ticks, illness and injury. The dogs live, eat and sleep with their herds. Breeding control is maintained by CCF through a contract and is covered in the guidelines for new owners in order to maintain the purity of the breed. Dogs are bred at the CCF Research and Education Centre and demonstration farm. A registry is also maintained to trace the breeding history of each dog and to document its placement and work. In 1996 semi-annual surveys

were initiated to monitor the progress of dogs and maintain contact with farmers (Marker 2000*c*).

LGD evaluation

The eye-stalk-chase sequence of herding behaviour in improperly bred or trained LGDs (such as those which farmers were using before the CCF's LGD Programme began) can cause a flight response in livestock, which in turn triggers hunting mode in predator species, especially the cheetah (Marker 2000*c*).

The importance of human supervision for puppies is stressed as they are vulnerable when not yet physically and mentally mature. Young dogs can suffer mental traumas while guarding stock that may prevent them from developing the confidence necessary to become successful adult guardians. One male puppy, showing good signs of socialisation (he was introduced at eight weeks of age and started to go out with herder and stock almost immediately) was killed by a troop of baboons 81 days after being introduced to the herd; he had been left unattended by the herder while out with the stock when less than five months old. Ticks present a major threat to dogs in the bush. Tick fever (*Ehrlichia canis*) and bont ticks (*Amblyomma hebraeum*) can cause pain, discomfort and damage to working dogs if not removed daily. Snake-bites also kill some dogs (Marker 2000*c*).

Attempts to introduce adult dogs to a herd failed. One male was not attentive to the herd, was afraid of the livestock and his size frightened both herd and herder. He ran away and was later found dead, his collar caught on a thorn bush. An unrelated four-year old female was also frightened of her new surroundings and repeatedly ran away; she was finally removed to a research centre for breeding purposes (Marker 2000*c*).

The effectiveness of individual dogs seems to be dependent on two variables: the lineage of the dog and, possibly more important, the attitude and expectations of the farmer involved (Marker 2000*c*).

One farmer reported that his Anatolian Shepherd had fought off two baboons – which are often reported killing small stock and ripping open their udders – that were aggressively threatening his herd. Other anecdotal accounts were reported of LGDs protecting their flocks from jackals, cheetahs, baboons and caracals. One LGD killed a leopard in defence of its flock. Cases of LGDs killing predators usually occurred near the corral after the dogs' initial warnings had not been heeded; a high incidence of rabies was found in jackals killed by LGDs (Marker 2000*c*).

The dogs have earned credibility and proven themselves capable of the task required of them. As word has spread of the effectiveness of the dogs, a waiting list

has developed of farmers wanting to join the programme. The programme continues to grow and is making an impact on livestock management practices in Namibia (Marker 2000*c*).

Other measures

Husbandry: Increased protection of young stock, such as the use of closely-watched calving camps. High concentrations of cattle during the calving season combined with a fast rotation schedule through smaller camps, thus not allowing local predators to become familiar with the management pattern. Farms with more camps tend to practice more intensive stock management, thus reducing predator conflict. Calving synchronised within the herd, with other farms in the area and with wildlife calving times. It is recommended to cull a cow that loses its calf to predation or fails to reproduce (Marker 2000*a*).

Enclosures: Use of corrals with thorn-brush barriers, lighted corrals and locations near human habitation. However, insufficiently protected corralled small stock can suffer higher losses as their panicked flight stimulates predators' killing instinct. Additional protection, eg. with electric fences (effective but needing intensive maintenance), of exotic game species such as blesbok and common impala, which may attract cheetahs in heavily bushed areas (Marker 2000*a*).

Conditioned Taste Aversion is being conducted (Marker 2000*a*).

Other guardians: Use of donkeys to protect calving herds. Use of mules, zebras, horse stallions and horned oxen for guarding. Leaving horns on a few members of the herd, especially females, to assist in aggression against predators. Some breeds of cattle, such as Brahman, Brahman crosses and Afrikaner are more protective of their calves and are better adapted to the Namibian environment. Some farmers consider mature cattle as less vulnerable to predators than heifers; placing heifers with older cows reduces losses (Marker 2000*a,b*).

Killing predators: Cheetahs can be legally shot to protect life or property. Historically farmers have removed them indiscriminately by shooting on sight or live-trapping. Ten thousand were removed from farmlands in 1980-2000. In 1992 the cheetah was listed in CITES Appendix 1 but Namibia was given a quota of 150 animals for trophy hunting and live export to recognised captive breeding facilities in order to stop indiscriminate killing by farmers (2000*a*).

THE AMERICAS

Canada

Livestock

Cattle, sheep and swine (Horstman and Gunson 1982).

Landscape and Husbandry

Twenty-five percent of all compensated losses in Alberta in 1974-79 occurred on grazing leases on public lands in the forested (unsettled) part of the province (Horstman and Gunson 1982).

Predator species and attacks

Coyote *Canis latrans* (Tapscott 1997).

Black bear *Ursus americanus*: Cattle accounted for 81%, sheep 9% and swine 9% of 541 approved, compensated livestock predation claims in Alberta in 1974-79. Most (71%) of the killed cattle were calves. All 18 bears judged to have been livestock killers were male; 4 were 1-3 years old, 6 were 4-7 and 4 were 13 years or older (4 undetermined). Bears generally killed 2-3 sheep; 3 cases involved 6-13 animals. Multiple kills were more common than single kills in sheep and swine cases and infrequent in cattle cases. Some victims of group slayings were barely consumed (Horstman and Gunson 1982).

Wolf *Canis lupus*: Between 52,000 and 60,000 in Canada as a whole (Hayes and Gunson 1995).

Cougar *Felis concolor* (Cluff and Murray 1995).

Losses

Coyote: Tapscott (1997) reported that the range and extent of predation on Ontario sheep had increased to the point where it threatened the viability of many operations. Producers lost almost three times the number of sheep and lambs in 1995 (3060) as they lost in 1986 (1149). During the four year period 1991-94 the sheep industry was compensated an average of $388,000 per year for losses to wild predators (excluding feral or domestic dogs). The coyote was the key culprit.

Black bear: Although probably underestimated in compensation statistics, predation is relatively uncommon considering the numbers of livestock and bears on shared pastures (Horstman and Gunson 1982).

LGD breeds and status

The current use of livestock guarding dogs has been introduced to Canada in a similar way to LGD programmes in the USA. Arons (1980) noted that interest increased after the ban of Compound 1080 poison. Cluff and Murray (1995 citing DogLog l(l): 2-4 1990, Livestock Guard Dog Association, Hampshire College, Amherst MA) reported that LGDs were introduced on an experimental basis to protect domestic sheep in forestry clear-cuts on Vancouver Island, British Columbia. The sheep assisted in brush control on clear-cuts while the dogs protected them from depredation by bears, cougars and wolves.

LGD evaluation

Green *et al* (1985) included producers from two Canadian provinces in their analysis of LGD costs, benefits and practicality (see USA LGD evaluation).

Other measures

Legal killing: Hayes and Gunson (1995) estimated that human caused wolf-mortality is 4-11% depending on region and is not the primary limitation to wolf numbers in Canada except along the southern edge of their distribution.

Navajo

Landscape

The Navajo reservation in Utah, Arizona and New Mexico, including the Hopi reservation in Arizona which it surrounds (Black and Green 1985).

Livestock

Sheep *Oves aries* and goats *Capra hireus* (Black and Green 1985).

Husbandry

Fifty-three flocks encountered by Black and Green (1985) were mixtures of sheep and goats, 2 were sheep only and 3 were goats only. The largest was 300 and the smallest 17 (av. 107). All goats appeared to be Spanish or Spanish-Angora crosses kept primarily for their mohair, except for 15 milk goats. The sheep were mostly mixed breeds kept for meat and wool. Sixty ranchers said they always corralled their herds at night and four said they usually did. Nineteen corrals were less than 200 m from the hogan (house), one was within 30 m and the most distant was 1600 m. Young goats and LGDs could leave and enter the corral at will, though sheep and adult goats were effectively contained. Eighty-eight percent of 51 ranchers questioned said they usually herded their sheep for several hours in the morning and evening, with the herd returned to the corral or near the homestead for 3-4

hours between these periods. Twelve percent said they usually herded all day. Herding was always on open, unfenced rangeland. Children, adults and the elderly, men and women, participated in herding, both on foot and horseback, though older Navajo were more likely to be involved in traditional livestock operations (Black and Green 1985 citing Black 1981). Twenty-two percent of 64 ranchers said herds were sometimes left to graze unsupervised, 14% said often and 64% said never, though the herd might be out of view of the herder for several minutes at a time (Black and Green 1985).

Predator species and attacks

Coyote *Canis latrans*: Most attacks seemed to occur when stray animals were accidentally left behind on the rangeland. Only 2% of 41 ranchers had experienced predation on flocks in corrals (Black and Green 1985).

Losses

Coyote: Sixty-five percent of 60 ranchers had suffered coyote depredation but only 17% considered it a serious problem (Black and Green 1985).

LGD breeds and status

The Navajo have used LGDs, which they refer to as "sheepdogs", as opposed to their house dogs and stray dogs, for 200 years (Lorenz and Coppinger 1986) or more (Black and Green 1985). They learned the techniques for raising these dogs from the Spanish and probably had experience of the Castillian Mastiffs or Mastiff x mongrel hybrids (Coppinger *et al* 1985). A total of 230 mixed-breed LGDs were recorded at 72 ranches visited by Black and Green (1985) in 1981. Of 200 sexed, 77% were male and 23% female. Forty-five (29%) of the 154 males were castrated. The mean weight of 17 adult dogs weighed was 17 kg (range 7-27). Estimated weights of 69 adults averaged 15 kg. Pups used as LGDs had been born on the homestead, obtained from neighbouring ranchers, friends and relatives or found abandoned along highways. Eighty-eight percent of 17 ranchers said they would not buy a good dog and 86% of 27 said they would not sell one. Thirty-four ranchers said they tried to raise puppies from especially good dogs (Black and Green 1985).

LGD training

The Navajo recipe for creating LGDs was summarised by Black and Green (1985) as follows:

> *"Raise or place mixed-breed pups in corrals with sheep, lambs, goats and kids at 4-5 weeks of age. Feed the pups dog food and table scraps. Provide no particular shelters such as dugouts or dog houses (the pups*

> *will sleep among the sheep and will dig their own dirt beds). Minimise handling and petting. Show no overt affection. Return pups that stray to the corral (chase them, scold them, toss objects at them). Allow pups to accompany the herds onto the rangeland as age permits. Punish bad behaviour such as biting or chasing the sheep or goats and pulling wool by scolding and spanking. Dispose of dogs that persist in chasing, biting or killing sheep."*

All 39 ranchers asked said it was important to begin with pups. Seventy-one percent of 55 ranchers said children were not allowed to play with the pups. The proximity of the corral to the hogan allowed almost constant observation of the pups, which were conditioned to remain near the corral/livestock by shouting, throwing objects at them and physically returning them. LGDs were associated with livestock throughout the year and were not excluded from any husbandry practice such as shearing, dipping and lambing (98% of 51 ranchers said no effort was made to exclude dogs from lambing areas). The only command used for LGDs was *dibe*, meaning sheep, sometimes accompanied by a gesture or thrown stick/stone, given when the dogs failed to accompany the herd as it left or if they approached the herder on the range. Punishments for dogs which harassed sheep included cutting off the tail and ear tips, beating, scolding, throwing objects, tying up and starving them and/or tying heavy objects such as a chain around their necks. Eighty-four percent of 45 ranchers asked said they destroyed (shot) dogs that consistently bothered or killed sheep. Feeding of LGDs was mostly done once a day near the corrals, with dog food, table scraps or a mixture of the two. Care was taken to isolate the feeding dogs from livestock to prevent sheep and goats eating the dogs' food (Black and Green 1985).

LGD evaluation

Eighty-six percent of 35 ranchers said they lost more sheep to coyotes when they did not have good LGDs. Ninety-one percent of 53 ranchers said their dogs chased coyotes and 92% of 52 said they disliked or showed aggression towards coyotes. Twenty-one percent of 67 knew of dogs that had killed coyotes; most said they kept them away by chasing and barking. Eight percent of 62 said that coyotes had been known to kill their LGDs. Several ranchers said that sometimes young pups were lost or killed by hawks, eagles or coyotes and one had lost a good LGD to his German Shepherd house dog (Black and Green 1985).

Black and Green (1985) speculated that the familiar surroundings of hogan and corral probably enhanced LGDs' territorial defence. They provided the following behavioural profile of Navajo mixed-breed LGDs based on direct observation and their interviews with owners:

> *"They are attentive to sheep and goats. They make short sallies to obtain food and water or to chase an occasional rabbit or ground squirrel but return to the corral or flock following these activities. They bark at other flocks and dogs encountered on open rangeland. They bark at and chase horses, burros or cows when encountered. They are not aggressive towards flock members of any age but are submissive and perform appeasement gestures toward sheep and goats that on occasion threaten them. They lick and groom the facial areas, ears and perineal regions of sheep and lambs but rarely those of goats and kids. They walk, rest and sleep among the flock while corralled or foraging on the range without alarming the flock members. They do not aggregate at the corrals or on the range but maintain a random dispersion among the flock. They respond as a group to intruding, unfamiliar dogs. They respond by barking, growling and running in the direction of taped coyote vocalisations. They bark at, chase and may occasionally kill coyotes. They are wary of their owners and some are difficult to approach depending upon the degree of socialisation to humans. They may approach, bark at and show aggression toward strange human intruders both at the corral and on the range. They know few commands but will approach someone bringing food and will return to the flock voluntarily or when given the command* dibe.*"*

Other measures

The proximity to the hogan probably decreased the likelihood of coyote attacks when the flock was at the corral (Black and Green 1985).

USA

Landscape

Lorenz (1985) reported that in the mid-1980s LGDs were being used in at least 35 states. Landscape varies from the northern Rocky mountains of Idaho, Montana and Wyoming, through Minnesota farms adjoining forested areas or wilderness (Paul 2000) to the Great Plains and more arid conditions in the southwest. The US Sheep Experiment Station (USSES) is located in Idaho in level to slightly rolling terrain with primarily sagebrush-bunchgrass vegetation (McGrew and Blakesley 1982).

Livestock

Cattle, sheep, goats, poultry and domestic dogs (in Lit.).

Husbandry

A wide variety of operations, from open range to fenced pastures. A Minnesota Cattle Association representative speaking at the *Beyond 2000: Realities of Global Wolf Restoration* symposium in Duluth, Minnesota on 25th February 2000 stated that 80% of beef cow herds in the state had less than 25 animals. Jarvis and Jarvis (2000) in Wisconsin had a "large" herd of sheep spread out on different pastures, some of which were fenced. Movements of livestock between paddocks and to milking parlours were managed with herding dogs (border collies). In Idaho, Montana and Wyoming large numbers of range cattle spread over vast areas of public land in summer, rarely monitored closely (Meier *et al* 2000). In a study encompassing a number of states (Green *et al* 1984), 22% of 45 producers had small farm flocks of 50 or fewer ewes or nannies, 49% had flocks of 51-500, 18% had flocks of 501-1000 and 11% had flocks of more than 1000. Pasture operations accounted for 73% (18% of total producers on 1.2-16 ha, 20% 17-65 ha, 20% 65-259 ha and 13% 259-810 ha; 1 producer fed sheep in a feed lot) and the other 27% grazed sheep primarily on rangeland for at least part of the year.

Predator species and attacks

Coyote *Canis latrans*: Listed as the principal livestock predator by producers responding to a questionnaire by Green *et al* (1984). See Knowlton *et al* (1999) for a detailed synthesis.

Domestic and feral dogs *Canis familiaris*: The second most important livestock predator after coyotes (Green *et al* 1984).

Wolf *Canis lupus*: 2500-3000 in Minnesota as of winter 1999-2000. Range has expanded significantly in recent years, more agricultural land has been colonised and depredation problems have increased (Paul 2000). Most losses in Minnesota occur in spring-summer when livestock are released to graze in open and wooded pastures. Spring calving is the worst time for losses, when livestock is released in close proximity to wolves. Mech *et al* (1988) found an inverse relationship between wolf depredation on domestic animals and severity of the preceding winter (related to increased availability/vulnerability of deer fawns). Adult cows are also killed or injured. Mostly only 1 or 2 cattle are killed, but an individual wolf may become habituated and kill 10-15 through a summer. Calving in forested or brushy pasture and disposal of the carcasses of livestock which died of other causes in or near the range (Paul 2000) or often left unburied at the edge of the range (Benson and Berg 2000) are believed to contribute to wolf depredation. One study found that farms suffering chronic cattle losses to wolves tended to be larger, had more cattle and had herds further from the house than farms with no losses (Mech *et al* 2000); it was tentatively suggested that farms with 240 acres (97 ha) or more and at least 35

head of cattle should pay special attention to proper disposal of carcasses. Finding killed animals may be a problem as a calf can be fully consumed in one night or dragged away (Paul 2000). Sheep are vulnerable to surplus killing: sometimes up to 30 are killed at one time. In one night 100-200 range turkeys may be killed causing $1000+ in damage. Wolves often return after a couple of nights (Paul 2000). Range and flock turkeys are vulnerable. Dogs are killed in yards (increasing as the wolf range expands into areas of denser human settlement) and either left or eaten; people fear for human safety in these cases (Paul 2000).

Wolf recovery efforts began in northwest Montana in the 1970s to encourage natural dispersal from nearby Canadian populations. The first wolves denned in Montana in 1986. The wolf population peaked at around 90 in 1996 and then declined after the severe 1996/97 winter to around 60-70 in 7 breeding groups, mostly near Glacier National Park (Bangs *et al* 2000). Wolves were reintroduced to Yellowstone National Park (Wyoming) and central Idaho in 1995 and 1996. According to Bangs *et al* (2000) there were around 150 wolves with 10 breeding pairs in Idaho and approximately 120 animals in Yellowstone by 1999-2000; Meier *et al* (2000) gave the figures for each population as nearly 170 animals by winter 1999-2000. Depredation on livestock in the greater Yellowstone and Idaho areas has been less than predicted by the pre-reintroduction Environmental Impact Assessment; in northwest Montana it peaked after the severe winter of 1996-97. Wolves following the migration of deer and elk to low-elevation winter range come into closer contact with livestock. Unsupervised cattle scattered over large areas are vulnerable in summer. Wolf depredation is more likely where sheep are present rather than cattle. A typical complaint is the loss of 10 sheep, but there have been cases of up to 60 at one time, compared to 1 or 2 calves. There have also been attacks on dogs and other domestic animals (Meier *et al* 2000).

Bobcat *Lynx rufus* (Green *et al* 1984; USDA 1998).

Bears *Ursus* spp.: (Green *et al* 1984). One (5 year old male) out of eight radio-collared black bears *Ursus americanus* killed sheep, though the others frequently crossed sheep ranges without incident (Jorgensen 1979 reviewed in Horstman and Gunson 1982).

Cougar or mountain lion *Felis concolor* (Green *et al* 1984; Jarvis and Jarvis 2000).

Fox *Vulpes* spp. and golden eagle *Aquila chrysaetos* as well as theft by man were mentioned by producers responding to a questionnaire by Green *et al* (1984).

Losses

Coyote: Estimated to kill an average of 1-2.5% of adult domestic sheep and 4-9% of lambs in the 17 western states (reviewed in Andelt 1992).

Wolf (Minnesota): Two early studies (Fritts and Mech 1981; Fritts 1982) reviewed by Ginsberg and Macdonald (1990) found that many reports made to the state by ranchers seeking compensation for wolf predation in Minnesota were completely unverified (76% of cattle and 73% of calves reported missing were never found) and there was only one confirmed report of wolf predation in 5 years in the area of northwest Minnesota where wolves had recently been protected; only 1% of scats examined had remains of cattle suspected to have been killed by wolves. According to Fritts (1982) over 99% of all Minnesota livestock producers were unaffected by wolves. From 1976-98 the number of farms suffering verified losses to wolves ranged from 9 to 99 per year (mean 80 or 1% from 1995-2000) out of 8000 in Minnesota (Paul 2000). However, the number of affected farms is increasing. From 1977-98 the highest cattle losses claimed by farmers in Minnesota were 0.83 per 1000 available in 1998 and the highest sheep losses claimed were 13.87 per 1000 available in 1990. Verified losses may be a minimum: some stock is not found (especially calves) and some losses are not verified or not reported because the farmer does not like the system. On the other hand, farmers often wrongly attribute depredation by coyotes to wolves. Minnesota State compensation paid per year for animals killed by wolves ranged from $14,444 to $67,438 in 1978-98 and averaged $45,320 per year from 1995-2000. The maximum payment per animal killed is $750 (previously $400), which is less than the value of the lost animals (Paul 2000). Compensation paid in the state up to 1998 totalled $664,361 (Fritts 2000). Paul (2000) reported losses to wolves in the ratio of 75% cattle, 13% dogs, 6% sheep and 3% poultry. Thousands of turkeys have been lost in some years (Meier 2001). Benson and Berg (2000) reported that there are claims of around 10% losses but the real figure is likely to be <1%. Farmers fail to distinguish between predation and scavenging.

Wolf (Northern Rockies): In NW Montana from 1987-98 an average of 5 cattle, 4 sheep and less than 1 dog were lost to wolves per year (Bangs *et al* 2000) compared to total losses to all causes in 1986-91 of 142,000 sheep and 86,000 cattle (Phillips and Jenkins 2000). Since the wolf reintroduction programmes of 1995 and 1996 there have been average annual losses to wolves of 2 cattle, 20 sheep and 1 dog in the greater Yellowstone area of Wyoming and 5 cattle, 21 sheep and 2 dogs in central Idaho – less than one third of pre-reintroduction predictions. Livestock producers who experienced losses to wolves were compensated c.$90,000 by the Defenders of Wildlife compensation fund (Bangs *et al* 2000). Documented levels of livestock (adult cattle and calves) missing at roundup are higher than before wolf reintroduction (Bangs *et al* 2000) and are becoming the most intense source of controversy in wolf management in these areas (Meier *et al* 2000). In the northern Rocky mountains from 1997 to 1999 verified wolf depredation accounted for

0.01% of all sheep losses and 0.03% of all cattle losses (Meier 2001). Annual losses average around 22 cattle (increasing) and 66 sheep (Meier *et al* 2000).

LGD breeds and status

Eurasian LGD breeds were taken to the New World in the 16th century by Spanish conquistadors (Cluff and Murray 1995 citing Pfeifer and Goos 1982) and/or 150 years ago (LGDA 1988) but their use in the USA was limited until the 1970s when many poisons were discontinued (Green and Woodruff 1980; McGrew and Blakesley 1982; Andelt 1992 citing Pfeifer and Goos 1982). The Livestock Guard Dog Project was begun at Hampshire College, Massachusetts in 1976 and a few years later the Livestock Guard Dog Association was founded (LGDA 1988). R. and L. Coppinger imported Maremmas, Anatolian Shepherds and Shar Planinetz (*sic.*) of working stock from Italy, Turkey and Yugoslavia respectively (Coppinger *et al* 1988). Later, LGDs were also imported by private breeders (Jarvis and Jarvis 2000).

Forty-five producers cited in Green *et al* (1984) owned Komondor, Great Pyrenees, Akbash, Anatolian Shepherd and Sharplaninac, a total of 84 dogs at the time of data collection, which had been used from 0.5 to 10 years. Of 22 sheep producers in Colorado in 1986 with LGDs, 7 used a total of 41 Akbash, 7 used 12 Komondors, 4 used 9 Great Pyreneees, 1 used 3 Anatolians, 1 used 2 Maremmas, 1 used 1 Maremma and 1 mixed-breed (Navajo) dog and 1 used a Komondor x collie hybrid (Andelt 1992). The Wisconsin farm of Jarvis and Jarvis (2000) used several Maremmas on partially fenced permanent pasture to protect milking sheep, dairy goats, llamas, alpacas and ratites (large birds) from wolves, coyotes, black bears and cougars.

The LGDA (1988) listed Old World LGD breeds known in the USA as Anatolian Shepherd Dog (Akbash or Karabash, *sic.*), Castro Laboreiro, Great Pyrenees, Komondor, Kuvasz, Maremma, Polish Tatra Sheepdog, Shar Planinetz, Slovak Tchouvatch (*sic.*) and Tibetan Mastiff.

Andelt (1999*a*) wrote that the Akbash and Great Pyrenees were the most popular breeds, although Anatolian Shepherd, Komondor, Maremma and Sharplaninetz were also used in Colorado. Most producers with less than 200 sheep or whose sheep grazed in less than 200-acre (81 ha) fields usually had one or two dogs whereas those with 1000 ewes and lambs on open range often used 2-5 (usually 3) LGDs. The extent of predation, dispersion of sheep and amount of brushy cover on the range also usually influenced the number of dogs used.

LGD training

Despite a relatively short history of use, the process of rearing and training LGDs has been refined, standardised and formally described in more detail in the USA than perhaps anywhere else in the world. In addition to the guidelines reviewed in the early part of this report ("Raising and training") Andelt (1999*a*) has provided this summary of the key points:

- *Treat your dog like a working partner in the operation from day one. Most troubles occur because the owners forget that the dogs are workers, not pets. Do not let the dogs play with children or herd dogs or hang around the house.*
- *Put the dog with sheep and leave it there. The best companions for a small pup are a few head of bum lambs in a small pen, preferably in a barn or isolated away from the flock. Place the pups with lambs at 8 weeks old, when pups develop a strong bond with sheep.*
- *If the pup is very young, put a chicken wire fence between it and the lambs. This gives it regular contact with the lambs but protects it from being trampled. Even when the pup is old enough to be with lambs, it is a good idea to provide a place where it can get away to rest, eat and be alone. A low fence or a creep with a few extra slats works fine. During this early exposure, check the pup regularly to ensure that it adjusts to being with lambs.*
- *As the pup gets older, integrate it into the working operation. Introduce it to equipment, machinery, other livestock (horses, cattle, chickens) and herding dog(s) so later it will not guard the sheep from them. It is important to spend time with the pup so it is not afraid of you and will allow you to catch it later. However, always return it to the lambs after a short time and praise it when it goes into the pen and greets the lambs. Do not pet or reward the dog when it wanders away from the sheep.*
- *Begin the dog in obedience training ("come", "no") during its early exposure to sheep. Supervise the dog when it is first introduced to new-born lambs and reprimand it if it chases sheep. Remember, the dog is a working partner and cannot perform this role if it does not understand its job.*
- *As the dog gets older, give it more opportunities to make decisions and take responsibilities. Move it from a small pen to a larger pen to a pasture and from a few head of lambs to the flock it eventually will*

guard. Observe the dog carefully, especially after each move or change in routine. Make sure it adjusts properly and correct any undesirable behaviours early. It is especially important that the dog remains with the sheep. Return the dog to the flock any time it tries to leave. Always praise the dog when it stays with the flock.

- *Raise the pup with lambs that you intend to incorporate into the main flock. Once one group of sheep accepts the dog, other sheep unaccustomed to guard dogs tend to accept it more quickly. If your sheep are spooky of a new dog, it may be best to introduce them in a small corral.*
- *Routine worming, vaccination and examination of your dog are essential for good health and performance. Regularly check ear canals, eyes, mouth and feet. Keep nails and hair on feet and under tail clipped, if needed. Look for cuts and scratches that can become infected or abscessed. You may need to shear or brush the dog's coat during hot weather. Provide high-quality dog food in a self-feeder near the sheep at all times. Put a barrier around the feeder to exclude the sheep, or the dog may remain near the feeder, guarding it from the sheep.*

LGD evaluation

Green *et al* (1984) reported that the greatest benefit of LGDs was in reducing predation. They also identified a number of other advantages and found few limitations to the type of conditions under which a good dog could be a benefit. Coppinger *et al* (1988) and the USDA (1998) have since written that they may not be suitable in large, multi-sectioned pastures with widely scattered sheep and recommended at least two LGDs for range operations or for large areas with several hundred sheep. Green and Woodruff (1990) recommended using aggressive breeds such as Anatolian, Akbash, and Komondor where bears, mountain lions and wolves are frequent predators. Less aggressive breeds such as Great Pyrenees are recommended for public lands where LGDs are more likely to encounter unfamiliar people (Andelt 1992).

A considerable body of research is available assessing the performance of livestock guarding dogs in the USA, very little of which is negative. This large volume of material has here been divided into the following subheadings: Effectiveness (reduction of predation, other benefits and levels of trustworthiness, attentiveness and protectiveness/aggression); Mechanism (observations and speculations on how LGDs might reduce livestock predation); Mortality (levels and causes); and Costs.

Effectiveness:

Controlled field-testing of traditional LGD breeds started in the late 1970s and Lorenz (1985), reviewing the results, reported that by 1984 65-75% of co-operating livestock producers were satisfied with their dogs' work. LGDs were being used in at least 35 states in both range operations and fenced pastures and were reported by producers to work equally well with large (>1000) and small (<100) flocks. A 1982 questionnaire found that 98 (62%) out of a sample of 158 adult LGDs were with flocks that had fewer losses since having dogs; 25 out of 75 LGDs with flocks that had previously suffered frequent attacks (6 or more per year) eliminated losses while the other 50 reduced losses. Other benefits of having LGDs were reported to be peace of mind (39/40 or 98% producers), less reliance on other forms of predator control (24/40 or 60%) and elimination of the need for night confinement (21/40 or 53%).

Of 137 LGDs of 5 different breeds owned by 45 producers in up to 16 states and two Canadian provinces, 109 (80%) were rated by their owners as effective guardians, 25 (18%) were replaced or destroyed because they were ineffective or untrustworthy and 3 (2%) were neither effective nor replaced (Green *et al* 1984). Eleven (25%) of 44 ranchers owned LGDs which had killed or injured livestock; fourteen (10%) of 135 dogs had killed or injured at least one sheep or goat, nine of which mostly in isolated incidents, often within the first two years of life. Five dogs (4%) had to be killed or given away because they became habitual livestock killers. One (2%) of 61 dogs at the USSES was a habitual sheep killer. Forty ranchers estimated average annual savings thanks to LGDs of 68 sheep/goats (range 0-1000) valued at an average of $2836 (range $0-$50,000 at 1982 prices). Two (5%) said their LGDs did not save any sheep or goats from predators and 5 (12%) said their LGDs saved more than 100 sheep per year. The overall mean damage caused by LGDs was $42 per dog. Twenty-seven (73%) of 37 producers experienced net annual savings thanks to their LGDs. Ten (27%) experienced net annual losses; of these, three had used LGDs for less than a year, three had had pre-dog losses of <5 lambs per year and four had had dogs that failed and were replaced (only one discontinued use of LGDs). Thirty-eight (84%) out of 45 producers felt that dogs were an economically practical method to protect their sheep/goats; only one said that they were not economically practical. Twenty-four of another 25 sheep/goat producers interviewed orally said their dogs were an economic asset. Ranchers said that 64% of Komondors, 48% of Great Pyrenees and 56% of other breeds (Akbash, Anatolian Shepherd and Sharplaninac) were aggressive to strange dogs on their property (Green *et al* 1984).

A ten year study (Coppinger *et al* 1988) of the Hampshire College LGD project begun in 1976 found that the average reduction in predation achieved by five

strains of LGDs (Anatolian Shepherds, Maremmas, Sharplaninetz, Anatolian/Shars and Maremma/Shars) was 64%, with predation reduced to zero for 53% of producers reporting in 1986. The only situations where LGDs were judged not effective were those where sheep were scattered widely over a large area and never flocked or where producers did not spend more than minimal time with the flock. The original intention of this study was to test 100 dogs in the northeast but, partly due to producer demand, by the end of 1987 the project was keeping records of 1091 dogs placed in 37 states, including in New England, Oregon, Texas, Minnesota, Colorado, Arkansas, Kentucky and West Virginia.

Andelt (1992) found that lower sheep mortalities in Colorado in 1986 were correlated with the presence of LGDs and felt that producers' estimates of the value of sheep saved by LGDs strongly suggested the lower mortalities were the result of the LGDs. Twenty of 21 producers rated the predator control performance of their LGDs as excellent or good, similar to reports from Kansas (Andelt 1992 citing Andelt 1985) and higher than ratings reported across the USA (Green *et al* 1984; Green and Woodruff 1988). Fourteen of 21 producers indicated that LGDs reduced their reliance on other predator control techniques; about one third indicated that they were a complement rather than a substitute. Andelt (1992 citing Andelt 1985) reported that 15 of 17 Kansas producers indicated that LGDs reduced their reliance on other predator control techniques. Green *et al* (1984) reported that 8 (18%) of 44 and approximately half of 25 other producers stated that LGDs were their only method of controlling predation. Of thirty producers in Colorado that had started using LGDs (Anatolian, Great Pyrenees, Komondor, Maremma, Shar Planinetz and various crosses between these breeds) between the mid-1970s and 1982 fourteen were still using LGDs in 1986. Of the remaining 16, four (all open-range) again used LGDs in 1987-91 and were satisfied with them. Seven (3 open-range, 2 fenced pasture and 2 combined) sold their sheep but were pleased with their dogs. Failures of LGDs were due to: one herder not liking the dogs, 2 dogs killed by vehicles, one dog following the herder and leaving the sheep to return to familiar (open-range) pastures, one dog rated "unsuccessful" though less than 1 year old and 1 dog possibly not staying with the sheep, although the producer may not have known how to manage his dogs correctly (Andelt 1992).

Andelt (1999*a*) and Andelt and Hopper (2000) reported that the number of Colorado sheep producers using LGDs increased from c.25 in 1986 to >159-161 in 1993. At the same time the percentage of sheep with dogs in fenced pastures and on open range increased from c.7% to c.65-68%. Andelt (1999*a*) reported that a total of 129 producers estimated that their 401 dogs reduced predation losses by $914,000 in 1993. Of 160-180 producers using LGDs in Colorado between 1990 and 1993, 84-85% rated their dogs' overall predator control performance as

excellent or good, 12-13% as fair and 3% as poor. The number of producers rating their dogs as excellent or good at reducing predation by specific predators was: 160 (89%) of 180 for coyotes, 48 (72%) of 67 for black bears, 34 (74%) of 46 for mountain lions and 95 (78%) of 122 for domestic dogs. One hundred and seventy-four (96%) of 182 producers would recommend use of LGDs to other producers. Andelt and Hopper (2000) gave these figures slightly differently: 125 producers indicated that their 392 dogs saved $891,440 of sheep from predation during 1993; a total of 154 (96%) of 161 producers would recommend use of LGDs to others. These authors also reported that producers with dogs, compared to producers without dogs, lost smaller proportions of their lambs to predators, especially coyotes, and smaller proportions of ewes and lambs to black bears and mountain lions. Overall, producers who did not have LGDs lost 5.9 (1986) and 2.1 (1993) times greater proportions of lambs to predators than those who did. Proportions of sheep killed by predators decreased with the number of years that producers used LGDs. Mortalities of ewes to predators regardless of type of operation and lamb mortality on open range decreased more from 1986 to 1993 for producers who obtained dogs between these years compared to producers who did not have dogs. More producers (n = 105) indicated effectiveness of their dogs did not change with time compared to those indicating that it did (n = 54). More producers (n = 35) also indicated their dogs became more effective over time compared to those indicating theirs became less effective (n = 19).

An Idaho sheep producer who lost an average of 12 lambs per year to coyotes from a pasture flock of 200 ewes lost only 4 over 5 years when he used a single LGD combined with other (unspecified) predation-control methods. An Oregon sheep producer lost only one lamb to coyotes in 6 years of using a single LGD to protect a pasture flock of 50 ewes, while neighbouring farms lost several sheep every year to coyotes and bobcats. A Wyoming sheep rancher significantly reduced coyote predation on his range sheep flocks for the first 3 years of using LGDs although the increasing coyote population returned losses to their previous levels by the fifth year (USDA 1998).

Jarvis and Jarvis (2000) reported that their Maremmas, as well as successfully chasing away coyotes, black bear and intruding deer – with the first dog to notice the danger said to call other dogs to help when necessary – also warned the farmers when other problems with their livestock arose, such as trapped animals, pregnant ewes cast on their backs or lambs born unnoticed. The dogs were particularly attentive and careful in guarding new-born lambs. The LGDs appeared upset – though without reported problems – when flock composition changed through sales. A combination of one or two LGDs with good fencing was recommended. As 50% of all sheep produced in the western United States in the mid 1980s were

raised within fenced pastures (Green and Woodruff 1987), the increased use of LGDs may be particularly effective in such areas (Ginsberg and Macdonald 1990).

Paul (2000) has reported that in Minnesota, guard animals (LGDs, donkeys and llamas) have been found to be effective only in limited situations for some individuals and has also stated (pers. comm. to Cluff and Murray 1995) that guard dogs were not effective in preventing livestock depredations in wooded pastures. However, Coppinger and Coppinger (1995) concluded that captive wolves in a large pasture and wild wolves in a Minnestota forest tended to avoid areas occupied by dogs, that dogs disrupted these wolves' predatory sequence, that individual LGDs (a 45 kg male Maremma x Sharplaninetz and 45 kg female Anatolian Shepherd) stationed within wolf territories prevented or reduced for limited periods access to supplies of meat (road-killed deer, farm-culled cows, calves or pigs and butcher's scraps) that wolves had become accustomed to visiting and that LGDs are particularly appropriate when the predator is an endangered or threatened species, such as the wolf in Minnesota. Black bears and ravens, which have also preyed on sheep, avoided bait sites with LGDs stationed at them. Some dogs bonded well to cattle (Coppinger and Coppinger 1987).

Mechanism

In controlled trials at the USSES, coyotes appeared to assess LGDs' abilities and killed sheep when the dogs were not with the flocks (McGrew and Blakesley 1982). However, the LGDs also modified their behaviour in response to coyote attacks and the aggressiveness of some increased through the trial period. Sheep adapted their behaviour, too: they stood with or ran to the LGD in over half the coyote attacks, especially those by the more aggressive of the two coyotes used in the trials. The sheep also established their bedding ground and spent an increasing amount of time where the LGDs spent most time and increased LGD effectiveness by detecting the coyote, almost always before the dogs (Komondors).

Pheromones, barking, coyote neophobia and coyote-dog encounters have been suggested as possible explanations for LGDs' reduction of predation (McGrew and Blakesley 1982 citing Linhart *et al* 1979). LGDs patrolling, barking and scent-marking around sheep did not appear to permanently repel coyotes (McGrew and Blakesley 1982). Komondors protected sheep by being near the flock and actively defending it. In 79 (52%) of 153 sheep-coyote interactions in captive conditions, the sheep either stayed with or ran to the dog and in 75 (95%) of these 79 cases the dog stood between the sheep and the coyote or chased the coyote away. In an additional 5 cases the dog ran to the sheep and repelled the coyote. The sheep were never attacked while with the dog. Navajo mongrels also actively repelled coyotes

(Black and Green 1985). Coppinger and Coppinger (1987) hypothesised that the presence of LGDs may prolong the time that predators need to prepare an attack, thus making the protected livestock energetically inefficient as a meal.

In a study of wolf-LGD encounters, no dog (or wolf) was injured, despite co-operative attacks by wolves on the LGDs. The wolves appeared to treat the dogs (and vice versa) as con-specifics, rather than prey items and long "battles" were judged to consist of displays rather than fighting intended to injure. Two LGDs worked better than one and reduced separation anxiety in isolated places (Coppinger and Coppinger 1987).

Mortality:

Lorenz (1985) reported that up to age two and a half years, 2 out of every 10 LGDs on the range and 1 out of every 10 used away from the range died annually. After age two and a half this decreased to 1 in 20 in both cases. Green *et al* (1984) reported that 21 (32%) of 65 LGDs during 5.5 years of study at the USSES died before reaching adulthood (mean age of death 10 months, range 8-54) and 2% were destroyed. Mortality rates were 18% in the first year, 27% birth to two years, 35% birth to three years and 41% birth to four years or, expressed in age classes, 0% 0-6 months, 5% 6-12, 16% 12-18, 9% 18-24, 8% 24-30 and 8% 30-36 months. At the New England Farm Center (NEFC) 143 (33%) of 435 LGDs died at an early age. Causes of death at the USSES and NEFC respectively were disease/surgical complications (18 and 24%), hit by a vehicle (23 and 13%), accident in field (9 and 22%), destroyed due to untrustworthiness (4 and 17%), shot by hunter or trespasser (23 and 7%) and unknown (23 and 17%).

Lorenz *et al* (1986) assessed causes of pre-senile mortality among 449 working LGDs in 31 states and its effects on their management and cost. No differences in mortality were found due to breed or sex, but dogs working on open rangelands died (nearly 75% before 38 months of age) more frequently than those working on farms (50%) or fenced ranches. The causes of death were accidents (over 50%), culling for inappropriate behaviour (33%) and diseases (9%). The high accident and culling rates among young dogs substantially increased the cost of LGDs as a predator control technique. The authors therefore recommended (1) increasing the awareness of producers that accidents are the main cause of LGD death, especially during the first 30 months of a dog's life and (2) reducing the number of culls by improving the genetics of the dogs and by training producers to manage them.

Wolves were reported to have killed four LGDs in the Tom Miner basin in Montana in 1999-2000. The rancher began to keep his dogs inside when wolves were around because he believed the dogs may have been attracting wolves (Int. Wolf 2000). One LGD, the only one present, was killed by wolves in Idaho; groups

of LGDs were said to be better (Meier *et al* 2000). Andelt (1992) reported that one LGD in Colorado was thought to have been killed by a predator (a mountain lion) when less than a year old. The Defenders of Wildlife compensation trust includes payment for LGDs (Meier *et al* 2000).

Costs:

Green *et al* (1984) reported first year costs of $883 for Komondors, the most expensive LGD breed surveyed, including purchase, shipping, food, veterinary expenses, travel, damage caused by the dog and miscellaneous costs. Subsequent annual costs for food, veterinary care, travel and miscellaneous expenses averaged $286. Andelt (1992 citing Andelt 1985) reported that pups cost an average of $240-$690 plus $26 shipping costs and food, veterinary care plus miscellaneous expenses averaged $250 per year. Andelt (1999*a*) reported costs for pups of Great Pyrenees ($150-$350) and Akbash ($300-$500), adults of each ($300 to over $500 and $500 to over $1000 respectively) and annual maintenance costs (around $250 on average). In comparison, Colorado producers with LGDs reported average annual savings per dog of $3216 in ewes and lambs (Andelt 1992).

Other measures

See Cluff and Murray (1995) for a thorough review and critique of lethal and non-lethal predator (wolf) control methods including traps (pitfalls, deadfalls, snares and steel traps), bounties, incentives, poisons (strychnine, Compound 1080, cyanide and thallium), aerial shooting, set guns, fish hooks and stomach piercers, hunting drives and corrals, denning, hunting and trapping, guard dogs, fences, light and sound repellents, chemical repellents, aversive conditioning, relocation of problem animals, diversionary feeding and fertility control.

Livestock producers reduced coyote predation using both lethal and non-lethal methods: various livestock management practices, frightening devices, trapping, snaring, calling and shooting, sodium cyanide guns, denning and aerial gunning. Government specialists in animal damage control primarily used lethal methods (Green *et al* 1984 citing Evans and Pearson 1980, Boggess *et al* 1980, Connelly 1982 and Green 1982; Andelt 1992 citing Andelt 1987).

A graduated system is used to reduce wolf-livestock conflict in the northern Rockies (Meier *et al* 2000):

1. Single instance of depredation: chemical and electronic aversive techniques, (including shock collars; Phillips and Jenkins 2000), harassment (but this may only work in the short-term; Phillips and Jenkins 2000) or capture and radio-collaring of one or more wolves (Meier *et al* 2000).

2. Repeated depredation: increased levels of control, up to and including lethal removal of entire packs – 24 wolves were killed in the three years up to winter 1999/2000 in the three recovery areas (Meier *et al* 2000). It was estimated before reintroduction that 10% of Idaho wolves would be removed annually due to livestock conflict – actual levels are much lower, but expected to increase (Bangs *et al* 2000). Lethal control involves 5-10% of the whole northern Rockies wolf population (Phillips and Jenkins 2000).

Once losses have been confirmed, a rancher may legally shoot a wolf, but there had been only 2 (Bangs *et al* 2000) or 3 (Meier *et al* 2000) cases by February 2000.

Legal killing: The US Fish and Wildlife Service depredation control programs from 1976-85 and the US Department of Agriculture depredation control program from 1986-98 captured from 15-227 (150-225 per year recently; mean 163 from 1990-2000) wolves per year in Minnesota. Trapping (leg-hold traps and snares) and removing wolves is allowed within half a mile of a farm soon after losses have occurred in Minnesota. Only depredating packs are targeted. In 75% of cases one or more wolves are captured (Paul 2000).

Aversion: Siren devices seem to be successful, especially in keeping wolves away from temporary, restricted areas such as around cabins. A signal from a radio-collared wolf sets off sirens and lights; no cattle were lost during tests in Montana. A second-generation device tested in Idaho was also successful – the rancher found tracks of wolves in snow approaching livestock and then retreating when it came in range of the siren (Meier *et al* 2000). Paul (2000) mentioned the "Electronic guard" – a flashing light/siren. Taste aversion trials with Lithium chloride and thiabendazole were planned in the Rocky mountains, but it was problematic to obtain permission from the Environmental Protection Agency for testing these chemicals (Meier *et al* 2000). In a 1998 test on a northwest Wisconsin beef farm the north and west boundaries of the ranch were scent marked with wolf scats and urine from 13th-16th April and an electronic howling device was installed which played howls for 15-30 seconds 3 times per night from 13th-29th April (nightly) and 30th April to 12th May (periodically). Two radio-collared adult wolves (one male, one female) averaged greater distances from the ranch during the trial (Schultz *et al* 2000).

Shock collars: On the same ranch as above the wolf female was caught and fitted with a dog shock collar on 14th May 1998 and subsequently given a shock when she was located on or near the ranch. From 14th May to 30th June the wolf moved further from the farm after being shocked, but the effect was lost from 1st July to 31st August. On 26th April 1999 she was trapped again and fitted with a new collar which administered a shock automatically when she approached within 50 metres

of a command centre in the middle of a calving pasture. No livestock were reported lost to wolves on this farm in 1999 – for the first time since 1994. Twenty-one calves were compensated in 1997 (3 wolves; no trial) and 18 in 1998 (4 wolves; simulated pack and mechanical shocking). In 1999 four wolves were present (Schultz *et al* 2000).

Relocation of predators: Efforts to relocate wolves depredating on livestock are being expanded (Meier *et al* 2000). In the northern Rocky mountains 2-4 wolves preying on livestock (<6%) are relocated or killed annually (Bangs *et al* 2000). According to Phillips and Jenkins (2000), relocation is costly and time-consuming and only 1 in 28 relocated wolves in NW Montana survived to reproduce. Fritts (1982 cited in Coppinger and Coppinger 1987) reported that relocated wolves tended to drift back towards farms with livestock.

Compensation: Defenders of Wildlife compensation trust (does not include payment for domestic dogs). This could be expanded to include pro-rata allowance for suspected but unverified livestock loss (e.g. missing animals) and increased payments to ranchers tolerating wolves on their property or allotments (Meier *et al* 2000).

Husbandry: Subsidies have been proposed for employing cowboys with cattle and herders to watch livestock, as well as for LGDs (Meier *et al* 2000).

Other guardians: Donkeys and llamas (Paul 2000). A wolf pack killed two out of three llamas guarding livestock southwest of Marion in Montana (Int. Wolf 2001).

ASIA

India

Landscape

Highly over-grazed and degraded semi-arid landscape (Jhala 2000).

Livestock

Cattle (a very large number), buffalo, goats and sheep (Jhala 2000).

Husbandry

Nomadic and resident. Shepherd always with the flock. Build corral at night (Jhala 2000).

Predator species and attacks

Wolf *Canis lupus pallipes.* Between 1500 and 2000, thought to be decreasing, in peninsular India. In some areas where wild prey is scarce wolves are heavily dependent on livestock and may follow pastoral communities as they migrate with their herds over long distances (WSGB 2000*c*; Kumar 2001).

Hyena *Hyaena hyaena,* jackal *Canis aurius*, leopard, Indian tiger and Asiatic lion (Kumar 2001).

Losses

Between 1991 and 1995 farmers and shepherds in the Maharashtra Great Indian Bustard Sanctuary suffered livestock losses worth $3246 (probably not all due to wolves). The average annual income there was $300 so all losses were significant. (Kumar 2001)

LGD breeds and status

"Guarding dogs" (Jhala 2000; Kumar 2001).

LGD evaluation

Jhala (2000) reported that dogs were very effective. For example, in early February 2000 four dogs killed a sub-adult wolf defending its den. Kumar (2001) disagreed, stating – without elaborating – that the use of guard dogs has been "unsuccessful".

Other measures

Husbandry: Night vigils, thorn corrals, bringing stock back to the village each night (Jhala 2000).

Illegal killing: Wolf pups are killed (smoked) in the den. Poisoning with pesticides (Jhala 2000), clubbing and attacks by sheepdogs (WSGB 2000*c*). Wolves are classified as endangered and therefore cannot be legally killed, though there is pressure to allow shooting in the *dhangar* (rancher) shepherd communities of the northern, central and western portions of the country where conflict is serious (Kumar 2001).

AUSTRALASIA

All information in this section was taken from the following websites visited in 2001 (the abbreviations in brackets have been used as references within the text):

Andeela Alpacas, Mittagong, Australia (AA)
htpp:www.andela.com.au/maremma/index.html

Mid North Kennels South Australia (MNK)
http://www.users.on.net/drussell/maremm.html

Selladore Maremmas, United Kingdom (SM)
http://www.selladore.u-net.com

Australia

Livestock

Sheep, goats, alpacas, poultry and deer (AA; MNK).

Husbandry

Large sheep farms as well as smallholdings with neighbours close by (AA).

Predator species and attacks

Foxes, wild dogs and birds of prey (MNK).

LGD breeds and status

Imported Maremma, at least some of them from the UK (SM).

LGD training

The US system of confining a pup to a small area with a few head of livestock, gradually letting it out into the herd under supervision until it can begin guarding at 6-12 months of age is appropriate for mainstream sheep farmers but not for smallholdings with regular visits from various groups of people. Instead, one small alpaca stud personally introduced its male Maremma to the various elements of the smallholding, including chicken house and paddocks, on a lead until he followed on command, familiarising the dog with the area he was expected to guard, giving

and reinforcing instructions as needed and gradually allowing the dog to form appropriate social relationships with the alpacas (AA).

LGD evaluation

Livestock breeders using Maremmas in Australia have reported increases in lambing and kidding of up to 35% due to the protection provided against predators (MNK). After training, the male Maremma mentioned above chose to sit with alpacas "for hours on end", especially when there were unfamiliar events such as visitors arriving with a car and trailer or neighbours having a party. The dog had to be introduced to female alpacas with young (crias) carefully and with support because they tended to react defensively, which was confusing for the dog. He learned to keep at a distance from such females but was still rated as attentive by his owners, to whom he also gave peace of mind by his continual presence. They pointed out that barking may bother some neighbours or, alternatively, neighbours may view the presence of LGDs as a protection for their own property and stock, too. A Maremma at a different alpaca farm was reported as having been destroyed after biting visitors (AA). Maremmas were rated as very protective towards children (MNK). Some may take up to 12 months to be totally effective in case of serious predation problems (AA).

EUROPE

Bulgaria

Landscape

Varies, but often rough, forested mountain terrain (Sedefchev 2000). Around 30% of Bulgaria is forested and 37% is arable land. There are large alpine meadows and pastures in the high mountains. The mountain forests are mostly of oak *Quercus* spp. and beech *Fagus sylvatica*, in Kraishte mixed with other deciduous trees and some areas are planted with pine *Pinus* spp (Tsingarska 1999). The Eastern Rhodopes mountains in the south have a mild Mediterranean climate. Some areas of forest have been cut and replanted with *Pinus nigra* (Tsingarska *et al* 1998).

Livestock

Sheep, goats, cattle, horses, donkeys and mules (Genov and Kostava 1993 reviewed in Kaczensky 1996; Tsingarska *et al* 1998).

Husbandry

Usually the sheep of individual owners in a village are amalgamated into a flock of 50-100 and taken by one shepherd with LGDs to the summer grazing grounds. There the shepherds sleep in cabins at night; sheep are left outside with LGDs. Owners of a combined flock may take it in turns to shepherd. Some shepherds have flocks of only their own animals (Tsingarska *et al* 1998). During the winter (from October/November) sheep and goats are generally kept in barns in or near the village (Genov and Gancev 1987 reviewed in Kaczensky 1996). In Pirin in the west, for example, forty shepherds amalgamate their sheep into one large herd in summer and move from the foothills up to alpine pastures at about 2600 m a.s.l. There is no enclosure for the sheep on the mountain and only basic conditions for the shepherds. However, due to a mild climate, year-round grazing is possible in some places, such as the Rhodope mountains. Cattle and horses roam free from spring to late autumn, unguarded (Genov and Kostava 1993 reviewed in Kaczensky 1996; Tsingarska *et al* 1998; Sedefchev 2000) or – in the case of two herds of cattle seen in Pirin in August 2001 (R. Rigg pers. obs. 2001) – accompanied by a single cowherd, one with and one without LGDs. One shepherd was described by Tsingarska *et al* (1998) as grazing his flock of 200 sheep at night during the summer to avoid high daytime temperatures and in winter moved them to more southerly mountains far from his village.

Predator species and attacks

Wolf *Canis lupus*: Population estimated at 800-1000 (Route and Aylsworth 1999). Donkeys and mules are mainly attacked while tethered to trees near villages. Cattle and horses are attacked on pastures, separated from the herd or chased over cliffs (Genov and Kostava 1993 reviewed in Kaczensky 1996). In the Eastern Rhodopes cattle are not attacked, donkeys rarely and then only young (M. Stoeva pers. comm. 2001); there have been some recent cases of attacks on horses, which had not happened in previous years (I. Ivanov pers. comm. 2001).

Brown bear *Ursus arctos*: Population estimated at around 900 in 1989 (Genov and Wanev 1992 reviewed in Kaczensky 1996) and c.700 in 2000 (Swenson *et al* 2000). Ninety percent of victims were sheep, which were preferred to goats. An average of 2.2 sheep (range 1-39) or 1.2 cattle or 1.3 horses were killed per attack. Most sheep were killed on the pasture as the bear tried to disperse the flock. Of 55 claims when the time of attack was known, 48 (87%) occurred between 22.00 and 04.00 (Genov and Wanev 1992 reviewed in Kaczensky 1996). Sheep and goats

were killed from April until December, peaking in July and August, with few attacks during winter when they are in barns (Genov and Gancev 1987 reviewed in Kaczensky 1996), though on rare occasions bears seemed to take advantage of bad weather to break into barns (Genov and Wanev 1992 reviewed in Kaczensky 1996), causing sheep to panic and sometimes die of suffocation or be killed in larger numbers than usual (Genov and Gancev 1987 reviewed in Kaczensky 1996).

Some flocks are attacked weekly (Sedefchev 2000). The greatest damage occurs in the Pirin and Rhodope mountains where sheep and goats are grazed year-round (Genov and Kostava 1993 reviewed in Kaczensky 1996).

Golden jackal *Canis aureus*. Not in the Eastern Rhodopes (Tsingarska *et al* 1998; I. Ivanov pers. comm. 2001).

Losses

Wolf: The average was 2001 head per year killed from 1984-88. Almost 3000 animals (mostly sheep) were killed in 1988, more than six times the damage by bears in that year and three times the damage by wolves in 1984 (Genov and Kostava 1993 reviewed in Kaczensky 1996). Damage is probably over-estimated due to the inclusion of some attacks by stray dogs (E. Tsingarska pers. comm. to Kaczensky 1996).

Bear: From 157 to 709 (averaging 380 more recently) head of livestock, mostly sheep, killed per year (Genov and Wanev 1992 and Genov and Gancev 1987 both reviewed in Kaczensky 1996).

High levels of poaching in the last 10 years have brought about a massive reduction in wild ungulate populations and this, along with insufficient protection, is thought to have increased large carnivore attacks on livestock, most often sheep (Tsingarska *et al* 1998).

LGD breeds and status

The tradition of livestock protection has been in existence in Bulgaria for thousands of years. However, the use of Karakatchan dogs was abandoned in some areas, such as the Eastern Rhodopes, during the collectivisation of agriculture under Communism. LGDs were killed or strayed into the forests (Tsingarska *et al* 1998; I. Ivanov and M. Stoeva both pers. comm. 2001) and few good dogs remained (Tsingarska *et al* 1998). In the more remote areas of the Western Rhodopes there was less collectivisation and so traditional methods, including the use of LGDs, have survived better (M. Stoeva pers. comm. 2001) although Tsingarska *et al* (1998) reported that the use of LGDs was rare in their project area within Kraishte and north Rila mountain.

Ten years ago the native Karakatchan, one of the most ancient LGD breeds, was on the verge of extinction. In December 1996 Green Balkans – Sofia (now Balkani Wildlife Society) organised a national workshop on wolves which led to the Programme for the Study and Conservation of Wolves in Bulgaria. One project within this programme, called "Wolf-Man Co-existence in Bulgaria", operated in co-operation with the Bulgarian Biodiversity Preservation Society (BBPS) – Semperviva to protect flocks and at the same time save the Karakatchan breed (Tsingarska *et al* 1998; Sedefchev 2000). The Karakatchan is threatened by crossbreeding with Caucasian Shepherd, St. Bernard and Newfoundland. A six year survey and inquiry by Semperviva found that hybrids did not have the ability to guard livestock (Tsingarska *et al* 1998). Project workers toured Pirin, Rila, Stara Planina and the Rhodopi to find the remaining working dogs and breed from these (M. Stoeva pers. comm. 2001). The first phase ran from June to December 1997 (Tsingarska *et al* 1998). Work began in the Eastern Rhodopes mountains and in 1999 and 2000 concentrated in the Kraishte, Rila and Pirin mountains of western Bulgaria, where there are relatively high concentrations of wolves and bears and nature conservation initiatives are in place (Sedefchev 2000).

Currently almost every flock is accompanied by LGDs, but these are mostly mixed-breeds. In general, shepherds who have LGDs keep 2-5 dogs to a herd (Landry 1999*b* citing K. Georgiev pers. comm.). Flocks with the native Karakatchan usually have two dogs, three where conditions are hard. For example, a flock of 700 sheep in Pirin is guarded by three dogs. Flocks using mixed-breeds may have more dogs (Sedefchev 2000). In August 2001 a herd of 50 cattle in Pirin (grazed there from April/May to Sept./Oct., depending on the weather) was accompanied by a single cowherd with 2 Karakatchans and a herding dog; in the Eastern Rhodopes a herd of c.400 goats grazing amongst open groves of almond trees was guarded by 3 Karakatchans and a mongrel; a flock of sheep in the same area visited during the night was closed in a barn with 3 Karakatchans and 2 mongrels roaming freely outside (R. Rigg pers. obs. 2001).

LGD training

Karakatchan pups are raised at the "KaraKitan" breeding station, owned by members of BBPS – Semperviva. This breeding station has the last of the old working dogs from known lines in order to ensure the origin of the pups being raised. BBPS – Semperviva members select which flocks are to receive dogs based on the frequency of losses to large carnivores as well as the motivation and opportunity of the shepherds to raise and keep LGDs. Usually a male and a female from different parents are given. In some cases, where conditions are hard, a third dog may be given. Socialisation is not considered a problem; pups usually start to

follow the flock of their own accord two or three days after being given to the shepherds. A two and a half month old male pup went with the flock the morning after he was introduced to the sheep. A three month old female pup "cried" on her second day with the shepherds because she wanted to be released to follow the sheep. Once the dogs are adult, any pups they have should be passed on to other shepherds to ensure the self-sustainability of the programme (Sedefchev 2000).

In the Eastern Rhodopes part of the project (which ran from 1997 to spring 2000) a total of 10 male-female pairs of dogs were given to different shepherds. Recipients were chosen that fulfilled the following criteria (M. Stoeva pers. comm. 2001):-

- They has at least 150-200 head of sheep/goats (not cows);
- The flock was grazed a maximum of 15 km from the village;
- The flock was not left unattended when grazing;
- The flock was brought back to the village every evening;
- There was a level of risk/conflict over losses.

The following regime was used for raising pups (M. Stoeva pers. comm. 2001):

- For the first 3-4 months project staff only talked to future owners, educating them about keeping Karakatchans. A contract was signed specifying the obligations of both parties. Once pups were placed (at age 30-40 days according to M. Stoeva pers. comm. 2001 although Tsingarska *et al* 1998 wrote 2-3 months), they were checked monthly to observe their behaviour and given veterinary treatment as needed;
- 1st to 3rd month: Pup in contact with young livestock through a fence but not left together with them. Once or twice each day for around an hour the pup was put in with the livestock, but only when supervised;
- 3rd to 4th month: Pup left together with young livestock;
- 4th to 5th month: Pup began to go out with the flock;
- 5th to 6th month: Pup together with all livestock including adults;
- Where older dogs were present, young dogs watched and learned from them;
- The diet of pups was carefully controlled by project staff up to the age of 9 months to ensure they grew well.

LGD evaluation

A 1997 survey found that, while good Karakatchan dogs were scarce, there were no complaints of predator damage to livestock where they were kept (Tsingarska *et al* 1998). Dogs must be brave enough to attack predators (presence alone is not enough) and strong enough to drive them off. There are direct conflicts between large carnivores and LGDs in which weaker dogs are often killed. A flock of 700 sheep on Pirin mountain was previously guarded by more than five mixed-breed

dogs but lost, according to the shepherds, an average of 25-30 sheep per year to large carnivores before they were replaced with three Karakatchans. During three years of the Karakatchan project, there were no losses to predators in this or the other protected flocks, despite numerous attacks (Sedefchev 2000).

Three LGDs in the Eastern Rhodopes part of the project were poisoned and there were some problems with neighbours due to LGDs eating their domestic turkeys. None of the 20 dogs in this area had to be taken back from shepherds – all of whom did what had been agreed, though some better than others (M. Stoeva pers. comm. 2001). At least one dog had died by 2001 (R. Rigg unpub. data).

Tsingarska *et al* (1998) stated that the first results of guarding abilities can be observed and registered when LGDs are one and a half years old.

One shepherd in the Eastern Rhodopes responsible for a collective herd of 150 goats and sheep said that he had lost only one animal to wolves in the 3 years since he was given 2 Karakatchan dogs, whereas his village used to lose c.15 annually. He stated that wolf numbers had fallen in his area in the same period, although adding that 9 sheep/goats had been dragged from a nearby barn on the edge of the village and killed in 2000. He received his dogs when they were 2-3 months old and left them to follow the flock without any formal training. He said he trusted them and felt safe with them present (R. Rigg unpub. data).

Other measures

Legal killing: of wolves is encouraged year-round with bounties (a quarter of a month's salary plus timber per wolf killed). Removing pups from dens is permitted. Campaigns to reduce wolf populations are launched annually by the Union of Hunters and Fishermen. The Forestry Committee regards 150-200 wolves as an optimal number which would prevent damage to livestock and wild ungulates (Tsingarska *et al* 1998).

Illegal killing: Poisoning wolves; in some cases this has accidentally killed LGDs (Sedefchev 2000). The use of opiates (Phenobarbitol) was officially banned by the Forestry Committee in April 1993 but illegal poisoning continued (Tsingarska 1996). Trapping and snaring (Tsingarska *et al* 1998).

Alternative food-base: Genov and Wanev (1992 reviewed in Kaczensky 1996) suggested feeding bears in spring and autumn to reduce their predation on livestock.

France

Landscape

The Alps, high mountains with forests and mountain meadows. The Jura mountains with meadows and forests and the Vosges and Pyrenees mountains (in Lit).

Livestock

Sheep and goats (in Lit.).

Husbandry

"La transhumance": Most sheep are brought from the lowlands of southern France up to the Alps in spring where they spend five months on mountain pastures. There is year-round grazing in some areas. Flocks have from a few hundred (CSM 1999) up to over 3000, but typically 1000-2000 head (B. Lequette pers. comm. to Kaczensky 1996). There are estimated to be 120,000 to 140,000 (85,000 on high altitude pastures; Espuno 2000) sheep in Mercantour National Park during the summer – 20,000 within the wolf range – and 60,000-70,000 graze there all year round (Lequette *et al* 1995; B. Lequette pers. comm. to Kaczensky 1996). Traditionally shepherds stayed with their flocks all summer and slept out on the mountainside (CSM 1999), but this has changed with greater accessibility by car (B. Lequette pers. comm. to Kaczensky 1996). Flocks are now never attended by more than one shepherd (Lequette *et al* 2000), almost all remain alone at night, sometimes are even left alone (B. Lequette pers. comm. to Kaczensky 1996) or with LGDs for several days and are only checked 2-3 times a week. Milk sheep are checked twice daily from spring to late summer and brought into a pen or enclosure each night (Bouvier and Arthur 1995 reviewed in Kaczensky 1996), but herding sheep only continues to some extent in the Pyrenees, where sheep milk production is important; sheep for meat are favoured in the Alps and graze freely all summer in many parts. Sheep in the Jura mountains are kept in open meadows intermingled with forest (Kaczensky 1996). Practices at some flocks in the Alps have changed again in response to the return of wolves from Italy in 1992 (Lequette B. and Houard T. 1995; Lequette *et al* 2000; T. Bennett pers. comm. 2000).

Predator species and attacks

Dog *Canis familiaris* (Bouvier and Arthur 1995 reviewed in Kaczensky 1996).

Wolf *Canis lupus*: Returned to France from Italy (confirmed by genetic analysis) after extirpation in the 1930s due to human hunting (Lequette *et al* 1995). The first sighting was a direct observation of two wolves on 5th November 1992 (Lequette

and Houard 1995). In late winter 1997 there were around 20 wolves in the French maritime Alps (Lequette 1997). Goodwin *et al* (2000) reported 30-50. There have been regular losses of sheep to wolves since 1993, with the mean number of attacks per herd per summer increasing yearly from 1994 to 1996 as the wolf population expanded in range and numbers, stabilising in 1996-97. Ninety percent of attacks have been at night (Espuno 2000). One shepherd reported that attacks were at night when wolves first reappeared, but later also occurred during the day (T. Bennett pers. comm. 2000). Attacks have often been focussed on a small percentage (Espuno 2000) – less than 20% (Lequette *et al* 2000) – of flocks. A case was reported of a large number of sheep, including pregnant ewes, many of which aborted, stampeding off a cliff while fleeing from wolves (T. Bennett pers. comm. 2000). A study in Mercantour National Park using records from the Direction Departementale de l'Agriculture et de la Foret, Mercantour National Park and Groupement d'Internet Economique Faune Sauvage de France – LIFE programme found that the number of wolf attacks per herd strongly correlated with herd size. Confinement of herds at night was related to lower numbers of attacks but no effect was detected of the day-time presence of a shepherd (Espuno 2000).

Brown bear *Ursus arctos*: Numbers in the Pyrenees dropped from c.150-200 in 1938 to 30 in 1971, 13-16 in 1983 and 6-8 in 1993 (reviewed in Kaczensky 1996). One bear was credited with 65 attacks on sheep in the Pyrenees in 1991 (Kaczensky 1996). Sheep kept for milk are less vulnerable than those for meat due to different husbandry practices (Bouvier and Arthur 1995 reviewed in Kaczensky 1996). Attacks in 1968-91 occurred from April to November, with a peak in September. Sheep seemed to be more vulnerable when on high pastures, from mid-July until mid-October (Nedelec *et al* 1995 reviewed in Kaczensky 1996).

Lynx *Lynx lynx*: In 1971-89, wild lynx caught in Slovakia were reintroduced to the Swiss Alps and Jura mountains on the Swiss-French border and in 1983-93 to the nearby Vosges in northeast France (Breitenmoser *et al* 1995 reviewed in Kaczensky 1996). In 1988-89 predation on livestock was consistently high from May to November (ONC 1989 reviewed in Kaczensky 1996).

Estimated losses

Dog: Stray dogs killed 667 sheep in the Haute-Savoie in 1983 (Bouvier and Arthur 1995 reviewed in Kaczensky 1996). Around 100,000 domestic animals are killed by stray dogs annually in France (reviewed in Landry 1999*b*), including 70,000 sheep (WSGB 1999*a*).

Wolf: In 1993, 36 sheep were killed in the Mercantour National Park area and 57,200 FF (c.$11,400) paid in compensation. In 1994, 98 were killed and 24 injured (21 died later), 200,000 FF (c.$40,000) paid. From January to early June

1995, 50 were killed and 24 injured (Lequette *et al* 1995) and throughout the year 95 attacks resulted in 408 sheep and goats killed (Lequette *et al* 1996*a*). In 1996 more than 500 sheep were killed from January to the end of October (Lequette *et al* 1996*b*) and 950,000 FF was paid in compensation throughout the year. In 1997 damage reached about 700 sheep, plus 118 paid at 75% of their value (Lequette 1997). Differentiating wolf/dog attacks is problematic (Lequette *et al* 1995) and there are many times more stray dogs than wolves in the area, so wolf damage might be somewhat over-estimated (B. Lequette pers. comm. to Kaczensky 1996; Lequette 1997). Wolves were blamed for more than 1000 sheep deaths in 1999. Farmers have claimed that around 3000 sheep in Mercantour National Park (WSGB 2000*a*) and 5000 sheep in the Alps (WSGB 2000*b*) were killed by wolves from 1992-99. Reuters (2000 quoting C. Guigo) reported 4000 animals killed since 1992 causing 11 million FF ($1.62 million) of damage.

Bear: Small losses in the Pyrenees, almost entirely of sheep and goats. Livestock depredation declined along with bear numbers from 1958 to 1990 and averaged 68 killed per year in 1968-91 (Nedelec *et al* 1995 reviewed in Kaczensky 1996) and c.75 in the ten years before 1996. In 1983 bears killed 66 sheep in the French Pyrenees (Bouvier and Arthur 1995 and Nedelec *et al* 1995 both reviewed in Kaczensky 1996).

Lynx: Minimal in the Alps and Vosges but considerable in the Jura mountains, beginning in 1988. An average of 123 livestock were killed per year in 1984-92 (reviewed in Kaczensky 1996). In 1989 more than 389 sheep and goats were killed during 219 attacks, with 77% of the damage in Ain district and 40% of these attacks in three communities or 1% of the lynx range. No significant difference in age preference was noted: in the Jura 155 adult sheep and 215 lambs were killed (ONC 1989 reviewed in Kaczensky 1996). Low wild ungulate density, vulnerability of sheep on pastures among forests and illegal releases of captive lynx were suggested as possible causes. In 1988 there were 74,328 sheep grazing in the Jura, but not all within the lynx range. (J.M. Vandel pers. comm. to Kaczensky 1996).

LGD breeds and status

The Great Pyrenean mountain dog was part of the livestock tradition in the Alps but their use became less common after the extirpation of large carnivores. Very few flocks in 1996 had LGDs (B. Lequette pers. comm. to Kaczensky 1996), although Landry (1999*b*) reported that some kept them for protection against bears and dogs. A project to help farmers protect their sheep with LGDs began in 1985. Usually one dog is sufficient to protect a flock. Since the return of wolves to France, the Pastou/Patou/Patois has been employed with a number of flocks (CSM

1999; Landry 1999*b*). One shepherd reported using a male Beauceron from the Massif Central which he stated both guarded and herded a combined flock of 1600 sheep (T. Bennett pers. comm. 2000).

LGD evaluation

Forty sheep from a flock of 1500 in Mercantour National Park were lost in 1993. After the introduction of a shepherd and two dogs, only five sheep were lost. Wolves killed just one sheep in 1998. In 1999 there were 6-8 wolves and four guarding dogs in the area. The local shepherd was convinced that it was not necessary to kill the wolves in order to protect livestock (Landry 1999*a*).

In the Queryas Regional Park in summer 2000 there were no attacks on 20 flocks inside enclosures with a shepherd and dog nearby (CSM 1999).

One shepherd's flock sustained six wolf attacks in 1999, but then had none since starting to use dogs, enclosures and a sound machine, but he was still not convinced that wolves and the transhumance of sheep could co-exist. Other shepherds were said to be more optimistic provided that the EU paid sufficiently for protective measures (CSM 1999).

There have been some cases reported of wolves killing LGDs (Landry 1999*a*).

The study in Mercantour National Park found that there were significantly lower numbers of attacks when LGDs were present, with a weak negative correlation between number of attacks and number of dogs present (Espuno 2000).

Other measures

Husbandry: The French Environment Ministry, through the Mercantour National Park budget, finances protection systems (shepherd huts, electric fences, LGDs) proposed to shepherds working in wolf areas (Lequette *et al* 1995). One farm initiated 24 hour guarding of their flock and constructed a 2 m high fence, buried 1 m into the ground, enclosing 6 acres (2.4 ha) around the barn (T. Bennett pers. comm. 2000). Cabins have been built or renovated on remote pastures so that shepherds can sleep closer to their sheep (CSM 1999). Electric fences are used to enclose flocks at night. They are usually portable and confine sheep but are not predator-proof (Espuno 2000). One shepherd reported that wolves had quickly learned to panic sheep into breaking out of electric fences (T. Bennett pers. comm. 2000).

Removing predators: All 3 large carnivores are fully legally protected (bear since 1962, lynx 1976 and wolf 1993) but the Environment Ministry can issue permits to remove a wolf, bear or lynx depredating on livestock. This is then done by wardens of the State Hunting Office by shooting or trapping at a previous kill or in the act of killing livestock. Eight lynx were removed from the Jura mountains in 1989-91

(Kaczensky 1996). Overall damage decreased after lynx removal, but in six cases removing a single lynx only gave relief from predation for 20 days (Vandel *et al* 1992 reviewed in Kaczensky 1996). Toxic collars were believed to have killed two lynx in the Jura (Kaczensky 1996). Many farmers call for wolves to be eradicated or confined in a fenced park, or for a zoning system to be introduced (Hutt 2000).

Illegal killing: Poaching of lynx has been a problem in the Vosges and Jura mountains (Kaczensky 1996). In the Alps there have been reports of poisoned sheep carcasses left where wolves are known to frequent (CSM 1999).

Protective collars: More than 1000 collars, made of 5mm leather with spikes or zinc plates, were fitted to sheep at around 23 different pastures in the Jura mountains from 1988-96. Seven pastures had no attacks and 16 had 106 attacks by lynx (60% of the pastures had only one attack per year before fitting sheep with collars). Fifty of the attacks were on flocks without collars and in 25 attacks 7 collared animals were killed. No information on collars was available for the remaining 31 attacks (Vandel unpub. data and Vandal and Stahl 1993 both reviewed in Kaczensky 1996).

Compensation: Established for losses to lynx in the Jura mountains in 1989 and the Alps in 1990 (Kaczensky 1996). Paid by the Fonds Français pour la Nature et l'Environment for wolf damage since 1993-4 (Lequette *et al* 1995; Espuno 2000). Seventy-five percent of the market price is paid if it is not sure whether damage was caused by wolves or dogs (Dahier 1995 reviewed in Kaczensky 1996). According to T. Bennett (pers. comm. 2000), because insurance is paid for losses to dogs and compensation for losses to wolves (carcasses must be shown), in cases where the predator involved is not certain, each responsible body may argue that the other should pay. After a confirmed wolf attack, stress compensation per head of surviving sheep is automatically paid as well as an additional amount for lost milk (Dahier 1995 reviewed in Kaczensky 1996). The market price of killed animals plus a fee for disturbance and additional effort are paid in the case of lynx (Kaczensky 1996).

Aversion: Aversive conditioning was attempted four times by chasing a bear, but attacks shifted to other areas (Camarra *et al* 1992 reviewed in Kaczensky 1996). Some shepherds use make-shift measures such as bird scarers or speakers placed round the corral and broadcasting intermittently through the night from a cassette recorder. Queyras Regional Park were reported to be using wardens and forestry workers to maintain a sporadic human presence on the mountains during winter in an attempt to keep wolves away from pastures (CSM 1999).

Italy

Landscape

The Abruzzo region in the Apennine mountains, central Italy. Below 1100 m a.s.l. are oak *Quercus* spp. and hornbeam *Carpinus betulus*, with extensive pastures and arable land in the valleys. Thick beech *Fagus sylvatica* forests cover slopes from 1100 m to 1800 m a.s.l.; some primeval pine *Pinus* spp. forests survive in Abruzzo National Park. Above the forests are further extensive open pastures, with a rocky high mountain zone above them. In winter there is generally permanent snow cover above 900 m a.s.l. The north is largely un-wooded (Zimen 1981). The province of L'Aquila (5034 km^2) is between 600 m and 2912 m a.s.l. with 31% beech and oak *Quercus* spp. woodland and 27% dry upland grasslands and semi-natural pastures (Cozza *et al* 1996).

A separate area with wolves north of Rome, Monti della Tolfa, has hills of <600 m a.s.l. with typical Mediterranean bush vegetation, few human visitors and cattle left to wild pasture year-round (Boitani 1982; Boitani 2000).

Livestock

In L'Aquila Province the main livestock were sheep and goats (212,500, 48.3% of Abruzzo's total stock), cattle (29,230, 20%) and horses (14,400, 77%) as well as mules and donkeys (Cozza *et al* 1996). There are many free-roaming dogs (Boitani 1982).

Husbandry

The traditional system of shepherding in Abruzzo was and partially still is transhumance. Local flocks rarely exceeding 100-200 (maximum 300) sheep plus a few goats, are kept in areas above 760 m a.s.l. They spend the winter in villages, are driven out to pasture close by when there is no snow cover and are kept in stone sheds at night. In summer they are taken higher up the mountains to graze, guarded by shepherds with at least two LGDs, put into fenced pens at night and are not allowed out in fog (Zimen 1981; Boitani 1992). Larger flocks of up to several thousand from the plains are also managed by transhumance: eight months are spent at lowland farms and from June-October they are moved to uplands, housed in temporary folds at night and attended by shepherds and LGDs. Herding dogs are not used; shepherds keep their flocks together and drive them themselves. Cattle and horses are left to graze freely (Zimen 1981; Cozza *et al* 1996).

Landry (1999*b* citing P. Breber and F. Francisci both pers. comm.) noted that the sheep economy is mainly based on the manufacture of cheese. Sheep are milked in

the morning and then led to pastures accompanied by several guard dogs which form a pack in which each individual has a precise function. They are generally left on alpine pastures more or less without surveillance and then brought back in the evening for milking. In the north of Italy, milk-ewes have often been replaced with ewes for meat, which need less attention.

In L'Aquila Province, there is a lot of small-scale (average 7.6 ha) mixed farming, with 64% of farmers engaged in four or more enterprises on one farm. Sheep and goat flocks vary from on-farm flocks of 2-30 up to 500-1500 for dairy and meat production. Horses are often kept for recreation – sometimes allowed to graze unattended on abandoned farmland (mares with young are hobbled; Zimen 1981) – and mules and donkeys for work (Cozza *et al* 1996).

In other areas grazing is free and lambs, calves and foals are born on the pasture (Meriggi *et al* 1991). Flocks number 1000-2000 and are unguarded or have inexperienced shepherds with poor dogs (Boitani 1992).

Predator species and attacks

Wolf *Canis lupus*: Recovered from a fragmented population of 100-200 in isolated Apennine mountain ranges in the early 1970s (Boitani 1992) to a present population estimated at 400-500 extending throughout the whole Apennine range and into the Maritime Alps of France (Boitani 2000). As a result of the increased numbers and range of wolves over the last 25 years, wolf-livestock interactions have also changed drastically (Ciucci and Boitani 2000).

During a 1974-78 study in Abruzzo, wolves were seen to approach pens from downwind and sometimes to observe flocks for long periods. Attacks resulted in from 1 to 200-300 sheep killed at one time, with surplus killing only when wolves chased sheep out of the pen (Boitani 1982; Boitani 1992). Most losses recorded were of single sheep, either dragged out of the pen and eaten nearby at night, or killed when separated from the flock on the way back to the fold and/or in thick mist. There were also larger losses of up to ten sheep or, on two occasions, more than 100 which seemed to happen when the sheep panicked. Wolves took advantage of bad weather (mist, thunderstorms) to attack flocks. Pressure increased on domestic animals during the period of wolf pup-raising (Zimen 1981). Cattle were rarely attacked and only a few wolf packs seemed able to kill horses regularly (Boitani 1982). Predation on cattle and horses concerned almost exclusively calves and foals (reviewed in Kaczensky 1996), but even these were rarely killed by wolves and then usually when separated from their mother, despite being left to graze freely (Zimen 1981). In winter wolf depredation was limited to a few livestock. Wolves also killed and ate most kinds of domestic dogs, including hunting dogs (Boitani 1982).

Fico *et al* (1993 reviewed in Kaczensky 1996) found that in 1980-88 in Abruzzo wolf predation on horses was highest from April (the onset of foaling) until July, on sheep and goats from July until October and on cattle from May (calving) until November. Attacks by wolves on sheep and goats, cattle and horses occurred in every month of the year.

Stray and feral dogs *Canis familiaris*: c.3000-15,000 in the Abruzzo region (Fico *et al* 1993 reviewed in Cozza *et al* 1996 and Kaczensky 1996). A dog census in 1983 estimated 80,000 feral dogs and 850,000 free-roaming in Italy (Boitani and Ciucci 1993). Many attacks claimed to have been by wolves actually involved dogs (Zimen 1981; Boitani 1982).

A study in L'Aquila Province by Cozza *et al* (1996) of losses mostly (94.2%) attributed to wolves found that more cattle or equids were attacked in spring than sheep or goats. Almost all reported sheep damage was to adults (but losses of lambs were often not claimed due to their low value), whereas cattle and equids were mostly young stock. Attacks on sheep occurred slightly more often during the day (including dawn and dusk) whereas cattle and equids were attacked mostly at night. Most attacks were on animals at pasture (being herded, in the case of sheep and goats), in 13.4% of cases on an animal said to have become detached from the flock along the grazing route. Around one third (31.3%) of attacks on sheep were at the fold or in enclosed meadows. Most attacks occurred in wooded or scrub terrain, rather than open ground. Medium-large flocks and large cattle or equid management units were more exposed to high predation than smaller ones, but no association was found between level of predation and management or grazing system (except, possibly, the casual management of pet horses). It was concluded that reasons for predation rates were probably specific to each management unit.

Ciucci and Boitani (1998) investigated wolf- and dog-livestock conflicts (1992-95) and costs of compensation (1991-95) in the Tuscany region of central Italy. They found that most depredations (95.2%) involved sheep, with a mean annual loss of 2550 (± 730 SD) sheep or 0.35% of the regional stock. Sheep lost to predators by province were correlated with sheep density within areas containing wolves, but there were also marked geographical and temporal fluctuations in compensation costs. The highest levels of conflict were observed in provinces at the border of the wolf range, where livestock was left unattended most of the year and sheep density reached its highest regional levels. The authors reported that, according to approved damage claims in 1992-95, depredations were highly seasonal, increasing steadily from spring to early fall. They suggested this may follow trends in sheep availability on pastures and density fluctuations of local wolf packs. An average of 3 sheep (range 1-18) were killed per attack (n = 483); 42% of the attacks involved killing of 2 sheep. In addition, 21-113 sheep (19% of sheep lost or 2.3% of the

depredation events) were killed or attacked in mass slaughters. Depredations also resulted in 35% (n = 168) of sheep injured and 33% (n = 158) missing. Most sheep depredations occurred during the night, in pastures interspersed with wood or vegetative cover, and involved free-ranging flocks unattended by either shepherds or LGDs. High levels of conflict occurred in localised areas of intensive sheep production; 6% of the affected farms and 8% of the affected municipalities accounted for 32% of sheep lost to wolves and dogs across the region. Cozza *et al* (1996) reported similar results from L'Aquila, where the 4.1% of claimants considered to be chronically affected (2.1-7.8 claims per year) by predation accounted for 26.2% of all claims, while 87.9% of claimants were affected by predation less than once per year or on a single occasion.

Brown bear *Ursus arctos*: The isolated Abruzzo population is currently estimated at 40-50 (Swenson *et al* 2000) and was reported to be responsible for 4.8% of attacks on livestock (Cozza *et al* 1996) in the area. In 1980-88 sheep and goats were predated on throughout the year but mainly from July to October (with a dip in August). Cattle predation began in May (calving) and continued until December but was highest from July to September. Horses were attacked from April (foaling) until November, with a peak in June (after Fico *et al* 1993 in Kaczensky 1996).

Losses

According to Ciucci and Boitani (2000), approximately $2 million is paid in compensation per year for livestock losses to predators which, they say, seems to be the highest in Europe, but is still less than 20% of the compensation paid to Italian farmers for wild boar (*Sus scrofa*) damage to agricultural crops. The same authors (Ciucci and Boitani 1998) found that Tuscany's regional compensation programme cost $345,000 (± 93,000 SD) per year in 1991-95.

Wolf: Zimen (1981) and Boitani (1982) reported that many claims for damage by wolves in Abruzzo in the mid-1970s were fraudulent or the damage was done by dogs. Documented losses, mostly of sheep, averaged c.1489 head of livestock per year in 1974-78 and 1267 – including 16% horses – in 1980-88 (Boitani 1982; Fico *et al* 1993 reviewed in Kaczensky 1996). Compensation paid in Abruzzo totalled $103,000 in 1974 and $209,000 in 1977 (Boitani 1982) although, after re-calculating to take account of damage by dogs, averaged $61,000 per year from 1974 to 1978 or $2773 per wolf per year (Blanco *et al* 1992 after Boitani 1982). F. Tassi (pers. comm. to Zimen 1981) estimated that actual damage to livestock in Abruzzo National Park was only 20-30% of that claimed. Meriggi *et al* (1991 reviewed in Kaczensky 1996) reported that 45 head of livestock were killed in northern Italy in 1988.

In 1980-88, 83.9% of 4993 compensation claims in Abruzzo region were filed in L'Aquila Province. Almost all (94.2%) losses here were attributed to wolves, though only 3.9% of claims were verified by veterinarians. Over the period 1986-92, 615 management units or 28.2% of the total number censused in 1991 registered a total of 1777 claims. In the Abruzzo region in 1994, 0.14% of the total subsidies to agriculture were compensation for damage caused by species of scientific interest such as wolves and bears (Cozza *et al* 1996). Approximately 1.8 million euros were paid in compensation for wolf damage in 1996 and c.0.5-1.0 million euros were estimated for 1997 (Boitani 2000).

Dogs: Lack of specific professional support for evaluating canid attacks (especially distinguishing between wolf and dog attacks), as well as the previous lack of compensation for damage by dogs, which was not introduced until 1995 (1994 in Tuscony, Ciucci and Boitani 2000), is likely to have caused a significant level of bias in attributing losses to wolves which were actually caused by dogs or by neonatal and juvenile mortality (Cozza *et al* 1996). Boitani (1982) suggested that as many as 50% of claims in 1974-78 were actually due to damage by stray dogs.

Bear: Killed an average of 71 animals, mostly sheep and goats, per year in Abruzzo in 1980-88 and 0.75 in Trentino in 1978-89 (Fico *et al* 1993 reviewed in Kaczensky 1996).

LGD breeds and status

Shepherds use different races of dogs or mongrels to protect their flocks (Landry 1999*b* citing V. Guberti pers. comm.). Many LGDs observed in the 1970s wore collars with 5 cm metal spikes to protect them from wolves (Zimen 1981).

Cane da pastore Maremmano-Abruzzese or the Maremma has been used for more than 2000 years to protect sheep from bears and wolves. In the traditional transhumance system, still operating in some rural areas, flocks of up to 300 sheep on summer pastures are constantly attended by a shepherd along with 2-3 (Ciucci and Boitani 2000) or 5-15 (Landry 1999*b* citing P. Breber) dogs.

The Bergamo Shepherd dog was also traditionally a livestock guarding dog but its use seems to have become rare (reviewed in Landry 1999*b*).

LGD evaluation

Depredation problems were much less in areas where the traditional husbandry system of small flocks with shepherds and LGDs was still used than in areas where it had been abandoned (Boitani and Ciucci 1993; Ciucci and Boitani 1998) and larger flocks were attended by inexperienced shepherds and dogs. In some cases wolves seemed to have learned to approach sheep pens without being detected by LGDs though, in general, LGDs in Abruzzo were still an effective deterrent against

wolf attacks (Boitani 1982). Boitani (1987 cited in Coppinger and Coppinger 1995) noted that sheep were "well protected" against wolves by LGDs, although damage did occur.

LGDs are not always correctly socialised (Landry 1999*b*). Coppinger *et al* (1983) and Landry (1999*b*) observed that some dogs remained with livestock at stables while others accompanied shepherds. In the evening, when the sheep were together, some LGDs left the flock to roam in bands, causing a lot of damage in neighbouring flocks (Landry 1999*b* citing V. Guberti pers. comm.). However, Coppinger *et al* (1983) observed that in some regions (Monti della Laga) ewes fed in wooded areas under the surveillance of LGDs without shepherds present.

Other measures

Husbandry: The traditional method includes a number of anti-predator measures besides LGDs, such as keeping sheep in fenced pens at night (although the use of a cord net favours wolf attacks, Boitani 1982) and not allowing them out in fog (Zimen 1981; Boitani 1992). Zimen (1981) observed that when mist appeared in the mountains, the shepherds immediately took their flocks down to the valleys and, if it was misty there too, returned them to their sheds. However, inexperienced shepherds from outside the area, with large flocks or inexperienced dogs, did not always appreciate the danger or were unable to collect their many animals in time. The forest administration of Abruzzo built bear- and wolf-proof pens in the mountains in the 1970s (Zimen 1981). The WWF-sponsored Abruzzi Wolf Project in the mid-1970s recommended that one shepherd, with "sufficient" dogs, be in charge of no more than 100 sheep.

Illegal killing: Despite having full legal protection since 1976, 50-70 wolves (Boitani 2000) – a large proportion of the wolf population (Ciucci and Boitani 2000) – are killed illegally every year through shooting, poisoning and trapping (Boitani and Ciucci 1993), mostly by hunters rather than shepherds or livestock breeders (Boitani 1982). A bias towards blaming wolves for losses has led to antagonism towards them and indifference to solving the widespread problem of stray and feral dogs (Cozza *et al* 1996).

Fladry: This is a traditional technique for hunting wolves in Eastern Europe and Russia, which is based on wolves' unexplained reluctance to cross a barrier consisting of a long line suspended over the ground with strips of red material 40-50 cm long and 10 cm wide hanging down from it at 35-40 cm intervals (Okarma 1993). Recently it has been used by researchers in Poland (Okarma and Jêdrzejewski 1997) and Romania (Promberger *et al* 1997; Promberger-Fürpaß *et al* 2000) to trap wolves for fitting/replacing radio-collars. Trials at Rome Zoo in 1997-98 found that captive wolves never crossed such a barrier, even to reach their daily

food ration, when red or grey flags were placed 50 cm apart and touched the ground at the bottom. Wolves crossed the barrier if the flags were 75 cm apart or the rope was 25 cm or 75 cm from the ground. The Italian Agriculture Ministry accepted a research project to test the technique in a forest area in Abruzzo with a view to using it for protecting from wolves livestock which is kept in enclosures at night (Musiani *et al* 1999; Musiani *et al* 2000; Musiani 2000).

Alternative food-base: The reintroduction of red deer *Cervus elaphus* and roe deer *Capreolus capreolus* into the Abruzzo region provided alternative prey for wolves (Zimen 1981; Boitani 1982; Boitani 1992). A supplementary feeding programme to keep bears within Abruzzo National Park began in 1968 and subsequently has involved provision of fruit trees, crops and, sometimes, carrion sites (Boscagli 1995 reviewed in Kaczensky 1996).

Compensation: Ciucci and Boitani (1998) concluded that compensation programmes alone were not effective in reducing the conflict or in preventing illegal, private efforts to control wolf numbers. They recommended that improved husbandry should be encouraged and facilitated through financial incentives and public education. However, Cozza *et al* (1996) pointed out that the low probability of predation for each owner in L'Aquila means that investment in protective measures or changes in husbandry practice may not be viable even in areas with a high number of attacks.

Norway and Sweden

Landscape

Forested mountains. The northern boreal region is dominated by birch and conifer forests with large areas of minerotrophic mires. The southern boreal area also has coniferous forests interspersed with alder *Alnus incana* forests and mires (reviewed in Sagør *et al* 1997). The Snøhetta plateau in southern Norway is 4400 km^2 with peaks up to 2000 m a.s.l.. Valleys are dominated by birch *Betula pubescens* woodland, with pine *Pinus sylvestris* and spruce *Picea abies* at lower altitudes. Some valleys have roads, summer dairy farms and groups of summer cabins. The plateau is separated from similar neighbouring plateaux by valleys with permanent settlements and transport corridors. Timberline in the west (more oceanic climate) is at about 800 m a.s.l. and in the east (more continental) at around 1000 m a.s.l. (Landa *et al* 1999).

Livestock

Sheep and reindeer (in Lit.).

Husbandry

In Norway, two to two and a half million sheep are released into the forests and mountains, on unfenced, rough ranges for up to 3 months between spring and autumn (Hansen and Bakken 1999; Hansen and Smith 1999; Linnell 2000). Sheep are released onto mountain ranges in June, left to graze unattended and collected at the beginning of September (Landa *et al* 1999). Shepherds sometimes patrol the unfenced ranges for part of each day, but the sheep are often greatly dispersed; some breeds do not flock. Sheep are kept indoors during winter and lambing also occurs indoors in late April to early May. Sheep and lambs are then kept in fields close to the farm until early June (Kaczensky 1996).

Twenty herding co-operatives on Snøhetta plateau had an average of 1100 sheep each, increasing from 375 in 1979 to 1890 in 1994. The participation of sheep owners in co-operatives varied from 70-95% between municipalities. Rams were not released on the same ranges as ewes and lambs (Landa *et al* 1999).

Predator species and attacks

Brown bear *Ursus arctos*: The Scandinavian population of 25-50 is shared between Sweden and Norway (Linnell 2000). A typical bear attack results in the killing of one to several sheep, with occasional cases of surplus killing in confined settings. Sheep-killing bears were categorised as: (1) adult males with/without an associated family group; (2) sub-adult males leaving home ranges that overlapped livestock ranges, possibly becoming habitual livestock predators; or (3) transients (Mysterud 1980 reviewed in Linnell 2000*b*). Bears preferred ewes to lambs (Kvam *et al* 1995 cited in Sagør *et al* 1997 and Landa *et al* 1999; Knarrum 1996 reviewed in Kaczensky 1996). Damage in Hedmark County in 1990-93 was most intense in July and, especially, August, when there seemed to be more bears present in Norway. In the May/June breeding season some of Norway's primarily male population travel to Sweden. Depredation increased from 1981 to 1991 as bear numbers increased (reviewed in Kaczensky 1996).

Eurasian lynx *Lynx lynx* (Hansen and Bakken 1999; Linnell *et al* 2000*a*). Prefer lambs (Directorate for Nature Management pers. comm. to Sagør *et al* 1996).

Wolverine *Gulo gulo*: Minimum populations in 1995-97 were estimated at 120 individuals in the north of Norway and – isolated by c.100-200 km – 27±7 in the south on Snøhetta and surrounding plateaux (Landa *et al* 1998*b* reviewed in Landa *et al* 1999). Sheep and reindeer are particularly at risk; lambs are preferred (Directorate for Nature Management pers. comm. to Sagør *et al* 1996). Reported attacks have increased in recent years since the introduction of a compensation scheme, though numbers of ewes and lambs released onto summer pastures have also increased (Landa *et al* 1999). Attacks vary in time and space but some areas or

owners have consistently high losses. Most documented cases occur in the last few weeks of the grazing season (Børset 1995 and Mortensen 1995 both reviewed in Landa *et al* 1999), corresponding to the expected increase in wolverine caching behaviour before winter (Haglund 1966 reviewed in Landa *et al* 1999). Lambs on summer pastures are especially vulnerable – they are six times more at risk of being killed than ewes (Landa *et al* 1999) – and different breeds of sheep vary in awareness and anti-predator strategies (Hansen *et al* 1988 reviewed in Landa *et al* 1999). Dala sheep had higher losses than expected, whereas Norwegian short-tailed and fur-bearing breeds had lower (Landa *et al* 1999). Levels of sheep losses were strongly related to the occurrence of wolverine cub-rearing areas (Landa *et al* 1998*a* reviewed in Landa *et al* 1999).

Wolf *Canis lupus*: A total of 78-81 censused in Norway and Sweden in winter 1999-2000 (reviewed in Svarte 2000); 55-80 (Boitani 2000).

Golden eagle *Aquila chrysaetos* (Kaczensky 1996).

Losses

Up to 20% of reindeer *Rangifer terandus* may be preyed upon annually (Kvam *et al* 1995*a* reviewed in Hansen and Bakken 1999).

More than 100,000 sheep disappear from the summer range of Norway each year. In some areas depredation may exceed 70% of the total loss (Hansen and Bakken 1999). Many (if not most) missing sheep are never recovered. Studies with silent mortality transmitters by Kvam *et al* (1995*b*) and Mysterud *et al* (1994) reviewed in Kaczensky (1996) and Hansen and Bakken (1999) found that most losses were due to predators. Mysterrud and Warren (1994) marked 1891 lambs, of which 133 (7%) died; in 60% of cases this was attributed to predators. Compensation for loss to predators is annually paid on 3-5% of all sheep released in spring, which represents 13% of sheep lost to all causes. In some areas (e.g. Hedmark County) up to 13% of all sheep are lost to predators (Kaczensky 1996).

Bear: Cause the highest losses relative to their low numbers in Norway: an average of 2055 sheep per year (0.09% of total stock) in 1992-95 (Kaczensky 1996). In 1998, compensation was paid for 4265 sheep, which was an average of around 100 sheep killed per bear. Losses are usually well documented by trained personnel and have steadily increased over the last 10 years (Linnell 2000) in areas where there has been increased immigration from the increasing population of bears in Sweden. The percentage of ewes lost at two test sites on the border increased from 1.8% and 1.6% in 1981 to 9.3% and 6.3% in 1993 respectively (Sagør *et al* 1997). Nationally, less than 0.08% of sheep are lost and 1% of owners are affected, but individual owners may lose up to 28% of their stock (reviewed in Kaczensky 1996). In the

central Lierne area, bears caused 95% of ewe and 38% of lamb mortality (Knarrum 1996 reviewed in Kaczensky 1996).

Lynx: In Norway killed 4731 sheep per year (0.22% of total stock) in 1992-95 (Kaczensky 1996). Around 9000 lambs were lost in 1999. Radio-tracking of 34 lynx between 1994 and 1999 in southeastern and central Norway found rates of 38 (for adult male lynx), 53 (yearling males), 8 (adult females) and 26 (yearling females) livestock killed per 100 nights when lynx passed through a sheep flock (634 nights of intensive tracking; 63 sheep and 3 goats found killed in addition to wild prey such as roe deer). Livestock formed an insignificant part of lynx summer diet and there was no evidence for problem individuals, but males were found to kill livestock more than females (Linnell *et al* 2000*a*). Mysterud and Warren (1991 reviewed in Kaczensky 1996) fitted 1003 lambs in Hedmark County with silent mortality transmitters. Nineteen lambs (2%) and three ewes were subsequently found dead: 10 (45%) due to disease and 12 (55%) attributed to predation (9 certainly by lynx, 2 possibly by lynx and 1 unknown). Knarrum (1996 reviewed in Kaczensky 1996) found that lynx caused 5% of lamb summer mortality, which was 11% for all causes combined.

Wolverine: 50-85% of dead sheep found on Snøhetta plateau could be documented as killed by wolverines (Børset 1995 and Mortensen 1995 both cited in Landa *et al* 1999).

Wolf: Ginsberg and Macdonald (1990 citing Naess and Mysterud 1987) reported losses of 0.02% of the sheep crop. In 1992-95, an average of 207 sheep per year or 0.009% of total stock available in Norway were killed (Kaczensky 1996). Environment Ministry figures stated that 612 sheep were lost to wolves in Hedmark County in 2000 (Hutt 2001).

LGD breeds and status

Although sheep were managed more closely than at present in the 19th century, when large carnivores were more common (Nedkvitne *et al* 1995 reviewed in Sagør *et al* 1997), there has never been a tradition of using LGDs in Norway (Kaczensky 1996; Hansen and Bakken 1999). Some were imported from Italy and Poland for an experimental project which was in its third year by March 2000 (Linnell 2000). Norwegian strains of Great Pyrenees (mainly bred as show dogs) were tested for their ability to protect livestock by Hansen and Bakken (1999).

LGD training

The Great Pyrenees tested by Hansen and Bakken (1999) and Hansen and Smith (1999) were not reared with sheep until the age of 12-16 weeks and were handled a lot by several different people, due to the influence of the breeders and the

Norwegian Kennel Club. Males were castrated but bitches were not spayed. In Hansen and Smith's (1999) trials – conducted from 7th June to 3rd September 1995 – sheep were familiarised with 10 two- and three-year old Great Pyrenees in small paddocks during a 3 week period before being released onto 35 km^2 of mountain and forest range, where the LGDs then worked in teams of 2-3 to guard 624 lambs and ewes in two flocks.

LGD evaluation

Three Great Pyrenees tested by Wikan (1996 reviewed in Hansen and Bakken 1999) chased bears; a bear needed at least 4-5 encounters with the dogs before it left the area.

Of 13 Great Pyrenees (11 male) from 7 litters and two breeders tested by Hansen and Bakken (1999), none were aggressive towards unfamiliar people and aggression towards other dogs (most offensive) and unfamiliar sheep, horse and cattle was low, but 10 of the 11 LGDs tested chased reindeer. Regular exposure of pups to reindeer may solve this problem. Two males and one female tested in autumn 1995 all chased a 150 kg male bear for 25 minutes away from the area and then returned to their flock. The female was most persistent in chasing and she also chased a wolverine in a separate trial (Staaland *et al* 1998 reviewed in Hansen and Bakken 1999). The bear returned within one hour. LGDs did not seem to be protective of their flock, though they never chased sheep. It was concluded that better socialisation would improve this. Some of the younger dogs pursued unknown sheep when these fled from the dogs. The authors suggested that such behaviour could cause difficulties on rangeland where different flocks meet.

Hansen and Smith (1999) reported that mean loss (predators, disease and accidents) in flocks with LGDs decreased by 7% from 1994 to 1995, whereas that in seven neighbouring flocks decreased by 3.7%. Bear depredation started 14 days earlier on flocks outside the study area. Most losses on one of the research flocks occurred when sheep wandered out of the study area, into areas where LGDs were not regularly used. The authors tested three different methods of using LGDs and found that LGDs working within a 1 km^2 fenced pasture ("pasture dogs") had a better anti-predatory effect than free-ranging, unsupervised LGDs ("loose dogs") or LGDs walking with a dog handler ("patrol dogs"). No sheep were killed inside the fenced pasture.

Due to late and poor socialisation, all the LGDs tested were more strongly bonded to people than to sheep. The loose dogs ran to settlements, did not cover the whole area where the sheep were widely dispersed, chased and killed wildlife and – in some cases – sheep. The pasture dogs also left their flocks to find people. The patrol dogs only seemed to be effective when actually present; bears killed sheep a

few hours after LGD and handler left the area. No sheep were lost within the fenced pasture, though other factors may have contributed in addition to the presence of LGDs. It was concluded that Norwegian sheep husbandry would have to be adapted to suit LGDs by using sheep breeds which flock in conjunction with well-socialised LGDs and shepherds (recommended for areas with highest depredation), enclosing grazing areas and placing sheep with LGDs inside or by using – at night – patrol dogs with a dog handler.

Hansen *et al* (1997 reviewed in Hansen and Bakken 1999) reported fewer losses of lambs to lynx with LGDs present.

Linnell (2000) stated that flocks involved in the experimental testing of LGDs did not have a single case of bear predation in two years. However, shepherds with herding dogs are needed to prevent flocks spreading out so that LGDs can guard them effectively. These would be new components in Norwegian sheep husbandry which involve extra expense and farmers are often slow to accept new methods. It seems that improved husbandry practices including use of shepherds and LGDs would greatly reduce losses but economics may restrict their use.

A research project funded by the Norwegian Institute for Nature Research (NINA) has had some success in using a shepherd and border collie herding dogs to keep Norwegian sheep together as a flock. It is expected to take ten years to bring back a sufficient herding instinct in Norwegian sheep and to establish a system of shepherds and watchdogs (NMFA 1997).

Other measures – Norway

See Linnell *et al* (1996) for a review.

Aversion: Collars with a chemical dispenser were fitted to sheep and tested against wolverines with promising early results. The method may also be a useful protection against lynx but probably not against bears, which lack a specific bite site (DNM 1996 reviewed in Kaczensky 1996). In each of 16 trials in Hedmark county bears were successfully "scared away" from sheep grazing areas without showing any aggressive behaviour (Wabakken and Maartmann 1994 reviewed in Kaczensky 1996).

Protective collars: Leather/steel collars worn by livestock were found to be slightly effective against lynx (DNM 1996 reviewed in Kaczensky 1996).

Husbandry: Bringing sheep in from the forest in early August to avoid the season with the highest losses to wolverines and, partially, bears is recommended (Sagør *et al* 1997; Landa *et al* 1999), but farmers lose up to 30% of the grazing season by doing so (Linnell 2000) and incur increased costs for hay (P. Wabakken pers. comm. to Kaczensky 1996). Landa *et al* (1999) recommend the use of less

susceptible sheep breeds in wolverine areas. Some farmers have been encouraged to change to milk production or, more promising due to the national over-production of milk, beef (Kaczensky 1996). Subsidies have been paid for increased sheep monitoring but proved ineffective due to the lack of real shepherding and activity in the daytime only (DNM 1996 reviewed in Kaczensky 1996).

Legal killing: Shooting 16 presumed problem bears in two test areas did not reduce sheep losses in the following year. Removed individuals were quickly replaced by bears immigrating from Sweden (Sagør *et al* 1997). Special permits are issued in summer to kill wolverines in areas with high depredation on reindeer. In addition, wolverine numbers have been controlled by licensed hunting in winter since 1993 in the north and since 1997 in the northeast. However, on the Snøhetta plateau, killing wolverines had no observable effect on losses of ewes. An observed reduction in the losses of ewes and lambs combined in the same year that wolverines were killed was not measurable in subsequent years (Landa *et al* 1999). In October 2000 the Directorate for Nature Management stated that the combined use of anti-wolf resources had amounted to several tens of millions of Norwegian kroner in recent years and that it did not consider it realistic to implement measures of such a magnitude in subsequent years (Svarte 2000). Licensed hunters were therefore paid to remove two entire wolf packs – mostly achieved by shooting from helicopters – during the winter of 2000-1 (Hutt 2001).

Relocation: Two problem bears were caught for relocation; one died in transit and the other returned over a distance of 124 km to the area of capture within 81 days but was then hit by a train (Wabakken and Maartmann 1994 reviewed in Kaczensky 1996). Some zoning of sheep and bear areas is likely in the long-term (Sagør *et al* 1997; Linnell 2000). Removing sheep from areas where wolverine are known to rear young is expected to reduce losses (Landa *et al* 1999).

Other measures – Sweden

Wildlife damage is firstly prevented through hunting management of predator populations, secondly through grants towards preventive measures such as electric fences and thirdly compensated (Levin 2000*a*).

Anti-predator fences: Sheep owners can be subsidised by the county administrative board when buying a predator-proof fence and are the most positive towards wolves of all social groups; in an attitudes survey, 91% said they were willing to accept wolves in their area. There has been no record of a wolf killing a sheep inside a functioning electric fence (Angelstam 1999; Levin 2000*b*; A. Bjärvall speaking at the Beyond 2000: Realities of Global Wolf Restoration symposium in Duluth, Minnesota on 26th February 2000). In a 1997 study at the Wildlife Damage Center, Grimsö Research Station, electric fences kept all bears away from beehives

within fenced areas whereas all hives in the control plots were destroyed. The Centre recommended using four or five plain, galvanised and high tensile wires of 1.6-2.5 mm diameter at heights of 20, 40, 60, 90 (and 120) cm from the ground to deter wolves, bears and lynx. Stakes are usually set at 4-5 m intervals, with sturdier ones at corners. Voltage should be at least 5000V. The largest fence reported enclosed a pasture of 40 ha (Levin 2000*b*).

Relocation of livestock: In mid-February 1997, after a pack of five wolves had preyed on semi-domestic reindeer in northern Sweden in 1996, snowmobiles and a helicopter were used to move the reindeer herd out of the area considered to be wolf territory. The plan was supported by some forest companies, who offered suitable alternative areas for the reindeer. No wolf-reindeer conflicts were subsequently reported (Bjärvall 1997).

Illegal killing: Villagers had previously rejected the above reindeer relocation when it was proposed and instead applied for a permit to kill all five wolves. The Environmental Protection Agency rejected the application on December 20th but two wolves (the remaining three were snow-tracked in the area in March) were killed illegally before the reindeer relocation went ahead (Bjärvall 1997).

Poland

Landscape

The Polish Carpathian mountains, including the Bieszcady mountains in the southeast which consist of long parallel ridges, highest peak at 1346 m a.s.l., separated by wide valleys. The area is mostly forested, with beech *Fagus sylvatica* dominant, plus fir *Abies alba*, spruce *Picea excelsa*, grey alder *Aldus incana* and sycamore *Acer pseudoplanatus*. Above 1150 m a.s.l. are sub-alpine meadows or *po³onina*. Winters are long (snow cover for 90-140 days) and can be fairly severe (snow depth often 150 cm). The main wild ungulates are red deer *Cervus elaphus*, roe deer *Capreolus capreolus* and wild boar *Sus scrofa*. Human settlement is relatively sparse in the mountains (Vološèuk 1999).

Livestock

Sheep, cattle, goats and horses in the south (Œmietana and Klimek 1993; Bloch 1995; Bobek *et al* 1993; Œmietana and Wajda 1997). Only sheep were predated in the west (Promberger and Hofer 1994 reviewed in Kaczensky 1996) and mostly sheep in the area of Bieszcady studied by Œmietana (2000).

Husbandry

In the Bieszcady mountains in the southeast as well as Podhale (the region under the Tatra mountains), livestock are grazed in the traditional way on summer pastures, with shepherds and LGDs in constant attendance. Sheep are often kept in enclosures or barns at night, with the LGDs either inside or outside the enclosure (Bloch 1995; H. Okarma pers. comm. to Kaczensky 1996) and in stables or barns during the winter (Œmietana and Klimek 1993). Kossak (1998) wrote that cattle and sheep in Poland are left on pastures all day, often insufficiently guarded or even left unprotected.

Predator species and attacks

Wolf *Canis lupus*: 600-700 in the whole country (Goodwin *et al* 2000). Attacks on livestock away from human habitation can take place at any time of day, in any weather and in any configuration of terrain; poor visibility due to bad weather and natural cover assist wolves but are not necessary conditions. Nevertheless, most attacks occur at night (from dusk till dawn), with no moon, in cloudy, foggy or rainy weather, in places protected by forest, bushes, tall corn or other tall agricultural plants, in naturally or artificially rugged terrain (with deep furrows, drainage canals, etc.) and often – though not always – at least 500 m from the nearest buildings. Most attacks are on cattle or sheep (Kossak 1998).

Of 16 occasions from 29th July to 2nd October 1994 when a radio-collared wolf was detected 900 metres or less from a sheep flock, seven (44%) occurred between 23.15 and 00.45 and the other 9 (56%) were between 05.15 and 06.15 (readings were taken every 15 minutes during "night shifts"). On a further 14 monitoring nights the collared wolf was not detected near the flock (after Bloch 1995).

Sporadic daytime attacks have occurred, such as on animals at the rear during a drive when shepherd and LGD were some distance away at the head of the flock, possibly by a small number of packs or breeding pairs specialised on livestock predation which are sometimes reported as appearing to be unafraid of people (Nowak and Mys³ajek 1999*a,b*). Research in Bialystok region found that in situations where young cattle stayed on the pasture with adult cows and bulls only calves of around 200 kg or calves left with mothers on a tether were killed or wounded. Wolves do not select according to sex, colour or breed. System of pasture (livestock free within fence or tethered in open terrain) is also non-selective, although animals which are both tethered and hobbled tend to be attacked rather than individuals which break loose (except tethered cows with free-roaming young). Herd size also plays no role in wolf attacks on cattle. In Bialystok region 75% of large livestock – mainly cattle – killed by wolves had bites on belly and flanks and 25% on the throat. Disembowelling of prey (70%) was also

characteristic. Sheep may be bitten on any part of the body, though mostly neck and head, belly and back. in some cases skin and muscles were not damaged, the sheep having been "strangled" with a twisted neck or broken spine (reviewed in Kossak 1998).

Brown bear *Ursus arctos*: Numbers were estimated at an average of 77 in the Polish Carpathian mountains in 1980-91 (Jakubiec 1995 reviewed in Kaczensky 1996) and perhaps 100 in the late 1990s (Goodwin *et al* 2000). Attacks on livestock are very rare and confined to some mountain areas (Kossak 1998).

Eurasian lynx *Lynx lynx*: Estimated at 185 individuals in the late 1990s (Goodwin *et al* 2000). Livestock depredation by lynx was not considered to be a problem (H. Okarma pers. comm. to Kaczensky 1996; Kossak 1998).

Losses

Wolf: In the 1950s losses were recorded annually. From November 1951 to October 1952, for example, wolves were reported to have killed 30 cows, 892 sheep, 2 horses and 20 pigs (Kowalski 1953 reviewed in Okarma 1993). From 1988 to 1992 an average of 461 sheep per year were killed in the Polish Carpathians, where there were estimated to be 350 wolves over 14982 km^2. Four cattle were unsuccessfully attacked (Bobek *et al* 1993 reviewed in Kaczensky 1996). Analysis of 221 wolf scats collected in the Bieszcady mountains from October 1989 to November 1992 estimated only 2.5% (spring) and 2.0% (summer) sheep biomass and 0% (spring and summer) cattle biomass in the wolf diet, despite a high density of wolves and hunters baiting with livestock carcasses during the autumn and winter (Œnietana and Klimek 1993; Œnietana and Wajda 1997). The greatest damage in this region occurs in an area of c.100 km^2 around Ustrzyki Dolne; c.800 sheep plus several goats and cows were killed in 1996-99, costing c.$50,000 (Nowak and Mys³ajek 1999*b*). According to Okarma (1993) losses of livestock to wolves nationally in the early 1990s were so insignificant and unimportant economically that no records were kept.

In the west, 11 sheep per year were killed on average in 1986-93 by a population of c.25 wolves (Promberger and Hofer 1994 reviewed in Kaczensky 1996).

Bear: Killed an average of 72 sheep and goats and 14 cattle per year in the Polish Carpathians in 1987-91 (Bobek *et al* 1993 reviewed in Kaczensky 1996).

LGD breeds and status

The Owczarek Podhalañski or Tatra Mountain Sheepdog has been used for centuries by the Goral people of southern Poland. They have traditionally been equipped with a collar with nails or made wholly from steel as a protection from wolves (Dereziñski 1999). The system of LGDs is still partially in place. One camp

of 500 sheep under the Tatra mountains studied in 1994 by Bloch (1995) had three adults. Continued use by farmers is also being complemented with efforts to reintroduce or spread LGDs where they have ceased to be used: Nowak and Mys³ajek (1999*a*) have provided detailed instructions in Polish for raising and training LGDs based on the US system in a booklet intended for livestock breeders in southern Poland. They recommended two dogs for herds of over 100 animals and three or four dogs for larger (300) herds and stated that it takes 18-20 months to raise LGDs. Œnietana (2000) has also followed the US model in raising LGDs for study in the Bieszcady mountains.

LGD evaluation

At a camp of c.500 sheep protected by three Podhalañski guarding dogs near the Tatry National Park, wolves killed just one sheep (a sick animal killed 300 metres from the pasture on 14th August) from the end of April until the beginning of October 1994, even though a pack of seven wolves had a den two kilometres from the pasture and frequently approached the sheep. Wolf presence near the camp was confirmed by radio-telemetry (one wolf collared), direct observation by shepherds (one morning in summer 1994 plus three wolves seen and chased away by shepherds after the sheep was killed on 14th August) and inferred by shepherds according to the varied barking of their LGDs on several other occasions. From 29th July to 30th September 1994 the LGDs barked on each of 9 occasions when radio-telemetry detected the collared wolf 100-300 metres from the flock. They did not bark on a further 7 occasions when the wolf was 700-900 metres away (after Bloch 1995). Out of 284 Tatry National Park visitors responding to a questionnaire asking for information on their experiences with the LGDs in this area, only 1 had been attacked and bitten (Bloch 1995).

The very low percentage of livestock in the wolf diet in the Bieszcady mountains was presumed to be due to the permanent guarding of livestock on pastures with LGDs and shepherds, as well as high densities of wild ungulate populations in the area (Œnietana and Klimek 1993). In 1993-94, 16 farmers interviewed in the area lost a total of 39 sheep out of 1265 (3.1%) to wolves and one cow out of 400 cattle (0.3%) to a bear; none of the 193 goats or 27 horses grazed in the same area was killed in these years. Of these 16 farmers, two who grazed their flocks far from human habitation but protected them with Podhalañski guarding dogs lost 25 out of 1050 sheep (2.4%) to wolves whereas the remaining farmers who grazed their flocks near dwellings but without any form of protection lost 14 out of 215 sheep (6.5%), so the loss of farmers not using LGDs was more than twice as great even though their animals were pastured near habitation (Œnietana 2000).

Of 7 LGDs introduced to 7 sheep and goat farms in Bieszcady beginning in 1995 and raised in two stages (between the 7th/8th week until the 4th month of the pup's life creating a strong emotional bond between it and livestock and from the 4th month strengthening the required behaviours of staying with and accompanying the flock and reacting aggressively to threats, as well as correcting unwanted behaviour such as leaving the flock or following people), two were fully effective, two only guarded alone at night near the sheep fold and "pastured" sheep together with a shepherd and the remaining three were still being trained at the time of writing (Œmietana 2000). The main problems with training were attributed to an inconsistent approach by the farmers and holes in pens on pastures combined with distractions such as other dogs or tourists offering food and attention. Nevertheless, since the introduction of LGDs five farms have had no losses and the others only low levels (1-2 head annually) from 50-200 animals pastured.

A few daytime attacks have been recorded even in the presence of a shepherd and LGD, such as when driving the flock from the pasture which extends the animals over a long distance. If a single LGD is walking in front, wolves can attack sheep at the back of the flock. Three or four LGDs are needed for larger flocks. The additional benefit of having more dogs is that in a group their courage is increased and their is more security in case one is unavailable. Some dogs may not be aggressive towards predators but are very vigilant and so can still be useful in barking to alarm other LGDs and shepherds and distracting the attention of predators away from the flock (Nowak and Mys³ajek 1999*a*).

Other measures

Enclosures: Bloch (1995) observed that sheep are brought into a fold at night, which provides some security by keeping them together and in the vicinity of LGDs and shepherds, as one of the most frightening factors for wolves is the presence of humans (Nowak and Mys³ajek 1999*a*). However, these two authors also noted that the pens currently used in southern Poland are usually 1.3 m high or less, whereas cases have been recorded of wolves pulling sheep over fences made of wire netting 1.5 m high. They suggested that, to keep wolves out, enclosures would have to be 3 m high and dug into the ground to a depth of 0.5 m, which would be expensive, time-consuming and need special permission.

Fladry: An old hunting technique recently also used by researchers (Okarma and Jêdrzejewski 1997) which uses lines made of thin but strong string with pieces of coloured (usually red) material 10x40 or 10x60 cm sewn on every 30-40 cm. For unknown reasons, wolves avoid crossing these lines. In using them to protect livestock the lines should be strung around the pasture (rather than around the fold), ideally attached to posts hammered into the ground so that the bottom edges of the

material are 15-20 cm above the ground and can move in the wind. In 1998 one livestock breeder in the Bieszczady mountains used clothes instead of material, but the effectiveness was not known at the time of writing (Nowak and Mys³ajek 1999*a*; S. Nowak pers. comm. 2001). In autumn 2000 the Association for Nature "Wolf" prepared two lengths of *fladry* each 200 m long which were hung on wooden fences enclosing livestock. They intended to prepare 15-20 further lengths for use in southern Poland in 2001 (S. Nowak pers. comm. 2001).

Electric fences: Many farmers enclose pastures using electric fences with two or three parallel wires, the highest about 1 m from the ground. Nowak and Mys³ajek (1999*a*) recommended adding barbed wire at the top and bottom to help prevent wolves jumping over or digging under the fence. *Fladry* could also be added. They reported that electric fences have often been used to good effect by livestock breeders in the Bieszczady and S³onne mountains.

Aversion: One livestock breeder in the S³onne mountains used fires and lamps near the fold to frighten wolves away at night, which proved to be effective (Nowak and Mys³ajek 1999*a*).

Portugal

Landscape

Ranges from high and steppe mountains (heavy rain and snow in winter) to lower plains with very hot, dry summers. Least populous and most mountainous regions in the centre and north of the country. There are low numbers of wild ungulates (Fonseca 2000*a*).

Livestock

Sheep and/or goats (Fonseca 2000*a*), cattle and horses (Alvares and Fonseca 2000).

Husbandry

Mountain flocks are always shepherded and confined for the night. On the plains, livestock are sometimes left alone during the day and at night are kept inside small metal fences, far from villages and protected only by dogs. Flocks range in size from 20 to 200 animals (Fonseca 2000*a*).

Predator species and attacks

Iberian wolf *Canis lupus signatus* Cabrera 1907: Around 300 in autumn 1996 (F. Fonseca in Tubbs 1997) and 250-300 in 1999 (Route and Aylsworth 1999). Fully protected since 1988, but restricted to the northwest and decreasing rapidly. Wolf presence is positively correlated to the occurrence of deciduous forest, agricultural

land, scrub lands and special hunting areas, which tend to be the best habitat. There is a negative correlation between wolf presence and the occurrence of coniferous forests and eucalyptus plantations. Attacks on livestock are increasing. There were around 100 per year in 1990-4 and 200+ in the late 1990s (Vingada *et al* 1999). Two wolf packs in northern Portugal near the Spanish border studied by Vos (2000) in 1996 fed exclusively on livestock, especially goats. Attacks on goats mostly affected flocks larger than 100 animals. Where horses were present, they were preyed on preferentially. F. Fonseca (in Tubbs 1997) stated that more damage is done to livestock in winter.

Feral dog *Canis familiaris*: Many losses blamed on wolves are actually due to feral dogs either abandoned by hunters after the hunting season or neglected local dogs seeking additional food (WSGB 1999*b* citing Grupo Lobo as the source).

Losses

Wolf diet in Portugal is almost exclusively based on domestic animals due to the low numbers of wild prey such as red and roe deer (F. Fonseca in Tubbs 1997; Fonseca 2000*a*). Euros 2900 per wolf was paid for damage in 1997 (Vingada *et al* 1999).

LGD breeds and status

The traditional use of LGDs has largely fallen out of use. Cão de Castro Laboreiro, Cão da Serra da Estrela and Rafeiro do Alentejo, the native Portuguese breeds, are becoming rare and most are used as pets or show dogs, with selection based on morphological characteristics rather than functional, behavioural or genetic aspects (Fonseca 2000*a*). An influx of breeds from abroad, the decline of livestock herding and poisoned baits intended to kill wolves have also contributed to the decline of the native LGD breeds (Pedro 1996-2000*c*).

In 1996 Grupo Lobo initiated a project to rehabilitate the use of Portuguese LGDs as a measure for wolf protection and, at the same time, to contribute to the recovery of these rare dog breeds. By March 2000 the project had placed 15 dogs (8 females and 7 males) with different flocks of sheep and/or goats. The project incorporates genetic analysis of the inbreeding coefficient for each LGD breed and has found the highest values for inbreeding in the Cão de Castro Laboreiro. The genetic data will be combined with morphological and behavioural data and pedigrees will be analysed to select the most important animals to cross according to their inbreeding coefficient and kinship value (Fonseca 2000*a*).

LGD training

Flocks were selected according to the level of damage and interest of shepherds to participate in the project. Pups were selected according to the behaviour and

morphology of the parents (working animals, whenever possible). The pups were integrated into the flocks at 2-3 months of age and were then kept in permanent contact with the flock, with minimal contact with people. From the time they were given to shepherds until they reached maturity, the dogs' physical and behavioural development were monitored on a monthly basis. This proved essential for the achievement of good working dogs as it allowed for the immediate correction of behaviour problems as they emerged and supervision of the conditions where the dogs are raised (Fonseca 2000*a*).

LGD evaluation

Flower (1971 cited without reference in Ginsberg and Macdonald 1990) concluded that the greatest deterrent to wolf predation on sheep was a guarding dog and shepherd. Once LGDs in the Grupo Lobo project reached maturity they began to prove efficient in flock protection. The amount of damage caused by wolves reduced and shepherds, who had previously distrusted and disbelieved the efficiency of LGDs, began to change their attitudes. Shepherds also began to show some tolerance towards wolves (Fonseca 2000*a*).

Other measures

Illegal killing: Especially by livestock owners (Fonseca 2000*a*) using poison or shooting from night-time hunting stations (WSGB 1999*b* citing Grupo Lobo as the source).

Alternative food-base: There are conservation efforts to increase populations of wild prey, such as roe deer (*Capreolus capreolus*) and reintroduce native wild goats (F. Fonseca in Tubbs 1997; Fonseca 2000*b*) as alternative prey for wolves.

Romania

Landscape

The Romanian Carpathian mountains, their foothills and the Apuseni mountains in the northwest, totalling around 70,000 km^2. The highest peaks are over 2500 m a.s.l. and extensive areas lie between 1500 and 2100 m a.s.l. Large carnivores are distributed throughout the region. In the county of Braºov, the mountains are 80% forested, with beech *Fagus sylvatica* forests at lower elevations, mixed forests (beech, fir *Abies alba*, spruce *Picea abies* and mountain maple *Acer pseudoplanatus*) between 900 and 1400 m and coniferous forests above 1400 m a.s.l. Timberline is at 1600-1800 m a.s.l. The complete elevation range of the area (c.2000 km^2) is c.600 m to c.2500 m a.s.l. The most important wild ungulates are red deer *Cervus elaphus*, roe deer *Capreolus capreolus* and wild boar *Sus scrofa* as

well as chamois *Rupicapra rupicapra*. There is a moderate continental climate with warm summers and cold winters. Livestock is grazed on meadows and pastures, including on meadows above the timberline in summer. Around 5 million sheep and 5 million people live in the area (Mertens and Promberger 2000*b*; reviewed in CLCP 2000; Goodwin *et al* 2000).

Livestock

Mertens and Promberger (2000*b*) and Mertens and Anghel (2000) reported that only sheep suffered significant damage in the area around Braºov which they monitored in 1998-2000, though cattle, pigs and horses were also common on summer pastures. Livestock husbandry has been restricted in the Retezat National Park (Vološèuk 1999) but still continues as some herders have no where else to take their animals (E. Stanciu pers. comm. 2001).

Husbandry

The small (10-30 head) sheep flocks of individual owners are usually amalgamated for the summer grazing season (4.5 months long) to create flocks of 300-500 (up to 1000), sometimes also with cattle, which are walked up to the mountains in May by 3-6 contract shepherds with 5-10 LGDs (Promberger 1999; Goodwin *et al* 2000). Shepherds often own part of the flock themselves (C. Promberger pers. comm. to Kaczensky 1996). Nineteen camps in the Braºov area analysed by Mertens and Anghel (2000) in 1999 had an average of 468 sheep per camp (range 100-1000), 35.3 cows (0-70), 11.1 pigs (0-30), 3.7 horses (0-15), 7.6 dogs (3-13) or 1 dog per 64.4 sheep (11-128) and 5.28 shepherds (2-12) or 1 shepherd per 88.2 sheep (33-200). Promberger (1999) stated that flocks are brought into secure camps and penned in small folds at night, with LGDs tied to posts around the fold and shepherds sleeping nearby. A camp in Nucºjoara valley just north of Retezat National Park seen in August 2001 had fencing and milking pens constructed from detachable willow hurdles. Another (abandoned) camp above the timber line within the NP had used cut dwarf pine *Pinus mugo* branches (R. Rigg pers. obs. 2001). Promberger has also reported (pers. comm. to Kaczensky 1996) that sheep are usually not penned at night (because, by law, fences must be moved every third night to avoid over-grazing) and, instead, they are gathered on open pastures with LGDs running freely around and shepherds sleeping next to the flock. This was the case at L. Zãnoaga, Retezat National Park in 2001 (R. Rigg pers. obs. 2001). Sheep are milked to make cheese; meat and wool are also produced (Promberger 1999).

Predator species and attacks

Wolf *Canis lupus*: c.2500-2800 (Ionescu 1993*a*; Mertens and Promberger 2000*b*). Anecdotal accounts have been reported of one or two wolves luring LGDs away from sheep, allowing their pack-mates to attack the flock from a different direction.

Larger herds seem to suffer more depredation (C. Promberger pers. comm. to Kaczensky 1996). Flocks were mostly attacked near or within the forest and, if kept on the pastures away from the forest, suffered few losses. Wolves were observed looking for opportunities to catch sheep during the day and appeared to move from one flock to the next (Promberger *et al* 2000). After two or three unsuccessful attacks on a particular camp, wolves stopped visiting (Promberger 1999).

Brown bear *Ursus arctos*: c.5400-6600 (Ionescu 1993*b*; Mertens and Promberger 2000*b*; CLCP 2000).

Lynx *Lynx lynx*: c.1500. Damage was insignificant in the area monitored by Mertens and Promberger (2000*b*) and Mertens and Anghel (2000) in 1998-2000.

Losses

No official statistics existed for wolf damage in the mid 1990s, though it was considerable, and statistics for losses to bears were only kept on a regional level (Kaczensky 1996). At 17 and 19 camps monitored in 1998 and 1999 respectively, wolves and bears killed 2.08% of all sheep each year, or an average of 9.94 sheep per camp. In 1999, each camp lost an average of 1.08 sheep (range 0-5), to bears and 1.84 sheep (0-16) to wolves or 2.92 sheep (0-16) to carnivores (Mertens and Anghel 2000). This equates to an average of $387.60 per camp each summer. In 2000 the damage was much less: 0.62% of all sheep were killed, an average of 2.92 sheep at each of 26 camps, a loss of $116.80 per camp (Mertens and Promberger 2000*b*; Mertens and Anghel 2000).

These levels of losses appear small but are significant in Romania's economic conditions: the economic damage due to depredation on livestock in 1998 and 1999 was estimated at 12% (3% in 2000) of total expenses at the camps studied (Mertens and Promberger 2000*b*; Mertens and Anghel 2000).

LGD breeds and status

Romanian Shepherd dog and Mioritic Shepherd dog (Landry 1999*b*). Traditional use and methods are fairly intact. Averages of 8.3 dogs, 5.3 shepherds, 476 sheep and 35 cattle per camp were recorded at 17 camps monitored in 1998, 19 in 1999 and 26 in 2000 (Mertens and Promberger 2000*b*). One flock of 520 non-milking sheep grazed at around 2000 m a.s.l. in Retezat National Park from June to August 2001 was attended by 4 mongrel LGDs and 2 shepherds. The shepherds had 8 horses and 2 foals around their camp and there were free-ranging herds of horses (unguarded) and cattle within a few kilometres (R.Rigg pers. obs. 2001).

LGD training

LGDs are not actively trained by people; as soon as they are old enough, they are put with the flock and are expected to learn from the adult dogs (Mertens and

Promberger 2000*b*). Some LGDs wear large, hand-made spiked collars as a protection from predators (Promberger 1999). Some wear a wooden beam hung from the collar which was originally to stop the dog chasing after wild animals, but examples seen in Retezat in 2001 were too short and high up near the neck to restrict movement significantly. These LGDs obeyed basic instructions from the shepherds, such as returning to the interior of the herd after rushing to the edge to confront and bark at a large (c.30) group of walkers (R. Rigg pers. obs. 2001).

LGD evaluation

The low levels (averages of 0.62% and 2.08% of all sheep in 2000 and 1998-9 respectively) of depredation recorded at camps with LGDs would seem to indicate that LGDs are successful at protecting flocks of sheep even in areas with high numbers of large carnivores (Mertens and Promberger 2000*b*).

Although Romanian LGDs are strong, aggressive, and protective, there have been problems when they leave their flocks unattended due to lack of training. The dogs are usually poorly fed (on boiled corn flour and whey) and so often leave the flock to search for additional food. In winter the flocks are broken up and LGDs stay with their owners – mostly shepherds – away from the flocks, so they are partially socialised with livestock and partly with people (Mertens and Promberger 2000*b*).

Differences in levels of losses, linked to the quality of livestock guarding dogs available, were observable between shepherd camps (Promberger *et al* 1996). A study found that the levels of depredation depended on how well the stock is guarded: attentive shepherds with good LGDs lost few animals (Promberger 1999). According to one of the shepherds with the flock visited in Retezat on 11th-12th August 2001 that had 4 mongrel LGDs, a "big bear" had killed 2 rams and 1 sheep on different nights "a couple of weeks" earlier (R. Rigg unpub. data). These LGDs walked among the flock as it grazed, usually spaced apart, or sat/lay on prominent positions. When near the camp, some spent time around the shepherds' hut but one apparently more sheep-socialised dog stayed constantly with the flock, lying near the edge of it in the evening. When approached slowly by two people on foot, this dog stood up and moved into the flock with tail between legs, casting suspicious backward glances (R. Rigg pers. obs. 2001).

Other measures

Electric fences: Trials were begun by the Carpathian Large Carnivore Project (CLCP) during the 2000 grazing season (Mertens and Promberger 2000*a*). Three fences were installed for c.2 months and one for a year, during which time no livestock within the fences were killed by large carnivores. Shepherds were often suspicious of the trials, afraid their animals could be harmed and reluctant to work

with the fences, but those using them have been very satisfied (Mertens and Boronia 2000).

Fladry: The CLCP intended to begin testing *fladry* to protect livestock after successfully using it to capture a wolf for research purposes (Promberger *et al* 1997; Mertens and Promberger 2000*a*; Promberger-Fürpaß *et al* 2000).

Legal killing: After the Second World War the wolf population reached 4600 (Ionescu 1993*a* reviewed in Kaczensky 1996) or more than 5000 (Promberger 1999) which caused great damage to livestock, resulting in a government anti-predator campaign including poisoning, unlimited shooting and trapping and killing pups. By the 1950-60s the wolf population had fallen to around 1000 in remote mountains. At present controlled hunting by professional game wardens with special permission is allowed after significant damage to livestock by large carnivores (Promberger 1999). Low levels of losses are tolerated, but if attacks become more frequent then shepherds ask local hunters (in case of wolf attacks) or Romsilva/hunters association (bear) for help (C. Promberger pers. comm. to Kaczensky 1996; CLCP 2000). In the first half of the 1990s around 10% of bear hunting licenses were reserved for shooting individuals causing damage and requests could also be made for professionals of the Romsilva forestry organisation or the hunters association to shoot further bears causing heavy livestock losses outside the hunting season (O. Ionescu pers. comm. to Kaczensky 1996).

Illegal killing: During long-term wolf research by the CLCP, hunters, poachers or shepherds killed 5 out of 12 radio-coloured wolves, some within weeks of the collar being fitted (Promberger 1999). There is some poaching with traps, snares and poison (Promberger and Mertens 2001).

Relocation: Several bears causing damage were relocated to remote areas in 1985-92 (O. Ionescu pers. comm. to Kaczensky 1996).

Slovakia

Landscape

The Western Carpathian and western-most section of the Eastern Carpathian mountains: include tertiary limestones, dolomites and young volcanic rocks. Relief across the country varies from wetlands at 94 m a.s.l. to high mountains with the highest peak at 2654 m a.s.l. However, large carnivores and traditional livestock herding occur mostly in the uplands of northwest, central, north and east Slovakia in Kysuce, Turiec, Orava, Liptov, Nízke Tatry, Podpo¾ana, Pohronie, Spiš, Gemer and Šariš regions. The most common tree species are beech *Fagus sylvatica*, spruce

Picea abies, oak *Quercus* spp., pine *Pinus sylvestris*, hornbeam *Carpinus betulus* and fir *Abies alba*. The main wild ungulate species are red deer *Cervus elaphus*, roe deer *Capreolus capreolus* and wild boar *Sus scrofa* (Vološèuk 1999; R. Rigg pers. obs. 1999-2001; Rigg and Finï o 2000).

Livestock

Sheep, goats and cattle (in Lit.).

Husbandry

In spring sheep are collected into flocks typically numbering 150-700 animals (often with a few goats) – occasionally 800-1000 – and taken by seasonally employed shepherds to graze on pastures in valleys, foothills and, in some areas or at particular times, on alpine or sub-alpine meadows, until the onset of winter. Flocks may belong to one owner or a collective, private or state-owned. Usually one shepherd with one or two small herding dogs attends the flock all day. In the evening the flock is brought into a seasonal camp called a *salaš* on or near the pastures and either gathered inside a moveable fold for the night with untrained dogs chained to posts and/or trees around it or, less typically, left un-penned with dogs chained around. Some shepherds generally sleep in a trailer or caravan (*maringotka*) nearby. In addition to being milked in the morning and evening, many flocks are also brought back to camp once during the day for milking. The milk is used to make a variety of cheeses in a wooden cabin called the *koliba* (Rigg 1999, 2001*a,b,c*). At one camp between Nízke Tatry and Muranská Planina National Parks observed from 30th June to 4th July 2000, which had three shepherds, 2 chained guarding dogs, one chained and two free herding dogs, two free pups (one herding, one untrained LGD) and one two month old LGD pup being socialised with lambs in a training enclosure (see cover photograph of this report), the following was the typical daily routine in taking care of c.380 sheep and goats (R. Rigg unpub. data):

05:00	Shepherds get up and immediately begin milking; dogs wake and bark.
06:30	Milking finishes; the flock lies under trees at the forest edge behind the milking pens.
07:00	One shepherd with herding dogs begins to take the flock out to pasture; the remaining shepherds stay in camp to make cheese.
11:30	The flock is brought back into camp and rests under trees.
13:30	The flock is rounded up for milking. Two shepherds milk while the third pushes (with herding dogs, a stick, whip or boot) the sheep and goats forward towards the milking pens. The herding dog pup joins in while the chained herding dog barks throughout.
14:30	Milking finishes; the flock grazes/browses near the camp.

15:15 One shepherd rounds up the flock with the two herding dogs and drives it out to pasture.
18:15 The flock is brought back to camp.
19:15 The flock moves itself to the milking pens in response to whistles and shouts from the shepherds standing in front of the *koliba*.
20:15 Milking finishes.
20:30 The flock is rounded up into a pen made of separate sections of metal fencing; the two chained guard dogs are moved nearer for the night (the shepherds began doing this after losing a sheep to a wolf two days earlier).
21:45 The shepherds go to bed in their *maringotka*, c.30 m from the flock.

Operations at many camps are often somewhat loosely managed, with carcasses left to rot in close proximity to live animals, on pastures or even in the camp itself. Camps and their flocks usually move to fresh pastures through the season. Livestock is kept in the village or in barns during the winter (R. Rigg pers. obs. 1999-2001).

The basis of this husbandry system of intensive utilisation of mountain pastures came to Slovakia from the Balkans and Romania with the Walachian colonisation, in the 13th and 14th centuries through to the 18th and 19th centuries (Laurinèík *et al* 1958; Podolák 1982; Stolièná 1997; Zuskinová 1999). Grazing on alpine meadows is now more restricted in the Západné, Belianské and Nízke Tatry mountains, where the timberline has been substantially lowered and the quality of grazing adversely affected (Jamnický 2000), but exceptions are sometimes granted for limited periods in parts of Nízke Tatry and livestock in other areas (e.g. Ve¾ká Fatra) is still regularly grazed on meadows above the timber line (R. Rigg pers. obs. 2001).

In areas where the pastures are not far from the village, some flocks are also taken back to the village each night during the herding season. Some villagers herd their own small numbers of cattle themselves or allow them to roam unsupervised, usually hobbled. Individual goats are often left tethered on long chains near villages (R. Rigg pers. obs. 1996-2001).

Predator species and attacks

Wolf *Canis lupus*: Naturally recovered from near extirpation in the 1950-70s (reviewed in Voskár 1993; Rigg 1998; Rigg and Finï o 1999, 2000 and Hell *et al* 2001). Population estimates vary from 140 in March 2000 and 2001 (J. Lukáè pers. comm. 2001), less than 180 individuals in March 1999 (LZVlk 2000) to the 1281 quoted in 2000's official hunting statistics; 118 were shot in the 2000 season from 1st Nov. to 15th Jan. (Lehocký *et al* 2001). The population is likely to number

between 150 and 300 individuals depending on the time of year. Brtek and Voskár (1987) reported that stray dogs (7.9%) were a more frequent food item than sheep (3.7%) in 161 scats collected in 1976-83. This has not been confirmed by an analysis of 353 scats collected from 15 mountain ranges across a wide area of central and eastern Slovakia in the 1990s, which found that domestic animals formed an insignificant portion (1.4% for sheep, cattle and dogs combined) of wolf diet (Kolenka 1997; Rigg and Finï o 2000; Strnádová 2000).

Brown bear *Ursus arctos*: Estimates for the population size in 1999-2000 were generally between 550 and 850 (Hell and Slameèka 1999 p.81; Finï o 2000; E. Baláž pers. comm. 2001). Official hunting statistics for the 2000 season quoted a figure of 1467 (Lehocký *et al* 2001). Škultéty (reviewed in Hell and Slameèka 1999 p.41-43) described successful attacks on domestic animals as occurring from April to September, though this data came from stomach contents of 27 bears shot in spring and autumn. A detailed analysis of scats from the Vysoké, Západné and Nízke Tatry by Jamnický (1988 reviewed in Hell and Slameèka 1999 p.41-43) showed that livestock are an unimportant part of the diet; preliminary results of a scat analysis in Poľana and Západné Tatry (E. Baláž pers. comm. 2001) and another mostly in Nízke Tatry and Západné Tatry in 2001 (R. Rigg unpub. data) agree.

Attacks often occur on animals in the fold at night but attacks by wolves – less often bears – are also reported to occur during the daytime, when the flock is out of camp, away from chained LGDs and usually attended by just one shepherd with one or two small mongrel herding dogs (R. Rigg pers. obs. 1999-2001). In 2000 at 21 flocks with a total of c.9150 sheep and goats (average 436 per flock), bears killed and wounded 28 sheep in 13 attacks (average 2.1 sheep per attack), all of which were at night, and wolves killed 16 sheep in 8 daytime attacks (average 2.0) on grazing animals and 51 sheep in 9 attacks (average 5.7 or, if an exceptional case of 22 sheep killed at one time is excluded, 3.6) on animals in the fold at night (after Finï o 2000). These results should not be taken as a representative sample, however, as this study aimed to document and describe attacks leading to losses, not to estimate levels of attacks or losses.

There is some anecdotal evidence that weather conditions influence the occurrence of attacks. The 22 sheep mentioned above, for example, were killed by wolves at night in fog and rain at the end of July (Rigg 2001*a*). The shepherd reported that 11 were killed and 11 injured (later died) outside the fold, having broken out in panic (Kubínyi 2000). In 2001, wolves killed or seriously injured c.40 sheep at the same location in the same month, again during a night-time thunderstorm (R. Rigg 2001*c*). The occurrence of vegetation cover on pastures and the proximity of a grazing flock to the forest edge also seem to be important factors (R. Rigg pers.

obs. 2000; Finï o 2000), as well as the vigilance of accompanying shepherds. Sixteen sheep and 7 goats were killed by wolves on 26th June 1999 when the flock was allowed to scatter into the forest (S. Ondruš pers. comm. 2000). On 30th June 2000 a wolf killed one ewe between 9 and 10 am when the shepherd briefly left his flock to go to the toilet. He claimed to have then driven the wolf off, after considerable effort on both his part in shouting and cracking his whip and on the part of the wolf, which he described repeatedly circling round in an attempt to attack from different sides of the flock. This shepherd and others reported seeing wolves observing their flocks from the cover of bushes or at the forest edge, sometimes for long periods (R. Rigg unpub. data).

It should be noted that both shepherds and owners are prone to exaggerate, report inaccurately and even invent (Hell and Slameèka 1999 p.91) accounts of predation. For example, on 21st June 2000 shepherds in the Horehron region said that wolves had killed a sheep at a neighbouring flock the day before, but the shepherds working at that flock stated that they had had no problems with predators since a wolf grabbed a sheep on the first day of herding, three weeks earlier. The owner of the first flock stated at the beginning of the 2000 season that he lost around 20 sheep every year, 5 or 6 at a time, but only minor losses occurred in 2000 (R. Rigg unpub. data).

Attacks can occur throughout the grazing season, which lasts from April/May until November, depending on the weather and location, though wolf attacks are often said to increase during pup raising in July and August (R. Rigg unpub. data.). Voskár (1993) reported wolf attacks on sheep within corrals every month from April to October inclusive (total of 131 attacks, 850 animals killed, mean 6.5 per attack, in the period 1979-89) on pastures from May to November (20, 174, 8.7) and in farmyards in November (2, 46, 23.0). Some rabbits (Finï o 2000) and poultry (S. Ondruš pers. comm. 2000) are taken by bears; for example, in summer 2000 a crowd of people sitting outside a pub in Nízke Tatry National Park watched in amazement as a bear chased free-range turkeys just across the road from them (R. Rigg unpub. data).

Lynx *Lynx lynx*: From 300 to 500 individuals (Rigg and Finï o 2000; Hell and Slameèka 2000). Hunting statistics reported 1037 in the 2000 season (Lehocký *et al* 2001). Cause only very minor losses to sheep and poultry, e.g. 5 sheep in 1997, which are not compensated (Hell *et al* 1997; Hell and Slameèka 2000 p.90).

Domestic dog *Canis familiaris:* Occasionally kill some animals in e.g. Nízke Tatry (S. Ondruš pers. comm. 2000), which may be blamed on wolves (Hell 1993 reviewed in Kaczensky 1996). Voskár (1993) reported a total of 975 sheep (1,358,000 Sk damage) killed by dogs in 20 attacks on corrals, pastures and

farmyards and 3 heifers (23,000 Sk damage) killed in two attacks on pastures/farmyards in the period 1979-89. However, 80% (780) of these sheep were killed in just 8 attacks on farmyards.

Losses

Wolf: Voskár (1993) reported a total of 1070 sheep (1,468,000 Sk damage) in 153 separate attacks and 28 heifers (254,000 Sk) in 6 attacks killed by wolves in the period from 1979 to 1989. In 1997, wolves were reported as having killed 191 sheep, 40 cattle and 3 goats (Hell *et al* 1997; Hell and Slameèka 1999 p.90). Wolves (lynx in a handful of cases) killed, according to hunting statistics, 353 head of livestock in 1999, causing 447,500 Sk (c.£6700) worth of damage (Hell *et al* 2001). Damage by wolves is not compensated and therefore often not documented (Rigg and Finï o 2000).

Bear: In 1986 bears killed 659 sheep and 1 cow (Hell and Bevilaqua 1988 reviewed in Kaczensky 1996; Hell and Slameèka 1999). In 1997 bears killed 395 sheep, 9 cattle and 7 goats (Hell *et al* 1997; Hell and Slameèka 1999 p.90). Losses to bears are compensated after inspection of the damage by an official commission and if reasonable prevention measures are judged to have been in place (S. Ondruš pers. comm. 2000) and so are fairly comprehensively reported. Compensation paid in the Slovak Republic for sheep and goats "damaged" by bears totalled 210,816 Sk (c.£3150) in 1998, 360,991 Sk (c.£5400) in 1999 and 351,903 Sk (c.£5300) in 2000. The figures for cattle were 176,269 Sk (c.£2650), 114,190 Sk (c.£1700) and 51,496 Sk (c.£770) respectively (Kassa 2001). In hunting grounds where permission to shoot a bear was given, the owner of the hunting ground must settle damages (Hell and Slameèka 1999 p.90).

Although the numbers of livestock killed and injured by large carnivores are small on a national economic scale, they can be significant for individual concerns (Rigg and Finï o 2000). The largest reported loss during a single attack in 2000 was of 22 sheep, worth together 110,000 Sk or around £1570 (Rigg 2001*a*). Some owners do not report minor damage – even if caused by bears, which would be compensated – as they consider the process of verifying the losses too much trouble and/or are afraid of their husbandry operation being inspected and so prefer to write off such small losses (R. Rigg unpub. data; S. Ondruš pers. comm. 2000). On the other hand, some claims may be falsely made in order to receive compensation (J. Jaòák pers. comm. 2000). In the Nízke Tatry region compensation is sometimes paid even when damage is judged to have been caused by wolves (S. Ondruš pers. comm. 2000).

LGD breeds and status

The native breed of LGD in Slovakia is the Slovenský èuvaè (Laurinèík J. *et al* 1958; Finï o 1997). In the past, every *salaš* had several for protecting livestock from predators and assisting shepherds with herding. A hunting law from the late 19th century decreed that free-roaming LGDs had to have a wooden beam hung from their necks which hung below the knees of the front legs to prevent them chasing after wild animals. This law was mostly not respected, especially in the mountains where no one checked (Jamnický 2000).

Currently around 100 pedigree Slovenský èuvaè pups are born each year throughout the country (J. Goliášová pers. comm. 2001). Breeding of the Slovenský èuvaè as well as of other traditional LGD breeds has become largely focussed on exhibition dogs and the traditional system of LGDs socialised to livestock is almost never used (R. Rigg pers. obs. 1999-2001), having presumably been abandoned either due to socio-economic changes during the Communist period (Bloch 1995) or to low levels of losses when large carnivore populations were much reduced (bears in the 1920-30s, Hell and Slameèka 1999 p.74; wolves at the end of the 19th century and again in the 1950-70s, Voskár 1993; Rigg and Finï o 2000). During tours of 6-8 camps in 1999 only one free-ranging adult LGD was seen which seemed to be at least partially socialised to sheep. In May-August 2000, 8 out of a total of 32 LGDs noted at 8 different camps were not chained. Of these, two were bitches nursing pups. One other bitch and four dogs stayed in camp and did not accompany the flock to pasture. The remaining dog was the only one of the 32 LGDs seen (average 4.0 per camp) which was not chained, went with the flock to pasture and followed the livestock rather than the shepherd. He had been bought in February on the advice of Muránska Planina National Park staff who had been informed about a project to renovate the tradition of LGDs (R. Rigg unpub. data).

Dogs used for protecting livestock are currently almost always chained to stakes or trees around the fold and milking pen, though at some camps they are released at night. Many of them are crossbreeds. The Caucasian ovcharka as well as other imported breeds are used at some camps (R. Rigg pers. obs. 2000-01). Camps observed in 2000 had an average of 426 sheep (range 210-600), including a few goats (maximum 34) in many cases and 3.0 chained dogs (range 1-7). These figures can only be taken as an approximate indication; sample size was rather small (n=8) and only one flock was counted by the observer. The shepherds' statements of flock size used in the other seven cases may have been inaccurate as the one flock that was counted had c.297 ewes, 34 goats, 4 kids and 26 lambs plus another 17 lambs that stayed in or near the camp, whereas the shepherd said he had 231 sheep and goats in total (R. Rigg unpub. data).

A five year wolf research project launched in spring 1994 (Finï o and Bloch 1995*a*) or 1993 (Finï o and Bloch 1995*b*) had the additional aim of renovating the traditional use of free-ranging, livestock-socialised LGDs. In 1995 two seven-week old Owczarek Podhalanski pups – brother and sister – were imported to Slovakia from G³odówka in southern Poland. They were socialised with sheep during the winter at a farm in the Nízke Tatry and the project supplied their regular vaccinations as well as dog food (Bloch 1995; Bloch and Finï o 1996). Finï o (1996; 2nd edition published in 1999) translated into Slovak the background information and guidelines for raising and training LGDs according to the US system (e.g. Lorenz and Coppinger 1986).

Preparation for a new project to continue these efforts to renovate the traditional use of LGDs began in 1998 (Rigg 1999). In spring 2000 the Protection of Livestock and the Conservation of Large Carnivores (PLCLC) project was launched (Rigg 2000). In its first year a total of 8 LGD pups – 5 Owczarek Podhalanski (the female imported from Poland in 1995) x Slovenský èuvaè crossbreeds, 2 Slovenský èuvaè and 1 Caucasian ovcharka – were trained at one farm and three sheep camps in the Nízke Tatry and Horehron area (Finï o 2000). The project expanded in both size and range in 2001 with funding for an additional 20 Slovenský èuvaè and Caucasian ovcharka pedigree or pure-bred pups in Nízke Tatry, Pohronie, Muránska Planina, Po¾ana, Liptov, Turiec, Kysuce and Východné Karpaty, again supplying veterinary treatment and supplementary food in most cases (R. Rigg 2001*c*).

LGD training

Two 7-week old Podhalañski pups imported from Poland in 1995 were raised during the winter lambing season and taken out with their flock to mountain pastures in the following spring (Bloch and Finï o 1996).

The PLCLC project roughly follows the guidelines of Lorenz and Coppinger (1986), constructing pens consisting of 6-8 metal or wooden frames 2-4 metres long and at least 1.5 metres high with deer fencing wire attached which are set up on summer pastures or in barns. Some pens have been improvised by shepherds. Ideally, one c.8 week old pup (range of 14 pups in 2001 was 5-11 weeks) is then placed in each pen with 5-6 sheep (initially lambs) which are replaced with different sheep every few days. However, the means and wishes of individual farmers and shepherds have led to variations, such as two or three pups together with either fewer or, sometimes, many more sheep (R. Rigg unpub. data).

LGD evaluation

Two herds with socialised LGDs lost a combined total of 7 sheep to predators in 1994-95 while a single herd with a chained dog lost 12 sheep and one herd without

any dogs lost 20 sheep (Bloch 1996 reviewed in Kazcensky 1996). The male Owczarek Podhalanski imported in 1995 was chained up in 2000 after biting several people, although he was said to have been a very effective guardian against large carnivores (R. Rigg unpub. data).

In 2000, the socialisation with lambs of two Slovenský èuvaè male pups began well, with only minor problems such as chasing of lambs, ear-chewing and leg- or tail-biting observed in July. However, in September both pups appeared timid. At least one had been harshly punished by shepherds and seemed to be insecure outside the refuge of the training pen (R. Rigg unpub. data), having only been socialised to two particular lambs which were left with the pup constantly rather than rotated with others (Finï o 2000) while the second may have been disturbed by the relocation of the sheep camp and/or his temporary separation from the flock during this process (R. Rigg unpub. data). This latter pup had shown signs of protective behaviour in the training pen on 1st July, when he was just 2 months old (R. Rigg unpub. data) and Finï o (2000) noted that he led and circled the flock, watched from elevations and barked to alert shepherds by six months of age.

Socialisation of a Caucasian ovcharka male also began well although the shepherds interrupted the training period by leaving him alone in the pen for some periods. Nevertheless he appeared to be trustworthy, attentive and bonded well to the livestock by the end of the 2000 herding season (R. Rigg unpub. data.; Finï o 2000). This dog seriously injured a drunken shepherd who hit him during the night in the 2001 season, but has otherwise been trustworthy (Finï o pers. comm. 2001).

There were numerous problems with the training of the five Owczarek Podhalanski x Slovenský èuvaè crossbreeds, which were not separated from each other for much of the critical socialisation period (R. Rigg unpub. data; Finï o 2000). One had to be chained up after it bit a passer-by during its first spring out with the flock (C. Sillero pers. comm. 2001).

Alcoholism among shepherds has often caused major problems and many shepherds also resent the extra work of moving the training pens when the grass has been grazed down as well as feeding the pups and rotating different sheep in the pen. Raising pups in barns, rather than on open pastures, seems to be more promising (R. Rigg 2001*c*).

At least three very weak/ill lambs have been killed by pups in training enclosures (R. Rigg unpub. data).

Other measures

Chained dogs: The current practice of chaining untrained LGDs around the fold and milking enclosure provides some protection, mainly at night, by barking to

alert shepherds (Bloch 1995; R. Rigg pers. obs. 2000-01) but losses have occurred when predators bypassed these dogs; their effectiveness is limited by the length of their chain (Coppinger and Coppinger 1994 reviewed in Landry 1999*b*; Bloch 1995; G. Bloch pers. comm. to Kaczensky 1996).

Aversion: Firecrackers are carried by some shepherds; they appear to be of some use in chasing off predators, though one shepherd reported that bears very quickly became habituated. One shepherd in Liptov carried a starting pistol to frighten bears. Some camps leave lamps on at night (R. Rigg unpub. data).

Legal killing: In the 2000 season, 118 wolves (no bag limit within the 1st Nov. to 15th Jan. season), 31 bears (permission given for 68) and 0 lynx (exceptions issued for 4) were officially reported shot (Lehocký *et al* 2001). Permission to shoot individuals reported to be causing damage during closed seasons is given by agreement between the Environment Ministry and the Agriculture Ministry (since 1995 in the case of bears, S. Ondruš pers. comm. 2000). There is pressure to devolve decisions on permission for shooting wolves to the regional level (see, for example, Hell and Slameèka 2000 or Kubínyi 2000). Bear hunting is planned annually with the aim of regulating numbers, but always fails to meet its targets (S. Ondruš and J. Lukáè both pers. comm. 2001). Bears are generally shot from 1st June to 30th November (S. Ondruš pers. comm. 2001) at baiting sites with maize, molasses or fruit, often by guests who provide a substantial income to hunting clubs, which therefore lobby to be given permission for bear shooting.

Illegal killing: Especially opportunistic shooting of wolves either during hunts for wild ungulates (Hell 1993) or, in the 1990s, at baiting sites for bears. Baiting with carcasses is now banned (J. Topercer and S. Ondruš both pers. comm. 2001). Hunters officially declared 27 wolves shot in 1996, 74 in 1997 and 54 in 1998 (Hell *et al* 2001) despite full legal protection effective since 1995. An open season was again granted from 1999 due to the strong pressure of the hunting lobby (Rigg and Finï o 2000). Bears (as well as lynx) are also occasionally poached (E. Baláž, S. Ondruš and Š. Šramka all pers. comm. 2000-01).

Electric fences: A flock of c.1000 sheep in an area of the Nízke Tatry well-known for the occurrence of wolves reported no losses for 2 or 3 years since starting to use an electric fence. One shepherd working with this flock said they had stopped using the fence in 2000 because they no longer lost any sheep (Rigg unpub. data). Many shepherds are reluctant to use such fences due to the extra work they require to install and maintain (Hell 1995 reviewed in Kaczensky 1996). On the night of 29th April 2000 a flock inside a fold protected by electric fence was attacked, probably by one or two wolves. Five sheep were killed, two injured and the others scattered due to poor installation of the fence. On two sides it had only one electrified wire

c.65 cm from the ground and on the other two sides were two wires at 50 cm and 70 cm (R. Rigg pers. obs. 2000). The fence was better constructed with three wires all round in 2001 and no losses had been suffered by October (R. Rigg pers. obs. 2001).

Fladry: Common in the northeast near the Polish border, using rags attached to lines and suspended around folds (J. Lukáè pers. comm. 2001).

Relocation: One sheep owner said that, after he had lost 9 sheep to bears on 5 or 6 separate occasions in July 2000, Muránska Planina National Park staff advised him to move his flock to a different location, but no other pastures were available to him. Shepherds of another flock c.7 km away claimed that they had had to move their camp in 1999 due to heavy losses to a female wolf. A wolf, possibly the one they described, successfully attacked the flock again when it was set up in its original location the following year (R. Rigg unpub. data). A small number of bears causing damage have been captured and put into zoos (S. Ondruš pers. comm. 2000).

Spain

Landscape

From mountains (Cantabrians and Pyrenees) to plains. In areas of highest wolf density (in the western Province of Zamora and south of the Cantabrian mountains in the north) the relief is uneven, with oak *Quercus pyrenaica* woods (isolated 15-35 km^2 patches about 30 km apart), surrounded by scrub and cereal cultivation; wolves breed in the woodland or even among extensive cereal fields without tree cover. Some flat, densely populated agricultural areas colonised by wolves since the 1980s have very few wild ungulates (only wild boar *Sus scrofa*) and in the 1990s fenced motorways were built which act as barriers, although wolves use road bridges to cross. Castilla-León is a flat, cereal-growing area which is almost treeless except for scattered woods of evergreen oak *Quercus rontundifolia* and pines *Pinus* spp. (Blanco *et al* 1992; Blanco and Cortés 2000).

Livestock

Sheep and goats, cattle and horses (in Lit.).

Husbandry

In mountain areas, livestock is free-ranging from May to November. On the plains, livestock is always protected by shepherds (Blanco 2000). In the Cantabrian

mountains and the Pyrenees sheep are partly guarded whereas cattle and horses are not at all (Kaczensky 1996).

Predator species and attacks

Iberian wolf *Canis lupus signatus* Cabrera 1907: An increasing population of around 2000 covering 100,000 km^2 mainly in the northwest – almost 90% in Galicia and Castilla-León (Blanco *et al* 1992; Blanco 2000). Blanco *et al* (1992) found that wolves preyed mostly (79.5%) on sheep and goats, as well as horses (17.6%) and cows (6.5%). The main factor influencing losses to wolves is the management system of livestock. The c.20% of Spain's wolves that live in mountain areas such as the Cantabrians cause c.77-80% (75% or $1375 per wolf per year according to Blanco 2001) of the losses. Surplus killing of unguarded livestock is common even within National Hunting Reserves, where wild ungulates (red deer *Cervus elaphus*, roe deer *Capreolus capreolus*, chamois *Rupicapra rupicapra* and wild boar) are abundant. The average damage per year by wolves can be 10 times higher in the mountains than on the plains (Blanco *et al* 1992; Blanco 2000). Losses are rare where livestock is tended by shepherds throughout the day and kept indoors overnight. Wolves' diet in these areas was found to be mostly sheep scavenged from carrion pits (Blanco and Cortés 2000). Losses have been high when wolves have expanded into sheep areas such as the Basque Country and the Picos de Europa National Park. Large, private fenced estates for red deer in the south lose some animals to wolves, but the wolves have been almost extirpated there due to illegal persecution by gamekeepers (Blanco 2000).

Brown bear *Ursus arctos*: Around 80, slightly decreasing, in the Cantabrian mountains plus 5-6 in the Western Pyrenees and around 6 in a recently reintroduced Central Pyrenees population. In the Cantabrian mountains sheep are very scarce within bear range so damage is moderate and surplus killing rare (Blanco 2000). On the basis of 929 scats collected in 1983-88, Clevenger *et al* (1992) concluded that domestic animals were a supplementary source of food, obtained mostly by scavenging. Claims for losses were made in every month of the year during the period from 1973 to 1990, but increased sharply with the onset of the grazing season in May and remained high until November (Garcia-Gaona 1995 reviewed in Kaczensky 1996). Purroy *et al* (1988 reviewed in Kaczensky 1996) found that damage to horses (44% of claims, or 24% if re-calculated according to numbers available) and cattle (29% or 22%) was more, or as, important as that to sheep and goats (27% or 44%). Clevenger *et al* (1994) found that attacks appeared to be opportunistic, with the most common domestic animal species and age classes preyed on most. Sheep are common in the Pyrenees and the few remaining bears cause much more damage in relation to their numbers than those in the Cantabrian mountains (Blanco 2000).

Iberian lynx *Lynx pardina*: Estimated numbers of 500-1000 (525-660 in Goodwin *et al* 2000) in sharply decreasing and very fragmented populations in the southwest. Almost never attack livestock (Blanco 2000).

Losses

Wolf: The annual damage to livestock in 1987/88 was $1,008,807 or 5174 sheep and goats, 448 cattle and 1196 horses and donkeys, mostly in Asturias, Galicia and León. Each wolf on average caused $500 of damage per year – which roughly equated to killing six sheep or one calf – but there was considerable regional variation. A total of $262,500 was paid in compensation from March 1986 to February 1987, around 25% of the estimated livestock damage; only 1% of damage was compensated in Galicia (Blanco *et al* 1992). In the 1990s the wolf population and livestock depredation rose; current annual damage was reported by Blanco (2001) as $825,000 to $1,100,000. Twelve percent of farmers are affected in the areas of greatest damage, suffering losses amounting to $440 each or 4% of average family income (Blanco 2001).

Bear: Seven million pesetas ($43,750) in compensation is paid per year in the Cantabrian mountains, 50% of which is estimated to be caused by bears (Blanco 2000). From 1973 to 1990, 681 claims of losses to livestock were accepted, with an average of 57 livestock lost per year. Total livestock depredation claims averaged $47,256 per year (Garcia-Gaona 1995 reviewed in Kaczensky 1996). In the Riaño National Hunting Reserve (715 km^2) in the Cantabrians 80 sheep and goats, 1 horse and 6 cattle were killed in 1974-84, an average of 7.9 livestock per year, by an estimated population of 6 bears (Purroy *et al* 1988 reviewed in Kaczensky 1996).

LGD breeds and status

Mastin Espagnol. LGDs wear a spiked anti-wolf collar or *carlonca* (Blanco and Cortés 2000). J. Naves (pers. comm. to Kaczensky 1996) reported that community authorities provided professional livestock owners with LGD pups for free on request, but training was not provided and there was no assessment of their use and effectiveness. Landry (1999*b* citing V. Vignon pers. comm.) reported that LGDs are used in Castile y Leon, Galicia and Navarro in the northwest and in the Cantabrian mountains (where they were observed by Bloch, reviewed in Bloch 1995). Three to 8 dogs accompany a shepherd who remains permanently with the sheep all summer. The sheep are penned at night and often left alone with the LGDs. Flocks are brought in every evening in winter. In the Cantabrian mountains, several dogs accompany herds of 20-30 cows which are left alone in summer. The herder re-fills an automatic feed distributor for the dogs once a week.

LGD evaluation

Unguarded livestock lost c.25 sheep per year per wolf whereas livestock guarded by shepherds and LGDs lost c.4.3 sheep per wolf per year, sometimes as low as 1-1.5 sheep per wolf per year even in areas of higher wolf densities (reviewed in Kaczensky 1996). Annual damage per wolf calculated by Blanco *et al* (1992) varied from $83 in the Subcantabrian area of greatest wolf density, to $359 in areas where shepherds guard livestock and up to $2083 in the areas of greatest damage, where livestock was not guarded.

Other measures

Husbandry: In some areas livestock is tended by shepherds throughout the day and kept indoors (Blanco and Cortés 2000), in the village or other shelter (Vila *et al* 1993) overnight.

Killing predators: Several hundred wolves – up to 550-750 – per year are killed by hunters, mostly illegally (Blanco *et al* 1992; Blanco 1997). In 1997 in the Sierra de la Culebra Hunting Reserve, where wolves are at their highest density in Spain at 7 per 100 km^2 and hunting is legal, the regional government of Castille y León sold permits to hunt two wolves at the price of about $3600 per wolf (Blanco 1997). Permits were auctioned in 1999 in Zamora, where poachers and sheep farmers were killing substantial numbers of wolves (Weyndling 1999).

Switzerland

Landscape

The alpine meadows of the Swiss Alps and the Jura mountains, a secondary chain of limestone mountains ranging from 372 m to 1679 m a.s.l. with deciduous forests (mainly beech *Fagus sylvatica*) on the slopes and coniferous forests (spruce *Picea abies* and fir *Abies alba*) on the ridges covering 58% of the highlands. Wild ungulates are roe deer *Capreolus capreolus* (increasing), chamois *Rupicapra rupicapra* (locally), red deer *Cervus elaphus* (low numbers) and wild boar *Sus scrofa* (Jobin *et al* 2000).

Livestock

Sheep – 250,000 in the Swiss Alps, increasing from year to year (Weber 2000) and goats (Haller 1992 and Breitenmoser and Haller 1993 reviewed in Jobin *et al* 2000).

Husbandry

Sheep are mostly free-ranging and unattended (Landry 2000*a*; Weber 2000).

Predator species and attacks

Lynx *Lynx lynx*: Reintroduced in the 1970s (Breitenmoser 1983 reviewed in Jobin *et al* 2000). Kill sheep and occasionally goats in the Swiss Alps (Haller 1992 and Breitenmoser and Haller 1993 reviewed in Jobin *et al* 2000). The seasonal pattern of predation seemed to follow the grazing season, increasing in April, highest in May-July and September (with an unexplained reduction in August) and relatively high in October and November (Capt and Breitenmoser 1993 reviewed in Kaczensky 1996).

One study of 617 kills made by 29 radio-collared lynx in the Jura mountains from March 1988 to May 1998 found no predation on domestic livestock, probably due to the rarity of sheep and abundance of wild prey in the study area (Jobin *et al* 2000), whereas predation on sheep has been a temporary problem in other parts of the Jura (Vandel *et al* 1992 reviewed in Jobin *et al* 2000). Radio-collared lynx in the Jura passed by vulnerable sheep enclosures and even killed a roe deer in the immediate vicinity without taking any notice of the sheep (Kaczensky 1996). Only one lynx in the northern Jura – where grazing was, unusually, still allowed in the forest and roe deer numbers were low – regularly killed sheep (U. Breitenmoser pers. comm. to Kaczensky 1996).

Wolf *Canis lupus*: Returned to Switzerland in 1994/5 (Landry 1996; Landry 2000*a*) from Italy via France (Landry 2000*b* citing Taberlet *et al* 1996).

Losses

Lynx: Losses became significant 10 years after reintroduction. In the period from 1984 until 1994, the highest losses for a single year occurred in 1988 (81, mostly sheep and goats), average 54 per year. For the same period, an average of $13,600 was paid annually in compensation (reviewed in Kaczensky 1996).

Wolf: At least 119 sheep were killed by at least two wolves from July 1995 to May 1996 in Valais. The damage was estimated at more than SFr.57,000 (Landry 1999*b* citing Landry 1997). Around 5000 sheep graze in canton Valais near the French-Italian border; 117 sheep were killed from 1995-April 1996 by an animal believed to be a wolf. Thirty to fifty percent of damages were paid by the federal authority, the rest were covered by the canton. In 1995 damages were partially covered by the nature conservation organisations SBN and WWF (Landry 1996).

LGD breeds and status

In the early 1990s, after a long absence of large carnivores in the area, Swiss livestock husbandry no longer included protection measures. Livestock guarding dogs were introduced after the reappearance of wolves in the Swiss Alps. The Swiss Wolf Project (SWP) was set up within the programme KORA (Co-ordinated

research projects for the conservation and management of carnivores in Switzerland) on 1st January 1999 and by November 2000 had paid for the introduction of 25 dogs, mainly Great Pyrenees as well as St. Bernard, into different sheep flocks (Weber 2000). The best number of dogs per flock is two or four. Usually there is one dog per 100 sheep. The sheep must be in a flock, so a shepherd is also needed (Landry 1999*a*). Landry (1999*b*) proposed that traditional Swiss breeds (Swiss Grand Bouvier, Bernese Bouvier or St. Bernard) would probably be more acceptable to local farmers but would take time to selectively breed. In the meantime, imported breeds such as the Great Pyrenees will be used. The St. Bernard may not have been originally used to protect livestock.

LGD training

The US model (e.g. Lorenz and Coppinger 1986) has been followed for raising and training LGDs (Landry 1999*a*).

LGD evaluation

The presence of a shepherd is often required to increase the effectiveness of LGDs and to prevent conflicts with tourists and hunters, but hiring shepherds is not economically viable for sheep owners in this area (Landry 2000*a*).

Other measures

Many farmers are reluctant to protect their flocks as this implies accepting the wolf's presence. However, several farmers agreed to apply preventive measures, paid for entirely by the SWP. In 2000 KORA engaged 8 shepherds and assistant shepherds to advise farmers or protect flocks in hot spots (Weber 2000).

Other guardians: In 1995 several farmers in Valais (southwest) bought donkeys and integrated them into their herds without major problems. Eighteen donkeys have been used (Weber 2000). Preliminary results show that they are good at protecting small (<50) flocks from dogs harassing sheep but their effectiveness against wolves is not yet known (Landry 2000*b*).

Electric fences: Have been used to protect smaller flocks (Weber 2000).

Legal killing: Permission can be granted by the Cantons to shoot individual wolves and lynx preying on livestock (Kaczensky 1996).

Illegal killing: Breitenmoser *et al* 1995 (reviewed in Kaczensky 1996) reported that 27 out of 103 lynx carcasses found had been illegally shot. Weber (2000) detailed cases of wolves shot illegally.

Protective collars: Thick leather belts with bells were tested against lynx predation but with inconclusive results (U. Breitenmoser pers. comm. to Kaczensky 1996).

Historical methods: In the past, deforestation, scare devices (noisy watermills, lanterns and fence posts), watch fires, groups to chase away bears, persecution, bounties, box traps made of rocks on lynx trails and leg hold traps were used (reviewed in Kaczensky 1996).

MIDDLE EAST

Israel

Landscape

The Golan Heights, an area of 1000 km^2 in northern Israel (Reichmann *et al* 2001)

Livestock

Sheep (c.5000 ewes) and cattle (c.12,000) on 350 km^2 of the Golan Heights in northern Israel (Gilady 2000).

Predator species and attacks

Wolf *Canis lupus pallipes*: c.150-200, including 80-100 in the Golan where since 1993 there has been an increase in the number of observations of wolves and concurrently in livestock predation (Gilady 2000; Reichmann *et al* 2001).

Losses

Ranchers estimated livestock losses to wolves in 1998-99 at approximately $280,000. Predation affected around 6% of all new-born stock (Gilady 2000).

LGD breeds and status

The Great Pyrenees and Maremma are raised in Israel and recently the Turkish Akbash has been tested. A government compensation fund provides financial assistance to buy LGDs (Gilady 2000).

LGD evaluation

The presence of LGDs with herds may reduce predation, but it is difficult to eliminate this entirely, so some ranchers fence some pastures. Dogs require skilled training and handling; only a small proportion are good. Net fencing is the most reliable but only includes a small area and is not used everywhere. A combination of methods seems promising (Gilady 2000). This author stated that in 1999 after

"protection methods" were employed livestock predation cases were reduced by 30%.

Other measures (Gilady 2000).

Removal of predators: Wolves are culled due to livestock predation and rabies transfer (despite protected status since 1954 and the present danger of extinction). Controlled hunting is conducted only by wildlife rangers or hunters with special permits during attempted predation. Foot traps are used to capture wolves where wolf damage is observed. Removal or transfer of wolves to zoos if dens are located within paddocks.

Anti-predator fencing: Fencing of pastures with a net fence. Electric fencing of birthing enclosures up to 200 ha is recommended. A government compensation fund provides financial assistance to buy electric fences and partial compensation for damage.

Aversion: Marking birthing enclosures every two or three days with dogs urinating or defecating around the perimeter.

Turkey

Landscape

Eastern Turkey is fairly dry. On the Anatolian Plateau there are alternating areas with an abundance of water in rivers, streams or lakes and arid, semi-desert conditions. Elevations range from 1000 m a.s.l. in valleys to 3500 m on the mountain peaks. Summers are dry with temperatures reaching 49°C. Winters have deep snow and temperatures down to –51°C (reviewed in Marker 2000*c*).

Livestock

Primarily sheep, such as the Middle Eastern "fat-tailed"/Kangal-Karaman in the Sivas-Kangal region and/or goats and cattle (Taylor 1998*a*,*b*).

Husbandry

Nomadic or semi-nomadic tending of livestock in large expanses of the interior. With the onset of warmer weather, flocks of sheep are moved away from the villages to *yaylas*, high summer pastures in the mountains, by shepherds with LGDs. Here the flocks are gathered into an earth-walled corral or *agil* at night and in bad weather. The corral sometimes includes a living area for the shepherds and their families. When the weather gets colder in autumn and the harvest is finished, the flocks are taken back to the villages and graze on harvested fields until they are

confined for the winter in low barns in the villages, as are other livestock such as goats and cattle as well as the LGDs (Taylor 1998*a,b*, 2000).

Predator species and attacks

Wolves and brown bears, foxes, stray dogs and wild boar (Turcoman Int' 2000*b*; Taylor 1998*a*, 2000).

LGD breeds and status

Native LGD breeds in Turkey are termed *çoban kopegi*, shepherd's dogs (as opposed to *av kopegi* or hunting dogs). Throughout most of the country *çoban kopegi* are neither pure nor pedigree bred and vary greatly in appearance, though tend to be large and territorial. In certain limited and relatively isolated areas, however, regional breeds have been pure-bred for hundreds of years. These include the white Akbash and black-masked Karabash – two forms of Anatolian Mastiff (*sic.*) – the Kangal and the Kars Dog. The Akbash is still used for guarding livestock, though changing demographics and agricultural practices as well as unintentional crossbreeding with generic "shepherd's dogs", sometimes military patrol dogs and more popular incoming breeds such as the Kangal (Turkey's "national dog"), Karabash-coloured dogs and German Shepherds has greatly reduced the pure Akbash Dog population in its native region. There are no native herding dog breeds in Turkey; crossbreeding "shepherd's dogs" (LGDs) with German, Dutch and Belgian Shepherds has resulted in dogs which chase rather than guard livestock (Taylor 1998*a,b*, 2000; Nelson 1996 reviewed in Taylor 1998*b*).

LGD training

A trip to Turkey recounted in Turcoman Int' (2000*b*), which had occurred "over thirty years" previously, described pups being "teased with realistically stuffed wolf skin". Good pups were said to be those that growled at this; any showing fear were "discarded". A broad head, large wide mouth, well curved tail, big feet and "a killer instinct" (of which shepherds believed a prominent dew claw to be a sign) were also favoured. The mother was said to teach the pups by knocking them down roughly and nipping their necks and ankles. At six months of age the pups began to go with the older dogs, but were only responsible for protecting the flock from other shepherds' dogs. Adult dogs covered 12 to 18 miles (19-29 km) per night while circling their flocks and hunting small game to supplement the scraps given to them by shepherds. Their ears were closely cropped and they wore iron-spiked collars with a piece of cloth beneath to protect the neck (Taylor 1998*b*).

LGD evaluation

Over thirty years ago, shepherds within the wolf range had roughly four dogs to every thousand sheep, usually three males to one bitch. These were said to fight with and even kill wolves (Turcoman Int' 2000*b*).

Other livestock guarding species

Donkeys

Donkeys require less care than LGDs and are more adaptable to change of owner, climate and activity. They seem to have an inherent dislike of dogs and other canids and will bray, bare their teeth, run, chase and attempt to bite and kick such intruders (Andelt 1999*a*). Around 1000-1800 of 11,000 Texas sheep and goat producers used guard donkeys in 1989. In Texas, 59% of producers rated donkeys as good or fair for deterring predation (primarily by coyotes). In another survey, 20% rated their donkeys as excellent or good.

Donkeys were often used to defend livestock from carnivores in Namibia when farms were developing a century ago. The practice almost vanished as the elimination of predators was favoured but is now making a come-back as part of carnivore conservation initiatives. An individual female donkey with each calving herd is considered best: it is recommended to use one donkey (or jenny with foal) in small open pastures with a moderate-size herd. Geldings can also be used, but donkey stallions can be aggressive to livestock. Breeding should preferably be synchronised so that the donkey gives birth to its foal a month before the cows begin to calve. A donkey should be allowed to bond with the herd it is to protect over a period of 4-6 weeks. Donkeys should be tested – by challenging them with a dog in a pen or small pasture – and those that are passive should not be used for guarding. One Namibian farmer who has used donkeys since 1986 has reduced his losses to almost zero. He had lost 32 calves to predators in one year before using donkeys. Other farmers involved in a personal survey gave similar information. Farmers indicated that using donkeys provides a high success rate in livestock protection at low cost and with easy management, though success rates varied. Improper husbandry or rearing practices and unrealistic expectations were judged to account for many failures (reviewed in Marker 1999, 2000*b*; Andelt 1999*a*; Landry 1999*b*).

Several farmers in the Valais, southwestern Switzerland, have bought donkeys since 1995to defend their sheep from wolves. It has been found that donkeys of any age can be integrated into flocks, although young animals are recommended; this process has not caused major problems and takes around a week for sheep to get accustomed to a donkey's presence. Stallions are not recommended due to their aggression, especially in autumn. One donkey consumes around 8 kg of hay daily, the same as 4-5 sheep. In barns, e.g. in winter and/or during lambing, the donkey should be placed in a stall – large enough for it to roll on the ground – near the sheep; the presence of a donkey seems to reassure the sheep. There may be some difficulties with using herding or guarding dogs in conjunction with donkeys or with grazing on steep slopes. Using several donkeys together is not recommended. A single donkey guarding a flock of up to 50 sheep in an enclosure seems to work best in the Swiss Alps and with a flock of 200-250 in mountain pastures, though their effectiveness against wolves is still unknown (reviewed in Landry 1999*b*, 2000*b*).

See also Tapscott's (1997) comprehensive "Guidelines for using donkeys as guard animals with sheep".

Livestock Guard Dogs, Llamas and Donkeys
http://www.colostate.edu/Depts/CoopExt/PUBS/LIVESTK/01218.html

Guidelines for using donkeys as guard animals with sheep
http://www.gov.on.ca/OMAFRA/english/livestock/sheep/facts/donkey2.htm

Llamas

Llamas are also naturally aggressive towards canids; typical responses are becoming alert, alarm calling, walking or running towards the predator, chasing, kicking, or pawing the predator, herding the sheep or positioning themselves between sheep and predator (Andelt 1999*a*).

Llamas are less expensive than LGDs, live 3 times longer and require no special feeds. Their use has been associated with reduced coyote depredation on livestock in test conditions, where 19 out of 21 growers reported fewer sheep lost to coyotes in the presence of llamas (NWRC 1997). One hundred and forty-five sheep producers surveyed by Iowa State University researchers in 1990, primarily in Montana, Wyoming, Colorado, California and Oregon, reported losing an average of 21% of their ewes and lambs to coyotes annually before acquiring a llama, and 7% with a llama in place. An average annual saving of $1253 was reported by 87 of

the producers. Eighty percent of producers rated their guard llamas as effective or very effective.

Large males were judged to be better than smaller individuals in a trial of gelded llamas vs. border collies, with size and alertness being the best predictors of guarding effectiveness (NWRC 1997). Cavalcanti and Knowlton (1998) found that leadership, alertness and weight of llamas correlated with aggression towards dogs in trails of 20 llamas and concluded that these traits could easily be used by producers to select individual llamas for use as livestock guardians. The effectiveness of gelded males, intact males and females was similar. However, more intact males (25% of 61) than gelded males (5% of 135) attempted to breed ewes. Some llamas were aggressive toward the sheep (reviewed in Andelt 1999*a*).

Andelt (1999*a*) stated that llamas appear to be less effective than livestock guarding dogs, are most effective in fenced pastures of less than 300 acres (121 ha). and most producers use one (found to be better than more) gelded male llama for 250-300 sheep. The effectiveness of llamas in protecting livestock from wolves in Montana has been questioned (Int. Wolf 2001).

Nearly all llamas in the Iowa survey were not raised with sheep and were not trained to guard sheep. The adjustment period for llamas and sheep lasted only a few hours for half the llamas, and nearly 80% adjusted within a week. Llamas introduced to sheep in corrals were apparently more effective guardians initially than those introduced in pastures, but in time losses were similar. Success was not related to age of llama when introduced, age of llama (after 1 or 2 years old) when guarding, presence/absence of lambs when the llama was introduced or between open and covered (forests, shrub lands, gullies, ravines, etc.) habitat (reviewed in Andelt 1999*a*).

Llamas as livestock guardians
http://www.llamas.co.uk/livestockguards.htm

Llamas as guardians
http://members.aol.com/LostCrk431/guardianllamas.html

OnLine Brochure: Llamas for Guarding Livestock
http://www.webcom.com/~degraham/Associations/GuardILA.html

Cattle

Landry (1999*b*) briefly reviewed the use of cattle and Marker (2000*a,b*) suggested leaving horns on some cattle and placing heifers with older cows to assist in anti-predator defence.

Relative effectiveness of LGDs, llamas and donkeys

Andelt (1999*a*) stated that LGDs effectively deter coyote and dog predation in fenced pastures and on open range, whereas llamas and donkeys appear best suited to fenced pastures of less than 300 acres (121 ha). Producers using LGDs reported a lower percentage of sheep lost than producers using llamas. Several producers indicate guard dogs can effectively deter bear and mountain lion predation, whereas llamas and donkeys were apparently afraid of mountain lions and their effectiveness in deterring bear predation was unknown. Donkeys were rated less successful than guard dogs and llamas. However, these comparisons are inconclusive because all three species were not rated in the same surveys or under the same conditions. Compared to LGDs, llamas and donkeys appeared less prone to accidental death, were longer lived, stayed in the same pasture as sheep and ate the same food, did not need to be raised with sheep and were less susceptible to lethal anti-predator devices used concurrently.

Livestock Guard Dogs, Llamas and Donkeys
http://www.colostate.edu/Depts/CoopExt/PUBS/LIVESTK/01218.html

LGDs and large carnivore-wildlife conflicts in Europe

Many of the conclusions drawn by Kaczensky (1996) in her review of large carnivore-livestock conflicts in Europe are still current, can be applied to a much wider geographic area and are relevant to any discussion of livestock guarding dogs. She found that in none of 12 countries was predation the main problem: the issues were more social and psychological. Grazing is possible in predator range, she stated, with efficient guarding techniques, but some losses must be tolerated.

Patterns of vulnerability in Europe (after Kaczensky 1996):-

- Sheep were most vulnerable;
- Predation was lowest for lynx and highest for wolves;
- Almost everywhere losses were <1% of total available stock;
- There was no obvious link between predator population size and losses or between sheep available and lost;
- Differences in guarding techniques appeared to be the most important factor affecting predation levels – bringing flocks into barns/electric fences or employing shepherds with LGDs at night were most effective against wolves and bears, along with grazing above the timber line, herding cattle rather than sheep, shortening the grazing season and using LGDs;
- A high natural prey base did not necessarily prevent high livestock losses;
- Livestock were most vulnerable at night and on forest range;
- Seasonal patterns varied between regions.

Possible non-lethal anti-predator techniques (after Kaczensky 1996):-

- Shorten the grazing season to avoid local peaks of predation;
- Guarding – LGDs must see predators approach, so they are recommend for large open areas or small fenced areas; in the former, sheep must flock and be max. 100-200 together;
- Put sheep in secure shelters in the late afternoon to avoid the main activity periods of wolf, bear and lynx (dusk, night and dawn);
- Otherwise: fence them on large open areas, or have shepherds near, use LGDs;
- Electric fencing is effective for small scale husbandry;
- Use protective collars (spikes, odour) for lynx and wolverine;
- Aversive conditioning for single problem animals, especially important individuals e.g. females in a declining population; ineffective if the whole grazing situation is problematic;
- Supplementary feed bears at remote sites – this may divert them from livestock;
- Increase the natural prey base where this is low;
- Zone predator core areas – must be large enough for viable populations (large interconnected areas of several 1000-10,000 km^2 for bear and wolf), minimise people conflicts with low numbers of livestock. This is the only solution where other intensive protection measures are not socially acceptable. It also requires guarding, improved husbandry and possibly staggered compensation/subsidies, technical support and different control actions/hunting quotas.

Conclusion

The use of livestock guarding dogs has greatly declined in many regions and for a variety of reasons. Some regional varieties, such as those of Afghanistan and Iran, may even no longer exist (de la Cruz 1995), while several others are rare and/or endangered, such as the Portuguese breeds (Fonseca 2000) and the Karakatchan in Bulgaria (Tsingarska *et al* 1998). These and others more common, at least in their country of origin, have been bred for show, as pets, property guardians or misused – Slovakia's chained dogs (Coppinger and Coppinger 1994), for example – which may have weakened their livestock protection capabilities. Crossbreeding is another threat (Kubyn 1995) to the integrity of breeds which has been found to adversely affect the guarding abilities of some dogs (Tsingarska *et al* 1998).

Nevertheless, in countries such as Italy (Ciucci and Boitani 2000) and Romania the LGD tradition seems never to have been interrupted although, despite their effectiveness against predators, the continued use of dogs and the associated need for shepherds may become unfeasible due to changing social and economic conditions (Mertens and Promberger 2000*a*). Elsewhere, as in Poland systematic, scientifically studied efforts to reverse this process and expand the use of LGDs as a strategy for encouraging large carnivore conservation are proceeding alongside and complementing traditional use (Nowak and Mys³ajek 1999*a*; Œnietana 2000).

Switzerland (Landry J.-M. 1999*b*) and France (CSM 1999) largely abandoned traditional strategies for protecting flocks from predators – including the use of livestock guarding dogs – after wolves and bears were eradicated from Alpine regions, but many farmers are now once again using LGDs as a result of recent natural recovery and reintroduction of large carnivores. In addition, livestock guarding dogs have been introduced on a trial basis to countries where there are no native breeds and their use is not traditional, such as Norway (Hansen and Bakken 1999), sometimes with very successful results, as in Namibia (Marker 2000*b*) and, most notably, the USA, where LGDs have become so widespread and well-studied (Coppinger *et al* 1988) that knowledge gained there is assisting LGD revival projects in areas of Europe where they are native but not now used (Landry 1999*b*).

Use of guarding dogs is especially appropriate for livestock protection when rare, threatened, endangered and legally protected species (Coppinger and Coppinger 1995) are causing the damage. Many LGD projects are currently operating in conjunction with broader initiatives for large carnivore conservation which, when these can provide funding and assistance to farmers for measures to reduce their livestock losses, offer a way to off-set the economic costs of using livestock guarding dogs and hence ensure they continue to be a (cost) effective option.

Annex I. Directory of LGD users and experts

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Other related website addresses

Carnivore Damage Prevention News
www.large-carnivores-lcie.org
www.kora.unibe.ch

Wildlife Conservation Research Unit (WildCRU)
www.wildcru.org

Carnivore Conservation
www.carnivoreconservation.org

IUCN SSC Canid Specialist Group
www.canids.org

IUCN SSC Cat Specialist Group
http://lynx.uio.no/catfolk/csg-home.htm

The International Association for Bear Research and Management
www.bearbiology.com

The Born Free Foundation
www.bornfree.org.uk

Damage Prevention and Control
www.conservation.state.mo.us/manag/coyotes/control.html

Internet Center for Wildlife Damage Management
www.ianr.unl.edu/wildlife/solutions/handbook/index.htm

Predator Defense Institute
http://www.enviroweb.org/pdi/alternat.htm

International Canine Federation
http://www.fci.be/english

American Kennel Club
http://www.akc.org

United Kennel Club
http://www.ukcdogs.com

The Kennel Club UK
http://www.the-kennel-club.org.uk

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