The extent of predation on livestock by large carnivores in Slovakia and mitigating carnivore-human conflict using livestock guarding dogs.

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Declaration

This thesis has been composed by the candidate. It has not been accepted in any previous application for a degree. The work has been done by the candidate except where otherwise stated by means of acknowledgements and citations. All quotations have been distinguished by quotation marks and the sources of information specifically acknowledged.

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Place

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Contents

Summary

Shepherds and farmers in the Carpathian Mountains of Slovakia report damage to livestock by recovered populations of native predators, particularly grey wolves (*Canis lupus*) and brown bears (*Ursus arctos*). This study reviewed the nature and extent of carnivore-human conflict and assessed the relative importance of livestock depredation as a threat to the long-term endurance of viable populations of large carnivores in the wild. The possibility of revitalizing the traditional use of livestock guarding dogs (*Canis lupus familiaris*) to protect sheep (*Ovis aries*) was assessed by conducting a literature survey on the use of livestock guarding dogs (LGDs) worldwide, observing working LGDs in several countries, examining the reasons why the tradition had been abandoned in the Slovak Carpathians and performing field trials of LGDs with livestock at working farms. These activities were undertaken as part of the Protection of Livestock and Conservation of Large Carnivores (PLCLC) project.

In order to evaluate spring-autumn diet of carnivores in livestock-raising areas a total of 373 bear and 70 wolf scats were collected in the Tatra and Fatra Mountains from March to November 2001-03 and their contents analysed. Bear diet was quantified using correction factors to convert % volume data into estimates of % dry matter ingested. The proportion of each prey item in wolf scats was calculated as frequency of occurrence and mean % volume. Experimentally derived regression equations were then used to convert the data into estimates of % biomass consumed. Livestock did not comprise a major component of the diet of either bears or wolves. Bear diet varied greatly among seasons. Plant material constituted 90.8% of total scat volume and 83.5% of estimated dry matter ingested. Green vegetation, mainly grasses/sedges and herbs, dominated in spring and early summer, with a shift to fruits (*Vaccinium myrtillus*, *Rubus idaeus*, *Vaccinium vitis-idaea*, *Sorbus aucuparia*) in July-October. Many bears utilised anthropogenic food sources, including hunters' ungulate feeding stations, crops (*Zea mays*, *Avena sativa, Triticum aestivum*), refuse and, to a lesser extent, orchards (*Malus* spp., *Prunus domestica*), but no domesticated vertebrates were identified in any of the analysed scats. Invertebrates occurred significantly more frequently and in greater quantities than large mammals. Wild ungulates

formed the main prey base of the wolf (mean % volume in scats = 91.4%). Cervidae (*Cervus elaphus*, *Capreolus capreolus*) occurred 3.5 times more frequently in scats than wild boar (*Sus scrofa*) and comprised 4.4 times more of the estimated biomass consumed. Juveniles (<1 year old) were estimated to account for 65.7-70.7% of cervid biomass consumed.

Carnivore-human conflicts were assessed on the bases of a literature review, informal interviews with hunters, conservationists and wildlife managers as well as the results of a questionnaire survey on public opinion, knowledge and attitudes. Predation on livestock seemed to be of little economic importance and was more a problem in perception than in reality. Although it was often cited in support of the need for increased hunting of large carnivores, it was of less concern in this respect than other issues such as instances of nuisance bears and predation by wolves on valued game species. Hunting did not necessarily appear to be the most immediate threat to bears, although it was evidently a major cause of wolf mortality. Twenty out of 24 regions (84%) with regular presence of bears and/or wolves were visited in order to assess farm conditions and anti-predator measures. Reports of losses to large carnivores were gathered by semi-structured interviews with farmers and shepherds for 164 flocks from 147 different farms. Surveyed flocks contained a total of c.79,000 sheep, c.23% of all sheep in Slovakia or c.26% of those in regions with bears/wolves. Data were compared with results from the Poľov 1-01 national hunters' questionnaire for 2000-02, and provided some idea of the extent of predation and an indication of various patterns among regions, years, seasons, time of day, species of predator and farm conditions. Overall, 48.0% of flocks (*n*=127) were not affected by wolf or bear predation at all during the period 2001-03. Some regions with carnivores had no reported losses while in other regions up to 82% of flocks were affected by predation in any one year, with a mean across all surveyed regions and all three years of 24.1%. In each year, ≤ 14.0% and ≤ 29.4% of surveyed flocks were allegedly affected by bear and wolf predation respectively. Particularly in the case of wolves, one farm suffering substantial losses to its various flocks (in single surplus killing events or as a result of multiple attacks) could account for up to 34.6% of total losses in a particular year at all surveyed farms combined. The distribution of reported losses was not adequately explained by estimates of the numbers of carnivores, particularly of bears. Very high losses were generally associated with poor husbandry and/or inadequate preventive measures.

For the field trials of livestock guarding dogs (LGDs), 14 pups of two breeds found in Slovakia (Slovenský čuvač and Caucasian shepherd dog) were raised with sheep at eight farms. A variety of measures were used to score the behaviour of each pup during c.500 hours of focal observations. The ability of yearling dogs to protect flocks was assessed by staging mock attacks in which a substitute predator (a German shepherd dog) was released from a concealed position and the responses of LGDs recorded. The effectiveness of LGDs at reducing losses to large carnivores was assessed by comparing reported losses in 2002 at flocks with and without free-ranging LGDs. A review of the use of LGDs elsewhere confirmed the appropriateness of this non-lethal method of livestock protection for sheep farms in the Slovak Carpathians. Behavioural observations found that the majority of dogs tested retained the key traits of trustworthiness, attentiveness and protectiveness considered necessary for successful LGDs. Whether or not a particular pup became integrated into a flock appeared to depend on the attitude and diligence of shepherds and therefore the developmental environments in which it was raised and expected to work rather than on its behavioural conformation or genotype. Twelve of the 14 pups raised (86%) developed good or intermediate patterns of behaviour in their first year of life. As yearlings, six dogs (43%) became very well or reasonably well integrated into flocks. Four dogs (29%) had good or intermediate behaviour but were excluded from flocks by shepherds. Two dogs with poor behavioural patterns (14%) and two with only intermediate scores for behavioural patterns had not been raised correctly.

Reported losses in 2002 at 13 flocks with free-ranging PLCLC project LGDs were significantly lower than expected and the maximum reported loss was only 14% of that at 42 surveyed flocks without free-ranging project LGDs in the same regions. A number of barriers were identified to the successful introduction of free-ranging LGDs to sheep farms in Slovakia. The most significant was the lack of knowledge, experience or motivation of many shepherds. Other problems included interactions of dogs with farm visitors, hunters threatening to shoot wandering dogs and economic instability leading to the sale of flocks.

Finally the implications of this research for the conservation management of large carnivores are discussed. Results on native carnivore diet and the pattern of livestock losses indicated that in a given year most flocks were not affected by predation and suggested that only a minority of carnivores caused damage to livestock. High losses at particular farms were largely the result of local conditions. Those caused by wolves seemed to be considerably higher than those by bears. It should be noted, however, that in addition to science, perceptions and politics are also important aspects of wildlife management. Human hunters often regard wolves as competitors for game, while at the same time wolves and bears are valued trophies, and feared by many. These issues are inter-linked with that of predation on livestock, complicating initiatives to resolve grievances. As carnivores in Slovakia exist in multi-use landscapes and there are only a few small, diminishing areas relatively free of human influence, conflicts with humans could have important consequences for carnivore survival in the medium to long term. Lethal control of wolves continues unabated, and relaxing restrictions on wolf hunting is being strongly advocated, although it would seem unlikely to succeed in reducing reported damage to livestock without threatening the maintenance of a viable population. On the other hand, although lethal control targeted at "problem" individuals may lead to a temporary reduction of losses, if the locality or farm practices remain unchanged, predation would be expected to resume within a few years. This study recommends the focussing of future efforts on the identification of vulnerable farms and the improvement of their preventive measures, with the use of livestock guarding dogs being one management option. However, several possible difficulties are identified in integrating LGDs into sheep flocks. Additionally it should be noted that, following the entry of the Slovak Republic to the European Union in May 2004, changes to the economy in general and the livestock industry in particular are likely to proceed apace, the consequences of which for carnivore conservation management are difficult to anticipate.

Chapter 1

Background to the study

Abstract: This chapter briefly describes Slovakia at the turn of the 21st century, wildlife management in the Slovak Carpathian Mountains and the context of the present research.

CONTENTS

INTRODUCTION

Slovakia is a small (49,035km^2), young Central European state with a high human population density (mean 110.1km^{-2} in 2001). It became an independent republic in 1993. Prior to the fall of communism in 1989, the area of present-day Slovakia formed part of the Czechoslovak Socialist Republic, between the USSR and democratic Western Europe. A large portion of the country lies within the Carpathian Mountains: 59% over 300m a.s.l., 14% of this between 750 and 2,655m a.s.l. Half of Slovakia's land surface is used for agriculture, mostly in lowlands and river valleys, and c.41% is forested (SOSR 2002). Ninety percent of forest cover is in the Carpathian Mountains. Despite ongoing environmental degradation caused by various human activities, particularly since the industrial revolution (Vološčuk 1994, Hell *et al*. 1997), natural biodiversity remains high. A large proportion (40-45%) of forest is semi-natural, with indigenous tree species occurring in mixed stands (Paule 1994, Zuskin 1998, SOSR 2002), although natural regeneration occurs in only 13-

20% of Slovakia's forests (Longauer 1994). Socio-political and economic changes in the 1990s, particularly the re-privatisation of land and transformation to a capitalist market economy, led to considerable damage to the countryside. Nevertheless, at the turn of the 21st century many montane forest and alpine ecosystems were relatively complete (Zuskin 1998), providing important refuges for vertebrates (Kropil *et al*. 1994, Hell *et al*. 1999), including native top predators.

THE RECOVERY OF LARGE CARNIVORES IN SLOVAKIA

Increasing numbers of humans and livestock, direct persecution, deforestation and the devastation of wild ungulate populations resulted in the elimination of the wolf (*Canis lupus*), brown bear (*Ursus arctos*) and Eurasian lynx (*Lynx lynx*) from most of Europe by the end of the 19th century, and in some regions much earlier (Breitenmoser 1998). In the area that is present-day Slovakia, trophy hunting and persecution almost eradicated large carnivores during the period 1890-1930 (Jamnický 1993), but small relict populations survived in the Carpathian Mountains. Populations of wild ungulates recovered in the second half of the 20th century and forest cover also increased (Voskár 1993). Curbs on hunting bears (from 1932), lynx (from 1936) and wolves (from 1975) and an improved prey base sufficed to allow a natural recovery and by the late 1980s to mid 1990s their numbers were at their highest levels since the 19th century (Hell and Slamečka 1996, 1999, Hell *et al*. 2001a). Concurrently, all three species were more widespread across the Western Carpathians than they had been during most of the 20th century, bringing many people into contact with large carnivores who had never before had experience of living near them or witnessing the results of their activities. Instances of golden jackals (*Canis aureus*) returning to lowland areas also began to be reported from 1989 (Hell and Bleho 1995, Danko 2002, Hell and Garaj 2002:93). Many local residents knew little about the carnivores living around them (Wechselberger *et al*. in prep.) and modern farmers and shepherds no longer knew how to effectively protect their animals against attacks (Sillero in Rigg 2001a). Partly perhaps because knowledge of prevention measures was lost during the period in which they were scarce, the return of wolves and bears resulted in renewed incidents of predation on livestock (Teren 1987), damage to beehives, crops and orchards (Janík 1997) and cases of human food-conditioned and human habituated bears injuring people (Rigg and Baleková 2003). The reduction of large ungulate populations in the 1990s, apparently a result of hunting, poaching and intensified agriculture, had the benefit of reducing damage to forest stands (Hell and Slamečka 1996, Hell *et al*. 1997, Stockman and Zuskin 1998, Finďo 1998, 1999a) but was perceived by many hunters as a negative phenomenon caused by "over-populated" large carnivores.

NATIONAL LAW AND INTERNATIONAL TREATIES

The populations of large carnivores in the Carpathians appear to be once again contiguous from the Czech Republic through Slovakia and Poland to the Ukraine (Koubek and Červený 1996, Hell and Finďo 1999, Beleš 2000, Okarma *et al*. 2000, Kunc 2001, Bartošová 2001, Koubek *et al*. 2002, Hell 2003, Červený and Koubek 2003 and references therein, Martínková and Zahradníková 2003 and references therein). Dispersal from Poland and the former USSR was an important factor in the recovery of the wolf in Slovakia (Teren 1987, Hell 1993, Finďo 1995), while re-establishment of carnivores in the eastern Czech Republic and northern Hungary is now largely dependent on dispersal from Slovakia (Janík *et al*. 1986, Hell 1992, Hell and Slamečka 1996, Szemethy and Heltai 1996, Koubek *et al*. 2002, Bartošová 2002, 2003, Gadó and Pačenovský 2003). At the end of the 20th century it was commonly acknowledged that, due to the international character of large carnivore populations in Europe, their conservation and management should be considered at the population rather than the national level. Many wide-ranging political decisions, including agricultural policy (Savelli *et al*. 1998), likely to affect the long-term future of large carnivores in Europe, were being made by the European Union (EU) at an almost continent-wide level (Boitani 2000a). These concepts were embedded in pan-European action plans for the bear (Swenson *et al*. 2000), wolf (Boitani 2000b) and lynx (Breitenmoser *et al*. 2000) endorsed by the Council of Europe and published as official documents within the framework of the Convention on the Conservation of European Wildlife and Natural Habitats (the Bern Convention). The overall goal of these plans was, "to maintain and restore, in coexistence with people, viable populations of large carnivores as an integral part of ecosystems and landscapes across Europe."

The Slovak Republic, a signatory to the Bern Convention, adopted numerous laws to bring its legislation into line with that of the EU ahead of membership from 1st May 2004. Political pressure from neighbouring states and lobbying by non-governmental organisations led to the establishment of two wildlife corridors with year-round protection for wolves to facilitate their dispersal to the Czech Republic and Hungary (Kunc 2001, Urban 2002, Gadó and Pačenovský 2003). At the Fifth Ministerial Conference on Environment for Europe in 2003 Slovakia signed the Draft Framework Convention on the Protection and Sustainable Development of the Carpathians, which stated that, "The Parties shall pursue policies aiming at conservation, sustainable use and restoration of biological and landscape diversity throughout the Carpathians. The Parties shall take appropriate measures to ensure ... the protection of ... large carnivores."

CONFLICTING WILDLIFE MANAGEMENT GOALS

Besides the Slovak Republic's political and legal commitments to protect them, their possible status as indicator, keystone, umbrella or flagship species (Estes 1996, Simberloff 1998, Gittleman *et al*. 2001 but cf. Linnell *et al*. 2000), their intrinsic worth, their right to exist (Bekoff 1998, 2001, Lynn 2003) and charisma (Mech 1996), wolves have been said to be deserving of protection in Slovakia due to a variety of possible benefits to humans as well as ecosystems. For example, wolves might reduce browse damage in forests by limiting ungulate populations (Voskár 1976, 1993, Remeník 1996, Finďo 1998; see also Adamic 2000, Hebblewhite *et al*. 2003, Mao *et al*. 2003), limit the spread of swine fever (*Pestis suum europaea*) in the wild boar (*Sus scrofa*) population (Strnádová 2000, 2003), of lung worms in the red deer (*Cervus elaphus*) population and of rabies in the fox (*Vulpes vulpes*) population (Voskár 1993), maintain the quality of ungulate populations by selectively removing weaker individuals (Voskár 1993, Strnádová 2003, but cf. Mech 1996) and generate profit for local people through ecotourism (Rigg and Finďo 2000). On the other hand, predation on livestock, competition for game and other perceived losses and threats to humans have led to the frequent claim that wolf and bear populations are currently too high in Slovakia and must be reduced or at least controlled by relaxing restrictions on hunting (see Hell and Finďo 1999, Luczy 2000, Hell and Slamečka 2000, Rakyta 2001, Klein 2002, Hlásnik 2002a,b, Hell 2003).

Despite the Slovak Republic's international commitments to nature conservation, some individuals (e.g. Hell and Gašparík 1999) continue to view wildlife abundance at the local or national level rather than at a population or European level. It is argued, perversely and yet sometimes successfully, that older hunting regulations over-ride new nature conservation legislation (Ďurík 2000). The result is a struggle between the Slovak Hunting Union together with the Agriculture Ministry versus the State Nature Conservancy under the Environment Ministry and non-government environmentalist organisations. The former take the view that populations should be exploited until there is urgent need for temporary cessation and aim to reduce carnivore numbers (I. Šuba pers. comm. 2003, J. Hlásnik pers. comm. 2004), while the latter appear to be trying to reach a situation where vulnerable and threatened species would be protected as a rule and could be hunted only exceptionally. The conflict has been particularly acute where the same species are regarded as harmful game animals in hunting regulations but listed as protected species in environmental legislation, as is currently the case with large carnivores. This has led to situations where it is not clear which legal provisions are valid (Kušík 1996, Okarma *et al.* 2000) and two different ministries deal with the same issues (Kassa 2003). Each ministry gives preference to its "own" legislation and pursues wildlife management goals frequently at odds with those of the other (e.g. Šíbl in prep.). In relation to wolf hunting, the dispute can be viewed as an unarticulated debate over whether or not wolf numbers should be controlled to enhance prey populations (see Theberge and Gauthier 1985, National Research Council 1997, Fritts *et al.* 2003, Herrero 2003). However, the conflict is part of a broader disagreement driven by two seemingly incompatible value-laden beliefs: that in Slovakia's mostly human-dominated landscapes human intervention is desirable and unavoidable, but can become sustainable, or that some areas can and should be set aside and left to develop predominantly under the influence of non-human evolutionary processes (see Fritts *et al.* 2003). Accelerated economic development within the EU has the potential to overshadow both positions. Other important factors detrimental to wildlife conservation initiatives are the widespread corruption for which the Slovak Republic was rebuked by the EU ahead of membership and an unhealthy competition, rather than cooperation, among organisations and individuals.

HUNTING, CONSERVATION AND DEVELOPMENT

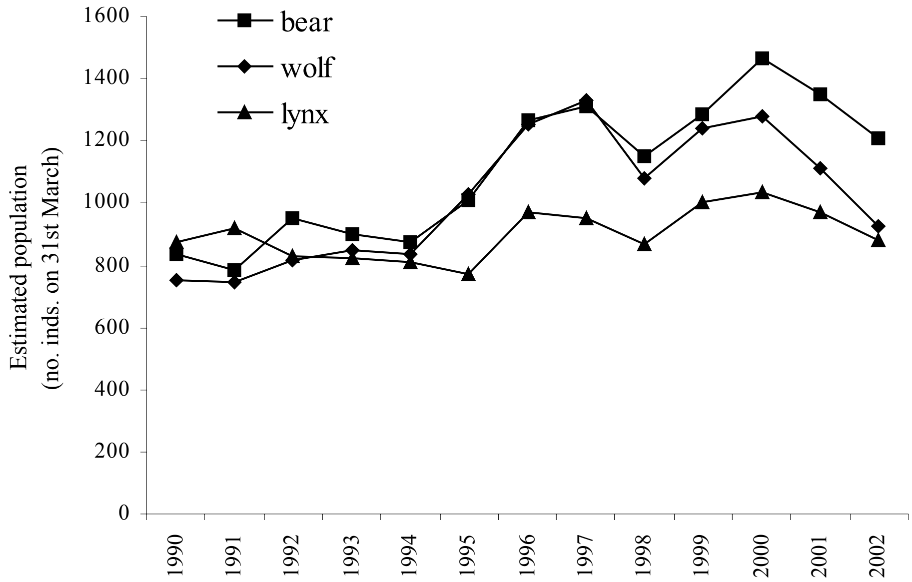
While some hunting advocates emphasise the need for an "ecological" basis to exploitation of wild animals (e.g. Ciberej 1998, Hell and Slamečka 1996, 2000, Hell *et al*. 2001b), hunting in Slovakia is dominated by management of game for trophies and meat in which wild ungulate populations are heavily manipulated through supplementary feeding, oral vaccination and predator control (Hell and Garaj 2002), with major effects on ecosystems (Voskár 1993). Game species have traditionally been categorised as either "beneficial" or "harmful" (Hell and Slamečka 1996). Native predators, particularly wolves, are listed among the latter and are viewed by many hunters and managers as competitors for human hunters (Červený *et al*. 2002; see also Mráz 1996a, Hell 2000a, Brtáň 2003). Predation by wild, native carnivores on free-living wild ungulates, even when it occurs in National Parks, is interpreted by hunters as a loss to their economic interests (see Mráz 1996a). Hunting advocates argue that carnivores must be culled to control their populations (Hell 2003, J. Hlásnik pers. comm. 2004, cf. Mech 2001), in order for hunters to tolerate their presence in hunting grounds (which cover c.90% of the country, including National Parks and Nature Reserves) and to limit poaching (e.g. Hell and Slamečka 2000, Ďurík 2000; see also LCIE Core Group 2001, Boitani 2003b).

Unfortunately, basic data on which sustainable hunting of large carnivores might be based (see Johnson *et al*. 2001) are lacking in Slovakia. As many authors have noted (e.g. Vantara 1990, Voskár 1991a, Hell and Slamečka 1996), hunters' estimates of abundance are highly inaccurate. A large-area tracking census in 2001 found that numbers of wolves had been over-estimated by at least 5.3-5.9 times, bears by 1.6 times and lynx by 2.9-3.7 times (re-calculated from data in Lehocký *et al*. 2000, 2001, Lehocký 2002). Extrapolating to the national level would drastically modify spring population estimates as follows: 212-242 wolves, 810-940 bears and 281-344 lynx (instead of 1,240-1,281 wolves, 1,288-1,467 bears and 1,004-1,037 lynx as estimated by hunters). Extrapolating from a population density of c.1 wolf 100 km^{-2}

observed in this census (Lehocký 2002) to the estimated size of occupied wolf range (c.21,000km^2, Finďo and Rigg unpub.) suggests a total of c.200 wolves in Slovakia in early winter. Even when limited hunting is permitted there are frequent infringements of regulations, particularly killing wolves outside the open season (R. Rigg unpub. data), shooting bears above stipulated weights (reviewed in Somorová 1997, Martínková and Zahradníková 2003), poaching of bears (S. Ondruš pers. comm. 2001-03) and the illegal use of traps (K. Soos pers. comm. 2003).

According to some workers (e.g. Voskár 1993, Finďo 1995), sustained persecution and a decrease in the natural prey base in conjunction with new threats such as habitat fragmentation (see Bright 1993) and development of mountain refuges could threaten the long-term survival of wolves in the Western Carpathians. Hell and Gašparík (1999) argued that shooting alone (without poisoning) has never eradicated a wolf population and so need not be further restricted. It is, however, limiting range expansion (e.g. Bartošová 2002; see also Andersone 2002). Modern hunters and poachers are better equipped than their predecessors, with high-powered rifles, night vision equipment, 4-wheel drive vehicles and mobile communication devices (GSM telephones) to coordinate their efforts. There may also be more subtle threats: negative effects of intensive hunting on European wolves have been suggested in a study from Latvia (Andersone 2002), including changes in demographic structure and hybridisation with dogs. The wolf population in Slovakia appeared to have begun to decline once again in the mid-1990s (E. Baláž pers. comm. 2003, Lukáč in prep.), possibly due to a decrease in its prey base (cf. Mech 1995b) and high hunting pressure. According to Hell and Slamečka (1996), these two reasons were responsible for a decline in lynx numbers during the 1990s. Although bears are relatively numerous in Slovakia at present, they may have declined locally (S. Ondruš pers. comm. 2003). Baláž (2003) thought that habitat loss and fragmentation caused by increased human use of mountain areas, development, forestry and hunting management, as well as poaching threaten the maintenance of a viable population of wild bears in the long-term due to detrimental effects on social structure, feeding ecology and habituation to humans. Hunters' estimates indicate declines in the populations of all three species since 2000 (Fig. 1.1). However, this is denied by hunting advocates at the Agriculture Ministry (e.g. J. Hlásnik pers. comm. 2004, M. Lehocký pers. comm. 2004), ironically on the basis that the annual bag of wolves remains high and occupied range has been increasing. Decreased bear hunting success has been blamed on "bureaucratic and useless" regulations (Hell 2003).

Fig. 1.1. Estimated numbers of large carnivores in Slovakia during the period 1990-2002 according to the Poľov 1–01 national hunters' questionnaire (from data in Richter 1991, Hell *et al.* 1993, Žilinec and Hell 1995, Sabadoš *et al.* 1996, 1997, 1998, SOSR 1997, 2000, 2002, Herz 1999, Lehocký *et al.* 2000, 2001, 2003a, Kaštier 2004).



Government nature conservation policy since 1976 has been to establish an extensive network of protected areas (Konôpka 1994, Kramárik 1995). In 1998 nearly a quarter of Slovakia's land surface had some degree of legal protection (Zuskin 1998) and by 2002 there were nine National Parks, all in upland regions. However, commercial forestry, hunting, livestock grazing and development were allowed to continue in most of these areas, including logging in many National Nature Reserves (B. and E. Baláž pers. comm. 2002-03, J. Strnádová pers. comm. 2003), thus limiting their conservation value. At the beginning of the 21st century wolves could still be legally shot inside National Parks (Radúch 2003a, S. Ondruš pers. comm. 2003) to reduce predation on wild ungulates (see Kováčiková 2003). Substantial portions of National Parks had been re-privatised following the end of communism, leading to unresolved conflicts with private interests over economic development (Stockmann 2001) that presented a major obstacle to implementation of the EU Habitats Directive and Natura 2000 (Urban 2000, 2002, Hell and Kaštier 2003, Viestová 2003, S. Ondruš pers. comm. 2003) as well as the effective functioning of Parks as wildlife refuges, despite apparently widespread support among local residents for this as a management goal (Wechselberger *et al*. in prep.).

Bear hunting has already been excluded from National Park core areas (S. Ondruš pers. comm 2002, Kassa 2003). During drafting of a new hunting law in 2004 there were attempts to implement similar measures for wolf hunting but they were strongly opposed by special interest groups (E. Baláž pers. comm. 2004). Even if hunting were banned within them, protected areas are neither large enough nor sufficiently connected to preserve viable populations of large carnivores in isolation (Linnell *et al*. 2000, Breitenmoser *et al*. 2002, Woodroffe *et al*. 2002a, Villemure 2003). Conservation of large carnivores therefore compels their presence in multi-use landscapes (Linnell *et al*. 1996, 2000, 2001a, 2002a), leading to conflicts with humans. Protective legislation is unlikely to succeed without public support (Breitenmoser 1998, Ďurík 2002, Woodroffe *et al*. 2002b, see Hell and Gašparík 1999), especially when infringements are seen to go unpunished (Ďurík 2000). Unless active steps are taken to help mitigate problems resulting from the presence of carnivores, conservation advocacy risks aggravating conflicts and increasing antagonism towards wild carnivores and any associated conservation initiatives (Linnell *et al*. 2000, Hell *et al*. 2001a, Sillero in Rigg 2001a). To achieve even an uneasy tolerance, local communities must be involved (Sillero-Zubiri and Laurenson 2001). There is therefore a need to identify broadly acceptable management techniques to limit negative effects of carnivore presence on human economic activities (Linnell *et al*. 1996) while preventing the combined impacts of habitat loss and fragmentation, reduced food availability and direct persecution (see Johnson *et al*. 2001) from eradicating species in need of protection, such as the wolf, bear and lynx in Europe.

LARGE CARNIVORE PREDATION ON LIVESTOCK

One of the most serious human-carnivore conflicts in Slovakia, indeed worldwide (Sillero-Zubiri and Laurenson 2001), to the extent that commercial agriculture, unprofitable as it may be, is a barrier to carnivore conservation (Savelli *et al*. 1998), is that of livestock losses. Wolves, in particular, often feature in reports that describe and illustrate with lurid photographs instances of surplus sheep killing. Although higher than in the recent past, losses appear to be low compared to a number of other areas in Europe (Kaczensky 1996), affect a minority of farms and have an insignificant impact on the agricultural sector (Rigg and Finďo 2000). However, predation can cause significant damage to individual farms, provoking hostility, especially towards wolves. Such hostility takes a variety of forms among different social groups: farmers and shepherds resent the loss of livestock and income, hunters interpret livestock depredation along with intolerably high losses of game animals as evidence that carnivores are "over-populated", while negative media reporting adversely influences public opinion and perceptions (Rigg 2002b, Wechselberger *et al*. in prep.). Hunting advocates are exerting strong pressure to increase lethal control of carnivores. However, the historical way to resolve human-carnivore conflicts, by eliminating the carnivores, is no longer acceptable to society (Mech 1995a, 1996, Radúch 2003b), as illustrated by Slovakia's reservation from the Bern Convention, which "permits the regulation of [wolf and bear] numbers without detriment to their survival and to the functions of these species in the natural ecosystems" (Council of Europe 2002). Alternative strategies for mitigating the livestock depredation conflict are therefore needed in order to achieve the goal of maintaining viable populations of large carnivores.

Many methods have been tried throughout the world to reduce conflicts over predation on livestock without eradicating carnivores (see reviews in Cluff and Murray 1995, Dolbeer *et al*. 1996, Kaczensky 1996, Linnell *et al*. 1996, Bangs and Shivik 2001, Rigg 2001a, Sillero-Zubiri and Laurenson 2001, Fritts *et al*. 2003). "The most rational and effective approach" (Boitani 2003b:335), a 3-stage strategy involving use of preventive measures, payment of compensation for damages and elimination of problem individuals, has been implemented in Slovakia, albeit imperfectly. Traditional methods to reduce losses in Europe included guarding by shepherds and dogs (Laurans 1975, Coppinger and Coppinger 1978), confining livestock at night (Espuno 2000) or during misty weather (Zimen 1981:275), the use of *fladry* – lengths of rope with pieces of cloth hanging down that wolves are reluctant to pass (Carbyn 1977 cited in Cluff and Murray 1995, Ribeiro *et al*. 2003) and retaliatory killing (Breitenmoser *et al*. 2002). A number of carnivore conservation initiatives have sought to revive some of these techniques as well as to develop new ones, e.g. electric fences (Levin 2000, 2002), predator-proof fencing (see Linnell *et al*. 1996), simulating the presence of a resident wolf pack (Schultz *et al*. 2000), chemical repellents (reviewed in Cluff and Murray 1995), conditioned taste aversion (Gustavson *et al*. 1974, Gustavson 1982), various audio and visual repellents (Fritts 1982, Fritts *et al*. 1992 cited in Fritts *et al*. 2003, Cluff and Murray 1995, Bangs and Shivik 2001, Shivik *et al*. 2003), harassing and shooting with rubber bullets (Bangs and Shivik 2001), putting protective collars on livestock (Kaczensky 1996), live capture of predating individuals and subsequent translocation or captivity (Fritts *et al*. 1984, 1985 cited in Fritts *et al*. 2003), sterilising wolves (Cluff and Murray 1995, Mech *et al*. 1996), diversionary feeding (e.g. Bangs *et al*. 2002), limited lethal control to remove problem individuals (e.g. Bangs *et al*. 2002 but cf. Linnell *et al*. 1996, 1999) and zoning control efforts to allow carnivores in some areas but exclude them from others (Mech 1995a, Kaczensky 1996, 1999, Linnell *et al*. 1996, 2002a). Losses to predation may also be reduced by modifying other aspects of husbandry, e.g. zoning livestock into areas with few carnivores (Linnell *et al*. 1996, 2002a), avoiding high risk areas by using alternative pastures (Bangs *et al*. 2002), avoiding high risk seasons by turning stock out to graze later (Bangs *et al*. 2002) or bringing it in earlier (Sagør *et al*. 1997, Landa *et al*. 1999), removing carrion and carcasses from pastures (Robel *et al*. 1981, Paul 2000 but cf. Mech *et al*. 2000), changing the breed (Landa *et al*. 1999, Hansen *et al*. 2001) or species of livestock (Kaczensky 1996, Zimmermann *et al*. 2003), leaving some cattle with horns to defend themselves or using various other guardian animals (Marker 2000a,b), ensuring that calving/lambing occurs under controlled conditions and adjusting the season so neonates are larger when released to pasture (Fico *et al*. 1993), banning free-grazing in carnivore range and prohibiting big game fences (Palacios 2003) as well as increasing alternative food sources, such as wild ungulates (Zimen 1981, Boitani 1982, Fonseca in Tubbs 1997 but cf. Linnell *et al*. 1996).

In Slovakia, calls for hunting to be limited to removal of problem individuals, as recommended in the IUCN's Bear Status Survey and Conservation Action Plan (Hell and Finďo 1999) are strongly opposed by hunting advocates (confusingly, sometimes including the same authors, e.g. Hell 2003), who argue that it is essential to conduct population control in order to limit population growth and expansion. Rakyta (2001) went so far as to claim that "a normal, healthy population of bears" does not usually attack cattle.

PROTECTION OF LIVESTOCK AND CONSERVATION OF LARGE CARNIVORES PROJECT

In response to the carnivore-livestock conflict, the Protection of Livestock and Conservation of Large Carnivores (PLCLC) project was conceived in Slovakia in 1998 to test and implement non-lethal methods of protecting livestock (Find'o and Rigg 1998). Beginning in 2000, core funding was provided by the Born Free Foundation as part of a joint Human-Wildlife Conflict Resolution programme with the Wildlife Conservation Research Unit at Oxford University. The overall goal was to demonstrate that adequate preventive measures could reduce losses of livestock to carnivores. It was hoped that this would ease the existing anti-predator feeling of many farmers and, ultimately, reduce the need for lethal control of carnivores. The conflict appeared to involve primarily sheep in upland areas where flocks were tended by shepherds on remote pastures from spring to autumn. Losses to wolves were reported to occur during the day as well as at night. It was therefore decided to attempt to revive the traditional use of livestock guarding dogs (LGDs), which could offer farmers 24-hour protection of their flocks without the need for unfamiliar, inconvenient and expensive technology or radical changes in husbandry. Although knowledge of how to raise them for livestock protection had apparently been lost in Slovakia, suitable dogs were available locally. The project would also be building on aborted attempts in the mid 1990s to renovate the tradition (Coppinger and Coppinger 1994a,b, Bloch 1995, Bloch and Find'o 1996). A secondary anticipated outcome was that the presence of well-raised and effective guarding dogs would eliminate the need for the cruel and relatively inefficient practice of permanently chaining dogs around flocks.

STUDY OBJECTIVES AND METHODS

The present study began in January 2001 as part of the PLCLC project. It had the following main objectives:–

(1) To study the impact of native predators on domestic animals in Slovakia by
   a) quantifying the diets of bears and wolves in livestock-raising areas with high levels of reported losses;
   b) analysing the extent and patterns of reported damage by carnivores to livestock.

(2) To investigate the possibility of using livestock guarding dogs (LGDs) to protect sheep in Slovakia by
   a) conducting a literature survey on the use of LGDs throughout the world;
   b) examining the reasons why the LGD tradition had been abandoned in Slovakia;
   c) performing field trials of LGDs with livestock at working farms in order to:
      - observe the development from pups of different guarding dog breeds;
      - test their ability as yearlings to protect a flock of sheep;
      - compare the levels of losses in flocks with and without free-ranging LGDs;
      - identify any barriers to the feasibility of revitalizing the LGD tradition in Slovakia.

Chapter 2

The diets of European brown bear (*Ursus arctos*) and grey wolf (*Canis lupus*) in the Tatra and Fatra Mountains of Slovakia

Abstract: This chapter describes and quantifies the diets of brown bears (*Ursus arctos*) and grey wolves (*Canis lupus*) in north central Slovakia from an analysis of 443 scats supplemented by direct observations and examination of foraging and feeding sites. Results are presented as frequency of occurrence as well as estimates of percentage volume and original dietary content. Seasonal changes in habitat use, the degree of carnivore-human conflicts and aspects of the results pertaining to the conservation and management of large carnivores are described and discussed.

CONTENTS

INTRODUCTION

The diets of carnivores, in conjunction with their predatory habits, frequently bring them into conflicts with humans. Such conflicts have resulted in persecution by humans with an intensity that has been sufficient to cause population decline, range contraction and in some cases extinction (Reynolds and Tapper 1996, Breitenmoser 1998, Woodroffe 2001, Woodroffe *et al*. 2002a but cf. Linnell *et al*. 2001b). Persecution and excessive hunting eliminated the brown bear (*Ursus arctos*), grey wolf (*Canis lupus*) and Eurasian lynx (*Lynx lynx*) from most of Europe, including the majority of Slovakia, by the early 20th century (Breitenmoser 1998). Subsequent legal protection allowed relict large carnivore populations to recover in the Slovak Carpathians, but with their recovery came a resurgence of carnivore-human conflicts. The renewal of bear hunting in the 1960s was partly in response to damage caused by bears to beehives and livestock (Janík 1997). When, in the mid 1990s, numbers of wild ungulates fell sharply across Slovakia, many hunters and wildlife managers blamed the decline on "over-populated" wolves, although excessive hunting and poaching as well as intensified agriculture seem to have been the cause (Hell and Slamečka 1996, Hell *et al*. 1997, Stockmann and Zuskin 1998, Finďo 1998). It has been frequently argued that "over-populated" carnivores, having devastated commercially valuable game stocks, then turned to domestic animals as alternative prey (discussed in Rigg 2003b). Likewise, the incidence of human habituated and food-conditioned bears has also been partially attributed to an "over-population" of bears (e.g. Hell 2003) while the decline of the Tatra chamois (*Rupicapra rupicapa tatrica*) has been blamed on predation by wolves and lynx (Kováč 1996a,c, Ballo 2002a,b, Hlásnik 2002b, Klein 2002, Radúch 2002a,b,c, 2003a, 2004).

Wolves are at low densities in the Slovak Carpathians (Okarma *et al*. 2000, Salvatori *et al*. 2002) and hunting pressure is high (Rigg and Finďo 2000). Bears, although currently at relatively high densities (Hell 2003), are vulnerable to over-hunting due to their low reproductive rate (Swenson *et al*. 2000). As history has shown, hunting and persecution can have devastating consequences for carnivores. Restrictions on sport hunting of bears were sufficient, without any other conservation action, to allow recovery of the bear population in the Western Carpathians (Martínková and

Zahradníková 2003). Restrictions on hunting likewise allowed wolves to increase in number and expand in range (Voskár 1993). Management decisions in general and hunting regulations in particular should be based on results of sound scientific research (Ratti and Garton 1996, Strickland *et al*. 1996). According to Litvaitis *et al*. (1996), it is essential to have a thorough understanding of a species' feeding ecology before management actions are implemented. It follows that if they do not have a major impact on livestock or populations of conservation concern, such as the Tatra chamois, then predators that have been identified as requiring legal protection and/or are within protected areas should not be persecuted on the basis of the premise that they do. Conversely, if it were found to be correct, that large carnivores have become reliant on domestic animals as a major prey item, as has been alleged in Slovakia, then even benign measures such as improved non-lethal livestock protection could present a threat to their survival that would need to be considered in any conservation management strategy (Breitenmoser *et al*. 2002).

Techniques used to study the diets of Carnivora, and their limitations, have been reviewed recently (Litvaitis *et al*. 1996, Litvaitis 2000, Peterson and Ciucci 2003). In general they can be divided into three categories: 1) direct observation of foraging, hunting and feeding (e.g. Murie 1944, 1985, Schaller 1972, Sillero-Zubiri and Gottelli 1995, MacNulty and Smith 2003), sometimes using lead animals (Crisler 1958, Russell and Enns 2003); 2) feeding site surveys, including examination of prey or carrion remains (e.g. Murie 1944, Mech 1966, Green *et al*. 1997, Smith *et al*. 2003); and 3) analysis of post-ingestion samples from stomach contents (e.g. Taylor 1964, Cuesta *et al*. 1991), faeces (Murie 1944, Putman 1984, Reynolds and Aebischer 1991, Kohn and Wayne 1997) and tissue samples (e.g. Hilderbrand *et al*. 1996, 1999a,b, Jacoby *et al*. 1999). Collection of data and samples may be enhanced by the use of radio telemetry (e.g. Knight and Judd 1983, Hamer and Herrero 1987, Håkan *et al*. 2003; see also Samuel and Fuller 1996), aerial tracking (Burkholder 1959), following tracks in snow (e.g. Śmietana and Klimek 1993), employing experienced guides to follow carnivore spoor (Pole 2000) or using dogs to locate killed animals (Knarrum *et al*. 2002, Håkan *et al*. 2003) and scats (faeces) of the target species (Wasser *et al*. 1999). Marking potential prey animals with radio collars that have a mortality mode (Mysterud and Warren 1997, Knarrum *et al*. 2002) has been used to measure predation rates on livestock. Radio telemetry has also been used to estimate kill rates by wolf packs (reviewed in Peterson and Ciucci 2003). The analysis of stable-isotopes in samples of hair and bone collagen (e.g. Hilderbrand *et al*. 1996, 1999a,b, Jacoby *et al*. 1999) has allowed comparison of the relative use of different food resources among individuals and populations. Amplifying DNA from scats and hair samples can also link additional information about individuals to their diet (Kohn and Wayne 1997, Wasser *et al*. 1997, Murphy *et al*. 2002). Quantifying the selection of food items by a species, rather than its use of them, requires measurement of availability or abundance (e.g. Hamer and Herrero 1987, Balharry 1993; see also Anderson and Gutzwiller 1996, Higgins et al. 1996, Koeln *et al*. 1996). Dietary preference has been assessed by presenting different food items in a "cafeteria experiment" (Litvaitis 2000) in both wild (e.g. Sillero-Zubiri and Gottelli 1995) and captive situations (Rodgers 1990). Food availability has been experimentally manipulated on a broader scale, mostly to investigate the effect of food supply on reproduction and density (studies of terrestrial vertebrates were reviewed by Boutin 1990).

Wildlife management relating to large carnivores in Slovakia has yet to complete the transition described by Ratti and Garton (1996), from natural history observations to rigorous scientific investigations using robust research design to test specific hypotheses. Few scientific studies have been done on the diets of live, free-ranging large carnivores in Slovakia and virtually none using modern methods. Brtek and Voskár (1985, 1987) examined wolf scats collected in 1976-83. Jamnický (1988) provided a list of 96 plant species or genera fed on, or likely to be fed on, by bears in the Tatra region and described the contents of a small sample of fresh bear scats. Baláž (2002) examined a larger sample of bear scats but only partially analysed them. Kolenka (1997), Rigg and Finďo (2000), Strnádová (2000, 2002), Finďo (2002a) and Lukáč (in prep.) collaborated to study wolf diet in the period 1992-99 by scat analysis and examination of prey remains found by tracking in snow, using radio telemetry and a dog. Somora (1965) and Halák (1993) offered various observations of bear natural history which included some information on food consumed. Other authors have reported ungulate mortality apparently attributable to predation (Bališ 1969, 1970, Chudík 1974, Bališ and Chudík 1976, Kováč 1984, 1996c, 2003, Voskár 1993, Beleš 2000). Discussions of predator-prey relations tend to be based on anecdotal evidence and coloured by the strong traditions of hunting and game management (see Salvatori *et al*. 2002). This may be so even at supposedly scientific conferences, where papers have recently been accepted for publication with titles such as, "My practical experiences…" (Ballo 2002a) and, "My personal view…" (Michalík 2002). Opinions are offered with little or no credible data to substantiate them, yet in some cases have resulted in management decisions that could have serious repercussions for protected species. There is therefore considerable need for more rigorous quantitative study of carnivores and other vulnerable wildlife in Slovakia.

Direct observations are rather difficult in the Carpathians, where large carnivores are typically active at night or crepuscular periods and use forested areas less accessible to humans for cover during the day (pers. obs. 1997-2003, Find'o *et al*. unpub.). Chance observations of bears are likely to be biased towards activities most easily seen, such as visits to hunters' bait stations, crops, orchards and rubbish containers. Some data are available from stomach analysis of legally shot individuals (Škultéty 1970, Hell and Sládek 1974, Teren 1987:120 citing Soviš, Hell and Slamečka 1996). These are limited to times of year when hunting was conducted and, in cases where bait was used, the results may be biased by the bait itself (Śmietana and Klimek 1993, Litvaitis *et al*. 1996) as well as by variation among age-sex classes in the use of bait (Frković *et al*. 2001). Radio tracking would have been too expensive and time-consuming. As the primary goal was to determine the degree of feeding on livestock typically grazed on pastures from April to November, snow cover and consequently snow tracking were limited to some locations during spring and late autumn. The collection and analysis of a large sample of scats was therefore selected as the most convenient and unobtrusive method available (Litvaitis 2000), supplemented with opportunistic observations of carnivores, their feeding sites and prey remains.

In order to quantify carnivore diet by scat analysis, Murie (1944) and numerous workers after him (including the authors of all previous quantitative studies of large carnivore diets in Slovakia) calculated the frequency of occurrence of each food item expressed as a percentage of the total number of scats or of separate food items summed across all scats. However, frequency of occurrence has been found to be a poor method for establishing the relative importance of different kinds of food

(Lockie 1959) because the identifiable faecal residues may not be in the same proportions as the biomasses of foods consumed (Floyd *et al*. 1978, Hewitt and Robbins 1996). The contents of scats vary with the digestibility, size and frequency of meals (reviewed in Litvaitis *et al*. 1996, Peterson and Ciucci 2003) and possibly differential rates of decay in the field following defecation (Jamnický 1988 but cf. Reynolds and Aebischer 1991). There are also a number of methodological difficulties associated with identifying scat contents and from them deducing diet (Reynolds and Aebischer 1991). Ciucci *et al*. (1996) compared results from four methods of wolf diet analysis: percentage occurrence, percentage of total dry weight, percentage of total volume and estimated biomass consumed. The latter measure was derived by using correction factors (CFs) for differential digestibility based on feeding trials with captive animals (Floyd *et al*. 1978, Weaver 1993). The most common inconsistencies among the methods concerned smaller prey, of less importance to the present study. However, the "biomass consumed" method produced a higher estimate for the proportion of domestic ungulates in the diet of wolves. Elgmork and Kaasa (1992) and Hewitt and Robbins (1996) found that the use of CFs for brown bears increased the estimated significance of more digestible items such as ungulates, rodents and fish relative to less digestible material such as coarse vegetation, roots, forbs and graminoid foliage. The relative importance rankings of fleshy fruits and insects fell only slightly and that of seeds remained unchanged.

The aims of the present research were to:–

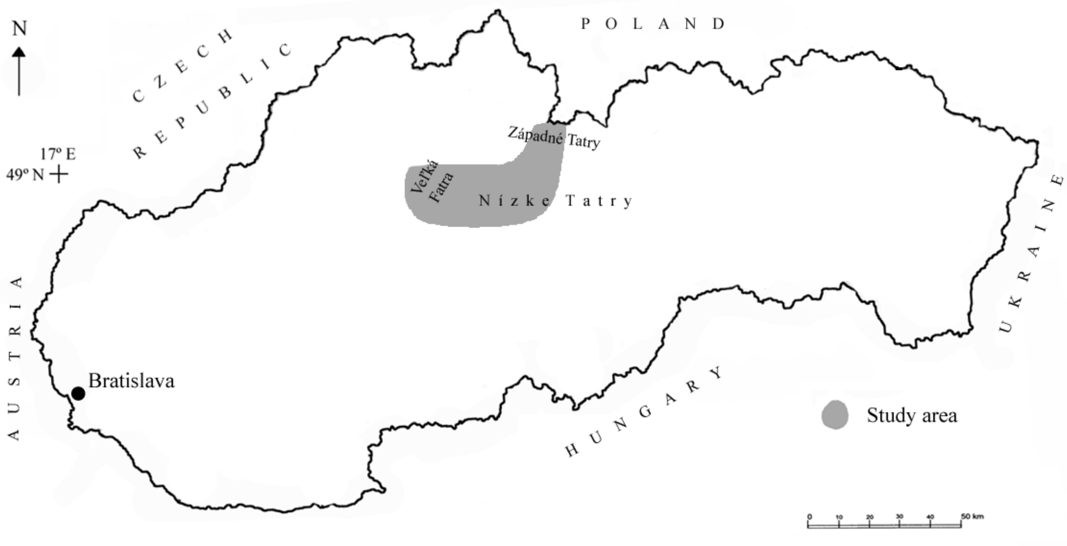
(1) Describe and quantify the diets of bears and wolves in livestock grazing areas and National Parks of northern Slovakia during the livestock grazing season.
(2) Estimate the numbers of livestock consumed by bears and wolves per year.
(3) Describe seasonal changes in food and habitat use.
(4) Examine the frequently made claim that bears and wolves are "over-populated" in Slovakia.

MATERIALS AND METHODS

Study area

The study was conducted in the Západné Tatry, Nízke Tatry, Veľká Fatra and Starohorské vrchy mountain ranges and adjacent regions of north central Slovakia (49° N, 19° E; Fig. 2.1). These areas were chosen due to the known presence of both wolves and bears in close proximity to pastures used for livestock grazing, including farms selected for trials of livestock guarding dogs (Chapter 4), with relatively high levels of reported livestock losses to predation. At the time of the study the large carnivores in each of these areas were not regarded as separate sub-populations (Swenson *et al*. 2000, Zedrosser *et al*. 2001). However, habitat considered suitable for large carnivores in Slovakia is quite fragmented (Salvatori 2003) and further development of existing transport corridors is likely to increase habitat fragmentation in the future. In particular, construction of the four-lane west-east highway D1, when completed, threatens to form a major barrier to the movements of animals between Tatranský and Nízke Tatry National Parks unless effective mitigation measures are implemented (see Adamič 1997 for the effects of highways on bears in Slovenia, Blanco and Cortes 2003 for wolves in Spain). The following ungulates occurred in all four study areas: red deer (*Cervus elaphus*), roe deer (*Capreolus capreolus*), wild boar (*Sus scrofa*) and chamois (native Tatra chamois *Rupicapra r. tatrica* in the Západné and Nízke Tatry, introduced Alpine chamois *R. r. rupicapra* in Veľká Fatra) as well as domestic cattle (*Bos taurus*) and sheep (*Ovis aries*) grazed on pastures from spring to autumn. Wolves recolonised the study area in the 1970-80s following previous extermination by hunting, trapping and poisoning (Voskár 1976, 1993, Kováč 1984, Mráz 1996a, Šimo 1996). Bears in the Western Carpathians were reduced to an isolated relict population of <50 animals in the 1930s (Feriancová 1955), but recovered following legal protection (reviewed in Martínková and Zahradníková 2003) and were present at relatively high densities in all areas of the present study.

Fig. 2.1. Location of the study area.



The majority of the fieldwork was conducted in three nearly adjoining areas. The first, in the Západné Tatry, was bounded to the south by the D1, to the west by Suchá dolina, to the north by the main ridges of the Západné Tatry and Červené vrchy and to the east by Kôprová dolina, a total area of c.400km^2. Elevation varied from 600m a.s.l. to 2,248m a.s.l. The southern part of the study area lay in the Liptov basin: relatively flat agricultural land, made up of a mosaic of pastures for cattle and sheep, arable fields (with mainly potatoes *Solanum tuberosum*, maize *Zea mays*, oats *Avena sativa* and wheat *Triticum aestivum*) and small patches of coniferous forest. There were around 15 villages in this part of Liptov, most of which had <1,000 inhabitants. At the edges of continuous forests there were large conglomerations of recreational cottages and holiday homes, several mountain hotels and some small ski slopes. An abrupt break of slope ran through the middle of the area from west to east at c.900m a.s.l. To the north of this line were the steep slopes of the Západné Tatry, where montane spruce (*Picea abies*) forests predominated; larch (*Larix decidua*) and rowan (*Sorbus aucuparia*) were common, together with arolla pine (*Pinus cembra*). The height of the upper timberline varied considerably depending upon slope, aspect, climate, hydrology and soil conditions, and in some areas had been considerably lowered in the past by shepherds and their livestock enlarging alpine meadows. Grazing above the timberline was gradually excluded from the area following the establishment of Tatranský National Park in 1948-49 (Janiga and Zámečniková 2002, Kováč 2003). In the sub-alpine zone from c.1,450-1,550m up to c.1,800m a.s.l. were dense stands of dwarf pine (*Pinus mugo*) interspersed with open meadows. Above c.1,800m a.s.l. was alpine tundra with some rocky cliffs. Extensive patches of bilberry (*Vaccinium myrtillus*) and cowberry (*V. vitis-idaea*) were found above the upper timberline as well as in more open, older forest stands and in clearings within the forest, on ridges or in valley bottoms. For much of its length the break of slope also marked the division between the core area (to the north) and buffer zone of Tatranský National Park. All the main north-south valleys in the Západné Tatry had marked tourist paths, either along asphalt roads or forest tracks, which could be quite busy during daylight hours in summer; some were used for cross-country skiing in winter. The main ridge and some lateral ridges also had hiking trails, although these were typically closed from 1st November to 15th June. Ridges without marked paths as well as valley slopes received very few visitors. Commercial forestry activities were conducted in some areas and hunting was also permitted; game management including supplementary feeding was the norm. According to Vološčuk (1999), mean annual air temperatures in Tatranský National Park varied from 5.5°C at the lowest elevations to –3.8°C on the summits of the High Tatras; mean annual precipitation likewise varied from 650 to 2,200mm and snow cover from 80 to 240 days.

The second area encompassed the central part of the Nízke Tatry Mountains, from Jasenianska dolina and Ľupčianska dolina in the west to road 72 in the east and from road 18 in the north to the villages of Mýto pod Ďumbierom, Tále, Krpáčovo and Jasenie in the south, an area of c.420km^2. Elevation varied from 500 to 2,043m a.s.l. Most work north of the main ridge was done in two substantial valleys with large areas of limestone-dolomite bedrock, Demänovská dolina and Jánska dolina, and on surrounding slopes and ridges. There was a large ski centre with several hotels in Demänovská dolina, one of the busiest areas for tourism in Nízke Tatry National Park (declared in 1978) both in winter and summer. Jánska dolina was also popular with hikers and skiers and had natural thermal springs with treatment facilities that attracted numerous visitors. Many of the surrounding valleys and ridges had marked hiking routes. Spruce forests predominated up to the natural timberline at 1,400-1,500m a.s.l., followed by a sub-alpine zone of dwarf pine up to 1,800m a.s.l., above which were alpine meadows that in the past were used for livestock grazing. The main ridge was formed of granite and showed signs of extensive re-modelling during glaciation. Two mountain lodges lay on the popular hiking and skiing route along the main ridge, one on Chopok and the other below Ďumbier, the two highest peaks in the Nízke Tatry. On the south side of the main ridge, below the alpine meadows and sub-alpine dwarf pine stands, mixed forests predominated. The main tree species were beech (*Fagus sylvatica*), spruce, fir (*Abies alba*) and maple (*Acer pseudoplanatus*). There were three developed tourism centres in this area with hotels, cottages, ski slopes and other facilities: one on the south-facing slopes of the main ridge (Trangoška-Srdiečko) and two further south (Krpáčovo and Tále). Mean annual temperatures ranged from 5.9°C in the river valley north of the mountains up to 0°C on the main ridge, where annual precipitation reached 1,400-1,500mm. Snow cover persisted at higher elevations and in north-facing basins for 180-220 days (Vološčuk 1999). Several herds of cattle and flocks of sheep were grazed in the mountains during the summer and substantially more livestock were found in the northern and south-western parts of the study area, lying outside the National Park and consisting of rolling hills with pastures and arable land. Hunting and game management, including supplementary feeding, were common. Some forests were commercially managed for timber extraction.

The third main area of work included c.300km^2 of the Veľká Fatra and Starohorské vrchy mountain ranges up to the western edge of the Nízke Tatry, bounded to the south by roads 577, 59 and 66, extending east as far as Nemecká. The north-east limit of the study area was taken to be the red marked hiking trail running from Veľká Chochuľa along Kozí chrbát to Zvolen, Krížna and as far north as Jarabiná. The north-western limit was set by Sklabinský potok and road 65. Elevation varied from 400m a.s.l. in the flood plains to the south-east and north-west, up to 1,592m a.s.l. in Veľká Fatra and 1,753m a.s.l. on Veľká Chochuľa peak. The majority of the area was mountainous terrain with mixed beech-spruce-fir forests predominating, many of them commercially managed. Limestone-dolomite formed the bedrock to a large extent, into which long, steep-sided valleys had been cut. Hiking and hunting were widespread. Cattle and sheep were grazed in the foothills and flood plains to the north-west and south-east, as well as on pastures cleared within the forest and on alpine meadows in Veľká Fatra. Agricultural land in the north-west of the study area was also used for growing crops, particularly maize. Veľká Fatra National Park was declared in 2002.

Collection and storage of scats and recording signs

Beginning in March 2001 the study area was investigated for signs of bear and wolf activity. Initial trial surveys were made in localities that, based on topography and vegetation, seemed likely to support large carnivores. Areas where faeces, tracks or other indications of wolf and bear presence were found were re-visited regularly until November 2003. Systematic surveying, for scats and signs, at fixed intervals was not possible due to unequal funding levels and study emphasis during the course of the project. Mountainous terrain and uneven accessibility made a random sampling design unfeasible (Mace and Jonkel 1986) and in any case scats were rarely found away from paths unless carnivore signs could be followed. Most collecting therefore occurred whilst walking along roads, tracks, paths and ridges. Sometimes in summer it was possible to track bears through vegetation and thus discover foraging sites and scats. Usually scats were collected individually as encountered. If several were found at the same site, a maximum of five scats were collected or, in rare cases when >c.30 bear scats were found at the same site, up to a maximum of seven. In the few cases where very many more were found (at hunters' ungulate feeding stations in late autumn), all scats were cursorily examined in the field, an apparently representative sample was collected and those not collected were scored for predominant content as judged by eye (after Murie 1944, 1985). The age classes (cub, sub-adult, adult) of bears leaving prints were estimated by measuring clear prints to ±0.5cm and using the regression equations of Hell and Sládek (1994; see also Kassa 1998b).

An attempt was made to collect a substantial number of scats from a variety of habitats across a wide geographic area in spring, summer and autumn of three different years. Collection was greatly facilitated by the opportunity to work off marked tourist routes in the National Parks, permission for which was obtained from September 2001 to May 2003. Most effort in searching for scats was concentrated in months when livestock were grazed on pastures and were therefore most vulnerable to predation (April-November), although the few scats found in March 2002 and 2003 were included in order to present a more complete account of diet throughout bears' active period. Halák (1993) reported that the last signs he observed of bear activity in the Západné Tatry during the years 1977-86 ranged from 4th November to

31st December and first signs of activity in spring ranged from 15th February to 11th April.

Home ranges from tens to hundreds of km^2 and occasional daily movements >20km have been recorded by radio telemetry studies of European brown bears (e.g. Clevenger et al. 1990, Roth and Huber 1996, Nygård et al. 2002). Home ranges of similar sizes or larger and mean daily movements of c.22-28 km have been reported for European wolves (e.g. Bloch 1995, Ciucci *et al*. 1997, Kusak and Huber 2000, Okarma *et al*. 1998, Jedrzejewski *et al*. 2001, Promberger *et al*. in litt., Finďo *et al*. unpub.; see review in Mech and Boitani 2003a). All scats were collected <15km and most of them <8km from livestock, which was therefore considered to have been potentially available to all carnivores that contributed scats to the sample.

Scats were identified to species on the basis of their size, shape, content and odour (Litvaitis *et al*. 1996) using personal observations and field guides (Kaczensky *et al*. 1999a,b, Bang and Dahlstrøm 2001); any of uncertain origin were excluded from the analysis. When a wolf or bear scat was identified, all that could be easily picked off the substrate was placed in a plastic bag and labelled with the location and date of collection. Location and elevation were determined by reference to topographic maps (1:50,000 or 1:25,000) and a handheld Global Positioning System (Garmin GPS 12, accuracy ±5-25 m). Where there were >5 scats at the same location, some were left in situ to observe as they deteriorated (Graber and White 1983). Scats tended to be washed away by heavy rain, dried out in the sun, were broken up by dung beetles (Order Coleoptera, Family Scarabaedidae), trampled by hikers or run over by vehicles, so they would have been unlikely to survive in the field for long periods. Occasionally, however, some scats were found in spring that had been deposited in autumn and preserved under snow; in general these were easily recognisable and were not collected (Mace and Jonkel 1986). Those clearly breaking up due to weathering or insect attack were also not collected (Reynolds and Aebischer 1991) and neither were those for which the month of defecation could not be judged with confidence. Scats were stored by freezing at between –15 and –20˚C as soon as possible after collection, which was usually on the same day but for a small number of scats found during fieldwork in remoter locations this was not possible until up to four days after collection.

Analysis of scats

Scats were removed from the freezer 12-48 hours prior to analysis and, once thawed, were investigated for dietary content following standard techniques (reviewed in Korschgen 1969, 1980, Litvaitis *et al*. 1996, Litvaitis 2000). Each scat was broken open manually in a bucket of water, with detergent added to those consisting mainly of hair and bone (Śmietana and Klimek 1993). It was then washed with tap water for several minutes through two sieves with 2.0mm and 1.0mm meshes. The material remaining on both sieves was spread out in clear water in a light-coloured 50x40x6cm plastic tray and dispersed with forceps to ensure that the whole scat was examined (Spaulding *et al*. 2000). Many scats were contaminated with live ants, dung beetles, maggots (*Musca* spp.) and other invertebrates. These were distinguishable from consumed specimens because usually many of them had emerged from the faecal material between collection and freezing and accumulated on the inside surface of the collection bag. They were discarded, as were any leaves, twigs and stones picked up with the sample. All the remaining material, whether floating on the water surface (as was usual for insects and hairs) or settled on the bottom of the tray, was then examined thoroughly for identifiable items.

The various items in each scat were identified at two levels of resolution (Mace and Jonkel 1986). Initially scat contents were placed in one of 10 broad categories: hard mast; fruit (termed "soft mast" in many studies); grasses/sedges (Gramineae and Cyperaceae, "graminoids"); other foliage ("forbs" or "herbage", leaves, buds and reproductive parts of trees); cultivated grains; large mammals; other vertebrates (small mammals, amphibians and birds); invertebrates; refuse; wood/bark. Recognisable genera and species were then listed individually. Mast, fruit, some forbs and cultivated grains were identified by comparison with field guides (Mihál *et al*. 1988, Grey-Wilson and Blamey 1995, Grau *et al*. 1996) and a reference collection from the study area. Mammalian hair was identified by examination of the medulla and cuticular surface structure under a 10x20 power stereoscopic microscope (Olympus BX40) enhanced using MicroImage software version 4.0 in comparison with a reference collection and the keys and atlases of Dziurdzik (1973) and Teerink (1991). The presence of bones and hooves or claws in many scats aided identification by comparison to reference material. Invertebrates were readily distinguishable macroscopically as wasps, ants, bees or other. The percentage volume of each item in a scat was estimated by eye to ±10% (e.g. Jamnický 1988, Clevenger *et al*. 1992, Baláž 2002). The total volume of each scat was measured to ±20ml by water displacement in a graduated cylinder after first squeezing out any excess water (Hewitt and Robbins 1996, Sato *et al*. 2000). Sub-samples of some scats were analysed for parasites at the University of Veterinary Medicine in Košice (Goldová *et al*. in press).

Analysis of diet

Only scats examined in the laboratory were included in the quantitative analyses of diets, a total of 373 bear scats and 70 wolf scats collected from April 2001 to November 2003. They were categorised by the month of defecation, aided by field observations of the appearance of scats of known ages (e.g. those found within various periods of time after particular locations had been cleared of scats) and their rates of decomposition, taking recent weather into account. Variation in decomposition rates of undigested items in scats (Jamnický 1988) as well as the site of defecation (degree of exposure to sun, amount of rainfall, vegetation growth, etc.) precluded more precise determination of scat age (Giannakos 1997). Only a small number of bear scats were collected from March (n=4) and so these were pooled with those from April. Scats were then divided into three seasons based on typical plant phenology across the study area, although there was considerable variation among localities due to altitude, aspect and landscape features: spring (March-May), summer (June-August) and autumn (September-November).

Several different sets of calculations were made to refine the analysis and, due to the lack of a standardised methodology for analysing diet based on the contents of scats (Sato *et al*. 2000), to allow comparison with various other studies. Firstly, the frequency of occurrence (%F) was calculated by dividing the number of scats in which a particular item occurred (Murie 1944, 1985) by the total number of scats in the sample and multiplying by 100, giving a simple measure of presence/absence.

$$\%F = \frac{\text{Number of scats in which item occurs}}{\text{Number of scats in the sample}} \times 100$$

For wolf scats, the relative frequency of occurrence (rel.%F) was calculated by dividing the number of scats in which an item occurred by the number of occurrences of all items in all scats in the sample and multiplying by 100 (Murie 1944, Elgmork and Kaasa 1992, Strnadová 2000). This method is a crude estimate of the relative frequency with which different items are consumed. It does not make allowance for variability in the size of food items, their digestibility or quantities consumed and therefore tends to over-estimate the significance of uncommon food items (Weaver and Hoffman 1979, Śmietana and Klimek 1993). This method was not used for bear scats due to the disparate taxonomic levels to which items in scats could be identified.

$$\text{rel.\%F} = \frac{\text{Number of scats in which the item occurs}}{\text{Number of item occurrences in all scats}} \times 100$$

The mean percentage volume (*m*%V) was calculated by first visually estimating the relative volumes of food items in scats containing >1 item (71.0% of bear scats, 5.7% of wolf scats) expressed as fractions to ±0.1, the sum of which was always 1.0 for each scat. The numbers of whole scats and fractions of scats in which an item occurred were then summed, the total divided by the number of scats in the sample and multiplied by 100 (Murie 1944, 1985, Weaver and Hoffman 1979, Jamnický 1988, Clevenger *et al*. 1992, Śmietana and Klimek 1993, Baláž 2002). This "aggregate percentage" (Litvaitis *et al*. 1996) gives equal importance to each scat regardless of its size.

$$m\text{\%V} = \frac{\Sigma\ \text{(visually estimated fraction of scat)}}{\text{Number of scats in the sample}} \times 100$$

The volume of an item in each bear scat was estimated by multiplying its visually estimated percentage volume by the measured volume of the scat. The percentage of total volume (%V) was then derived by summing the estimated volumes of the item in all scats, dividing by the total measured volume of all scats combined and multiplying by 100 (e.g. Mace and Jonkel 1983, Elgmork and Kaasa 1992, McLellan and Hovey 1995). This "aggregate volume" gives importance to the absolute volume of each item in all scats combined (Swanson and Bartonek 1970 cited in Litvaitis *et* *al*. 1996), rather than weighting the importance of individual scats equally. Unlike in Elgmork and Kaasa's 1992 study in Norway, bear scat volume was found to vary considerably (range 20-1,340ml, mean=253.2ml).

$$\%V = \frac{\Sigma\text{ (visually estimated fraction of scat x measured scat volume)}}{\Sigma\text{ (measured scat volume)}} \times 100$$

As the relative proportions of items in scats often do not reflect those of the items consumed (Lockie 1959, Floyd *et al*. 1978, Putman 1984, Litvaitis *et al*. 1996, Litvaitis 2000, Peterson and Ciucci 2003), correction factors (CFs) developed for the brown (grizzly) bear by Hewitt and Robbins (1996) were used to derive estimates of dry matter ingested by multiplying the estimate of %V for each item by the respective CF as follows: graminoid and other foliage (forbs) = 0.3; fleshy fruits including berries = 0.9; invertebrates = 1.1; hard mast including cultivated grains = 1.5; large mammals = 2.0; other vertebrates (small mammals, amphibians and birds) = 4.0. An arbitrary CF of 1.0 was used for refuse. Unidentified vertebrates were treated as large mammals. Each of the estimates of dry weight ingested was then divided by the sum of such estimates for all items and multiplied by 100 to obtain an estimate of percentage of dry matter (%D) contributed by each item to the total diet.

$$\%D = \frac{\%V\text{ of item x respective CR}}{\Sigma_{\text{all items}}\ (\%V\text{ x CR})} \times 100$$

For wolves, *m*%V was converted into an estimate of biomass consumed (%B) using the experimentally derived regression equations of Floyd *et al*. (1978) and procedures described by Śmietana and Klimek (1993). Macroscopic examination of bone and hoof material in wolf scats was used to classify cervid remains as either adult (>1 year old) or juvenile (<1 year old). It was assumed that the ratio of juveniles to adults was the same for remains that could not be classified (56.5%) as for those that could. Mean body masses of prey species were taken from Śmietana and Klimek (1993), except for wild boar and carnivores. Strnádová (2000) reported that wild boar preyed on by wolves in eastern Slovakia in the 1990s were typically 30-50kg; 40kg was therefore used as a mean body mass. The respective figure of 6kg for the fox (*Vuples vulpes*) was taken from the lower end of the range for adults given by Hell and Garaj (2002). A mean of 12kg was given by Macdonald and Barrett (1993) for badgers (*Meles meles*) in autumn. As hairs of red deer and roe deer could not be differentiated in most cases (Dziurdzik 1973), the remains of these two species were assumed to have been in the ratio of 3.2:1 as found in wolf scats from south-east Poland (Śmietana and Klimek 1993). The ratio of male:female red deer was taken from the same source. Previous studies in Slovakia have suggested that red deer is preyed on considerably more frequently than roe deer in the Tatra Mountains (Voskár 1993, Rigg and Finďo 2000, Strnádová 2000, 2002, Finďo *et al*. unpub.). Refuse, grass and unidentified items were excluded from this calculation.

$\%B = m\%V(0.02x + 0.38)$ *where* x *is the mean body mass of the prey item in kg*

Both the microscopic fraction of scats and any non-food components (pieces of wood and bark in bear scats, grass in wolf scats) were excluded from the analyses of dry matter or biomass ingested whereas non-food items were included in the frequency of occurrence data (see Reynolds and Aebischer 1991). Dry conifer needles occurring in bear scats with ants and apparently constituting nest material were not included in the diet analysis (Jamnický 1988). When estimating the mean percentage volume of items in bear scats, fruit and leaves or stems of the same species were combined and various other categories were amalgamated to allow comparison with previous studies in Slovakia (Jamnický 1988, Baláž 2002). However, fruit and foliage of the same species were treated separately for the estimates of frequency of occurrence (%F) and percentage of total volume (%V) so that the appropriate correction factors could be used to estimate percentages of dry matter ingested (%D).

RESULTS

Bears

Summary of diet and main food items

The distributions by study area and season of the 373 bear scats collected in 2001-03 and included in the diet analysis are shown in Table 2.1. A total of 40 different items at various taxonomic levels were identified in their contents. In the analysis of diet 10 main categories with various sub-divisions, a total of 32 separate items, were used to derive frequency of occurrence, percentage of total volume and percentage of dry matter ingested (Table 2.2).

Table 2.1. Sample of scats included in the analysis of bear diet according to year, season and area collected (ZT = Západné Tatry; NT = Nízke Tatry; VF-SV = Veľká Fatra and Starohorské vrchy).

	2001 *n* = 103			2002 *n* = 136			2003 *n* = 134			
Season	ZT	NT	VF-SV	ZT	NT	VF-SV	ZT	NT	VF-SV	Combined
Spring	5	16	2	9	30	1	11	11		85
Summer		15	18	4	48	5	33	19	2	144
Autumn	6	35	6	22	9	8	26	32		144
Total	11	66	26	35	87	14	70	62	2	373

Animal material comprised 7.5% of total scat volume and 14.7% of estimated dry matter ingested. No domesticated vertebrates were identified in any of the 373 bear scats analysed. Eight scats (%F=2.1%, %V=0.2%) contained remains of unknown vertebrates, typically small pieces of bone in spring scats. These are listed as unidentified large mammals in Tables 2.2 and 2.3 to indicate the maximum possible representation of ungulates in the sample, although the material may also have derived from other kinds of vertebrates and some was probably consumed as refuse. Cervidae were the most frequently identified vertebrates (%F=4.8%, %V=1.5%). Juvenile cervids (*n*=2) and wild boar (*n*=1) were identified in three scats from May-July. Bear hairs were found in two spring scats and two autumn scats (%F=1.1%, %V=0.1%), in one case comprising 100% of the scat. According to all four measures of diet used, invertebrates occurred significantly more frequently in scats (%F=26.8% versus %F=9.1%, χ^2=39.63, d.f.=1, P<0.001) and in greater quantities (%V=5.0% versus %V=2.2%, Wilcoxon's signed ranks test, P<0.001) than large mammals. Wasps and ants were the most important groups of invertebrates, occurring in 10.7% and 12.6% of scats respectively and comprising 2.6% and 2.0% of total scat volume. Adults as well as eggs and larvae were consumed. Bees comprised a trivial portion of diet (%F=1.1%, %V=0.1%). As expected, the use of correction factors to derive the percentage of dry matter ingested increased the estimated proportion of ungulates in the diet, but only to 5.8%. The significance of invertebrates in the diet also increased, to %D=7.2%. Rodents, amphibians and birds together constituted 1.7% of dry matter ingested (%F=1.6%, %V=0.3%).

Table 2.2. Seasonal and total frequency of occurrence (%F), percentage of total scat volume (%V) and estimated percentage of dry matter ingested (%D) of items identified in European brown bear scats from the Western Carpathian Mountains of north central Slovakia, spring-autumn 2001-03.

	Spring n = 85			Summer n = 144			Autumn n = 144			Total n = 373		
Item	%F	%V	%D	%F	%V	%D	%F	%V	%D	%F	%V	%D
Hard mast	**2.4**	**0.4**	**0.9**	**6.3**	**0.8**	**2.0**	**16.7**	**4.1**	**6.2**	**9.4**	**2.0**	**3.9**
Pinus cembra				0.7	0.1	0.2	4.2	2.1	3.1	1.9	0.8	1.6
Fagus sylvatica	1.2	0.3	0.8	2.8	0.6	1.4	6.3	1.1	1.7	3.8	0.7	1.4
Other	1.2	0.0	0.0	3.5	0.2	0.4	7.6	1.0	1.4	4.6	0.5	0.9
Fruit	**21.2**	**14.4**	**20.8**	**47.2**	**27.9**	**40.2**	**63.2**	**33.9**	**30.3**	**47.5**	**27.4**	**32.0**
Rubus idaeus				14.6	11.5	16.6	11.1	3.7	3.3	9.9	6.1	7.1
V. vitis-idaea				4.2	0.3	0.4	15.3	2.1	1.9	7.5	0.9	1.1
V. myrtillus				27.8	13.2	19.1	26.4	7.4	6.6	20.9	8.2	9.6
Malus spp.	4.7	0.8	1.1	5.6	1.9	2.7	17.4	14.0	12.6	9.9	6.4	7.4
Prunus domestica				0.7	0.0	0.0	2.1	0.3	0.3	1.1	0.1	0.1
Prunus spinosa	7.1	4.9	7.1							1.6	1.0	1.2
Sorbus aucuparia				2.1	0.3	0.4	12.5	2.4	2.2	5.6	1.0	1.2
Rosa canina	17.6	8.4	12.2	0.7	0.1	0.2	4.9	1.2	1.1	6.2	2.3	2.6
Other	2.4	0.3	0.4	3.5	0.6	0.8	9.0	2.8	2.5	5.4	1.4	1.6
Grasses/sedges	**58.8**	**51.5**	**24.8**	**52.1**	**32.7**	**15.7**	**22.9**	**7.5**	**2.2**	**42.4**	**26.8**	**10.4**
Other foliage †	**27.1**	**16.1**	**7.7**	**66.7**	**25.2**	**12.1**	**49.3**	**15.0**	**4.5**	**50.9**	**19.3**	**7.5**
Cultivated grains	**23.5**	**9.8**	**23.6**	**6.3**	**2.7**	**6.4**	**31.3**	**31.5**	**47.0**	**19.8**	**15.3**	**29.7**
Zea mays	16.5	3.1	7.4	3.5	1.6	3.9	11.8	7.5	11.1	9.7	4.2	8.1
Avena sativa	7.1	5.0	11.9	2.8	1.1	2.5	23.6	22.8	34.0	11.8	10.3	20.0
Other	4.7	1.8	4.3				4.2	1.2	1.8	2.7	0.8	1.6
Large mammals	**18.8**	**2.2**	**7.2**	**6.9**	**3.1**	**10.0**	**5.6**	**1.3**	**2.5**	**9.1**	**2.2**	**5.8**
Ovis aries										0	0	0
Bos taurus										0	0	0
Cervidae	7.1	1.2	3.7	4.9	2.0	6.3	3.5	1.1	2.2	4.8	1.5	3.8
Sus scrofa	3.5	0.3	1.0	0.7	0.9	2.9				1.1	0.4	1.1
Ursus arctos	2.4	0.4	1.4				2.4	0.1	0.2	1.1	0.1	0.4
unidentified*	5.9	0.3	1.1	1.4	0.4	0.2	0.8	0.0	0.1	2.1	0.2	0.5
Other vertebrates	**1.2**	**1.2**	**7.7**	**1.4**	**0.1**	**0.7**	**2.1**	**0.1**	**0.4**	**1.6**	**0.3**	**1.7**
Rodents							1.4	0.1	0.4	0.5	0.0	0.2
Amphibians	1.2	1.2	7.7							0.3	0.2	1.3
Birds				1.3	0.1	0.7	0.7	0.0	0.0	0.8	0.0	0.2
Invertebrates	**10.6**	**1.3**	**2.3**	**36.8**	**6.3**	**11.1**	**26.4**	**5.7**	**6.3**	**26.8**	**5.0**	**7.2**
Formicoidea	4.7	0.7	1.3	23.6	3.7	6.4	6.3	0.9	1.0	12.6	2.0	2.8
Vespidae				8.3	2.0	3.5	19.4	4.6	5.0	10.7	2.6	3.7
Apidae	1.2	0.2	0.3	1.4	0.3	0.5	0.7	0.0	0.0	1.1	0.1	0.2
Other	5.9	0.4	0.7	7.6	0.4	0.6	5.6	0.2	0.2	6.4	0.3	0.4
Refuse	**15.3**	**3.1**	**5.0**	**6.3**	**1.1**	**1.8**	**3.5**	**0.7**	**0.7**	**7.2**	**1.4**	**1.8**
Wood and bark			**-**	**1.4**	**0.0**	**-**	**3.5**	**0.1**	**-**	**1.9**	**0.1**	**-**

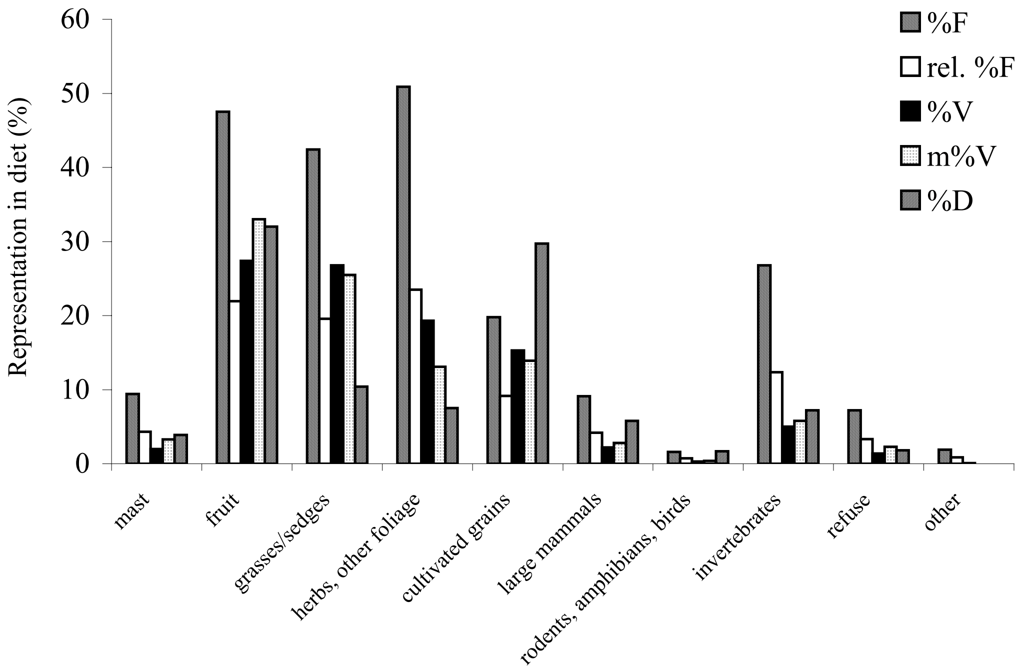
(* unidentified vertebrates; † includes buds and reproductive parts of deciduous trees.)

Plant material constituted 90.8% of total scat volume and 83.5% of estimated dry matter ingested. Grasses/sedges (FO=42.4%, %V=26.8%) and herbaceous plants plus tree foliage/buds (FO=50.9%, %V=19.3%) were the most frequently occurring items in scats. However, their dietary significance was greatly reduced when correction factors were applied, to 10.4% and 7.5% respectively of dry matter ingested. In terms of total volume and estimated dry matter ingested, fruits were the most important food category (%V=27.4%, %D=32.0%). Bilberries, apples (*Malus* spp.) and raspberries (*Rubus idaeus*) were the most frequently consumed species. Cultivated grains, mainly oats and maize, were only the fifth most commonly occurring of the 10 main categories, but after the application of correction factors were found to be the second most significant dietary category (%D=29.7%). Grains were consumed by bears both as unharvested crops and at hunters' feeding stations. Hard mast, primarily of arolla pine and beech, occurred in 9.4% of scats (mostly from 2003) and comprised 2.0% of total scat volume and 3.9% of dry matter ingested.

A number of items were found rarely. Remains of birds occurred in three scats (from June, August and October), rodents in two (September) and earthworms in two (May and July). The following were each found in only one scat: frogs' eggs (May), a snail (June), slugs (June) and a caterpillar (September). Besides plant and animal material, other food and non-food items were identified. Refuse, usually plastic or foil food wrapping but also eggshells, onion and potato peel as well as sanitary pads or tampons, occasionally cigarette filters and probably some bone fragments, occurred in ≥ 7.2% of scats (%V ≥ 1.4%, %D ≥ 1.8%). Evidence of bears foraging for refuse was most often found around tourist facilities in Demänovská dolina and in the area of Tále, Trangoška, Srdiečko and chata pod Ďumbierom. Track measurements (width of front foot 9-12cm) and opportunistic observations of bears (Table 2.4) suggested that sub-adults and/or females were involved. Pieces of wood or bark were found in seven scats (%F=1.9%, %V=0.1%), most of which also contained insects. Assuming that all apples in scats were from hunters' feeding stations or orchards and that all bees were domesticated, all anthropogenic food items combined amounted to ≥ 23.3% of total scat volume and ≥ 39.2% of dry matter ingested.

In order to allow direct comparison with the two previous quantitative studies of bear diet in Slovakia, eight main categories plus various sub-divisions, a total of 28 separate items, were used to derive mean percentage volumes (Table 2.3). According to this measure, green vegetation (grasses/sedges, herbs and tree leaves/buds) was the most important main category (*m*%V=38.7), followed by fruits (*m*%V=33.0). Using this measure the apparent significance of large mammals (2.8%) and cultivated grains (13.9%) was much lower compared to the percentage of dry matter ingested method, that of green vegetation was more than double and those of hard mast and invertebrates were similar. The mean percentage volume of refuse was 2.3%, that of all anthropogenic food items combined was $\geq 21.0\%$. The differences in results among the different methods used to analyse brown bear diet are shown in Fig. 2.2.

Fig. 2.2. Comparison of five methods used to analyse the diet of brown bears in north central Slovakia in 2001-03: frequency of occurrence in scats (%F), relative frequency of occurrence in scats (rel.%F = $\%F/\Sigma_{\text{all items}}(\%F)x100$), percentage of total scat volume (%V), mean percentage volume in scats (*m*%V) and estimated percentage of dry matter ingested (%D).



Seasonal changes in diet and habitat use

Considerable variation in bear diet was found among months. Seasonal changes in the estimated percentage of dry matter consumed and mean percentage volumes of the main food categories identified in the sample of scats are illustrated in Figs. 2.3 and 2.4 respectively.

Table 2.3. Sum of fractions of scats (no.) in which items were found and the mean percentage volume (*m*%V) of items found in brown bear scats. (* unidentified vertebrates)

	Item	March-April *n* = 30		May *n* = 55		June *n* = 52		July *n* = 41		August *n* = 51		September *n* = 73		October *n* = 46		November *n* = 25		Total *n* = 373	
		no.	*m*%V	no.	*m*%V	no.	*m*%V	no.	*m*%V	no.	*m*%V	no.	*m*%V	no.	*m*%V	no.	*m*%V	no.	*m*%V
Mast	*Pinus cembra*									0.2	0.4			1.0	2.2	5.0	20.0	6.2	**1.7**
	Fagus sylvatica			0.3	0.5			0.1	0.2	0.4	0.8	1.0	1.3	0.2	0.4	2.0	8.0	3.9	**1.1**
	other			0.1	0.1	0.1	0.1			0.4	0.8	1.1	1.5	0.1	0.2	0.2	0.6	1.9	**0.5**
Fruits	*Rubus idaeus*							5.5	13.4	9.4	18.3	5.4	7.4	1.7	3.7			21.9	**5.9**
	Vaccinium vitis-idaea					0.8	1.6	0.7	1.7	0.5	1.0	1.3	1.8	3.5	7.5	2.5	10.0	9.3	**2.5**
	Vaccinium myrtillus							12.2	29.8	16.1	31.6	13.4	18.3	9.9	21.5	0.8	3.2	52.4	**14.0**
	Malus spp.	1.1	3.7							2.1	4.0	5.1	7.0	4.7	10.2	1.8	7.0	14.7	**3.9**
	Prunus domestica									0.1	0.2	0.3	0.4	0.2	0.4			0.6	**0.2**
	Prunus spinosa	2.8	9.3	0.1	0.2													2.9	**0.8**
	Sorbus aucuparia									0.7	1.4	2.3	3.1	1.7	3.7			4.7	**1.3**
	Rosa canina	2.8	9.4	6.7	12.1					0.2	0.4	0.7	0.9	0.8	1.7	0.1	0.4	11.2	**3.0**
	other	0.2	0.5							1.0	2.0	1.9	2.6	2.1	4.5			5.1	**1.4**
Green vegetation		10.9	36.2	35.5	64.5	45.7	87.8	14.8	36.1	11.2	21.9	18.9	25.8	7.4	16.1	0.2	0.8	144.4	**38.7**
Grains	*Zea mays*	2.0	6.5	3.4	6.2			0.6	1.3	1.4	2.6	4.8	6.5	1.0	2.2	4.8	19.1	17.8	**4.8**
	Avena sativa	2.5	8.3	1.0	1.8			2.0	4.9	1.0	2.0	4.8	6.5	8.7	18.8	7.4	29.5	27.3	**7.3**
	other	0.8	2.7	1.3	2.4					0.3	0.6	4.3	5.8					6.7	**1.8**
Large mammals	*Ovis aries*																	0	**0**
	Bos taurus																	0	**0**
	Cervidae	1.3	4.3	1.1	2.0	1.5	2.8			0.9	1.8	0.2	0.2	1.0	2.2			5.9	**1.6**
	Sus scrofa	0.4	1.0	0.2	0.4			0.7	1.7									1.3	**0.3**
	Ursus arctos	1.0	3.3	0.1	0.2							0.5	0.6					1.6	**0.4**
	unidentified*	0.2	0.7	0.6	1.0	0.1	0.2			0.9	1.8					0.1	0.2	1.8	**0.5**
Rodents, amphibians, birds				1.0	1.8	0.1	0.1			0.1	0.1	0.5	0.6	0.1	0.1			1.6	**0.4**
Inverteb.	Formicoidea	0.1	0.3	0.8	1.4	2.3	4.5	3.5	8.4	0.5	1.0	1.4	1.9	0.1	0.1			8.6	**2.3**
	Vespidae							0.1	0.1	2.5	4.8	4.9	6.8	1.4	2.9			8.8	**2.4**
	Apidae			1.0	1.8	0.8	1.5	0.6	1.5			0.1	0.1					2.5	**0.7**
	other			0.3	0.5	0.5	0.9	0.2	0.5			0.3	0.5			0.3	1.2	1.5	**0.4**
Refuse		4.0	13.5	1.8	3.3	0.3	0.5	0.1	0.3	1.3	2.5	0.3	0.4	0.7	1.5			8.5	**2.3**

Fig. 2.3. Seasonal changes in the estimated percentage of dry matter ingested of food categories identified in 373 brown bear scats collected in north central Slovakia in 2001-03.

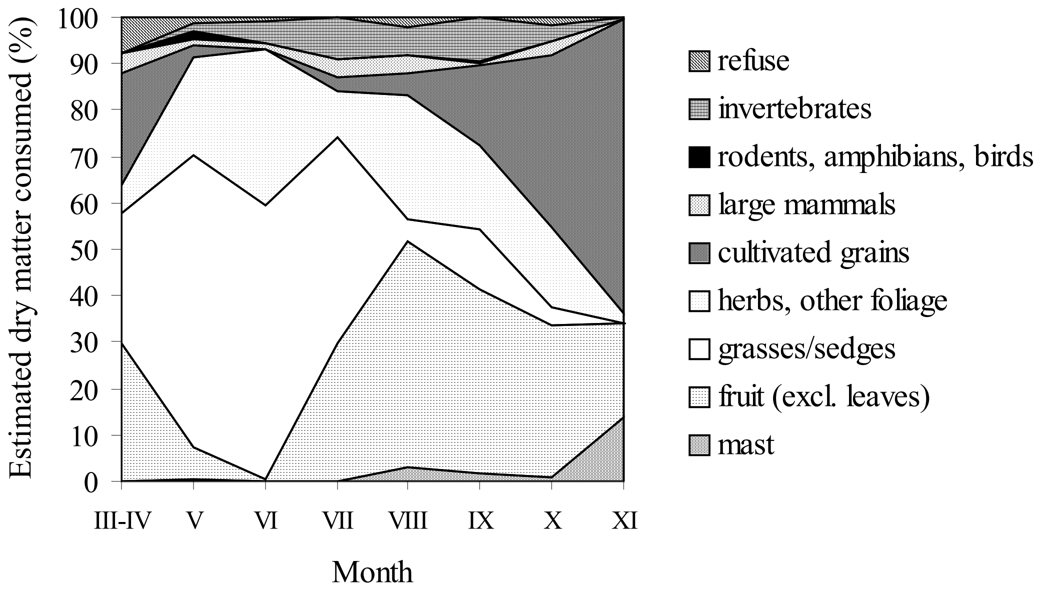
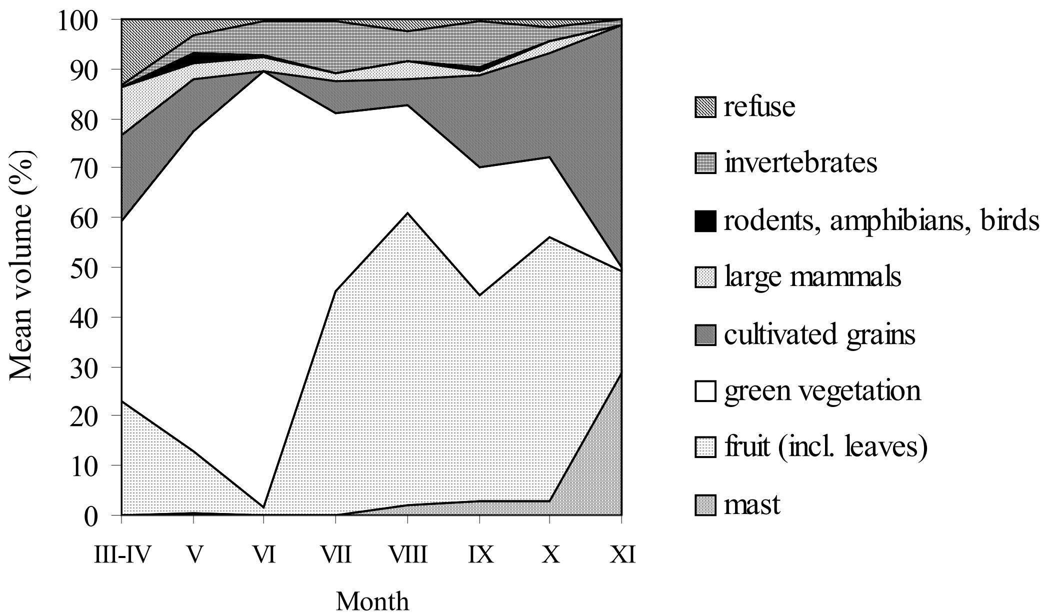


Fig. 2.4. Seasonal changes in the mean percentage volume in scats of food categories identified in 373 brown bear scats collected in north central Slovakia in 2001-03.



Spring

The earliest signs of bear activity noted after winter were judged to be those of a sub-adult attracted to a hunters' feeding station at c.810m a.s.l. in the Západné Tatry on 2/2/03. The earliest date that tracks of a female with cubs-of-the-year were seen was on 30/3/02 at c.1,200m a.s.l. in the Nízke Tatry. Fresh tracks on snow of a lone cub were seen in dense spruce forest at c.1,200m a.s.l. in the Západné Tatry on 5/4/01. Tracks judged to be those of a female with a yearling cub were seen on 31/3/02, apparently in the vicinity of a den among rocks at c.1,400m a.s.l. on a steep eastern-facing slope in the Západné Tatry. No evidence of feeding or foraging was associated with any of these tracks besides those of the sub-adult. The earliest date that a scat was collected was on 21/3/03 near a hunters' feeding station in the Západné Tatry. The other three March scats collected contained apples (2 scats), oats (1), maize (1), wild boar (1), unidentified vertebrate (1), rose hips (1) and refuse (1).

Overall, the most frequently occurring categories in spring were grasses/sedges (%F=58.8%, %V=51.5%) and herbs/other vegetation (%F=27.1%, %V=16.1%). However, their significance as a percentage of estimated dry matter ingested was much lower (24.8% and 7.7% respectively). Besides graminoids, fruits remaining from the previous year were important spring food items, particularly rose hips (%V=8.4%, %D=12.2%) and sloes (%V=4.9%, %D=7.1%). Cultivated grains from hunters' feeding stations were also a major dietary component (%V=9.8%, %D=23.6%). Refuse was significantly more frequently consumed in spring than in any other season (chi-square test of association using actual frequencies of occurrence, χ^2=11.47, d.f.=2, P=0.003), while invertebrates (χ^2=18.74, d.f.=2, P<0.001), rodents and birds (none found in spring scats) as well as hard mast (χ^2=15.59, d.f.=2, P<0.001) were least often fed on during this season. Remains of large mammals were found in 18.8% of spring scats. They comprised only 2.2% of total spring scat volume but 7.2% of estimated dry matter ingested. All anthropogenic items combined accounted for ≥ 13.9% of total scat volume and ≥ 30.0% of dry matter consumed in spring. Bears' utilisation of refuse declined significantly from a peak mean percentage volume of 13.5% in March-April to 3.3% in May (Mann-Whitney U test adjusted for ties, P<0.05). Their consumption of apples and oats at hunters' feeding stations also apparently declined during the same period (from 3.7% to 0% *m*%V and from 8.3% to 1.8% *m*%V respectively), as did that of sloe berries (from 9.3% to 0.2% *m*%V). Conversely, bears focussed more on graminoids and forbs as the growing season progressed. The mean percentage volume of these items in scats increased from 36.2% in March-April to 64.5% in May (Mann-Whitney U test, P<0.005).

Three separate opportunistic observations were made of eight bears at three different locations in March-May (Table 2.4). The feeding and foraging activities of these bears were in general accord with the results of the scat analysis. Two bears were seen foraging for refuse in mid April, four fed on maize at a hunters' feeding station in late April and two grazed on graminoids/forbs on sub-alpine meadows in late May. Bears seen on 1st June were above timberline where spring conditions prevailed. They were also feeding on graminoids/forbs.

Summer

Large mammals occurred significantly less frequently in summer scats (%F=6.9%) than spring scats (χ^2=7.49, d.f.=1, P=0.006) but comprised a greater percentage of total scat volume (3.1%) and dry matter ingested (10.0%). Graminoids and forbs were the most frequently occurring items (52.1% and 66.7% respectively) although, as in spring, their significance was much lower in terms of dry matter ingested (15.7% and 12.1% respectively). Consumption of graminoids and forbs peaked in June (*m*%V=87.8%) from when it declined to August (*m*%V=21.9%). Fruit was the most important of the main food categories in terms of dry matter ingested (%D=40.2). Late summer bear scats contained a greater volume of fruits than of graminoids and forbs (mean percentage volumes of 44.9% versus 36.1% in July and 58.9% versus 21.9% in August). Wild fruits, mainly bilberries and raspberries, were consumed far more frequently than cultivated fruits in summer (26.0% versus 1.9% using %V and 37.5% versus 2.7% using %V). Invertebrates were found in 36.8% of summer scats. Ants were the most important item in this category, comprising 3.7% of total scat volume and 6.4% of dry matter ingested. Occurrence of ants was highest in June (*m*%V=4.5%) and July (*m*%V=8.4%) while that of wasps peaked later, in August (*m*%V=4.8%) and September (*m*%V=6.8%). Rocks turned over by bears foraging for insects were observed in June, tree stumps and fallen logs were found broken open from spring to autumn and remains of wasp nests that had been fed on by bears were found several times in September. Items of anthropogenic origin were least utilised by bears in summer, when all such items combined accounted for $\geq$ 6.0% of total scat volume and $\geq$ 11.4% of dry matter consumed. No cultivated grains were found in June scats and they were uncommon in scats from July and August. Five bears were observed at four different locations in June-August (Table

2.4). Three of these bears were seen on 1st June in locations where spring conditions still prevailed. Of the remaining two observed in summer conditions, one fed on raspberries and the other, probably a human food-conditioned female, on refuse.

Autumn

Fruits were also an important food source in autumn (%V=33.9%, %D=30.3%), particularly apples, bilberries and to a lesser extent rowan and cowberries. The most frequent items in September were bilberries (*m*%V=18.3%) as well as graminoids and forbs (*m*%V=25.8%). Bilberries continued to be an important item in October (*m*%V=21.5%) and the mean percentage volume of apples (10.2%) and rowan (3.7%) peaked in this month while that of graminoids and forbs fell to 16.1%. Cowberries (*m*%V=10.0%) and hard mast (*m*%V=28.6%), mostly of arolla pine and beech, reached their greatest significance in November. Overall, however, the autumnal diet of bears in the study area was found to be dominated by cultivated grains (%V=31.5%, %D=47.0%). In late summer and early autumn bears descended to lower elevations to feed on oats, wheat and maize in fields, especially around Veľká Fatra and in the south-western part of the Nízke Tatry. A female with cubs repeatedly passed a flock of sheep at c.700m a.s.l. on the western edge of Veľká Fatra in August-September 2002 in order to feed in a field of maize without ever attempting to attack the livestock.

Cultivated grains and apples were also available at hunters' feeding stations throughout most of the study area. This source of food was utilised to a considerable degree, particularly in November, when the mean percentage volumes of maize (19.1%) and oats (29.5%) reached their highest levels. For example, on 25/10/02 a total of 115 fresh bear scats were counted at and around a single hunters' feeding station for ungulates at c.1,100m a.s.l. in Kôprová dolina, Západné Tatry, of which 100 (87.0%) were judged to contain predominantly grains, 13 (11.3%) mostly cowberries or rowan berries, one consisted mainly of ungulate remains and one of herbaceous plants. Bears were still visiting this site until at least 9/11/02 and used feeding stations in the area in 2003 until at least 15/11/03, despite the concurrent availability and evident consumption by the same bears of abundant cowberries and arolla pine seeds. In October of both 2001 and 2002 up to 100 bear scats were found

Table 2.4. Opportunistic observations of brown bears in north central Slovakia (CET = Central European Time; ZT = Západné Tatry; NT = Nízke Tatry; VF-SV = Veľká Fatra, Starohorské vrchy).

Date, time, location	Details of feeding, behaviour and circumstances	Notes
	March-May	
14/4/03 (16.45-19.00h CET) Hunters' feeding station in ZT, 1,000m a.s.l.	Hay, grain and maize left for ungulates and bears. Herd of red deer and a bear present when observers approached. Bear fled but returned after 30 mins., fed on maize for 30 mins. then left. 45 mins. later 3 other bears arrived together and fed on maize for 30 mins.	There was a deer carcass chained to the ground at this site on 30/3/03.
29/4/02 (04.45-04.55h CET) Tourist resort in NT, 980m a.s.l.	Two bears came to refuse bins in Demänovská dolina making low contact calls. One tried to open a bin (designed to be bear-proof), unsuccessfully, by shoving with forepaws. Prints measured on the bins suggested the bear was c.60-80kg.	One may have been a 67kg female legally shot nearby on 8/5/02 following the alleged injury of a tourist.
31/5/02 (18.00-19.15h CET) Sub-alpine meadows in ZT, 1,600m a.s.l.	Two bears estimated by E. Baláž to be a male of c.250kg and female of c.130kg. Female had much more body fat. Mostly grazing in a grassy gully above timberline. Male made several attempts at courtship, female retreated.	Still present and unaware of the two observers when left.
	June-August	
1/6/02 (10.30-13.00h CET) ZT, 1,600m a.s.l.	Same two bears as on 31/5/02, same location. Feeding on graminoids and/or forbs. Female now more relaxed and accepted male's advances. Mated briefly.	Present, unaware of observers when left.
1/6/03 (05:00-05:45h CET) Alpine meadows in ZT, 2,000m a.s.l.	Young bear. Standing when first seen; moved a few metres then lay down, rested and observed surroundings. Examination of the area after the bear had left showed that it had been feeding on grasses.	After some time bear caught scent of researcher and fled.
18/6/02 (23.00-23.20h CET) Tourist lodge in NT, 1,700m a.s.l.	Bear fed at a latrine also used for disposing of refuse outside a mountain tourist lodge above timberline.	
19/6/02 (21.20-22.10h CET) Tourist lodge in NT, 1,700m a.s.l.	Same location as on 18/6/02. Bear first seen briefly at about 21.20h. Half an hour later it reappeared from dwarf pine and repeatedly approached latrine/refuse. Lodge staff threw fireworks, from which it ran but soon returned. Several tourists approached to take photographs and offer food. Bear slowly approached to c.20m; some tourists panicked and ran to lodge, bear responded by loping a few steps towards them. People still outside retreated slowly, bear chased off with more fireworks.	Probably a 93kg female legally shot 6km away on 17/8/02 that had been fed by people and injured 6 illegal campers in three separate incidents of breaking into tents.
25/6/02 (c.23:00h CET) NT, 1,700m a.s.l.	Same location, almost certainly the same bear seen on 18/6/02 and 19/6/02.	
23/7/02 (20.15-20.25h CET) Clear-cut in mixed forest 15km from VF-SV, 700m a.s.l.	Young bear feeding on raspberries. Two fresh scats in the immediate vicinity full of raspberry seeds. Bear fed so intensely that remained unaware of researcher standing in open <100m away.	2km from village where several bears were reported to feed regularly at an orchard.
	September-November	
7/11/01 (19.30-19.40h CET) Tourist resort in NT, 1,100m a.s.l.	Bear appeared cautiously near hotel in Demänovská dolina and ran across car park. It was filmed by one of several TV crews that had been waiting for it to make one of its regular appearances.	This individual had been seen in the area almost daily and was fed by hotel staff.

in the vicinity of feeding stations with oats, maize, potatoes and apples at c.900-1,100m a.s.l. in Jánska dolina, Nízke Tatry. In this case bears seemed to be greatly focussed on this food source and a few apple trees next to a nearby forester's house, with virtually all scats judged to contain predominantly oats or apples. No scats and only one set of bear tracks were found from 1 to 5km away from these sites in two days' of searching. Hunters' ungulate feeding stations were also regularly used by bears in Veľká Fatra (pers. obs. 2002-03, Ľ. Remeník pers. comm. 2002).

All anthropogenic items combined accounted for ≥ 46.5% of total scat volume and ≥ 60.6% of dry matter consumed, the highest of the three seasons. Occurrences of ungulates (%V=1.3%, %D=2.5%), graminoids (%V=7.5%, %D=2.2%), forbs (%V=15.0%, %D=4.5%) and refuse (%V=0.7%, %D=0.7%) were lowest in autumn while that of hard mast was highest (%V=4.1%, %D=6.2%). Invertebrates, mainly wasps, were found in 26.4% of scats and contributed 6.3% of dry matter ingested. A single bear observed opportunistically in autumn was human food-conditioned and partially human habituated (Table 2.4). Tracks in snow showed that a bear (possibly the one seen) actively sought food in the vicinity of tourist facilities in Demänovská valley, 8-9km from the hunters' feeding stations in Jánska valley, until at least 9/12/01. Most bears seemed to be denning by this time. One bear scat seen but not collected on the south side of the Nízke Tatry in mid-December 2001 was described as being full of beech mast (S. Ondruš pers. comm. 2002).

Wolves

Diet and habitat use

Details of the season and area in which scats were collected are given in Table 2.5. The sample of wolf scats collected was rather small (*n*=70) for differences between seasons, years or areas to be tested for significance and therefore results of the diet analysis are presented only for the whole sample combined (Table 2.6).

Table 2.5. Sample of scats included in the analysis of wolf diet according to year, season and area collected (ZT = Západné Tatry; NT = Nízke Tatry; VF-SV = Veľká Fatra, Starohorské vrchy).

	2001 $n = 10$			2002 $n = 28$			2003 $n = 32$			
Season	ZT	NT	VF-SV	ZT	NT	VF-SV	ZT	NT	VF-SV	Combined
Spring	2	1		6	9	3	4	2		27
Summer			1		7		13	2		23
Autumn		6		3			3	5	3	20
Total	2	7	1	9	16	3	20	9	3	70

Table 2.6. Frequency of occurrence (%F), relative frequency of occurrence (rel.%F), mean percentage volume (*m*%V) and estimated percentage of biomass consumed (%B) of items identified in wolf scats collected from the Western Carpathian Mountains of north central Slovakia, spring-autumn 2001-03.

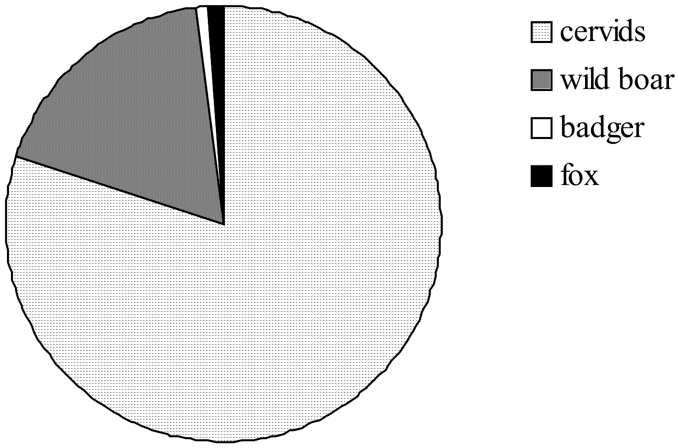
	$n = 70$			
Item	%F	rel.%F	*m*%V	%B
Ovis aries	0	0	0	0
Bos taurus	0	0	0	0
Cervidae	74.3	57.1	72.1	80.0
Sus scrofa	21.4	16.5	19.3	18.2
Meles meles	1.4	1.1	1.4	0.7
Vulpes vulpes	2.9	2.2	2.9	1.1
Unidentified vertebrates	4.3	3.3	4.3	-
Grass	24.3	18.7	-	-
Refuse	1.4	1.1	0.1	-

No domesticated animals were identified in any of the analysed scats, although three scats (%F=4.3%, *m*%V=4.3%) contained remains of unidentified vertebrates. Wolf predation on sheep and cattle was known to have occurred in the study area in 2001-03 (Chapter 3). Cervids were by far the most important food item, found in 74.3% of all scats with a mean percentage volume of 72.1% and comprising an estimated 80.0% of biomass consumed (Fig. 2.5). Of 20 scats in which the remains of cervids could be distinguished as either adult (>1 year old) or juvenile (<1 year old), 17 contained remains of juveniles and three of adults. The ratio of juvenile:adult cervids identified in wolf scats was highest in summer (8:1) and lowest in spring (4:1). Juveniles were estimated to account for between 65.7% (in spring) and 70.7% (in autumn) of cervid biomass consumed by wolves. Although fawns were preyed on most frequently in summer, their contribution to biomass consumed was not higher than in other seasons due to their smaller size. The second most important item was wild boar, which was found in 21.4% of scats with a mean percentage volume of 19.3%. It comprised an estimated 18.2% of the total biomass consumed. Three items were each found once (badger, refuse) or twice (fox) in different scats from August-September. The two scats containing fox were collected on the same day from the same locality (Poludnica, Nízke Tatry). The refuse was estimated to comprise <10% of the volume of the scat in which it was found, whereas the remains of badger and fox comprised all or almost all of the respective scats in which they occurred. Grass was found in 24.3% of scats. A total of four adult wolves were observed by the researcher on three separate occasions during the course of the study, providing some examples of habitat use, hunting behaviour and response to humans (Table 2.7).

Table 2.7. Opportunistic observations of wolves in north central Slovakia, 2001-03 (CET = Central European Time; ZT = Západné Tatry; NT = Nízke Tatry).

Date, time, location	Behaviour and circumstances	Notes
	Spring	
20/3/01 (08.00-08.05h CET) Spruce forest in ZT, c.1,200m a.s.l.	Two wolves resting together on an overgrown forest track.	Did not notice researcher until he had (unintentionally) approached to within 30m of them. One fled immediately, followed by the other more slowly.
7/4/03 (14.30-14.35h CET) Snow-covered pastures in ZT, c.950m a.s.l.	A large adult wolf ran to cover in spruce forest at a distance of c.100 metres. Tracks showed it had been accompanied by a second, smaller wolf. Each fled from observers in opposite directions.	Earlier tracking in snow showed that a pack of five wolves had criss-crossed through open stands of birch (*Betula pendula*) investigating tracks of red deer and hazel grouse (*Bonasa bonasia*). Pack had divided into two shortly before wolf seen.
	Summer	
18/6/02 (07.30-07.35h CET) Sub-alpine meadows in NT c.1,700m a.s.l.	An adult wolf crossed a lateral ridge above timberline and ran down a gully. It slowed to a trot and crossed a sub-alpine meadow, sniffing here and there as it went, before going out of sight among dwarf pine. At 08.15 a group of at least 8 adult and 4 juvenile wild boar ran from a different direction into the area that the wolf had been moving towards when last seen.	On 24/6/02 at 08.30 two project volunteers saw a wolf 4.5km to the NW, apparently following a roe deer that had crossed the main ridge from N to S c.20 min. earlier. Wolf was <20m from hidden observers when it noticed them, turned and fled back N. A wolf was also seen attempting to cross the Nízke Tatry main ridge by project volunteers on 26/6/03. It, too, immediately fled from humans.
29/6/2003 (05.40h CET) in NT	Howling of 2-3 wolves heard coming from below main ridge.	Seemed to be in upper montane or sub-alpine vegetation zone on N side..

Fig. 2.5. Percentage biomass of food items consumed by wolves in north central Slovakia during spring-autumn as estimated from the contents of 70 scats collected in the Tatra and Fatra Mountains between April 2001 and November 2003.



DISCUSSION

Limitations of data and assumptions

McLellan and Hovey (1995) described four types of error associated with the quantitative assessment of diet based on scat analysis: 1) scats from the wrong species may be collected; 2) each scat deposited by the target species may not have an equal chance of being collected; 3) the volume of faecal residue produced after consumption of a given amount of food varies among different food items; and 4) scats vary in size. In relation to consumption of vertebrate material, a major limitation of scat analysis is that it does not distinguish between items obtained by predation and by scavenging.

As there were only one species of bear and one species of large wild canid in the study area, identification of scats in the field was relatively simple. Bear scats, although highly variable according to food consumed, tended to be easily distinguished from those of other species in the study area. Uncertainty in some cases was removed by examining associated tracks, particularly in snow or mud. As reported by Ciucci *et al*. (1996), there may have been some confusion of wolf scats with those of domestic dogs (*Canis lupus familiaris*). Stray and feral dogs were not common in the study area, so this would most likely concern pets, sheep dogs or hunting dogs, that were usually restricted in their movements. Fresh wolf scats had a characteristic odour (pers. obs. 1997-2003) that aided identification. Scats of uncertain origin were excluded from the analysis. It was assumed on the basis of these observations and precautions that few if any scats from the wrong species were included in the analysis, although some smaller wolf scats resembling those of the fox or lynx may have been excluded.

The majority of scats were collected by the researcher while walking along survey routes at a fairly uniform speed between dawn and dusk. Some scats were collected by others during a variety of activities in the study area. This may have introduced a bias if the contents of scats found more easily tended to differ from those less likely to be collected. For example, results could be considerably biased if collection was inadvertently concentrated nearer some food sources than others (cf. Murie 1944, 1985). Jorgensen (1983) found that bear scats with fruit were concentrated nearer the food source, had fewer different items and had a much greater bulk volume than scats containing grass and forbs. As individual bears may be relatively sedentary near a food source for several days (pers. obs. 2002-03, E. Baláž pers. comm. 2003), it is possible that scats with certain food items may have been less likely to be collected than others if some food sources consistently occurred at greater distances from survey routes. The available network of forestry roads, tracks and paths for hunting and hiking was extensive in most of the study area, but the sample of scats collected was haphazard rather than truly random (Martin and Bateson 1993:132). The results may also have been influenced by seasonal variation in weather, vegetation growth, leaf litter, degree of insect activity (Reynolds and Aebischer 1991, Giannakos 1997) as well as site of defecation (e.g. width of track or path, type of substrate) making some scats more visible than others.

Scats collected at or near hunters' feeding stations presented a particular problem. In two cases over 100 scats were found at the same site, the inclusion or exclusion of which would make a significant difference to the overall results. Baláž (2002) excluded scats from such sites (E. Baláž pers. comm. 2003) but included those found along tracks leading to them. However, following this logic, scats in the vicinity of any food source, natural or anthropogenic, would have to be excluded.

The number of individual carnivores contributing scats to the sample was unknown. Hamer and Herrero (1987) found that the diets of two radio-collared brown bears did not differ greatly from those of other bears in their study area. However, the identification of livestock-killing and non-livestock killing individuals within the same population (e.g. Knight and Judd 1983) suggests that diet can vary substantially between individual brown bears. Jacoby *et al*. (1999) found differences between individual bears in North America in their use of meat, with adult male brown bears being most carnivorous. The bias in diet analysis so caused would be expected to increase as individual variation increases but decrease as the proportion of the population contributing scats to the sample increases. In this study it was assumed that collecting a large number of scats over a wide area in three different years would limit any individual bias by including scats from many different animals.

Effort to collect scats varied between months. As food abundance and availability also varied between seasons, summing results across the year could lead to bias towards food items consumed in months during which more scats were collected. This error cannot be corrected by weighting months equally (cf. Elgmork and Kaasa 1992) due to the changing biochemical and physiological states of bears from hypophagia in spring through normal activity in summer to hyperphagia in autumn (Nelson *et al*. 1983) that presumably result in different defecation rates. On the other hand, effort required to find scats also varies at different times of year (Reynolds and Aebischer 1991, Giannakos 1997), so increasing effort when scats are harder to find is appropriate. The combined effect of variations in effort required, effort expended, food available and scats produced was unknown and so it is probably best to consider the results for bears on a monthly or seasonal basis rather than summed throughout the year. This also has the benefit of emphasising the considerable changes in diet between seasons (Murie 1944).

The third source of error described by McLellan and Hovey (1995), that of the discrepancy between proportions of different items in scat content versus food consumed, was compensated for using correction factors (Hewitt and Robbins 1996) and regression equations (Floyd *et al*. 1978). Jamnický (1988) emphasised the need to collect scats in a fresh state, before differing rates of decomposition in the field could alter the proportions of the various components. Reynolds and Aebischer (1991), however, found that this need not necessarily be a major concern. A greater difficulty is that even in the freshest scats some ingested items are not represented by sufficient undigested material to be identified. For example, on 11/4/03 a bear was tracked across snow-covered pastures below the Západné Tatry. It had stopped to feed on soft tissue adhering to the discarded skull and leg bones of a cow. Within 100 metres the bear deposited a scat of a mucous-like consistency that washed completely through a sieve of 1.0mm mesh and would have been unidentifiable had the food source itself not been found. Hewitt and Robbins (1996) could not establish a correction factor for fish due to a lack of identifiable remains in scats. In the present study the same problem was encountered when a captive bear was fed meat without hide or hair. Balharry (1993) reported that nine out of 55 scats (16%) from captive martens (*Martes martes*) fed solely on roe deer carrion contained no identifiable, undigested remains. The consumption of meat by bears may therefore be under-estimated by studies based on scat analysis.

In the present study it was assumed, as is usual in scat analyses, that material washed through a 1.0mm sieve and discarded, or that was retained on the sieve but was unidentifiable, derived proportionately from all identified items. Reynolds and Aebischer (1991) found that this was not so for foxes. These authors described a number of other methodological problems rarely considered in studies of large carnivore diet. They recommended pilot studies, computer modelling, detailed examination of each scat's microscopic fraction followed by extensive statistical manipulations. Other authors have considered the differences in results too minor to be of serious concern, or else the time necessary for such procedures excessive or unjustifiable given other errors and uncertainties in, for example, the collection of scats (see Litvaitis *et al*. 1996). Examination of the discarded microscopic fraction of scats might have identified more remains of smaller prey, such as earthworm chaetae or fragments of feathers (Reynolds and Aebischer 1991). Microhistological techniques could have identified some plant remains to genus or species level (Žilinec 1993, Litvaitis *et al*. 1996). However, these are difficult and time-consuming processes and, as the main aim of this study was to investigate the importance of livestock in bear and wolf diets, they were not attempted.

Finally, error caused by variability in bear scat size was greatly reduced by deriving total percentage volume in addition to frequency of occurrence and mean percentage volume. (Wolf scats were less variable in size: mean=76.8ml, st. dev.=60.8) Visual estimation of percentage volume is a commonly used method, but it has been employed with many slight variations that limit comparability between studies (cf. Mealey 1980, Jorgensen 1983, Mace and Jonkel 1986, Hamer and Herrero 1987, Ohdachi and Aoi 1987, Mattson *et al*. 1991, Clevenger *et al*. 1992, Elgmork and Kaasa 1992, McLellan and Hovey 1995, Swenson *et al*. 1999) and it has been criticised as non-quantitative and therefore subjective (Sato *et al*. 2000). In this study, volume classes (cf. Mealey 1980, etc.) were not used because when the mid points of volume class estimates for all items in a scat were summed, the total estimated volume differed by up to 30% from the measured scat volume. Hamer and Herrero (1987) noted that converting ordinal data to ratio data is invalid. To avoid subjective visual estimates, some authors have manually separated food items to measure their volumes (e.g. Cicnjak *et al*. 1987) or dry masses (e.g. Ohdachi and Aoi 1987). Bear scats collected during this study contained up to nine separately identified food items (mean=2.5 items/scat, 70.0% >1 item/scat), many of them consisting of numerous small organisms or fragments of organisms. It would have been extremely difficult and time-consuming to separate them (Elgmork and Kaasa 1992, Balharry 1993). As a quick but reasonably accurate alternative, Sato *et al*. (2000) proposed the point-frame method, originally developed for diet studies of ungulates. However, this method may over-estimate flat items and under-estimate bulky items. Due to the large size of many scats collected (≤ 1,340ml), sub-sampling would have been necessary, precluding the examination of entire scats. In the present study and that of Spaulding *et al*. (2000), examining each scat in its entirety was found to be important in recording all identifiable components and therefore was considered a more worthwhile use of the time available than refining volume estimates. Small amounts of mammal hair could have been overlooked in some scats if they had not been examined thoroughly. Items that often appeared in small amounts, such as insects, would have been under-estimated (cf. Baláž 2002) and some items occurring only rarely, e.g. fragments of soft-bodied invertebrates, might have been missed. Such details in the analysis of diet were judged to be of lesser importance compared to the vagaries of scat collection. A different problem was the presence of non-food items such as plastic wrappers in several scats, which indicated that food (refuse) had been consumed but provided no information on quantity.

The results obtained describe food use, which does not necessarily imply selection (Litvaitis *et al*. 1996, Litvaitis 2000). Due to time and other constraints on the present study, a detailed assessment of food availability or abundance in the field was not undertaken and so only limited conclusions can be drawn about bears' and wolves' food or habitat preferences. As the abundance and availability of food vary by location, as well as season, the findings cannot necessarily be applied to other areas. Mace and Jonkel (1986) found substantial local variation in brown bear diet due to food availability in Montana as did Ohdachi and Aoi (1987) in Japan. Murie (1985), Hamer and Herrero (1983, 1987) and Mattson *et al*. (1991) also found considerable variation in food use by bears among years according to availability. Baláž (2002) noted this in Slovakia: for example, rowan berries were a minor food item (1.5% by percentage occurrence) during the three years of his study (1999-2001) but bears had fed on them substantially in previous years of high abundance and apparently as a result had been active later in the year. McLellan and Hovey (1995) asserted that most inter-annual variation in natural foods consumed by bears results from changes in fruit abundance. To some extent such problems might be reduced by gathering more scats over a longer period. Litvaitis *et al*. (1996) noted that there are no agreed minimum sample sizes for diet studies, although Reynolds and Aebischer (1991) discussed how an appropriate sample size might be determined for any given research project through a pilot study and statistical analyses. Korschgen (1980) concluded that a set of samples is large enough when additional samples offer no new or additional information. As brown bears (Murie 1985, Swenson *et al*. 2000) and grey wolves (Mech and Boitani 2003b) are adaptable opportunists that feed on a wide variety of foods, and vary their diets depending on availability, both within and among years, it is likely that only a very long-term study could hope to document all utilised food items, during which the habitat itself could change substantially. Mattson *et al*. (1991) were still finding new and significant bear foods in Yellowstone after 11 years of study. Murie (1985), working in Alaska, collected 810 bear scats over a 24-year period but still did not find in them all items which he knew from observations that bears consumed. Combining scat analysis with radio telemetry, focal observations and detailed examination of feeding signs (Phillips 1987, Raine and Kansas 1990, MacHutchon and Wellwood 2003) might provide a more complete record of diet. However, Jamnický (1988, 2003) reported that in more than 40 years of fieldwork and examination of over 400 scats from the Tatras, he saw no evidence of bears having consumed arolla pine nuts, whereas in autumn 2003 bears fed on them in substantial quantities in part of the area where he conducted his research (present study). The results of this study should therefore be taken as a rather coarse-grained snapshot of the situation in particular parts of the Western Carpathians during spring-autumn of 2001-03.

Major food types and seasonal changes

<u>Bears</u>

Two previous quantitative studies have been conducted on bear diet in the present study area. Jamnický (1988) found plant material in 92.6% of 68 fresh scats with a mean percentage volume of 86.3%. He reported the frequency of occurrence of both red deer (*m*%V=2.1%) and sheep (*m*%V=2.2%) as 2.9%. Invertebrates, primarily ants, had a mean percentage volume of 9.3%. Baláž (2002) estimated the mean percentage volume of plant material in 291 scats as 96.3% and of both wild vertebrates and invertebrates as 1.9%. He found no domesticated animal remains. The results of the present study confirm the dominance of plant material (*m*%V=88.9%, %D=83.5%) in the diet of bears in north central Slovakia. The mean percentage volume of vertebrates (3.2%) was intermediate between that of the two previous studies. Baláž (2002, pers. comm. 2003) did not thoroughly examine all scats and so may have underestimated the occurrence of vertebrates as well as invertebrates and other less bulky items. In the present study, the use of correction factors to estimate the percentage of dry matter ingested more than doubled the apparent significance of vertebrates compared to the mean percentage volume method. Vertebrates nonetheless comprised only 7.5% of the estimated diet. Despite their relatively small representation in the diet, animal foods may provide essential nutrients such as amino acids (Eagle and Pelton 1983, Rode and Robbins 2000). Use of conversion factors to calculate the energy content of foods consumed (cf. Elgmork and Kaasa 1992) would probably have further increased the estimated significance of large mammals in bear diet. Predation on livestock was known to have occurred in the study area in 2001-03 (Chapter 3) but was evidently not frequent enough to be detected by scat analysis. As the present study was conducted in regions with some of the highest reported losses to bear predation in the country (Chapter 3), it is clear that livestock is not an important component of brown bear diet in Slovakia.

Although they seldom gain weight until berries ripen in summer, bears usually move to areas where they can find food in early spring (Herrero 1985). In the present study area this typically meant descending from den sites on less accessible mountain slopes still under snow and with very little available food in February-April besides carcasses of winter-killed animals to valleys that had been greatly modified by human activities including deforestation for agriculture, game management and construction of settlements, cottages and tourist infrastructure. Here bears fed on fruits from the previous year, herbaceous vegetation in early stages of growth but also artificial food sources provided by hunters. Consumption of refuse was highest in April. Bears also ate new growth of several deciduous tree species, such as beech leaves and buds, alder fruit (*Alnus* sp.) and goat willow inflorescences (*Salix caprea*). Several of the spring and early summer foods identified in the present research have been documented in previous studies reviewed by Herrero (1985, 2002), including berries left on plants from the previous year, winter-killed mammals, newborn ungulates, ants and refuse (see also Jamnický 1988, Green *et al*. 1997, Elgmork and Unander 1998, Swenson *et al*. 1999). Consumption of earthworms by bears has seldom been reported (Mattson *et al*. 2002).

From April until June the content of collected scats became increasingly dominated by graminoids and forbs. Jamnický (1988) supposed that the prevalence of grasses and herbs in the diet of bears in the Tatra Mountains was due to the reduced availability of carcasses following a decline in livestock grazing in mountain regions. The same author (Jamnický 2003) believed that bears' order of preference for foods is as follows: honey > meat > fruits and mast > vegetation > cultivated grains > ants. His assertion that grasses, herbs and ants are "less suitable food … for a member of the Carnivora Order" is unjustified. The brown bear is adapted to an omnivorous diet anatomically, physiologically and, by selection of food and habitat, behaviourally

(Kurtén 1976, Nelson *et al*. 1983, Herrero 1985, Hamer and Herrero 1987, Stirling and Derocher 1990, Swenson *et al*. 2000). Plant food comprised at least 62% and up to 98% of brown bear diet in all 13 studies from Eurasia and five studies from North America reviewed by Elgmork and Kaasa (1992 but cf. Jacoby *et al*. 1999), with graminoids and herbs typically the dominant food type in spring-summer, as found in the present study and those of Jamnický (1988) and Baláž (2002). Brown bears seek shoots, leaves and stems in early stages of growth when they are succulent, easily digested and high in nutrients. In spring bears forage in sites where snow melts and growth begins early, such as south-facing avalanche slopes, and subsequently move to areas where growth begins later, as at higher altitudes and on north-facing slopes, or lasts longer, e.g. moist meadows, along streams, springs and where snow persists (Mealey 1980, Herrero 1985, Hamer and Herrero 1987, Clevenger *et al*. 1992).

As summer progressed and most plant growth ended, bears began to focus on ripening fruits. When bilberries and raspberries were available in July-September, the proportion of graminoids and forbs in the diet was much lower than in spring and early summer. A switch from foliage to fruits or hard mast has been documented in many previous studies of brown bear diet in Central Europe (Slobodyan 1976, Cicnjak *et al*. 1987, Baláž 2002), southern Europe (Zunino and Herrero 1972, Clevenger *et al*. 1992), Scandinavia (Elgmork and Kaasa 1992), the former U.S.S.R. (e.g. Sharafutdinov and Korotkov 1976), Japan (Ohdachi and Aoi 1987) and North America (e.g. McClellan and Hovey 1995, Rode and Robbins 2000). Carbohydrate-rich fruits and fat-rich mast are some of the most important foods used by bears to build up fat reserves in preparation for winter denning. Animal matter, primarily salmonids and ungulates, can also contribute substantially to autumn fattening. As reproductive success in bears is directly related to body mass in autumn, the availability of high energy foods has an important influence on bears at the population as well as the individual level (Rogers 1976, Stringham 1986, 1990, Blanchard 1987, Herrero 1985, Hilderbrand *et al*. 1999a,b; see also Ferguson and McLoughlin 2000). In the present study, predation on livestock was found to increase from late summer to autumn (Chapter 3). This may have been related to pre-winter fattening as well as availability of livestock on pastures in close proximity to forest cover.

The proportion of anthropogenic food found in scats was much higher in the present study than in previous quantitative studies of bear diet in Slovakia. Jamnický (1988) reported only sheep and bees in 68 fresh bear scats with mean percentage volumes of 2.2% and 2.7% respectively. In Baláž's (2002) study, all anthropogenic food combined had a mean percentage volume of 6.3% and was comprised mainly of grains and root crops consumed at hunters' feeding stations in autumn. This discrepancy was presumably due mainly to the focus of the present study on areas of higher human utilisation with a greater incidence of hunters' feeding stations, arable land, livestock, settlements, orchards, and tourist infrastructure. However, both Baláž (2002, pers. comm. 2003) and Jamnický (1988, pers. comm. 2002) may have biased their results towards natural food sources by not collecting scats from localities with hunters' feeding stations. As feeding on anthropogenic food sources varies greatly among seasons, being lowest in early summer and highest in autumn and early spring, the relative number of scats collected in each month affects estimates of total yearly percentage of anthropogenic foods. Baláž (2002) included a greater proportion of summer scats (48.5% of scats analysed) than in the present study (38.6%).

Wolves

The results of the present study confirm the finding of other recent work on wolf diet in the Western Carpathians of Slovakia, that cervids are most frequently consumed (Kolenka 1997, Rigg and Finďo 2000, Strnádová 2000, Finďo 2002a). The ratio of cervids to wild boar was very similar to that found by Strnádová (2000) in a much larger sample of scats from a wider geographic area. Brtek and Voskár's study (1985, 1987, Voskár 1993, Brtek 1997a,b) placed wild boar ahead of cervids. However, it was conducted during a period when wolves were most numerous in eastern Slovakia and included scats from early spring, autumn and winter so the results probably reflect temporal or geographic variations. Okarma (1995) and Strnádová (2000) concluded that wild boar could be locally more important in wolf diet than cervids. In the Carpathians, wild boar are more vulnerable to wolf predation in deep snow (Śmietana and Klimek 1993, Strnádová 2000). The finding that a high proportion of ungulates are consumed as juveniles has been reported by previous studies in the Carpathians (Śmietana and Klimek 1993, Voskár 1993, Brtek 1997a, Strnádová

2000) and other regions of Europe (see Okarma 1995) as well as in North America and elsewhere (reviewed in Mech 1970, Mech and Peterson 2003).

Red deer is the preferred prey of wolves in much of Europe (Cuesta *et al*. 1991, Śmietana and Klimek 1993, Jędrzejewski *et al*. 1994, 2003, Okarma 1995, Okarma *et al*. 1995, Adamic 2000, Rigg and Find'o 2000, Śmietana 2002, Nowak 2003, Mattioli *et al*. 2003, Carrasco 2003, Gazzola 2003). Young animals, often fawns, are typically the most prevalent age class. Predation on livestock has been observed to decrease during wild ungulate calving seasons (Chapter 3, Śmietana 2002). Wolf predation can contribute substantially to total natural mortality of cervids, especially red deer. Predation is usually a less important factor for wild boar, whose body structure, active defence behaviour and large groups maintained year round make them a difficult and dangerous prey that most predators avoid (Jędrzejewski *et al*. 1994, Okarma 1995, Okarma *et al*. 1995). Where they are taken, juveniles are selected (Brtek and Voskár 1985, 1987, Śmietana and Klimek 1993, Voskár 1993, Strnádová 2000). According to Kováč (1996c) wolves caused up to 57.3% of total known red deer mortality in TANAP during the period 1981-94 and 39.3% of known wild boar mortality in 1984-87.

Wolf diet is often more varied in summer than in winter (e.g. Bibikov 1982, Find'o 2002a, Håkan *et al*. 2003). The small sample size probably partly explains the apparently narrow diet breadth found in the present study. Wolf scats containing bilberries and beech leaves were seen in 2003 and 2004 (pers. obs., S. Ondruš pers. comm.). Although they usually rely on large ungulates for food, wolves have been described as flexible and opportunistic predators and scavengers (see reviews in Mech 1970, Okarma 1995, Peterson and Ciucci 2003). By exploiting alternative food sources including livestock, carrion, fruit and refuse they have persisted, sometimes at high densities, in parts of Europe and Asia where humans have fragmented, altered or destroyed habitat and reduced or extirpated native prey species (Bibikov 1982, Boitani 1982, Cuesta *et al*. 1991, Papageorgiou *et al*. 1994, Meriggi and Lovari 1996, Álvares and Petrucci-Fonseca 2000, Blanco 2000a, Blanco and Cortés 2000, Jhala 2000, Vos 2000, Barja and Bárcena 2003, Soria *et al*. 2003). The present study confirms that in the Western Carpathian Mountains of Slovakia wolves remain almost entirely independent of anthropogenic food sources.

The overall relative dietary importance to wolves of wild versus domestic prey appears to depend upon the abundance/vulnerability of wild prey and the availability/accessibility of livestock (Blanco *et al*. 1992, Meriggi and Lovari 1996). Where wild ungulates are scarce, wolves prey mostly on domesticated animals (e.g. Papageorgiou *et al*. 1994, F. Álvares pers. comm. 2003). Rapid reduction of wild ungulate populations by human hunters can apparently result in increased predation by wolves on domesticated animals (Tsingarska-Sedefcheva and Dutsov 2003, W. Śmietana pers. comm. 2003). Conversely, wolves have often been found to prey less on livestock where wild prey populations have remained healthy or have been restored (Fritts *et al*. 2003). However, wolves have a tendency to try to attack any large ungulates they encounter (Mech 1970:298-299) and so untended, unprotected livestock may still be selected even where wild ungulate densities are high (Blanco *et al*. 1992, Kazcensky 1996, Linnell *et al*. 1996). Linnell *et al*. (1999) hypothesised that most individuals of large carnivore species will at least occasionally kill accessible livestock whereas Mech (1995b citing Fritts and Mech 1981) stated that most wolves did not. Several recent studies in areas with livestock losses to wolves have reported that, where wild prey was available, only a minority of packs killed livestock (Treves *et al*. 2001, 2003, Jedrzejewski *et al*. 2003, Muhly *et al*. 2003). There is evidence of traditions among wolf packs and lineages (Haber 2003), including of prey preference (Bibikov 1982, H. Schneider pers. comm. 2004). It has often been assumed that intense persecution disrupts wolf population demographic structure, particularly by the removal of socially dominant "alpha" individuals, thereby impairing hunting ability and leading to increased predation on livestock (e.g. Voskár 1976, 1993). Results of recent research in North America, however, have called into question this implied reliance of wolves on cooperative hunting (Mech and Peterson 2003, Peterson and Ciucci 2003, MacNulty and Smith 2003 but cf. Haber 2003), the significance to a wolf pack of losing "alpha" animals (Brainerd *et al*. 2003) and the applicability of the linear dominance hierarchy concept to most wild wolf packs (Mech and Boitani 2003a, Packard 2003 but cf. Haber 2003). Olson in 1938 and Murie in 1944 noted that wolf packs are essentially extended family groups.

Seasonal and other factors affect the relative availability and vulnerability of wild versus domestic prey, hence influencing predation rates. In general, losses of livestock in Europe, as elsewhere, increase during the grazing season, especially where livestock is grazed in or near forests or on alpine pastures (Kaczensky 1996, 1999, Weber 2003). During winter, livestock closed in barns is far less accessible to wolves whereas winter conditions tend to increase wolf hunting success on wild ungulates (Śmietana and Klimek 1993, reviewed in Okarma 1995, Peterson and Ciucci 2003). Many researchers in Europe have concluded that local conditions, livestock husbandry and guarding techniques affect the degree of depredation (Chapters 3 and 5, Okarma 1995, Kaczensky 1996, 1999). In the present study domestic animals were found to form a negligible portion of the diet of wolves in north central Slovakia, despite their abundance, presumably due to a combination of medium to high wild ungulate densities (K. Chute unpub. data collected for the Slovak Wildlife Society from pellet counts in 2003) and persistence of traditional husbandry systems in which flocks are attended by shepherds. Low frequency of livestock in wolf diet was reported from all previous quantitative studies in Slovakia (Brtek and Voskár 1985, 1987, Voskár 1993, Kolenka 1997, Rigg and Finďo 2000, Strnádová 2000, Finďo 2002a, Janiga and Hrkľová 2002, Lukáč in prep.).

Brtek and Voskár (1985, 1987) found remains of dogs and foxes more often than those of sheep in wolf scats. Finďo (2002a) questioned their data, but it may represent local variation. Loss of dogs to wolves was reported by shepherds in eastern Slovakia (Chapter 4), is common in neighbouring Ukraine (Dyky and Delehan in prep.) and increased in neighbouring southern Poland following reduction of ungulate numbers (W. Śmietana pers. comm. 2003). Predation by wolves on pet, guardian, stray/feral and hunting dogs has also been reported from Romania (H. Schneider pers. comm. 2004), European Russia (Bologov and Miltner 2003, Casulli 2003), Italy (Boitani 1982), Scandinavia (Kojola and Kuittinen 2000 for Finland, Karlsson 2003 for Sweden) and North America (Jurewicz and Thiel 2000, Bangs *et al*. 2002, 2003, Jurewicz 2003, Treves *et al*. 2003).

Are large carnivores "over-populated" in Slovakia?

"Over-population" is a term which has been frequently used, particularly by hunting advocates, to describe large carnivores in Slovakia (Wechselberger *et al*. in prep.) but in this context it has rarely been defined. A testable scientific hypothesis would be that the population of a given species has exceeded the biological carrying capacity of its natural habitats (McCullough 1979 cited in Strickland *et al*. 1996) and as a result is damaging them, for example when high densities of deer cause considerable damage to woodland or hinder regeneration by bark peeling and browsing (Richter 1973 cited in Voskár 1976, Paulenka 1989, Hell 1989, Finďo 1999a). As public opinion and politics as well as science are involved in wildlife management (Boitani 1995, Strickland *et al*. 1996, Sharpe *et al*. 2001), to the extent that large carnivore conservation in Europe is currently more a socio-political than a biological challenge (e.g. Bath and Farmer 2000), a second testable hypothesis is that carnivore populations have exceeded the cultural or sociological carrying capacity (Ellingwood and Spignesi 1986 and Decker and Purdy 1988 cited in Strickland *et al*. 1996), i.e. there are more carnivores than people are willing to tolerate. This is a rather fluid concept as tolerance may depend on factors such as knowledge, experience, awareness and perception that vary among social groups and can change considerably over short periods of time (e.g. Hunziker *et al*. 1998). Most modern carnivore conservation initiatives attempt to influence acceptance through education and public relations work (e.g. LeCount and Baldwin 1986, Bath and Majic 2003, Gangass 2003, Tsingarska-Sedefcheva 2003, Morgan *et al*. 2004).

Bears

Very high densities of bears have been reported locally from some parts of Slovakia (but cf. Okarma *et al*. 2000, Salvatori *et al*. 2002). In an area of 400km^2 in the Slovak Eastern Carpathians where the bear population had recently recovered, bear density in 2000 was estimated by Pčola (2003), on the basis of opportunistic records of occurrence, at 4.5 inds. 100km^{-2}. A track count in early December 2001 recorded a density of c.11 bears 100km^{-2} in a c.800km^2 area of high human use in central Slovakia (after Lehocký 2002). This area was near the southern limit of bear range in the Western Carpathians. The presence of bears c.40km to the south-west was considered undesirable for economic and human safety reasons (Hell 2003). Track counts in the excellent bear habitat of Veľká Fatra National Park (c.400km^2) indicated a population density of c.12 bears 100km^{-2} in 2000 (after Ľ. Remeník pers. comm. 2001-02). A census of bears in Malá Fatra National Park (c.225km^2) conducted by direct observations in spring 2003 suggested a density of approximately 13 inds. 100km^{-2} (after E. Baláž pers. comm. 2003). Nevertheless, no excessive damage by bears to natural habitats or wildlife species has been documented in Slovakia, their impact on wild ungulates being insignificant (Kováč 1984, 2003) and damage to forest stands largely limited to occasional bark peeling (Sabadoš and Śimiak 1981, Jamnický 1987). After 25 years of study in Alaska, Murie (1985) concluded that brown bears have little impact on natural habitats. They might play a role in seed dispersal (Giannakos 1997, Sathyakumar and Viswanath 2003; see also Tardiff and Stanford 1998). The proposition that high densities of bears are harmful to natural habitats in Slovakia therefore seems untenable.

An alternative hypothesis is that the bear population is being maintained at artificially high levels by anthropogenic foods, leading to increased inter-specific competition with humans. Hell (1987 cited in Martínková and Zahradníková 2003) estimated the carrying capacity of Slovakia's bear habitat at 400 individuals and Hell and Finďo (1999) considered 450 to be the "optimal number" of bears. This is the number of bears estimated to have been in Slovakia in the 1970s (Sabadoš and Śimiak 1981, Richter 1991), c.50-75% of the current accepted population estimate (Hell 2003, Kassa 2003). Sabadoš and Śimiak (1981) reported that 485,137 Kčs were paid in compensation for damage in 1977 (Fig. 3.2). The rate of bear predation on livestock in LM region in 1956-64 was estimated at 0.5-0.7 sheep and c.0.3 cattle/adult bear/year (Jamnický 1988), which is similar to the estimated mean loss/bear/year for LM region in 2003 (Chapter 3). Kováč (1996b) recalled that the first recorded case of nuisance behaviour (destruction of beehives) by a bear in Tatranský National Park occurred in 1964. According to Šprocha (1977 cited in Sabadoš and Śimiak 1981), compensation was paid for damage caused by bears in Slovakia totaling 218,261 Kčs in 1965 and 391,276 Kčs in 1966. It follows that one or more of the following must be true: there were 33-100% more bears in 1956-64 than was supposed; the current biological carrying capacity has been 33-100% over-estimated; the biological carrying capacity was 33-100% lower in 1956-64 than it is now; or nuisance behaviour and damage can occur even when biological carrying capacity has not been reached. Recent hunters' estimates for the number of bears in Slovakia are widely considered to be over-estimated by 50-100%, so the first point seems unlikely. The most likely explanation would seem to be that the higher rate of predation on livestock in 1956-64, albeit by a smaller number of bears, was due to the fact that livestock was far more abundant in bear habitat during the 1950-60s than in 2000-03 (Jamnický 1988, 2003).

At the European level, damage to human economic interests is not correlated with bear population size. A very small number of bears can cause substantial damage to unprotected livestock and apiaries (Kaczensky 1996, 1999). For example, in spring-summer 2000 a single bear in the eastern Czech Republic caused damage amounting to c.30% of the mean total annual compensation payment resulting from damage caused by Slovakia's entire population of 600-800 bears (Kunc 2001, Bartošová 2002, 2003, Šulgan 2002). Therefore it cannot be assumed that maintaining a population at or below the estimated carrying capacity of natural habitat would suffice to eliminate damage and nuisance behaviour in adjacent or interwoven human-dominated landscapes. The present study (Chapter 3) found that numbers of sheep better explained regional variation in reported losses to bear predation than numbers of bears. Furthermore, even in the midst of extensive pristine habitat many bears are attracted to and congregate at calorie-rich anthropogenic food sources, including refuse (Wright 1913, Herrero 1985, 2002, McLellan 1990, Shideler and Hechtel 2002; see also Bakeless 1964 but cf. Gilbert 2002). Mattson (1990) concluded that bears make substantial use of agricultural crops wherever they are available although they often do so at night and in more remote locations in order to avoid humans. The balance between anthropogenic and natural food in the diet of a particular bear probably depends on the relative availability of each, the animal's social status, past experience and learning as well as bear population density (see reviews in Mattson 1990, McLellan 1990).

In the present study the most frequently utilised anthropogenic food items were cultivated grains, a substantial proportion of which were consumed at hunters' feeding stations. How many bears rely on such food for survival and if its removal would result in population decline, increased intra-specific competition, a shift to a more natural diet or increased use of other anthropogenic food sources (crops, livestock, beehives), and whether instances of aggressive nuisance behaviour would increase or decrease, cannot be answered from data currently available. Bears have been observed at very high densities in parts of Slovakia with few anthropogenic food sources (Baláž 2002). If there are more bears in Slovakia than natural habitats alone would support, it seems likely that this is due in some measure to supplementary feeding by hunters and bears' use of crops. A reduction in population might therefore be achieved by reducing the availability of these food sources to bears. To reach firmer conclusions would require a detailed study of food and habitat availability, quality and selection (e.g. Herrero et al. 1986, Noyce and Coy 1990, Clevenger et al. 1997, Costello et al. 2003) or a field experiment in which changes in mortality, breeding success or offspring survival were measured following the exclusion of bears from anthropogenic food over a wide area and for several years (cf. Boutin 1990) as was possible in North America following the closure of refuse dumps previously used by many bears (Stringham 1983 but cf. McLellan 1994, Herrero 1985).

The resumption of bear hunting in Slovakia from 1962 was intended to limit population growth and damage (Janík 1997, Kassa 1998b, 2003) but it failed to prevent continued population expansion (Janík 1997, Martínková and Zahradníková 2003). Quotas were planned to remove initially 5% and later 10% of the estimated population per year. Up to 1980 no quotas on age-sex categories were set and the hunt, focussed heavily on trophies, selectively removed large males from the population. This apparently distorted the population's social structure, which some authors believe accelerated population growth and resulted in more instances of nuisance behaviour due to an unnatural abundance of young individuals. This belief led to measures to restore a more natural demographic structure by selectively removing smaller individuals and protecting larger ones (Janík 1997, Kassa 1998b, 2003, Hell and Slamečka 1999, Baláž 2003, Hell 2003, Martínková and Zahradníková 2003). In the period c.1998-2001 bears in general and large adult males in particular seemed to be more numerous in a c.90km^2 area of very high quality bear habitat with minimal human disturbance than in a 400km^2 area of high human use near the southern limit of the contemporary range (cf. Baláž 2002, 2003, Lehocký 2002). Some hunting advocates have taken an almost opposite view, that further removal of large adult males would decrease intra-specific competition thereby increasing the availability of high quality natural habitat to subordinate individuals and hence would reduce instances of nuisance behaviour. Despite the failure of hunting to limit it, population growth now appears to have at least stopped (Hell 2003) and possibly reversed (Fig. 1.1), presumably due to food limitations and density-dependent effects such as intra-specific competition and predation (Taylor 1994, Goss-Custard and Sutherland 1997, Miller *et al*. 2003; see also Kováč 1999, Baláž 2003). Nevertheless it is still claimed that "the number regulation of Slovakia's bear population [by hunting] is unavoidable" (Hell 2003) and "the largest predator in Europe has no natural enemy besides man and only man is able to regulate its population" (Rakyta 2001).

Trophy hunting almost extirpated bears from the Western Carpathians in the early 20th century (Hell and Slamečka 1999) and systematically removed large males from the population in 1962-1989 (Sabadoš and Śimiak 1981). Population data currently available in Slovakia are insufficient for firm conclusions to be reached (Kassa 2003). Mechanisms of population regulation in bears are in any case not well understood (Taylor 1994). Studies of the Scandinavian bear population found decreased cub survivorship following selective removal of adult males, which it was suggested was due to sexually selected infanticide (Swenson *et al*. 1997, 2001a,b). However, Miller *et al*. (2003) found that in heavily hunted populations of brown bears in Alaska cub survivorship was higher and litter sizes were larger or unchanged compared to nearby unhunted populations thought to be near carrying capacity. These authors concluded that density-dependent effects influenced cub survivorship only in populations near carrying capacity. Bear habitat in the Western Carpathians is generally assumed to be saturated (Hell and Finďo 1999, Swenson *et al*. 2000, Zedrosser *et al*. 2001), so the Alaskan model is probably the more pertinent at the present time.

Swenson *et al*. (2000) have pointed out that hunting for goals other than reducing conflicts may not be permitted under current EU regulations. However, there is clearly a strong desire among Slovak hunters for a commercial harvest (see Hell and Slamečka 1999, Hell 2003). Some leading experts believe that hunting and lethal control can be compatible with and even support long-term conservation goals for large carnivores in Europe by mitigating conflicts and providing incentives (LCIE Core Group 2001, Salvatori *et al*. 2002). Sustainable harvesting of European brown bears is apparently possible given adequate data, controls and enforcement of regulations (Swenson *et al*. 2000). Hunters are, understandably, more motivated by profitable trophy hunting in attractive natural habitat than the removal of nuisance bears from the vicinity of tourist infrastructure or settlements (pers. obs. 2001-03, S. Ondruš pers. comm. 2001). Strict limits on the maximum size of bears that can be hunted, intended to restore a more natural population structure (Kassa 1998a, 2003), are very unpopular with hunters and hunting advocates due to the smaller income and lesser prestige of small trophies (Hlásnik 2002a, Hell 2003) and may partly explain the consistent failure since 1994 to fulfil hunting quotas (Kassa 1998a, 2003, Hell 2003). Calls for hunting to be limited to the removal of problem individuals, as recommended in the IUCN's Bear Status Survey and Conservation Action Plan (Hell and Finďo 1999), are strongly opposed by hunting advocates (confusingly, sometimes by the same individual(s), e.g. Hell 2003). On the other hand, a commercial harvest is strongly opposed by conservation advocates (e.g. Baláž 2003).

Observed high densities of bears in Slovakia, believed to be at or near carrying capacity, might be interpreted as indicating that a higher hunting harvest could be compatible with conservation goals (Taylor 1994, Swenson *et al*. 2000, LCIE Core Group 2001). This might also reduce conflicts (LCIE Core Group 2001, Hell 2003) by raising satisfaction in the hunting community and, perhaps, by helping to limit damage. On the other hand, bear habitat in Slovakia is the most fragmented of the major Carpathian countries (Salvatori 2003) and human intrusion into and alteration of habitat is likely to have a considerable impact as a result of accelerated economic development following entry to the EU. Some parts of the population may already be in decline (Chapter 1). In the longer term, even selective removal of habituated and other nuisance individuals could begin to pose a threat to bear populations as human use of and change to currently occupied bear habitat continue to increase (Mattson 1990). Diminishing availability to bears of refuges free from human disturbance has the potential to lead to a greater degree of habituation to humans and more bear-human conflicts (Baláž 2003). Mattson (1990) suggested that there are only two possible options that would allow long-term survival of viable bear populations in such circumstances: 1) allow human use of bear habitat to increase but accept the heightened risk of bear-human conflicts or 2) maintain areas free of human intrusion for bears but continue to remove nuisance individuals. It is not yet clear how either of these strategies could be implemented effectively in Slovakia given the current socio-political and economic climate. Tolerance and acceptance of large carnivores are high among rural residents in a region with high bear densities and relatively frequent carnivore-human conflicts (Wechselberger *et al.* in prep.). The main problem appears to be the stand-off between advocates of hunting versus those of protection coupled with the rise of private economic interests and lobbying. Some form of zoning of management priorities and actions (Mech 1995a, Linnell *et al.* 1996, 2002a, Baláž 2003, Fritts *et al.* 2003) is highly desirable but this has been opposed by hunting advocates. Non-lethal preventive measures and treatments of nuisance individuals offer some options (Rauer *et al.* 2003, Rigg and Baleková 2003) if sufficient alternative food sources and refuges can be preserved (see Gibeau *et al.* 2001). Increasing hunting quotas and lethal control of nuisance animals therefore require careful monitoring of population trend and demographic structure and, in view of Slovakia's commitments to bear and habitat conservation, should no longer be regarded as the preferred solution to all bear-human conflicts.

Wolves

The assertion that wolves have exceeded biological carrying capacity in Slovakia is irreconcilable with the low proportion of anthropogenic foods in wolf diet found by the present study and all previous quantitative studies. Little data is available from Slovakia that would allow robust conclusions to be drawn on the influence of predation on wild prey populations. Studies elsewhere have found that wolf predation can be both additive and compensatory and may or may not limit prey populations (e.g. National Research Council 1997). The apparent reduction of wolf numbers in both Slovakia and south-west Poland following reductions in numbers of red deer by human hunters suggests that the "bottom up" effect of availability of prey limiting predator numbers prevailed over the opposite, "top down", effect of predators on prey. Excluding the edges of the range in the Czech Republic and Hungary, the density of the wolf population in the Carpathian Mountains appears to be at its lowest in Slovakia (Salvatori *et al.* 2002).

The majority of Slovak hunters and game managers seem convinced that wolf populations would, without lethal control by human hunters, continue to grow indefinitely. However, food availability i.e. vulnerable prey biomass is probably the ultimate limiting factor (Mech 1995b, Fuller *et al*. 2003). Density dependence is also of fundamental importance in population biology (Goss-Custard and Sutherland 1997). Natural wolf population regulation mechanisms are thought to include suppression of reproduction and decreased pup survival (Mech 1970, but cf. Fuller *et al*. 2003). Wolf numbers have fallen recently in south-east Poland despite a ban on wolf hunting, presumably due to decreased prey base (Śmietana 2002, W. Śmietana pers. comm. 2002, H. Okarma pers. comm. 2003). A moratorium on hunting in Algonquin National Park from 1958 also had no apparent effect on wolf numbers (The Raven 1998). It may be that high wolf mortality in Slovakia due to harvest by humans has been mostly compensatory (cf. The Raven 1998, Fuller *et al*. 2003) or has actually been stimulating increased reproduction. J. Lukáč (pers. comm. 2003) suggested that the annual winter cull simply removes most of the young of the year along with a few older animals. Voskár (1976, 1993) believed that the removal of adult wolves led to an increase in young animals (cf. Mech 1970), which he thought resulted in more predation on livestock.

Wechselberger *et al*. (in prep.) found widespread acceptance of carnivores in Slovakia among residents in areas with both high and low densities of carnivores and carnivore-human conflicts, refuting the hypothesis that social carrying capacity has been exceeded. Whilst attitudes to wolves were typically more negative than those to bears and lynx, this probably at least partly relates to cultural perceptions linked to past history rather than present reality and therefore may change with education and as people have more experience of co-existence with wolves (Boitani 1995, 2003b, Fritts *et al*. 2003). Wechselberger *et al*. (in prep.) found that the most negative attitudes were held by farmers and shepherds. A number of legal measures have been taken to mitigate carnivore-livestock conflicts. Implementation of preventive measures has been greatly impaired by the apathy and lack of knowledge of farm personnel (Chapter 4). Although hunters were found to hold more positive attitudes towards large carnivores (Wechselberger *et al*. in prep.), many wanted to increase lethal control of wolves despite their low density and recent population decline.

SUMMARY

- In order to evaluate spring-autumn diet of carnivores in livestock-raising areas a total of 373 bear and 70 wolf scats were collected in the Tatra and Fatra Mountains from March to November 2001-03 and their contents analysed.

- Bear diet was quantified using correction factors to convert % volume data into estimates of % dry matter ingested. The proportion of each prey item in wolf scats was calculated as frequency of occurrence and mean % volume. Experimentally derived regression equations were then used to convert the data into estimates of % biomass consumed.

- Livestock did not comprise a major component of the diet of either bears or wolves.

- Bear diet varied greatly among seasons. Plant material constituted 90.8% of total scat volume and 83.5% of estimated dry matter ingested. Green vegetation, mainly grasses/sedges and herbs, dominated in spring and early summer, with a shift to fruits (*Vaccinium myrtillus*, *Rubus idaeus*, *Vaccinium vitis-idaea*, *Sorbus aucuparia*) in July-October.

- Many bears utilised anthropogenic food sources, including hunters' ungulate feeding stations, crops (*Zea mays*, *Avena sativa, Triticum aestivum*), refuse and, to a lesser extent, orchards (*Malus* spp., *Prunus domestica*), but no domesticated vertebrates were identified in any of the analysed scats. Invertebrates occurred significantly more frequently and in greater quantities than large mammals.

- Wild ungulates formed the main prey base of the wolf (mean % volume in scats = 91.4%). Cervidae (*Cervus elaphus*, *Capreolus capreolus*) occurred 3.5 times more frequently in scats than wild boar (*Sus scrofa*) and comprised 4.4 times more of the estimated biomass consumed. Juveniles (<1 year old) were estimated to account for 65.7-70.7% of cervid biomass consumed.

Chapter 3

Extent and patterns of predation by large carnivores on livestock in Slovakia

Abstract: This chapter examines the scale of the conflict over predation by wolves (*Canis lupus*), bears (*Ursus arctos*) and lynx (*Lynx lynx*) on livestock in the Slovak Carpathian Mountains. Losses reported by shepherds and farmers during a survey of 164 flocks of sheep (*Ovis aries*) across 20 regions of Slovakia are presented and analysed in terms of distribution among regions, seasons, time of day and correlation to estimated numbers of sheep and carnivores. Cautious estimates are derived for the total loss to large carnivores in 2001-03 and factors associated with high losses at individual farms are investigated.

CONTENTS

INTRODUCTION

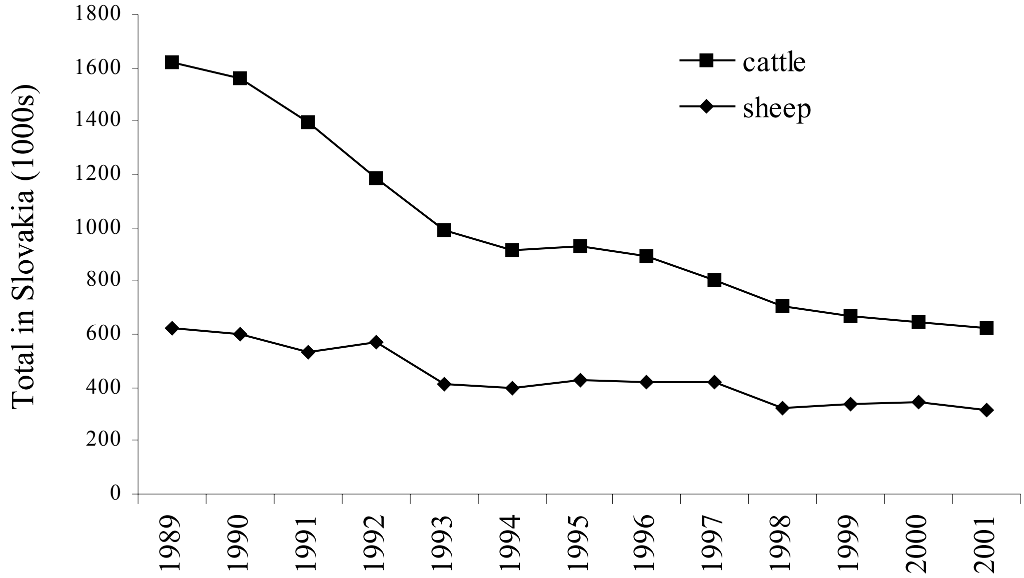
The Wallachian system of sheep (*Ovis aries*) breeding, based on transhumance, was introduced to the Slovak Carpathians from Romania and the Balkans during the Wallachian colonisation from the 14th to the 17th centuries (Laurinčík *et al*. 1958, Podolák 1967, 1982, 1984, Urbancová 1975, Stoličná 1997, Zuskinová 1999). In contrast to earlier, largely lowland breeding of sheep for wool, meat and skins, it provided a means of intensively utilising upland areas for livestock grazing and milk production. In the Wallachian system, sheep and goats (*Capra hircus*) were gathered into flocks in the spring and first grazed on meadows and pastures around villages and in valleys until mid May. Then, following snow-melt, they were taken by seasonally employed shepherds to natural pastures on mountain ridges above timberline ("hole") or man-made pastures in forested areas created by felling and removing trees ("poľany"). These pastures were up to 10km from the nearest settlement and between 1,000 and 2,000m a.s.l., so flocks were kept at temporary folds throughout the summer, where shepherds also stayed in a camp or *salaš* (Laurinčík *et al*. 1958). The remoteness of these pastures, their proximity to forest cover and lack of a secure enclosure at night left livestock vulnerable to predation.

Shepherds in mountain areas usually kept several large dogs (*Canis lupus familiaris*) to protect the flock (Chapter 4) and were sometimes compelled to actively defend livestock from the attacks of wolves (*Canis lupus*) and bears (*Ursus arctos*), particularly at night (Teren (1987; see also Pčola 2003). Up until the mid 20th century large carnivores were intensively persecuted throughout their European ranges in retaliation for predation on livestock (Jamnický 1993, Breitenmoser 1998). According to Hungarian hunting laws VI/1872 and XX/1883, also valid in Slovakia, bears, wolves and lynx (*Lynx lynx*) could be killed at any time by anyone on his or her own land (Jamnický 1993, Hell and Slamečka 1996, Ciberej 2002). Traps for carnivores were placed at the end of March and removed at the end of May or beginning of June, before livestock were put out to graze. Bounties were paid and specialist bear and wolf hunters used all available means, including poisoning with strychnine during the period 1855-1880 (Podolák 1967:142, Teren 1987:84-85, Jamnický 1993, Hell and Slamečka 1996). Persecution and sport hunting virtually eradicated wolves (Hell *et al*. 2001a) and lynx (Hell and Slamečka 1996) from Slovakia and reduced the population of bears in the Western Carpathians to relict level (Hell and Slamečka 1999).

The early forms of the Wallachian system in Slovakia closely resembled summer livestock camps still extant in Romania and Bulgaria at the beginning of the 21st century (Slavkovský 1997, pers. obs. 2002-03). In the most widespread form, sheep owners formed a society (*salašný spolok*) and elected a manager (*salašník*) who hired shepherds (*valasi*), arranged common pastures and determined the division of milk products. Some flocks belonged to single owners, or the owner of a large flock also pastured the sheep of other owners. Milking and cheese-making were done by hand under the auspices of the head shepherd (*bača*). The grazing season traditionally began on St. George's Day (24th April) and lasted until St. Michael's Day (29th September), Demeter's Day (26th October) or, exceptionally, until St. Martin's Day (11th November), although livestock was grazed outdoors for as long as possible. Productivity was assessed on 24th June, St. John's Day (Laurinčík *et al*. 1958, Podolák 1984, M. Dzúrik pers. comm. 2002). Young cattle (*Bos taurus*) were also grazed on mountain pastures, in some areas without supervision by herdsmen, while dairy cows were generally pastured on the highest quality pastures around villages to promote milk production and facilitate milking. In autumn, livestock was brought back to graze on lower pastures, fallow land and scythed meadows nearer the villages until the onset of winter, when they were closed in barns and fed on hay, dried clover or foliage cut from deciduous trees (Slavkovský 1997).

Collectivisation of farming during the socialist period of 1948-89, parodied in the Slovak feature film, "Očovské pastoràle", directed by J. Zachar (1988), had major socio-economic repercussions that hastened the decline of the transhumance system, a decline that has continued during subsequent reforms and establishment of a market economy. Despite substantial subsidies, at the end of the 20th century around 45% of all farms in Slovakia were unprofitable and sheep numbers declined by 46% from 1990 to 1998 (MP SR 2000b; Fig. 3.1). Sheep breeding remains largely concentrated in Carpathian regions and retains most of the features described above, but grazing on alpine meadows has been largely excluded from the Tatra Mountains, where timberlines were substantially lowered and the quality of grassland adversely affected by over-grazing (Jamnický 2000).

Fig. 3.1. Total numbers of cattle and sheep in Slovakia during the period 1989-2001 (data from SOSR 1997, 2000, 2002, MP SR 2000c, Žatkovič 2001a,b).

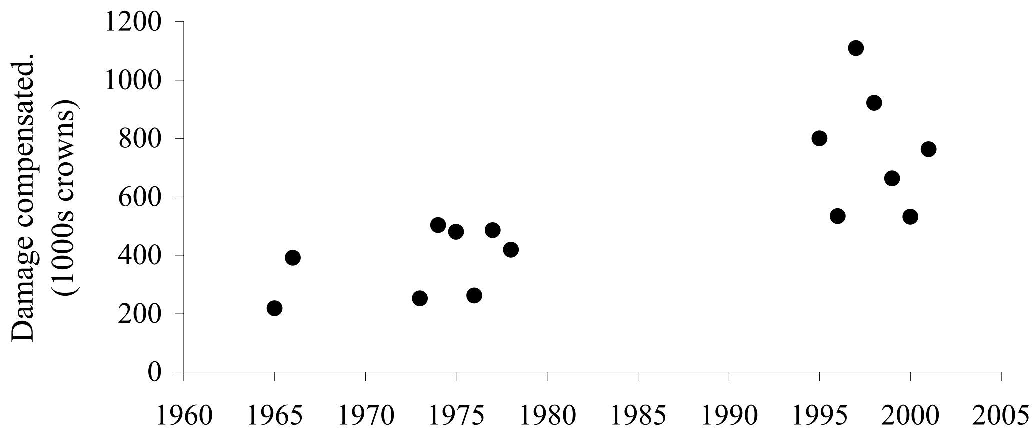


Many flocks are run by commercial enterprises based on former cooperative farms, a minority of them still in state ownership. Since the mid 1960s there has been a growth in the use of milking machines (Zuskinová 1999:115-117). Stricter controls on hygiene imposed by the European Union may threaten the future viability of Wallachian-style sheep breeding at less profitable farms that cannot afford to invest in new equipment (MP SR 2000b). As sheep dairy products and wool are now less important to village communities, shepherds have lost much of their previous status in society (I. Zuskinová pers. comm. 2003). Farmers struggle to find enough men able and willing to take on the long hours and hard manual labour of hand-milking 80-100 sheep up to three times daily while living in basic conditions and often being unable to return home for weeks at a time, so they are forced to employ less than ideal candidates (Podolák 1984, J. Podolák pers. comm. 2002, pers. obs. 1998-2004). Alcoholism is widespread amongst farm workers and standards of animal husbandry can be very poor (pers. obs. 1998-2004, R. Coppinger pers. comm. 2003). Operations are often somewhat loosely managed, with carcasses left to rot in close proximity to live animals, on pastures or within the *salaš* or farmyard (pers. obs. 1998-2003).

Protection of livestock has also relaxed. Shepherds no longer sleep by the flock as they did in the past (Podolák 1962, 1967, 1972) and still do in Romania (pers. obs. 2002-03), but in a nearby cabin, caravan (*maringotka*) or building. Livestock guarding dogs are almost everywhere permanently chained.

Against this background of decline and change, large carnivores have returned and with them the ancient conflict over livestock depredation (Klescht 1983, Janík 1997, Rigg and Finďo 2000, Martínková and Zahradníková 2003; Fig. 3.2). The situation is, however, quite different to when large carnivores were last relatively numerous. They are now protected by law in Slovakia, as in most European states, in order to meet national and international wildlife conservation goals (Boitani 2000b, Breitenmoser *et al*. 2000, Swenson *et al*. 2000, Salvatori *et al*. 2002), although the degree of protection is rather limited for wolves. Linnell *et al*. (2001b) concluded that large carnivores can persist even at high human densities given favourable management policy. The long-term survival of viable populations of wolves, bears and lynx could nevertheless be compromised if insufficiently mitigated conflicts lead to greater hostility towards carnivores and rejection by hunters, farmers and the wider public of measures necessary to protect them (Breitenmoser 1998, Sillero in Rigg 2001a).

Fig. 3.2. Total compensation paid for damage attributed to bears in Slovakia during the periods 1965-1978 and 1995-2001. Figures for the years 1965-1978 are in Czechoslovak crowns (Kčs) whereas those from 1995 onwards are in Slovak crowns (Sk). During the present study €1 ≈ 40 Sk. (Data are from Šprocha 1977, Sabadoš and Śimiak 1981, Somorová 1997, Kassa 1999, 2001, 2002, Kassa in Pilinský 2001.)



Ongoing conservation advocacy following the successful recovery of carnivores has led to a backlash, mainly from hunting organisations and livestock breeders (Voskár 1993). Predation on livestock and other forms of damage to human interests in Slovakia are frequently blamed on the "over-population" of bears and wolves (Wechselberger *et al*. in prep.). Hell and Finďo (1999:97) stated that, even allowing for the inaccuracy of hunters' population estimates, there are currently 1.5-2.0 times as many bears in Slovakia as "considered optimal". This is claimed to be at least partially responsible for damage to beehives, livestock and crops as well as the arising of human food-conditioned and human habituated individuals (Hell 2003). In support of its campaign for relaxation of restrictions on hunting and increased lethal control of carnivores, the Slovak Hunting Union has compiled a dossier (Krajniak 2003) on losses allegedly caused by large carnivores based on the unverified reports of local hunting clubs. Game managers at the Agriculture Ministry regard the goal of the annual open season on wolves as being to reduce wolf numbers (J. Hlásnik pers. comm. 2004). Negative aspects of bears and wolves, often accompanied by pro-hunting rhetoric, are preferentially publicised by the popular press, influencing public opinion (Wechselberger *et al*. in prep.) and fostering the common explanation that conflicts are the result of there being too many carnivores and are therefore best reduced by allowing hunters to shoot more wolves and bears. There are currently no reliable state-wide data on the numbers of carnivores in Slovakia or estimates of what might constitute minimum viable populations in the Western Carpathians. As of August 2004 there were still no limits on the number of wolves that could be killed and no comprehensive national management plans or clear population goals for large carnivores, as recommended by the Council of Europe's action plans for the bear (Swenson *et al*. 2000), wolf (Boitani 2000b) and lynx (Breitenmoser *et al*. 2000).

Kaczensky's (1996, 1999) study of 12 European countries with large carnivores concluded that there was no obvious link between predator population size and losses of livestock. She reviewed a number of cases in which very small numbers of carnivores, even a single bear, were responsible for as much as half of all damage in certain years. Local differences in guarding techniques seemed to be the most important factor explaining differences in predation levels. Species of livestock, type of range (forested or open) and an alternative food base were also influential. Studies in Europe have shown that, within the same region, properly guarded livestock suffered lower losses than unguarded or poorly guarded stock (Blanco *et al*. 1992, Boitani and Ciucci 1993). In response to wolf predation at a state-owned farm in eastern Slovakia in 1982, Klescht (1983) wrote that every flock should be accompanied by a responsible shepherd with livestock guarding dogs, noting that even one wolf can cause high losses to neglected livestock. Teren (1987:122) also considered it the responsibility of shepherds to protect flocks from predators with "a sufficient number of good, large dogs". Voskár (1993) recommended that insurance companies should insure livestock against wolf predation only if each flock had 2-3 adult guarding dogs, aversive devices and "a sufficient number of personnel". Factors have been identified that appear to predispose particular farms to high losses (Robel *et al*. 1981 in Fritts *et al*. 2003, Paul 2000, Treves *et al*. 2001 but cf. Mech 2000, Jedrzejewski *et al*. 2003). Studies in Europe (Jedrzejewski *et al*. 2003) and N. America (Knight and Judd 1983, Muhly *et al*. 2003, Treves *et al*. 2001, 2003) found that only a minority of individual carnivores in a given area killed livestock. Linnell *et al*. (1996, 1999), although questioning the paradigm of "problem individuals" (abnormally persistent livestock killers), or at least the possibility of identifying and removing them, considered selective control preferable to widespread population reduction, as advocated by the Slovak Hunting Union and the Agriculture Ministry.

The present research sought to investigate some of the claims commonly made in Slovakia concerning large carnivore predation on livestock and to quantify the scale of the problem. It was hypothesised that factors besides numbers of carnivores might best explain differences in levels of losses between farms and regions as well as over time. The following objectives were set:–

(1) Describe and quantify the extent of predation on livestock in Slovakia.
(2) Examine seasonal, regional and local variation in reported losses.
(3) Investigate the relationship between the reported levels of losses suffered to individual flocks and variables including region, predator species, estimated numbers of predators, livestock density, number and species, flock size, shepherds' experience and the prevention measures used.
(4) Document cases of high losses, including surplus killing, and investigate their relationship to the above factors.
(5) Identify any factors that might characterise farms suffering high losses.

MATERIALS AND METHODS

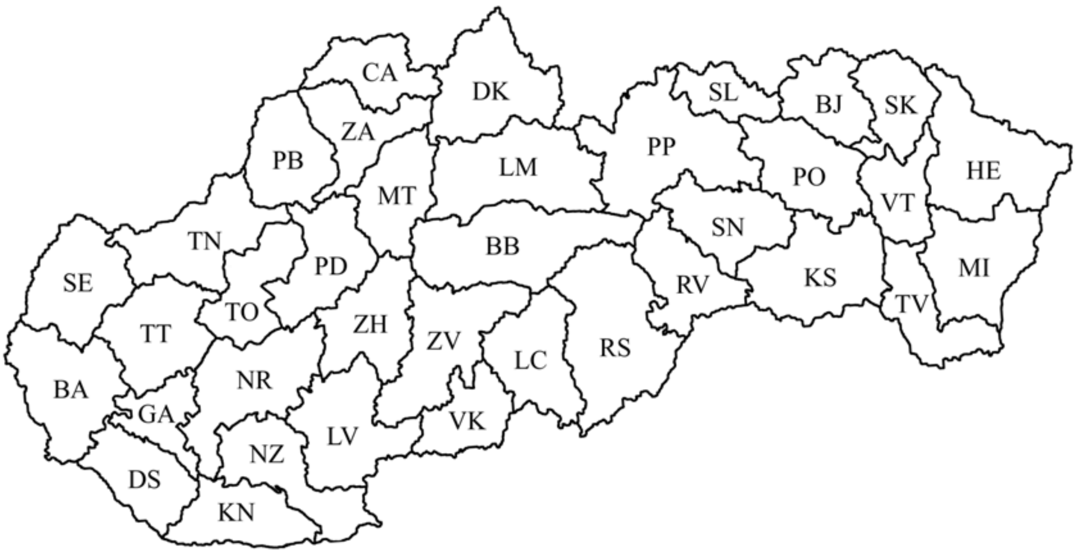
Study area

The extent and patterns of predation on livestock in Slovakia were studied at the national, regional and local levels. According to official statistics (SOSR 2002), in 2001 the Slovak Republic had a total area of 49,035km^2 with a mean human population density of 110.1km^{-2}. Over half the country lay within the Carpathian Mountains, 59% between 300m and 2,655m a.s.l. The remainder was primarily floodplains of the Danube and its tributaries connected to the Panonian–TransTisa geographical region. In the early 21st century approximately 50% of Slovakia's land surface was used for agriculture. Permanent grassland increased steadily during the period 1997-2001, reaching a total area of 8,740km^2 or 17.8% of the country in 2001 (SOSR 2002; see also Feranec and Oťaheľ 2001). Numbers of cattle had declined steadily from 1.36 million in 1960 to 625,000 in 2001 and numbers of sheep from 465,000 to 316,000 respectively (MP SR 2000c, SOSR 2002; Fig. 3.2). Published data from a survey of farms (MP SR 2000c) showed that the vast majority of remaining sheep were in the Carpathian regions, closely corresponding to the largely overlapping ranges of bears (Martínková and Zahradníková 2003), lynx (Adamec 2003) and wolves (Strnádová 2000): 78.4% of all sheep were in regions with bears, 88.9% in regions with wolves and 89.1% with bears and/or wolves (calculated from data in MP SR 2000c, Kaštier 2004); compare Appendices 1 and 2. J. Dubravská (pers. comm. 2002) at the Ministry of Agriculture estimated that in 2002 there were approximately 300 *salaše* (seasonal sheep camps) in Slovakia, the majority of them in areas with large carnivores.

Sources of data

Data on livestock were obtained from published surveys by the Slovak Republic's Statistical Office (SOSR 1997, 2000, 2002) and Agriculture Ministry (MP SR 2000a,b,c, 2002, Žatkovič 2001a,b) as well as information compiled by regional branches of the Agriculture Ministry and State Veterinary and Food Institutes in response to a written request in 2001. The data so obtained yielded figures on the livestock industry at the level of administrative region, of which there were 36 (Fig. 3.3). This was therefore taken as the basic unit in analyses of losses to predation. Verified losses caused by bears in the period 1998-2002 were assessed from the compensation claim records filled out by damage inspection commissions and held at the State Nature Conservancy (provided by M. Adamec) as well as Veľká Fatra National Park (Ľ. Remeník), Tatranský National Park, Liptovský Mikuláš District Office (D. Kováč), Slovenský Kras National Park (M. Olekšák) and published in the literature (Kassa 1999, 2001, 2002). Such records were mostly unavailable for other protected predator species such as the wolf because, until a change in law valid from 2003, compensation was only payable for damage caused by bears (Kassa 2003). Additional figures on livestock losses to large carnivores were compiled from the published literature (Sabadoš and Śimiak 1981, Teren 1987, Jamnický 1988, Voskár 1993, Kaczensky 1996, 1999, Somorová 1997, Hell *et al*. 1997, 2001a, Hell and Slamečka 1999, 2000, Rigg 2002a, 2003b, Martínková and Zahradníková 2003, Finďo 2003) and unpublished reports (Finďo 2000, 2001, 2002b, Hlásnik 2002a, Krajniak 2003).

Fig. 3.3. Abbreviations used for administrative regions of Slovakia. See Appendix 1 for details.



In order to investigate the relationship between predator numbers or density and reported losses, a summary by district of estimated wolf, lynx and bear numbers, damage to livestock and game as well as hunting results for the years 2000, 2001 and 2002 was commissioned from Zvolen Forestry Research Institute (Kaštier 2004; see

Appendix 2) using figures from the Poľov 1–01 national hunters' questionnaire, which all hunting ground users are obliged to complete annually. These were the only available figures from Slovakia that dealt with large carnivore populations nationwide. Workers compiling the figures for Poľov 1–01 acknowledge that hunters' estimates of large carnivore populations are substantially over-estimated (Herz 1999, Lehocký 2002, Lehocký *et al*. 2003a) due to the inherent difficulty of surveying wildlife populations (Lancia *et al*. 1996), unintentional multiple counts of the same individuals within and among hunting grounds and possibly deliberate misrepresentation (Martínková and Zahradníková 2003). Therefore the estimated relative distributions of large carnivores among regions were considered rather than absolute numbers of carnivores. Reports of carnivores from Poľov 1–01 (Kaštier 2004) were used on a present/absent basis to distinguish regions with and without regular occurrence of wolves and bears: a region was considered to have wolves/bears if they were reported by hunters in ≥ 2 of the three years.

Survey of farm conditions and reported losses

Data collection

It was apparent from damage records that in Slovakia most losses to carnivores concerned sheep at Wallachian-style farms in upland areas and that predation on livestock by lynx was rare (it was greater in the 1950s and 1960s; Hell and Sládek 1974, Hell and Slamečka 1996), tending to involve single sheep wandering away rather than attacks on flocks in corrals (Hell and Slamečka 2000). Attention during fieldwork was therefore focussed on wolf and bear predation in Slovakia's Carpathian regions. Aided by the data gathered, as well as information from shepherds, farmers and other contacts plus prior knowledge of farm locations, during August and September 2003 a stratified random sample (Bart and Notz 1996:35-36, Dytham 1999:25) of 164 flocks of sheep belonging to 147 farms in 18 of the 19 regions identified as having wolves and bears (and lynx) plus two of the additional five regions with wolves (and lynx) only. The regions covered included 57.4% of Slovakia's surface area, 83.4% of the national sheep herd, c.94% of bears and c.97% of wolves (SOSR 1997, MP SR 2000c, Kaštier 2004). In each region, an effort was made to include flocks grazed in a representative variety of locations at different altitudes and distances from main roads and settlements. The flocks visited were reported by shepherds to contain a total of c.79,000 sheep, representing c.28% of sheep in the regions surveyed, c.26% of sheep in all regions with wolves and bears and c.23% of the national herd. For each flock, the data in a pre-prepared recording schedule (Appendix 3) were collected by semi-structured interview with one or more shepherd(s) and/or other farm personnel (manager, veterinarian, accountant). Whenever possible, both the shepherd(s) working with the flock and the livestock owner or home farm were contacted to cross-check information. The recording schedule was usually completed by the interviewer. A pilot study in 2000-02 and previous experience were taken into account when designing the schedule to anticipate what type and number of questions most shepherds and farmers would be able and willing to answer (Moser and Kalton 1971, Baker 1988, Oppenheim 1992). The response rate to the interview (though not to every item) was >95%. At the majority of flocks (n=95, 57.9%), a shepherd or farmer also gave answers to a questionnaire on knowledge and attitudes (Wechselberger *et al*. in prep.; see Chapter 5). The response rate for this questionnaire was >90%. As many farms as possible were contacted by telephone or re-visited in November-December to confirm information given previously and to include reports of losses during the period August to November 2003.

Due to the complexity inherent in some of the questions (for example, what is considered to constitute a preventive measure), face-to-face interviewing was preferred to a postal survey (as conducted by Finďo 2001, 2002b, 2003) so that ambiguous answers could be clarified. Although interviews are subject to interviewer bias and error, site visits allowed farm conditions and use of preventive measures to be verified directly. Shepherds' accounts of losses at other farms were found to be highly unreliable and so were discounted. Likewise, media reports of losses were only considered if they could be independently verified, usually by a site visit within a week of the incident. If confirmed, they were included in the analysis of high losses but were not added to the survey of farm conditions and reported losses to avoid bias towards events more likely to attract publicity (cf. Voskár 1993, Finďo 2000). The random design for sampling of farms avoided the very probable error of non-respondents differing significantly from respondents (Scott 1961, Moser and Kalton 1971). This potentially serious bias can invalidate survey results, particularly when response rate is low and non-respondents are not followed up. Other likely sources of error, such as comparing reports from disparate sources and varying methodology within the same comparison were avoided.

Data analysis

When reports on losses differed among farm personnel on the same farm, the highest figure was used. If the same respondent estimated losses as a range, the mid-point was taken. Results from farms that could not be re-contacted at the end of the grazing season were excluded from analyses of losses for 2003 in order to avoid bias towards the earlier part of the year, but were included in 2001 and 2002 and in the analysis of farm conditions and preventive measures. To estimate total national losses, damage levels in regions with bears (TO, ZH) and wolves (MI, VT, ZH) that were not included in the survey were estimated by extrapolating from the percentage of sheep reported lost in the adjoining surveyed region which seemed most similar in terms of geography, numbers of sheep plus numbers and distribution of carnivores. In order to assess the validity of survey responses (Moser and Kalton 1971), losses reported by shepherds and farmers participating in the survey were compared to records of compensation claims. These were considered the most reliable measure of losses due to the requirement for a site visit by a damage inspection commission that included qualified personnel experienced in assessing cause of death. Losses to bears were compensated after a site visit if the commission concurred that the damage was caused by bears and if "reasonable prevention measures" were judged to have been in place. Some farmers may not have reported trivial losses. On the other hand, there were likely to be some false claims; compensation was occasionally paid even if damage was not judged to have been caused by bears (S. Ondruš pers. comm. 2000). Prior to 2003 the law did not require damage by wolves to be compensated and so it was rarely dealt with by inspection commissions. Reported losses and damage inspection reports were also compared to hunters' estimates of livestock killed, which were available for the whole country in Poľov 1-01 (Farkáš *et al*. 2001a,b, Lehocký *et al*. 2003a,b, Kaštier 2004) but were presumably the least accurate figures due to being a secondary source of information. The data collected on farm conditions and reported losses were not normally distributed (Anderson-Darling test, $P<0.05$) and so were analysed using non-parametric statistics within the software package Minitab for Windows Release 13.

RESULTS

National extent of reported losses

Losses to bears and wolves during the period 2001-03 as reported by shepherds and farmers for 154 flocks surveyed in 18 regions with both bears and wolves plus an additional 10 flocks in two regions with wolves only are summarised in Tables 3.1 and 3.2. A total of 85 sheep were reported lost to bears in 2001 from a total of 66,970 sheep at 135 flocks, equivalent to a mean loss of 0.6 sheep/flock (range=0-35) or 0.13% of all sheep in the surveyed flocks. The respective figures in 2002 were 128.5 sheep lost from a total of 69,720 sheep at 141 flocks, mean=0.9 sheep/flock (range=0-25) or 0.18% of sheep. In 2003, 78 sheep were reported lost to bears from a total of 64,471 sheep at 133 flocks, mean=0.6 sheep/flock (range=0-20) or 0.12% of sheep. Reported losses to wolves were as follows: 341 sheep from a total of 69,436 sheep at 141 flocks, mean=2.4 sheep/flock (range=0-60) or 0.49% of sheep in the surveyed flocks in 2001, 508.5 sheep from a total of 73,115 sheep at 149 flocks, mean=3.4 sheep/flock (range=0-63) or 0.70% of all sheep in 2002 and 297.5 sheep from a total of 68,316 sheep at 142 flocks, mean=2.1 sheep/flock (range=0-22) or 0.44% of all sheep in 2003. If only flocks in regions with both species are considered, total reported losses to wolves were 3.7-3.8 times greater than those to bears in all three years. Using the Sign test with flock as the sample unit, the difference was significant in 2002 (n=140, P<0.05) and highly significant in 2001 and 2003 (n=133, P<0.005). This could reflect either a genuine difference in damage levels or some other form of difference, such as accuracy of reporting or perceptions of the two predator species (see Discussion).

If the observed mean percentage loss/flock is used to estimate the total national loss from the number of sheep in regions with bears and wolves, estimates with 95% confidence intervals for the total loss of sheep to bears are as follows: 323.6±261.0 in 2001, 570.6±338.4 in 2002 and 324.9±193.4 in 2003. Differences among years are statistically significant (χ^2=99.56, d.f.=2, P<0.001). The respective estimates for losses of sheep to wolves are 1,952.5±1,250.2, 2,432.0±1,169.7 and 1,504.5±604.7. Differences among years are statistically significant (χ^2=219.20, d.f.=2, P<0.001).

This method does not account for variation in the level of losses among regions. By extrapolating from reported losses at surveyed flocks to a total estimated loss in each region on the basis of the proportion of sheep surveyed, as well as by deriving estimates of losses in regions not surveyed, the total loss of sheep to bears in Slovakia was estimated at 168.6 animals in 2001, 397.4 in 2002 and 302.5 in 2003 (Table 3.1). The respective estimates for wolves were 1,361.7, 2,078.9 and 1,435.1 (Table 3.2). The annual national loss of sheep estimated on the basis of farmers and shepherds reports was therefore 3.6 times greater for wolves than for bears in 2003, 6.9 times greater in 2002 and 8.1 times greater in 2001, all statistically significant differences (Mann-Whitney *U* test, $P<0.05$).

Taking 340,000 as the approximate total number of sheep in the Slovak Republic in 2001-03 (SOSR 2002) and deriving the number of sheep in each region on the basis of figures in MP SR (2000c; see Appendix 1), it follows that there were c.266,400 sheep in the 20 regions with bears. The level of annual loss to bear predation estimated on the basis of farmers' and shepherds' reports (168.6-397.4 sheep/year) therefore implies an annual loss to bear predation of 0.06-0.15% of all sheep in regions with bears or 0.05-0.12% of all sheep in Slovakia. Based on an estimate of c.302,200 sheep in the 23 regions with wolves, the reported loss to wolf predation was 0.5-0.7% of all sheep in regions with wolves or 0.4-0.6% of all sheep in Slovakia. Using the range of total annual damage nationally as estimated from reported losses at surveyed flocks together with the widely accepted population estimate for brown bears (600-800 individuals; Hell 2003, Kassa 2003) it was estimated that bear predation caused a mean loss of 0.2-0.7 sheep/bear/year in Slovakia in 2001-03. Taking 200-300 individuals as an approximate estimate of the number of wolves in Slovakia during this period (see Chapter 1), the equivalent figure for wolf predation was estimated at 4.5-10.4 sheep/wolf/year.

From the above figures it follows that the annual damage allegedly caused by large carnivores to the sheep industry simply in terms of the replacement value of lost animals (i.e. excluding lost production, loss of earnings, etc.), based on a typical average compensation payment in 2001-02 of 2,000 Sk or c.€50/sheep (Ľ. Remeník pers. comm. 2002, D. Kováč pers. comm. 2002), was c.€8,450-19,850 by bears and

Table 3.1. Sheep lost to bear predation reported for 154 flocks in 18 regions with bears and extrapolations for regions with bears not surveyed. Estimates of total loss to bears in each region in 2001-03 were extrapolated by percentage of sheep surveyed. The number of flocks surveyed in each region is given in brackets. Total national loss was estimated by summing estimated regional losses.

	2001			2002			2003		
Region (*n* flocks)	% of sheep	reported losses	total loss	% of sheep	reported losses	total loss	% of sheep	reported losses	total loss
BB (12)	20.5	0	0.0	20.5	7	34.1	19.1	18	94.2
BJ (6)	71.0	0	0.0	71.0	0	0.0	43.9	0	0.0
CA (5)	17.2	0	0.0	13.9	0	0.0	11.0	0	0.0
DK (14)	33.8	5	16.0	31.2	23	73.6	31.2	0	0.0
HE (6)	38.1	0	0.0	38.1	0	0.0	26.8	0	0.0
KS (5)	34.8	0	0.0	34.8	0	0.0	10.9	0	0.0
LC (4)	12.7	0	0.0	8.0	0	0.0	12.7	0	0.0
LM (19)	49.8	39	86.2	47.9	83.5	174.3	48.3	12.5	25.9
MT (12)	43.3	0	0.0	43.3	0	0.0	40.5	0	0.0
PB (3)	10.3	0	0.0	10.3	0	0.0	10.3	0	0.0
PD (5)	80.8	35	43.3	80.8	0	0.0	80.8	20	24.8
PP (10)	25.0	0	0.0	25.0	0	0.0	22.4	0	0.0
RS (12)	17.9	0	0.0	12.8	10	78.2	17.9	15	84.0
RV (11)	24.1	0	0.0	16.5	0	0.0	21.9	7	31.9
SL (8)	55.4	4	8.2	55.4	0	0.0	55.4	0	0.0
SN (9)	18.7	0	0.0	18.7	0	0.0	11.0	0	0.0
TO (0)	0.0	-	0.0	0.0	-	0.0	0.0	-	0.0
ZA (5)	52.5	0	0.0	52.5	0	0.0	52.5	0	0.0
ZH (0)	0.0	-	4.7	0.0	-	11.7	0.0	-	13.1
ZV (8)	22.8	2	10.2	19.7	5	25.4	17.5	5	28.6
Total	(19.7)	85	168.6	(20.5)	128.5	397.4	(19.0)	78	302.5

Table 3.2. Sheep lost to wolf predation reported for 164 flocks in 20 regions with wolves and extrapolations for three regions with wolves not surveyed. See caption to Table 3.1. for methodology.

	2001			2002			2003		
Region (*n* flocks)	% of sheep	reported losses	total loss	% of sheep	reported losses	total loss	% of sheep	reported losses	total loss
BB (12)	18.2	24	131.9	20.5	105	512.2	19.1	24	125.6
BJ (6)	71.0	0	0.0	71.0	0	0.0	43.9	0	0.0
CA (5)	13.9	0	0.0	13.9	0	0.0	11.0	6	54.5
DK (14)	31.2	77	246.5	31.2	188	601.8	31.2	78	249.7
HE (6)	38.1	12	31.5	32.5	11	33.9	26.8	12.5	46.6
KS (5)	34.8	0	0.0	34.8	0	0.0	10.9	0	0.0
LC (4)	8.0	0	0.0	8.0	0	0.0	12.7	0	0.0
LM (19)	45.3	56	123.7	47.9	72	150.3	48.3	12	24.8
MI (0)	0.0	-	17.7	0.0	-	19.1	0.0	-	26.2
MT (12)	43.3	63	145.7	43.3	0	0.0	40.5	0	0.0
PB (3)	10.3	0	0.0	10.3	0	0.0	10.3	0	0.0
PD (5)	80.8	0	0.0	80.8	0	0.0	80.8	0	0.0
PO (6)	11.0	24	219.1	13.0	30	231.0	11.0	3	27.4
PP (10)	25.0	9	36.0	25.0	27	108.1	22.4	1	4.5
RS (12)	12.8	0	0.0	12.8	10	78.2	17.9	35.5	198.8
RV (11)	9.2	7	76.5	16.5	47	284.1	21.9	60	273.8
SK (4)	12.3	0	0.0	12.3	1	8.1	19.1	3	15.7
SL (8)	48.5	12	24.7	55.4	14	25.3	55.4	24.5	44.2
SN (9)	18.7	55	293.5	18.7	2	10.7	11.0	21	191.5
VT (0)	0.0	-	0.0	0.0	-	5.1	0.0	-	9.9
ZA (5)	47.5	0	0.0	52.5	0	0.0	52.5	0	0.0
ZH (0)	0.0	-	4.7	0.0	-	3.5	0.0	-	44.8
ZV (8)	19.7	2	10.2	19.7	1.5	7.6	17.5	17	97.1
Total	(20.4)	341	1,361.7	(21.5)	508.5	2,078.9	(20.1)	297.5	1,435.1

c.€54,480-103,950 by wolves. This is equivalent to c.€10-35/bear/year and c.€225-520/wolf/year.

Regional distribution of losses and percentage of flocks affected

Overall, 66 out of 127 flocks (52.0%) for which data were available in all three years reportedly suffered some losses to predation by wolves or bears during the period 2001-03. The percentage of surveyed flocks allegedly affected by predation in any particular year ranged from 24.3% in 2001 (n=144) to 35.7% in 2003 (n=143). At 119 flocks in 18 surveyed regions with both bears and wolves for which figures were available for all three years, the predator species causing losses was significantly more frequently reported to have been the wolf than the bear (chi-square test of association using actual frequencies of occurrence, χ^2=22.67, d.f.=1, P<0.001).

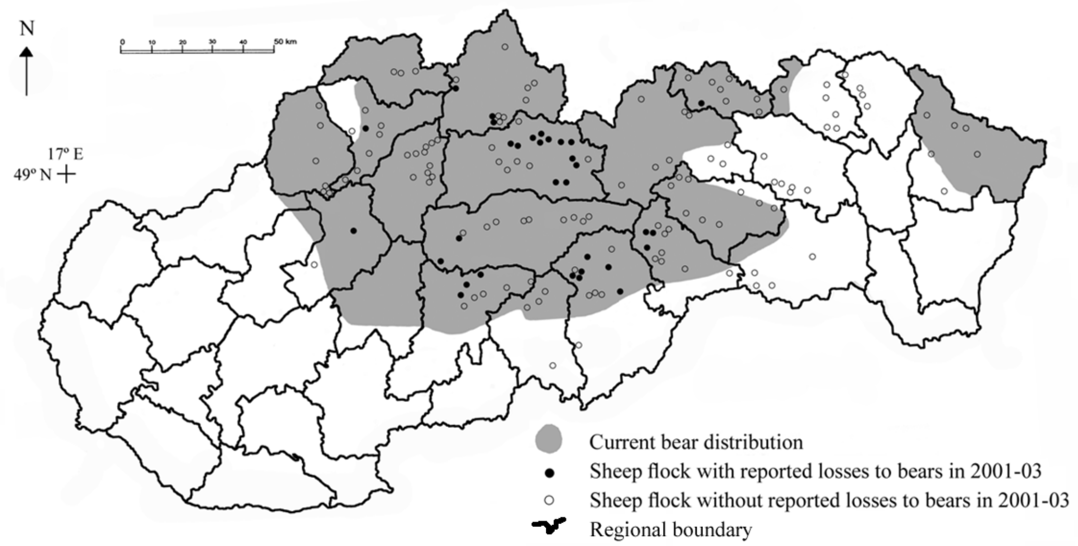
Considering only regions for which data were available from ≥ 5 flocks, regional differences in the mean reported number of sheep lost/flock and the percentage of flock lost to both bears and wolves were significant in both 2002 and 2003 (Kruskal-Wallis test adjusted for ties, P<0.05). For five of the 20 regions surveyed (BJ, KS, LC, PB, ZA), no losses to either wolves or bears were reported at surveyed flocks in any year. In 10 of the 18 surveyed regions within bear range no losses to bears were reported in any of the three years. No losses to wolves in any year were reported in six of the 20 surveyed regions with wolves.

Table 3.3. Mean, variance and spread of the percentage of surveyed flocks in regions with bears and/or wolves for which losses to bears and/or wolves in 2001-03 were reported.

Proportion of flocks with reported losses	losses to bears n=18 regions			losses to wolves n=20 regions			losses to bears/wolves n=20 regions		
	2001	2002	2003	2001	2002	2003	2001	2002	2003
Mean	5.5%	9.4%	9.6%	17.1%	19.8%	26.7%	18.7%	22.5%	31.1%
Variance	120.0	310.4	202.9	325.4	389.6	760.4	338.1	631.1	815.1
Minimum	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Maximum	41.2%	61.1%	33.3%	50.0%	50.0%	75.0%	52.9%	72.2%	81.8%

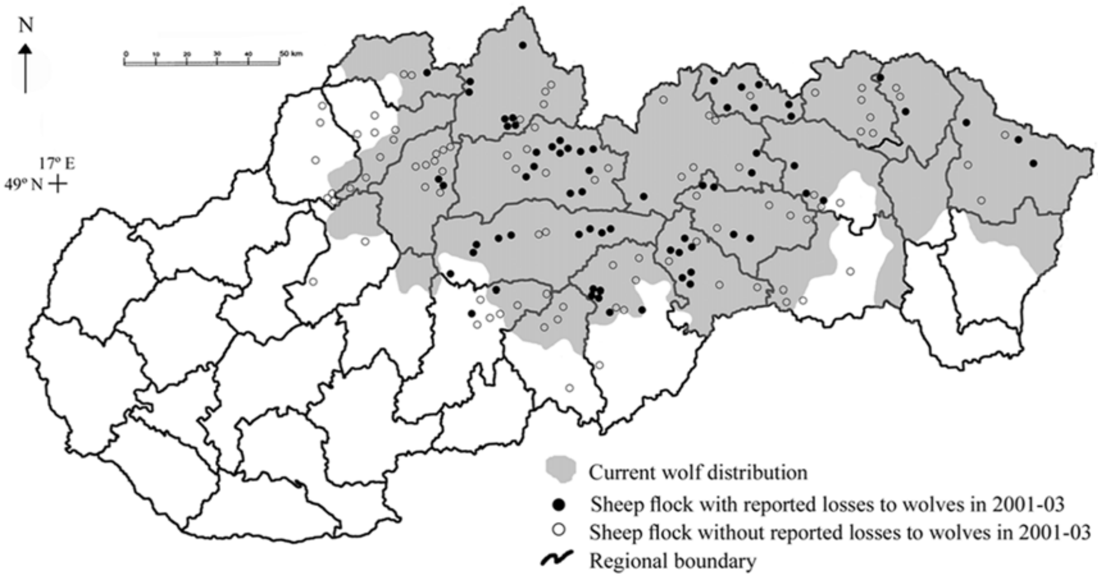
Regional differences in the percentage of flocks for which losses were reported also suggest that losses were highly clumped (Dytham 1999:34-35): the variance was considerably greater than the mean for all three years for both wolves and bears as well as wolves and bears combined (Table3.3). The majority of reported losses to bears were concentrated in a small number of regions, primarily BB, DK, LM, PD, RS and ZV (Fig. 3.4). Reported losses to wolves were concentrated mainly in regions BB, DK, LM, PO, RV, RS and SN (Fig. 3.5). The maximum percentages of farms affected in a region in a particular year were 61.1% for bears (LM, 2002), 75.0% for wolves (HE and SL, 2003) and 81.8% for wolves and bears combined (RV, 2003). The mean proportion of flocks alleged to have suffered from predation by bears and/or wolves increased from 2001 to 2002 and from 2002 for 2003, but these differences are not statistically significant (Mann-Whitney *U* test, $P>0.05$).

Fig. 3.4. Flocks affected by bear predation in 2001-03 as reported by shepherds and farmers. The extent of bear distribution was adapted from several sources (Janík 1997, Hell and Slamečka 1999, Servheen *et al*. 1999, Svenson *et al*. 2000, Martínková and Zahradníková 2003, Kaštier 2004).



Total estimated losses to bears correlated with size of region only in 2002 ($r_s=0.487$, $P<0.05$). Total estimated losses to wolves also correlated to size of region in 2002 ($r_s=0.602$, $P<0.05$), but not in 2001 or 2003, suggesting that the disparity in levels of losses among regions is not simply a reflection of their relative sizes. Three measures of losses were used to further examine variation among regions: total estimated loss in number of sheep/year as extrapolated from reported losses, percentage of flocks affected and mean percentage of flock lost.

Fig. 3.5. Flocks affected by wolf predation in 2001-03 as reported by shepherds and farmers. The extent of wolf distribution was adapted from maps in Strnádová (2000) and data in Kaštier (2004).



Relationship between sheep numbers and reported losses

<u>Bears</u>

The clumped distributions of losses among regions were tested for correlations to numbers of sheep using Spearman rank-order correlation with region as the sample unit. Three measures of losses were used: total estimated number of sheep reported lost (including killed, died/euthanised due to injuries and missing) as extrapolated from reported losses at surveyed flocks, the percentage of surveyed flocks affected and the estimated percentage of all sheep in the region reported lost. No significant correlation was found between number of sheep and any of the measures of losses in 2001. Significant, high correlations were found in 2002 between number of sheep and sheep lost to bears (r_s=0.733, P=0.001) as well as percentage of flocks affected by bear predation (r_s=0.736, P=0.001) and percentage of all sheep lost (r_s=0.723, P=0.001), indicating a marked relationship between sheep available and bear predation (Martin and Bateson 1993:144 citing Guilford in relation to Pearson correlations). The values of the coefficients of determination (r^2, Martin and Bateson 1993:141) indicate that number of sheep accounted for 52-54% of the observed variations in measures of reported losses to bear predation in 2002.

Wolves

Spearman rank-order correlation was also used to test the data on reported wolf predation. Moderate but significant correlations were found between number of sheep and sheep reported lost to wolves in 2001 (r_s=0.461, P=0.041) and in 2002 (r_s=0.633, P=0.003). No significant correlation was found between number of sheep and percentage of flocks affected by wolf predation in either year. A moderate but significant correlation (r_s=0.552, P=0.012) was found between number of sheep and percentage of all sheep lost to wolves in 2002.

Relationship between predator numbers and reported losses

Bears

Taking region as the sample unit, correlations between estimated numbers of carnivores (Kaštier 2004) and reported losses in the years 2001 and 2002 were tested for using Spearman rank-order correlation. The same three measures of losses were used as in the tests for correlations with number of sheep. No significant correlation was found between estimated number of bears and reported losses to bears, percentage of flocks affected by bear predation or percentage of all sheep reported lost to bears in 2001. A significant, moderate correlation (r_s=0.697, P=0.001) was found between estimated number of bears and sheep reported lost to bears in 2002 as well as flocks affected by bear predation in 2002 (r_s=0.684, P=0.002). The correlation between estimated number of bears and percentage of all sheep lost to bears was significant and high in 2002 (r_s=0.702, P=0.001). These results show that neither number of sheep nor number of bears explained variation in any of the three measures of losses to bears in 2001. In contrast, all three measures of losses showed significant, moderate-high correlations with both number of sheep and estimated number of bears in 2002. The observed variation in losses was better explained by variation in number of sheep than estimated number of bears for all three measures tested.

Wolves

Moderate but significant correlations were found between estimated number of wolves and sheep reported lost to wolves in 2001 (r_s=0.535, P=0.015) and 2002 (r_s=0.606, P=0.005), percentage of flocks affected by wolf predation in 2001

(r_s=0.469, P=0.037) and 2002 (r_s=0.642, P=0.002) as well as percentage of all sheep lost to wolves in 2001 (r_s=0.524, P=0.018) and 2002 (r_s=0.609, P=0.004). The data therefore suggest that variation in reported losses among regions is better explained by estimated number of wolves than number of sheep. However, the values of the coefficients of determination r^2 suggest that variation in wolf numbers accounted for only 22-41% of the observed variations in the three measures of losses to wolf predation.

Local impact of predation

Number and percentage of sheep lost per flock

The range of losses among flocks in any one year was 0-66 sheep/flock (Fig. 3.6). No predation by wolves or bears in any year was reported for 61 out of 127 flocks (48.0%) for which data were available in all three years plus an additional 19 out of 23 flocks (82.6%) for which data were available in only two years. The percentage of flocks for which no predation was reported in a particular year ranged from 64.3% in 2003 (n=143) to 75.7% in 2001 (n=144). The mean number of sheep lost and the mean percentage of flock lost to wolf and bear predation combined at surveyed flocks were respectively 3.0 sheep/flock (range=0-60) and 0.8% (range=0-20.0%) in 2001, 4.3 sheep/flock (range=0-66) and 1.0% (range=0-13.2%) in 2002 and 2.6 sheep/flock (range=0-22) and 0.6% (range=0-6.3%) in 2003. Predation by bears and/or wolves in all three years was reported for 17 flocks (13.4%, n=127) and at two out of three years for 19 flocks (15.0%). Those 13 of the 17 flocks reportedly suffering predation every year for which a figure of the loss was reported for each year allegedly lost a combined total of 450.5 sheep over the three years (mean=11.6±6.3 sheep/flock/year, 95% confidence interval), 36.5% of all reported losses during the same period at all flocks for which figures were reported in all three years (n=122). Less than 11% of flocks in any one year had total losses of ≥ 11 sheep. However, these flocks accounted for 56.0-75.5% of all losses at all flocks combined (Fig. 3.7).

Figure 3.6. The percentage of flocks for which different levels of loss to bears and wolves combined were reported for the period 2001-03.

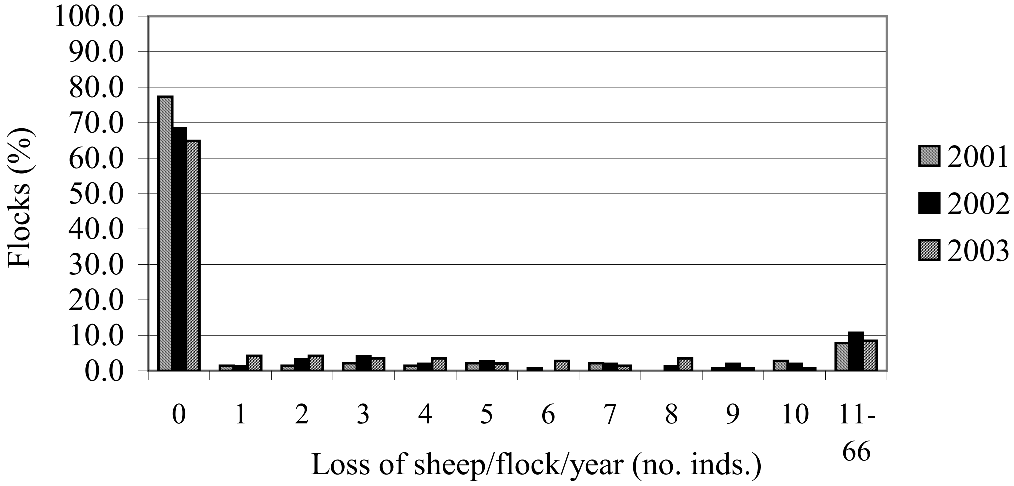
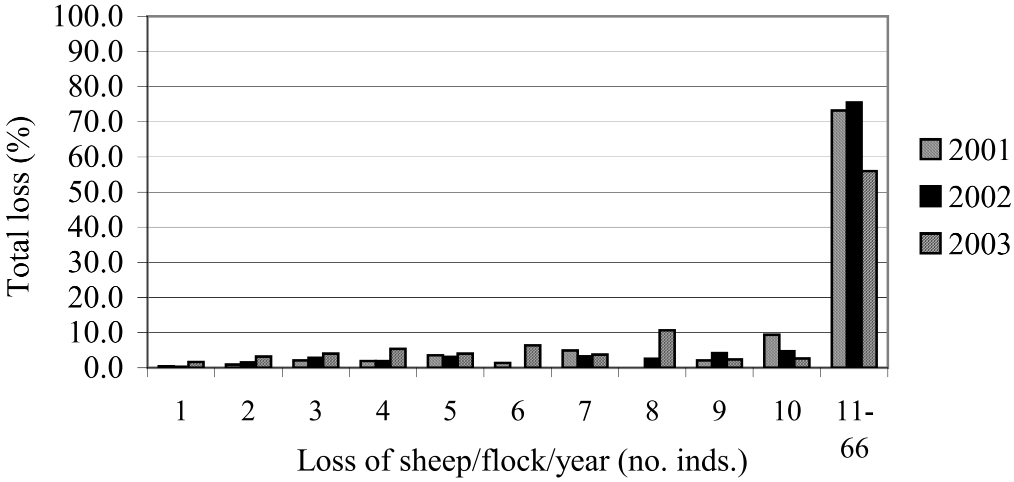


Figure 3.7. Percentage of all sheep reported lost to wolf and bear predation as a function of loss per flock.



Bears

In regions with bears, 93 out of 119 flocks (78.2%) did not suffer any reported losses to bears in any year (Fig. 3.4). The percentage of flocks for which no predation by bears was reported in a particular year ranged from 85.8% in 2003 (*n*=134) to 91.9% in 2001 (*n*=135) (Fig. 3.8). The mean reported number of sheep lost and the mean percentage of flock lost to bear predation in surveyed regions with bears were respectively 0.6 sheep/flock (max.=35) and 0.1% (max.=5.0%) in 2001 (*n*=144), 0.9

sheep/flock (max.=25) and 0.2% (max.=6.1%) in 2002 (*n*=150) and 0.6 sheep/flock (max.=20) and 0.1% (max.=2.9%) in 2003 (*n*=142). Only five flocks (4.2%) had reported losses in all three years but they accounted for 26.7% (71 of 268 sheep) of total reported losses at flocks for which data were available every year. In each of the three years, a small number of flocks with high reported losses accounted for a large percentage of total losses (Fig. 3.9). For example, two out of 135 flocks in 2001 accounted for 54.1% of all losses and a single flock (actually one attack) accounted for 25.6% of all losses reported at 133 flocks in 2003.

Fig. 3.8. The percentage of flocks for which different levels of loss to bears were reported for the period 2001-03.

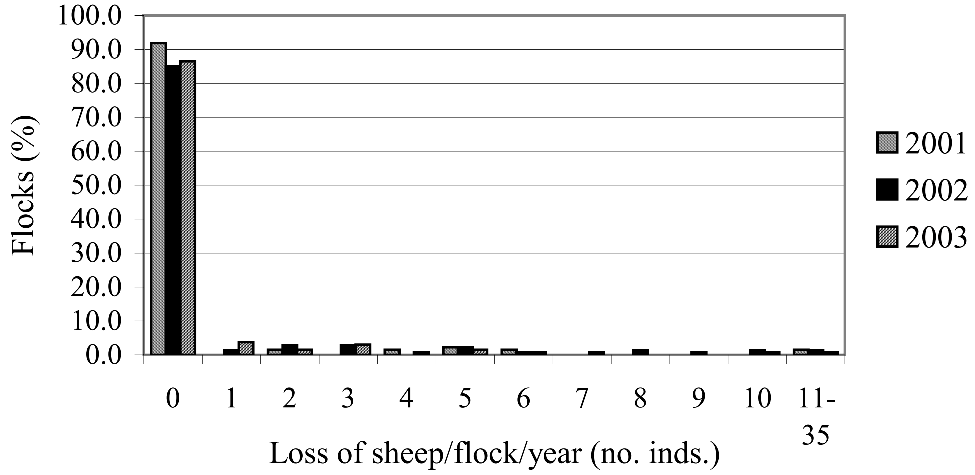
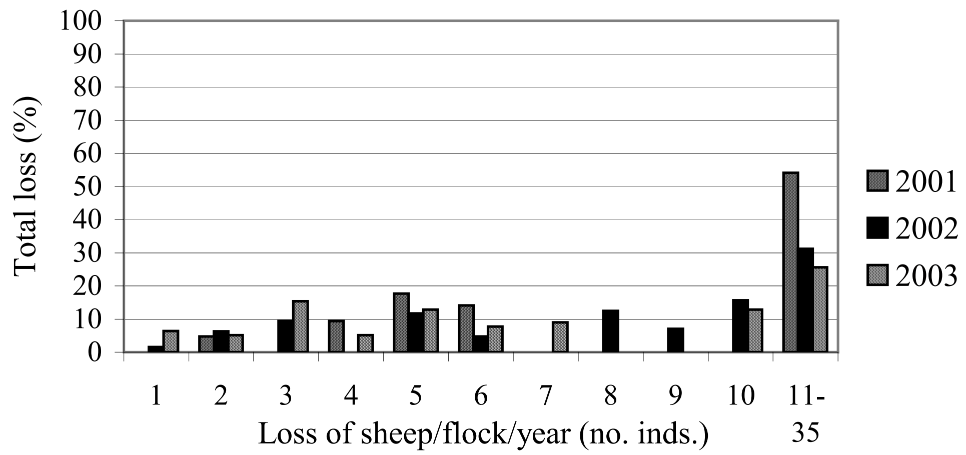


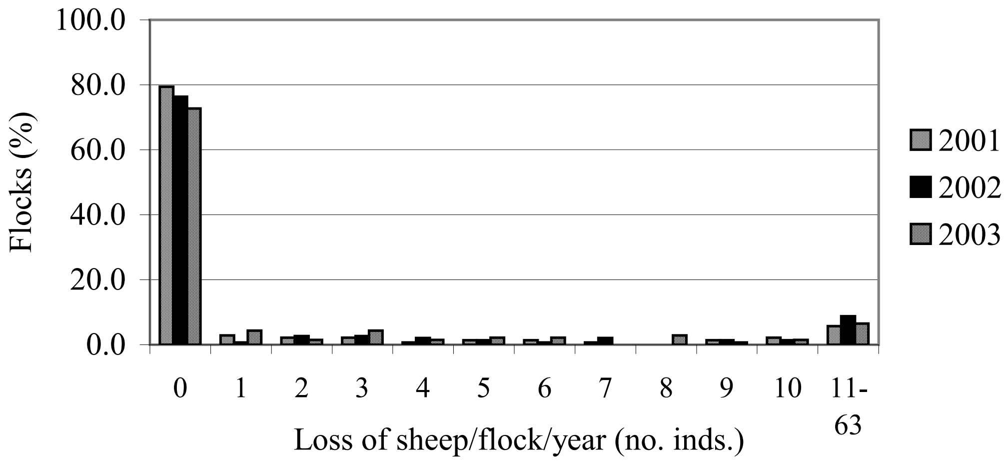
Fig. 3.9. Percentage of all sheep reported lost to bear predation as a function of loss per flock.



Wolves

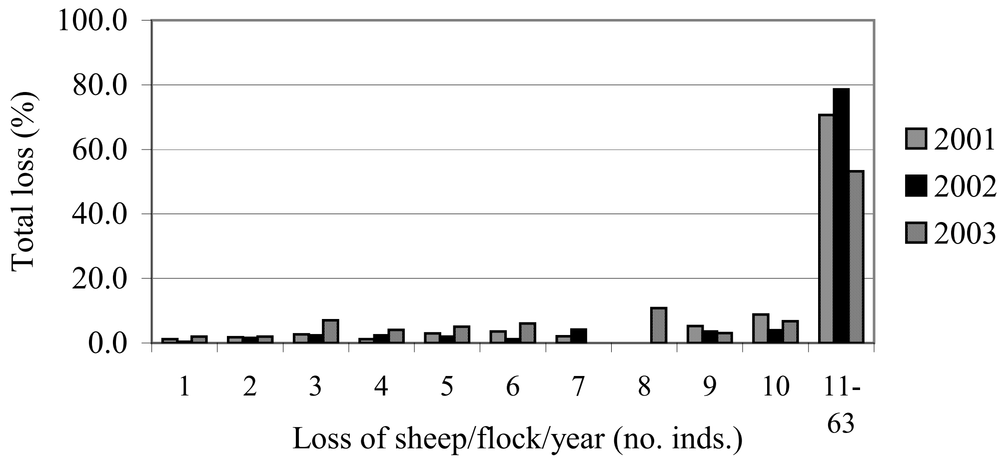
In regions with wolves, no predation by wolves in any year was reported at 61 out of 127 flocks (48.0%) for which data were available each year (Fig. 3.5). The percentage of flocks for which no predation by wolves was reported in a particular year ranged from 70.6% in 2003 (*n*=143) to 77.8% in 2001 (*n*=144) (Fig. 3.10). The mean number of sheep lost and the mean percentage of flock lost to wolf predation in surveyed regions with wolves were respectively 2.4 sheep/flock (max.=60) and 0.6% (max.=20.0%) in 2001 (*n*=141), 3.4 sheep/flock (max.=63) and 0.8% (max.=12.6%) in 2002 (*n*=149) and 2.1 sheep/flock (max.=22) and 0.5% (max.=6.3%) in 2003 (*n*=142). Predation by wolves in all three years was reported at 14 flocks (11.0%). Figures of losses were reported for each year at 10 of these flocks: reputedly a combined total of 349.5 sheep were lost to wolves over the three years (mean=11.7±8.3 sheep/flock/year, 95% confidence interval), accounting for 35.3% of all reported losses at all flocks (*n*=122).

Fig. 3.10. The percentage of flocks for which different levels of loss to wolves were reported for the period 2001-03.



In every year, between four and nine flocks accounted for >50% of all reported losses at 141-149 flocks (Fig. 3.11). In 2001, eight flocks with reported losses of ≥ 11 sheep suffered 70.7% of all the losses at 141 flocks and just three flocks accounted for 48.4%. In 2002, 78.5% of all losses among 149 flocks were at 13 flocks for which losses of ≥ 11 sheep were reported. In 2003, flocks at which ≥ 11 sheep were lost, i.e. nine out of 142 flocks, accounted for 53.0% of all reported losses. The same 16 flocks accounted for >50% of reported losses every year. At these 16 flocks, a total of >678 sheep were reported lost, >59.1% of all losses reported in 2001-03. Reputedly the worst affected flock lost 128 sheep in these three years, 11.2% of all reported losses at all 164 flocks in the survey combined.

Fig. 3.11. Percentage of all sheep reported lost to wolf predation as a function of loss per flock.



Associations between bear and wolf predation and losses among years

Flocks that reportedly suffered some losses to bears or wolves in 2002 were significantly more likely than expected by chance to also allegedly suffer losses in 2003 (n=131, χ^2=27.01, d.f.=1, P<0.001). Furthermore, the combined number of sheep reported lost to bears and wolves at flocks in 2003 was found to have a highly significant correlation to the reported loss at the same flocks in 2002 (r_s=0.460, P<0.001). Considering only flocks in regions with bears and wolves and for which data were available in all three years (n=119), flocks that reportedly suffered some losses to wolves during the period 2001-03 (Table 3.4) were significantly more likely than expected by chance to also allegedly suffer losses to bears (χ^2=10.23, d.f.=1, P<0.001). These results suggest that some aspect(s) of individual flocks or their location renders them more vulnerable to predation.

Table 3.4. The numbers and percentage of surveyed flocks in 18 surveyed regions with both wolves and bears for which some losses to wolves or bears were reported and those without reported losses in the period 2001-03. Only flocks for which data were available in all three years are included (*n*=119).

	Flocks reported to have suffered losses during period 2001-03 due to predation by:									
Region (*n* flocks)	wolves only		bears only		either wolves or bears		both wolves and bears		neither wolves nor bears	
	no.	%	no.	%	no.	%	no.	%	no.	%
BB (9)	5	55.6	1	11.1	6	66.7	1	11.1	2	22.2
BJ (3)									3	100.0
CA (3)	2	66.7			2	66.7			1	33.3
DK (12)	4	33.3	1	8.3	5	41.7	3	25.0	4	33..3
HE (4)	3	75.0			3	75.0			1	25.0
KS (2)									2	100.0
LC (3)									3	100.0
LM (17)	2	11.8	1	5.9	3	17.6	10	58.8	4	23.5
MT (11)	2	18.2			2	18.2			9	81.8
PB (3)									3	100.0
PD (5)			1	20.0	1	20.0			4	80.0
PP (9)	3	33.3			3	33.3			6	66.7
RS (8)	1	12.5	2	25.0	3	37.5	1	12.5	4	50.0
RV (7)	4	57.1			4	57.1	2	28.6	1	14.3
SL (7)	5	71.4			5	71.4	2	14.3	1	14.3
SN (6)	4	66.7			4	66.7			2	33.3
ZA (4)									4	100.0
ZV (6)			1	16.7	1	16.7	1	16.7	4	66.7
All (119)	35	29.4	7	5.9	42	35.3	19	16.0	58	48.7

<u>Other predators</u>

The interview schedule did not specifically ask about losses to other predators, but in several instances shepherds and farmers offered information relating to losses besides those caused by wolves and bears. In two cases, one sheep was reported to have been killed by a lynx. Ravens (*Corvus corax*) were mentioned in one instance as having attacked six lambs. Attacks by foxes (*Vulpes vulpes*) in the past were mentioned by one shepherd. A total of 14 sheep were said to have been killed by dogs at four different flocks and some of the losses apportioned to wolves by shepherds were said by farm representatives to have been caused by wolves or dogs. One sheep was apparently stolen (problems with thieves were mentioned by several shepherds) and one ran away. In two cases losses reported as wolf damage by shepherds were said by a farm representative to have been unproven. In three cases shepherds reported losses to wolves and bears whereas the home farm representative said there had been none, in two cases this situation was reversed and in three other cases the reports of losses given by shepherds and farmer representatives were also irreconcilable.

Relationship between farm conditions and reported losses

Size of flock

From the data presented above it is apparent that the great majority of losses occurred at a minority of flocks and that the considerable variation observed in levels of reported losses to predation, both among and within regions, can not be explained solely in terms of numbers of predators, especially of bears. It was supposed that local conditions would influence the level of losses suffered at individual flocks. Table 3.5 presents a regional summary of the data gathered on farm conditions at the 164 flocks surveyed in 2003. Taking flock as the sample unit, no significant correlations were found between total reported loss to bears and wolves combined or percentage of flock reported lost in 2003 and size of flock (respectively n=139, r_s=-0.009, P=0.916 and n=139, r_s=-0.049, P=0.566). No significant correlations were found between total reported loss to bears and wolves combined in 2003 and size of flock when only flocks kept in a sheepfold or left free at night were included in the analysis (n=93, r_s=0.026, P=0.801) or if only flocks in BB, DK, LM and RS regions were considered (n=53, r_s=0.074, P=0.596). Neither were any significant correlations found when region was taken as the sample unit (Spearman rank-order correlation, n=18, P>0.05).

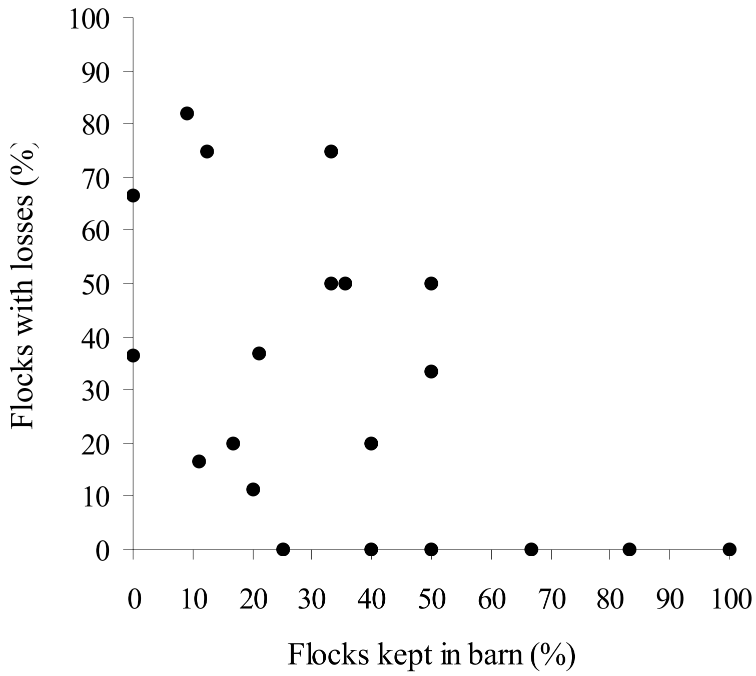
Method of night confinement

Considering region as the sample unit, a significant negative correlation (r_s=-0.546, P=0.013) was found between the percentage of flocks in a region kept in a barn at night and the percentage of flocks in the region affected by predation in 2003 (Fig. 3.12).

Table 3.5. Conditions in 2003 at 164 flocks surveyed in 20 regions with bears and/or wolves.

Region (*n* flocks)	Flock size (*m* no. sheep)	*bača* working at flock (*m* no. years)	night confinement (% flocks)				have dogs (% flocks)			have dogs total/ flock (*m* no. dogs)	have electric fence (% flocks)
			sheep fold	barn	free on range	farm yard	on chain	free at night	free		
BB (12)	459.2	3.9	100.0	0.0	0.0	0.0	100.0	0.0	0.0	7.0	8.3
BJ (6)	590.0	10.7	50.0	50.0	0.0	0.0	60.0	0.0	50.0	4.2	16.7
CA (5)	357.0	4.7	40.0	0.0	60.0	0.0	75.0	25.0	0.0	3.0	20.0
DK (14)	468.6	13.5	71.4	35.7	7.1	0.0	53.8	0.0	53.8	4.3	44.4
HE (6)	281.7	11.2	66.7	33.3	33.3	0.0	83.3	16.7	33.3	4.5	16.7
KS (5)	858.6	10.6	0.0	100.0	0.0	0.0	100.0	0.0	25.0	5.5	20.0
LC (4)	377.5	7.3	75.0	25.0	0.0	0.0	100.0	0.0	0.0	3.8	0.0
LM (19)	545.0	7.9	68.4	21.1	5.3	10.5	94.7	31.6	10.5	6.4	42.1
MT (12)	394.5	11.0	16.7	83.3	8.3	0.0	100.0	0.0	50.0	5.8	9.1
PB (3)	426.7	-	33.3	66.7	0.0	0.0	0.0	33.3	66.7	5.0	33.3
PD (5)	470.0	11.0	20.0	40.0	40.0	0.0	60.0	40.0	100.0	6.2	40.0
PO (6)	425.8	10.7	83.3	16.7	0.0	0.0	66.7	16.7	50.0	5.0	0.0
PP (10)	491.3	8.0	90.0	20.0	0.0	0.0	90.0	20.0	30.0	6.7	10.0
RS (12)	352.5	6.4	58.3	33.3	8.3	0.0	100.0	8.3	16.7	5.8	22.2
RV (11)	379.5	6.8	90.9	9.1	0.0	0.0	90.9	0.0	45.5	4.9	0.0
SK (4)	422.5	3.0	50.0	50.0	0.0	0.0	33.3	66.7	33.3	4.8	0.0
SL (8)	720.0	4.3	87.5	12.5	12.5	0.0	100.0	0.0	57.1	6.3	42.9
SN (9)	334.7	14.3	88.9	11.1	0.0	0.0	44.4	66.7	22.2	6.2	0.0
ZA (5)	756.6	7.0	40.0	40.0	20.0	0.0	60.0	0.0	60.0	4.0	20.0
ZV (8)	658.8	10.8	50.0	50.0	12.5	0.0	75.0	37.5	37.5	7.6	0.0
All (164)	480.2	8.1	62.5	29.3	6.7	1.2	80.6	16.8	34.2	5.5	18.4

Fig. 3.12. Significant negative correlation (r_s=-0.546, P=0.013) between the percentage of flocks in a region kept in a barn at night and the percentage of flocks in the same region affected by predation. Data are for 2003.



In order to further investigate factors which could account for differences in reported losses among flocks, two extreme categories were formed: “no losses” included all flocks at which no losses to predation were reported during the period 2001-03 (n=61) while “high losses” were those which suffered predation by bears or wolves in ≥ 2 of the three years and/or allegedly lost ≥ 10 sheep in any one year (n=51). Flocks in the “high losses” group accounted for 83.2-96.0% of all reported losses each year. The data on farm conditions were then examined for differences between the two groups.

The most significant difference detected (chi-square test of association using actual frequencies of occurrence, χ^2=21.41, d.f.=1, P<0.001) between the two groups was in the method of night-time confinement. In the “no losses” group, 26/61 flocks (43%) were kept in a temporary sheepfold (“košiar”) or left loose on the pasture and 35/61 (57%) were always or sometimes confined in a barn or farmyard at night, whereas in the “high losses” group the respective figures were 43/51 (86%) and 8/51 (16%). Considering all flocks with complete data on night confinement and reported losses for 2003, flocks kept in a sheepfold or left free on the pasture at night (n=93) had mean reported losses to wolves and bears of 3.6 sheep/flock whereas flocks always or sometimes returned to a barn (n=47) lost a mean of 0.4 sheep/flock, a highly significant difference (Mann-Whitney U test, P<0.001). As 67.1-70.1% of the losses to wolves and up to 86.2% of losses to bears were reported by shepherds and farmers to have occurred at night (see below), the pertinence of the method of night confinement is clear. Furthermore, once flocks were confined to barns for the winter (usually in November or early December) losses rapidly declined to zero and attacks were then rarely reported until spring. It can therefore be concluded, perhaps rather obviously, that flocks kept in simple sheepfolds at traditional *salaše* are much more vulnerable to predation than those confined in a barn or a securely fenced farmyard at night.

These results explain much of the observed differences among regions. For example, in MT region most flocks were grazed nearer to villages than in the past and were often returned to the farmyard at night. Nine out of 12 flocks observed in this region were in the “no losses” category and only one was in the “high losses” category. In the neighbouring regions of BB and LM, however, many flocks were still grazed in a more traditional, Wallachian-style system and so were more likely to be kept in a sheepfold on the pasture at night. Seven out of 12 flocks surveyed in BB and 10 of 19 in LM (all except one kept in sheepfolds) were in the "high losses" group whereas only two and four respectively were in the "no losses" group (half of them kept in sheepfolds). Some regions had a mixture of husbandry practices and a correspondingly heterogeneous pattern of reported predation. In RS, for example, four flocks all kept in sheepfolds at night in summer had "high losses" and four all kept in barns had "no losses". Nevertheless, the method of night confinement does not account for all observed variation in reported losses. Twenty-six flocks with "no losses" were kept in sheepfolds or left free on pastures. They tended to occur in regions with relatively few or no losses overall, such as BJ, LC and ZA. Only seven were in regions with consistently high levels of reported losses (BB, LM, PO, RV and SN). From the data collected, no significant differences could be discerned between flocks confined in sheepfolds with "no losses" versus those with "high losses" in the same regions, although the former were relatively small (mean=379.3 sheep, range 276-470). Perhaps additional, unmeasured variables were significant, such as the usual distance of the sheepfold from the nearest continuous woodland or other potential cover for predators. As in several instances high losses were the result of single attacks, some factors may have been case-specific (see below).

Using the Mann-Whitney *U* test ($P<0.05$) no significant differences were found between the "no losses" and "high losses" groups in number of livestock guarding dogs (mean=3.1 and 3.0 respectively), number of livestock guarding dogs per 100 sheep (mean=0.9 and 0.7 respectively), number of all dogs (mean=5.4 and 5.8 respectively), number of all dogs per 100 sheep (mean=1.2 for both), number of years the head shepherd (*bača*) had been working at the flock by 2003 (mean=10.5 and 8.5 respectively) or number of sheep in the flock (mean=507.2 and 453.0 respectively). Some of these factors were, however, pertinent to known individual cases. For example, inexperience was apparently responsible for the loss of 20 sheep to bear predation at a flock in PD region on 9-10/12/03, 25.6% of all losses to bears reported at 133 surveyed flocks in that year. Owners from a lowland region without large carnivores had left this flock, unlike others in the area, in an insecure barn on remote summer pastures at >700m a.s.l. long after the end of the grazing season and first snowfall (pers. obs. 2003, V. Slobodník pers. comm. 2004).

Dogs

Before the survey was conducted dogs were known to have been present at almost all upland sheep farms in Slovakia, although livestock guarding dogs were rarely socialised with sheep in the 1990s (Coppinger and Coppinger 1994a,b). Instead, most were used in one of three ways: 1) permanently chained near the sheepfold or farm buildings, which may have provided some protection, mainly by barking to alert shepherds at night (Bloch 1995), 2) chained during the day but released at night, or 3) left free to wander. In the present research, data were collected on the number, type and use of dogs. Analysis of the effectiveness of different types of dogs and their use is complicated by several factors. Many shepherds did not clearly distinguish between herding and guarding dogs and so when it was reported that dogs were left free-ranging it was often not clear to which kind of sheepdog this referred. In addition, the use of dogs sometimes changed in response to predation. For example, some shepherds reacted to the presence of predators by releasing dogs at night that had previously been permanently chained.

The mean reported total number of dogs/flock was 5.5 (range 0-15), with means of 3.0 "large" (guarding) dogs/flock (*n*=63, range 0-10) and 3.8 "small" (herding) dogs/flock (*n*=55, range 0-10). No significant correlations were found between total number of dogs/flock and total reported losses in 2003 (n=123, r_s=-0.058, P=0.527) or between number of guarding dogs and reported losses (n=54, r_s=-0.090, P=0.515). Although free-ranging dogs were reported at 34.2% of surveyed flocks for which this question was answered (*n*=153), with a mean of 2.3 free-ranging dogs/flock, well-trained livestock guarding dogs bonded to sheep and regularly accompanying flocks to pasture were found to be extremely rare. It was confirmed that the practice of chaining dogs permanently was very widespread (Table 3.5). Dogs were reported to be used in this way at 125 (80.6%) of flocks overall and at 100% of flocks surveyed in six out of 20 regions, including some with high levels of losses (BB and RS), with a mean of 2.9 chained dogs/flock. Dogs were reported to be released at night at 26 (16.8%) of the surveyed flocks, with a mean of 1.8 dogs/flock released at night. There were no significant differences in reported losses to wolves, bears or wolves and bears combined in 2003 for flocks where some dogs were said to be free-ranging or released at night (*n*=66) versus those where only chained dogs were mentioned (*n*=76) (Mann-Whitney *U* test, P>0.05). The chi-square test of association indicated that at flocks with well-raised, free-ranging LGDs placed as part of the Protection of Livestock and Conservation of Large Carnivores project (*n*=13; Chapter 4) there were significantly fewer reported losses to bears and wolves combined than expected (χ^2=20.58, d.f.=1, P<0.001) in comparison to other flocks in the same regions without such dogs (*n*=42). The mean and maximum losses of sheep (or goats) in 2002 reported for flocks with and without well-raised, free-ranging PLCLC project LGDs were respectively 1.1 versus 3.6 sheep/flock and five versus 35 sheep.

Electric fences

Only 28 out of 152 flocks (18.4%) were found to have an electric fence and in six out of 20 regions, including some with high levels of losses (PO, RV and SN) none of the surveyed flocks had one (Table 3.5). At some flocks where fences had been installed shepherds left them switched off. In other cases the fences were inadequate (did not conform to recommended parameters for predator-exclusion fencing, see Levin 2002, Mertens *et al*. 2002) and/or had been badly set up. Predators sometimes succeeded in passing between, over or under electrified wires and killed sheep, or livestock frightened by predators stampeded out of the fence and were subsequently attacked and killed. A shepherd in MT region believed that a single strand of electrified wire around the sheepfold was sufficient to repel large carnivores. He thought they would be able to feel the current through the air and would avoid it. The ineffectiveness of electric fences used at flocks surveyed in 2003 is shown by the finding that there was no significant difference (Mann-Whitney *U* test, P>0.5) in numbers of sheep reported lost to bears, to wolves or to bears and wolves combined at flocks with electric fences (*n*=27, mean loss = 2.4 sheep/flock, range 0-18) compared to those without (*n*=104, mean loss = 2.4 sheep/flock, range 0-21).

Other non-lethal preventive measures

Of 136 shepherds and farmers who answered the question on preventive measures, 34 (25.0%) said that they used methods besides livestock guarding dogs and electric fences to protect sheep from carnivores. Table 3.6 lists the methods that were mentioned. Shepherds regarded fireworks and firecrackers, lamps and other aversive devices as helpful but some said that predators quickly habituate to them. In a few cases attacking predators were chased away without losses, in others wolves and bears were said to be “not afraid of anything” and succeeded in killing sheep despite attempts by shepherds to repel them. Actively repelling predators obviously depends on an attack being detected. According to J. Lukáč (pers. comm. 2001) a system common in north-east Slovakia and similar to Polish *fladry* (Okarma and Jędrzejewski 1997) involves suspending a rope around the sheepfold with rags attached that are free to move in the breeze and apparently frighten wolves. It was not seen during the present study.

Table 3.6. Anti-predator measures (besides livestock guarding dogs and electric fences) that Slovak shepherds reported using at 136 flocks (response rate to this item in questionnaire = 82.9%).

Preventive measure (excluding LGDs/electric fences)	no. mentions	% flocks
none	102	75.0
guarding/patrolling	17	11.7
return flock to farmyard and/or inside secure fencing	9	6.6
lamps	4	2.9
fireworks, firecrackers	4	2.9
shepherd's axe (*valaška*)	1	0.7
leave carcasses	1	0.7
unspecified	1	0.7

During interviews, several shepherds and farmers reported that some measures had been very successful in preventing, reducing or even eliminating losses to predation. These are listed in Table 3.7. The use of some was probably more widespread than suggested by the number of times they were mentioned. For example, three cases were known in 2000-02 of flocks in MT region being immediately moved to lower altitude pastures nearer the village and closed in a barn at night following successful attacks by predators, after which no further losses were sustained.

Table 3.7. Preventive measures reported by Slovak shepherds and farmers to have been very effective in preventing or reducing losses of sheep to wolves and bears.

Preventive measure	no. mentions
close the flock in a barn or farmyard at night or when it rains	8
have good livestock guarding dogs	5
change location, e.g. graze the flock nearer the village	3
chase predators away	3
use an electric fence	2
increase vigilance (sleep nearer flock, keep watch, chain dogs nearer)	2
provide alternative food for bears nearby	2
(nothing helped)	(2)

Shepherds' experience and attitudes

Taking flock as the sample unit, no significant correlations were found between total reported loss to bears and wolves combined or percentage of flock reported lost in 2003 and the number of years that the head shepherd (*bača*) had been working at the flock (respectively n=94, r_s=-0.022, P=0.832 and n=94, r_s=-0.024, P=0.818). No significant correlations were found between these factors at the regional level (Spearman rank-order correlation, n=18, P>0.05). Data were not collected on the number of shepherds working at flocks (cf. Mertens and Promberger 2001) as this tended to vary over the course of the grazing season. Several shepherds reported having seen bears (17 cases), wolves (11) and lynx (4) passing or observing their flock without ever attacking. Although it is possible that such "harmless" predators were watching for a favourable opportunity to attack, Fritts *et al*. (2003) have pointed out that wolves often spend considerable time near livestock without showing much interest in them, even sometimes being observed passing cattle with calves in order to hunt wild ungulates. While a minority of shepherds felt helpless to reduce damage by wolves and bears, others believed that their preventive measures had been effective (Table 3.7). In individual cases the attitude of shepherds might have had an influence on the level of losses, for example through their diligence in applying preventive measures. However, out of 82 shepherds or farmers who responded to the question on whether they were interested in improving methods of livestock protection, 59 (72.0%) answered yes. Levels of reported losses to predation in 2002 and 2003 combined were significantly higher at flocks where there was interest in improving preventive measures compared to where there was not or the question was not answered (Mann-Whitney *U* test, P<0.005). Shepherds working at flocks in the "high losses" group were significantly more likely than expected to answer "yes" to this question, while shepherds working at flocks in the "no losses" group were more likely to answer "no" or not respond to this question (χ^2=11.98, d.f.=2, P<0.005). On the other hand, lack of knowledge, experience or motivation to use preventive measures effectively, such as taking the trouble to install adequate electric fencing or to raise livestock guarding dogs appropriately, was evidently an issue in many cases.

Other case-specific factors

Several other factors probably influenced levels of losses to predation on a case-by-case basis, either over the course of the grazing season or during individual attacks.

Data were not collected on macro-habitat variables such as proportion of the surrounding area in various land cover types (e.g. forest, field, pasture), cover types bordering pastures and proximity to regularly travelled roads or human habitations. As most flocks were rotated around different locations and night confinement sites also changed, an analysis of habitat characteristics pertinent to individual predation events would require identification of kill sites. Time limitations precluded systematic data collection. However, there was some evidence from opportunistic examination of known kill sites that vegetation and other cover was important for predators, both for approaching flocks undetected and for escaping with, feeding on or caching prey. For example, in the surroundings of Liptovská Lúžna, LM region, several flocks were attacked by wolves and bears in summer-autumn 2003 and spring-summer 2004 while in close proximity to or within forest cover, both at night and during the day. At the end of July 2000, 11 sheep were killed and 11 injured (later died) by wolves in Veľká Fatra, MT region, during a night-time thunderstorm. The flock was taken to the same location in 2001 and was again attacked at night in July during inclement weather, with the loss or serious injury of c.40 sheep.

Specific details of livestock and husbandry (age class, time of lambing, health condition) might have been pertinent in some cases. For example, during a surplus killing event in BB region on the night of 7-8th May 2002 wolves appeared to select lambing ewes, their newborn lambs and kids in an area near forest cover and surrounded by bushes. Predators sometimes selected individual sheep and other livestock in some way disadvantaged, as when limping sheep at the back of a moving flock were attacked or animals lost or trapped were killed. Losses also occurred during the daytime when predators that had apparently been observing flocks from cover rushed out to attack. Such a case occurred between 09.00 and 10.00h on 30th June 2000 in BB region, when a wolf succeeded in killing a sheep while the flock was temporarily left unattended on the pasture.

Patterns of attacks and losses according to season, time and weather

<u>Bears</u>

Losses of sheep to bear predation reported for 2001-03 showed a first, lesser peak in May, a drop in June (evident in all three individual years) followed by a steep increase to August and then a decline to November (Fig. 3.18). The losses shown for April and December each occurred in a single attack in 2003 (Fig. 3.19). No losses were reported in January-March of any year. The chi-square goodness of fit test indicated that reported losses in the period May-October did not follow a flat distribution, i.e. losses were not equally likely in all months (χ^2=33.42, d.f.=5, P<0.001). Although relatively few sheep were lost in June, this month had the highest number of reported attacks (compare Fig. 3.13 and Fig. 3.14).

Figure 3.13. Seasonality of reported sheep losses due to bear predation in Slovakia, 2001-03.

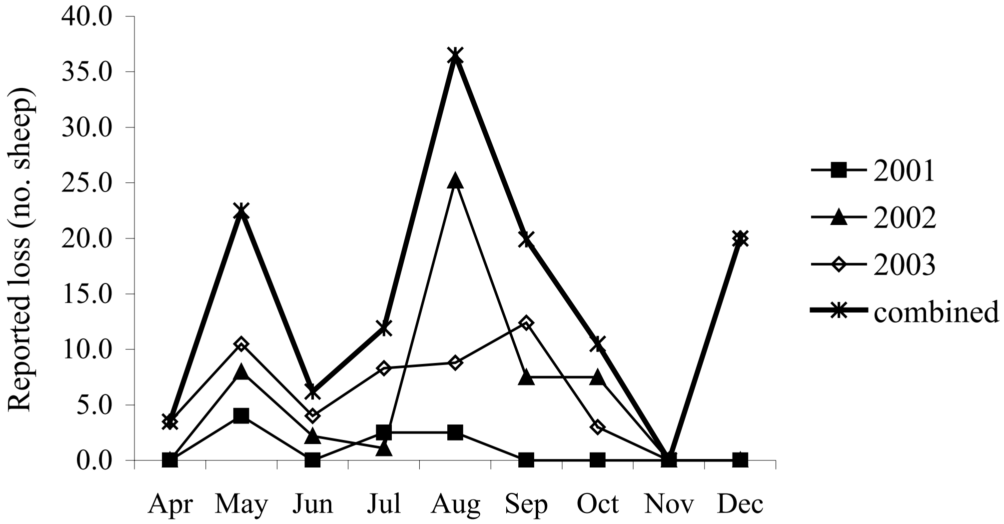
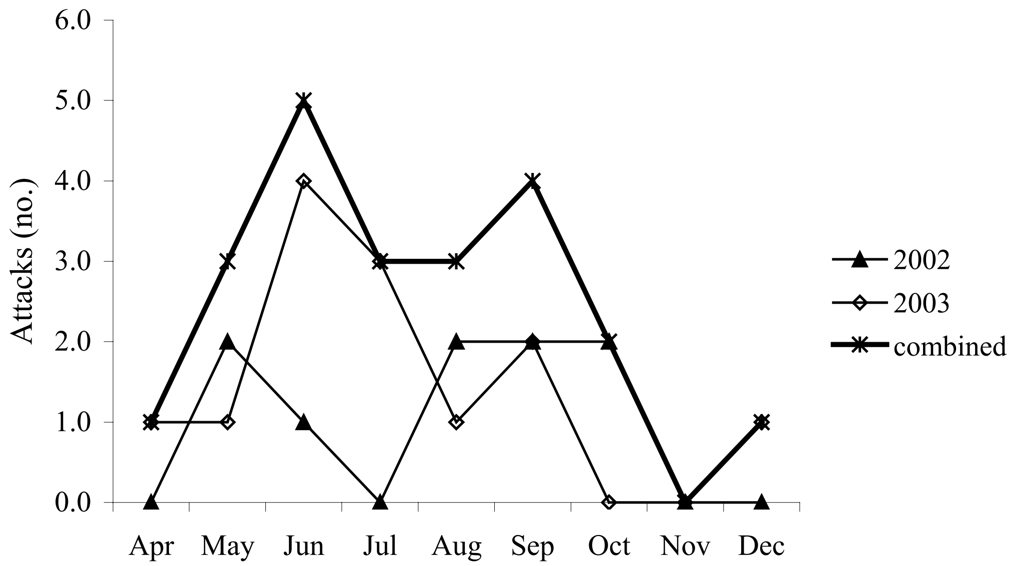


Figure 3.14. Seasonality of reported bear attacks on sheep flocks in Slovakia. A total of 69 sheep were reported lost in 23 separately distinguishable attacks in 2002-03.



The number of sheep lost per attack by bears as reported by shepherds and farmers varied from 0 to 20 (n=23, mode=1, mean=3.0±2.1, 95% confidence interval). In 87.0% of reported attacks (20/23), 0-3 sheep were lost. These attacks accounted for 42.0% of the total number of sheep lost in all attacks (compare Fig. 3.15 with Fig. 3.16). Two attacks in which 15 and 20 sheep were lost accounted for 50.7% of all losses.

Figure 3.15. Number of sheep lost per attack by bears as reported by shepherds and farmers.

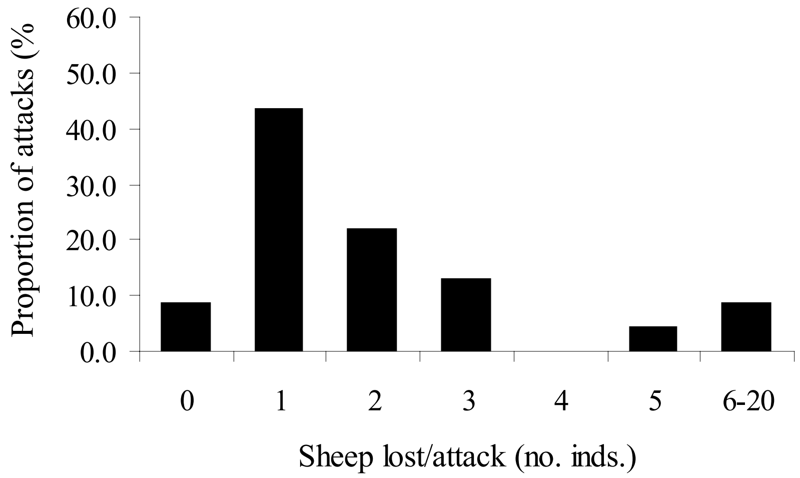
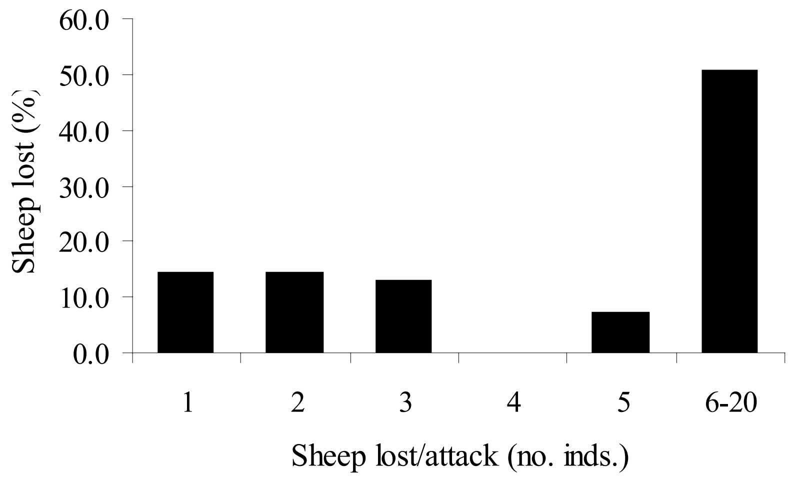


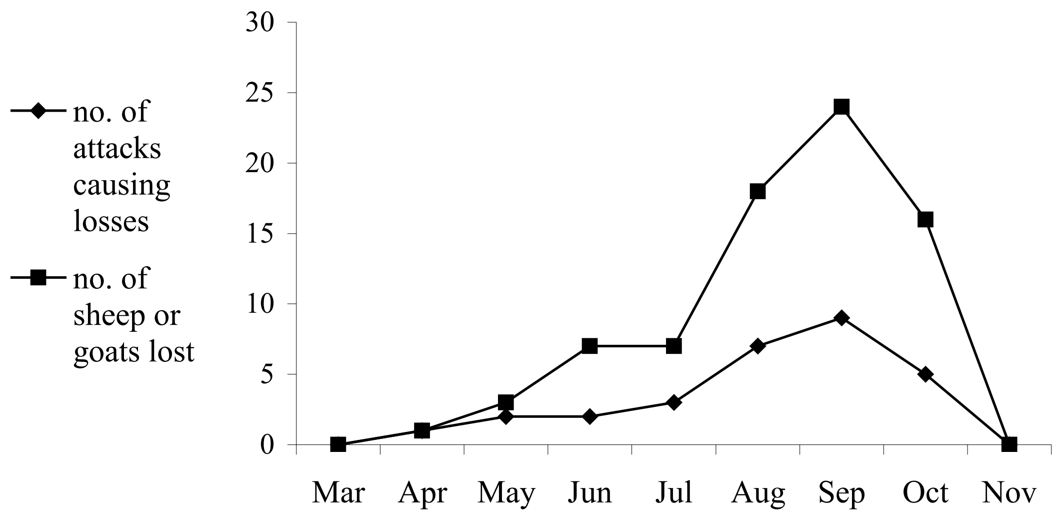
Figure 3.16. Percentage of total sheep lost to bear predation as a function of loss per attack.



The time of day at which bears attacked sheep was described in 13 reports of separate attacks. Bears allegedly attacked "at night" in 11 cases, causing a mean loss of 1.1 sheep/attack, and "in the early morning" in the remaining two cases, causing a mean loss of 4.0 sheep/attack. When all accounts of losses for which an indication of time of day was given (*n*=32) are considered, irrespective of whether or not the losses could be distinguished as separate attacks, the ratio of day:night was 6:26 and the respective total losses 17:106. A specific time was given in only one case, 01.30h. No information was given on weather conditions during bear attacks and a description of the predating bear was given in only one case, "a female with cubs".

Due to the much smaller number of reports of bear predation on sheep in comparison to wolf predation, sample size for the above analyses was small and therefore more susceptible to influence by errors in reporting. Losses verified by the damage inspection commission in LM region were therefore also examined for comparison. During the period 1999-2001 a total of 76 sheep were confirmed killed by bears in 29 separate attacks. The distributions of verified losses and attacks closely matched, with gradual rises to peaks in September followed by steeper declines to November (Fig. 3.22). The rate of increase in number of attacks levelled off from May to June and that of losses from June to July. No attacks or losses were confirmed in November-March. In 76% of bear attacks verified in 1999-2001 by the LM region damage inspection commission 1-3 sheep were killed.

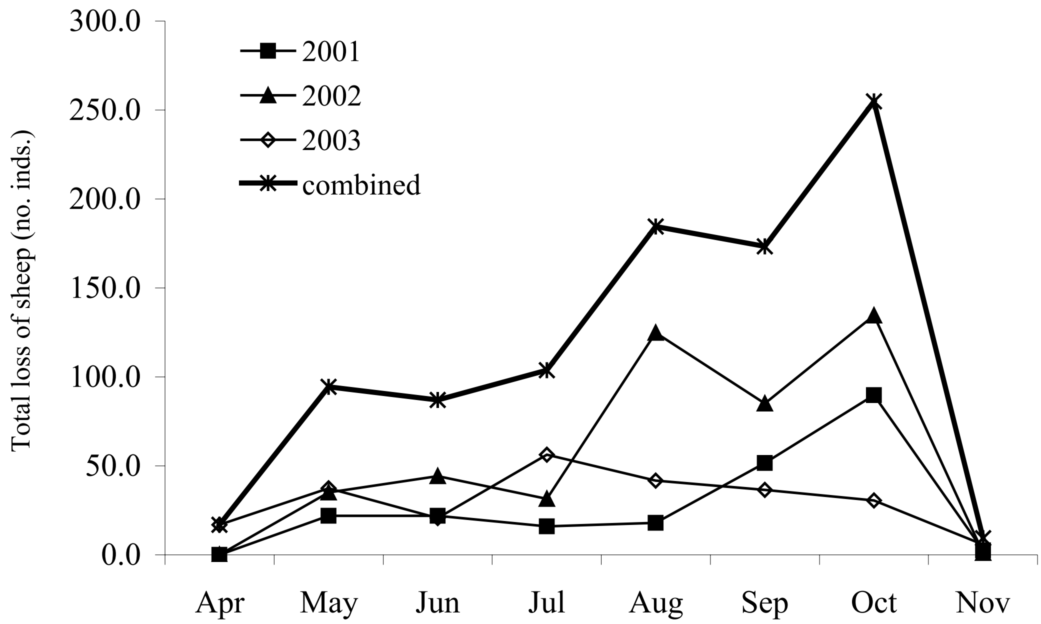
Figure 3.17. Seasonality of bear predation on sheep as verified by the damage inspection commission in LM region, 1999-2001.



Wolves

With all reports for 2001-03 combined there was a gradual increase in the number of sheep reported lost to wolves from April to a peak in October, with slight dips in June and September, followed by a steep decline in November (Fig. 3.18). No losses at flocks in the survey were reported for December-March in any year of the survey, although a wolf killed at least one sheep in a barn in SK region in January 2004 (K. Soos pers. comm. 2004). Reported losses among months in the period May-October did not follow a flat distribution, i.e. losses were not equally likely in all months (χ^2=146.53, d.f.=5, P<0.001).

Figure 3.18. Seasonality of reported sheep losses due to wolf predation in Slovakia, 2001-03.



For some flocks losses were reported as totals by month or year. Sufficient information was available to distinguish and describe 60 separate attacks by wolves in which a total of 333 sheep were reported lost (killed, euthanised/died from injuries or never found) and 34 more injured (recovered). Those reported as injured but recovered were not included in the following analyses. Attacks gradually increased in number from April, with a peak in August, followed by a gradual decline to November (Fig. 3.19), although the differences in number of attacks/month were not significant within the period May-October (χ^2=4.62, d.f.=5, P=0.463). The mean number of sheep lost per attack varied from 9.6 in May and 8.7 in October to 2.0 in

June and November and 0.0 in December-April, suggesting that serious attacks were more likely to happen in May and October than in other months, but the differences within the period May-October were not statistically significant (Kruskal-Wallis test adjusted for ties, d.f.=5, H=4.3, P=0.508). The number of sheep reported lost per month in the 60 separate attacks reached its highest value in May due mainly to a small number of serious attacks (≥ 5 sheep lost), fell steeply in June, rose again in July and August due to increasing numbers of attacks (some of them serious) and then declined to November, but with a slight rise in October, again largely due to a small number of serious attacks (Fig. 3.20).

Figure 3.19. Seasonality of reported wolf attacks on sheep flocks in Slovakia, 2001-03.

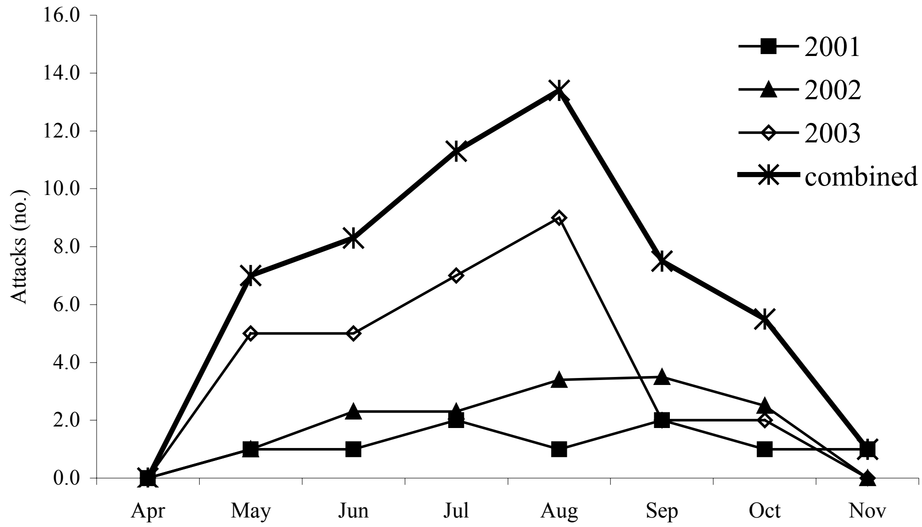
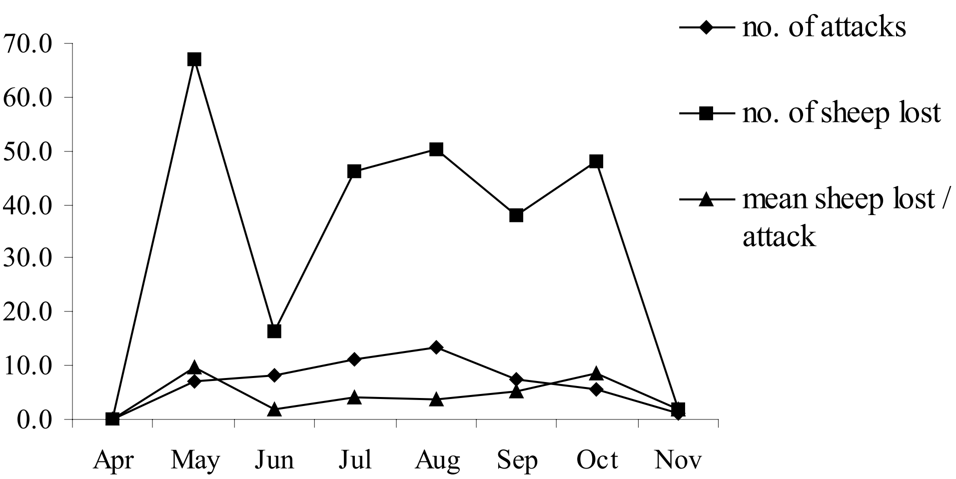


Figure 3.20. Changes by month in number of attacks, mean number of sheep lost per attack and total number of sheep lost for 60 separate attacks by wolves on sheep flocks reported in Slovakia, 2001-03.



As shown in Fig. 3.20, variation in the mean number of sheep lost per attack had a marked effect on the distribution of total losses among months for attacks that could be separately distinguished. The reported number of sheep lost per attack by wolves varied from 0 to 60 (*n*=60, mode=1, mean=5.6±2.7, 95% confidence interval). In 68.3% of reported attacks (41/60) 0-2 sheep were lost. However, these attacks accounted for only 13.2% of the total number of sheep lost in all attacks (compare Figs. 3.21-3.22). Attacks in which ≥ 10 sheep were lost, although comprising only 16.7% of reported attacks (10/60), accounted for 68.8% of all sheep lost.

Figure 3.21. Number of sheep lost per attack by wolves as reported by shepherds and farmers.

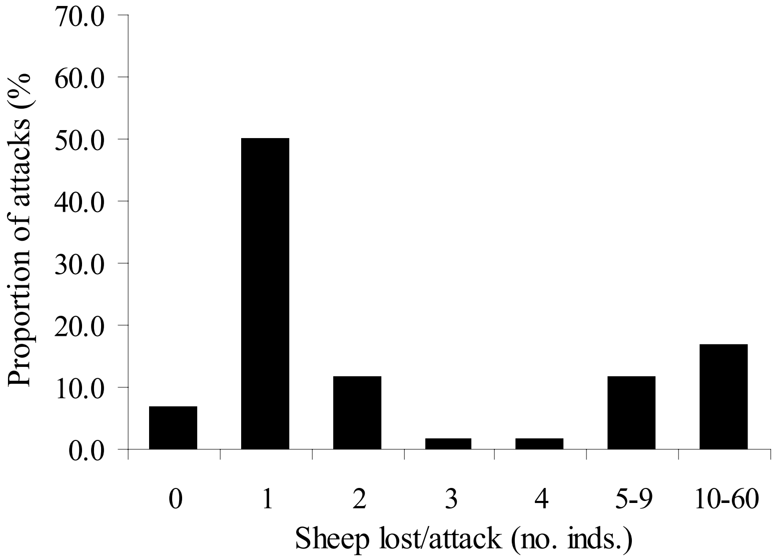
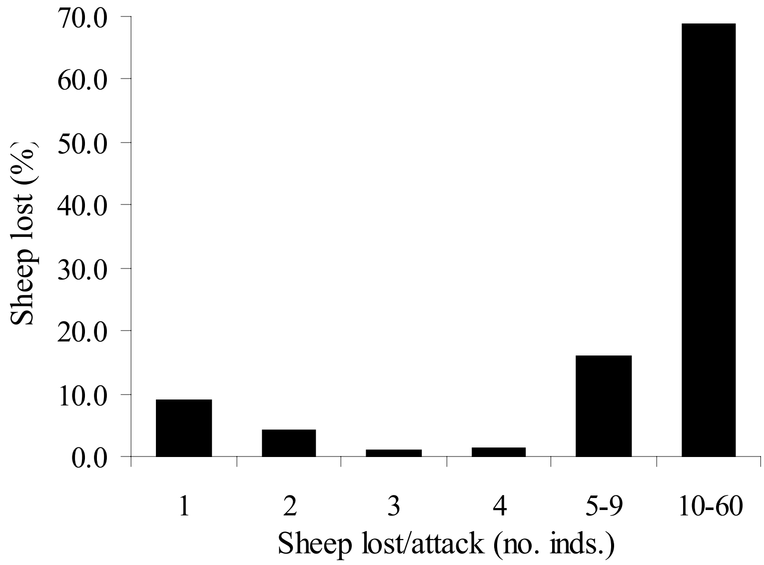


Figure 3.22. Percentage of total sheep lost to wolf predation as a function of loss per attacks.



An indication of when the attack occurred was given for 45 separate attacks. In nine cases the approximate time was specified, otherwise it was described in broader terms such as “day”, “night”, “afternoon”, etc. These reports were grouped into two categories, day (from early morning to evening) and night. Wolf attacks were reported to occur equally during the day (51.1%) and at night (48.9%). However, attacks at night seemed to cause a higher mean loss of sheep (6.7±4.3, 95% confidence interval) than those during the day (3.1±2.1, 95% confidence interval) and therefore accounted for a greater proportion (67.1%) of the total reported losses, although the difference is not statistically significant (Mann-Whitney *U* test, $P>0.05$) if length of day is not taken into account. Attacks in which ≥ 5 sheep were lost were reported to occur more at night ($n=8$) than during the day ($n=5$). When all accounts of losses for which an indication of time of day was given ($n=84$) are considered, irrespective of whether or not the losses could be distinguished as separate attacks, day:night were mentioned in the ration 34:57 and the respective total losses were 157:384, showing significantly higher losses at night than between morning and evening (Mann-Whitney *U* test, $P<0.05$). If a specific time was given, it was always between 23.45 and 02.45h for attacks at night ($n=7$). Only two specific times were given for daytime attacks, 09.00 and 12.30h.

There were too few reports ($n=6$) of weather conditions during separately distinguishable attacks to test for statistical significance. In three cases it was said to have been “raining” and in three cases “clear”. When all accounts of losses for which an indication of weather was given ($n=12$) are considered, irrespective of whether or not the losses could be distinguished as separate attacks, there were six mentions of “rain”, two of “mist” and four that it was “clear”, possibly suggesting that predators were more likely to attack when weather conditions provided cover.

Shepherds and farmers in nine cases reported the number of wolves it was claimed had been seen attacking sheep. In three cases “a lone wolf” was reported, in two cases “two wolves”, in two cases “a female with young”, in one case “a pack” and in one case “a pack of 2-5 wolves at different times”. This very limited information does not suggest that any particular class/cohort of wolf individual or social group was consistently involved in predation on livestock.

Circumstances associated with high losses

From the above analyses it is apparent that some flocks sustained far higher losses than others and that there was a tendency for the same flocks to have reported losses to both bears and wolves as well as in multiple years. Flocks suffered high losses in either or both of two ways: multiple attacks causing cumulative losses and single severe cases of "surplus killing", where many animals are killed and left partially or wholly uneaten (Kruuk 1972). Particularly in the case of wolves, a small number of flocks from which substantial losses were reported accounted for a very large proportion of the total losses in all regions combined. For example, one of four flocks belonging to a co-operative farm in Malatiná, DK region, reportedly lost 60 sheep to wolves in 2001, 15.5% of the combined total loss to wolves at 136 surveyed flocks, or 21.4 times higher than the average loss. Three of the flocks at this co-operative farm had reported losses to wolves in 2002 totalling 176 sheep, 17.3 times higher than the average loss per flock and accounting for 37.1% of total reported losses to wolves at 140 surveyed flocks.

Much of the variation in levels of losses among flocks is explained by a combination of the region in which flocks are located (in turn showing a high correlation between sheep numbers and reported losses to bear predation and moderate correlations between wolf numbers as well as sheep numbers and reported losses to wolf predation) and method of night confinement. However, it was also found that within the same region some flocks suffered high losses while others confined in the same way at night did not have any reported losses. It therefore seems that there were other, case-specific factors influencing the level of losses to predation. Table 3.8 briefly describes seven cases of surplus killing (≥ 5 sheep killed) for which details were obtained by site visit and interviewing shepherds and farmers or damage inspection commission personnel (S. Ondruš, V. Slobodník). Most of these attacks were by wolves and occurred at night. Circumstances increasing the vulnerability of the flock and/or weakness, failure or lack of preventive measures were identified in each case.

Table 3.8. Details of seven cases of surplus killing of sheep/goats in Slovakia in 1999-2003.

Date (time)	Region, predator	Loss	Circumstances	Preventive measures
26/6/99	BB wolf	16 sheep and 7 goats killed.	Fog and rain. Flock wandered into forest.	None – flock left unattended.
May 2000 (night)	LM wolf	7 sheep killed	Sheep panicked and ran out through fencing.	Poorly constructed and incomplete electric fence.
July 2000 (night, before 02.00h)	MT wolf	11 sheep killed and 11 injured later died.	Storm. Flock of yearling sheep kept overnight on remote pasture surrounded by forest cover.	(1 shepherd and 1 herding dog sleeping in nearby trailer).
19/7/01 (02.00-05.30h)	MT wolf	c.18 sheep missing, 2 found alive but died, 19 seriously injured.	"Bad weather". Flock from same farm and in same location as July 2000 attack.	(1 shepherd and 1 herding dog sleeping in nearby trailer).
8/5/02 (c.01.30h)	BB wolf	17 adult sheep and ≥ 16 lambs/kids killed.	Small flock of lambing sheep and goats fenced within lines of bushes. Flock of ewes in nearby open area with several chained dogs not attacked.	Several shepherds attempted to chase wolves away with firecrackers and lights.
c.30/8/03 (c.04.00h)	LM wolf	8 sheep killed (2 thoroughly eaten), ≥ 14 injured.	Flock of yearling sheep in sheepfold <100m from forest edge with some trees/bushes nearer.	3 chained dogs.
9-10/12/03 (night)	PD bear	5 sheep killed, 15 missing.	Flock still on remote pastures several days after substantial snowfall.	Put inside insecure barn.

DISCUSSION

Limitations of data and assumptions

Flock size as reported in 2003 (present study) and distribution of sheep among regions according to data from 1999 (MP SR 2000c) were assumed to have been similar in 2001 and 2002, any discrepancy being of less significance than errors in reporting losses. Changes in livestock numbers reported at the national level were assumed to have occurred fairly evenly across the regions. Scaling from the results of a farm survey (MP SR 2000c) to a national herd numbering 340,000 sheep (SOSR

2002) produced estimates of the total number of sheep in each region that did not always match figures given by regional branches of the Agriculture Ministry.

Population estimates in the Poľov 1–01 national hunters' questionnaire are highly inaccurate, especially for wolves. For example, a tracking census over an area of $800km^2$ in 2001 suggested that numbers of wolves had been over-estimated by at least 5.3-5.9 times, bears by 1.6 times and lynx by 2.9-3.7 times (re-calculated from data in Lehocký *et al*. 2000, 2001, Lehocký 2002). However, as the method used is essentially the same each year and throughout the country and is conducted by similar personnel, it was assumed that the margin of error would be comparable among years (Martínková and Zahradníková 2003) and regions. Reports of presence/absence were taken to be reliable at the regional level. The proportion of each region occupied by carnivores was not taken into account. This can vary considerably among years (Strnádová 2000) and as dispersing wolves and bears have been recorded tens of kilometres beyond the estimated limits of their respective ranges (Hell and Slamečka 1999, Strnádová 2000, Hell *et al*. 2001) it was assumed that all livestock in a region with carnivores was at risk of predation. Conversely, it was assumed that farms in regions considered not to have wolves or bears in 2000-02 (results of the Poľov 1-01 national hunting survey for 2003 were not available at the time of writing) did not suffer losses to predation by these species during the period of study, 2001-03. This was partly confirmed for the two regions in the survey (PO and SK) identified as having wolves but not bears, in neither of which were losses to bears reported at any of the surveyed flocks. In addition, the regional branch of the Agriculture Ministry reported that there had been no predation by large carnivores in TN region as of 17/6/02. Nevertheless it is possible that some dispersing individuals may have caused additional losses in other regions or that losses would have been reported by farmers and shepherds despite a lack of carnivores (cf. Bangs *et al*. 1995).

Given the above assumptions, the body of data gathered in the farm survey provide an order of magnitude for the extent of predation and an indication of various patterns, but individual reports should not be considered accurate in every respect. Moser and Kalton (1971) provided a detailed critique of surveys, the results of which are dependent on the accessibility to the respondent or interviewee of the required information, his or her understanding of what is being asked and his or her motivation to give accurate answers. In a situation where hostility to predators is high and missing sheep must be accounted for, motivation for accuracy in reporting losses can be expected to be low. In the area most comprehensively covered by the present study, Liptovský Mikuláš district of LM region, shepherds and farmers reported twice as many sheep lost to bears in 2001 at flocks surveyed as were confirmed for the whole district by the damage inspection commission (Cheben and Kováč 2002). Some of this discrepancy could be due to compensation not being sought for minor losses. However, during the survey the accounts of shepherds sometimes differed considerably from those of farm administrators. Shepherds may genuinely have had more knowledge of predation than farm administrators, or vice versa. Alternatively, shepherds (or farm administrators) may have reported missing sheep as depredated without having confirmation (E. Baláž pers. comm. 2004), or they may have forgotten some information. Hell and Slamečka (1999:91) have stated that shepherds and livestock owners in Slovakia are prone to report inaccurately, exaggerate and invent accounts of predation. Sabadoš and Śimiak (1981) estimated that damage reported to have been caused by bears was 30-40% greater than actual damage. According to official records, in the years 1997-2001 only 54-62% of annual damage reported as caused by bears was compensated, although some of this difference may have been due to administration (Hlásnik 2002a). In some cases, predation reported during the present study was known to have been exaggerated. For example, at a farm in MT region in July 2001 wolves (probably) caused the following losses of sheep: 18 missing never found; two of seven missing but found later died; 19 seriously injured (Rigg 2003c). During the survey this was reported by a shepherd as 60 sheep lost, i.e. 150-300% over-estimated. At a flock in LM region, during the survey shepherds claimed that 10 sheep in 2002 and 5-6 sheep in 2003 had been lost to bears. When the farm was revisited in spring 2004, shepherds then reported the losses as 18 in 2002 and 36 in 2003, to both bears and wolves. A comparison of results from the present study with official records of damage to livestock is presented on the national level in Table 3.9. Losses of sheep to wolves reported by shepherds and farmers in the present research were an order of magnitude higher than losses of all livestock to wolves and lynx as reported by hunters. Reported losses to bears were similar.

Table 3.9. Numbers of livestock lost to large carnivores in Slovakia estimated by the present study (PS) compared to official records from 2000-02. LVÚ figures were compiled from the unverified reports of hunters (Farkáš *et al*. 2001a,b, Lehocký *et al*. 2003b, Kaštier 2004). State Nature Conservancy (SNC) figures were based on reports of damage inspection commissions following visits to sites of alleged bear predation (Kassa 2001, 2002). [* Refers to all species of livestock and damage by wolves and lynx combined.]

Source of data	2000			2001			2002		
	bear		wolf	bear		wolf	bear		wolf
	sheep/ goats	cattle	sheep/ goats	sheep/ goats	cattle	sheep/ goats	sheep/ goats	cattle	sheep/ goats
PS	-	-	-	324±261	-	1,953±1,250	571±338	-	2,432±1,170
LVÚ	260	10	168*	272	9	170*	329	15	245*
SNC	>185	6	-	>197	5	-	-	-	-

Survey results for 2001 are presumably the least accurate of the three years due to the time lapse between events and survey (Moser and Kalton 1971). Even within one week of an attack some shepherds could not remember details of how many sheep had been killed, injured or lost, at what time or even on which day the attack had happened and gave different answers to different people on different days (pers. obs. 2003 versus S. Ondruš pers. comm. 2003). In rare cases shepherds claimed not to know how many sheep were in the flock they had charge of or to whom they belonged. For consistency of methodology, figures from the survey were used to analyse extent and patterns of predation, but the best available information was used to assess factors associated with high losses.

Even with the will to do so, accurately determining why livestock die is not a simple task. Various manuals are available for distinguishing predator species by examining prey remains (Kaczensky *et al*. 1997, 1999, Wade and Bowns 1997, Kossak 1998). However, experienced investigators cannot always identify wolf predation from evidence at a kill site (Fritts *et al*. 2003). Determining the cause of death may not be possible if carcasses are found in an advanced state of decay or are never recovered (S. Ondruš pers. comm. 2003). Distinguishing between attacks by wolves and dogs can be difficult or impossible (Boitani 1982, Cozza *et al*. 1996, Kaczensky 1996, Kossak 1998). In Italy, Boitani (1982) estimated that up to 50% of losses attributed to wolves may have been caused by domestic dogs. Wolf involvement could be confirmed in only 25-55% of complaint cases in various regions of N. America and Italy (references in Fritts *et al*. 2003). According to Bangs *et al*. (1995), 86% of cattle reported lost to wolves in the western USA in 1991 were in states without wolves. Some shepherds and farmers interviewed for the present study acknowledged such difficulties in their reporting; others may have mistakenly (E. Baláž pers. comm. 2004) or dishonestly attributed missing livestock to predation. Possibly the far greater scale of losses attributed to wolves than those to bears was partly due to more negative attitudes towards wolves (Wechselberger *et al*. in prep.). Uncritical acceptance of reports of predation by shepherds, farmers, hunters and the media seems certain to result in error when estimating the scale of losses.

Shepherds and farmers were asked to distinguish between “killed” and “injured” animals. The term “injured” is imprecise and could be interpreted to include animals with minor bites and scratches that quickly healed or only those so badly injured that they did not live long after the attack (S. Ondruš pers. comm. 2003), or their value and productivity were in some way impaired. “Injured” animals were therefore not analysed separately. Those reported to have died as a result of their injuries or which were euthanised were included in the total lost. Animals reported missing after an attack were likewise considered to have been killed. For this reason and those described above, the survey results should be taken as an estimate of the likely upper limit of losses to predation and may be somewhat exaggerated, particularly in the case of predation by wolves.

The impact of predation on Slovakia’s livestock industry

The results of the present study conform to several broad characteristics of carnivore-livestock conflicts in Europe identified by Kaczensky (1996, 1999) in a review of data from 12 countries. She concluded that reported losses were greatest for wolves and least (almost nonexistent in the present study) for lynx, with total losses usually amounting to <1% of livestock available (in the present study 0.5-0.9% of all sheep in regions with bears and/or wolves). Overall, losses of livestock to bears in Slovakia seem to be minor and are lower than in several regions of Europe with far fewer carnivores (Kaczensky 1996:73, 1999, Fourli 1999), presumably due at least partly to the continued presence of shepherds, use of some preventive measures and relative abundance of alternative food sources. Wolves were reported to cause considerably higher losses, although wolf predation is known to be difficult to distinguish from that of dogs and, because attitudes to wolves were more negative than those to bears (Wechselberger *et al.* in prep.), aggravated by a lack of compensation for damage caused by wolves prior to 1/1/03, there may have been a tendency to exaggerate the extent of wolf predation. On the other hand, wolf attacks tend to result in more livestock killed than is usual during bear attacks and instances of surplus killing are more common (Fourli 1999).

The estimated mean loss to predation of 2.6-4.3 sheep/flock/year reported by shepherds in the Slovak Carpathians is somewhat lower than a figure of 9.9 reported from part of the Romanian Carpathians (Mertens and Promberger 2001). The number of sheep killed/bear/year in Slovakia seems to be low. Mertens and Promberger (2001) estimated that in Braşov County, Romania, 1.5 sheep/year were killed in 1998-99 by bears or wolves. In Norway, an extreme case, the average has been estimated to be c.50-100 sheep/bear/year (Linnell 2000, Swenson and Andrén in prep.). Whilst the mean loss of 4.5-10.4 sheep/wolf/year estimated for Slovakia by the present research is greater than that calculated in Mertens and Promberger's study, it is not particularly high when compared to regions of Europe beyond the Carpathian Mountains. Small numbers of wolves naturally re-colonising parts of France (Lequette *et al.* 1996a,b, Lequette 1997), Switzerland (Breitenmoser 1998) and Norway (Kaczensky 1996) have caused substantial losses to a minority of flocks in limited areas where livestock protection measures were relaxed or abandoned after the previous extirpation of large carnivores. For example, 20-30 wolves in Mercantour National Park, France, were thought to be responsible for killing c.20-30 sheep/wolf/year in 1995-97 (after Lequette *et al.* 1996a,b, Lequette 1997). Swenson and Andrén (in prep.) estimated that c.26 wolves in Norway were responsible for killing c.25 sheep/wolf/year. Wolf diet in parts of southern Europe is almost exclusively based on domestic animals due to a scarcity of wild prey (Cuesta *et al.* 1991, Papageorgiou *et al.* 1994, Meriggi and Lovari 1996, Álvares and Petrucci-Fonseca 2000, Blanco 2000a, Blanco and Cortés 2000, Vos 2000, Barja and Bárcena 2003, Soria *et al.* 2003, F. Álvares pers. comm. 2003).

The economic costs of predation are difficult to compare among countries due to differences in assessment and verification procedures as well as in livestock and currency values (Kaczensky 1996, 1999, Fourli 1999). Published estimates of livestock damage in terms of cost/wolf/year range from c.€5 in North America (Carbyn 1987 cited in Fritts *et al*. 2003) to c.€1,200-3,200 in Italy, c.€2,800-2,900 in Spain and Portugal (Blanco *et al*. 1992, Vingada *et al*. 1999), c.€6,000 in France (Lequette in Mertens and Promberger 2001) and, perhaps the highest livestock damage cost/wolf/year in the world, c.€8,000 in Switzerland (Weber 2003). The cost of damage/bear/year appeared to be somewhat lower in those EU countries reviewed by Fourli (1999). In terms of total economic cost of predation, Italy seems to have the highest in Europe: according to Ciucci and Boitani (2000) c.€2 million/year were paid in compensation for livestock losses. Losses estimated by the present research fall well short of these extremes and surely have little economic impact on Slovakia's livestock industry or even on all but a small minority of individual farms, for example those where the relatively rare incidences of major surplus killing by wolves occur. Boitani (2000b:17) noted that, in general, damage caused by wolf predation is very low when compared to other causes of livestock mortality and is almost irrelevant as a percentage of the livestock industry. Total annual subsidies to agriculture in the Slovak Republic from 1999 to 2001 amounted to 0.93-1.08% of GDP per annum (MP SR 2002), four orders of magnitude greater than the compensation paid for damage caused by bears (Kassa 2001, 2002, Hlásnik 2002a). Even in Norway, bear predation is important only locally: the number of sheep killed by bears is insignificant compared with total sheep mortality across the country (Mysterud 1980). In Europe, damage caused by wild ungulates, particularly wild boar (*Sus scrofa*), is typically far higher than that caused by carnivores and losses of arable crops may be considerably greater than those of livestock. However, public opinions tend to be influenced by perceptions more than reality (Fourli 1999) and are aggravated by fear (Swenson and Andrén in prep.). Kaczensky (1996) concluded that in Europe carnivore-livestock conflicts are more of a social and psychological problem than a financial one, although they may cause significant economic losses to individual people in some poor rural areas (cf. Mertens and Promberger 2001).

An important finding of the present research was that most losses are concentrated at a minority of flocks, with <11% of flocks accounting for 56.0-75.5% of all reported losses in any one year. There are a number of similar findings in the published literature. In Romania, 64% of flocks surveyed lost <2% of animals to predation by bears and wolves per year while 8% of flocks lost >10% (after Mertens and Promberger 2001). More than 80% of reported predator-caused sheep deaths were at 22% of flocks monitored in Kansas (Robel *et al*. 1981). Less than 20% of flocks in Mercantour National Park were said to be affected by wolf predation (Espuno 2000, Lequette *et al*. 2000). Camarra (1986) found that 49.5% of bear predation on sheep in the French Pyrenees in 1968-79 occurred in 10% of the total predation range. Although some Norwegian farmers lost almost 30% of their animals to bear predation, <1% of livestock owners were affected and <0.08% of total stock was lost (Kaczensky 1996, Knarrum *et al*. 2002). Lynx predation on sheep in the French Jura (Stahl *et al*. 2001a,b, 2002) was found to be largely clustered in a few small "hot-spots". Cozza *et al*. (1996) discovered that 4.1% of damage compensation claimants in central Italy accounted for >33% of all claims. These authors felt that the reasons for predation were case-specific. Kaczensky (1996, 1999) thought that local differences in livestock guarding techniques were the most important factor explaining differences in predation levels among regions of Europe. Both of these conclusions were supported by findings of the present study.

Patterns of attacks and losses

A number of other patterns emerged from the present research into predation on livestock by bears and wolves in the Slovak Carpathians. Some of these are discussed briefly below and comparisons are drawn with results of previous studies in Europe and N. America. It seems clear from the significant variation in reported attacks and losses in spring-autumn versus in winter as well as during daylight versus at night, along with the importance of the method of night confinement as found by the present study, that the relative availability and vulnerability of livestock and/or degree of cover for approaching predators are of fundamental importance to the level of losses sustained.

<u>Local conditions, preventive measures and total losses</u>

Kazcensky (1996, 1999) found that damage levels in Europe could not be predicted from predator population size (or number of livestock available) alone. Herding techniques, species of livestock, type of range (forested or open) and alternative prey base all had important influences. Numerous other researchers have also concluded that local conditions play a key role in the extent of livestock losses to large carnivores (Zunino and Herrero 1972, Pearson and Caroline 1981, Robel *et al*. 1981, Zimen 1981, Boitani 1982, Jorgensen 1983, Kleschta 1983, Nass *et al*. 1984, Blanco *et al*. 1992, Boitani and Ciucci 1993, Fico *et al*. 1993, Kaczensky 1996, 1999, Ciucci and Boitani 1998, Promberger 1999, Espuno 2000, Paul 2000, Mertens and Promberger 2001, Stahl *et al*. 2001a,b, 2002, Fritts *et al*. 2003, Jedrzejewski *et al*. 2003, Muhly *et al*. 2003, Treves *et al*. 2001, 2003). Several recent studies have sought to identify characteristics that might predispose particular localities to predation. In general, untended livestock in remote pastures sustain the highest losses to wolves in Europe and N. America (references in Fritts *et al*. 2003). The distribution of the wolf, bear and lynx in Europe, including Slovakia, is closely linked to forest cover, so livestock are most vulnerable in or near woodland (Nass *et al*. 1984, Kaczensky 1996, 1999). Most cases of livestock depredation by wolves in Poland are caused by a few packs living at the edges of large wooded areas or in small forest and pasture mosaics (Jedrzejewski *et al*. 2003). In the Romanian Carpathians, attacks were more likely to occur on livestock in proximity to forest cover than in open areas (Salvatori and Mertens 2002). Farms that suffered losses to wolves in Wisconsin could be distinguished from those that did not on the basis of landscape features. Wolf packs implicated in predation on livestock lived in more forested areas than other packs (Treves *et al*. 2001, 2003). In south-western Alberta, ranches at higher elevations and in areas of greater vegetation productivity were found to be at risk of depredation by wolves (Muhly *et al*. 2003). Mech *et al*. (2000) found that farms in Minnesota that suffered chronic depredation were larger, had more cattle and had herds father from the farmhouse in comparison to nearby matched farms with no wolf predation. Calving in forested or brushy pastures and disposal of livestock carcasses in or near pastures, the latter being a common practice in Slovakia, were believed to be contributory factors (Paul 2000 but cf. Mech *et al*. 2000). Fico *et al*. (1993) also noted that newborn livestock in remote locations are more vulnerable. This was apparently an important factor in a case of surplus killing in the BB region of Slovakia on 8/5/02. In Braşov County, Romania, Mertens and Promberger (2001) found that the number of sheep/flock, but not the percentage of flock, killed by large carnivores was positively correlated with flock size. Espuno (2000) found a strong correlation between size of sheep flock and number of wolf attacks/flock in the Mercantour Mountains of France. No such relationships were detected in the present research.

Meriggi and Lovari (1996) concluded that the simultaneous reintroduction of several wild ungulate species in areas of southern Europe where they were absent or scarce was likely to reduce predation on livestock. However, Kaczensky (1996) found that high densities of natural prey did not necessarily prevent high livestock losses. Linnell *et al*. (1996) noted that increasing wild prey populations might sometimes result in increased predator populations and hence more predation on livestock. In Spain, livestock losses were highest in areas with high densities of wild ungulates; husbandry methods seemed to be the most important factor (Blanco *et al*. 1992). Bears in open, coniferous forest range in south-east Norway displayed "very persistent and efficient use of the sheep as a food source", despite an abundance of moose (*Alces alces*) in the area (Mysterud and Warren 1997). Alternative prey (roe deer *Capreolus capreolus*) was higher within "hot-spots" of lynx predation on sheep in the French Jura identified by Stahl *et al*. (2001a,b, 2002). Such "hot-spots" reappeared at the same sites years after interruption and removal of lynx, suggesting that causal factors may relate to landscape features, livestock husbandry practices or predator behavioural ecology.

When a particular locality seems to be prone to predation, probably the only way to achieve long-term reduction in losses, besides moving elsewhere or removing all predators and preventing their return, is to change livestock husbandry systems. A number of studies have shown that, within the same area, properly guarded livestock suffered lower losses than unguarded or poorly guarded stock (e.g. Blanco *et al*. 1992, Boitani and Ciucci 1993). In the present study, some farms in Slovakia were found to have successfully reduced losses by returning stock to a barn or farmyard at night, using dogs, electric fences or other aversive devices. Moving stock to alternative pastures had also been an effective strategy in a number of cases. Other farms had not implemented sufficient preventive measures and continued to suffer regular high losses. For example, in 2001 when farms were being selected for field trials of livestock guarding dogs (Chapter 4), a farm in DK region was said to have had annual losses of >20 sheep/flock/year among its 4-5 flocks. Nevertheless the chairman declined to introduce free-ranging LGDs. When it was visited in 2003 for inclusion in the farm survey, the mean loss to wolves and bears reported at this farm for the period 2001-03 was 19.6 sheep/flock/year, 6.8 times higher than the overall mean at surveyed flocks. Four of the farm's five flocks had allegedly lost a combined total of 294 sheep over this 3-year period, accounting for 23.8% of all losses reported at all 122 flocks for which data were available in all three years. Assistance in improving preventive measures was again declined.

Many non-lethal methods of livestock protection as well as selective lethal control have been used in different grazing situations with various degrees of success (Chapter 1; see reviews in Cluff and Murray 1995, Dolbeer *et al*. 1996, Kaczensky 1996, Linnell *et al*. 1996, Bangs and Shivik 2001, Rigg 2001a, Sillero-Zubiri and Laurenson 2001, Fritts *et al*. 2003). So far, none of these techniques can guarantee to eliminate predation entirely, but several have been shown to reduce losses substantially. Two of the most effective and at the same time most appropriate for Slovak conditions are livestock guarding dogs and electric fences. The present research confirmed that although large guard dogs are almost ubiquitous at Slovak sheep farms and electric fences have begun to be used at some, they are often so poorly implemented as to be of very little benefit. Very high losses occurred at several surveyed flocks nominally protected by chained dogs or electric fences. In Italy, problems of predation by wolves, domestic dogs and brown bears have been much less in areas where the traditional husbandry system of small flocks with shepherds and free-ranging livestock guarding dogs was still used compared to areas where it had been abandoned (Zunino and Herrero 1972, Zimen 1981, Boitani 1982, Boitani and Ciucci 1993, Ciucci and Boitani 1998). During trials in the Romanian Carpathians, losses were reduced to practically zero when flocks were within fully functional electric fences (Mertens *et al*. 2002). While preventive measures could clearly be improved in many cases, most sheep flocks in Slovakia are usually constantly attended by shepherds and so are less vulnerable to predation than the mostly untended flocks of the French and Swiss Alps (Espuno 2000, Weber 2003) and Norway (Mysterud and Warren 1997).

<u>Variation among seasons and years</u>

Evidence of a similar distribution of losses was found in the present study for both bears and wolves as that reported by Śmietana (2002) for wolf predation on livestock

(95% sheep) in the Polish Carpathians, with an initial smaller peak in May and a main peak in August-October. Broadly similar seasonal patterns were reported from Slovakia by Voskár (1993) and Finďo (2001, 2002). Śmietana (2002) explained the reduction in June-July as due to the availability of red deer fawns (*Cervus elaphus*). A peak of predation in late summer and autumn has been reported for wolves in the Polish Western Carpathians (Nowak 2003) and Bulgaria (Tsingarska-Sedefcheva and Dutsov 2003). Fritts *et al*. (2003) believed that the increasing food requirements of growing pups explain the relatively high losses of sheep to wolves at this time of year. In the French Pyrenees during the period 1968-79 the predation rate by bears on sheep peaked between late August and the third week in September, when flocks occupied high elevation subalpine pastures (Röben 1980, Camarra 1986). A combination of season and grazing location seemed to account for the peak of losses in Switzerland, where wolves preyed on sheep mostly during the summer when flocks were on mountain pastures above 2,000m a.s.l. (Weber 2003). Shortening the grazing season has been proposed as a means to avoid seasons of highest losses in Norway (Kaczensky 1996, Sagør *et al*. 1997, Landa *et al*. 1999). In the present study, very few losses were reported while livestock was confined to barns for the winter (December-March). Kaczensky (1996) also concluded that livestock closed in barns was usually safe from predation by wolves. Cessation of losses to wolves in winter has been reported by other recent studies in Europe (Śmietana 2002, Tsingarska-Sedefcheva and Dutsov 2003).

It has been noted that predation may be a greater risk when other food sources are limited. Failure of hard mast or fruit crops might result in higher damage statistics for bears (Rogers 1976 cited in Herrero 1985, Garshelis 1989 cited in Kaczensky 1996, 1999, see also review in Mattson 1990). In the present research, reported losses were significantly higher in 2002 than in 2003. Crops of beech mast and limba pine were far greater in 2003 compared to 2002 in much of northern Slovakia.

<u>Identity of predator</u>

In the present study, wolves were reported to cause significantly higher losses to sheep than were bears in each of the three years considered, while lynx were implicated in very few cases. Reports from a similar environment in Romania with livestock husbandry practices comparable to many farms included in the present study (Mertens and Promberger 2001) suggested that species killing livestock during the summers of 1998 and 1999 were primarily the wolf (59.9% of kills) and bear (39.7%). Kaczensky (1996) found that in Europe the level of predation on livestock is generally highest for wolf and lowest for lynx. Voskár (1976, 1993) believed that young wolves and packs from which dominant individuals had been removed by hunters were more likely to prey on livestock than older animals and intact packs due to impaired hunting ability. However, there is little evidence that livestock killing wolves (Fritts *et al*. 1992 cited in Fritts *et al*. 2003a) or other carnivores (Linnell *et al*. 1999) are old, injured or otherwise less able to kill wild prey. Some adult wolves probably use livestock to cope with the increasing demands of provisioning young (Fritts *et al*. 2003a). It is a common belief among Slovak farmers and shepherds that female carnivores use livestock to teach their offspring to hunt (pers. obs. 2001-04). Data from the present research can neither confirm nor refute this hypothesis. A number of studies elsewhere have identified particular "problem individuals/packs" (see below) or, among solitary species, a "problem sex" (see Mattson 1990 for bears, Odden *et al*. 2002 for lynx) as being persistent livestock killers. Adult male brown bears have been found to prey most often on cattle and sheep (Mysterud 1980, Knight and Judd 1983, reviewed in Mattson 1990). Sub-adult bears tend to prey on smaller animals such as sheep and yearling cattle (Mysterud 1980, Knight and Judd 1983) while females are less frequent predators on livestock.

Selection of livestock

Kaczensky (1996, 1999) found that across Europe sheep are by far the most vulnerable livestock and are often preyed on preferentially (but cf. Mertens and Promberger 2001, who concluded that sheep were preyed on in proportion to their abundance in Romania). According to Mattson (1990), bears exhibit distinct preferences for different species and age classes of livestock, their order of preference being approximately: swine (*Sus domesticus*) > ewes > lambs > calves and yearling cattle > cows > horses (*Equus caballus*) > bulls. In Norway, brown bears killed ewes and rams significantly more often than lambs (Mysterud and Warren 1997, Knarrum *et al*. 2002). Ewes equipped with bells were selected, presumably as bears learned to locate them by sound. Lighter breeds of sheep were found to have stronger anti-predatory reactions (Hansen *et al*. 2001). Sheep or goats were preyed on most by wolves in Bulgaria (Tsingarska-Sedefcheva and Dutsov 2003), Italy (Boitani 1982), the Polish Carpathians (Śmietana 2002, Jedrzejewski *et al.* 2003, Nowak 2003), Portugal (Vos 2000), Romania (Mertens and Promberger 2001), Spain (Blanco *et al*. 1992) and Switzerland (Weber 2003) as well as the north-western United States (Bangs *et al*. 2003). Wolves appear to select adult sheep and goats rather than lambs and kids, but attack more young cattle than adults (Fritts *et al*. 2003). There are some regions where wolves select other domestic species, such as dogs in European Russia (Bologov and Miltner 2003, Casulli 2003) and the Ukraine (Dyky and Delehan in prep.) and horses in northern Portugal (Álvares and Petrucci-Fonseca 2000, Vos 2000). Replacing sheep with cattle has been proposed as a means to reduce losses (Zimmermann *et al*. 2003). The present study collected data systematically only for losses of sheep/goats, but the results were consistent with the conclusion that they were preferred to cattle. Shepherds and farmers at 142 surveyed flocks reported a total loss to bears and wolves of 375 sheep in 2003 while six of them claimed to have knowledge of a total of 58 head of cattle killed in the same year (allegedly 2 cows and 9 yearlings by bears, 44 yearlings and 3 calves by wolves). Some of these reports were corroborated by other sources.

<u>Number of animals killed per attack</u>

According to the reports of Slovak shepherds and farmers in the present study, 87.0% of attacks by bears and 70.1% of attacks by wolves resulted in 0-3 sheep being lost. In the Romanian Carpathians, 88% of reported attacks by large carnivores involved 1-3 sheep killed (Mertens and Promberger 2001) while in the Polish Carpathians 93% of attacks on sheep by wolves resulted in the death of 1-3 sheep (Śmietana 2002). In 90% of recorded wolf attacks on livestock in north-west Spain, 1-2 sheep were killed (Soria 2003). Fritts et al. (2003) noted averages of 4.4-7.6 sheep killed by wolves per attack reported in the published literature. The mean in the present study was 5.6±2.6 (95% confidence intervals, mode=1, median=1).

In rare instances reported during the present research, >10 sheep were said to have been killed in a single attack, usually by wolves. Such attacks accounted for a high proportion of total losses reported and evidently contributed to the negative attitudes of farmers and shepherds to wolves. Surplus sheep killing by wolves is frequently mentioned in the published literature: e.g. 40 sheep killed in one night in the

Apennine Mountains of Italy (Boitani 2003b), 34 killed or injured in one night in Minnesota, 21-113 killed per attack in Tuscany, up to 80 killed per attack in Czechoslovakia (references in Fritts *et al*. 2003). Large numbers of animals are sometimes killed in predator-provoked accidents. Two hundred sheep were killed in the French Alps in September 2003 when they fell while fleeing from wolves (B. Lequette pers. comm. 2003). Such accidents were also recounted by Slovak shepherds interviewed during the present study. Surplus killing has been reported for a number of other Canidae as well as Ursidae and Felidae (Kruuk 1972, Linnell *et al.* 1999). There is some evidence that free-ranging livestock guarding dogs are able to prevent it, presumably by harassing attacking predators. In the Romanian Carpathians, surplus killing was never reported at flocks protected by such dogs (Mertens and Promberger 2001) and there have been no instances at flocks protected by free-ranging LGDs placed within the Protection of Livestock and Conservation of Large Carnivores project in Slovakia (Chapter 4).

Linnell *et al*. (1999) regarded surplus killing as an extension of natural multiple-killing behaviour, where multiple prey items that require more than one meal to consume are killed in a single event but are then fully consumed over a long period. Such behaviour has been observed in wolves (Crisler 1958, Mech 1970, Mech and Peterson 2003). Mysterud (1980) distinguished two patterns of "overkill" by bears: surplus killing and extreme food selection, in which only the most nutritious parts (breast fat deposits and udders) were eaten. The opportunity to make several kills in a short space of time rarely arises with wild prey and usually involves some factor or unusual conditions making the prey more vulnerable (Linnell *et al*. 1999). Surplus killing of livestock may therefore be a normal predatory response to an unusual situation: unnaturally high densities of easily caught prey that lack most of their natural anti-predatory instincts placed in enclosures or areas from which they cannot escape but where they are accessible to predators. Kruuk (1972) offered a physiological/neurological explanation of the phenomenon. He suggested that killing behaviour is not inhibited by killing and satiation, i.e. even if it is not hungry a carnivore may continue to kill while prey is still available, and that killing does not necessarily lead to eating because each of these behaviours has its own trigger(s) and inhibitor(s). Mysterud (1980) suggested that extreme food selection might increase with sheep density. According to this hypothesis, as sheep density increases, the number of animals killed would be expected to increase but the amount eaten from each carcass would decrease in a functional response. The present study found a significant positive correlation between sheep numbers in a region and numbers of sheep reported lost to bears.

Time of day and weather conditions

The majority of attacks and losses were said by shepherds and farmers to have occurred at night, but daytime attacks by wolves were apparently not unusual. Attacks by wolves on sheep in Slovakia during daylight hours have been reported by previous authors (Voskár 1993, Mráz 1996b, Finďo 2000). Kusak and Huber (2000) observed daytime predatory attacks on sheep by radio-collared wolves in Croatia. Although such behaviour exposes predators to greater danger and risk of discovery before making a kill or feeding, grazing flocks are usually accompanied by only a single shepherd with a small herding dog. Wolves attacking during the day therefore avoided the majority of shepherds and dogs plus electric fences, if used, at the sheepfold. On the other hand, attacks at night seemed to result in more sheep being killed, presumably because shepherds detected them and intervened later or not at all. Finďo (2000) also reported some evidence that attacks at night caused higher losses than those during the day, whereas media reports collated by Voskár (1993) suggested the opposite. Mertens and Promberger (2001) found that 56% of losses in the Romanian Carpathians were said to have occurred at night. Wolves naturally dispersing into the Mercantour Mountains of France from Italy attacked livestock at night in 90% of cases (Espuno 2000). Jorgensen (1983) reported that brown (grizzly) bears killed sheep in a mountain area bordering Yellowstone National Park only at night, whereas black bears (*Ursus americanus*) killed sheep both at night and during the day. Kaczensky (1996) concluded that throughout Europe livestock were most vulnerable at night.

Some evidence was found in this study to support the common assertion that weather conditions influence the occurrence of carnivore attacks on livestock. Zimen (1981) observed that shepherds familiar with wolves in the Apennine Mountains of Italy immediately moved their flocks to lower elevations or put them in sheds during misty weather. Camarra (1986) reported weak relationships between rainy conditions and high predation and between warm weather and a low predation rate by bears on sheep in the French Pyrenees. See also references in Kaczensky (1996). Weather can have a delayed effect. Predation by wolves on livestock in Montana peaked after a severe winter reduced wild ungulate numbers (Bangs *et al*. 1998, Meier *et al*. 2000) but was lower in Minnesota following severe winters, apparently due to the increased vulnerability of deer fawns (Mech *et al*. 1988).

Hunting and reduction of losses

During the period of study, lynx were fully protected year-round, bears were shot at bait by permit only from 1st June to 30th November (c.25-35 ind./year) and wolves could be legally shot in unlimited numbers from 1st November to 15th January (81-113 ind./year were reported shot in 2000-02; Kaštier 2004). One of the stated aims of permitting bear and wolf hunting was to reduce damage to agriculture by controlling carnivore populations. Exceptions could also be issued to permit the removal of individuals believed to have caused repeated damage (Adamec 2003, Kassa 2003). Three bears were shot on this basis in 2000 (Kassa 2001), one was caught in 2001 (Kassa 2002) and six were shot in 2002 (Lehocký *et al*. 2003a). Very few shepherds at surveyed flocks had guns, but some farm representatives were members of hunting clubs. In addition, shepherds or farmers often informed local hunters when they lost sheep or saw predators near their flocks. Evidence of the illegal killing of wolves, bears and lynx was found, including by trapping (banned in Slovakia), particularly in the east of the country (K. Soos pers. comm. 2003). Several bears were poached in central Slovakia, although this was sometimes commercially motivated (Ďurík 2000, 2002, Kassa 2001, 2002, S. Ondruš pers. comm. 2001-03, E. Baláž pers. comm. 2001-03, Lehocký *et al*. 2003a).

Mysterud and Warren (1997) found no simple relationship between extent of losses and overall density of bear populations in Norway; extreme food selection and surplus killing could lead to considerable losses of sheep even in areas with few bears at very low density. Losses of sheep and compensation payments are much higher in Norway than in Sweden, despite lower densities of carnivores (Swenson and Andrén in prep.). In Spain, damage was found to be distributed unevenly and did not correspond to numbers of wolves (Blanco *et al*. 1992); losses were highest where livestock was unguarded, even where wild ungulates were abundant. Kaczensky (1996, 1999) concluded that there was no obvious link between predator population size and losses among regions of Europe. On the other hand, some longitudinal studies have suggested that there can be such a relationship within the same region over time, leading to increasing losses as a carnivore population grows (e.g. Duchamp et al. 2003 for wolves in France) or decreasing losses as it declines (e.g. Röben 1980, Camarra 1986 for bears in the Pyrenees).

Kaczensky (1996, 1999) reviewed a number of cases in which very small numbers of "problem individuals", even a single bear, were responsible for half of all damage in certain years. Linnell *et al*. (1999) questioned the existence of problem animals, asserted that predation on livestock should be regarded as normal behaviour for a predator and hypothesised that most individuals of large carnivore species will at least occasionally kill accessible livestock. Nevertheless, several studies have concluded that a minority of carnivores were involved in predation on livestock and in some cases identified specific individuals that were responsible for a high proportion of damage. For example, Sumiński (1976) described a case from south-east Poland in which a c.300kg old male bear killed more than 70 cattle and horses over a 5-month period in 1971, including during daylight hours. In spring and summer 2000 a healthy c.150kg male bear believed to be from Slovakia killed one calf, 27 sheep, 239 rabbits and 34 poultry and demolished at least nine apiaries in Moravia, Czech Republic (Kunc 2001, Bartošová 2002, 2003, Šulgan 2002). The total damage, c.€5,000, was around 30% of the average annual compensation paid in the period 1998-2001 for damage to livestock and beehives caused by all 600-800 bears in Slovakia. Circumstantial evidence suggested that a single old male bear was responsible for predation in a particular part of the French Pyrenees (Camarra 1986). Of 37 radio-collared brown (grizzly) bears monitored in and around Yellowstone National Park by Knight and Judd (1983), 10 (27.0%) were known or suspected livestock killers: three preyed on cattle and six on sheep but only one on both. All the cattle killers were adults whereas four sub-adults attacked sheep. The researchers noted that most bears meeting livestock did not make kills. A more recent study on wolves in Wisconsin found that two-thirds of wolf packs ranged near livestock without causing problems. Farms suffering losses could be distinguished from those not on the basis of landscape features (Treves *et al*. 2001, 2003). Results from Poland also found that only a small proportion of wolf packs were involved in predation on livestock: c.60% of packs caused no damage, whereas 7% of packs caused 57% of the total damage (Jedrzejewski *et al*. 2003). There have been some analogous results for lynx: in an expanding population in the Swiss Jura Mountains, only two of nine radio-collared lynx became habitual livestock killers; other individuals with access to the same flocks were only occasional killers. No obvious reason for the difference could be identified (Stahl *et al*. 2001a,b, 2002).

Jorgensen (1983) concluded that the removal of individual livestock-killing bears could be an effective way to reduce or stop predation, but should be done very selectively and as soon as possible after an incident. However, shooting bears thought to have killed sheep in Norway had no effect on the number of ewes killed in the following season, probably due to immigration of other bears (Sagør *et al*. 1997). There have been similar findings for wolverines *Gulo gulo* (Landa *et al*. 1999). If Linnell *et al*. (1999) were correct in their belief that predation on livestock is better viewed as the behaviour of "normal" rather than "problem" individuals, this implies that in a country such as Slovakia, where carnivores and livestock occur in the same multiple-use landscape, making livestock less available to carnivores, e.g. by the use of protective measures such as livestock guarding dogs, is likely to be a more effective strategy to reduce losses than trying to remove individual predators or reducing the total predator population density through less selective lethal control, as currently conducted on wolves.

SUMMARY

- Twenty out of 24 regions (84%) with regular presence of bears and/or wolves were visited in order to assess farm conditions and anti-predator measures. Reports of losses to large carnivores were gathered by semi-structured interviews with farmers and shepherds for 164 flocks from 147 different farms.

- Surveyed flocks contained a total of c.79,000 sheep, c.23% of all sheep in Slovakia or c.26% of those in regions with bears/wolves. Data were compared with results from the Poľov 1-01 national hunters' questionnaire for 2000-02, and provided some idea of the extent of predation and an indication of various patterns among regions, years, seasons, time of day, species of predator and farm conditions.

- Overall, 48.0% of flocks (*n*=127) were not affected by wolf or bear predation at all during the period 2001-03. Some regions with carnivores had no reported losses while in other regions up to 82% of flocks were affected by predation in any one year, with a mean across all surveyed regions and all three years of 24.1%.

- In each year, ≤ 14.0% and ≤ 29.4% of surveyed flocks were allegedly affected by bear and wolf predation respectively.

- Particularly in the case of wolves, one farm suffering substantial losses to its various flocks (in single surplus killing events or as a result of multiple attacks) could account for up to 34.6% of total losses in a particular year at all surveyed farms combined.

- The distribution of reported losses was not adequately explained by estimates of the numbers of carnivores, particularly of bears.

- Very high losses were generally associated with poor husbandry and/or inadequate preventive measures.

Chapter 4

Testing the feasibility and effectiveness of livestock guarding dogs in the Slovak Carpathian Mountains

Abstract: This chapter presents behavioural observations of 14 pups from two recognised livestock guarding dog breeds (Slovenský čuvač and Caucasian shepherd dog) that were raised with sheep in 2001-03 at eight different farms in the Slovak Carpathian Mountains. An analysis is made of the degree to which pups became socialised to sheep and to what extent they exhibited desirable traits (attentive, trustworthy, protective). Responses of four yearlings to simulated predator attacks are reported and the effectiveness of dogs placed at farms as part of the Protection of Livestock and Conservation of Large Carnivores project is assessed in terms of reported sheep losses in 2002. Several factors that hindered the integration of dogs into flocks are described.

CONTENTS

INTRODUCTION

> *"At a remote sheep farm lived a dog named Bodrík. For a long time the shepherd was happy with him because he allowed no wolf to come near the sheepfold, neither during the day nor during the night."*
>
> (Bednar 2001:9)

These lines from the traditional fairy tale "Starý Bodrík a vlk" or "Old Bodrík and the wolf", collected in Slovakia by Pavol Dobšinský (b.1828, d.1885), describe a livestock guarding dog (*Canis lupus familiaris*) effectively protecting a flock of sheep (*Ovis aries*). Livestock guarding dogs (LGDs) probably came to the Slovak Carpathians from Romania and the Balkans (Hála 2001) during the Wallachian colonisation in the 14th–17th centuries (Laurinčík *et al*. 1958, Podolák 1967, 1972, 1982, Urbancová 1975, Stoličná 1997, Zuskinová 1999). Modern breeders, following early writers on the origins of domestic dogs (e.g. Darwin 1883, Lorenz 1954), believed they were the descendants of Arctic wolves (*Canis lupus*) that migrated southwards during the last glacial period (Kurz 1958, FCI Standard issued on 18/8/65 in Barlik *et al*. 1977). This theory now seems redundant in light of the results of recent genetic research suggesting that all domestic dogs originated in East Asia (Savolainen *et al*. 2002), but LGDs have certainly existed for thousands of years (Ryder 1983) and were already common in Europe during the Roman period (Barlik *et al*. 1977, Coppinger and Coppinger 2001). Rather than conducting sheep or cattle (*Bos taurus*) from one place to another, as do herding dogs such as the Scottish border collie, LGDs protect the flock from external threats (Coppinger and Coppinger 1993). They work by staying with the livestock and driving away intruders (McGrew and Blakesley 1982).

The renewed use of LGDs has been promoted as a traditional, mostly non-lethal form of predator control that could facilitate carnivore conservation (Coppinger *et al*. 1988, Ginsberg and Macdonald 1990, Rigg *et al*. 2003, but cf. Coppinger *et al*. 2003, who argued that fragile populations of wild canids might be threatened by the presence of domestic dogs). A domesticated carnivore has thus come to protect not only its domesticated former prey but also, indirectly, its own wild progenitor, the wolf (Clutton-Brock 1999, Wayne and Vilà 2003). Many studies have found LGDs to be highly successful in reducing losses to predation (reviewed in Rigg 2001a). Livestock guarding dogs are currently used on open range, fenced pastures and small holdings in Europe, the Middle East, Asia, Africa, the Americas and Australia to protect stock from canids (domestic dog *Canis lupus familiaris*, coyote *C. latrans*, grey wolf *C. lupus*, dingo *C. dingo*, red fox *Vulpes vulpes*), felids (lynx *Lynx lynx*, puma *Felis concolor*, cheetah *Acinonyx jubatas*, leopard *Panthera pardus*), ursids (brown bear *Ursus arctos*, black bear *U. americanus*), hyaenas (brown hyaena *Parahyena brunnea*) and primates (Savanna baboon *Papio hamadryas*). Sheep, goats and cattle are most commonly protected but LGDs have also been used with a variety of other stock such as poultry, equids, alpacas (*Vicugna pacos*) and llamas (*Llama glama*), cervids and even the ostrich (*Struthio camelus*), rhea (*Rhea americana*) and emu (*Dromaius novaehollandiae*) (Rigg 2001a, Dawydiak and Sims 2004).

Coppinger and Coppinger (1978) described three aspects of behaviour required for a dog to succeed as a livestock guardian: it must be attentive (pays attention to and follows livestock), trustworthy (does not harm them) and protective (wards off external threats). These behavioural traits are not discrete, but a minimum standard must be maintained by the dog for all three (Coppinger *et al*. 1983). How this can be achieved was summed up by Coppinger (1992b): “The dog should be kept with, brought up with, socialised with and bonded with the stock it is going to protect.” The critical or sensitive period for domestic dogs to form social attachments is between 2-4 and 12-14 weeks of age (Scott and Marston 1950, Scott and Fuller 1965, Bateson 1979). During this period they can form strong social bonds to other species and so come to display intra-specific social behaviours inter-specifically (Coppinger and Coppinger 2001). The social bonding of LGDs to species with which they have become familiar, including livestock, is facilitated by their weak predatory motor patterns (Coppinger *et al*. 1988). It has been suggested that LGDs display arrested development or behavioural neoteny of predatory motor sequences, which therefore do not become fully operational (Coppinger and Smith 1983, Coppinger *et al*. 1987, 1988 but cf. Coppinger and Schneider 1995, Coppinger and Coppinger 2001). The retention of juvenile characteristics throughout their adult lives apparently blurs species-specific recognition, allowing social bonding with other species, including livestock. This is in contrast with herding dogs, whose eye-stalk-chase approaches to livestock are predatory motor patterns inherited from the wolf or wolf-like ancestor of domestic dogs (Coppinger *et al*. 1985 citing Holmes 1966, Vines 1981). Differences in neurotransmitters have been found between LGDs and herding dogs which may underlie the behavioural differences (Arons 1989 cited in Coppinger and Coppinger 1993). Although dogs of some breeds have sometimes been successfully introduced into flocks when more than six months old (Green and Woodruff 1980 cited in Coppinger *et al*. 1983, S. Ribeiro pers. comm. 2003), social attachment can be weak or fail if begun later than 16 weeks of age (see Krogstad *et al*. 2000, Marker 2000c) so training is usually begun with 4-8 week old pups (Sims and Dawydiak 1990, USDA 1998, Coppinger and Coppinger 2001, Dawydiak and Sims 2004). Darwin (1845) observed pups suckled by ewes in South America, but this is not required for successful bonding (Arons 1980). Whilst exposure and bonding to livestock during the critical period are generally considered the basis of success, further corrective training may be needed until dogs are 18-30 months old (Sims and Dawydiak 1990, Dawydiak and Sims 2004).

Acquisition of the requisite behavioural traits is dependent not only on the developmental environment influencing experience and learning but also on genetic inheritance (Scott and Fuller 1965). Not all pups are capable of becoming good livestock guardians, regardless of how they are raised (Coppinger and Coppinger 2001). Suitable dogs include the Polish Owczarek Podhalański, Bulgaria's Karakatchan, the Kuvasz and Komondor in Hungary, the Great Pyrenees and Spanish Pyrenean Mastiff, Italian Maremmano-Abruzzese, Carpathian and Mioritic sheepdogs of Romania, the Šarplaninac of former Yugoslavia, several types of dog in Portugal and various Russian, Turkish and other Asian dogs (see e.g. Fogle 2000:300-361). The type of LGD regarded as native to Slovakia is the Valaský pes karpatský, also referred to as the Slovenský strážny pes, karpatský valaský pes, veľký valašský pes, Tatranský čuvač, lipták or strážko. It was used with cattle as well as sheep (Kurz 1958). Early modern breeders distinguished between a large mountain race and a smaller lowland race (Hrůza 1947). A so-called "bundáš" form of sheepdog has been described, confusingly also referred to as the Tatranský ovčiarský pes (Kurz 1958, Plánovský *et al*. 1967). The description given by Kurz (1958) of the Valaský pes karpatský most closely resembles a typical LGD, whereas the "bundáš" appears to have been physically and behaviourally a mixture of guarding and herding dogs, with pricked rather than pendant ears like most LGDs (cf. photographs and descriptions in Kurz 1958, Plánovský *et al*. 1967:177-179). Kurz (1958) lamented that "bundáš" and "strážko" forms were frequently crossbred by hobbyists in Moravia, but included a photograph of a working "Tatranský pes of the čuvač x bundáš hybrid-type" guarding sheep. In 1965/69 the Federation Cynologique Internationale (FCI) registered a single breed of LGD from Slovakia under the name Slovenský čuvač to avoid confusion with the Polish Tatra sheepdog (Barlík *et al*. 1977). The weight (36-44kg for a male, 31-37kg for a female), height (62-70cm and 59-65cm respectively) and pendant ears of modern Slovenský čuvač match descriptions of the Valaský pes karpatský but not those of the "bundáš" (FCI Standard issued on 18/8/65 in Barlik *et al*. 1977).

Distinctions which did not affect working ability were more relevant to modern dog breeders and nationalists than to shepherds, dogs, sheep and predators. For example, LGDs in Slovakia were much more varied in colour (see Hála 2001:96) than the modern breed Standard for the Slovenský čuvač allows. The validity and desirability of classifying LGDs into separate breeds as if they derived from discrete, sexually-isolated populations has been challenged by several authors (e.g. de la Cruz 1995, Sponenberg 2000, Coppinger and Coppinger 2001). They argued that the earliest forms of working dogs arose by natural rather then artificial selection and that different forms of LGDs result from regional variations in a continuous, inter-breeding population of dogs spread from western Europe to Asia, compounded by founder effects, geographical factors (latitude, altitude) and shepherds' values and beliefs. According to this theory, dividing a set of dogs that is phenotypically very similar and had no obvious barriers to inter-breeding prior to modern breed clubs, into Polish Owczarek Podhalański, Slovak čuvač and Hungarian kuvasz and Komondor is misguided or motivated by nationalism. Photographs from the 1960s held at the photo-archive of the Slovak National Museum in Martin show Komondor-type dogs or perhaps mixed Komondor-čuvač used as LGDs at sheep farms in Veľká Fatra, northern Slovakia. Mongrels, crossbreeds or dogs from local sub-populations not recognised as breeds have made effective livestock guardians (Black 1981, Black and Green 1985, Coppinger *et al*. 1985, Coppinger and Coppinger 2001). Mixed breed or mongrel LGDs are common in Romania (Rigg 2001a, Dawydiak and Sims 2004) and Italy (Landry 1999 citing Guberti) but were judged to be deficient in guarding ability in Bulgaria (Tsingarska *et al*. 1998, I. Ivanov pers. comm. 2001) and Portugal (Pedro 1996-2000b, Fonseca 2000, S. Ribeiro pers. comm. 2003). Crossing with non-guardian breeds has diminished the effectiveness as LGDs of some Russian Ovcharkas (Sponenberg 2000) and Caucasian shepherd dogs (Dawydiak and Sims 2004).

Modern dog breeding, founded on a concept of "pure breeds", arose from 19th century English views of animal husbandry and has led to the standardisation of breeds by artificial selection (Darwin 1859, 1883, de la Cruz 1995, Sponenberg 2000, Coppinger and Coppinger 2001). Although kennel clubs might intend to preserve a "rare breed", the risks of genetic diseases and inbreeding depression are increased by closing stud books to dogs outside a relatively small registered population. In addition, working ability is threatened by selective breeding for physical characteristics congenial to companion and show animals (Lorenz 1954, de la Cruz 1995, Pedro 1996-2000a, Landry 1999, Fogle 2000, Sponenberg 2000, Budiansky 2001, Coppinger and Coppinger 2001, Dawydiak and Sims 2004). "Pure-breeding" of Slovenský čuvač to preserve what was perceived to be a unique and threatened type of dog began in 1929 with a male and female taken from the Liptov Tatras region of northern Slovakia (Hrůza 1947, Barlík *et al*. 1977, Barlík 1992). By the beginning of the 21st century there were about 2,000 registered pedigree čuvač in Slovakia producing 60-100 pups/year (J. Goliašová pers. comm. 2003). Modern dog breeding had become so distanced from working dogs that the Slovenský čuvač Club in Slovakia did not consider farm dogs suitable for inclusion in its breeding programme and instead sought to reinvigorate pedigree bloodlines using non-working dogs from Finland and the Ukraine.

In the past it was usual for flocks grazed in the Slovak Carpathian Mountains to be accompanied by up to 10 free-ranging čuvače providing protection from predators and thieves (Podolák 1967:109, Jamnický 2000). Ján Hála's (2001) illustrations and description of čuvače guarding flocks by day and *salaš* (a camp used as a base for grazing livestock from spring-autumn) by night portray the continued tradition of LGDs in northern Slovakia up to the late 1940s: "The dogs were like bears, the whole village was afraid of them" (Hála 2001:97). Kurz (1958:342) included a photograph of a čuvač-type dog among grazing sheep with a dangle stick to prevent it chasing wild animals. Čuvače were often fitted with this device along with a spiked metal collar to protect them from wolves and bears (Podolák 1967, 1982, Hála 2001), equipment still common in Bulgaria, Romania, Portugal and Turkey (pers. obs. 2001-03). Herding dogs were not formerly widespread in mountainous areas of Slovakia (Plánovský *et al*. 1967). According to some authors and older shepherds, there were sheepdogs in Slovakia able to perform a mixture of guarding and herding duties, although this seems to refer to the "bundáš" form (Kurz 1958, Barlik *et al*. 1977, Polách 1988, Dawydiak and Sims 2004, Rigg unpub. data).

Manuals on animal husbandry published in the 1950s and 1960s during the socialist period distinguished between "large" (guarding), "medium-sized" ("bundáš") and "small" (herding) sheepdogs (Kurz 1958, Plánovský *et al*. 1967), advised that guarding dogs, but not herding dogs, could be chained (Kováč 1953) and suggested that the Tatranský čuvač was not a suitable dog to accompany flocks to pasture (Kurz 1958). In the early 1960s ethnologist Ján Podolák (1967:109) observed that "tame" LGDs were taken out to pasture but "dangerous" ones were chained near the "koliba" (shepherds' hut) during the day and released at night. Most surviving photographs of LGDs from this period show them chained, although there are a few of apparently free-ranging čuvače accompanying shepherds and flocks to pasture (Podolák 1962, 1967, 1982, Photo-archive of the Slovak National Museum). Chained LGDs are visible in the 1971 feature film "Nevesta hôl" directed by M. Ťapák. More recent authors have recommended inappropriate breeds for livestock guarding. Besides the Slovenský čuvač, Teren (1987:122) suggested laikas (hunting dogs) and Voskár (1993) mentioned the German shepherd dog (a herding dog). Such errors apparently stem from a failure to distinguish between the behavioural traits of guarding versus herding types of sheepdogs, a mistake made by many modern shepherds in Slovakia (pers. obs. 2001-04).

At the end of the 20th century Slovak shepherds still kept large dogs for livestock protection, usually unregistered Slovenský čuvače as well as the Caucasian shepherd dog, Central Asian sheepdog, Owczarek Podhalański or mongrels/crossbreeds, but they were almost always chained to stakes or trees around the sheepfold or farm buildings (Coppinger and Coppinger 1994a, Rigg 2002b). Chaining dogs alters their behaviour, typically making them more aggressive, which Finďo (1997, 1999) believed was the original intention, and limits their anti-predator capability to the length of the chain (Coppinger and Coppinger 1994b) or alerting shepherds with their barking. Many of Slovakia's chained dogs suffer both emotionally as they are deprived of social interaction and physically if left on open pastures in the summer without access to shade or water. Why livestock guarding dogs in Slovakia came to be permanently chained is not entirely clear (Rigg 2002b). Perhaps it was part of the continuing decline in agriculture and loss of traditional knowledge hastened by collectivisation of farming during the communist period (1948-1989), the removal of personal responsibility having led to apathy. In Slovakia many other dogs besides LGDs are routinely chained up simply to keep them near what they are required to guard. The demise of large carnivores in the early 20th century may have meant that theft was a greater threat than predation and so guarding dogs were kept near the farm buildings while herding dogs were more commonly taken out to pasture (Podolák 1967:109-110, 1982:150-151, Zuskinová 1999). Laurans (1975 cited in Coppinger and Coppinger 1993) discussed the replacement of guarding dogs with herding dogs following the decline of large carnivores in Europe. Most Agriculture Ministry staff, ethnographic researchers of agriculture and even shepherds interviewed in 2002 confused herding with guarding dogs (Rigg 2002b). As sheep and cattle were excluded from some high mountain areas following their designation as National Parks (Tatranský N.P. in 1948-49, Nízke Tatry N.P. in 1978) herding dogs were increasingly needed to keep flocks away from agricultural crops in lower lying areas nearer settlements, a role for which the "bundáš" was sometimes used (see Kurz 1958, Barlik *et al*. 1977). Dogs accompanying flocks at lower elevations would also have come into more contact with unfamiliar people. Many modern shepherds in Slovakia are reluctant to release their guarding dogs for fear they might attack walkers, farm visitors or berry and mushroom pickers. Novák (1943:320-332) described the rise in popularity of tourism in livestock-rearing areas of Slovakia prior to the Second World War.

One of the aims of a wolf research project conducted in the Tatra Mountains in 1994-98 was to revitalize the use of free-ranging, sheep-socialised LGDs in Slovakia. Two Owczarek Podhalanski pups were imported from Głodówka in southern Poland, where the LGD tradition had endured, and socialised with sheep during the winter at a farm in the Nízke Tatry (Bloch 1995, Bloch and Find'o 1996). Find'o (1997, 1999) translated into Slovak the background information and guidelines for raising and training LGDs according to a system developed in the USA (Lorenz and Coppinger 1986). A broader initiative was proposed (Coppinger and Coppinger 1994a,b) but funds were not forthcoming, the project ended and the imported dogs were chained up. Proposals for a new attempt to revive Slovakia's livestock guarding dog tradition were prepared by Finďo and Rigg (1998). The Born Free Foundation agreed to provide core funding to launch the Protection of Livestock and Conservation of Large Carnivores (PLCLC) project in 2000. The present research into the feasibility and effectiveness of raising LGDs at sheep farms in Slovakia was conducted as part of this project in 2001-03. Rather than importing pups, it was decided to test the working abilities of those available in Slovakia. The native Slovenský čuvač was an obvious choice. However, due to concerns that its behavioural conformation might have been adversely affected by breeding for pets and show dogs over several generations, it was decided also to test a second, more natural breed. The Caucasian shepherd dog was selected as it was assumed to have been less altered by modern breeding programmes (Finďo 2000), although this was not necessarily the case as many Caucasian shepherd dogs have been selectively bred, including by out-crossing, for military use and property guarding (see Dawydiak and Sims 2004).

The main aims of the study were to:–

(1) Observe the degree to which LGD pups available in Slovakia bond to livestock and if they become sufficiently attentive, trustworthy and protective.
(2) Test the ability of yearling LGDs to protect a flock of sheep from a simulated predator.
(3) Assess the extent to which LGDs placed at farms as part of the PLCLC project appear to affect the level of reported losses to predation.
(4) Identify any barriers to the successful reintroduction of free-ranging livestock guarding dogs as a non-lethal form of predator control at sheep farms in the Slovak Carpathians.

MATERIALS AND METHODS

Study area

Field trials of livestock guarding dogs took place at working farms within the Slovak Carpathian Mountains in the following regions: Čadca (CA), Humenné (HE), Liptovský Mikuláš (LM) and Martin (MT). See Chapter 3 for a map of regions in Slovakia. LM and MT regions were regarded as being in the core areas of wolf, bear and lynx distributions in Slovakia (Kaštier 2004). See Chapter 2 for more detailed descriptions of these regions. Wolves had survived in HE region throughout the 20th century during periods when they had been eradicated from most of the rest of Slovakia due to immigration from the east (Voskár 1993), while bears had recovered there more recently and were at lower densities than in central Slovakia (Pčola 2003). The farm where pups were located (49° N, 22° E) was on the edge of Poloniny National Park not far from the Slovak-Ukraine border, the European Union's external, unfenced border since May 2004. Altitude ranged from 200m a.s.l. in the valley bottom to surrounding ridges and peaks >1,000m a.s.l. Ridges and slopes above c.300m a.s.l. were covered with extensive semi-natural and commercial forests dominated by beech (*Fagus sylvatica*). Although human settlements were scattered through the lower lying parts of the region, many of them were somewhat depopulated due to emigration. The farm and its pastures were at 220-300m a.s.l.

All three large carnivore species had been recorded at low densities in CA region, near the western limit of their distributions in the Carpathian Mountains (Kaštier 2004). Human settlement was very widespread in this region and most habitats had been greatly altered by human activities. A substantial proportion of forest cover had been converted from the original beech-dominated communities to spruce (*Picea abies*) monoculture. In the area around the farm where pups were placed (49° N, 18° E), between the Javorniky and Beskydy Mountains and not far from unfenced borders with the Czech Republic and Poland, altitudes ranged from c.400m a.s.l. in the densely human-populated Kysuca River valley to forested ridges and peaks of c.600-1,100m a.s.l.

Details of farms where pups were raised are given in Table 4.1. Husbandry generally followed practices typical of contemporary upland sheep farms in the Slovak Carpathian Mountains. Besides lambs sold for meat at Easter (sometimes Christmas), the focus of production was on milk. Sheep were sheared twice per year but wool was of little or no economic importance. Most flocks were based at temporary camps called *salaše* from spring until autumn in order to allow pastures more distant from the home farm or village to be utilized whilst sheep could still be milked daily. All pastures were unfenced, typically forming part of a mosaic of agricultural land and forest cover (farms 1-3 and 8) or lying at the edge or in the midst of extensive forest-covered mountains (farms 4-7). Sheep were generally purebred or crossbred Valaška or Cigajka with some Merino, the core of the flock belonging to the farm with additional sheep added from private owners for the grazing season. Ewes were milked in the morning by hand by 3-5 shepherds and then grazed from c.08.00 to c.16.00h, with a noon milking at some farms in April-August when milk production was highest. At least one shepherd with herding dog was habitually in attendance during the day. In the evening the ewes were milked again, grazed briefly and then most often were gathered into a mobile sheepfold constructed from metal fence sections. At night, one or more shepherd(s) slept in a nearby caravan, cabin or farm building. The milk was made into a variety of cheeses, either by hand on site by the head shepherd (*bača*) or at a processing plant. Yearling sheep were either grazed separately or added to flocks of ewes later in the season. Breeding generally took placed at the *salaše* in August-September. Sheep were then grazed outdoors near villages until major snowfall, usually in November. In the winter they were kept in barns and fed on dry feed, either at the home farm or having been returned to their respective private owners. Most lambing occurred in barns in January-February.

Selection of farms

Before the 2001 grazing season began a meeting was held at the LM regional branch of the Agriculture Ministry to which local farmers were invited. Of those farmers that attended and wished to be included in the trials, two who reported having lost livestock to predators in the preceding three years were selected for placement of pups. Four farms in MT region, one in CA region and one in HE region were chosen

Table 4.1. Farms where LGD pups were first located and details of flocks, pastures, approximate distance from nearest forest cover and permanent human settlement, method and location of night confinement and preventive measures used in 2001. Previous losses were reported by shepherds/farmers and had not necessarily been verified.

Region	No. farm (type)	Details of flock(s)	Location of pastures	Night confinement	Preventive measures	Previous losses of sheep
CA	1. PD Raková (collective)	2 flocks each of 220 ewes	valley, forest patches 200m, village <500m	loose at *salaš*, 500m a.s.l.	1 chained dog	25 in 1997 and 46 in 1998 all to wolf
HE	2. AF Stakčín (company)	200 ewes and 100 yearlings	valley, large beech forest patches <100m, village 2km	loose in unfenced farmyard, 200m a.s.l.	none	a few attacks by stray dogs each year
LM	3. Spolchov Východná (company)	460 ewes and 85 yearlings	submontane, forest patches <100m, village 2-3km away	sheepfold at *salaš*, 900m a.s.l.	chained dogs, petrol lamps, firecrackers	1-2 per year to wolf or bear in 1998-2001
LM	4. E. Tholt (private)	2 flocks each of c.500 ewes	narrow valley bottom, forest edge <100m, village c.4km	sheepfold at *salaš*, 800m a.s.l.	chained dogs, inadequate electric fence	7 sheep to wolf in 2000
MT	5. RD Valča (collective)	350 ewes and 100 yearlings	<100m from edge of v. large mixed forest, village <2km	sheepfold at *salaš*, 500m a.s.l.	chained dogs, electric lights, radio left on	6 to bear in 1999
MT	6. PD Sklabiňa (collective)	480 ewes and 120 yearlings	<100m from edge of v. large mixed forest, village c.3km	sheepfold at *salaš*, 700m a.s.l.	chained dogs, petrol lamp, single strand of electrified wire	25 in 1997, 1 in 1998 and 4 in 2000 all to wolf
MT	7. PD Belá Dulice (collective)	5 flocks, details given for one most predated	up to 1,400m a.s.l., 6km from village, surrounded by mixed forest	loose or in shed at *salaš*, 1,000m a.s.l.	none	16 in 1999 and 20 in 2000 to wolf or bear, 24 to wolf and 2 to bear in 2001
MT	8. SHR Dzúrik (private)	540 ewes, 120 lambs and 310 yearlings	open range, small copses, village 2km, extensive forest >4km away	loose on pasture next to farm at 500m a.s.l.	chained dogs (1 sometimes free at night), halogen lamp, patrolling	thieves stole 2-4 per year in 1998-2001

early in the 2001 grazing season after site visits to discuss the project with farmers and shepherds. Priority was given to farms where personnel seemed to be motivated and losses to predators in recent years were reported (Table 4.1). Several farms were visited in DK region as well as in the western part of LM region but, despite reporting very high losses in some cases, none wished to participate in the project. Other farms were included in the PLCLC project in 2000-03 on the bases of interest, losses to predation in recent years and an assessment of the likely ability and willingness of farm personnel to raise LGDs in appropriate conditions.

Selection of pups

Given the lack of free-ranging, sheep-socialised LGDs in Slovakia, two sources of pups were available: dogs from strains bred as companions or property guardians, either with or without pedigree papers, and those born on farms, invariably where adult LGDs were chained and did not have pedigree papers. Pups from reputable breeders and with pedigree papers were preferred in order to be confident of their origins and identities. In order to begin all trials within the 2001 grazing season, three supposedly "pure-blood" Caucasian shepherd dogs without pedigree papers were bought from a private owner and two čuvač-type pups without pedigree papers were bought from a shepherd in LM region. Details of all 14 pups included in behavioural observations are given in Table 4.2. Most other dogs placed as part of the PLCLC project and included in the assessment of effect on reported losses came from registered breeders, had pedigree papers and were either Caucasian shepherd dogs or Slovenský čuvače. Five sibling Slovenský čuvač x Owczarek Podhalański hybrids were included (Find'o 2000). Although LGDs are often neutered (Black and Green 1985, Dawydiak and Sims 2004), dogs within the PLCLC project were left intact so those which proved successful could be used to establish working strains.

Table 4.2. Details of LGD pups included in field trials and behavioural observations. "Farm" refers to the location where pups were raised and "w/sheep" the age from which they were put with sheep. Sets of dogs with the same dates of birth belonged to the same litter.

Name	Breed	Pedigree	Sex	Born	w/sheep	Farm
Asan	Caucasian shepherd dog	yes	m	4/5/01	13 weeks	6
Axo	Slovenský čuvač	yes	m	31/5/01	10 weeks	2
Bak	Slovenský čuvač	yes	m	3/4/01	8 weeks	4
Barón	Slovenský čuvač	yes	m	3/4/01	8 weeks	3
Bianca	Slovenský čuvač	yes	f	25/5/01	7 weeks	1
Blanca	Slovenský čuvač	yes	f	25/5/01	7 weeks	2
Brita	Slovenský čuvač	yes	f	25/5/01	11 weeks	4
Dona	Caucasian shepherd dog	no	f	20/7/01	7 weeks	8
Eva	Slovenský čuvač	no	f	10/6/01	5 weeks	3
Finestra	Caucasian shepherd dog	yes	f	16/8/01	6 weeks	7
Flávia	Caucasian shepherd dog	yes	f	16/8/01	6 weeks	7
Goro	Slovenský čuvač	no	m	10/6/01	5 weeks	1
Maco	Caucasian shepherd dog	no	m	20/7/01	7 weeks	8
Pazúr	Caucasian shepherd dog	no	m	20/7/01	7 weeks	5

It has been noted that, although there are traits regarded as typical for particular types of LGDs, variation among individual dogs within a breed, even within the same litter, can be greater than that among breeds (Coppinger and Coppinger 2001, Dawydiak and Sims 2004). The choice of which pups to take from a litter may therefore be important. Puppy aptitude tests, although based on rather subjective observer ratings, may provide an indication of a dog's personality. Tests adapted for livestock guarding dogs (Sims and Dawydiak 1990) were not available to the researcher until after the 14 pups used for behavioural observations were already >6 months old, so unfortunately they could not be used to investigate if there was a link between pups' scores in the tests and their subsequent success as adult LGDs. Instead, nine čuvač-type pups seen at farms in 2002, including four of Eva's first litter of pups (probably sired by Barón), were tested in order to ascertain whether their behaviour and scores generally conformed to those considered desirable in livestock guarding dogs. The methodology for these tests was described by Sims and Dawydiak (1990) and Dawydiak and Sims (2004). Most LGD pups tested by these authors were found to be independent in nature and tended to have scores of 3-5, although 6-7 was not unusual. LGDs showing highly social/dominant traits (scores of mostly 1 or 2) were rare. Quieter, less active and more reserved pups were said to be best suited for guarding livestock. Generally pups should neither be aggressive to livestock nor completely ignore it.

Raising pups and bonding them to sheep

Successful livestock guarding dogs have been raised by shepherds using very simple methods. For example, the Navajo put 4-5 week old pups with sheep and goats, encouraged them to stay with the flock, punished wandering or harassing livestock and shot dogs that were consistently untrustworthy (Black and Green 1985). The only command used was to tell the dog to return to the flock. In Romania, pups were left with flocks and expected to learn from adult dogs (Mertens and Promberger 2000). As neither experienced shepherds nor working adult dogs were available in Slovakia, a methodology developed in the USA for introducing guarding dogs into a livestock operation was adopted for the PLCLC project (Lorenz and Coppinger 1986, USDA 1998). Pens were constructed of 6-8 metal or wooden frames, one of which had a door, which were 2-4m long and c.1.5m high with deer fencing wire attached. These were set up on summer pastures or in barns. Some shepherds improvised simpler enclosures within farmyards. In most cases two such pens or enclosures were set up at each farm so that two unrelated pups could be raised separately with sheep. This was not possible at all farms due to a shortage of pups and different wishes of farmers. Pens set up on pastures had a shelter for the pup and a simple barrier to restrict sheep's access to the dog's food. To avoid over-grazing, enclosures were moved every few days. Alternatively, grass was scythed and fed to the sheep within or they were released for short periods to graze.

Placement of pups began in the last week of May and was completed by the second week of September 2001. The age of pups' first contact with sheep varied from five to 13 weeks according to the availability of suitable pups and farmers wishing to receive them (Table 4.2). Two pups (Eva and Goro) were born on a sheep farm. Each pup was vaccinated by a qualified veterinarian against distemper, parvovirus and rabies and regularly wormed. In most cases, farmers were helped with the cost of raising pups by supplying high quality commercial dog food. Regular telephone contact was maintained with farmers and shepherds. Farms were visited at least once a month, usually more often, in order to carry out health checks of the pups (see Appendix 4), discuss progress with farmers and shepherds, help solve any problems and observe pup behaviour. Shepherds were asked to keep pups in contact throughout the socialisation period with at least 5-6 young sheep that were to be regularly exchanged for different sheep, and to minimise the pups' interactions with other dogs and humans. Subsequently they were asked to begin taking the pups along with sheep to pasture, until eventually young livestock guarding dogs would be able to accompany the flock throughout the day. Shepherds were advised on how to correct common undesirable behaviour such as wool-pulling and chasing sheep (Sims and Dawydiak 1990). During the winter 2001-02 dogs were to be left in barns together with sheep, before accompanying them to pasture throughout the following grazing season. It was emphasised that females should not be allowed to breed before the end of this period.

Unfortunately a great deal of variation was introduced into the methodology due to the means, wishes (generally to minimise additional work) and opinions on raising dogs of individual shepherds and farmers. Despite a written declaration and much time spent negotiating throughout the study, it was sometimes impossible to persuade farm personnel to keep to agreed terms. Finestra and Flávia were left together during socialisation, as were Bianca and Goro and to some extent Maco and Dona. Eva was left together with Barón for the first five weeks of her bonding period, Asan was not put with sheep until he was 13 weeks old and Brita's contact with sheep during and following the critical period was very limited. Bak, Barón, Bianca, Brita, Eva and Goro were frequently able to escape from pens or barns, leave the sheep and either wander away or stay near the shepherds. The number of sheep with which LGDs spent the winter of 2001-02 varied from <10 rams (Barón, Eva) to >100 lambing ewes (Axo). In some cases a single LGD was present and in others there were two.

Problems became worse during LGDs' sub-adult period (aged 6-12+ months, Coppinger and Coppinger 1993). Most obnoxious behaviour such as chasing and biting sheep or wandering can be corrected, or dogs grow out of it (Sims and Dawydiak 1990; see also Coppinger and Coppinger 2001), but many shepherds were not patient enough to persevere with training or were unwilling to do extra work. Seasonally employed shepherds tended to be the worst in this respect. Many were heavy drinkers, occasionally to the extent that they were incapable of performing even their usual shepherding duties. Drunken shepherds were seen beating and kicking sheep at several farms. Although this was denied, the very wary behaviour of some dogs towards shepherds suggested they had been beaten. Barón and Eva were certainly poorly fed and generally neglected. At other times lonely shepherds treated pups as companion animals or thought a pup would be better cared for if it was allowed to stay near them (Barón, Eva). Young dogs that wandered or chased sheep were often excluded from the flock and permanently shut in a barn or pen (Pazúr), chained up (Bak, Bianca, Brita, Dona, Goro) or left to wander (Barón, Eva, Flávia, Maco). As it became clear that some of these dogs would be given no further training or opportunity to rejoin their original flocks, most of them were relocated to other farms during the second year of the study. In the assessment of developmental environments, the method of raising pups was rated by marking a cross on a scale drawn between the minimum expression (not at all following recommended guidelines) and maximum expression (perfectly following guidelines) of the item being assessed (Martin and Bateson 1993:81 after Feaver *et al*. 1986). The rating was then converted into a score as follows: lower third of the range = 1 ("poor"); middle third = 2 ("intermediate"); upper third = 3 ("good").

Assessment of behavioural traits and overall outcome

Attentiveness and trustworthiness

For a dog to be successful as a guardian it must be trustworthy and stay with livestock. Livestock guarding dogs have greatly attenuated, or missing, predatory behaviour, allowing them to form social attachments with sheep. If the bonding process has been successful, dogs should show intra-species behaviours, such as active and passive submission, towards sheep (see Coppinger and Coppinger 1978, 2001, Arons 1980, Coppinger *et al*. 1983, 1988, Coppinger and Schneider 1995). Observations were conducted to assess the nature of dog-sheep interactions and the attentiveness of dogs to sheep. Preliminary qualitative observations totalling 242h were conducted by various people (the researcher, project workers and volunteers, veterinarians) in 2001 in order to assess the conditions under which dogs were raised during the critical period, to monitor dog-sheep interactions and to identify the most important behavioural patterns of dogs for further study as well as appropriate methods to measure them. During farm visits, farmers and shepherds were asked to comment on dogs' behaviour towards sheep.

According to the results of the preliminary observations and following the guidelines of Martin and Bateson (1993) as well as studies of LGD behaviour (McGrew and Blakesley 1982, Coppinger *et al*. 1983, Hansen and Bakken 1999), a quantitative focal observation protocol was devised involving four continuous hours of observations every two months for each pup >6 months old (Appendix 5). Using this protocol a total of 128h of observations were conducted in 2002 by the researcher during the morning grazing period for sheep on pastures or, for pups with sheep in barns, during and after morning feeding (Table 4.3). An electronic beeper (Timex Reef Gear wristwatch) was used to mark fixed intervals of time for instantaneous sampling. Dogs and sheep quickly habituated to the sound and so, provided the beeper was started some minutes before observations began, it had no marked effect on the focal animal's behaviour during the period of observation. The first two sets of observations were conducted when dogs were between six and 10 months old and were in barns with sheep during winter 2001-02. Subsequent observations were of dogs aged between 10 and 14 months old with flocks grazing on pastures. Some additional continuous 24-36 hour watches were done by project volunteers using a simplified protocol to record the focal animal's distance from sheep, shepherd, observer and any other dog(s) as well as its behaviour.

Table 4.3. Schedule of behavioural observations of 14 LGDs raised with sheep in 2001-02. The total number of hours for which preliminary observations were conducted are given and whether they took place in a barn, farmyard or on pastures. Focal observations (FO) were all conducted by the researcher over 4-hour periods following the same protocol. The status of each dog at the end of the 2002 grazing season is given for each dog at 14-20 months of age.

Dog	Month of life						
	3rd – 4th	5th – 6th	7th – 8th	9th – 10th	11th – 12th	13th – 14th	15th – 20th
Asan	24 pasture	7.5 past.	-	FO barn	FO pasture	FO pasture	working
Axo	14 barn	6.5 yard	FO barn	FO barn	FO pasture	FO pasture	working
Bak	24 barn	-	-	FO barn	(chained)	(chained)	(chained)
Barón	24 barn	-	1.5 barn	FO barn	FO barn	FO pasture	working
Bianca	-	7 barn	FO barn/yard	FO yard	(chained)	-	(penned)
Blanka	9 barn	6 yard	FO barn	FO barn	FO pasture	FO pasture	working
Brita	24 barn	-	FO barn	(chained)	(chained)	(w/pups)	(w/pups)
Dona	6.5 barn	-	FO barn	(ill)	(removed)	(removed)	(removed)
Eva	24 barn	1.5 barn	FO barn	FO barn	(pregnant)	(w/pups)	working
Finestra	19 barn	-	FO barn	FO past.	(chained)	(in heat)	working
Flávia	13 barn	-	FO barn	FO barn	FO pasture	(penned)	(penned)
Goro	10 pasture	7 barn	FO barn/yard	FO yard	(chained)	(penned)	(penned)
Maco	6.5 pasture	-	FO barn	FO barn	(chained)	(chained)	(chained)
Pazúr	7 past./barn	-	FO barn	FO barn	(penned)	(penned)	(penned)

Location of the trials at several working farms with different facilities and where shepherds and farmers held various attitudes, as well as different birth dates of pups, precluded standardisation of circumstances in which behaviour was measured (cf. Scott and Fuller 1965). For example, shepherds and other dogs besides the focal animal were sometimes present and sometimes not, numbers of sheep varied and, at corresponding ages, some dogs were in barns or enclosures while others were on pastures. In order to conduct observations of social behaviour, dogs that had been separated from sheep were placed with them and dogs that had been chained were released, but their behaviour was certainly influenced by the situation they had been in prior to observations and by the change itself. Therefore, to allow valid comparisons to be made among dogs the patterns of behaviour of each dog were rated by a single observer (the researcher) who had become familiar with all the dogs over a period of several months (see Martin and Bateson 1993:80-83). The outcome of each trial at the end of the study period was also rated according to the extent to which the dog was integrated into the flock (was bonded to sheep, left free-ranging and regularly accompanied sheep to pasture). Ratings were made using the same methodology as for assessment of developmental environments. Due to the small sample of dogs in the trials, behavioural observations and ratings were analysed using simple non-parametric statistics within the software package Minitab for Windows Release 13. As sample size would have been even further reduced if farms or litter-averages rather than individual dogs were treated as independent data points (Martin and Bateson 1993), substantial use was made of anecdotal evidence from observations by the researcher, shepherds and project workers or volunteers. Some conclusions are therefore somewhat speculative.

Protectiveness

Coppinger *et al*. (2003) suggested that LGDs do not "consciously" guard livestock, but rather behave so as to partition resources, which has the effect of protecting livestock from predation. On the basis of observing interactions between LGDs and wolves and noting a lack of injuries to LGDs that had supposedly fought with wolves, Coppinger and Coppinger (1987, 1995, 2001) concluded that LGDs rarely fight with predators. They believed that the presence of LGDs and their interference in predatory attacks by various forms of social behaviour would be sufficient to divert most attacks or make livestock energetically inefficient as a meal for predators. Coppinger *et al*. (1988) concluded that protective dogs were those that were attentive and that additional behaviours such as aggressiveness were not necessary. LGDs typically react to predators with barking and a running approach, from which most predators retreat and avoid physical confrontation (Green and Woodruff 1989). LGDs have been observed pursuing predators, including brown bears and wolves, over considerable distances (Green and Woodruff 1989, Hansen and Bakken 1999, Christiansen 2002, Lequette 2003). Physical fights between LGDs and carnivores in Bulgaria are said to be "not rare" (Sedefchev 2003), LGDs have been injured during encounters with bears and wolves in Slovakia (pers. obs. 2000-04) and occasionally killed by wolves in the USA (Meier *et al*. 2000, Bangs and Shivik 2001). McGrew and Blakesley (1982) concluded that LGDs reduce losses by being near livestock and actively defending it.

Any protective behaviour seen during focal observations was noted on the recording schedule. Preliminary observations had shown that juvenile dogs (<c.6 months old)

typically slept for most of the night and so observations in barns were conducted only during daylight hours. Shepherds and farmers were able to observe dogs daily, therefore they were interviewed informally during each visit and notes taken of any comments they made relating to protectiveness. During the 2002 grazing season some free-ranging LGDs were also observed at night using a night vision scope (Zenit/Bushnell 26-4366). Brief notes were taken on their proximity to livestock and any protective behaviour observed. At 15-17 months of age four dogs that were then regularly accompanying flocks to pasture were tested for their response to a simulated predator attack. A digital video camera (Sony DCR-TRV240E PAL) was used to record each of the trials. As the dogs were evidently still relatively young and inexperienced, although all had already had some contact with large carnivores, an unfamiliar German shepherd bitch was used rather than a larger, more aggressive dog as originally planned. Asan and Finestra were tested separately with their respective flocks on 1/10/02. Axo and Blanca, because they were placed at the same flock, were tested together on 3/10/02. In each case, a dog handler endeavoured to remain hidden behind vegetation while approaching to <100m of the nearest sheep. He then released the "predator" and, if necessary, encouraged her to run towards the flock. After the first such trial, the "predator" was led away, sheep and dogs were given time to settle and the procedure repeated from a different direction. The following were recorded: 1) the distance of the "predator" from the nearest sheep and the LGD when it was detected by the LGD; 2) the LGD's immediate response on detecting the "predator"; 3) the LGD's behaviour when confronting the "predator".

Assessment of effectiveness in reducing losses to predation

Losses reported for the 2002 grazing season were compared at flocks with free-ranging LGDs of 1-2 years old placed as part of the PLCLC project (experimental group) versus those without such dogs (control groups). Data for the experimental group, gathered during farm visits and interviews with shepherds and farmers, were adapted from PLCLC project reports (Find'o 2002b, Rigg 2002b). The flocks included eight of the 14 dogs in the behavioural observations (Asan at farm 6, Axo and Blanca at farm 2, Barón and Eva at farm 8, Maco and Flávia at farm 7 and Finestra also at farm 7 but with a different flock). Control group data were also gathered during farm visits and interviews (Chapter 3), thus avoiding the potential bias of using a different methodology for each group. The mean and range of losses were calculated for flocks without free-ranging project LGDs in the same regions as those with free-ranging LGDs in order to avoid bias due to the substantial regional variation in reported losses.

RESULTS

Integrating dogs into flocks

Puppy aptitude tests

In puppy aptitude tests, the mode of scores was between 2 and 6 on a scale of 1-7 for all nine pups tested. The most common mode was 6 (4/9 pups), suggesting a "shy, aloof and highly independent" personality (Dawydiak and Sims 2004:138). Of Eva's pups, one male and one female each had a mode of 2 whereas a second female in the same litter had a mode of 6 and half of the scores for a second male were 5 or 6. Dora, a female pedigree Slovenský čuvač raised at farm 6 from December 2002 as a replacement for Asan, had scores of mostly 5 or 6. She became quite attentive to livestock and was successfully integrated into the flock, although was somewhat timid in her first 1.5 years of life. All pups tested showed the same submissive response to livestock: "Fearful or cautious, looks at stock then away, tail down". These results suggest that the pups tested generally conformed to characteristics that would be expected in good livestock guarding dogs and mostly showed few signs of social dominance or aggression, but not all pups in the same litter appeared to be equally suitable.

Behavioural observations and shepherds' reports

All 14 pups placed at farms in 2001 were successfully raised to adulthood and lived until ≥ 3 years of age. Scores for the developmental environments in which they were raised, the behavioural patterns of dogs up to the age of 20 months and overall outcomes in terms of the degree to which yearling dogs became integrated into flocks in their first full grazing season are presented in Table 4.4. During their first 1.5 years of life, 12 of the 14 pups (86%) developed behavioural patterns judged to be good (score=3) or intermediate (score=2). As yearlings, 10 dogs (71%) followed sheep to pasture to some extent. Six of them (Asan, Axo, Blanca, Barón, Eva, Finestra), had good or intermediate behavioural patterns, were left mostly free-ranging and were regularly allowed to accompany flocks during their first full grazing season (2002) and were therefore given scores of 2 or 3 for integration into flock. Two of them had been relocated from the flock where they were initially raised and where integration into flock was given a score of 1 because they had been prevented from accompanying sheep by shepherds (Barón, Eva). Six other dogs were given a score of 1 for integration into their first flocks. Four of them were prevented from accompanying sheep by shepherds despite showing good or intermediate behavioural patterns (Bak, Bianca, Dona, Pazúr) and two were judged to have poor behavioural patterns (Brita, Goro). Two dogs given a score of 2 or 3 for integration into their first flocks, where they had shown good or intermediate patterns of behaviour, were relocated at the start of the 2002 grazing season to a second flock where they were initially free-ranging and accompanied sheep to pasture, but were subsequently excluded from the flock by shepherds (Flávia, Maco).

All 10 dogs with a score of 1 for any of the developmental environments also received a score of 1 for integration into the flock where they began their first full grazing season (following relocation, in the case of Flávia and Maco). Conversely, dogs given a score or 2 or 3 for integration into the flock where they began their first full grazing season had scores of 2 or 3 for all three developmental environments. The product of the three scores for developmental environments in which dogs given a score of 1 ("poor") for integration at their first flock had been raised was significantly lower than that of dogs with a score of 2 ("intermediate") or 3 ("good") for integration (Fig. 4.1; Mann-Whitney U test adjusted for ties, $P<0.005$). The difference in the product of the three scores for behavioural patterns between dogs poorly integrated into their first flocks and those with an intermediate or good score for integration was borderline significant (Mann-Whitney U test, $P=0.0528$, Mann-Whitney U test adjusted for ties, $P=0.0476$).

Small sample sizes precluded chi-square tests of association for several individual items. Tests were only valid when scores of 1 and 2 were combined. An apparent association was found between score for attentiveness and that for integration at first

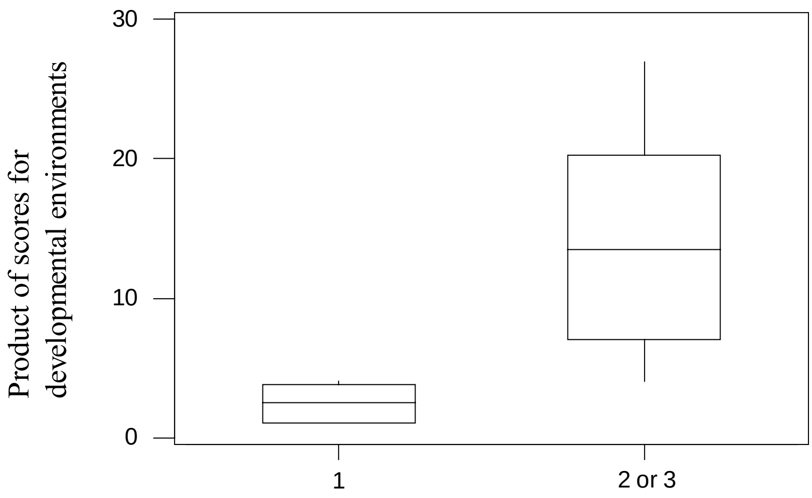
Table 4.4. Summary of results from trials in which 14 LGD pups were raised at sheep farms in Slovakia, 2001-02. Developmental environments were judged on their adherence to recommended guidelines; behaviours were assessed during observations of the dogs up to the age of c.1.5 years; integration into flock was based on the degree to which yearlings were bonded to sheep, left free-ranging and allowed to attend sheep during their first full grazing season. All items were rated by the same observer and scored as follows: 1 = poor, 2 = intermediate, 3 = good.

	Developmental environments			Dog behaviours			Integration into flocks	
Dogs (grouped by litter)	Critical period (c.2-4 mths old)	1st winter in barn (c.6-12 mths old)	1st grazing season (c.8-20 mths old)	Attentive	Trustworthy	Protective	At flock where pup first placed	At second flock (if dog relocated)
Slovenský čuvače								
Axo	2	3	3	3	3	2	3	-
Bianca	1	1	1	2	2	2	1	-
Blanca	3	3	3	3	3	3	3	-
Brita	1	1	1*	1	1	2	1*	1
Bak	3	1	1*	2	2	3	1*	1
Barón	2	2	1*	2	3	2	1*	2
Eva	2	2	1*	3	3	3	1*	2
Goro	1	1	1	1	2	1	1	-
Caucasian shepherd dogs								
Asan	2	3	3	2	3	3	2	-
Finestra	2	2	2**	2	3	3	(2)	2**
Flávia	2	2	1**	2	2	3	(2)	1**
Dona	3	1	1	3	3	2	1	-
Maco	3	3	1**	3	3	3	(3)	1**
Pazúr	2	1	1	2	2	2	1	-

(** Finestra, Flávia and Maco were moved from their first flocks to different flocks at the start of the 2002 grazing season and so the development environment score for 1st grazing season refers to the second flock where they were placed. * Bak, Barón, Brita and Eva were relocated later in the year.)

flock (χ^2=6.873, d.f.=1, P=0.009). Although this is to some extent an auto-correlation, the integration of a dog into a flock depended not only on it paying attention to and following sheep (i.e. being attentive) but also on shepherds allowing it to remain with sheep. Whether shepherds did so was apparently influenced by factors other than dog behaviour, as no clear association was found between scores for trustworthiness and integration (χ^2=2.864, d.f.=1, P=0.091) or between protectiveness and integration (χ^2=0.424, d.f.=1, P=0.515). Using Spearman's rank-order correlation as a comparative measure (disregarding lack of continuity for one variable common to both analyses), a highly significant high positive correlation was

Fig. 4.1. Product of scores for developmental environments in which dogs were raised for those dogs given a score of 1 ("poor") for integration into flock compared to that of those given a score of 2 ("intermediate") or 3 ("good"), showing interquartile ranges and outliers.



detected between the product of developmental environment scores and score for integration into first flock (r_s=0.853, P<0.001) but a weaker and less significant correlation between the product of scores for behavioural patterns and score for integration into first flock (r_s=0.625, P=0.017); compare Figs. 4.2 and 4.3. No significant difference was detected in age when first put with sheep between dogs with a score of 1 for integration into first flock and those with a score of 2 or 3 (Mann-Whitney U test adjusted for ties, P=0.843). No significant correlations were found between age when first put with sheep and product of scores for behavioural patterns (r_s=-0.099, P=0.736), product of developmental environment scores (r_s=0.177, P=0.546) or score for integration into first flock (r_s=0.109, P=0.712). Using the Mann-Whitney U test (P<0.05), no significant differences were detected between breeds or sexes in the product of scores for the developmental environments in which they were raised, the product of scores for their behavioural patterns or the score of integration into first flock. The chi-square test of association indicated that the distribution of scores of 1 versus either 2 or 3 for integration into the flock where they ended the 2002 grazing season was not significantly different for Slovenský čuvač versus Caucasian shepherd dog (χ^2=0.389, d.f.=1, P=0.533) or for male versus

Fig. 4.2. High correlation (r_s=0.853, P<0.001) between the product of scores for the developmental environments in which pups were raised and the degree to which they became integrated into sheep flocks.

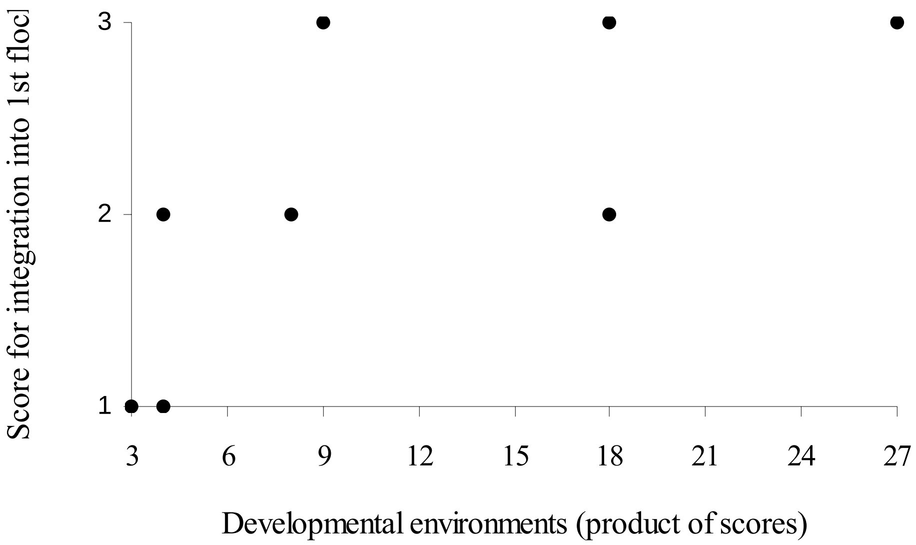
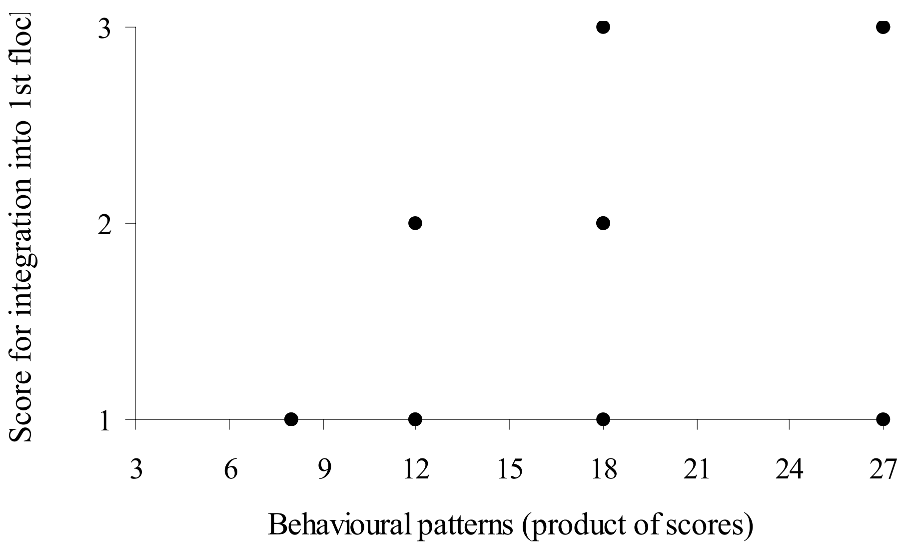
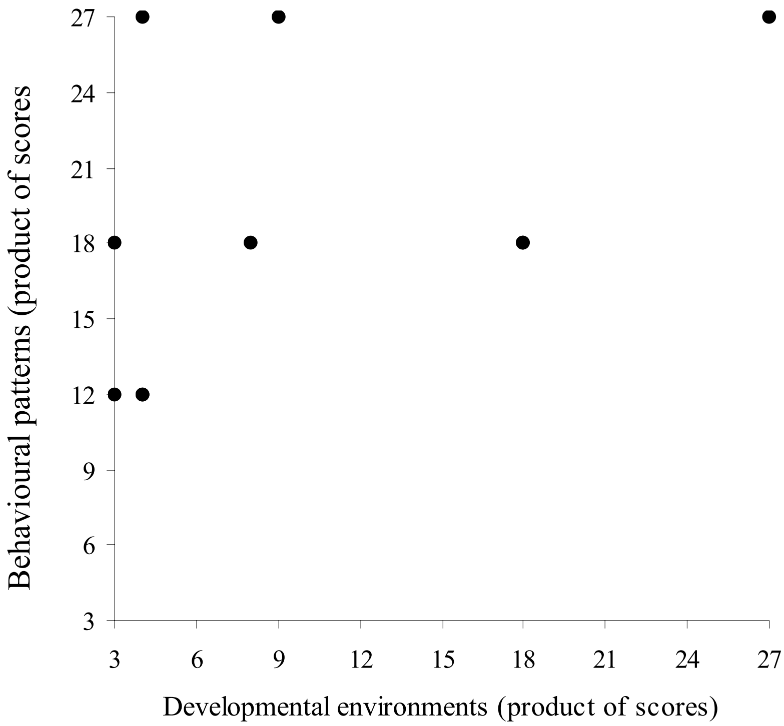


Fig. 4.3. Moderate correlation (r_s=0.625, P<0.017) between the product of scores for behavioural patterns of 14 LGDs and the degree to which they became integrated into sheep flocks.



female (χ^2=0.0001, d.f.=1, P=1.000). A highly significant positive correlation was found between the product of developmental environment scores and the product of scores for behavioural patterns (r_s=0.828, P<0.001; see Fig. 4.4). These results suggest that the developmental environments in which dogs were raised had an important influence on their behavioural patterns. How dogs were raised was also closely related to the overall outcome in terms of the degree to which they became integrated into flocks, whereas this seemed to be less influenced by dogs' behavioural patterns. In this respect, trustworthiness appeared to be more important than protectiveness.

Fig. 4.4. High correlation (r_s=0.828, P<0.001) between the product of scores for the developmental environments in which pups were raised and the product of scores for behavioural patterns.



Breed had an indirect influence in two cases. The head shepherd and owner of the flock where Maco and Dona were first placed at farm 8 said before the start of the 2002 grazing season that he would prefer to have Slovenský čuvače. Although he claimed that he had chained up non-pedigree Caucasian shepherd dog Dona and later arranged for her to be used as a property guard dog because she had been harassing sheep, she had shown very good, trustworthy behaviour during periods of observation. Dona's brother Maco was also moved away and they were later replaced with Barón and Eva relocated from farm 3. Both of these dogs, but particularly Eva, were allowed to become considerably better integrated into the flock than they had at their first flock. Pazúr was also not accepted by shepherds. All three non-pedigree

Caucasian shepherd dogs were relatively small and did not appear to be "pure-blood", as the breeder had claimed. This was at least partially responsible for them not being more valued by shepherds.

Table 4.5. The same scores presented in Table 4.4 but showing dogs grouped according to the flocks where they were placed. In all cases except Flávia-Finestra and Maco-Dona, who were siblings, dogs placed at the same flock were unrelated as defined by pedigree clubs.

Farm		Dogs (grouped by flock)	Developmental environments			Dog behaviours			Integration into flocks	
1st	2nd		Critical period (c.2-4 mths old)	1st winter in barn (c.6-12 mths old)	1st grazing season (c.8-20 mths old)	Attentive	Trustworthy	Protective	At flock where pup first placed	At second flock (if dog relocated)
Slovenský čuvače										
2		Axo	2**	3	3	3	3	2	3	-
2		Blanca	3	3	3	3	3	3	3	-
4	#	Bak	3	1	1	2	2	3	1	1
4	#	Brita	1	1	1	1	1	2	1	1
3	8	Barón	2	2	1	2	3	2	1	2
3	8	Eva	2	2	1	3	3	3	1	2
1		Bianca	1	1	1	2	2	2	1	-
1		Goro	1	1	1	1	2	1	1	-
Caucasian shepherd dogs										
6		Asan	2**	3	3	2	3	3	2	-
7a	7b	Finestra	2	2	2	2	3	3	2	2
7a		Flávia*	2	2		2	2	3	2	
	7c	Flávia*			1	2	2	3		1
	7c	Maco*			1	3	3	3		1
8		Maco*	3	3		3	3	3	3	
8		Dona	3	1	1	3	3	2	1	-
5		Pazúr	2	1	1	2	2	2	1	-

(Flávia and Maco were relocated from their respective original flocks and paired together for their first full grazing season. The pertinent scores for each period have therefore been shown with each of the dogs with which they were paired. 7a-c refer to three different flocks at the same farm. Finestra was also moved at the start of the grazing season, whereas Bak, Barón, Brita and Eva were relocated later in the year. # Bak and Brita were relocated to a farm where no project dogs had previously been placed. ** Axo and Asan were raised very well by shepherds but were given a score of 2 for the critical period because they were already 10 and 13 weeks old respectively when first put with sheep.)*

Among the dogs included in the trials were five sets of siblings. In two cases when two siblings were included and raised at different flocks, they were each given the same score for integration at the flock where they were first placed (Table 4.5). In one case when two siblings were raised together at the same flock they received the same score for integration. However, when one of them (Flávia) and an unrelated dog (Maco) with a better score for integration at his first flock were put together at a flock where neither had been raised, the integration scores for both dropped to 1. The shepherds at this flock were concerned that milk production would fall if the dogs disturbed grazing sheep and so they prevented them from accompanying the flock. Both dogs had to be relocated again. In both cases when three siblings were included and raised at different farms, two of them were given a score of 1 for integration whereas the third received a score of 3. In contrast, the integration scores for all five pairs of unrelated dogs placed at the same flocks were identical for both dogs, both at the flock where they were first raised and for the second flock if they were relocated together (Table 4.5). These results are based on a small sample and have therefore not been analysed statistically. However, they are consistent with the conclusion that the success or failure of integrating dogs into flocks was determined more by the attitudes and knowledge of shepherds, their willingness (and ability) to accept free-ranging LGDs and do the extra work required to provide them with appropriate developmental environments, than by genetically determined differences in behaviour among the dogs tested.

In 2003, their second full grazing season, 6/14 dogs (43%) were left partially or entirely free-ranging at a total of four different farms and were allowed to accompany sheep to pasture. One of them had previously been judged to have poor behavioural patterns (Goro) whereas the other five had intermediate or good scores for all developmental environments and behavioural patterns (except for the first grazing season scores of Barón and Eva, based on their first flock before relocation). The most sheep-attentive and fully integrated into flocks, in decreasing order as ranked by the researcher on the basis of occasional informal observations, were: Blanca > Axo > Finestra > Eva > Barón > Goro. Of the other eight dogs, one remained entirely removed from contact with sheep (Dona), two were at their original flocks but were rarely (Bianca) or never (Pazúr) left free-ranging, two had been relocated to a different farm where, after some failed attempts to integrate them into flocks, they were permanently chained up (Brita) or relocated again and removed from contact with sheep (Bak) and three had been relocated for the first (Asan) or second time (Flávia, Maco) and kept permanently within fenced farmyards.

Attentiveness

Pups and lambs investigated each other and made initial social contact within minutes of being put together. Although not rated at the time, all 14 pups showed the same submissive response to livestock as did pups included in aptitude tests. Over the course of the next few days, pups proceeded from investigating sheep by smell to licking their heads, muzzles and anuses. Most pups also attempted to initiate play. Typically by the age of 11-12 weeks, sometimes earlier, pups were seen walking and sleeping among sheep, licking those nearest them and sometimes growling or snapping at sheep that ate their food or crowded them. Differences among dogs in their attentiveness to sheep were clearly visible by 15-16 weeks of age. For example, the farmer/head shepherd where they were placed reported that by this age Dona and Maco were going to the flock without him commanding them, as he had done earlier. At the same age Blanca and Axo retreated among sheep if approached. The head shepherd consistently punished them if he saw them leaving the sheep. By 32 weeks of age they were completely attentive to sheep, almost never leaving the flock, and were wary of all people. In contrast, when 16-week old Brita was released among sheep on the pasture she completely ignored them and instead followed people, including some previously unknown to her. She had had only intermittent contact with sheep beginning at 11 weeks of age. However, some dogs that seemed unpromising at this stage later showed improved attentiveness in different circumstances (Eva, Goro).

Where dogs were left together before the end of the critical period or encountered herding dogs, they showed more interest in other dogs than in sheep (Finestra and Flávia, Brita when Asan was left with her for a few days, Barón when Eva was initially put in his enclosure). During the critical period Goro was seen sheltering among sheep from wet and cold weather. However, he was neither encouraged to stay with sheep nor prevented from leaving them and by 40 weeks of age he was wandering extensively. Shepherds permanently chained him and Bianca outside the barn in which sheep were over-wintering. At other farms, too, the actions of some shepherds hindered the bonding process and discouraged or prevented dogs from following sheep. These included not keeping dogs with sheep during the critical period, allowing them to wander, feeding them away from the sheep and treating them as pets (Barón, Brita, Eva), calling dogs back from grazing flocks to the attending shepherd with herding dog (Asan, Pazúr), actively excluding dogs from flocks to prevent obnoxious behaviour such as chasing or biting sheep (Finestra, Flávia, Maco and possibly Dona) or simply refusing to allow free-ranging LGDs to accompany flocks (Bak). Sometimes such actions resulted from a failure to understand the importance of providing appropriate developmental environments, in other cases shepherds were more motivated by a desire to maintain milk production and hence income in the short-term than by the longer-term goal of implementing preventive measures against predation.

The attentiveness to sheep of the 14 dogs when aged between six and 10 months was assessed quantitatively during the winter of 2001-02 in barns and farmyards. Conditions at each farm were slightly different, reducing the comparability of some measures. For example, the maximum distance that dogs could be from sheep depended on the size and layout of barns while the nearest neighbour to a dog was influenced by whether or not shepherds or other dogs were present and how many sheep there were. The measure that best seemed to indicate the degree to which a dog was bonded to sheep, i.e. was choosing to be among them and was accepted by them without causing excessive disruption, was a 1/0 score by instantaneous sampling at one minute intervals that recorded whether the line of sight between observer and focal animal was clear or was intercepted by one or more sheep. Frequency of this "between" measure varied highly significantly among dogs (χ^2=794.534, d.f.=13, P<0.001), from <10 (Brita, Goro) to 240, the maximum possible (Axo). See Fig. 4.6. When grouped according to the overall rating of attentiveness for each dog as judged by the researcher (Tables 4.4 and 4.5) there was almost no overlap of the interquartile ranges (Fig. 4.7). Small sample size invalidated many statistical tests. The chi-square test of association between the researcher-rated score for developmental environment during the critical period and that for attentiveness was at the threshold of significance when scores of 1 and 2 were combined (χ^2=3.764, d.f.=1, P=0.052). These results suggest that developmental environments in which dogs were raised influencing their experience and learning were important factors in the development of attentiveness to livestock in addition to any genetically inherited traits facilitating inter-specific social bonding.

Fig. 4.6. The attentiveness to sheep of 14 LGD pups aged between six and 10 months old in barns during winter. "Between" was a 1/0 score of whether there was ≥ 1 sheep between observer and focal animal, recorded by instantaneous sampling at one minute intervals during four continuous hours of focal observations.

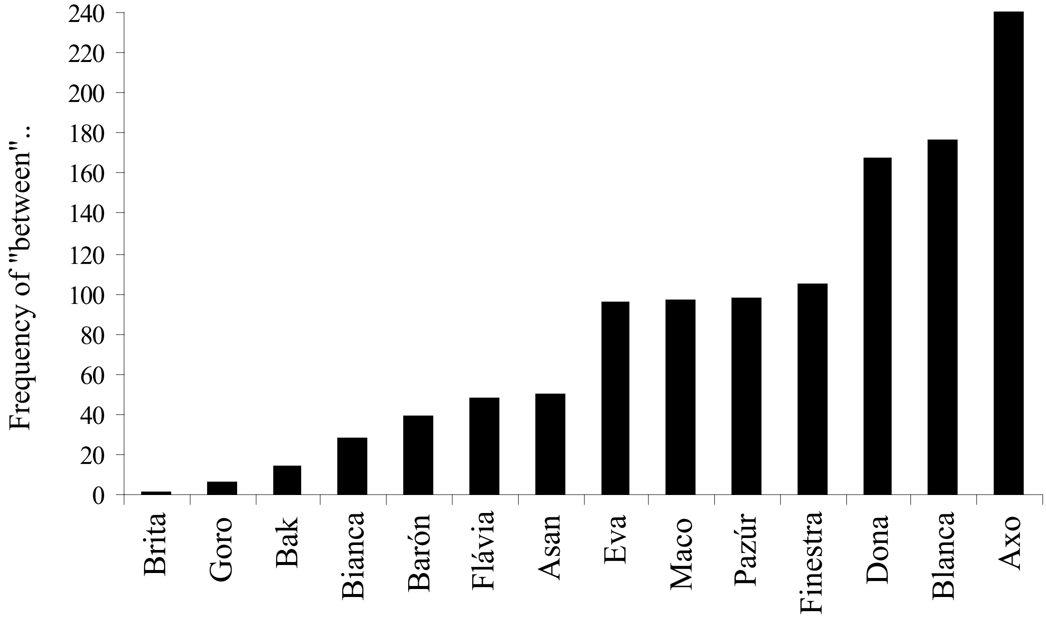
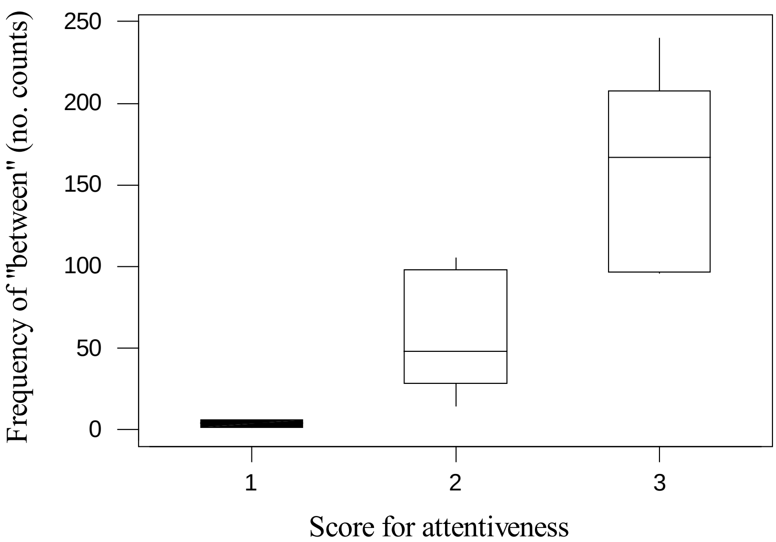
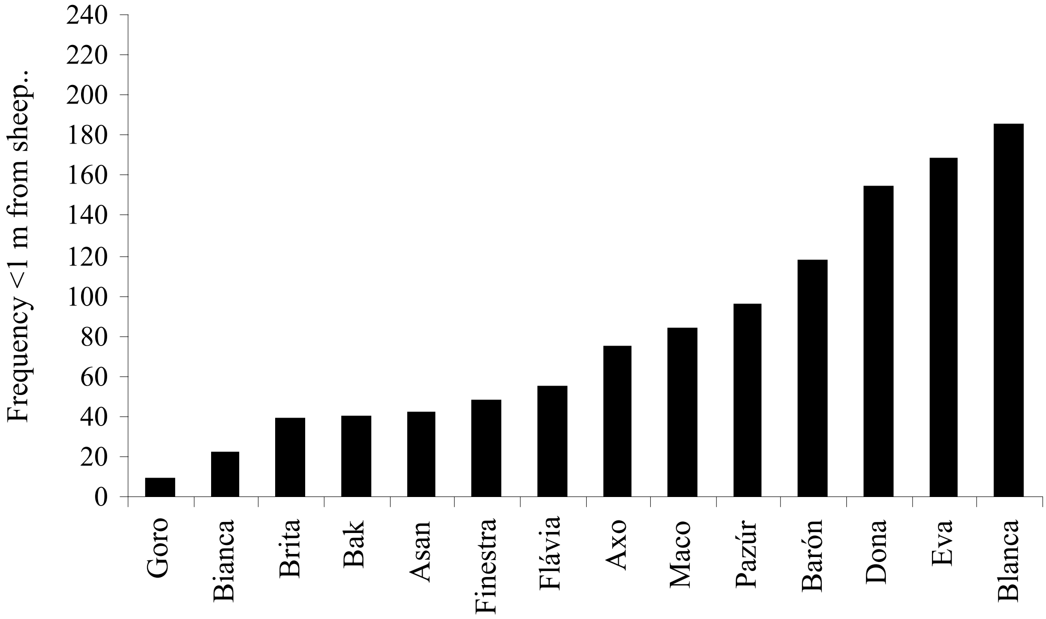


Fig. 4.7. Correspondence of scores for attentiveness as rated by the researcher and an instantaneous sampling method (see Tables 4.4 and 4.5).



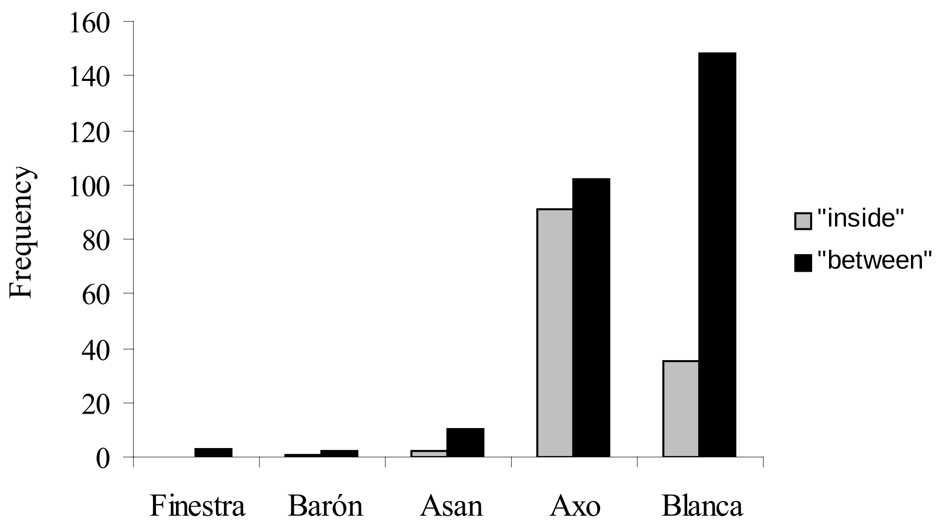
Attentiveness to sheep was also measured by recording the frequency of instantaneous samples at one minute intervals in which the focal animal was <1m from the nearest sheep (Fig. 4.8). A significant moderate correlation (r_s=0.697, P=0.006) was found between the frequency of this measure and that of "between".

Fig. 4.8. The attentiveness to sheep of 14 LGD pups aged between six and 10 months old in barns during winter as measured by recording distance between focal animal and the nearest sheep by instantaneous sampling at one minute intervals during four continuous hours of focal observations.



Dogs between the ages of 10 and 14 months were assessed on pastures during the 2002 grazing season. Only five could be observed accompanying flocks. The remaining nine dogs had been removed, chained up, penned or otherwise prevented from accompanying flocks, were pregnant or had pups (Fig. 4.3). Some measures of behaviour proved of little use for comparison among dogs due to important variations in conditions, such as presence or absence of shepherd. Two measures that seemed to give representative results were the "between" measure as used in barns and a 1/0 score by instantaneous sampling at one minute intervals of whether the focal LGD was inside or outside the flock (Fig. 4.9). The frequencies of both measures varied highly significantly among dogs ("inside": χ^2=239.643, d.f.=4, P<0.001; "between": χ^2=346.717, d.f.=4, P<0.001). Axo and Blanca were clearly the most strongly bonded to sheep, which they accompanied to pastures and remained among or near without the presence of a shepherd. Finestra spent the whole observation period next to the attending shepherd and herding dog or chasing after the herding dog. Asan sometimes followed sheep, sometimes the shepherd, herding dog or observer and at other times wandered away from the flock. Barón tended either to try to play with sheep and chase them or to wander away.

Fig. 4.9. The attentiveness to sheep on pastures of 5 LGDs aged between 10 and 14 months old as assessed using two instantaneous sampling measures at one minute intervals during four continuous hours of observations. "Inside" was a 1/0 score of whether the focal animal was inside the flock. "Between" was a 1/0 score of whether there was ≥ 1 sheep between observer and focal animal.



Wandering away from the flock seemed to be mostly a problem of males. Of two siblings raised at different flocks, the female became more attentive than the male (Eva>Goro). In every case where a male and female were raised in similar conditions at the same flock, the female was more attentive (Bianca>Goro, Eva>Barón, Blanca>Axo, Dona>Maco). Eva paid noticeably more attention to sheep than Barón when they were 27 and 37 weeks old respectively. Although Blanca had appeared less attentive than Axo during the critical period, she was more so by 14 months of age. Brita was less attentive than Bak but had later and much less contact with sheep during the critical period. Asan sometimes left the flock at farm 6 and went to a nearby flock of sheep that he had spent the winter with or else wandered into the village where the home farm was located. Dora, a female who replaced him, was more attentive to sheep than he had been, although this could also have been because she was put with sheep several weeks earlier.

The attentiveness of individual dogs varied under different circumstances. LGDs were typically more attentive at night. Although Barón was quite inattentive to sheep during the day, he spent much more time near the resting flock from late evening to early morning. Training, such as by leading dogs on a leash, was observed to improve attentiveness. Goro's attentiveness seemed to improve with age. In the case of Eva and to a lesser extent Barón, moving them to a farm with more tolerant shepherds improved their attentiveness. Weather conditions also influenced the proximity of dogs to sheep. Asan, a typical male Caucasian shepherd dog, had very thick dark-coloured fur. By one year of age he weighed >60kg and by two years of age had grown to >80kg. During hot sunny weather he often left the flock to seek shade. Even the most attentive dogs, Blanca and Axo, left the flock to seek shade or water, but less often, less far from the sheep and for shorter periods than Asan. Some dogs also sheltered at the "koliba" from heavy rain. The proportion of the grazing season that females spent with flocks was reduced by pregnancy and pup-rearing. Shepherds often seemed unable to prevent females from being mated. Eva and Brita both had pups during their first full grazing season and Blanca, Brita and Flávia during their second. Blanca spent very little time with her pups and often left them alone in a barn while she rejoined the flock. Bak and Barón seemed reluctant to follow flocks while Brita and Eva were with their pups in barns.

Trustworthiness

From the beginning of the socialisation period, all pups were seen showing submissive behaviour such as looking away, turning the head aside or face licking when approached by sheep. However, the majority of dogs indulged in obnoxious play behaviour, particularly chasing sheep and biting their ears and legs, pulling their wool and tails, sometimes grasping them by the neck or head and wrestling with them, as well as sexually mounting them. Such behaviour was sometimes aggravated by excessive energy, as when c.4-month old Asan and Blanca chased their own tails and raced around as well as pursued sheep. Axo chased sheep repeatedly when he first went with them to pasture at 22 weeks old even though he had not been seen doing so previously. Skittish sheep that fled from LGDs were likely to be chased and some dogs learned to provoke sheep into running. This problem was worse with lambs or yearling sheep than with ewes or rams. Sheep seemed more likely to run from the larger, dark-coloured Caucasian shepherd dog than the smaller, more sheep-like Slovenský čuvač. The observer was occasionally obliged to intervene during focal observations of 6-10 month old dogs to stop excessive chasing and biting of sheep (Brita, Finestra, Flávia, Pazúr). Dogs usually stopped such behaviour if shouted at.

Playful behaviour sometimes became very rough and resulted in the injury or even death of sheep, particularly young or sickly lambs. According to shepherds, one or more lambs died as a result of chasing or rough play by Bak, Barón, Blanca and Eva. None was consumed. It is possible that some of them died due to previous ill health, as shepherds often put very weak animals in training enclosures with LGDs. Bak and Brita killed sheep after being relocated to a different farm at c.1 year of age. It was not clear that any of these deaths involved predatory behaviour by LGDs. Flávia showed some playful eye-stalk-chase behaviour directed towards Finestra at six months of age but this was no longer evident when she was eight months old. Asan and Barón chased small birds but Maco did not. Asan, Bak, Goro and Bianca chased and killed poultry. Ten-month old Goro was seen stalking a farm cat (*Felis catus*) before he and Bianca chased and treed it, whereas 5-month old Axo reacted to one with curiosity and tried to initiate play. During his second year of life Asan may have killed a young wild boar (*Sus scrofa*) while Eva was said to have tried to catch hares (*Lepus europaeus*). According to the head shepherd, Axo and Blanca never chased wild animals. There was no evidence to support the common belief among shepherds that if a dog tasted blood it would become a sheep-killer. Several dogs were left either alone or in pairs with lambing ewes without any problems (Axo, Blanca, Dona, Finestra, Flávia, Maco). Axo and Blanca were repeatedly observed waiting near ewes for afterbirths, pulling out amniotic sacks hanging from ewes to consume them and licking newborn lambs.

In general, the frequency of obnoxious behaviour decreased as dogs grew older. Bak and Barón, when 12-13 weeks old, bit the ears of sheep but shepherds said they stopped doing this by 14 weeks of age. Blanca chased lambs very vigorously when 11 weeks old (Axo did not) and also bit their ears and grabbed their tails. She did not chase or bite sheep when observed at five months old. Eva regularly played with sheep and nibbled their ears at three months of age but was less playful by six months of age, at a time when 8-month old Barón was not seen to play with sheep at all. Dogs that continued to chase sheep or goats after six months of age often targeted particular individuals, such as a kid with a bandaged leg (Flávia, Finestra) or certain sheep with bells (Axo). Shepherds also reported that LGDs would sometimes try to exclude new animals from the flock (Axo, Blanca). Some LGDs ran after herding dogs and tried either to play with them or prevent them reaching sheep. Shepherds used leash training to encourage Asan to stop this behaviour after two months with the flock on pastures (at 60 weeks of age) whereas Axo, Blanca and Finestra were allowed to persist. Eva, Maco and Pazúr started imitating the behaviour of herding dogs but seemed to grow out of this. Once sheep were accustomed to the presence of LGDs they stopped running from them and were much less disturbed by their presence and activity. When 8-month old Blanca was first let out to pasture with her flock in spring she ran so vigorously through the midst of the flock that she accidentally collided with a sheep and knocked it over. The sheep calmly stood up and resumed grazing along with the rest.

No significant association was found between the researcher-rated score for critical period and that for trustworthiness (scores of 1 and 2 combined, χ^2=0.729, d.f.=1, P=0.393). However, environment, experience and learning did seem to influence the degree of obnoxious behaviour. Brita, who had had minimal contact with sheep during the critical period, persistently ignored sheep completely or harassed them relentlessly. This behaviour was clear at four months of age and was still apparent when she was three years old. A similar bipolar pattern of either ignoring or harassing sheep was shown by Bianca and Goro following an extended period of being chained up outside the barn. On the other hand, shepherds reported that only one lamb had damaged ears caused by Maco or Dona. These dogs rarely bothered sheep during focal observations while they were together. When Maco was relocated with Flávia, however, he harassed sheep considerably more often and the shepherd at his original farm claimed that Dona also began harassing sheep after he was removed. There was some evidence that two dogs put together before six months of age expressed more playful and obnoxious behaviour towards livestock. Axo and Blanca chased sheep when put together briefly at 25 weeks old. Two sets of dogs that were not consistently separated during the critical period regularly chased and bit sheep (Flávia and Finestra, Bianca and Goro). On the other hand, 17-week old Maco and Dona both accompanied their flock to pasture without chasing sheep.

A boundary between trustworthiness and attentiveness was often hard to identify. At 18 weeks old, Asan was very attentive to sheep, lying among them and grooming them, but he chased and bit some. He also sexually mounted sheep and as a yearling had to be restrained while rams were mating ewes in order to stop him interfering. The attitudes of shepherds were very important in this regard. Tolerant shepherds recognised that dogs exhibiting obnoxious behaviours were being attentive to sheep and so tried to correct undesirable behaviour without removing LGDs permanently from the flock. Although one lamb died while in the training enclosure with Blanca, the remaining lambs were left with her. The shepherd shouted at her if he saw her harassing sheep. Both she and Axo became extremely trustworthy and attentive, although as yearlings and even two year olds they continued to occasionally chase individual animals from the flock. The shepherd often left his sheep to graze alone with these dogs and he expressed great satisfaction and peace of mind, despite some losses to wolves in their first full grazing season. In contrast, less tolerant shepherds concerned about possible loss of lambs or milk tended to solve problems of trustworthiness by removing LGDs from livestock, particularly milking ewes (Bak, Bianca, Brita, Goro, Flávia, Maco, Pazúr). Sometimes shepherds called LGDs away from grazing sheep even when they behaved calmly towards them (Asan, Pazúr). Such actions apparently aggravated problems of obnoxious behaviour (Bak, Bianca, Brita, Goro, Pazúr) and might also have discouraged attentiveness.

Protectiveness

Behavioural observations and shepherds' reports

By the age of 15-16 weeks several pups were exhibiting basic protective behaviour: advancing towards perceived threats while barking, growling or huffing, imposing themselves between sheep and threat, retreating back among sheep if approached (Axo, Bak, Blanca). When accompanying sheep to pasture, 4-month old Maco and Dona were observed walking ahead or above the flock and resting at sites with a wide view of sheep and surroundings. Maco barked, growled and advanced towards perceived threats such as approaching people or passing roe deer (*Capreolus*

capreolus). Dona rarely showed such behaviours. At a similar age Blanca also frequently stood or rested on a rise above sheep in the farmyard, as did Asan when observed on pastures at six months of age. By eight months old some dogs, including at least one female (Bianca), were using raised leg urination. Shepherds reported that during their first full grazing season dogs regularly patrolled and scent-marked the pasture/forest boundary. Whereas juvenile pups had slept through most of the night while in barns, the majority of dogs >6 months old were more vigilant and protective at night, particularly when outside. Asan barked at the slightest sound after dark when he was 18 weeks old. Clearly dogs were only usefully protective while they were with or near sheep. The observed increase in attentiveness of some dogs to sheep at night therefore improved their effective protectiveness. Less attentive dogs that remained near farm buildings (e.g. Asan, Barón) could also be effectively protective when the flock returned from pastures for milking and in the evening. Likewise dogs that followed shepherd rather than sheep could still be protective while accompanying the flock (e.g. Finestra). The protectiveness of individual dogs also varied with other circumstances. For example, Asan became more aggressive if there was a bitch in heat.

Most Caucasian shepherd dogs (4/6) were given a score of 3 for protectiveness, whereas only 3/8 Slovenský čuvače received this score, but the difference is not significant (χ^2=1.167, d.f.=1, *P*=0.280). Using the chi-square test of association, no significant difference was found in researcher-rated score of protectiveness for males versus females (scores of 1 and 2 combined, χ^2=0.286, d.f.=1, *P*=0.593). However, differences were apparent between dogs raised at the same farm. In three cases females were judged to be more protective (Eva>Barón, Blanca>Axo, Bianca>Goro) and in two cases males (Maco>Dona, Bak>Brita). When she was only eight weeks old shepherds had noted that Eva seemed “sharper” than Barón. No significant association was found between the researcher-rated score for critical period and that for protectiveness (scores of 1 and 2 combined, χ^2=0.729, d.f.=1, *P*=0.393). These results suggest that variations in protectiveness might have been more due to inherited traits than were those of attentiveness, but small sample size precludes firm conclusions.

Two dogs in the same flock seemed to be more confident, protective and effective at confronting intruders than one. The head shepherd at farm 8 described how 4-month old Maco and Dona had together chased away an aggressive 5-6 year old German shepherd dog. Sometimes when one dog began barking, the other ran to it and began barking, apparently before being aware of what the threat might be. Both dogs often then ran together towards the perceived threat, one or both of them barking. Such behaviour was seen with Blanco and Axo, Maco and Dona and Eva and Barón. Sometimes one dog ignored barking or growling by the other. Some pairs of LGDs complemented each other. For example, Axo was less protective than Blanca, but "supported" her by going to her when she barked. In addition, they were often seen in different parts of the flock and so presumably were more likely to detect threats than a single dog would have been. Dona and Maco also sometimes rested at opposite ends of the barn, each by an entrance, when they were 7-8 months old.

Shepherds described several early encounters between wild predators and LGDs. Asan was said to have barked fiercely when he first encountered a bear at night before he was six months old, but he did not chase it. When she was a yearling Finestra also barked at a bear without approaching closer than 50m. However, in her second full grazing season she was reported to have chased a bear away from the flock for a considerable distance. During an attack by wolves, the flock at farm 2 became separated into two parts. The shepherd described how he saw Axo stay with one part and Blanca with the other. He believed that they had prevented greater losses. Other forms of protective behaviour besides aggression to predators were also described. Blanca and Axo discovered a sheep that was trapped and unable to return to the farmyard. They stayed with her and barked until the shepherd arrived. Dona and Maco were said to have chased young lambs back to their mothers if they escaped from barn stalls. The researcher saw Axo apparently encourage straggling sheep to catch up with the flock by running at them.

Simulated predator attacks

At the start of the first trial, Asan was resting in shade above the grazing flock. A shepherd with herding dog was on the opposite side of the flock from where the dog handler with "predator" approached. The released "predator" reached the flock and began chasing sheep before Asan detected it. He noticed the disturbance <10 seconds after the attack began at a time when the "predator" was c.100m from where he was lying (Table 4.6). He stood up with raised tail and looked towards the commotion, then ran to the scene. After initially confronting the "predator", which did not yield, he became uncertain and shied away from threats by the "predator". He then sniffed the two nearest sheep and lay down between them and the "predator". He appeared more confident and aggressive in the second trial, in which he pursued the "predator" back to the dog handler, barking, growling and occasionally lunging at it, before returning to the flock. In both cases sheep fled from the "predator" but scattered only slightly as Asan ran among them and quickly resumed grazing after he had passed.

Finestra was much more aggressive towards the "predator" than Asan had been. She detected it at a distance of c.50m. A herding dog ran with her to confront the "predator". Both of them barked and growled at the "predator", Finestra seemed about to physically attack it. The second trial was very similar.

Table 4.6. Responses of four 15-17 month old LGDs to two simulated predator attacks, giving the distances from "predator" (a German shepherd dog) to LGD and to sheep when it was detected by dogs, the LGD's immediate response on detecting the "predator" and the LGD's behaviour towards the "predator" during the subsequent encounter. Axo and Blanca were tested together.

Dog	1st trial			2nd trial		
	detected "predator"	immediate response	behaviour in encounter	detected "predator"	immediate response	behaviour in encounter
Asan	<10m from sheep, 100m from LGD	stood up, raised tail, looked for disturbance then ran to "predator"	initially confronted "predator", but shied from her threats and lunges	<5m from sheep, 50m from LGD	reacted mostly to fleeing sheep, rushed to disturbance	barking, growling, lunging at "predator"
Axo	<10m from sheep, 50m from LGD	ran quietly towards "predator", tail raised	stood side-on between sheep and "predator", tail up, some barking	<20m from sheep, 50m from LGD	growled at scent, moved through flock to "predator"	(recognised "predator" from 1st trial, became calm)
Blanca	<10m from sheep, 50m from LGD	ran quietly towards "predator", tail raised	stood side-on between sheep and "predator", tail up, barking	did not detect "predator"	-	-
Finestra	50m from LGD and flock	ran towards "predator", barking, tail raised	tail up, very aggressive barking and growling	50m from LGD and flock	ran towards "predator", barking, tail raised	tail up, very aggressive barking and growling

Axo and Blanca accompanied the same flock during trials, without shepherd or herding dog. Handler and "predator" approached undetected behind vegetation cover to <20m from passing sheep while both LGDs were sniffing around at the rear of the flock. They discovered the released "predator" when it was 50m from them and <10m from the nearest sheep. They reacted instantly by running to the intruder with tails raised but making little noise. They imposed themselves between sheep and "predator", turning side-on with tails raised. When the dog handler led the "predator" away, Blanca almost immediately returned to the flock. Axo returned to the sheep around five minutes later, having briefly followed the dog handler and "predator". In the second trial, Axo showed the same initial reaction but during the encounter he recognised the "predator" and stopped behaving aggressively towards her. Blanca was lying with a different part of the flock and remained unaware of the incident.

These trials show that two dogs together confronted a threat with more confidence and success than one. Two dogs also appeared to be better at detecting threats. LGDs in their second year of life were clearly still immature. In particular, Asan lacked confidence when encountering a "predator". In each trial, using bushes or patches of woodland as cover, the "predator" got within striking distance of sheep before it was discovered, suggesting that LGDs would not necessarily have been able to prevent some sheep being injured or killed in a real attack, but would probably have harassed predators, perhaps preventing further kills. In every trial the "predator" stopped approaching or chasing sheep in order to confront dogs. Other observations suggest that the dogs would have been more vigilant and protective at night. Keeping sheep away from vegetation cover would presumably reduce opportunities for predators to approach close to sheep without being detected by LGDs.

Reduction of losses

The mean and range of reported losses in 2002 at flocks with and without free-ranging livestock guarding dogs placed as part of the PLCLC project are given in Table 4.7. Reported losses to wolves as well as to both bears and wolves combined were substantially lower at 13 flocks with free-ranging project LGDs (mean=0.7 and 1.1 sheep/flock respectively) compared to 42 surveyed flocks in the same regions without free-ranging project LGDs (mean=3.0 and 3.6 sheep/flock respectively). No significant difference in losses was detected between the two groups using the Mann-Whitney *U* test ($P>0.05$). However, the chi-square test of association indicated that at flocks with free-ranging project LGDs there were significantly fewer reported losses to bears and wolves combined than expected ($\chi^2=20.58$, d.f.=1, $P<0.001$). The difference in mean combined loss was less when the control group was weighted to the same geographical distribution as the experimental group. The maximum total reported loss at a single flock was five sheep for flocks with project LGDs compared to 35 or 66 sheep (depending on the control group considered) for those without. This might imply that LGDs successfully prevented both major surplus killing and substantial cumulative losses. However, losses of ≥ 10 sheep were relatively rare (12.8% of 149 surveyed flocks for which reports on predation in 2002 were provided) and sample size for the experimental group was much smaller than that of the control groups. The degree of difference between breeds and sexes could not be readily assessed due to small sample sizes and various different combinations of dogs at the same flock.

Table 4.7. Reported losses to bears and wolves in 2002 at flocks with and without free-ranging livestock guarding dogs (LGDs) raised in 2001 and 2002 as part of the Protection of Livestock and Conservation of Large Carnivores project in Slovakia.

	Reported losses of sheep or goats to large carnivores					
	bears		wolves		bears and wolves	
	mean	range	mean	range	mean	Range
Experimental group						
Flocks with free-ranging PLCLC project LGDs (*n*=13)	0.4	0-4	0.7	0-5	1.1	0-5
Control groups						
All flocks surveyed in all regions with predator (*n*=149 wolves, *n*=150 bears, *n*=149 bears and wolves combined)	0.9	0-25	3.4	0-63	4.3	0-66
Flocks without free-ranging LGDs in same regions as experimental group (*n*=42)	0.5	0-5	3.0	0-35	3.6	0-35
Flocks without free-ranging LGDs weighted to same regional distribution as flocks in experimental group	0.6	-	2.6	-	3.2	-
Flocks without free-ranging LGDs, with two out-liers (reported losses ≥ 30) excluded, weighted to same regional distribution as flocks in experimental group	0.6	-	1.5	-	2.1	-

According to shepherds' reports, losses to predators occurred in 2002 at two flocks with LGDs raised for the present study. On the night of 12-13/9/02 a lone shepherd sleeping in a trailer near his flock of non-milking sheep on a pasture in close proximity to continuous forest cover was said to have been woken by dogs barking at around 02.30-03.00h. He went out with a lamp and saw a bear which he estimated to be <100kg; it killed three ewes and a ram, fed and left of its own accord. Thirteen-month old Finestra and a herding dog were said to have barked at the bear but did not approach nearer than 50m. The next day the flock was moved to pastures nearer the village and no further losses were recorded. No sheep were predated during the same grazing season at a flock of 450-600 milking ewes and young sheep guarded by Asan, <5km away, despite a female bear and cubs passing several times to reach a maize field. Other nearby flocks with free-ranging LGDs in the study (a flock of milking ewes with Maco and Flávia and another with Barón and Eva) also had no losses in 2002, whereas the flock of ewes where Pazúr had been permanently confined to his training pen was reported to have lost five sheep to bear predation in autumn. The second flock to suffer losses, at farm 2, was apparently attacked by wolves at night on two separate occasions in the unfenced yard of a former collective farm <100m from forest cover. The head shepherd believed he saw a wolf grab a small herding dog during the first attack, at around midnight on 15-16/9/02. A second dog and three sheep could not be found the next morning. The second attack apparently happened on the night of 22-23/9/02 but was only inferred when the remaining two herding dogs, a young sheep and a goat could not be found. Despite these losses, the shepherds were pleased with Blanca and Axo, sure that more sheep would have been lost without them. A much larger portion of this flock (c.80 sheep) had died during winter 2001-02 due to a bad batch of feed. As a result very few lambs reached the required weight stipulated by buyers and there was no milk production in 2002.

No losses were reported during the 2003 grazing season at any of the flocks protected by free-ranging dogs from among the 14 raised for the behavioural observations: Axo and Blanca at farm 2, Barón and Eva at farm 8, Finestra at farm 7 and Goro at farm 1, plus Dora (replaced Asan) at farm 6.

DISCUSSION

Reduction of losses

Probably the most important question to ask about LGDs and other preventive measures is do they work, i.e. are losses reduced? (Coppinger *et al*. 1988), although it has been noted that reducing losses is not a prerequisite to mitigating conflicts (L. Boitani pers. comm. 2003). Several studies in the USA (McGrew and Blakesley 1982, Green *et al*. 1984, Green and Woodruff 1989, Andelt 1992, 1999, Andelt and Hopper 2000) and elsewhere (reviewed in Rigg 2001a) have shown that properly used LGDs reduced losses to various predators in a variety of situations. Find'o (2002) presented figures from Slovakia implying very substantial differences in reported predation at flocks with versus those without free-ranging dogs. The results of the present study suggest that Find'o's work may have suffered from five important sources of bias. Firstly, different methodologies were used to gather data for the experimental and control groups. Secondly, the experimental and control groups were not in the same regions, when there is known to be considerable variation among regions (Chapter 3). Thirdly, the control group data were mainly respondents to a postal questionnaire survey in which there was no follow-up of non-respondents (Scott 1961, Moser and Kalton 1971). Almost all farmers (92%) in Find'o's control group reported losses, a high proportion being of ≥ 10 sheep (34%). In the present study, 31.3% of 150 flocks surveyed by site visit and follow-up telephone call reported losses in 2002 and only 12.8% of flocks had reported losses of ≥ 10 sheep (Chapter 3), suggesting that farmers were much more likely to be included in Find'o's control group if they reported losses, perhaps because farmers that had suffered losses to predation were more likely to return the postal questionnaire than those who had not. Fourthly, Find'o's control group appeared to lack a standard sample unit: some items were flocks, some were farms with more than one flock and at least one was neither of these. Fifthly, because relatively few farmers reported losing ≥ 10 sheep to predation in 2002, such cases were much more likely to be included in Find'o's larger control group (*n*=38) than in his experimental group (*n*=14). A small number of farms reporting high losses account for the majority of reported losses at all farms (Chapter 3). The present study avoided all except the fifth of these sources of bias and still found a significantly lower level of reported losses at flocks with free-ranging PLCLC project LGDs compared to other flocks in the same regions without, although the difference was not as great as that reported by Find'o (2002).

Losses to wolves seemed to be reduced more by the presence of free-ranging LGDs than those to bears. If this was a genuine effect rather than a statistical bias, perhaps it can be explained by intra-specific interactions between dogs and wolves, as described by Coppinger and Coppinger (1987, 1995). The maximum loss reported at a flock with free-ranging LGD(s) was of five sheep, compared to 35-66 sheep at other flocks. This may have been due to the smaller sample size of flocks with free-ranging LGDs and the infrequency of losses ≥ 10 sheep (Chapter 3), or it might indicate that LGDs prevented predators killing large numbers of livestock and their presence discouraged repeat attacks, perhaps by making livestock an energetically inefficient food source (Coppinger and Coppinger 1987, 1995). LGDs have been filmed in the French Alps repeatedly harassing and chasing wolves attempting to attack a flock. Although two sheep were eventually killed, the wolves had to expend a lot of energy running away from dogs over a period of hours (Lequette 2003). Mertens and Promberger (2001) did not record any incidents of surplus killing at flocks they studied in Romania, which they speculated might be partially explained by the presence of LGDs. Shepherds they interviewed reported that their dogs chased predators away before they could make multiple kills.

Dogs in the present study were observed to be more attentive, vigilant and protective at night. As most attacks on livestock by carnivores occur at night (Chapter 3), daytime inattentive dogs can still help to prevent losses. However, wolves are frequently reported to attack during the daytime, although tending to cause fewer losses than at night (Chapter 3). Free-ranging LGDs attentive to sheep are therefore particularly appropriate where wolves are expected to cause losses. The apparent reduction in losses found in the present study was less for bears than for wolves. In Slovakia, shepherds and farmers reported far fewer sheep killed by bears than by wolves and almost all attacks were said to occur at night (Chapter 3). In situations where only bears are expected to cause losses, other forms of protection such as strong electric fences around sheepfolds may therefore be preferable to LGDs because they can be installed quickly. Electric fences have been found to be very effective at preventing losses to predators in mountainous regions of Europe (Mertens and Boronia 2000, Angst *et al*. 2002, Mertens and Promberger 2003). The effectiveness of electric fences seen in Slovakia was limited by the use of inadequate equipment and poor installation or maintenance (Chapter 3).

Differences among dogs

The 14 LGDs used for behavioural observations in the present study were from four different litters of čuvač-type dogs and three litters of Caucasian shepherd-type dogs. This sample was both too small for detailed statistical analysis and subject to bias due to variation in methodology. Without a much larger sample and more uniform developmental environments in which each pup's experiences and opportunities for learning were standardised, and less variation of the circumstances in which pups were observed, few robust conclusions can be reached regarding inherent differences among breeds/strains or sexes and their relative effectiveness at reducing losses to predation. However, some of the unintended variation introduced by shepherds had the benefit of providing insights into the relative importance of inheritance and learning in the development of desirable behavioural patterns and the success or failure of integrating LGDs into flocks of sheep in Slovakia. Unrelated dogs placed at the same farm consistently had similar outcomes which, combined with behavioural scores and puppy aptitude tests, suggests that most dogs tested had sufficient (genetic) potential to become good guardians but that the developmental environments in which they were raised and expected to work were of decisive importance. Coppinger and Coppinger (2001) emphasised that genetics and developmental environments cannot be considered separately. While dogs inherit certain potentials, their behaviour in adulthood is shaped by the environment in which they develop, particularly during the critical period.

In the present study, attentiveness in particular seemed to be greatly influenced by the method of upbringing. Coppinger *et al*. (1988) regarded attentiveness as the key to success in raising LGDs. These authors concluded that if a dog was attentive it was also protective. However, in the present study there were evident differences in personality, including degree of protectiveness, among dogs raised in similar conditions. Although no statistically significant difference was found between breeds, a greater proportion of Caucasian shepherd dogs than of Slovenský čuvače were given the highest score for protectiveness. Finďo (2002b) felt that Caucasian shepherd dogs showed more courage than Slovenský čuvače when confronting determined predators. The dogs in the present study and many of those in Finďo's study (2000, 2001, 2002b) were rather young to assess their effectiveness. Earlier studies (Coppinger *et al*. 1983, Andelt 1999) have excluded yearlings or farms that had been using LGDs for less than a year from analyses of predation reduction. According to Dawydiak and Sims (2004), particular characteristics are associated with different LGD breeds, although variation within breeds, even within litters, can be greater than that between breeds. While many Slovak shepherds clearly admired the formidable size of Caucasian shepherd dogs, and in some cases rejected small dogs with good behavioural patterns, some researchers have asserted that large size and aggressiveness are not necessary characters for successful guardians (Black and Green 1985, Coppinger *et al*. 1988, Coppinger and Coppinger 2001 but cf. Sedefchev 2003). Indeed, less aggressive dogs might be more appropriate where encounters with people are a concern (cf. Andelt 1992, Green and Woodruff 1988), as in Slovakia. In addition, Caucasian shepherd dogs suffered more from heat, leading to a reduction in daytime attentiveness, and disturbed sheep more.

Feasibility of introducing LGDs

The present study was originally conceived to test whether the Slovenský čuvač retained traits for guarding, if the presence of free-ranging Slovenský čuvače and Caucasian shepherd dogs reduced losses to predation and to what extent variables such as breed, sex and method of raising influenced the effectiveness of the individual dogs. As work progressed, however, it became more of a feasibility study examining the circumstances under which it was possible to raise LGDs at farms in Slovakia. Major difficulties in working with agricultural workers were encountered throughout the duration of the PLCLC project in 2000-04 (Finďo 2000, 2001, 2002b, Rigg 2001b, 2002b) and are probably the greatest obstacle to revitalizing the proper use of livestock guarding dogs in Slovakia. The majority of dogs in the present study showed good or acceptable patterns of behaviour and apparently had potential to become successful guardians. Nevertheless only a minority were successfully integrated into flocks. Several factors that hindered this process are described below.

Apathy of shepherds

Agriculture in Slovakia, as elsewhere in Europe, dramatically declined during the 20th century. The removal of personal property and responsibility by the collectivisation of farming under communism in 1948-1989 seemed to produce a lingering sense of apathy. Many shepherds encountered during the course of the PLCLC project were alcoholics who neglected or even abused animals under their care and were very reluctant to accept new ways of working. As they were not held responsible for losses of sheep to predation, seasonally employed shepherds had little motivation to perform extra work in order to raise and train LGDs, particularly because they would not necessarily be returning to the same farm the following year. Some simply discounted the possible effectiveness of LGDs, or believed they would harm sheep, and so reacted to disruptive behaviour by excluding dogs from the flock. Shepherds employed for the milking season, in particular, were motivated by the desire to minimise extra work and maximise milk output. They were typically highly intolerant of young LGDs playing with ewes. Between late summer and early winter seemed to be the best time of year for beginning to bond pups to livestock. The head shepherd or *bača* has traditionally been responsible for the day to day management of the seasonal livestock fold or *salaš* (where predation is most likely to occur) and so it was essential that he was in favour of having LGDs in order to ensure that pups were raised well and allowed to accompany flocks.

Lack of knowledge and experience

Even among shepherds and farmers who made serious efforts to raise LGDs well, problems still arose due to lack of experience. Although LGDs have been part of the Slovak livestock industry for centuries, not only has the original way of using them been abandoned but also knowledge of how to raise good dogs has been almost completely forgotten. Few shepherds were aware of the developmental and behavioural differences between herding and guarding dogs and so did not understand or else disregarded the importance of following guidelines in the raising and training of LGDs. Education efforts therefore need to begin at a very basic level and in most cases considerable practical support and intervention is needed to prevent potentially good dogs being permanently chained, lost or killed.

Lack of knowledge and experience were compounded by prior beliefs. Many shepherds assumed that large, aggressive dogs would make effective guardians (even if chained up) rather than those attentive to sheep. Such beliefs influenced their diligence in following guidelines for raising LGDs and hence the degree of success of incorporating dogs into flocks. The conviction that LGDs might cause the deaths of many sheep by panic and asphyxiation in barns or that if a dog tasted blood it would become an habitual sheep killer led to dogs being separated from sheep, sometimes permanently. Some shepherds called LGDs away from sheep, thinking they should stay at heal, like herding dogs. Being large dogs, LGDs typically require from one to three years to mature and begin guarding effectively (Sims and Dawydiak 1990, USDA 1998). Sheep also needed time to become familiar with dogs. Many shepherds were too quick to begin judging the effectiveness of dogs.

Aggression of LGDs to people

During a survey of Slovak sheep farms in 2003 (Chapter 3), the most frequent reason expressed by shepherds for not having free-ranging LGDs was concern that they might attack people (walkers, farm visitors, berry/mushroom pickers, local residents). Illustrator and writer Jan Hála, who lived among rural people in northern Slovakia from 1923 to 1959, noted that "Boli to psi ani medvedina, celá dedina sa ich bála", "The dogs [LGDs] were like bears, the whole village was afraid of them" (Hála 2001:97). Farmers and shepherds participating in the present research project were advised to post signs warning of the presence of free-ranging guard dogs, but none of them did so. Barón chased and lightly bit a visitor on a motorcycle in the late evening. The farmer was afraid that he might lose customers for cheese and so chained him up. Asan also chased motorcycles and cars and, although was not said to be aggressive to people normally, asserted his dominance when there was a bitch in heat. His large size frightened some people who therefore fled, triggering a playful pursuit. Hikers frightened by LGDs have been a problem in the Swiss Alps (Landry 2003a). Out of 284 visitors to the Slovak-Polish border region responding to a questionnaire asking for information on their experiences with LGDs in the area, only one reported having been bitten (Bloch 1995). In the Romanian Carpathians, LGDs at neighbouring flocks differed markedly in their level of aggression to walkers (pers. obs. 2003). Travellers in the past have described carrying sticks or throwing stones to ward off aggressive LGDs in Romania, Greece and Turkey (see Hubbard 1947). In contrast, free-ranging LGDs in northern Portugal were frequently seen accompanying flocks along public roads and through villages, apparently without conflict (pers. obs. 2003). Studies in the USA have identified different levels of aggression among breeds (Green and Woodruff 1988, Andelt 1992). As yearlings, 3/8 dogs (38%) included in the PLCLC project in 2000 bit people, one of them seriously, but in general they were not considered to be aggressive (Finďo 2001). In the present study, Bak was very nervous after being relocated to a different farm and bit a shepherd there out of fear. There was a similar problem with Asan. Other dogs were relocated without such problems.

Attentiveness and trustworthiness

Almost all pups in the present study showed some obnoxious behaviour towards sheep. Even the best dogs vigorously chased sheep when they first accompanied flocks to pasture at five months old. How shepherds responded to such behaviour was of great importance. Most disruptive behaviour can be corrected, given sufficient patience and a degree of tolerance (Sims and Dawydiak 1990:45-80, Coppinger 1992a). According to these authors, LGD behaviour can change substantially as dogs mature and a seemingly unsuccessful adolescent may still prove to be a good guardian. In the USA c.75% of trained dogs became good guardians (USDA 1998). The use of a drag or wooden beam dangled from the collar was explained to several shepherds as a means to prevent dogs chasing sheep, but none of them ever tried these techniques, even though such devices were used in the past in Slovakia to prevent LGDs chasing game (Kurz 1958:342, Podolák 1967:109, Jamnický 2000) and are still sometimes put on herding dogs (pers. obs. 2001-03). Instead, some shepherds responded to disruptive, overly attentive behaviour (see Coppinger 1992a) by discouraging or preventing attentiveness. More tolerant shepherds used a leash to train dogs not to chase sheep or punished them if they did so excessively, while still allowing them to accompany flocks. In order to assuage concerns of lost milk productivity, young and playful dogs can be raised and trained with non-milking sheep, i.e. lambs, yearlings, rams or possibly ewes after the milking season has ended. This is best begun in a barn or a fenced off section of farmyard. Socialising pups with sheep in mobile enclosures on pastures in spring and summer was usually less successful due to the considerable extra work it involved for shepherds.

Dog mortality

All 14 dogs in the present study lived to at least three years of age. However, 6/16 (38%) other dogs placed at farms as part of the PLCLC project in 2001-02 had been killed before they reached the age of two (after Find'o 2002). Three were shot (or were thought to have been shot), one was poisoned and two were hit by vehicles. Shepherds were generally in close contact with local hunters and some farm managers were themselves also hunters (farms 1, 3 and 7). Nevertheless, despite being fully informed of the project's purpose, users of some hunting grounds threatened to shoot LGDs if they wandered because they were concerned that they might kill game animals. According to hunting laws valid during the course of the project (act no. 23/1962 and amendment no. 99/1993), hunters had the right to shoot a dog >200m from the flock. These laws were passed at a time when free-ranging LGDs had already largely disappeared from Slovakia. LGDs in Romania are exempt from such regulations if they are identified by a dangle stick (A. Mertens pers. comm. 2003). Recommendations to put coloured collars on dogs in the present study were rarely followed by shepherds. More attentive dogs would be expected to be less vulnerable to being shot by hunters. Vehicle collisions and shooting have been identified as major causes of LGD mortality in the USA, along with accidents, disease and culling due to untrustworthiness (Green *et al.* 1984, Lorenz 1985). Lorenz *et al.* (1986) found that nearly 75% of LGDs working on open rangeland in the USA died before 38 months of age.

Cost

Some shepherds interviewed (Chapter 3) were not interested in acquiring more dogs because of the perceived cost of feeding them. Nevertheless almost all flocks visited had several tethered LGDs, so purchase or maintenance costs did not seem to be a barrier and in any case many dogs were fed on low-cost foods, such as whey. The mean number of large dogs (LGDs) at surveyed flocks was 3.0, fewer than were observed accompanying flocks in similar conditions in the Romanian Carpathians (pers. obs. 2001-03, Mertens and Promberger 2001). However, the total number of dogs at one camp was up to 15. Shepherds could perhaps reduce dog-related costs and labour along with losses to predation by having a smaller number of more effective, free-ranging dogs.

Socio-economic change

Farming in Slovakia was not very profitable during the course of the PLCLC project and owners of flocks at three farms where LGDs had been placed, including one in the present study (farm 2), decided to stop keeping sheep. There was much uncertainty and reform leading up to and following Slovakia's entry to the EU in May 2004. A proposed requirement for pasteurisation had threatened to force many farms out of business at the beginning of 2002, but was dropped. There seemed to be a trend moving away from traditional hand-milking of sheep and production of cheeses at summer sheep camps towards introducing milking machines and exporting milk from farms to processing plants. This, along with more stringent EU hygiene requirements, loss of subsidies, continuing difficulty in recruiting shepherds for hand-milking and perhaps more focus on meat production might lead to fewer flocks grazed in remote areas. Farms that survive might make increased use of pastures nearer villages and barns for night confinement, as has happened in the Martin region (Chapter 3). If these changes happen, they could complicate the introduction of LGDs but at the same time might to some extent reduce the need for additional preventive measures. On the other hand, less hardy breeds introduced to increase productivity and other changes in husbandry might make some flocks more vulnerable to predation. Within existing EU countries, the use of shepherds and livestock guarding dogs is not always economically viable (Landry 2003b). The prevailing uncertainty and instability in Slovakia made it difficult to implement a longer-term strategy such as LGDs.

SUMMARY

- Fourteen pups of two recognised livestock guarding dog breeds found in Slovakia (Slovenský čuvač and Caucasian shepherd dog) were raised with sheep at eight farms. A variety of measures were used to score the behaviour of each pup during c.500 hours of focal observations.

- The effectiveness of LGDs at reducing losses to large carnivores was assessed by comparing reported losses in 2002 at flocks with and without free-ranging LGDs raised as part of the Protection of Livestock and Conservation of Large Carnivores (PLCLC) project.

- Behavioural observations found that the majority of dogs tested (12/14 or 86%) retained the key traits of trustworthiness, attentiveness and protectiveness considered necessary for successful LGDs.

- As yearlings, six of the 14 dogs (43%) became very well or reasonably well integrated into flocks. Whether or not a particular pup became integrated into a flock appeared to depend on the attitude and diligence of shepherds and therefore the developmental environments in which it was raised and expected to work rather than on its behavioural conformation or genotype.

- Reported losses in 2002 at 13 flocks with free-ranging LGDs were significantly lower than expected and the maximum reported loss was only 14% of that at 42 surveyed flocks without free-ranging PLCLC project LGDs in the same regions.

- A literature review confirmed the appropriateness of this non-lethal method of livestock protection in the Slovak Carpathians However, the trials identified a number of barriers to the successful introduction of free-ranging LGDs to sheep farms in Slovakia. The most significant was the lack of knowledge, experience or motivation of many shepherds. Other problems included interactions of dogs with farm visitors, hunters threatening to shoot wandering dogs and economic instability leading to the sale of flocks.

Chapter 5

A review of carnivore-human conflicts in Slovakia

Abstract: This chapter presents an overview of current conflicts in Slovakia that may have important repercussions for the long-term conservation of large carnivores. The most pertinent issues are described on the bases of a literature review and informal interviews with wildlife and hunting managers, governmental and non-governmental conservation workers and researchers as well as relevant results from the present research and the preliminary findings from a questionnaire survey of public opinion, knowledge and attitudes to bears (*Ursus arctos*), wolves (*Canis lupus*) and lynx (*Lynx lynx*) conducted in 2003-04 in a region of Slovakia with high densities of large carnivores and a second region with only rare occurrences of these species.

CONTENTS

INTRODUCTION

Conflicts with humans are a major threat to survival for many wildlife species (Woodroffe *et al*. 2002a). Conflicts have resulted in persecution of carnivores by humans with an intensity sufficient to cause population decline, range contraction and in some cases extinction (Reynolds and Tapper 1996, Breitenmoser 1998, Woodroffe 2001, Woodroffe *et al*. 2002a). The present research sought to examine the most incisive current conflicts involving large carnivores in Slovakia in order to put livestock predation into context and perspective and to ascertain to what degree the successful reduction of losses to predation might reduce conflicts and lethal control of carnivores, thus promoting carnivore conservation.

MATERIALS AND METHODS

A review was conducted of carnivore-related content in recent scientific, popular, nature conservation and hunting literature to identify those carnivore-human conflicts in Slovakia that seemed to cause most concern. Irregular informal interviews were held with wildlife and hunting managers, governmental and non-governmental conservation workers and researchers, hunters, foresters, shepherds, farmers and local residents in order to determine the range of opinions on each issue. Account was taken of preliminary findings from a questionnaire survey (Wechselberger *et al*. in prep.) conducted in 2003-04 of public opinion, knowledge and attitudes to large carnivores in a region with high densities of large carnivores (Litpovský Mikuláš) and a region with only rare occurrences of these species (Trenčín). Perceptions of each issue were then compared with available scientific data. As lynx (*Lynx lynx*) had rarely been implicated in losses of livestock (Hell and Slamečka 2000), only bears (*Ursus arctos*) and wolves (*Canis lupus*) were considered. Broader issues such as habitat loss and fragmentation were examined in terms of how they might affect more direct forms of conflict.

RESULTS AND DISCUSSION

Bears

Damage to livestock, beehives and crops

The results of the present study (Chapter 2) show that bears in north central Slovakia rarely consume livestock but that other anthropogenic food items form a substantial portion of their diet ($m\%V \geq 21.0\%$, $\%D \geq 39.2\%$). The great majority of this material (75.7% of dry anthropogenic matter ingested) consisted of cultivated grains. Bears fed on oats (*Avena sativa*) and maize (*Zea mays*) in fields in late summer and early autumn, especially around Veľká Fatra and in the south-western part of the Nízke Tatry. In the Západné Tatry and Nízke Tatry cultivated grains and apples (*Malus* spp.) were fed on most frequently at hunters' feeding stations, particularly in late autumn. From 1962 to 2002 compensation was paid for damage to livestock and beehives but not to crops (Hlásnik 2002a, Kassa 2003). State-paid compensation was extended to include unharvested crops by Act No. 543/2002 on Nature and Landscape Protection, valid from 1/1/03. Hell (2003) estimated the total damage caused by bears in Slovakia at around 1 million Sk/year (c.€25,000/year), which is a trivial amount compared to the subsidies of c.€200 million/year paid to agriculture in 1999-2001 (MP SR 2002) and an average of 35.7 million Sk/year (c.€890,000/year) spent in 1991-97 on protecting forest stands from ungulate browse damage (Find'o 1999a). According to the new law, payment of compensation is conditional on use of appropriate preventive measures. Together with education and awareness campaigns (e.g. Rigg 2003b, 2004, Beťková and Rigg 2004) this could help to limit damage and conflicts.

Bears make substantial use of agricultural crops wherever they are available and not necessarily only when natural food sources are inadequate (Mattson 1990), although nuisance behaviour by black bears (*Ursus americanus*) tends to increase in years of berry crop or mast failure (Rogers 1976 cited in Herrero 1985, Garshelis 1989 cited in Kaczensky 1996, 1999). Different age-sex classes of bears tend to be involved in different types of nuisance behaviours (Mattson 1990). Several Slovak authors have attributed problems with bears to excessive gathering by people of bilberries, cowberries and raspberries (Jamnický 1988, 2003, Baláž 2003, Hell 2003, Kováč 2003, Radúch 2003). Spring to early summer 2001 had relatively few instances of nuisance behaviour by bears in the High Tatras (Hoholíková 2001c). A young food-conditioned and unwary female obtained food from and injured tourists during the summer (Šturcel 2001). Reported levels of damage to livestock were relatively high in 2002 (Chapter 3), there were frequent reports of wary and unwary bears feeding on refuse, orchards and pre-harvest crops (pers. obs. 2002, Remeník pers. comm. 2002, S. Ondruš pers. comm. 2002) as well as at least four separate cases of human injuries caused by two different food-conditioned bears in the Nízke Tatry (Rigg 2002b). In 2003 reported livestock losses were lower (Chapter 3), bears rarely fed on crops around the Nízke Tatry (S. Ondruš pers. comm. 2003) and there seemed to be few problems with nuisance bears. No measurements of fruit production were attempted as part of the present study, but bilberries (*Vaccinium myrtillus*) appeared to be abundant in the Tatras during all three years. The crop of beech mast (*Fagus sylvatica*) was poor in the Nízke Tatry and Veľká Fatra in 2001 and 2002 but substantial in 2003, a year in which several other species produced abundant crops in the study area, including arolla pine (*Pinus cembra*) and cowberry (*Vaccinium vitis-idaea*). Artificial feeding of ungulates and bears by hunters seemed to be fairly consistent from year to year. From the data available, it is not possible to conclude with confidence whether the observed reduction in damage to livestock and crops as well as nuisance behaviour in 2003 compared to 2002 was due more to the removal of a small number of food-conditioned individuals, increased availability of natural foods, a reduction in the bear population, a combination of these factors or some other factor(s). As nuisance bears removed from the Nízke and Vysoké Tatry in 2001-02 were not the only human-food conditioned individuals known to be present, the relative abundance of natural food sources may have been an influential factor.

It has been suggested that human-carnivore conflicts in Europe might be reduced if large carnivore populations were regularly culled to maintain their populations at lower densities than a given area could potentially support (LCIE Core Group 2001, Boitani 2003a,b). In Slovenia, a negative correlation was found between the relative size of the hunting quota in the bear core area and spatial expansion of the bear population into peripheral areas (Jerina and Adamic 2002) where most damage occurred (Jonozovic and Adamic 2002). However, Slovakia is a very different situation from Slovenia, because most damage tends to occur in the core of the range, not the periphery (Chapter 3). This difference is largely accounted for by different human settlement and land-use patterns: in Slovenia, sheep (*Ovis aries*) and humans are at higher densities in the periphery than in the core area (Štrumbelj and Kryštufek 2003), whereas in Slovakia the human population is more evenly distributed and most sheep are in regions where bears are most numerous (Chapter 3). High densities of bears have been reported locally from some parts of Slovakia (Baláž 2002, 2003, Lehocký 2002, Pčola 2003). However, the relative level of conflicts also depends on several other factors such as the nature and scale of human activities and local characteristics including use of preventive measures (Chapter 3).

Human injury and nuisance bears

Fatal attacks by carnivores on people are rare (Linnell *et al*. 2002b) and none are known from Slovakia since the turn of the 20th century (Hell and Finďo 1999, Hell and Slamečka 1999, Hell *et al*. 2001a). Nevertheless, human injuries caused by bears are highly emotive, often selectively publicised and a source of fear for many people in Slovakia (Wechselberger *et al*. in prep.). Every spring during the present study, prime-time television news programmes announced that bears had left their dens, were hungry and therefore aggressive, implying that they could attack humans. Although up to 10 people are injured by bears each year in Slovakia (Hell and Bevilaqua 1988, Hell and Slamečka 1999, Rigg 2002b, Hell 2003), some of them in spring, no cases have been documented of predatory attacks (Martínková and Zahradníková 2003). According to Herrero (1985, 2002) there is no evidence that bears are particularly hungry on emerging from their dens. They may remain in a hibernation-like state for a few weeks consuming little, a physiological condition termed hypophagia (Nelson *et al.* 1983). Provided that adequate food was available in autumn, they still have a significant layer of back and rump fat and in many areas continue losing weight until berries ripen in late summer (Herrero 1985).

Some attacks on humans are by bears surprised at close range and acting in self defence, defending cubs or a food source. Hunters are occasionally attacked by injured bears (Hell and Bevilaqua 1988, Hell and Slamečka 1999, Rigg 2000b, Baláž

2003, Kassa 2003). However, a substantial proportion of injuries known to have occurred during the present study were inflicted by human food-conditioned individuals (Rigg 2002b). Herrero (1970, 1985, 2002) identified habituation to humans and anthropogenic food as the underlying cause of many attacks by bears on humans in North America, including predaceous and fatal attacks (Herrero and Fleck 1990). Despite some limited attempts in the past to install bear-proof containers, human food and refuse were readily available to bears in several areas within Tatranský and Nízke Tatry National Parks. Residents had little awareness of bear safety issues and preventive measures (Wechselberger *et al.* in prep.). Bears were seen foraging around tourist facilities in the Nízke Tatry in spring, summer and autumn and were fed, sometimes directly, by tourists wanting to take photographs, by well-meaning hotel staff and local residents thinking they were helping bears and even by curious National Park volunteers (pers. obs. 2001-02). A number of previous authors (e.g. Kráľ 1999, 2000) have also described bears feeding from refuse containers in human settlements and tourist resorts in the Tatra Mountains. A highly-publicised case in summer 2001 led to an international conference on nuisance bears (Rigg and Baleková 2003), renewed debate on bear conservation and hunting management and a non-governmental initiative to raise knowledge and awareness of bears in Slovakia (Rigg 2004). Media reporting of bear attacks on humans apparently has a considerable influence on attitudes to bears and so presumably also on the level of support for bear conservation (Wechselberger *et al.* in prep.). Much of it exaggerates the danger of large carnivores and the damage they cause. On the other hand, environmentalists and animal rights activists have also indulged in sensationalist reporting of threats posed by hunters to bears and wolves (e.g. Freedom for Animals and Wolf Forest Protection Movement websites and newsletters 2002-04; see also Blanco 1998, Mech 2000).

In the present study, refuse was found most often in scats from April, but was apparently a supplemental food important to only a few bears in a few locations (cf. review in Mattson 1990). Kráľ (1999, 2001) and Kováč (2003) reported that bears in the High Tatras most often visited refuse containers and other anthropogenic food sources in spring and late autumn. Kúdola and Lehota (2001) described hand-feeding a c.100kg free-living bear on the northern edge of Nízke Tatry National Park in August. Hell and Slamečka (1999:98-101) published photographs of a free-living bear being hand-fed in the Západné Tatry and described how it was regularly allowed into a house. In other instances bears have occasionally broken into buildings to obtain food. Such behaviour by a single bear in June and a female with three cubs in October 2000 were described by Stodola (2001). Evidence of a bear having broken into a hotel in Demänovská dolina, Nízke Tatry, was seen in September 2001. Hotel staff in the area described a number of other similar incidents. The State Nature Conservancy seemed reluctant to act in some cases, instead blaming local people and tourists for attracting the bears. This fuelled obvious hostility towards both conservationists and bears.

According to Teren (1987:90), Kováč (1996) and Remeník (1999), most nuisance bears are young individuals (3-4 years old) or females with several cubs. Of three nuisance bears removed from the Nízke Tatry and High Tatras during this study, two were juveniles (K. Soos pers. comm. 2002, S. Ondruš pers. comm. 2002) and the third was judged to be 5-7 years old (Martínková and Zahradníková 2003). Incidents of nuisance bears in the High Tatras increased from the early 1980s but it has been estimated that only 5-10% of bears in the National Park are regularly involved in nuisance activity (Kováč 1996). Hunting advocates (e.g. Hell 2003) claim that individuals utilise anthropogenic food sources and become human food-conditioned at least partially due to an "over-population" of bears. It has been argued that a reduction in wild ungulate populations since the 1980s, a decline in numbers of livestock in mountain areas and excessive berry picking by humans have reduced bears' natural food base. Dominant males are said to exclude weaker individuals from the best remaining habitat with the consequence that food-stressed juveniles and females with cubs are forced to move nearer human-occupied areas and feed from anthropogenic food sources (Jamnický 1988, 2003, Kováč 1996, 2003, Rakyta 2001, Hell 2003). Although there are precedents in the published literature (e.g. Mueller *et al*. 2004; see also reviews in Mattson 1990, Taylor 1994), unfortunately no data have been gathered in Slovakia to test these hypotheses and so no firm conclusions can be drawn. There are, however, a number of indications that the situation might not be as simple as this explanation suggests. During the present study it was found that the same individuals utilised both natural and anthropogenic food sources and habitats concurrently. Despite the intensive collection of berries by people in easily accessible areas, remoter localities still had an abundance of berries in late autumn (pers. obs. 2002-03). Not all apparently good habitat seemed to be occupied by bears (S. Ondruš pers. comm. 2002) and large adult males were believed to be relatively scarce in the Western Carpathian bear population as a whole due to poorly planned trophy hunting from the 1960s to the mid 1980s (Sabadoš and Śimiak 1981, Kassa 1998a, 2003, Baláž 2002, 2003, Martínková and Zahradníková 2003). There may also be other explanations for the observed abundance of sub-adults in some areas. For example, bears in areas of higher human use such as at the edges of occupied bear habitat probably tend to be killed earlier than those in areas of less human use (Mueller *et al*. 2004).

The assertion of some Slovak environmentalists and animal rights activists, that almost all bear-human conflicts can be blamed on human activities and behaviour (e.g. Freedom for Animals and Wolf Forest Protection Movement websites 2002-04, non-governmental conservation organisations' recommendations in Rigg and Baleková 2003:132-133) forms part of a more general strategy to restrict commercial forestry and hunting activities (K. Baleková pers. comm. 2002, J. Lukáč pers. comm. 2002) and as such may be misguided. Conversely, the tendency of hunting advocates to explain most problems with bears as being due to all suitable habitat having been occupied is surely an over-simplification. There are nutritional reasons why bears consume mixed diets even when fruit is abundant (Rode and Robbins 2000). Herrero (1985, 2002) postulated that bears, rather than being compelled to, might choose to feed on the easily-digested, calorie-rich foods in refuse, thereby gaining weight rapidly and improving their reproductive success. Rogers (1976 cited in Herrero 1985) demonstrated that the reproductive success of black bear females in Minnesota was strongly related to nutrition. Blanchard (1987) found that brown (grizzly) bears that fed on refuse were heavier than those that did not and that reproductive success was highly correlated with mean adult female weight. The three nuisance bears removed from the Tatras in 2001-02 were all females. During the present study, pine martens (*Martes martes*) and squirrels (*Sciurus vulgaris*) were observed feeding from refuse containers also visited by bears. Even some red deer (*Cervus elaphus*) fed on refuse in the High Tatras (Hoholíková 2001d; see also Hoholíková 2001a). That curious bears and other animals will investigate new, anthropogenic sources of food in the midst of pristine wilderness habitat was discovered by explorers of the Rocky Mountains at the turn of the 19th century (Lewis and Clark in Bakeless 1964). Brown (grizzly) bears fed heavily on refuse at open dumps in Yellowstone National Park from 1895 until 1968-71, when the dumps were closed (Stringham 1983). It was believed that almost all bears in the Park visited the sites at least occasionally; up to 70 individuals were seen feeding at one site in the same night. Brown (grizzly) bears have been recorded travelling over 38km from backcountry den sites in Banff National Park to reach refuse dumps (Herrero 1985). In the Romanian Carpathian Mountains, bears travelled to refuse containers from a distance of at least 15km (Mertens and Sandor 2000) and to hunters' feeding stations from up to 17km (Weber 1987). Use of refuse by wolves was observed in the same area (Promberger *et al*. 1997). Swenson *et al*. (1998) reported evidence for pre-saturation dispersal from an expanding bear population in Scandinavia.

Supplementary feeding

Halák (1993), Kováč (1996, 2003) and other state forestry employees (see Kováčiková 2003) have advocated diversionary feeding in spring as a means to reduce nuisance bear behaviour. It was observed at four locations in the High Tatras during the present study but there seemed to be motivated more by financial gain than non-lethal conflict resolution (pers. obs. 2003). At least one bear that had been fed by foresters and watched by paying eco-tourists in spring was shot during the autumn hunt (M. Janiga pers. comm. 2004). Supplementary feeding of bears in the High Tatras can be traced back at least to 1905, when it was used to maintain and increase numbers of bears for sport hunting (Feriancová 1955). Providing bears with more food without increasing hunting quotas can be expected to increase survival rate, reproductive success and therefore population size. Boutin (1990), in a review of over 130 studies involving the experimental manipulation of food available to terrestrial vertebrates, found clear tendencies among individuals with access to supplemental foods: reduced home ranges, increased body weights and advanced age and timing of reproduction. Therefore in the long-term supplementary feeding might increase rather then decrease bear-human conflicts (cf. Linnell *et al*. 1996). Providing carcasses in the Slovenian bear core conservation area (BCCA) in conjunction with a hunting quota did not stop outward dispersal at an average rate of 2km/year (Jerina and Adamic 2002). Damage caused by bears in newly occupied areas, with <20% of the total estimated bear population, accounted for >70% of compensation payments; 5-6% of all bears in the Slovenian Alps caused c.67% of reported damages (Klenzendorf and Vaughan 1999, Jonozovic and Adamic 2002).

Opinions differ as to the influence of supplementary feeding on bears at the individual level. Herrero (1970, 1985, 2002) found a high injury rate attributable to brown (grizzly) bears that had learned to associate human presence and odours with food. Discussing feeding stations in remote locations normally closed to the public, Kaczensky (1996) and Swenson *et al*. (2000) thought that bears habituated to human odours only at the sites themselves and remained wary elsewhere. Hunting advocates in Slovakia (P. Hell pers. comm. to K. Baleková 2002) strongly deny that supplementary feeding can lead to nuisance behaviour and have called for it to be increased, including by the provision of carcasses (e.g. Hell 2003). However, supplementary feeding with carcasses is believed to have increased the aggressiveness of bears towards humans in Slovenia (Jonozovic and Adamic 2002). Adamič (2003) presented data showing significantly more "pronounced aggressiveness", "hanging around settlements" and "aggressive food seeking" behaviour by bears in the BCCA where year-round supplementary feeding was routine compared to those in areas where it was not normally conducted.

In the present study a large proportion of bear scats collected contained maize, oats or apples that had been consumed at hunters' feeding stations in early spring and again from September to a peak in November. Feeding stations specifically for bears were seen <100 metres from marked tourist paths, at locations which required bears to cross public roads in order to reach them as well as within National Nature Reserves, a designation intended to preserve habitats in a condition minimally influenced by human activity. In June of 2002 and 2003 bears fed on maize, apples and cereals left within 1.5km of one of the largest and busiest concentrations of hotels and recreational cottages in the Nízke Tatry. A nuisance bear that had injured six people was shot at a tourist facility 5km from this site on 17/8/02. Furthermore, bears fed on supplementary food provided by hunters for ungulates at many additional locations, some of them even less appropriate. For example, in February-March 2003 at least one bear was attracted to oats at a feeding station in the Západné Tatry, from where it proceeded to investigate several weekend cottages in the immediate surroundings. A popular cross-country skiing and hiking route passed though the area within 200 metres of the feeding station.

Competition with human hunters

In the present study wild ungulates were shown to form a small portion of bear diet, some of it presumably obtained by scavenging. The brown bear is a relatively unsuccessful hunter (reviewed in Herrero 1985, Swenson *et al*. 2000). Only 78 (1.4%) of 5,626 recorded large ungulate deaths in the original TANAP during the period 1954-91 were attributed to bear predation (Kováč 1984, 2003). Competition with human hunters for game is not a major source of conflict in Slovakia (Wechselberger *et al*. in prep.). Bears cause some damage to ungulate feeders and food stores (pers. obs. 2001-03, Kráľ 2001, Ľ. Remeník pers. comm 2002, J. Ciberej pers. comm. 2002). Human injuries have resulted when hunters mistakenly shot bears instead of wild boar (*Sus scrofa*) during drive hunts (Baláž 2003, Hell 2003). Captive wild boar were allegedly attacked by a bear in Nízke Tatry National Park during the course of the present study (S. Ondruš pers. comm. 2003). There have been some complaints of game being frightened away or becoming more wary in areas recently resettled by bears (I. Šuba pers. comm. 2003).

Bear hunting

As implicit in the above review, much of the conflict concerning bears in Slovakia is human-human, rather than bear-human and largely centres around a value judgement of whether or not bears should be hunted commercially. Until the advent of National Parks, an Environment Ministry and the State Nature Conservancy, wildlife management in Slovakia was largely dominated by forester-hunters whose aim was to restore or preserve game populations for human exploitation. This philosophy is still very prominent (Salvatori *et al*. 2002), despite the emergence in human society as a whole of environmental awareness and ethical considerations regarding wildlife and its conservation (see Mech 1995a, 1996, Sharpe *et al*. 2001). The functioning of National Parks as refuges for wildlife, free from human exploitation, apparently enjoys substantial support among local residents (Wechselberger *et al*. in prep.) but has so far been obstructed by special interest groups, particularly forestry and agricultural companies or collectives, hunters, and developers. The public is poorly informed on issues of wildlife conservation and management in Slovakia (Wechselberger *et al*. in prep.), where democracy and public participation are still in their infancy (cf. Švajda 2002, Vančura 2002, Sharpe *et al*. 2001, Boitani 2003). Instances of nuisance behaviour by bears have been seized upon by both hunters and environmentalists alike as opportunities to blame their opponents, resulting in a highly polarised discussion (see Rigg and Baleková 2003). Almost no scientific research has been done on bears besides analyses of harvest results (Kassa 2003) and so managers have little information on which to base management plans or develop strategies to resolve conflicts. What few data are available have been supplemented with a great deal of conjecture while being used and abused to advocate for or against hunting (cf. Hlásnik 2002a, Hell 2003 versus Baláž 2003). The prioritising of bear hunting in areas of high bear-human conflicts, although intended to reduce such conflicts by eliminating problem bears and/or reducing population density locally (Kassa 2003), actually seems to be aggravating bear-human conflicts as hunters collect "evidence" of bear "over-population" to justify their applications for hunting permits. This may give the impression to fearful local residents that all damage or nuisance behaviour by bears can be explained in terms of excessive numbers of bears and solved by decreasing restrictions on hunting (see Wechselberger et al. in prep.).

Wolves

Damage to livestock

The results of the present study have confirmed that domesticated animals are not an important dietary item for wolves in Slovakia, even in regions with some of the highest levels of reported losses (Chapter 3). Nevertheless predation on livestock is frequently cited as evidence that wolves are "over-populated" (see Rigg 2001b, 2002a,b, Wechselberger *et al*. in prep.), is given disproportionate media coverage (Rigg 2001b, 2002a,b, 2003b,c) and is part of the justification for the population control of both wolves and bears (Kassa 2003) for which the Slovak Republic made a reservation from the Bern Convention (Council of Europe 2002:40, Urban 2002). Predation by wolves on livestock seems to cause considerably more damage than that by bears. However, the economic cost has no significant impact on Slovakia's livestock industry and is of genuine concern only to a small minority of farms (Chapter 3). Since 1/1/03 the state has been legally obliged to pay compensation for damage accepted as having been caused by protected species including wolves if, at the time of the attack, livestock was within a building or an electric fence or was under the direct watch of a person or sheepdog (*Canis lupus familiaris*), which is usually the case (Chapter 3). There are initiatives to assist farmers with non-lethal methods of livestock protection (Chapter 4) and legal provisions allow exceptions to be issued for the killing of predators believed to be responsible for repeated damage at the same or neighbouring locations (Kassa 2003). This 3-stage system of implementing preventive measures, paying compensation for losses and occasionally removing problem individuals was described by Boitani (2003b:335) as "the most rational and effective approach" to limiting conflicts over predation on livestock. Slovakia's open season on wolves from 1st November to 15th January, with no hunting quota, therefore no longer seems justifiable on the basis of reducing livestock losses.

Boitani (1995, 2003a) noted that conflicts over predation on livestock are influenced more by human attitudes than levels of losses. He noted that in Italy local people were more tolerant of losses where wolves had always been present. Wolves were almost entirely eradicated from Slovakia 30 years ago and recovered relatively recently (Voskár 1976, 1993, Find'o 1995, Hell *et al*. 2001). Many older shepherds and other local residents readily refer to times they remember when wolves and bears were scarce (Rigg 2003c, Wechselberger *et al*. in prep.). Agriculture has changed considerably since carnivores were last numerous. Many modern shepherds are inexperienced with carnivores and the use of preventive measures (Chapter 3). On the other hand, sheep are far less numerous in carnivore range and tend to be in less vulnerable locations than in the past due to socio-economic changes and the exclusion of grazing from many pastures in National Parks (Chapter 3). Perhaps tolerance and acceptance of co-existence will increase over time and with education.

Human injury

Very few incidents have been documented in Slovakia of wolves injuring humans. They have been of two types: people attacked at random by unwary, rabid wolves and shepherds bitten by wolves that they had attacked in defence of their stock. No predaceous attacks by wolves on humans were confirmed during the 20th century, although there may have been such cases in the past (Teren 1987, Hell *et al*. 2001a, Linnell *et al*. 2002b). Nevertheless many people fear wolves and believe them to be a threat to human life (Wechselberger *et al*. in prep.). Such perceptions are more culturally derived than factually based (Lopez 1978, Boitani 1995, 2003b, Linnell *et al*. 2002b, Fritts *et al*. 2003) but are likely to influence the level of support for conservation measures necessary for wolf survival (Rigg 2003b).

Competition with human hunters

Probably the most intractable wolf-human conflict in Slovakia is that of inter-specific competition for prey, particularly red deer. The results of the present study confirm that game species (cervids and wild boar) form the majority of wolf diet in Slovakia. The perception of wolves as vermin and competitors for human hunters lay behind the intense persecution that almost eradicated wolves from Slovakia in the early 20th century and again in the early 1970s (Voskár 1976, 1993, Hell *et al*. 2001a). Since the most recent recovery of wolves in Slovakia, an extensive network of protected areas has been established across much of the current range (Konôpka 1994, Kramárik 1995) and there are now several legal restrictions placed on hunting (Salvatori *et al*. 2002). However, hunting management is almost as widespread within National Parks as outside them and conflict over wolves killing economically valuable game animals is equally high (see Mráz 1996a). At the turn of the 21st century unlimited numbers of wolves could still be shot in almost all National Parks in Slovakia, the main motivation for which was apparently perception of the wolf as a competitor (see Mráz 1996a, Hlásnik 2002a, Kováčiková 2003, Wechselberger *et al*. in prep.). Lethal control seems to be regarded by hunters and managers as the essential reduction of vermin that damages game either belonging to them or under their care (e.g. Hlásnik 2002a, pers. comm. 2004, D. Kováč pers. comm. 2002, I. Šuba pers. comm. 2003, Jurík 2004, cf. Boitani 2000b), rather than a management decision to control predator populations in order to increase populations of wild animals for human hunters, the morality of which could and, in a democracy, should be subject to informed public discussion (cf. Theberge and Gauthier 1985, Boitani 1995, National Research Council 1997, Fritts *et al*. 2003, Herrero 2003). There have even been calls for state funds to be used to compensate hunters for free-living wild animals killed by carnivores (e.g. Hlásnik 2002a), an idea partly implemented in Act No. 543/2002 on Nature and Landscape Protection, valid from 1/1/03.

In the highly polarised dispute between advocates of hunting versus those of protection, science is often ignored in favour of simple rhetoric. Many assumptions are made but few are tested against research results. Good quality scientific research on wolf-prey relations is in any case almost completely lacking in Slovakia and the flow of new techniques and results from abroad has been slow due to political, financial and lingual barriers. The complexities of predator-prey theory and the range of factors, some obvious but many more subtle, that influence predator numbers/densities, prey numbers/densities and their interactions (see reviews in Mech 1970, 1995b, Theberge and Gauthier 1985, Johnson 1996, Reynolds and Tapper 1996, Strickland et al. 1996, Mech and Peterson 2003) have been largely ignored.

Hunters and game managers tend to take the view that every animal killed by wolves is one less for human hunters, although (Boitani 2000b) has stated that predation is normally largely compensatory, contributing to overall density-dependent mortality factors. Several workers have noted that many ungulates killed or scavenged by wolves in Slovakia during open hunting seasons were those shot but not recovered by hunters (Voskár 1993, Lukáč in prep., Finďo *et al*. unpub.). Whilst Mech (1996) concluded that generally when predators are removed from ecosystems there is an increase in their prey, wolf control has not always increased prey populations (National Research Council 1997). Theberge and Gauthier (1985) modelled the dynamics of theoretical ungulate populations under different nutritional-climatic conditions and concluded that in many situations removing predators (wolves) would result in increased mortality of ungulates due to other factors. Every predator-prey system has unique characteristics that determine the effect of predation on prey populations, of prey availability on predator populations and of other factors on both (Mech and Peterson 2003).

Possible long-term benefits of wolf presence to prey populations and ecosystems, such as the selective removal of weak individuals (Mech 1970, Voskár 1993, Mech and Peterson 2003 but cf. Mech 1995b), are largely not understood, are not acknowledged or are denied by Slovak hunters and game managers (e.g. Mráz 1996a, Hlásnik 2002a). Predation rates on game may to some extent be inadvertently increased by hunters, such as by the routine removal of wolf-killed ungulates that have not been completely consumed (Voskár 1993, pers. obs. 2001-03). Ungulates concentrating at feeders in winter are vulnerable to predation and possible surplus killing, particularly in deep snow (Voskár 1993, Mech and Peterson 2003; see also Mráz 1996a). The constant fluctuation of wolf numbers and range caused by high hunting pressure may not allow prey animals to adapt their behaviour to the presence of wolves (see Mech and Peterson 2003).

Whilst little research has been done on wolf-prey relations in Slovakia, a wealth of data has been gathered elsewhere. Indeed, the wolf has been one of the most studied of all wild species (Mech 1995b). Notwithstanding this, many basic principles of wolf ecology and predator-prey dynamics are poorly understood and important details continue to be the subject of considerable debate (see reviews in Mech 1970, 1995b, Mech and Peterson 2003). Unsettled questions include the extent to which wolf predation is additive rather than compensatory, the degree to which wolves regulate prey populations and how other factors predispose prey to predation (Mech 1995b). As noted by Mech (1995b), even when data is gathered objectively, the same results may be interpreted variously by individuals with different basic outlooks.

Predation on threatened species

Many hunters and game managers (e.g. Hlásnik 2002b, Klein 2002) but also some National Park zoologists (Kováč 1996a,c, Radúch 2002a,b,c, 2004) and rangers (e.g. Ballo 2002a,b) have called for increased lethal control of wolves and lynx as well as reduction of efforts to protect golden eagles (*Aquila chrysaetos*), claiming predators to be responsible for a major decline in numbers of the critically endangered Tatra chamois (*Rupicapra rupicapra tatrica*). Alternatively, it has been claimed that, after hunters and poachers reduced deer populations, some wolves and lynx became "specialised" on chamois (Janiga and Hrkľová 2002, Radúch 2003a, Adamec 2003). Kováč (1996c) and Radúch (2003a) have argued that inter-specific competition from wolves has forced lynx to higher elevations where they predate more frequently on chamois. On the basis of such opinions, ministerial permission has been given to remove 4-5 lynx from Tatranský National Park by trapping and shooting (Hoholíková 2001b, Radúch 2002b). Hell *et al*. (1996) presented data indicating that wolf-lynx competition was low in Slovakia and that neither limited numbers of roe deer. Wolf predation on chamois was considered minimal in 1956-62 (Chudík 1974), in 1976-83 (Brtek and Voskár 1985, 1987, Voskár 1993), in 1992-99 (Strnádová 2002) and in 2001-03 (present study).

Evidence for the impact of predators on chamois has relied on scat analysis (Janiga and Hrkľová 2002), which cannot distinguish between predation and scavenging, correlation analyses (Chovancová 2001b), which do not imply causation, and anecdotal reports of predators seen in alpine and sub-alpine habitats (e.g. Ballo 2002a, Radúch 2002b), which has been commonly observed in other mountain ranges without Tatra chamois (e.g. pers. obs. 2001-03, J. Topercer pers. comm. 2001, E. Baláž pers. comm. 2004). Hell and Slamečka (1996) noted that Alpine chamois (*R. rupicapra rupicapra*) introduced to Veľká Fatra and Slovenský raj, where they occupy lower altitudes in forest habitats, are more vulnerable to predation pressure but have prospered. Predator control was nevertheless being advocated (e.g. Kováč 1996) before any systematic investigation had been conducted on the reason(s) for the chamois population decline and was included in the first project proposal drafted in 1997 for chamois protection in Tatranský National Park (Radúch 2002c). The ultimate reason(s) is(are) still not clear after 3.5 years of monitoring and research by the Tatra Chamois Rescue Programme. The available evidence, sometimes presented by the same authors that have blamed carnivores (e.g. Radúch 2004), suggests that climate change (Luczy 2004), in particular deep snow and strong winds in May (Chovancová and Gömöry 1999), and cessation of livestock grazing in alpine areas (Janiga and Zámečniková 2002) are likely to have had a greater impact on chamois numbers than has predation pressure. Poaching and disturbance by other human activities (Hell and Slamečka 1996, Gašinec 2002, Ondruš 2002) may have also been significant. Two population bottlenecks caused by over-hunting during the First and Second World Wars could have led to genetic problems such as loss of heterozygosity due to founder effects and genetic drifts, as well as inbreeding depression due to the spread of deleterious alleles (Schoenwald-Cox *et al*. 1983 cited in Scott *et al*. 1996). Low genetic diversity has been reported for chamois in the High

Tatras (Martínková unpub. data) and Kováč (1996) noted that natality had been generally low in the 1980s and 1990s. Evidence of heavy metal pollution has also been suggested as a contributing factor (Chovancová 2001a, M. Janiga pers. comm. 2003-04). According to Scott *et al*. (1996), in such circumstances any means to increase reproductive success, including the reduction of proximate causes such as predation, is desirable to shorten the endangered phase and accelerate the recovery phase. By 2003 chamois numbers had apparently begun to increase despite a failure to kill or capture any lynx, primarily due to high natality (Radúch 2004, Rigg unpub. data 2001-04).

During the present study it seemed that wolves with territories partly within the Tatranský and Nízke Tatry National Parks made more use of upper montane, sub-alpine and alpine habitats, where Tatra chamois occurred, in spring and summer. However, no evidence of successful predation on chamois was recorded. Instead, wolves continued to feed on red and roe deer, which were also observed to move to higher localities in the Nízke and Západné Tatry in May-June and subsequent warm summer months. Other potential prey were observed in chamois range frequented by wolves: wild boar were seen with young in the sub-alpine zone in June and brown hares (*Lepus europaeus*), identified as an occasional food item of wolves by other studies in Slovakia (Find'o 2002a, Janiga and Hrkľová 2002), were present in the alpine zone along with marmots (*Marmota marmota*). Although wolves, like bears, scavenge on chamois killed in avalanches and perhaps, like lynx and golden eagles, occasionally prey on them, particularly in late winter and spring (see Ondruš 2002, Radúch 2002b, Chovancová 2004), there was no indication that predation pressure was preventing chamois population recovery. Natality in both chamois populations increased during the period of study (Rigg unpub. data 2001-04, Ondruš 2002, Radúch 2004).

Wolf hunting

The issue of wolf hunting, like that of bear hunting, has also become a highly polarised human-human conflict between advocates for and against. The wolf is a prized trophy in Slovakia. However, unlike in the case of the bear it is not usually hunted for its commercial value but rather, besides as an affirmation of prowess and masculinity (cf. Mech 1970:338), to remove what is commonly perceived as a competitor (Voskár 1976, 1993; see also Hlásnik 2002a). Legal restrictions on hunting allowed the population in Slovakia to recover from the previous human-caused low in the early 1970s but hunting pressure is still very intense. Wolf population density seems to be lower in Slovakia than in any other country with a major portion of the Carpathian Mountains (Salvatori *et al*. 2002) and was the only Carpathian country in which the wolf population was reported to have declined in the period 1990-99 (Okarma *et al*. 2000), yet there is strong lobbying to increase hunting (e.g. Hlásnik 2002a, Krajniak 2003). Arguments are advanced that wolves should be managed (i.e. hunted) like other game animals in order to control their numbers, "maintain balance" and "give other species a chance" (Hlásnik 2002a, Zajaz in Kováčiková 2003, M. Lehocký pers. comm. 2004), ignoring the fact that ungulates are intensively fed supplementary food whereas wolves are given no such assistance. The resistance of hunters to wolf conservation has apparently been aggravated by demands from environmentalists and animal rights activists for full year-round protection throughout the country (pers. obs. 2001-04; see also Finďo 1998, Huber 2000, Hell *et al*. 2001, Śmietana 2002, Kováčiková 2003). Conversely, as the hunting of ungulates is currently permitted in all Slovakia's National Parks and of wolves in most of them, and there are no quotas on the number or age classes of wolves that can be killed inside or outside Parks, wolves persist in Slovakia largely due to the ban on trapping, poisoning and removing pups from dens, a long closed season, their high reproductive potential and possibly also due to dispersal from Poland and the Ukraine (Voskár 1993, Finďo 1995).

Researchers elsewhere have concluded that some lethal control is inevitable to restrict the dispersal of wolves into areas of high human use (Mech 1996, 2001) and to placate hunters and livestock breeders (Hell and Slamečka 2000; see also Boitani 2000b, 2003). Wolf populations can sustain high harvest levels (Fuller *et al*. 2002). However, to many people it would seem unreasonable to allow unlimited numbers of a protected native species to be shot in National Parks in order to reduce its predation on common native prey species for the benefit of a special interest group. The public is in favour of managing National Parks as refuges for wildlife, not as hunting grounds (Wechselberger *et al*. in prep.). Unfortunately, large portions of National Parks are not in state ownership (Stockmann 2001). Zoning of management has been recommended as a means to segregate carnivores and human interests (Mech 1995a, Kaczensky 1996, 1999, Linnell *et al*. 1996, 2002a, Baláž 2003, Fritts *et al*. 2003). The situation in Slovakia is complicated by multi-use landscapes, but Linnell *et al*. (2001b) concluded that both carnivores and their prey can be hunted and yet persist at high human densities given favourable management policy. The Council of Europe's "Action plan for the conservation of wolves in Europe" (Boitani 2000b) recommended the establishment of planned wolf management including clear population goals. It stated that hunting of wolves as currently practiced in Slovakia, "without any real control, any bag limit … will be no longer acceptable and wolf hunting must be brought within the limit of any biologically sound harvest scheme". In response, an expert commission was established to draft national management plans for large carnivores in Slovakia, but initially at least its progress was greatly hindered by the division of its members along the lines of hunting advocates versus full protection advocates (J. Lukáč pers. comm. 2001-03; see also Hell 2003).

SUMMARY

- Carnivore-human conflicts were assessed on the bases of a literature review, informal interviews with hunters, conservationists and wildlife managers as well as the results of a questionnaire survey on public opinion, knowledge and attitudes.

- Predation on livestock seemed to be of little economic importance and was more a problem in perception than in reality. Although it was often cited in support of the need for increased hunting of large carnivores, it was of less concern in this respect than other issues such as instances of nuisance bears and predation by wolves on valued game species.

- Hunting did not necessarily appear to be the most immediate threat to bears, although it was evidently a major cause of wolf mortality.

- Human hunters often regarded wolves as competitors for game, while at the same time wolves and bears were valued trophies, and feared by many.

- These issues were inter-linked with that of predation on livestock, complicating initiatives to resolve grievances over losses.

- As carnivores in Slovakia exist in multi-use landscapes and there are only a few small, diminishing areas relatively free of human influence, conflicts with humans could have important consequences for carnivore survival in the medium to long term.

- Indiscriminate lethal control of wolves would seem unlikely to succeed in reducing reported damage to livestock without threatening the maintenance of a viable population. On the other hand, although lethal control targeted at "problem" individuals may lead to a temporary reduction of losses, if the locality or farm practices remain unchanged, predation would be expected to resume within a few years.

Chapter 6

Summary of results and implications for the conservation and management of large carnivores in Slovakia

In order to assess the overall implications of the research results, a series of questions were considered:–

Can using free-ranging sheep socialised LGDs in Slovakia:

(1) Reduce losses to predation?
(2) Reduce human-carnivore conflicts?
(3) Reduce hostility to large carnivores?
(4) Reduce legal and illegal killing of carnivores?
(5) Contribute to large carnivore conservation in Slovakia in the long term?

From the results of the present research, the following conclusions were drawn in response to the questions posed:–

Livestock guarding dogs

- Slovenský čuvače and Caucasian shepherd dogs in Slovakia retain traits desirable for livestock guarding dogs. Almost all the dogs tested seemed capable of becoming effective guardians.
- The presence of LGDs alone did not necessarily deter predators or stop all losses, but the mean and maximum reported losses at flocks with one or more free-ranging LGDs were significantly lower than those at other flocks in the same regions.
- There was some anecdotal evidence for differences between breeds. Caucasian shepherd dogs were perhaps more likely than Slovenský čuvače to exhibit aggressive protective behaviour which may make them more effective at repelling determined predators. However, they suffered more from heat and caused more initial disturbance to flocks. The Slovenský čuvač might be a better choice where there are concerns about dog-human encounters.

- The environments in which dogs were raised had an important influence on the development of attentive and trustworthy behaviour patterns and in some cases were the limiting factor in the outcome of integrating LGDs into flocks. The likelihood of dogs becoming successful guardians can probably be increased by careful consideration of the time of year and location in which they are raised.
- A successful outcome was not guaranteed by bonding pups to livestock. Shepherds' concerns about sub-adult dogs disrupting flocks with over-attentive behaviour often led to dogs being removed from contact with sheep. This tended to discourage attentiveness and aggravated problems of untrustworthy behaviour, in some cases leading to dogs that would probably have become good guardians being permanently excluded from flocks. The attitudes of shepherds were therefore of key importance in the success or failure of established free-ranging, sheep socialised LGDs.
- Many farmers and shepherds were reluctant to undertake extra work in order to implement more effective preventive measures against predators, even where high losses had been reported. Strengthening the link between compensation payments and the implementation of effective preventive measures might be helpful in this regard.
- Several external factors hindered revitalizing the proper use of LGDs, including dogs being shot by hunters, encounters with walkers and farm visitors and socio-economic changes both within the livestock industry and on a broader scale.

Bear and wolf predation on livestock

- No remains of livestock were found in any of 373 bear and 70 wolf scats collected in the Tatra and Fatra Mountains from March to November 2001-03. As some of the highest levels of losses to carnivores are from farms within or near these regions, it can be concluded that livestock does not form a significant component of bear or wolf diet in Slovakia.
- Overall, 48.0% of flocks surveyed (n=127) were not affected by wolf or bear predation at all during the period 2001-03.
- In each year, ≤ 14.0% and ≤ 29.4% of surveyed flocks were allegedly affected by bear and wolf predation respectively.

- Some regions with carnivores had no reported losses while in other regions up to 82% of flocks were affected by predation in any one year, with a mean across all surveyed regions and all three years of 24.1%.
- Particularly in the case of wolves, one farm suffering substantial losses to its various flocks (in single surplus killing events or as a result of multiple attacks) could account for up to a third of total losses in a particular year at all surveyed farms combined.
- The distribution of reported losses was not adequately explained by estimates of the numbers of carnivores, particularly of bears. Very high losses were generally associated with poor husbandry and/or inadequate preventive measures.
- According to the reports of shepherds and farmers, 87.0% of attacks by bears and 70.1% of attacks by wolves resulted in 0-3 sheep being lost.
- Losses to wolves seemed to be considerably higher than those to bears. Wolves were often reported to attack during the day as well as at night. The main peak of losses to both bears and wolves was in August-September (October) but attacks in May were also reported to result in substantial losses. Various factors appeared to increase the vulnerability of flocks and predispose them to attack.

Carnivore-livestock conflicts

- There is a substantial psychological, social and perhaps also political element to the carnivore-livestock conflict. Damage is perceived to be more serious than the economic losses would appear to warrant (reports implied that 0.5-0.9% of all sheep in regions with bears and/or wolves were lost to predators annually).
- The conflict is only one of several involving large carnivores in Slovakia which are to some extent inter-linked, complicating initiatives to resolve grievances.
- In a survey of public opinions, shepherds and farmers were found to hold the most negative attitudes towards large carnivores of any occupational group considered. In general, hunters tended to hold much more positive attitudes and were in favour of limited numbers of carnivores being maintained in Slovakia, but they were motivated to hunt bears and wolves by a variety of reasons besides reduction of livestock depredations and other nuisance behaviour. Data that might allow a carefully regulated sustainable harvest were lacking.

References

Adamec M. (2003). Rozšírenie, stav a ochrana vlka (*Canis lupus*) a rysa (*Lynx Lynx*) na Slovensku. In: *Vlky a rysy v oblasti slovensko-maďarských hraníc.* (*Wolves and lynx in the Slovak-Hungarian border region.*) Gadó G.P. and Pačenovský S. eds. WWF Maďarsko, Budapest: 30-34. (in Slovak.)

Adamič M. (1997). The expanding brown bear population of Slovenia: a chance for bear recovery in the southeastern Alps. *Int. Conf. Bear Res. and Manage*. **9(2)**: 25-29.

Adamic M. (2000). Recovery of Western Dinaric population of the wolf (*Canis lupus*) in the period 1991-1998: 8 years monitoring in Wildlife Reserve Sneznik, Slovenia. In: *Beyond 2000 Realities of Global Wolf Restoration. Program and abstracts*. International Wolf Center, Ely, Minnesota: 47.

Adamič M. (2003). The brown bear in Slovenia: a brief summary of the 20th century population dynamics and future conservation issues. In: *Living with bears: a large carnivore in a shrinking world*. Kryštufek B., Flajšman B. and Griffiths H.I. eds. Ecological Forum LDS, Ljubljana: 157-171.

Álvares F. and Petrucci-Fonseca F. (2000). Implications of free-grazing cattle on wolf (*Canis lupus*) conservation in Portugal. In: *Beyond 2000 Realities of Global Wolf Restoration. Program and abstracts.* International Wolf Center, Ely, Minnesota: 28.

Andelt W.F. (1992). Effectiveness of livestock guarding dogs for reducing predation on domestic sheep. *Wildl. Soc. Bull.* **20**: 55-62.

Andelt W.F. (1999). Relative effectiveness of guarding-dog breeds to deter predation on domestic sheep in Colorado. *Wildl. Soc. Bull*. **27(2)**: 706-714.

Andelt W.F. and Hopper S.N. (2000). Livestock guard dogs reduce predation on domestic sheep in Colorado. *J. Range Manage.* **52(3)**: 259-267.

Anderson S.H. and Gutzwiller K.J. (1996). Habitat evaluation methods. In: *Research and management techniques for wildlife and habitats*. 5th ed., rev. Bookhout T.A. ed. The Wildlife Society, Bethseda, Md.: 592-606.

Andersone Ž. (2002). *The wolf* (Canis lupus *L., 1758*) *in Latvia: status, demography, morphometry, trophic ecology and genetics in relation to current management practices.* Doctoral thesis. Latvijas Universitate, Riga. 75 pp.

Angst C., Landry J.-M., Linnell J. and Breitenmoser U. eds. (2002). *Carnivore Damage Prevention News* **5**: 1-20.

Arons C. (1980). Raising livestock guarding dogs. *Sheep Canada* **5(3)**: 5-7.

Arons C. (1989). *Genetic variability within a species: differences in behavior, development, and neurochemistry among three types of domestic dogs and their F1 hybrids*. PhD thesis. University of Connecticut, Storrs, Connecticut.

Bakeless J. ed. (1964). *The journals of Lewis and Clark*. Mentor, New York. 384 pp.

Baker T.L. (1988). *Doing social research*. McGraw-Hill, Singapore. 483 pp.

Baláž E. (2002). *Ekológia medveďa hnedého* (Ursus arctos *L.*) *v Západných Tatrách a na Poľane*. *(The ecology of the brown bear* (Ursus arctos *L.*) *in the Western Tatras and in Poľana.)* Masters thesis. Technická univerzita vo Zvolene. 55 pp. (in Slovak.)

Baláž E. (2003). Options for preventing the arising of nuisance brown bear individuals. In: *The integrated solution to the problem of nuisance bears* (Ursus arctos). Rigg R. and Baleková K. eds. Conference proceedings, Nová Sedlica, Slovakia 11-12.4.2002: 7-16.

Balharry D. (1993). *Factors affecting the distribution and population density of pine martens* (Martes martes *L.*) *in Scotland*. PhD thesis. University of Aberdeen. 139 pp.

Bališ M. (1969). Veľké šelmy a párnokopytníci v TANAP-e. (Large carnivores and ungulates in TANAP.) *Ochrana přírody* **24(6)**: 157-161. (in Slovak.)

Bališ M. (1970). (Are the large carnivores a real threat to game?) *Poľovníctvo a rybárstvo* **22(6)**: 9-10. (in Slovak.)

Bališ M. and Chudík I. (1976). Účasť rysa ostrovida (*Lynx lynx* L.) na stratách divožijúcich párnokopytníkov v Tatranskom národnom parku. (The share of the Eurasian lynx (*Lynx lynx* L.) in losses of free-living ungulates in the Tatras National Park.) *Zborník prác o Tatranskom národnom parku* **18**: 66-79. (in Slovak.)

Ballo M. (2002a). Moje praktické skúsenosti z terénneho monitoringu tatranských kamzíkov. (My practical experiences from the field monitoring of the Tatra Chamois) In: *Ochrana kamzika*. (*Chamois protection*) Janiga M. and Švajda J. eds. TANAP, NAPANT, IHAB: 40-44. (in Slovak with English abstract.)

Ballo M. (2002b). Neznásilňujme prírodu. (Let's not violate nature.). *Ochrana prírody Slovenska* **2002(3)**: 23. (in Slovak.)

Bang P. and Dahlstrøm P. (2001). *Animal tracks and signs*. Oxford University Press, Oxford. 264 pp.

Bangs E. and Shivik J. (2001). Managing wolf conflict with livestock in the Northwestern United States. *Carnivore Damage Prevention News* **3**: 2-5.

Bangs E.E., Fritts S.H., Harms D.R., Fontaine J.A., Jimenez M.D., Brewster W.G. Niemeyer C.C. (1995). Control of endangered wolves in Montana. In: *Ecology and conservation of wolves in a changing world*. Carbyn L.N., Fritts S.H. and Seip D.R. eds. Proceedings of the Second North American Symposium on Wolves. Edmonton, Alberta. 1992: 127-134.

Bangs E.E., Fritts S.H., Fontaine J.A., Smith D.W., Murphy K.M., Mack C.M. and Niemeyer C.C. (1998). Status of gray wolf restoration in Montana, Idaho and Wyoming. *Wildl. Soc. Bull.* **26**: 785-798.

Bangs E.E., Oakleaf J. and Bradley L. (2002). Management of wolf-human conflict in the northwestern United States. In: *People and wildlife: conflict or coexistence?* Abstracts of The Zoological Society of London and Wildlife Conservation Society symposium, London.

Bangs E.E., Fontaine J.A., Jimenez M.D., Meier T.J., Niemeyer C.C., Smith D.W., Mack C.M. and Asher V. (2003). Restoration of the gray wolf in the northwestern

United States. In: *World Wolf Congress 2003 Bridging Science and Community.* Book of abstracts. Banff, Canada: 37.

Barja I. and Bárcena F. (2003). Temporal changes in trophic behavior by wolf in NW Spain. In: *World Wolf Congress 2003 Bridging Science and Community*. Book of abstracts. Banff, Canada: 65.

Barlík D., Duchaj J., Kurz V. and Malík V. (1977). *Slovenský čuvač*. (*Slovak čuvač*) Príroda, Bratislava. 209 pp. (in Slovak.)

Barlík D. (1992). *Plemenárska kniha slovenských (tatranských) čuvačov ročníky 1929 to 1992*. (*Pedigree book of the Slovenský (Tatranský) 1929-1992.*) Animapress, Bratislava. 209 pp (in Slovak.)

Bart J. and Notz W. (1996). Data analysis. In: *Research and management techniques for wildlife and habitats.* 5th ed., rev. Bookhout T.A. ed. The Wildlife Society, Bethseda, Md.: 24-74.

Bartošová D. (2001). Současný výskyt a ochrana rysa ostrovida, medvěda hnědého a vlka na západním okraji Západních Karpat v CHKO Beskydy. (Present occurrence and conservation of the Eurasian lynx, brown bear and wolf at the western edge of the Western Carpathians in Beskydy Protected Landscape Area.) *Chránené územia Slovenska* **47**: 14-17. (in Czech with English summary.)

Bartošová D. (2002). Rys ostrovid, medvěd hnědý a vlk v Beskydech. (Eurasian lynx, brown bear and wolf in the Beskydy.) In: *Výskum a ochrana cicavcov na Slovensku* **V**. Urban P. ed. Štátna ochrana prírody, Banská Bytrica: 57-67. (in Czech.)

Bartošová D. (2003). Experiences with the brown bear in Beskydy Protected Landscape Area. In: *The integrated solution to the problem of nuisance bears* (Ursus arctos). Rigg R. and Baleková K. eds. Conference proceedings, Nová Sedlica, Slovakia 11-12.4.2002: 41-51.

Bateson P. (1979). How do sensitive periods arise and what are they for? *Anim. Behav*. **27**: 470-486.

Bath A. and Farmer L. (2000). *Europe's carnivores: a survey of children's attitudes towards wolves, bears and otters*. WWF-UK, Godalming. 12 pp.

Bath A. and Majic A. (2003). Integrating a human dimensions approach to addressing wolf management issues in Europe. In: *World Wolf Congress 2003 Bridging Science and Community*. Book of abstracts. Banff, Canada: 28.

Bednar L. (2001). *Slovak tales for young and old: Pavol Dobšinský in English and Slovak*. Bolchazy-Carducci, Illinois and Kriváň, Bratislava. 136 pp.

Bekoff M. (1998). *Encyclopedia of animal rights and animal welfare*. Westport, CT: Greenwood Publishing Group.

Bekoff M. (2001). Human-carnivore interactions: adopting proactive strategies for complex problems. In: *Carnivore Conservation*. Gittleman J.L., Funk S.M., Macdonald D. and Wayne R.K. eds. Cambridge University Press, Cambridge: 179-195.

Beleš P. (2000). Mapovanie veľkých šeliem v CHKO Kysuce-Beskydy. (Mapping large carnivores in the Kysuce-Beskydy Protected Landscape Area.) *Enviromagazín* **5(1)**: 19. (in Slovak.)

Beťková S. and Rigg R. (2004). *Po stopách medveďov*. (*In the tracks of bears*.) Slovak Wildlife Society, Liptovský Hrádok. 26 pp. (in Slovak.)

Bevilaqua F. (1998). Ako zistiť početnosť medveďov? (How to determine the number of bears?) *Poľovníctvo a rybárstvo* **50(7)**: 11. (in Slovak.)

Beyer D.E., Hammill J.H., Johnson B.J., Lonsway D.H. and Roell B.J. (2003). Translocation of wolves associated with livestock depredation in a recovering population. In: *World Wolf Congress 2003 Bridging Science and Community*. Book of abstracts. Banff, Canada: 31.

Bibikov D.I. (1982). Wolf ecology and management in the USSR. In: *Wolves of the world*. Harrington F.H. and Paquet P.C. eds. Noyes Publications, New Jersey: 120-133.

Black H.L. (1981). Navajo sheep and goat guarding dogs: a New World solution to the coyote problem. *Rangelands* **3**: 235-237.

Black H.L. and Green J.S. (1985). Navajo use of mixed-breed dogs for management of predators. *Journal of range management* **38(1)**: 11-15.

Blanchard B.M. (1987). Size and growth patterns of the Yellowstone grizzly bear. *Int. Conf. Bear. Res. and Manage*. **7**: 99-107.

Blanco J.C. (1998). The extinction of the wolf in Spain: account of a scientific fraud. *Biologica* **26**: 56-59.

Blanco J.C. (2000a). Wolf recolonization of agricultural areas in Spain. In: *Beyond 2000 Realities of Global Wolf Restoration. Program and abstracts*. International Wolf Center, Ely, Minnesota: 26.

Blanco J.C. (2000b). Large carnivore damage in Spain. *Carnivore Damage Prevention News* **1**: 5-6.

Blanco J.C. and Cortés Y. (2000). Wolf recolonisation of agricultural areas in Spain. In: *Beyond 2000 Realities of Global Wolf Restoration. Program and abstracts*. International Wolf Center, Ely, Minnesota: 26.

Blanco J.C. and Cortes Y. (2003). Impact of two kinds of barriers on wolves in Spain. In: *World Wolf Congress 2003 Bridging Science and Community*. Book of abstracts. Banff, Canada: 66.

Blanco J.C., Reig S. and Cuesta L. (1992). Distribution, status and conservation problems of the wolf *Canis lupus* in Spain. *Biol. Cons*. **60**: 73-80.

Bloch G.E. (1995). *Renovation of livestock guarding dog-management in Slovakia and the use of livestock guarding dogs as defenders against wolves in southern Poland*. Unpublished report. Gesellschaft zum Schutz der Wölfe e.V., Germany. 7 pp.

Bloch G. and Finďo S. (1996). Wolf ecology and livestock guarding dogs in the Slovakian Carpathians. *European Wolf Newsletter* **3**.

Bohuš I. (2002). Poľovnícke pamätníky 1934-1947. (Hunting annuls 1934-1947.) *Tatry* **XLI(5)**: 16-17. (in Slovak.)

Boitani L. (1982). Wolf management in intensively used areas of Italy. In: *Wolves of the world*. Harrington F.H. and Paquet P.C. eds. Noyes Publications, New Jersey: 158-172.

Boitani L. (1995). Ecological and cultural diversities in the evolution of wolf-human relationships. In: *Ecology and conservation of wolves in a changing world*. Carbyn L.N., Fritts S.H. and Seip D.R. eds. Proceedings of the Second North American Symposium on Wolves. Edmonton, Alberta. 1992: 3-11.

Boitani L. (2000a). Wolves in Europe: broadening the scales of wolf conservation. In: *Beyond 2000 Realities of Global Wolf Restoration. Program and abstracts*. International Wolf Center, Ely, Minnesota: 62.

Boitani L. (2000b). *Action plan for the conservation of wolves in Europe* (Canis lupus). Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention), Nature and Environment No.113, Council of Europe Publishing, Strasbourg.

Boitani L. (2003a). How many wolves are enough? The wolf-human interface and the role of biology, ethics and politics. In: *World Wolf Congress 2003 Bridging Science and Community*. Book of abstracts. Banff, Canada: 19.

Boitani L. (2003b). Wolf conservation and recovery. In: *Wolves: behavior, ecology and conservation*. Mech D.L. and Boitani L. eds. The University of Chicago Press, Chicago and London: 317-340.

Boitani L. and Ciucci P. (1993). Wolves in Italy: critical issues for their conservation. In: *Wolves in Europe, status and perspectives*. Promberger C. and Schröder W. eds Workshop proceedings. Munich Wildlife Society, Oberammergau, Germany: 75-90.

Bologov V.V. and Miltner D. (2003). Wolf depredation on domestic dogs in Central part of European Russia. In: *World Wolf Congress 2003 Bridging Science and Community*. Book of abstracts. Banff, Canada: 39-40.

Boutin S. (1990). Food supplementation experiments with terrestrial vertebrates: patterns, problems and the future. *Canadian Journal of Zoology* **69**: 203-220.

Breinard S.M., Bangs E.E., Bradley E., Fontaine J., Hall W.H. Jr., Iliopoulos Y., Jiminez M., Joswiak E., Liberg O., Mack C., Meier T., Niemeyer C., Pedersen H.C., Sand H., Schultz R.N., Smith D.W., Wabakken P. and Wydeven A.P. (2003). The effects of alpha wolf loss on reproductive success and pack dynamics. In: *World Wolf Congress 2003 Bridging Science and Community*. Book of abstracts. Banff, Canada: 56.

Breitenmoser U. (1998). Large predators in the Alps: the fall and rise of man's competitors. *Biological Conservation* **83(3)**: 279-289.

Breitenmoser U., Breitenmoser-Würsten C.H., Okarma H., Kaphegyi T., Kaphygyi-Wallmann U. and Müller U.M. (2000). *Action plan for the conservation of the Eurasian lynx in Europe* (Lynx lynx). Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention), Nature and Environment No.112, Council of Europe Publishing, Strasbourg.

Breitenmoser U., Angst C., Weber J.M., Landry J.M., Linnell J. and Breitenmoser-Würsten C. (2002). Non-lethal techniques for reducing predation. In: *People and wildlife: conflict or coexistence?* Abstracts of The Zoological Society of London and Wildlife Conservation Society symposium, London.

Bright P.W. (1993). Habitat fragmentation – problems and predications for British mammals. *Mammal Rev.* **23(3/4):** 101-111.

Brtáň P. (2003). Komentár k poklesu populácie kamíčej zveri v Tanape. (Commentary on the decline of the chamois population in TANAP.) *Hubertlov* **VII(2)**: 10. (in Slovak.)

Brtek Ľ. (1997a). Čo lovia vlci. (What wolves hunt.) *Poľovníctvo a rybárstvo* **49(2)**: 4. (in Slovak.)

Brtek Ľ. (1997b). O stratégii lovu vlkov. (On the hunting strategy of wolves.) *Poľovníctvo a rybárstvo* **49(4)**: 6-7. (in Slovak.)

Brtek Ľ. and Voskár J. (1985). Potrava vlka v podmienkach slovenských Karpát. (The diet of the wolf in Slovak Carpathian conditions.) *Les* **41**: 126-129. (in Slovak.)

Brtek Ľ. and Voskár J. (1987). Potravná biológia vlka v podmienkach slovenských Karpát. (Feeding biology of the wolf in Slovak Carpathian conditions.) *Biológia* **42**: 985-990. (in Slovak.)

Budiansky S. (2001). *The truth about dogs*. Weidenfeld and Nicolson, London. 263 pp.

Burkholder B.L. (1959). Movements and behaviour of a wolf pack in Alaska. *J. Wildl. Mgmt*. **23**: 1-11.

Burkovský J. (1998). Virgin forests and the protection of biodiversity. *Enviromagazín* III(May extra issue): 29.

Camarra J.J. (1986). Changes in bear predation on livestock in the Western French Pyrenees from 1986 to 1979. *Int. Conf. Bear Res. and Manage*. **6**: 183-186.

Carbyn L. (1977). *Report on the Canadian Wildlife Service involvement in IUCN-WWF wolf project (1240) in Poland*. Report submitted to the International Union for Conservation of Nature and Natural Resources/Species Survival Commission Wolf Specialist Group. 44 pp.

Carbyn L. (1987). Gray wolf and red wolf. In: *Wild fur-bearer management and conservation in North America*. Novak M., Baker J.A., Obbard M.E. and Malloch B. eds. Ontario Ministry of Natural Resources, Toronto: 378-393.

Carrasco R., Azorit C., Calvo J. and Muñoz-Cobo J. (2003). Wolf predation on wild ungulates in southern Spain: a description of wolf attacks. In: *World Wolf Congress 2003 Bridging Science and Community*. Book of abstracts. Banff, Canada: 67.

Casulli A. (2003). Hunting practices increase the prevalence of *Trichinella* in wolves from North-West Russia. In: *World Wolf Congress 2003 Bridging Science and Community*. Book of abstracts. Banff, Canada: 68.

Červený J. and Koubek P. (2003). The brown bear in the Czech Republic. In: *Living with bears: a large carnivore in a shrinking world*. Kryštufek B., Flajšman B. and Griffiths H.I. eds. Ecological Forum LDS, Ljubljana: 244-257.

Červený J., Koubek P. and Luděk B. (2002). *Eurasian lynx* (Lynx lynx) *and its chances for survival in Central Europe*. URL: http://www.large-carnivores-lcie.org/cerveny.doc On Web January 2004

Cheben J. and Kováč D. (2002). *Škody spôsobené medveďmi v roku 2001 v okrese Liptovský Mikuláš.* (*Damage caused by bears in 2001 in Liptovský Mikuláš district.*) Summary report of the damage inspection commission. 1 pp. (in Slovak.)

Chovancová B. (2001a). Kamzík – objekt výskumu 5. časť. (The chamois – subject of research part 5.) *Tatry* **XL(1)**: 5. (in Slovak.)

Chovancová B. (2001b). Kamzík – objekt výskumu 7. časť. (The chamois – subject of research part 7.) *Tatry* **XL(3)**: 5. (in Slovak.)

Chovancová B. (2004). Stará kamzica dožila. (An old chamois died.) *Tatry* **XLIII(3)**: 20. (in Slovak.)

Chovancová B. and Gömöry D. (1999). Vplyv prírodných činiteľov na populáciu kamzíka vrchovského tatranského (*Rupicapra rupicapra tatrica*, Bl. 1971) v Tatranskom národnom parku (Influence of natural factors on the population of the Tatra Chamois (*Rupicapra rupicapra tatrica*, Bl. 1971) in the Tatras National Park.) *Folia Venatoria* **28-29**: 85-97. (in Slovak with English summary.)

Christiansen F. (2002). Preventive measures toward predator damages on sheep; herding and the use of livestock guarding dogs in Lierne community. In: *Living with bears. Information, program and abstracts from the 14th International Conference on Bear Research and Management*. Kvam T. and Sørenson O.J. eds. Nord-Trøndelag University College, Steinkjer, Norway: 88.

Chudík I. (1974). Príčiny strát a vplyvu veľkých šeliem (Carnivora) na populácie raticovej zveri v TANAP-e. (Causes of loss and the influence of large carnivores (Carnivora) on the populations of ungulates in TANAP.) *Folia Venatoria* **4**: 83-94. (in Slovak.)

Ciberej J. (1998). Poľovníci a ochrana prírody. (Hunters and nature conservation). *Poľovníctvo a rybárstvo* **50(2)**: 10-11. (in Slovak.)

Ciberej J. (2002). Ako obhospodarovať rysa na Slovensku v zmysle Akčných plánov pre ochranu veľkých šeliem v Európe. (How to manage the lynx in Slovakia in the meaning of the Action Plans for the conservation of large carnivores in Europe.) *Hubertlov* **VI(6)**: 6-8. (in Slovak.)

Cicnjak L., Huber D., Roth H.U., Ruff R.L. and Vinovrski Z. (1987). Food habits of brown bears in Plitvice Lakes National Park, Yugoslavia. *Int. Conf. Bear Res. and Manage*. **7**: 221-226.

Ciucci P., Boitani L., Pellicioni E.R., Massimiliano R. and Guy I. (1996). A comparison of scat analysis methods to assess the diet of the wolf *Canis lupus. Wildlife Biology* **2**: 37-48.

Ciucci P., Boitani L., Francisci F. and Andreoli G. (1997). Home range, activity and movements of a wolf pack in Central Italy. *Journal of Zoology* **243**: 803-819.

Clevenger A.P., Purroy F.J. and Pelton M.R. (1990). Movement and activity patterns of a European brown bear in the Cantabrian mountains, Spain. *Int. Conf. Bear Res. and Manage*. **8**: 205-211.

Clevenger A.P., Purroy F.J. and Pelton M.R. (1992). Food habits of brown bears (*Ursus arctos*) in the Cantabrian mountains, Spain. *J. Mamm*. **73(2)**: 415-421.

Clevenger A.P., Purroy F.J. and Campos M.A. (1997). Habitat assessment of a relict brown bear *Ursus arctos* population in northern Spain. *Biological Conservation* **80**: 17-22.

Cluff H.D. and Murray D.L. (1995). Review of wolf control methods in North America. In: *Ecology and conservation of wolves in a changing world*. Carbyn

L.N., Fritts S.H. and Seip D.R. eds. Proceedings of the Second North American Symposium on Wolves. Edmonton, Alberta. 1992: 491-504.

Clutton-Brock J. (1999). *A natural history of domesticated mammals*. 2nd ed. Cambridge University Press, Cambridge. 238 pp.

Coppinger L. (1992a). The workshop: getting through that juvenile period. *DogLog*. Livestock Guard Dog Association **2(3-4)**: 6-12.

Coppinger L. (1992b). Sheepdog environments in the Old World. *DogLog*. Livestock Guard Dog Association **2(3-4)**: 12-14.

Coppinger R. and Coppinger L. (1978). *Livestock guarding dogs*. Hampshire College, Amherst MA. 25 pp.

Coppinger R. and Coppinger L. (1987). *Increasing the effectiveness of livestock guarding dogs/reducing predation by wolves on livestock in Minnesota with livestock guarding dogs*. Year-end report to USDA/APHIS/ADC (grant award 12-16-72-007). Hampshire College, Amherst, Massachusetts. 27 pp.

Coppinger L. and Coppinger R. (1993). Dogs for herding and guarding livestock. In: *Livestock handling and transport*. Grandin T. ed. CAB International, Wallingford, Oxford: 179-196.

Coppinger R. and Coppinger L. (1994a). *The predicament of flock-guarding dogs in the Tatra mountains, Slovakia*. Hampshire College, Amherst MA. 7 pp.

Coppinger R. and Coppinger L. (1994b). *Draft proposal. Renovation of livestock guarding dog management in Slovakia.* Hampshire College, Amherst MA. 4 pp.

Coppinger R. and Coppinger L. (1995). Interactions between livestock and wolves. In: *Ecology and conservation of wolves in a changing world*. Carbyn L.N., Fritts S.H. and Seip D.R., eds. Proceedings of the Second North American Symposium on Wolves. Edmonton, Alberta. 1992: 523-526.

Coppinger R. and Coppinger L. (2001). Dogs: a startling new understanding of canine origin, behavior and evolution. Scribner, New York. 352 pp.

Coppinger R. and Schneider R. (1995). Evolution of working dogs. In: *The domestic dog: its evolution, behaviour and interactions with people*. Serpell J. ed. Cambridge University Press, Cambridge: 21-47.

Coppinger R.P. and Smith C.K. (1983). The domestication of evolution. *Environmental Conservation* **10(4)**: 283-292.

Coppinger R., Lorenz J., Glendinning J. and Pinardi P. (1983). Attentiveness of guarding dogs for reducing predation on domestic sheep. *J. Range Manage*. **36(3)**: 275-279.

Coppinger R.P., Smith C.K. and Miller L. (1985). Observations on why mongrels may make effective livestock protecting dogs. *J. Range Manage*. **38(6)**: 560-561.

Coppinger R., Glendinning J., Torop E., Matthay C., Sutherland M. and Smith C. (1987). Degree of behavioural neoteny differentiates canid polymorphs. *Ethology* **75**: 89-108.

Coppinger R., Coppinger L., Langeloh G., Gettler L. and Lorenz J. (1988). A decade of use of livestock guarding dogs. In: *Proc. Vertebr. Pest Conf.* Crabb A.C. and Marsh R.E. eds. University of Calif., Davis. **13**: 209-214.

Coppinger R., Ortolani A. and Lord K. (2003). The use of guardian dogs for controlling predation in peasant pastoral communities. In: *World Wolf Congress 2003 Bridging Science and Community*. Book of abstracts. Banff, Canada: 41.

Costello C.M., Jones D.E., Inman R.M., Inman K.H., Thompson B.C. and Quigley H.B. (2003). Relationship of variable mast production to American black bear reproductive parameters in New Mexico. *Ursus* **14**: 1-16.

Council of Europe (2002). *Convention on the conservation of European wildlife and natural habitats*. Secretariat Memorandum. Directorate of Culture and of Cultural and Natural Heritage, Council of Europe, Strasbourg. 55 pp.

Cozza K., Fico R., Battistini M.-L. and Rogers E. (1996). The damage-conservation interface illustrated by predation on domestic livestock in central Italy. *Biological Conservation* **78**: 329-336.

Crisler L. (1958). *Arctic wild.* Harper and Row, New York.

Cuesta L., Barcena F., Palacios F. and Reig S. (1991). The trophic ecology of the Iberian Wolf (*Canis lupus signatus* Cabrera 1907). A new analysis of stomach's data. *Mammalia* **55(2)**: 239-254.

Danko Š. (2002). Šakaly na Zemplíne? Unikátne doklady v zoologickej zbierke Zemplínskeho múzea I. (Jackals in Zemplin? Unique records in the zoological collection of Zemplin Museum I.) *Zemplín* **I(1)**: 3-5. (in Slovak.)

Darwin C. (1845). *Journal of researches into the natural history and geology of the countries visited during the voyage of H.M.S. Beagle round the world, under the command of Captain Fitz Roy, R.N.* John Murray, London.

Darwin C. (1859). *On the origin of species by natural selection or, the preservation of favoured races in the struggle for life.* John Murray, London.

Darwin C. (1883). *The variation of animals and plants under domestication*. 2nd ed. revised. D. Appleton and Company, New York.

Dawydiak O. and Sims D.E. (2004). *Livestock protection dogs: selection, care and training*. 2nd ed. Alpine, Loveland, CO. 244 pp.

Decker D.J. and Purdy K.G. (1988). Toward a concept of wildlife acceptance capacity in wildlife management. *Wildl. Soc. Bull*. **16**: 53-57.

Dolbeer R.A., Holler N.R. and Hawthorne D.W. (1996). Identification and control of wildlife damage. In: *Research and management techniques for wildlife and habitats.* 5th ed., rev. Bookhout T.A. ed. The Wildlife Society, Bethseda, Md.: 474-506.

Ďurík J. (2000). Plánované veľkoplošné poľovnícke obhospodarovanie veľkých šeliem – základný predpoklad ich prežitia a prosperity. (Planned large-scale hunting management of large carnivores – the basic supposition for their survival and prosperity.) *Hubertlov* **IV(3)**: 4-6. (in Slovak.)

Ďurík J. (2002). Vráťme sa z kratšej cesty. (Let's return from the shorter road.) *Hubertlov* **VI(4)**: 8-9. (in Slovak.)

Dyky I. and Delehan I. (in prep.). Present state of wolf population in the Lviv Province: Skolivsky Beskydy (Beszczady) in the comparison with the whole Ukrainian Carpathians. In: Proceedings of the 2003 conference "The wolf in the Carpathians" held in Bystra, Poland.

Dziurdzik B. (1973). Key to the identification of hairs of mammals from Poland. *Acta Zoologica Cracoviensia*. **Tom XVIII (4)**: 73-113. (in Polish.)

Dytham C. (1999). *Choosing and using statistics: a biologist's guide*. Blackwell Science, Oxford. 218 pp.

Eagle T.C. and Pelton M.R. (1983). Seasonal nutrition of black bears in the Great Smoky Mountains National Park. *Int. Conf. Bear Res. and Manage*. **5**: 94-101.

Elgmork K. and Kaasa J. (1992). Food habits and foraging of the brown bear *Ursus arctos* in central south Norway. *Ecogeography* **15(1)**: 101-110.

Elgmork K. and Unander S. (1998). Brown bear use of ant mounds in Scandinavia. *Ursus* **10**: 269-274.

Ellingwood M.R. and Spignesi J.V. (1986). Management of an urban deer herd and the concept of cultural carrying capacity. *Trans. Northeast Deer Tech Comm., Vt. Fish Dep.* **22**: 42-45.

Espuno N. (2000). Effect of herd management practices on wolf predation on livestock in the Mercantour mountains, France. In: *Beyond 2000 Realities of Global Wolf Restoration. Program and abstracts*. International Wolf Center, Ely, Minnesota: 85.

Estes J.A. (1996). Predators and ecosystem management. *Wildlife Society Bulletin* **24(3)**: 390-396.

Farkáš J., Lehocký M., Cibula R., Jurkecková H., Šníderová R. and Hošková A. (2001a). *Poľovnícka štatistika ročenka slovenskej republiky za rok 2000*. (*Hunting statistics yearbook of the Slovak Republic for the year 2000*.) Lesnický vyskumný ústav, Zvolen. (in Slovak.)

Farkáš J., Lehocký M., Cibula R., Jurkecková H. and Murgašová A. (2001b). *Poľovnícka štatistika ročenka slovenskej republiky za rok 2001*. (*Hunting statistics yearbook of the Slovak Republic for the year 2001*.) Lesnický vyskumný ústav, Zvolen. (in Slovak.)

Feaver J., Mendl M. and Bateson P. (1986). A method for rating the individual distinctiveness of domestic cats. *Animal Behaviour* **34**: 1016-1025.

Feranec J. and Oťaheľ J. (2001). *Land cover of Slovakia*. Veda, Bratislava. 124 pp.

Ferguson S.H. and McLoughlin P.D. (2000). Effect of energy availability, seasonality, and geographic range on brown bear life history. *Ecography* **23(2)**: 193-200.

Feriancová Z. (1955). Rozšírenie niektorých vzácnych druhov cicavcov na Slovensku. (The distribution of some rare mammal species in Slovakia.) *Práce 2. sekcie Slovenska akademia vied* **1**: 30-40. (in Slovak.)

Fico R., Morosetti G. and Giovannini A. (1993). The impact of predators on livestock in the Abruzzo region of Italy. *Rev. Sci. Tech. O.I.E.* **12**: 39-50.

Finďo S. (1995). Súčasná situácia a perspektívy ochrany vlka obyčajného (*Canis lupus*) na Slovensku. (Current situation and perspectives for wolf (*Canis lupus*) conservation.) *Výskum a ochrana cicavcov na Slovensku* **II**: 37-46. (in Slovak with English summary.)

Fiňo S. (1997). *Obnovenie tradície využívania pastierskych strážnych psov*. (*Renovating the tradition of using livestock guarding dogs*.) Nadácia pre zachovanie zveri Slovenských Karpát, Zvolen. 44 pp. (in Slovak.)

Fiňo S. (1998). K príčinám zmien početnosti jelenej zveri u nás po roku 1990: ľudský vplyv rozhodujúci. (To the cause of changes in the numbers of red deer in Slovakia since 1990: the human factor decides.) *Poľovníctvo a rybárstvo* **50(4)**: 4-5. (in Slovak.)

Fiňo S. (1999a). Škody spôsobené prežúvavou zverou v lesoch Slovenska v rokoch 1991-1997. (Damage caused by ruminant game in the forests of Slovakia in the years 1991-1997.) *Folia Venatoria* **28-29**: 111-117. (in Slovak with English summary.)

Fiňo S. (1999b). *Obnovenie tradície využívania pastierskych strážnych psov*. (*Renovating the tradition of using livestock guarding dogs*.) 2nd ed. Abies, Tulčík. 48 pp. (in Slovak.)

Fiňo S. (2000). *Livestock guarding dogs and carnivore conservation in Slovakia*. Unpublished annual report. 21 pp.

Fiňo S. (2001). *Livestock guarding dogs and carnivore conservation in Slovakia*. Unpublished annual report. 15 pp.

Fiňo S. (2002a). Potravná ekológia vlka (*Canis lupus*) v Slovenských Karpatoch. (Feeding ecology of the wolf (*Canis lupus*) in the Slovak Carpathians.) In: *Výskum a ochrana cicavcov na Slovensku* **V**. Urban P. ed. Štátna ochrana prírody, Banská Bytrica: 43-55. (in Slovak with English summary.)

Fiňo S. (2002b). *Livestock guarding dogs and carnivore conservation in Slovakia*. Unpublished annual report. 17 pp.

Fiňo S. (2003). Veľké šelmy a hospodárske zvierata. (Large carnivores and livestock.) *Poľovníctvo a rybárstvo* **55(11)**: 8-9. (in Slovak.)

Fiňo S. and Bloch G. (1995). Wolf ecology and livestock guarding dogs (Slovakian Carpathians). *European Wolf Newsletter* **2**.

Fiňo S. and Rigg R. (1998). Proposal submitted to the Born Free Foundation for the project Protection of Livestock and Conservation of Large Carnivores in Slovakia.

Fiňo, S. and Rigg, R. (unpub.). *Distribution and numbers of large carnivores in Slovakia and neighbouring territories*. Paper submitted to J. Wildl. Res. in 1998.

Fiňo S., Paquet P., Bloch G., Chovancová B. and Križan P. (unpub.). *Wolf movements and home ranges in the Slovak Carpathians*. Paper submitted to Acta Theriologica in 1997.

Firmánszky G. (2003). Usadenie sa vlkov a rysov v Zemplínskom pohorí. (Settlement of wolves and lynx in the Zemplín hills.) In: *Vlky a rysy v oblasti slovensko-maďarských hraníc*. (*Wolves and lynx in the Slovak-Hungarian border region*.) Gadó G.P. and Pačenovský S. eds. WWF Maďarsko, Budapest: 51-54. (in Slovak.)

Floyd T.J., Mech L.D. and Jordan P.A. (1978). Relating wolf scat content to prey consumed. *Journal of Wildlife Management* **42**: 528-532.

Fogle B. (2000). *The new encyclopedia of the dog*. Dorling Kindersley, London. 416 pp.

Fonseca F.-P. (2000). The recovery of livestock guarding dogs' use and the Iberian wolf conservation in Portugal – promising results. *Carnivore Damage Prevention News* **1**: 8-9.

Fourli M. (1999). *Compensation for damage caused by bears and wolves in the European Union*. Office for Official Publications of the European Communities, Luxembourg. 68 pp.

Fritts S.H. (1982). *Wolf depredation on livestock in Minnesota*. Resource Publ. 145. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C. 11 pp.

Fritts S.H. and Mech L.D. (1981). *Dynamics, movements, and feeding ecology of a newly protected wolf population in northwestern Minnesota*. Wildlife Monographs, no. 80. The Wildlife Society, Bethseda, MD. 79 pp.

Fritts S.H., Paul W.J., Mech L.D. (1984). Movements of translocated wolves in Minnesota. *J. Wildl. Mgmt*. **48**: 709-721.

Fritts S.H., Paul W.J., Mech L.D. (1985). Can relocated wolves survive? *Wildl. Soc. Bull*. **13**: 459-463.

Fritts S.H., Paul W.J., Mech L.D. and Scott D.P. (1992). *Trends and management of wolf-livestock conflicts in Minnesota*. Resource Publ. 181. U.S. Fish and Wildlife Service, Washington, D.C. 27 pp.

Fritts S.H., Stephenson R.O., Hayes R.D. and Boitani L. (2003). Wolves and humans. In: *Wolves: behavior, ecology and conservation*. Mech D.L. and Boitani L. eds. The University of Chicago Press, Chicago and London: 289-316.

Frković A., Huber D. and Kusak J. (2001). Brown bear litter sizes in Croatia. *Ursus* **12**: 103-106.

Fuller T.K., Mech L.D. and Cochrane J.F. (2003). Wolf population dynamics. In: *Wolves: behavior, ecology and conservation*. Mech D.L. and Boitani L. eds. The University of Chicago Press, Chicago and London: 161-191.

Gadó G.P. and Pačenovský S. eds. (2003). *Vlky a rysy v oblasti slovensko-maďarských hraníc*. (Wolves and lynx in the Slovak-Hungarian border region.) WWF Maďarsko, Budapest. 76 pp. (in Slovak.)

Gangaas K.E. (2003). Can an educational program change attitude towards wolves from fear to curiosity? In: *World Wolf Congress 2003 Bridging Science and Community*. Book of abstracts. Banff, Canada: 35-36.

Garshelis D.L. (1989). Nuisance bear activity and management in Minnesota. In: *Bear-people conflicts*. Proceedings of a symposium on management strategies: 169-180.

Gašinec I. (2002). Eliminácia vplyvu negatívnych antropogénnych faktorov na úbytok kamzíka vrchovského tatranského v Tatranskom národnom parku. (Elimination of influence of negative anthropogenic factors to decreasing of the Tatra Chamois population in the Tatra National Park.) In: *Ochrana kamzíka*. (*Chamois protection.*) Janiga M. and Švajda J. eds. TANAP, NAPANT, IHAB: 217-228. (in Slovak with English abstract.)

Gašparík Ľ. (1997). Nepresnosťou k presnosti? (Inaccuracy to precision?) *Poľovníctvo a rybárstvo* **49(4)**: 10-11. (in Slovak.)

Gazzola A., Avanzinelli E., Bertelli I., Bertotto P., Tolosano A. and Apollonio M. (2003). Wolf predation and ungulate mortality in Italian Alps. In: *World Wolf Congress 2003 Bridging Science and Community*. Book of abstracts. Banff, Canada: 70.

Giannakos P. (1997). *Frugivory and seed dispersal by carnivores*. PhD thesis. University of Durham. 233 pp.

Gibeau M.L., Herrero S., McLellan B.N. and Woods J.G. (2001). Managing for grizzly bear security areas in Banff National Park and the Central Canadian Rocky Mountains. *Ursus* **12**: 121-130.

Gilbert B. (2002). Emerging from the dark side: a re-interpretation of grizzly-human relationships based on current and historical evidence. In: *Living with bears. Information, program and abstracts from the 14th International Conference on Bear Research and Management*. Kvam T. and Sørenson O.J. eds. Nord-Trøndelag University College, Steinkjer, Norway: 74.

Ginsberg J.R. and Macdonald D.W. (1990). *Foxes, wolves, jackals, and dogs. An action plan for the conservation of canids*. IUCN Publications, Gland, Switzerland. 116 pp.

Gittleman J.L., Funk S.M., Macdonald D. and Wayne R.K. (2001). Why “carnivore conservation”? In: *Carnivore Conservation*. Gittleman J.L., Funk S.M., Macdonald D. and Wayne R.K. eds. Cambridge University Press, Cambridge: 1-7.

Goldová M., Ciberej J. and Rigg R. (in press). Medveď hnedý (*Ursus arctos*) a parazitárne zoonózy. (The brown bear (*Ursus arctos*) and parasitic zoonoses.) *Folia Venatoria* **00**: 000-000. (in Slovak.)

Goss-Custard J.D. and Sutherland W.J. (1997). Individual behaviour, populations and conservation. In: *Behavioural ecology: an evolutionary approach*. 4th ed. Krebs J.R. and Davies N.B. Blackwell Science, Oxford: 373-395.

Graber D.M. and White M. (1983). Black bear food habits in Yosemite National Park. *Int. Conf. Bear Res. and Manage*. **5**: 1-10.

Grau J., Jung R. and Münker B. (1996). *Dužinaté plody, bylinky*. (*Fleshy fruits and herbs*.) Ikar, Bratislava. 288 pp. (in Slovak.)

Green J.S. and Woodruff R.A. (1980). Is predator control going to the dogs? *Rangelands* **2**: 187-189.

Green J.S. and Woodruff R.A. (1988). Breed comparisons and characteristics of use of livestock guarding dogs. *J. Range Manage***. 41**: 249-251.

Green J.S. and Woodruff R.A. (1989). Livestock-guarding dogs reduce depredation by bears. In: *Bear-people conflicts – Proc. of a symposium on management strategies*. Northwest Territories Dept. of Renew. Res.: 49-53.

Green J.S., Woodruff R.A. and Tueller T.T. (1984). Livestock-guarding dogs for predator control: costs, benefits and practicality. *Wildl. Soc. Bull*. **12**: 44-50.

Green G.I., Mattson D.J. and Peek J.M. (1997). Spring feeding on ungulate carcasses by grizzly bears in Yellowstone National Park. *J. Wildl. Manage*. **61(4)**: 1040-1055.

Grey-Wilson C. and Blamey M. (1995). *Alpine flowers of Britain and Europe*. 2nd ed. HarperCollins, London. 377 pp.

Gustavson C.R. (1982). An evaluation of taste aversion control of wolf (*Canis lupus*) predation in northern Minnesota. *Appl. Anim. Ethol*. **9**: 63-71.

Gustavson C.R., Garcia J., Hankins W.G. and Rusiniak K.W. (1974). Coyote predation control by aversive conditioning. *Science* **184**: 581-583.

Haber G. (2003). Persistence and social organisation of wolf family lineages, Denali National Park, Alaska. In: *World Wolf Congress 2003 Bridging Science and Community*. Book of abstracts. Banff, Canada: 45.

Håkan S., Liberg O., Johansson Ö., Wabakken P., Zimmerman B. and Ahlqvist P. (2003). Summer predation patterns of Scandinavian wolves. In: *World Wolf Congress 2003 Bridging Science and Community*. Book of abstracts. Banff, Canada: 51.

Hála J. (2001). *Salašnícka epopeja*. (*A shepherd's epic*.) Q-ex, Trenčín. 144 pp. (in Slovak.)

Halák K. (1993). Populácia medveďa hnedého (Ursus arctos L., 1758) v Západných Tatrách. (The population of the brown bear (Ursus arctos L., 1758) in the Western Tatras.) *Zborník prác o Tatranskom Národnom Parku* **33**: 227-234. (in Slovak with English summary.)

Hamer D. and Herrero S. eds. (1983). *Ecological studies of the grizzly bear in Banff National Park*. Final report for Parks Canada. University of Calgary, Alberta. 303 pp.

Hamer D. and Herrero S. (1987). Grizzly bear food and habitat in the Front Ranges of Banff National Park, Alberta. *Int. Conf. Bear Res. and Manage*. **7**: 199-213.

Hansen I. and Bakken M. (1999). Livestock-guarding dogs in Norway: Part I. Interactions. *J. Range Manage.* **52(1)**: 2-6.

Hansen I., Christiansen F., Hansen H.S., Braastad B. and Bakken M. (2001). Variation in behavioural responses of ewes towards predator-related stimuli. *Applied Animal Behaviour Science* **70**: 227-237.

Hebblewhite M., White C., Hurd T. and Nietvelt C. (2003). Wolf recolonization triggers trophic cascade in Banff National Park. In: *World Wolf Congress 2003 Bridging Science and Community*. Book of abstracts. Banff, Canada: 54.

Hell P. (1987). Strategy and tactics of game management of bear in Czechoslovakia. In: *Problematika medveďa na Slovensku.* (*The issue of the bear in Slovakia*.) Hell P. ed. VÚLH, Zvolen: 22-43. (in Slovak.)

Hell P. (1989). Vývoj stavov raticovej zveri z hľadiska škôd ňou spôsobených. (The development of ungulate game populations from the point of view of damage caused by them.) In: *Problematika zveri v lesných ekosystémoch*. Proceedings of symposium. Lesoprojekt, Zvolen: 22-35. (in Slovak.)

Hell P. (1992). Managing the lynx population in Czechoslovakia. In: *The situation, conservation needs and reintroduction of lynx in Europe*. Environmental Encounters No. 11. Council of Europe Press: 36-39.

Hell P. (1993). Current situation and perspectives of the wolf in Czechoslovakia. In: *Wolves in Europe, status and perspectives*. Promberger C. and Schröder W. eds Workshop proceedings. Munich Wildlife Society, Oberammergau, Germany: 36-42.

Hell P. (2000a). *Návrh biologických a legislatívnych zásad a manažmentu vlka na Slovensku*. (*Proposal for the biological and legislative basis and management of the wolf in Slovakia.*) Záznam z pracovného rokovania medzirezortnej Komisie pre veľké šelmy, Zvolen. 6 pp. (in Slovak.)

Hell P. (2000b). O predátoroch bez mantinelizmu. (On predators without barriers.) *Poľovníctvo a rybárstvo* **52(11)**: 16. (in Slovak.)

Hell P. (2003). Current problems of the co-existence of man and bear in the Slovak Carpathians and options for their solution. In: *The integrated solution to the problem of nuisance bears* (Ursus arctos). Rigg R. and Baleková K. eds. Conference proceedings, Nová Sedlica, Slovakia 11-12.4.2002: 65-75.

Hell P. and Bevilaqua (1988). Das Zusammenleben des Menschen mit dem Braunbären (*Ursus arctos*) in den Westkarpaten. (The co-existence of people with brown bears (*Ursus arctos*) in the Western Carpathians.) *Zeitschrift für Jagdwissenschaft*. **34**: 153-163. (in German.)

Hell P. and Bleho Š. (1995). Novodobý výskyt šakala obyčajného (*Canis aureus*) na Slovensku. (Contemporary occurrence of jackal (*Canis aureus*) in Slovakia.) *Folia ventoria* **25**: 183-187 (in Slovak with English summary.)

Hell P. and Finďo S. (1999). Status and management of the brown bear in Slovakia. In: *Bears. Status survey and conservation action plan*. Servheen C., Herrero S. and Peyton B. compilers. IUCN Gland, Switzerland and Cambridge, UK: 96-100.

Hell P. and Garaj P. (2002). *Nová príručka poľovníka do vrecka*. (*The new hunter's pocket guide*) Príroda, Bratislava. 288 pp. (in Slovak.)

Hell P. and Gašparík J. (1999). Kriticky o vyhláške MŽP SR o chránených rastlinách a živočíchoch. Prestaňme ustupovať. (Critique of the Environment Ministry of the Slovak Republic's decree on protected flora and fauna. Let's stop retreating.) *Poľovníctvo a rybárstvo* **51(12)**: 3,10. (in Slovak.)

Hell P. and Kaštier P. (2003). Naše poľovníctvo a NATURA 2000. (Our hunting and Natura 2000.) *Hubertlov* **VII(6)**: 4-5. (in Slovak.)

Hell P. and Sabadoš K. (1995). Niektoré parametre západokarpatskej populácie medveďa hnedého na Slovensku. (Some parameters of the Western Carpathian brown bear population in Slovakia.) *Folia ventoria* **25**: 97-104 (in Slovak with English summary.)

Hell P. and Sládek J. (1974). *Trofejové šelmy na Slovensku. (Trophy carnivores in Slovakia.)* Príroda, Bratislava. 257 pp. (in Slovak.)

Hell P. and Slamečka J. (1996). Present status of the lynx (*Lynx lynx*) in Slovakia. In: Lynx in the Czech and Slovak Republics. Koubek P. and Červený J. *Acta Sc. Nat. Brno* **30(3)**:64-78.

Hell P. and Slamečka J. (1999). *Medveď v slovenských Karpatoch a vo svete. (The bear in the Slovak Carpathians and in the world.)* PaRPress, Bratislava. 150 pp. (in Slovak.)

Hell P. and Slamečka J. (2000). Problematika veľkých šeliem na Slovensku. (The issue of large carnivores in Slovakia.) *Hubertlov* **IV(6)**: 4-6. (in Slovak.)

Hell P., Žilinec M. and Orosz J. (1993). Ako sme hospodárili roku 1991. (How we managed in 1991). *Poľovníctvo a rybárstvo* **45(9)**: 4-5. (in Slovak.)

Hell P., Fľak P. and Slamečka J. (1996). Vplyv veľkých šeliem na zajačiu a srnčiu zver. (The influence of large carnivores on the hare and roe deer.) *Poľovníctvo a rybárstvo* **48(10)**: 4-5. (in Slovak.)

Hell P., Slamečka J. and Pivko J. (1997). Výsledky prieskumu vybraných negatívnych vplyvov na životné prostredie zveri na Slovensku pred politicko-ekonomickou transformáciou. (Results from the survey of selected negative influences on the game environment in Slovakia before economic and political transformation. *Folia ventoria* **26-27**: 159-168. (in Slovak with English summary.)

Hell P., Lehocký M. and Gašparík J. (1999). Populačná hustota, trofejová kvalita a lov jelenej zveri na Slovensku vo vzťahu k lesnatosti poľovných oblastí. (Population density, trophy quality and hunting of red deer in Slovakia in relation to forest coverage of hunting areas.) *Folia ventoria* **28-29**: 7-22. (in Slovak with English summary.)

Hell P., Slamečka J. and Gašparík J. (2001a). *Vlk v slovenských Karpatoch a vo svete. (The wolf in the Slovak Carpathians and in the world.)* PaRPress, Bratislava. 200 pp. (in Slovak.)

Hell P., Konôpka J. and Garaj P. (2001b). Úvaha o manažmente zveri v 21. storočí. (Contemplation of game management in the 21st century.) *Hubertlov* **V(2)**: 4-8. (in Slovak.)

Herrero S. (1970). Human injury inflicted by grizzly bears. *Science* **170**: 593-598.

Herrero S. (1985). *Bear attacks: their causes and avoidance*. 1st ed. The Lyons Press, N.Y. 287 pp.

Herrero S. (2002). *Bear attacks: their causes and avoidance*. Rev. ed. The Lyons Press, Guilford, CT. 282 pp.

Herrero S. (2003). Should wolf populations be controlled to enhance prey populations? In: *World Wolf Congress 2003 Bridging Science and Community*. Book of abstracts. Banff, Canada: 19-20.

Herrero S. and Fleck S. (1990). Injury to people inflicted by black, grizzly or polar bears: recent trends and new insights. *Int. Conf. Bear Res. and Manage.* **8**: 25-32.

Herrero S., McCrory W. and Pelchat B. (1986). Using grizzly bear habitat evaluations to locate trails and campsites in Kananaskis Provincial Park. *Int. Conf. Bear Res. and Manage.* **6**: 187-193.

Herz J. (1999). Poľovnícka štatistika za sezónu 1998/1999. Ďalší súbor nepresných čísel. (Hunting statistics for the 1998/199 season. Another file of imprecise figures.) *Poľovníctvo a rybárstvo* **51(11)**: 6-7. (in Slovak.)

Hewitt D.G. and Robbins C.T. (1996). Estimating grizzly bear food habits from fecal analysis. *Wildlife Society Bulletin* **24(3)**: 547-550.

Higgins K.F., Oldemeyer J.L., Jenkins K.J., Clambey G.K. and Harlow R.F. (1996). Vegetation sampling and measurement. In: *Research and management techniques for wildlife and habitats*. 5th ed., rev. Bookhout T.A. ed. The Wildlife Society, Bethseda, Md.: 567-591.

Hilderbrand G.V., Farley S.D., Robbins C.T., Hanley T.A., Titus K. and Servheen C. (1996). Use of stable isotopes to determine diets of living and extinct bears. *Can. J. Zool*. **74**: 2080-2088.

Hilderbrand G.V., Schwartz C.C., Robbins C.T., Jacoby M.E., Hanley T.A., Arthur S.M. and Servheen C. (1999a). The importance of meat, particularly salmon, to body size, population productivity, and conservation of North American brown bears. *Can. J. Zool*. **77**: 132-138.

Hilderbrand G.V., Jenkins S.G., Schwartz C.C., Hanley T.A. and Robbins C.T. (1999b). Effect of seasonal differences in dietary meat intake on changes in body mass and composition in wild and captive brown bears. *Can. J. Zool*. **77**: 1623-1630.

Hlásnik J. (2002a). *Problematika riešenia škôd, spôsobených chránenými druhmi zveri*. (The issue of solving damage caused by protected game species.) Záznam z pracovného rokovania medzirezortnej Komisie pre veľké šelmy, Zvolen. 3 pp. (in Slovak.)

Hlásnik J. (2002b). Kamzíky v PZ Poľana. (Chamois in PZ Poľana.) *Hubertlov* **VI(2)**: 9. (in Slovak.)

Hoholíková T. (2001a). Jelene v tatranských osadách. (Red deer in Tatra settlements.) *Tatry* **XL(1)**: 3. (in Slovak.)

Hoholíková T. (2001b). Odchyt rysov zatiaľ bez úspechov. (Trapping of lynx so far without success.) *Tatry* **XL(2)**: 9. (in Slovak.)

Hoholíková T. (2001c). Medvedie teritórium – nevstupovať. (Bear territory – do not enter.) *Tatry* **XL(5)**: 7. (in Slovak.)

Hoholíková T. (2001d). Z turistických chodníkov. (From the hiking trail.) *Tatry* **XL(6)**: 10. (in Slovak.)

Holmes J. (1966). *The farmer's dog*. Popular Dogs, London.

Hrůza A. (1947). *Čuvač. Monografie o československém národním plemeni psů*. (*The čuvač. A monograph on a Czechoslovak national dog breed.*) Pokorny a spol., Brno. (in Czech.)

Hubbard C.L.B. (1947). *Working dogs of the world*. Sidgwick and Jackson Limited, London.

Huber D. (2000). Temporary wolf management plan for Croatia. In: *Beyond 2000 Realities of Global Wolf Restoration. Program and abstracts*. International Wolf Center, Ely, Minnesota: 31.

Huber D. and Roth H.V. (1986). Home ranges and movements of brown bears in Plitvice Lakes National Park, Yugoslavia. *Int. Conf. Bear Res. and Manage*. **6**: 93-96.

Hunziker M., Egli E. and Wallner A. (1998). Return of predators: reasons for existence or lack of public acceptance. In: *Workshop on human dimension in large carnivore conservation*. Strahm D. ed. KORA Bericht Nr. 3. KORA, Muri: 25-30.

Jacoby M.E., Hilderbrand G.V., Servheen C., Schwartz C.C., Arthur S.M., Hanley T.A., Robbins C.T. and Michener R. (1999). Trophic relations of brown and black bears in several western North American ecosystems. *J. Wildl. Manage*. **63(3)**: 921-929.

Jamnický J. (1987). Formy komunikácie medveďa hnedého (*Ursus arctos* L.). (Forms of communication of the brown bear (*Ursus arctos* L.).) *Folia Venatoria* **17**: 151-167. (in Slovak with English summary.)

Jamnický J. (1988). Potrava medveďa hnedého (*Ursus arctos* L.) v tatranskej oblasti. (The diet of the brown bear (*Ursus arctos* L.) in the Tatra region.) *Folia Venatoria* **18**: 197-213. (in Slovak with English summary.)

Jamnický J. (1993). Lov medveďa hnedého a vlka obyčajného na Slovensku pred sto rokmi. (The hunt of the brown bear and European wolf in Slovakia a hundred years ago.) *Folia Venatoria* **23**: 221-229. (in Slovak with English summary.)

Jamnický J. (2000). Otázniky nad kamzíkmi. (Question marks over chamois.) *Tatry* **XXXIX(5)**: 8-9. (in Slovak.)

Jamnický J. (2003). Čo medveď žerie najradšej? (What does the bear prefer to eat?) *Tatry* **XLII(4)**: 12-13. (in Slovak.)

Janiga M. and Hrkľová G. (2002). Kamzík (*R. rupicapra*) v potrave vlkov (*C. lupus*) v Tatrách a Nízkych Tatrách. (Chamois (*R. rupicapra*) in the diet of wolves (*C. lupus*) in the Tatra Mountains and the Low Tatra Mountains.) In: *Ochrana kamzíka*. (*Chamois protection.*) Janiga M. and Švajda J. eds. TANAP, NAPANT, IHAB: 51-55. (in Slovak with English abstract.)

Janiga M. and Zámečniková H. (2002). Zoologická charakteristika historických údajov o kamzíkoch (*Rupicapra rupicapra tatrica* Blahout 1971) v Tatrách ako podklad pre vyhodnotenie ich súčasnej početnosti. (Zoological characteristics of the historical data on chamois (*Rupicapra rupicapra tatrica* Blahout 1971) as a base for the evaluation of their current abundance in the Tatra mountains.) In: *Ochrana kamzíka*. (*Chamois protection.*) Janiga M. and Švajda J. eds. TANAP, NAPANT, IHAB: 99-182. (in Slovak with English abstract.)

Janík M. (1997). Biogeography, demography and management of *Ursus arctos* in the Western Carpathians. *Int. Conf. Bear Res. and Manage*. **9(2)**: 125-128.

Janík M., Voskár J. and Buday M. (1986). Súčasné rozšírenie medveďa hnedého (*Ursus arctos*) v Československu. (Present distribution of the brown bear (*Ursus arctos*) in Czechoslovakia.) *Folia Venatoria* **16**: 331-352. (in Slovak.)

Jędrzejewska B., Okarma H., Jędrzejewski W. and Miłkowski L. (1994). Effects of exploitation and protection on forest structure, ungulate density and wolf predation in Białowieża Primeval Forest, Poland. *Journal of Applied Ecology* **31**: 664-676.

Jedrzejewski W., Schmidt K., Theuerkauf B., Jedrzejewska B. and Okarma H. (2001). Daily movements and territory use by radio-collared wolves, *Canis lupus*, in Bialowieza Primeval Forest in Poland. *Can. J. Zool.* **79**: 1993-2004.

Jedrzejewski W., Nowak S., Jedrzejewski B., Myslajek R., Rogala M. and Schmidt K. (2003). Factors affecting wolf distribution, numbers and livestock depredation in Poland. In: *World Wolf Congress 2003 Bridging Science and Community*. Book of abstracts. Banff, Canada: 38.

Jerina K. and Adamic M. (2002). The brown bear's (*Ursus arctos*) spatial expansion in Slovenia: speed of expansion and saturation dependent dispersion. In: *Living* *with bears. Information, program and abstracts from the 14th International Conference on Bear Research and Management*. Kvam T. and Sørenson O.J. eds. Nord-Trøndelag University College, Steinkjer, Norway: 79.

Jhala Y. (2000). Human-wolf conflict in India. In: *Beyond 2000 Realities of Global Wolf Restoration. Program and abstracts*. International Wolf Center, Ely, Minnesota: 26-27.

Jobin A., Molinari P. and Breitenmoser U. (2000). Prey spectrum, prey preference and consumption rates of Eurasian lynx in the Swiss Jura Mountains. *Acta Theriologica* **45**: 243-252.

Johnson D.H. (1996). Population analysis. In: *Research and management techniques for wildlife and habitats.* 5th ed., rev. Bookhout T.A. ed. The Wildlife Society, Bethseda, Md.: 419-444.

Johnson W.E., Eizirik E. and Lento G.M. (2001). The control, exploitation and conservation of carnivores. In: *Carnivore Conservation*. Gittleman J.L., Funk S.M., Macdonald D. and Wayne R.K. eds. Cambridge University Press, Cambridge: 196-219.

Jonozovic M. and Adamic M. (2002). Density of European brown bears and the extent of reported bear damages in Slovenia: do they have anything in common? In: *Living with bears. Information, program and abstracts from the 14th International Conference on Bear Research and Management*. Kvam T. and Sørenson O.J. eds. Nord-Trøndelag University College, Steinkjer, Norway: 82.

Jorgensen C. J. (1983). Bear-sheep interactions, Targhee National Forest. *Int. Conf. Bear Res. and Manage*. **5**: 191-200.

Jurdíková N. (2000). The decline of the Tatra chamois. *Caprinae Newsletter of the IUCN/SSC Caprinae Specialist Group* **2000(December)**: 4-6.

Jurewicz R.L. and Thiel K.A. (2000). Wolf depredation in Wisconsin 1976-1999. In: *Beyond 2000 Realities of Global Wolf Restoration. Program and abstracts*. International Wolf Center, Ely, Minnesota: 87.

Jurewicz R. (2003). Wisconsin wolf damage control program. In: *World Wolf Congress 2003 Bridging Science and Community*. Book of abstracts. Banff, Canada: 73.

Jurík M. (2004). Stopy viedli ďaleko do doliny. (The tracks led far into the valley.) *Tatry* **XLIII**: 7. (in Slovak.)

Kaczensky P. (1996). *Large carnivore-livestock conflicts in Europe*. Wildbiologische Gesellschaft München e.V., Linderhof, Germany. 106 pp.

Kaczensky P. (1999). Large carnivore depredation on livestock in Europe. *Ursus* **11**: 59-72.

Kaczensky P., Huber T., Huber D., Frković A. and Fico R. (1999a). *Wer was es?* (*Who was it?*) Wildbiologiche Gesellschaft München e.V. (in German.)

Kaczensky P., Huber T., Huber D., Frković A. and Fico R. (1999b). *Kto to bol?* (*Who was it?*) SAŽP, Banská Bystrica and Správa národných parkov SR, Liptovský Mikuláš. 48 pp. (in Slovak.)

Karlsson J. (2003). Interactions between wolves and dogs in Scandinavia. In: *Beyond 2000 Realities of Global Wolf Restoration. Program and abstracts*. International Wolf Center, Ely, Minnesota: 40.

Kassa M. (1998a). Analýza lovu medveďa hnedého (*Ursus arctos*) na Slovensku. (An anlysis of brown bear (*Ursus arctos*) hunting in Slovakia.) *Chránené územia Slovenska*. **38**: 20-22. (in Slovak.)

Kassa M. (1998b). Určovanie hmotnosti medveďa hnedého (*Ursus arctos*) na základe veľkosti jeho stop. (Determining the weight of a brown bear (*Ursus arctos*) on the basis of the size of its track.) *Chránené územia Slovenska*. **38**: 19-20. (in Slovak.)

Kassa M. (1999). Škody spôsobené medveďom v roku 1998 na Slovensku. (Damage caused by the bear in 1998 in Slovakia.) *Chránené územia Slovenska*. **40**: 23-24. (in Slovak.)

Kassa M. (2001). Škody spôsobené medveďom hnedým v roku 2000. (Damage caused by the brown bear in 2000.) *Chránené územia Slovenska*. **47**: 22-23. (in Slovak.)

Kassa M. (2002). Škody spôsobené medveďom v roku 2001. (Damage caused by the bear in 2001.) *Chránené územia Slovenska*. **51**: 16. (in Slovak.)

Kassa M. (2003). Management system of the brown bear in Slovakia. In: *The integrated solution to the problem of nuisance bears* (Ursus arctos). Rigg R. and Baleková K. eds. Conference proceedings, Nová Sedlica, Slovakia 11-12.4.2002: 17-25.

Kaštier P. (2004). *Summary by district of results from national hunters' questionnaire Poľov 1-01 for the years 2000, 2001 and 2002*. Commissioned report. Zvolen Forestry Research Institute, Zvolen. (in Slovak.)

Klein V. (2002). Kamzíky v PZ Poľana. (Chamois in PZ Poľana.) *Hubertlov* **VI(2)**: 8-9. (in Slovak.)

Klenzendorf S.A. and Vaughan M.R. (1999). An overview of brown bear management in six European countries. *Ursus* **11**: 163-178.

Klescht V. (1983). Prečo vlci škodia poľnohospodárstvu? (Why do wolves damage agriculture?) *Spravodajca Chránené územia Slovenska* **2**: 60-63. (in Slovak.)

Klučiarovský V. (1996). O vlkoch z praxe. (On wolves from experience.) *Poľovníctvo a rybárstvo* **48(3)**: 18. (in Slovak.)

Knarrum V., Sørenson O.J., Eggen T., Kvam T., Opseth O. and Eidsmo A. (2002). Brown bear prey selection on domestic sheep in Norway. In: *Living with bears. Information, program and abstracts from the 14th International Conference on Bear Research and Management*. Kvam T. and Sørenson O.J. eds. Nord-Trøndelag University College, Steinkjer, Norway: 85.

Knight R.R. and Judd S.L. (1983). Grizzly bears that kill livestock. *Int. Conf. Bear Res. and Manage*. **5**: 186-190.

Koeln G.T., Cowardin L.M. and Strong L.L. (1996). Geographic information systems. In: *Research and management techniques for wildlife and habitats.* 5th ed., rev. Bookhout T.A. ed. The Wildlife Society, Bethseda, Md.: 540-566.

Kohn M.H. and Wayne R.K. (1997). Facts from feces revisited. *Trends in Ecology and Evolution* **12(6)**: 223-227.

Kojola I. and Kuittinen J. (2000). Wolf attacks on dogs in Finland. In: *Beyond 2000 Realities of Global Wolf Restoration. Program and abstracts*. International Wolf Center, Ely, Minnesota: 88.

Kolenka T. (1997). *Potravná ekológia vlka v Západných Karpatoch. (Feeding ecology of the wolf in the Western Carpathians.)* Masters thesis. Lesnícka fakulta TU, Zvolen. 39 pp. (in Slovak.)

Konôpka J. (1994). State forestry and environment policy in the Slovak Republic. In: *Conservation of forests in Central Europe*. Paulenka J. and Paule L. eds. Arbora Publishers, Zvolen: 111-122.

Koreň M. (2002). K niektorým teoreticko-metodickým otázkam Programu záchrany kamzíka vrchovského tatranského na roky 2001-2005. (Some notes on theoretical-methodical questions of the Tatras Chamois Rescue Programme 2001-2005.) In: *Ochrana kamzíka*. (*Chamois protection*.) Janiga M. and Švajda J. eds. TANAP, NAPANT, IHAB: 245-250. (in Slovak with English abstract.)

Korschgen L.J. (1969). Procedures for food-habits analyses. In: *Wildlife management techniques*. 3rd ed. Giles R.H. editor. The Wildlife Society, Washington D.C.: 233-250.

Korschgen L.J. (1980). Procedures for food-habits analyses. In: *Wildlife management techniques manual*. 4th ed. Schemnitz S.D. ed. The Wildlife Society, Washington D.C.: 113-127.

Kossak S. (1998). *Wilk – zabaójca zwierąt gospodarskich?* (*The wolf – killer of domestic animals?*) Agencja Reklamowo-Wydawnicza, A. Grzegorczyk, Warszawa. 41 pp. (in Polish.)

Koubek P. and Červený J. (1996). *Lynx in the Czech and Slovak Republics*. Acta Sc. Nat. Brno 30(3). 78 pp.

Koubek P., Červený J. and Luděk B. (2002). *Large carnivores in the Czech Republic – distribution, status and management*. URL: http://www.large-carnivores-lcie.org/koubek.doc.

Kováč V. (1953). Ovčiarstvo. (Sheep breeding.) ŠPN, Bratislava. 415 pp. (in Slovak.)

Kováč J. (1984). Úhyn raticovej zveri v TANAPe. (Ungulate deaths in TANAP.) *Poľovníctvo a rybárstvo* **36(11)**: 11. (in Slovak.)

Kováč J. (1996a). Kamzík vrchovský tatranský a jeho minulosť, prítomnosť a budúcnosť. (The Tatra mountain chamois and its past, present and future.) *Poľovníctvo a rybárstvo* **48(1)**: 8. (in Slovak.)

Kováč J. (1996b). Medveď hnedý v Tatranskom národnom parku. (The brown bear in the Tatras National Park.) *Poľovníctvo a rybárstvo* **48(2)**: 8-9. (in Slovak.)

Kováč J. (1996c). Pôsobenie vlka obyčajného. (The influence of the wolf.) *Poľovníctvo a rybárstvo* **48(4)**: 8. (in Slovak.)

Kováč J. (1997). Ostrov v mori civilizácie. (An island in a sea of civilisation.) *Poľovníctvo a rybárstvo* **49(12)**: 4-5. (in Slovak.)

Kováč J. (1999). Medveď usmrtil medvieďa. (Male bear killed a young bear.) *Tatry* **XXXVIII(4)**: 7. (in Slovak.)

Kováč J. (2003). The issue of nuisance bears in the Tatras National Park. In: *The integrated solution to the problem of nuisance bears* (Ursus arctos). Rigg R. and Baleková K. eds. Conference proceedings, Nová Sedlica, Slovakia 11-12.4.2002: 77-88.

Kováčiková M. (2003). Podbanské sa mu stalo domovom. (Podbanské became his home.) *Tatry* **XLII(4)**: 8-9. (in Slovak.)

Krajniak D. (2003). *Problematika riešenia regulácie veľkých šeliem a návrh postupu získavania dokumentácie škôd a úrazov spôsobených veľkými šelmami na Slovensku a v zahraničí a návrh systému riešení na ich zníženie*. (The issue of resolving the control of large carnivores and a proposal for a procedure for obtaining documentation of damages and injuries caused by large carnivores in Slovakia and abroad and a proposal for a system for a solution to their reduction.) Unpublished report to the Slovak Hunting Union. 7 pp. (in Slovak.)

Kráľ P. (1999). Nehaňte medveďa! (Don't blame the bear!) *Tatry* **XXXVIII(4)**: 8-9. (in Slovak.)

Kráľ P. (2000). Ohrozuje medveď chodníky? (Does the bear threaten trails?) *Tatry* **XXXIX(3)**: 10. (in Slovak.)

Kráľ P. (2001). Prikrmovanie medveďov. (Feeding bears.) *Tatry* **XL(2)**: 6. (in Slovak.)

Kramárik J. (1995). Vyhodnotenie plnenie „Projektu budovania siete chránených území v SSR do r.2000." (Evaluating completion of "Building a protected area network in the SSR project up to 2000".) *Chránené územia Slovenska* **23**: 2-3. (in Slovak.)

Krogstad S., Christiansen F., Smith M.E., Røste O.C., Aanesland N., Tillung R.H. and Thorud L. (2000). *Forebyggende tiltak mot rovviltskader på sau. Gjeting og bruk av vokterhund i Lierne*. (*Protective measures against depredation on sheep: shepherding and use of livestock guardian dogs in Lierne*.) Final report 2000. NINA Fagrapport 41. 66 pp. (in Norwegian with English abstract.)

Kropil R., Dudich A. and Finďo S. (1994). Natural forests of the Western Carpathians – important areas of animal diversity. In: *Conservation of forests in Central Europe*. Paulenka J. and Paule L. eds. Arbora Publishers, Zvolen: 55-61.

Kruuk H. (1972). Surplus killing by carnivores. *J. Zool., London* **166**: 133-244

Kúdola P. and Lehota K. (2001). Bez pozvania. (Without invitation.) *Hubertlov* **V(1)**: 23. (in Slovak.)

Kunc L. (2001). Veľké šelmy na Morave. (Large carnivores in Moravia.) *Poľovníctvo a rybárstvo* **53(12)**: 16. (in Slovak.)

Kurtén B. (1976). *The cave bear story: life and death of a vanished animal.* Columbia University Press, N.Y. 163 pp.

Kurz V. (1958). Ovčiarský pes. (The sheepdog.) In: *Ovčiarstvo a salašníctvo*. (*Sheep breeding and shepherding.*) Laurinčík J. *et al*.. SVPL, Bratislava: 336-382. (in Slovak.)

Kusak J. and Huber D. (2000). Tracking a wolf pack in livestock-raising areas of Dalmatia, southern Croatia. In: *Beyond 2000 Realities of Global Wolf Restoration. Program and abstracts*. International Wolf Center, Ely, Minnesota: 32-33.

Kušík P. (1996). Kto má pravdu? (Who is right?) *Poľovníctvo a rybárstvo* **48(6)**: 13. (in Slovak.)

Lancia R.A., Nichols J.D. and Pollock K.H. (1996). Estimating the number of animals in wildlife populations. In: *Research and management techniques for wildlife and habitats.* 5th ed., rev. Bookhout T.A. ed. The Wildlife Society, Bethseda, Md.: 215-253.

Landa A., Gudvangen K., Swenson J.E. and Røskaft E. (1999). Factors associated with wolverine *Gulo gulo* predation on domestic sheep. *Journal of Applied Ecology* **36**: 963-973.

Landry J.-M. (1999). *The use of guard dogs in the Swiss Alps: a first analysis*. KORA report No. 2. 26 pp. URL: www.kora.unibe.ch/main.htm?ge/publics/reports.htm On Web 2001.

Landry J.M. (2003a). A social approach to increase the success of livestock guarding dogs integration. In: *World Wolf Congress 2003 Bridging Science and Community*. Book of abstracts. Banff, Canada: 74.

Landry J.M. (2003b). The wolf return to the Swiss Alps: a difficult compromise. In: *World Wolf Congress 2003 Bridging Science and Community*. Book of abstracts. Banff, Canada: 75.

Laurans R. (1975). Chiens de garde et chiens de conduite des moutons. (Sheep guarding and conducting dogs.) *Ethnozootechnie* **12**: 15-18. (in French.) English translation published in 1992. In: Sheepdog environments in the Old World. *DogLog* **2(3-4)**: 12-14.

Laurinčík J., Mikuš M., Plánovský Ľ., Fischer P., Kováč V., Janotík J. and Kurz V (1958). *Ovčiarstvo a salašníctvo*. (*Sheep breeding and shepherding.*) SVPL, Bratislava. 495 pp. (in Slovak.)

LCIE Core Group (2001). Large Carnivore Initiative for Europe Core Group position statement on the use of hunting, and lethal control, as means of managing large carnivore populations. 4 pp. URL: www.large-carnivores-lcie.org On Web 2001.

LeCount A.L. and Baldwin K.L. (1986). The bear in the classroom. *Int. Conf. Bear Res. and Manage*. **6**: 209-217.

Lehocký M. (2002). Veľkoplošné sčítanie šeliem. (Large-area census of carnivores.) *Poľovníctvo a rybárstvo* **54(6)**: 8-9. (in Slovak.)

Lehocký M., Farkaš J. and Cibula R. (2000). Poľovnícka štatistika – výsledky poľovníckeho hospodárenia v sezóne 1999/2000. (Hunting statistics – results of hunting management in the 1999/2000 season.) *Poľovníctvo a rybárstvo* **52(11)**: 18-20. (in Slovak.)

Lehocký M., Farkaš J. and Cibula R. (2001). Poľovníctvo štatistika za r. 2000. (Hunting statistics for the year 2000.) *Poľovníctvo a rybárstvo* **53(7)**: 4-7. (in Slovak.)

Lehocký M., Cibula R. and Kaštier P. (2003a). Výsledky poľovníckej štatistiky na Slovensku za rok 2002. (Results of hunting statistics in Slovakia for the year 2002.) *Poľovníctvo a rybárstvo* **55(10)**: 20-21. (in Slovak.)

Lehocký M., Kaštier P., Cibula R., Jurkecková H. and Murgašová A. (2003b). *Poľovnícka štatistika ročenka slovenskej republiky za rok 2002*. (*Hunting *statistics yearbook of the Slovak Republic for the year 2002*.) Lesnický vyskumný ústav, Zvolen. (in Slovak.)

Lequette B. (1997). Mercantour wolves continue to grow. *European Wolf Newsletter* **5**.

Lequette B. (2003). Livestock guarding dogs protecting sheep from wolves. In: *World Wolf Congress 2003 Bridging Science and Community*. Book of abstracts. Banff, Canada: 18.

Lequette B., Poulle M.L., Dahier T. and Houard T. (1996a). Wolf monitoring in Maritime Alps. *European Wolf Newsletter* **3**.

Lequette B., Poulle M.L., Houard T and Dahier T. (1996b). Problems through livestock depredation. *European Wolf Newsletter* **4**.

Lequette B., Poulle M.-L. and Dahier T. (2000). Coexistence of wolves and sheep breeding activity in the French Alps: A new challenge for 2000. In: *Beyond 2000 Realities of Global Wolf Restoration. Program and abstracts*. International Wolf Center, Ely, Minnesota: 33.

Levin M. (2000). Electrical fences against large predators. *Carnivore Damage Prevention News* **2**: 6-7.

Levin M. (2002). How to prevent damage from large predators with electric fences. *Carnivore Damage Prevention News* **5**: 5-8.

Linnell J.D.C. (2000). Norwegian brown bears: holders of an unwanted world record. *Carnivore Damage Prevention News* **1**: 4-5.

Linnell J.D.C., Smith M.E., Odden J., Kaczensky P. and Swenson J. (1996). *Carnivores and sheep farming in Norway. 4. Strategies for the reduction of carnivore-livestock conflicts: a review*. NINA Oppdragsmelding 443. 118 pp.

Linnell J.D.C., Odden J., Smith M.E., Aanes R. and Swenson J. (1999). Large carnivores that kill livestock: do "problem individuals" really exist? *Wildlife Society Bulletin* **27(3)**: 698-705.

Linnell J.D.C., Swenson J. and Andersen R. (2000). Conservation of biodiversity in Scandinavian boreal forests: large carnivores as flagships, umbrellas, indicators, or keystones? *Biodiversity and Conservation* **9**: 857-868.

Linnell J.D.C., Andersen R., Kvam T., Andrén H., Liberg O., Odden J. and Moa P.F. (2001a). Home range size and choice of management strategy for lynx in Scandinavia. *Environmental Management* **27(6)**: 869-879.

Linnell J.D.C., Swenson J.E. and Andersen R. (2001b). Predators and people: conservation of large carnivores is possible at high human densities if management policy is favourable. *Animal Conservation* **4**: 345-349.

Linnell J.D.C., Nilsen E.B., Lande U.S., Herfindal I., Odden J., Skogen K., Andersen R. and Breitenmoser U. (2002a). Zoning as a means of mitigating conflicts with large carnivores. In: *People and wildlife: conflict or coexistence?* Abstracts of The Zoological Society of London and Wildlife Conservation Society symposium, London.

Linnell J.D.C., Andersen R., Andersone Ž., Balčiauskas L., Blanco J.C., Boitani L., Brainerd S., Breitenmoser U., Kojola I., Liberg O., Løe J., Okarma H., Pedersen H.C., Promberger C., Sand H., Solberg E.J., Valdmann H. and Wabakken P.

(2002b). *The fear of wolves: A review of wolf attacks on humans*. NINA Oppdragsmelding 731. 65 pp.

Litvaitis J.A. (2000). Investigating food habits of terrestrial vertebrates. In: *Research techniques in animal ecology: controversies and consequences*. Boitani L. and Fuller T.K. eds. Columbia University Press, New York: 165-190.

Litvaitis J.A., Titus K. and Anderson E. (1996). Measuring vertebrate use of terrestrial habitats and foods. In: *Research and management techniques for wildlife and habitats.* 5th ed., rev. Bookhout T.A. ed. The Wildlife Society, Bethseda, Md.: 254-274.

Lockie J.D. (1959). The estimation of the food of foxes. *Journal of Wildlife Management* **23**: 224-227.

Longauer R. (1994). Forests of Slovakia. In: *Conservation of forests in Central Europe*. Paulenka J. and Paule L. eds. Arbora Publishers, Zvolen: 133-138.

Lopez B.H. (1978). *Of wolves and men*. Charles Scribner's Sons, New York. 309 pp.

Lorenz K. (1954). Man meets dog. Methuen. & Co. Ltd., London. 198 pp.

Lorenz J.R. (1985). *Introducing livestock-guarding dogs*. Extension Circular 1224/June. Oregon State University Extension Service. 4 pp.

Lorenz J.R. and Coppinger L. (1986). *Raising and training a livestock-guarding dog*. Extension Circular 1238/April. Oregon State University Extension Service. 8 pp.

Lorenz J.R., Coppinger R.P. and Sutherland M.R. (1986). Causes and economic effects of mortality in livestock guarding dogs. *J. Range Manage*. **39(4)**: 293-295.

Luczy G. (2004). „Upeču" sa tatranské kamzíky? (Are Tatra chamois "roasting"?) *Tatry* **XLIII(1)**:4. (in Slovak.)

Luczy G. (2000). Prežijú rok 2005? (Will they survive 2005?) *Tatry* **XXXIX(3)**:4-5. (in Slovak.)

Lukáč J. (in prep.). Wolves in Slovakia. Understand and protect? In: Proceedings of the 2003 conference "The wolf in the Carpathians" held in Bystra, Poland.

Lynn W.S. (2003). Sound science is never enough: ethics, science and values in wolf recovery. In: *World Wolf Congress 2003 Bridging Science and Community*. Book of abstracts. Banff, Canada: 24.

MacDonald D. and Barrett P. (1993). *Mammals of Britain and Europe.* Collins, London. 448 pp.

Mace R.D. and Jonkel C.J. (1986). Local food habits of the grizzly bear in Montana. *Int. Conf. Bear Res. and Manage*. **6**: 105-110.

MacHutchon A.G. and Wellwood D.W. (2003). Grizzly bear food habits in the northern Yukon, Canada. *Ursus* **14(2)**: 225-235.

MacNulty D.R. and Smith D.W. (2003). Group hunting behaviour in wolves. In: *World Wolf Congress 2003 Bridging Science and Community*. Book of abstracts. Banff, Canada: 57-58.

Majda M. (2001). Úrazy strážcov v teréne. (Injuries of rangers in the field.) *Ochrana prírody Slovenska* **2001(2)**: 22. (in Slovak.)

Mao J.S., Boyce M., Smith D.W., Singer F.J., Vales D.J. and Vore J.M. (2003). Elk habitat selection before and after wolf reintroduction in Yellowstone National Park. In: *World Wolf Congress 2003 Bridging Science and Community*. Book of abstracts. Banff, Canada: 55.

Marker L. (2000a). *Cheetah conservation in Southern Africa*. Felid Taxon Advisory Group Action Plan - III. URL: www.csew.com/felidtag/pages/Reports/ActionPlan2000_III.htm. On Web 2001.

Marker L. (2000b). Donkeys protecting livestock in Namibia. *Carnivore Damage Prevention News* **2**: 7-8.

Marker L. (2000c). *Livestock guarding dogs*. Unpublished panel report. 4 pp.

Martin P. and Bateson P. (1993). *Measuring behaviour: an introductory guide.* 2nd ed. Cambridge University Press, Cambridge. 222 pp.

Martínková N. and Zahradníková A. (2003). The brown bear in Slovakia. In: *Living with bears: a large carnivore in a shrinking world*. Kryštufek B., Flajšman B. and Griffiths H.I. eds. Ecological Forum LDS, Ljubljana: 258-271.

Mattioli L., Capitani C., Avanzinelli E., Bertelli I., Gazzola A. and Apollonio M. (2003). Impact of wolf predation and harvesting on roe deer in north-eastern Tuscany. In: *World Wolf Congress 2003 Bridging Science and Community*. Book of abstracts. Banff, Canada: 67.

Mattson D.J. (1990). Human impacts on bear habitat use. *Int. Conf. Bear Res. and Manage*. **8**: 33-56.

Mattson D.J., Blanchard B.M. and Knight R.R. (1991). Food habits of Yellowstone grizzly bears, 1977-1987. *Can. J. Zool*. **69**: 1619-1629.

Mattson D.J., French M.G. and French S.P. (2002). Consumption of earthworms by Yellowstone grizzly bears. *Ursus* **13**: 105-110.

McCullough D.R. (1979). *The George Reserve deer herd: population ecology of a K-selected species*. Univ. Michigan Press, Ann Arbor. 271 pp.

McGrew J.C. and Blakesley C.S. (1982). How Komondor dogs reduce sheep losses to coyotes. *J. Range Manage.* **35(6)**: 693-696.

McLellan B.N. (1990). Relationships between human industrial activity and grizzly bears. *Int. Conf. Bear Res. and Manage*. **8**: 57-64.

McLellan B.N. (1994). Density-dependent population regulation of brown bears. In: *Density-dependent population regulation of black, brown, and polar bears*. Taylor M. ed. Int. Conf. Bear Res. and Manage. Monogr. Series No. 3: 15-24.

McLellan B.N. and Hovey F.W. (1995). The diet of grizzly bears in the Flathead River drainage of southeastern British Columbia. *Can. J. Zool*. **73**: 704-712.

Mealey S.P. (1980). The natural food habits of grizzly bears in Yellowstone National Park, 1973-74. *Int. Conf. Bear Res. and Manage*. **4**: 281-292.

Mech L.D. (1966). *The wolves of Isle Royale.* U.S. National Park Service Fauna Series 7.

Mech L.D. (1970). *The wolf: the ecology and behavior of an endangered species*. Doubleday/Natural History Press, Garden City, N.Y. 384 pp.

Mech L.D. (1995a). The challenge and opportunity of recovering wolf populations. *Conservation Biology* **9(2)**: 270-278.

Mech L.D. (1995b). What do we know about wolves and what more do we need to know? In: *Ecology and conservation of wolves in a changing world*. Carbyn L.N., Fritts S.H. and Seip D.R. eds. Proceedings of the Second North American Symposium on Wolves. Edmonton, Alberta. 1992: 537-545.

Mech L.D. (1996). A new era for carnivore conservation. *Wildlife Society Bulletin* **24(3)**: 397-401.

Mech L.D. (2000). Wolf restoration to the Adirondacks: the advantages and disadvantages of public participation in the decision. In: *Wolves and human communities: biology, politics and ethics.* Sharpe V.A., Norton B. and Donnelly S. eds. Island Press, Washington, D.C.: 13-22.

Mech L.D. (2001). Managing Minnesota's recovered wolves. *Wildlife Society Bulletin* **29(1)**: 70-77.

Mech L.D. (2003). Examining some common claims about wolf ecology and behavior. In: *World Wolf Congress 2003 Bridging Science and Community*. Book of abstracts. Banff, Canada: 62.

Mech L.D. and Boitani L. (2003a). Wolf social ecology. In: *Wolves: behavior, ecology and conservation*. Mech L.D. and Boitani L. eds. The University of Chicago Press, Chicago and London: 1-34.

Mech L.D. and Boitani L. eds. (2003b). *Wolves: behavior, ecology and conservation*. The University of Chicago Press, Chicago and London. 448 pp.

Mech L.D. and Peterson R.O. (2003). Wolf-prey relations. In: *Wolves: behavior, ecology and conservation*. Mech D.L. and Boitani L. eds. The University of Chicago Press, Chicago and London: 131-160.

Mech L.D., Fritts S.H. and Paul W.J. (1988). Relationship between winter severity and wolf depredations on domestic animals in Minnesota. *Wildl. Soc. Bull.* **16**: 269-272.

Mech L.D., Fritts S.H. and Nelson M.E. (1996). Wolf management in the 21st century: From public input to sterilization. *J. Wildl. Res.* **1**: 195-198.

Mech L.D., Harper E.K., Meier T.J. and Paul W.J. (2000). Assessing factors that may predispose Minnesota farms to wolf depredations on cattle. In: *Beyond 2000 Realities of Global Wolf Restoration. Program and abstracts*. International Wolf Center, Ely, Minnesota: 30-31.

Meier T., Bangs E., Fontaine J., Boyd D., Jimenez M., Cox B., Mack C. and Niemeyer C. (2000). Livestock depredation and wolf control in the northern Rocky Mountain states. In: *Beyond 2000 Realities of Global Wolf Restoration. Program and abstracts*. International Wolf Center, Ely, Minnesota: 33.

Meriggi A. and Lovari S. (1996). A review of wolf predation in southern Europe: does the wolf prefer wild prey to livestock? *Journal of Applied Ecology* **33**: 1561-1571.

Mertens A. and Anghel C. (2000). Livestock depredation. In: *Carpathian Large Carnivore Project annual report 2000*. CLCP. S&G Print, Haco International: 18-19.

Mertens A. and Boronia V. (2000). Livestock conflicts. In: *Carpathian Large Carnivore Project annual report 2000*. CLCP. S&G Print, Haco International: 45-46.

Mertens A. and Promberger C. (2000). Problems in damage prevention in Romania. *Carnivore Damage Prevention News* **2**: 5-6.

Mertens A. and Promberger C. (2001). Economic aspects of large carnivore-livestock conflicts in Romania. *Ursus* **12**: 173-180.

Mertens A. and Promberger C. (2003). Recommendations to reduce carnivore-livestock conflicts, based on a 5-year analysis in Romania. In: *Carpathian workshop on large carnivore conservation*. Directorate of Culture and of Cultural and Natural Heritage, Council of Europe, Strasbourg: 28.

Mertens A. and Sandor A. (2000). Bears. In: *Carpathian Large Carnivore Project annual report 2000*. CLCP. S&G Print, Haco International: 14-15.

Mertens A., Promberger C. and Gheorge P. (2002). Testing and implementing the use of electric fences for night corrals in Romania. *Carnivore Damage Prevention News* **5**: 2-5.

Michalík D. (2002). Môj osobný pohľad na ochranu kamzíkov. (My personal view of the chamois protection.) In: *Ochrana kamzíka*. (*Chamois protection.*) Janiga M. and Švajda J. eds. TANAP, NAPANT, IHAB: 89-98. (in Slovak with English abstract.)

Mihál I., Šoltés R. and Šoltésová A. (1988). *Kvety Tatier*. (*Flowers of the Tatras*.) Príroda, Bratislava. 176 pp. (in Slovak.)

Miller S.D., Sellers R.A. and Keay J.A. (2003). Effects of hunting on brown bear cub survival and litter size in Alaska. *Ursus* **14(2)**: 130-152.

Morgan C.P., Davis J., Ford T. and Laney N. (2004). Promoting understanding: the approach of the North Cascades Grizzly Bear Outreach Project. *Ursus* **15(1)**: 137-141.

Moser C.A. and Kalton G. (1971). *Survey methods in social investigation.* 2nd ed. Gower Publishing, Aldershot. 555 pp.

MP SR (2000a). *Správa o poľnohospodárstve a potravinárstve v Slovenskej republike 2000 (Zelená správa). (Report on agriculture and the food industry in the Slovak Republic in 2000 (The Green Report).)* Ministerstvo pôdohospodárstva Slovenskej republiky, Bratislava. 302 pp. (in Slovak.)

MP SR (2000b). *Negotiating position of the Slovak Republic. Chapter 7: Agriculture*. Ministerstvo pôdohospodárstva Slovenskej Republiky, Bratislava. 101 pp.

MP SR (2000c). *Koncepcia rozvoja chovu oviec v SR do roku*. (*Concept of sheep breeding development in the Slovak Republic up to 2005.*) URL: http://www.mpsr.sk/index.php On Web 2001-2004. (in Slovak.)

MP SR (2002). *The Green Report*. Ministry of Agriculture of the Slovak Republic, Bratislava. 100 pp.

Mráz I. (1996a). Vlci „zhltli“ pol milióna korún. (Wolves “devoured” half a million crowns.) *Poľovníctvo a rybárstvo* **48(6)**: 6. (in Slovak.)

Mráz I. (1996b). Ako lovia vlci (1). (How wolves hunt (1).) *Poľovníctvo a rybárstvo* **48(8)**: 8-9. (in Slovak.)

Mráz I. (1996c). Ako lovia vlci (2). How wolves hunt (2).) *Poľovníctvo a rybárstvo* **48(9)**: 18. (in Slovak.)

Mueller C., Herrero S. and Gibeau M.L. (2004). Distribution of subadult grizzly bears in relation to human development in the Bow River Watershed, Alberta. *Int. Conf. Bear Res. and Manage*. **15(1)**: 35-47.

Muhly T., Callaghan C., Alexander S., Mamo C., Gates C.C. and Musiani M. (2003). Predicting risk of livestock depredation by wolves in southwestern Alberta. In: *World Wolf Congress 2003 Bridging Science and Community*. Book of abstracts. Banff, Canada: 38.

Murie A. (1944). *The wolves of Mount McKinley.* U.S. National Park Service Fauna Series No. 5. U.S. Government Printing Office, Washington, D.C. 238 pp.

Murie A. (1985). *The grizzlies of Mount McKinley.* University of Washington Press ed. 251 pp.

Murphy M.A., Waits L.P., Kendall K.C., Wasser S.K., Higbee J.A. and Bogden R. (2002). An evaluation of long-term preservation methods for brown bear (*Ursus arctos*) faecal DNA samples. *Conservation Genetics* **3(4)**: 435-440.

Musiani M. (2000). Preventing wolf predation on livestock with light-mobile barriers. *Carnivore Damage Prevention News* **1**: 3-4.

Musiani M., Mamo C., Boitani L., Callaghan C., Gates C.C., Breck S. and Volpi G. (2003). Human-wolf conflicts in Western North America: can fladry protect livestock? In: *World Wolf Congress 2003 Bridging Science and Community*. Book of abstracts. Banff, Canada: 77.

Mysterud I. (1980). Bear management and sheep husbandry in Norway, with discussion of predatory behavior significant for evaluation of livestock losses. *Int. Conf. Bear Res. and Manage*. **4**: 233-241.

Mysterud I. and Warren J.T. (1997). Brown bear depredation on domestic sheep registered with mortality transmitters. *Int. Conf. Bear Res. and Manage*. **9(2)**: 107-111.

Nass R.D., Lynch G. and Theade J. (1984). Circumstances associated with predation rates on sheep and goats. *Journal of Range Management* **37**: 423-426.

National Research Council (1997). *Wolves, bears and their prey in Alaska: biological and social challenges in wildlife management*. National Academy Press, Washington D.C. 207 pp.

Nelson R.A., Folk G.E., Pfeiffer E.W., Craighead J.J., Jonkel C.J. and Steiger D.L. (1983). Behavior, biochemistry, and hibernation in black, grizzly, and polar bears. *Int. Conf. Bear Res. and Manage*. **5**: 284-290.

Novák Ľ. (1943). *Slovenská vlastiveda I*. (*Slovak humanities I.*) Vydanie slovenskej akadémie vied a umeni, Bratislava. (in Slovak.)

Nowak S. (2003). Wolf predation on ungulates and livestock in the Western Carpathian Mountains (S Poland). In: *World Wolf Congress 2003 Bridging Science and Community*. Book of abstracts. Banff, Canada: 77.

Nowak S. and Mysłajek R. (2003). To prevent conflicts – a program of wolf conservation in the Western Carpathians (S Poland). In: *World Wolf Congress 2003 Bridging Science and Community*. Book of abstracts. Banff, Canada: 60-61.

Nowak S. and Mysłajek R. (in prep.). Modelowy program ochrony wilka *Canis Lupus* W Karpatach zachodnich. (Model programme for conservation of the wolf *Canis lupus* in the Western Carpathians.) In: Proceedings of the 2003 conference "The wolf in the Carpathians" held in Bystra, Poland. (in Polish.)

Noyce K.V. and Coy P.L. (1990). Abundance and productivity of bear food species in different forest types of northcentral Minnesota. *Int. Conf. on Bear Res. and Manage.* **8**: 169-181.

Noyce K.V. and Garshelis D.L. (1997). Influence of natural food abundance on black bear harvests in Minnesota. *J. of Wildl. Manage*. **61**: 1067-1074.

Nygård T., Berntsen F., Bjørnnes E., Brøseth H., Kvam T., Pedersen H.P., Sørensen O.J. and Swensson J. (2002). Home range sizes of brown bear in a border area between Norway and Sweden with different livestock husbandry patterns. In: *Living with bears. Information, program and abstracts from the 14th International Conference on Bear Research and Management*. Kvam T. and Sørenson O.J. eds. Nord-Trøndelag University College, Steinkjer, Norway: 109.

Odden J., Linnell J.D.C., Moa P.F., Herfindal I., Kvam T. and Andersen R. (2002). Lynx depredation on domestic sheep in Norway. *Journal of Wildlife Management* **66(1)**: 98-105.

Ohdachi S. and Aoi T. (1987). Food habits of brown bears in Hokkaido, Japan. *Int. Conf. Bear Res. and Manage*. **7**: 215-220.

Okarma H. (1995). The trophic ecology of wolves and their predatory role in ungulate communities of forest ecosystems in Europe. *Acta Theriologica* **40**: 335-386.

Okarma H. and Jędrzejewski W. (1997). Live-trapping wolves with nets. *Wildlife Society Bulletin* **25**: 78-82.

Okarma H., Jędrzejewska B., Jędrzejewski W., Krasiński Z.A. and Miłkowski L. (1995). The roles of predation, snow cover, acorn crop, and man-related factors on ungulate mortality in Białowieża Primeval Forest, Poland. *Acta Theriologica* **40(2)**: 197-217.

Okarma H., Jedrzejewski W., Schmidt K., Sniezko S., Bunevich A.N. and Jedrzejewska B. (1998). Home ranges of wolves in Bialowieza Primeval Forest, Poland, compared with other Eurasian populations. *J. Mammal.* **79**: 842-852.

Okarma H., Dovhanych Y., Find'o S., Ionescu O., Koubek P. and Szemethy L. (2000). *Status of carnivores in the Carpathian ecoregion*. Carpathian Ecoregion Initiative. 37 pp.

Olson S.F. (1938). Organization and range of the pack. *Ecology* **19**: 168-170.

Ondruš S. (2002). Poznámky k programu záchrany kamzíka vrchovského tatranského v NAPANT-e. (Remarks to the conservation programme for the Tatra mountain chamois in the Low Tatras National Park.) In: *Ochrana kamzíka*. (*Chamois protection*.) Janiga M. and Švajda J. eds.TANAP, NAPANT, IHAB: 183-194. (in Slovak with English abstract.)

Oppenheim A.N. (1992). *Questionnaire design, interviewing and attitude assessment*. 2nd ed. Printer Publishers, London. 303 pp.

Packard J.M. (2003). Wolf behavior: reproductive, social, and intelligent. In: *Wolves: behavior, ecology and conservation*. Mech L.D. and Boitani L. eds. The University of Chicago Press, Chicago and London: 35-65.

Palacios F. (2003). Improving wolf habitat in SW European countries. In: *World Wolf Congress 2003 Bridging Science and Community*. Book of abstracts. Banff, Canada: 21.

Palomero G., Herrero J., García-Serrano A. and Blanco J.C. (2002). Brown bear (*Ursus arctos* L.) interactions with large mammals and implications for its conservation in the Cantabrian mountains. In: *Living with bears. Information, program and abstracts from the 14th International Conference on Bear Research and Management*. Kvam T. and Sørenson O.J. eds. Nord-Trøndelag University College, Steinkjer, Norway: 78.

Papageorgiou N., Vlachos C., Sfougaris A. and Tsachalidis E. (1994). Status and diet of wolves in Greece. *Acta Theriologica* **39(4)**: 411-416.

Paul W.J. (2000). Trends and management of wolf-livestock conflicts in Minnesota. In: *Beyond 2000 Realities of Global Wolf Restoration. Program and abstracts*. International Wolf Center, Ely, Minnesota: 35.

Paule L. (1994). Biodiversity of the Western Carpathians' forest ecosystems. In: *Conservation of forests in Central Europe*. Paulenka J. and Paule L. eds. Arbora Publishers, Zvolen: 31-38.

Paulenka J. (1989). Škody spôsobené zverou v lesoch MLVH SSR. (Damage caused by game in the forests of MLVH SSR) In: *Problematika zveri v lesných ekosystémoch*. (*The issue of game in forest ecosystems*) Proceedings of symposium. Lesoprojekt, Zvolen: 42-51.

Pčola Š. (2003). Current status of the bear population in the Slovak Eastern Carpathians. In: *The integrated solution to the problem of nuisance bears* (Ursus arctos). Rigg R. and Baleková K. eds. Conference proceedings, Nová Sedlica, Slovakia 11-12.4.2002: 127-130.

Pearson E.W. and Caroline M. (1981). Predator control in relation to livestock losses in central Texas. *Journal of Range Management* **34(6)**: 435-441.

Pedersen V.A., Linnell J.D.C., Andersen R., Andrén H., Lindén M. and Segerström P. (1999). Winter lynx *Lynx lynx* predation on semi-domestic reindeer *Rangifer tarandus* in northern Sweden. *Wildl. Biol*. **5(4)**: 203-211.

Pedro S.R. (1996-2000*a*). *Characteristics of the breed*. URL: http://www.geocities.com/mop07231/cl_descP2.htm On Web 2001.

Pedro S.R. (1996-2000b). *A "forgotten jewel" versus a "dying breed"*. URL: http://www.geocities.com/mop07231/cl_jewelP6.htm On Web 2001.

Peterson R. and Ciucci P. (2003). The wolf as a carnivore. In: *Wolves: behavior, ecology and conservation*. Mech D.L. and Boitani L. eds. The University of Chicago Press, Chicago and London: 104-130.

Phillips M.K. (1987). Behavior and habitat use of grizzly bears in northeastern Alaska. *Int. Conf. Bear Res. and Manage*. **7**: 159-167.

Pilinksý P. (2001). *Záznam z pracovného rokovania v súvislosti s reguláciou početnosti populaácie medveďa hnedého na rok 2001*. (*Minutes of a working meeting in connection with the number regulation of the brown bear population in 2001*.) 5 pp. (in Slovak.)

Plánovský Ľ., Novák R., Malík J. and Sedlák V. (1967). *Pasenie a salašníctvo*. (*Grazing and shepherding*.) Slovenské vydavateľstvo pôdohospodárskej literatúry, Bratislava. 199 pp. (in Slovak.)

Podolák J. (1962). Prvé výsledky výskumu pastierstva v oblasti Vysokých Tatier. (First results of research on shepherding in the High Tatras region) *Slovenský národopis* **10**: 124-140. (in Slovak.)

Podolák J. (1967). *Pastierstvo v oblasti Vysokých Tatier*. (*Shepherding in the High Tatras region.*) SAV, Bratislava. 212 pp. (in Slovak.)

Podolák J. (1972). Niektoré problémy porovnávacieho štúdia ľudových kultúr karpatskej oblasti (na základe etnografických materiálov o pastierstve). (Some problems in comparing studies of folk culture in Carpathian regions (on the basis of ethnographic material on shepherding.)) In: *Ľudová kultúra v Karpatoch*. (*Folk culture in the Carpathians*.) Vydavateľstvo SAV, Bratislava: 31-62. (in Slovak.)

Podolák J. (1982). *Tradičné ovčiarstvo na Slovensku*. (*Traditional sheep breeding in Slovakia.*) Veda, Bratislava. 232 pp. (in Slovak.)

Podolák J. (1982). Traditional utilization of the production of sheep milk in Slovakia. *Ethnologia Slavica* **16**: 49-79.

Polách A. (1988). Ovčácký pes a jeho použití u stáda. (The sheep dog and its use in the flock.) In: *Chov oviec*. (*Sheep breeding.*) Gajdošík M. and Polách A. eds. Príroda, Bratislava: 272-276. (in Slovak.)

Pole A. (2000). *The behaviour and ecology of African wild dogs,* Lycaon pictus*, in an environment with reduced competitor density*. PhD thesis. University of Aberdeen, Aberdeen. 307 pp.

Promberger C. (1999). Project wolf. *BBC Wildlife Magazine* **17(6)**: 70-76.

Promberger C., Ionescu O., Petre L., Roschak C., Surth P., Furpaß B., Todicesu L., Sandor A., Minca M., Stan T., Homm H., Predoiu G. and Scurtu M. (1997). *Carpathian large carnivore project: annual report 1996/1997*. Munich Wildlife Society, Ettal, Germany.

Putman R.J. (1984). Facts from faeces. *Mammal Rev*. **14(2)**: 79-97.

Radúch J. (2002a). Tatranské kamzíky a ich predátory. (Tatra chamois and their predators.) *Poľovníctvo a rybárstvo* **54(1)**: 6-7. (in Slovak.)

Radúch J. (2002b). Význam predátorov v ekológii tatranského kamzíka. (The significance of predators in the ecology of the Tatra chamois.) In: *Ochrana kamzíka*. (*Chamois protection*.) Janiga M. and Švajda J. eds. TANAP, NAPANT, IHAB: 56-66. (in Slovak with English abstract.)

Radúch J. (2002c). Príprava a štruktúra projektu ochrany kamzíka v rokoch 1999-2000. (Preparation and structure of the Tatra Chamois Project in 1999-2000.) In: *Ochrana kamzíka*. (*Chamois protection*.) Janiga M. and Švajda J. eds. TANAP, NAPANT, IHAB: 205-208. (in Slovak with English abstract.)

Radúch J. (2003a). Vlk siaha po náhrade. (The wolf reaches compensation.) *Poľovníctvo a rybárstvo* **55(2)**: 8-9. (in Slovak.)

Radúch J. (2003b). Prevention of problems with nuisance bears through protecting their biotope. In: *The integrated solution to the problem of nuisance bears* (Ursus arctos). Rigg R. and Baleková K. eds. Conference proceedings, Nová Sedlica, Slovakia 11-12.4.2002: 53-63.

Radúch J. (2004). Prvé dobré signály. (The first good signs.) *Poľovníctvo a rybárstvo* **56(1)**: 6-7. (in Slovak.)

Raine R.M. and Kansas J.L. (1990). Black bear seasonal food habits and distribution by elevation in Banff National Park, Alberta. *Int. Conf. Bear Res. and Manage.* **8**: 297-304.

Rakyta E. (2001). Dynamika rastu populácie a lov medveďov na Slovensku. Otázniky nad medveďou populáciou. (The dynamics of population increase and hunting of the bear in Slovakia. Question marks over the bear population.) *Poľovníctvo a rybárstvo* **53(3)**: 4-6. (in Slovak.)

Ratti J.T. and Garton E.O. (1996). Research and experimental design. In: *Research and management techniques for wildlife and habitats.* 5th ed., rev. Bookhout T.A. ed. The Wildlife Society, Bethseda, Md.: 1-23.

Rauer G. (2003). Brown bear management in Austria: experiences with aversive conditioning. In: *The integrated solution to the problem of nuisance bears* (Ursus arctos). Rigg R. and Baleková K. eds. Conference proceedings, Nová Sedlica, Slovakia 11-12.4.2002: 119-126.

Rauer G., Kaczensky P. and Knauer F. (2003). Experiences with aversive conditioning of habituated brown bears in Austria and other European countries. *Ursus* **14(2)**: 215-224.

Remeník Ľ. (1996). O vlkovi bez emócií. (On wolves without emotions.) *Poľovníctvo a rybárstvo* **48(12).** (in Slovak.)

Remeník Ľ. (1999). Etickejšie obhospodarovanie medveďa hnedého. (Ethical management of the brown bear.) *Poľovníctvo a rybárstvo* **51(5)**: 6. (in Slovak.)

Remeník Ľ. (2000). Ešte k lovu medveďa. (More on bear hunting.) *Poľovníctvo a rybárstvo* **52(6)**: 20. (in Slovak.)

Reynolds J.C. and Aebischer N.J. (1991). Comparison and quantification of carnivore diet by faecal analysis: a critique, with recommendations, based on a study of the Fox *Vulpes vulpes*. *Mammal Review* **21(3)**: 97-122.

Reynolds J.C. and Tapper S.C. (1996). Control of mammalian predators in game management and conservation. *Mammal Review* **26**: 127-156.

Ribeiro S., Almada M. and Petrucci-Fonseca F. (2003). Recovery of traditional techniques of livestock protection from wolf predation in Portugal. In: *World Wolf Congress 2003 Bridging Science and Community*. Book of abstracts. Banff, Canada: 40.

Richter V. (1991). Lov zveri a produkcia diviny (Game hunting and production.). *Poľovníctvo a rybárstvo* **42(9)**: 8-9. (in Slovak.)

Rigg R. (2001a). *Livestock guarding dogs: their current use world wide*. IUCN/SSC Canid Specialist Group Occasional Paper No 1 [online]. 133 pp. URL: http://www.canids.org/occasionalpapers On Web 2001-2004.

Rigg R. (2001b). *The use of livestock guarding dogs to protect sheep and goats from large carnivores in Slovakia.* Unpublished report. The Slovak Wildlife Society. 25 pp.

Rigg R. (2002a). *The use of livestock guarding dogs to protect sheep and goats from large carnivores in Slovakia.* 2001 report [online]. 25 pp. URL: *http://www.carnivoreconservation.org* On Web February 2002.

Rigg R. (2002b). *The use of livestock guarding dogs to protect sheep and goats from large carnivores in Slovakia.* Unpublished report. The Slovak Wildlife Society. 39 pp.

Rigg R. (2003a). The use of livestock guarding dogs to protect sheep and goats from bears and wolves. In: *The integrated solution to the problem of nuisance bears* (Ursus arctos). Rigg R. and Baleková K. eds. Conference proceedings, Nová Sedlica, Slovakia 11-12.4.2002: 27-40.

Rigg R. (2003b). Perceptions and reality in conflicts over large carnivores in Slovakia: who's afraid of what? In: *Carpathian workshop on large carnivore conservation*. Directorate of Culture and of Cultural and Natural Heritage, Council of Europe, Strasbourg: 30.

Rigg R. (2003c). Pastierske strážne psy a zachovanie populácie vlka na Slovensku. (Livestock guarding dogs and conservation of the wolf population in Slovakia.) In: *Vlky a rysy v oblasti slovensko-maďarských hraníc*. (*Wolves and lynx in the Slovak-Hungarian border region*.) Gadó G.P. and Pačenovský S. eds. WWF Maďarsko, Budapest: 62-70. (in Slovak.)

Rigg R. (2004). The B.E.A.R.S. Project: Bear Education, Awareness and Research in Slovakia. Half-year report to the World Wide Fund for Nature. Slovak Wildlife Society, Liptovský Hrádok. 2 pp.

Rigg R. and Baleková K. eds. (2003). *The integrated solution to the problem of nuisance bears* (Ursus arctos). Sloboda zvierat, Bratislava, Slovakia. 142 pp.

Rigg R.M. and Finďo S. (2000). Wolves in the Western Carpathians: past, present and future. In: *Beyond 2000 Realities of Global Wolf Restoration. Program and abstracts*. International Wolf Center, Ely, Minnesota: 95.

Rigg R. and Gorman M. (2002). The use of livestock guarding dogs to protect sheep from bears and wolves in Slovakia. In: *Living with bears. Information, program and abstracts from the 14th International Conference on Bear Research and Management*. Kvam T. and Sørenson O.J. eds. Nord-Trøndelag University College, Steinkjer, Norway: 96.

Rigg R., Gorman M. and Sillero-Zubiri C. (2003). Livestock guarding dogs and their modern role in large carnivore conservation initiatives. In: *World Wolf Congress 2003 Bridging Science and Community*. Book of abstracts. Banff, Canada: 41.

Robel R.J., Dayton A.D., Henderson F.R., Meduna R.L. and Sqaeth C.W. (1981). Relationships between husbandry methods and sheep losses to canine predators. *J. Wildl. Mgmt*. **45**: 894-911.

Röben P. (1980). Status of the brown bear in the Pyrenees. *Int. Conf. Bear Res. and Manage*. **4**: 243-247.

Rode K.D. and Robbins C.T. (2000). Why bears consume mixed diets during fruit abundance. *Can. J. Zool.* **78**: 1640-1645.

Rodgers A.R. (1990). Evaluating preference in laboratory studies of diet selection. *Canadian Journal Zoology* **68**: 188-190.

Rogers L. (1976). Effects of mast and berry crop failure on survival, growth, and reproductive success of black bears. *Trans. 41st North Amer. Wildl. and Nat. Resources Conf.*: 431-438.

Russell C. and Enns M. (2003). *Learning to be wild: raising orphan grizzlies.* Hutchinson, London. 154 pp.

Ryder M.L. (1983). *Sheep and Man*. Gerald Duckworth and Co., London.

Sabadoš K and Śimiak M. (1981). Rozšírenie a poľovné obhospodarovanie medveďa hnedého (*Ursus arctos* L.) na Slovensku. (The distribution and hunting management of the brown bear (*Ursus arctos* L.) in Slovakia.) Folia Venatoria **10-11**: 15-33. (in Slovak with English summary.)

Sabadoš K., Farkaš J. and Ďurička J. (1996). Sezóna v číslach. (The season in figures.) *Poľovníctvo a rybárstvo* **48(12)**: 8. (in Slovak.)

Sabadoš K. *et al*. (1997). Poľovníctvo v štatistike. Sezóna 1996/1997. (Hunting in statistics. The 1996/1997 season.) *Poľovníctvo a rybárstvo* **49(10)**: 8-9. (in Slovak.)

Sabadoš K. *et al*. (1998). Slovenské poľovnícke hospodárenie v r.1997. (Slovak hunting management in 1997.) *Poľovníctvo a rybárstvo* **50(11)**: 10-11. (in Slovak.)

Sagør J.T., Swenson J.E. and Røskaft E. (1997). Compatibility of brown bear *Ursus arctos* and free-ranging sheep in Norway. *Biol. Cons*. **81**: 91-95.

Salvatori V. (2003). Mapping environmental suitability for large carnivores in the Carpathians. In: *Carpathian workshop on large carnivore conservation*. Directorate of Culture and of Cultural and Natural Heritage, Council of Europe, Strasbourg: 25-26.

Salvatori V. and Mertens A. (2002). Mapping probability of carnivore-livestock conflicts in the Romanian Carpathian Mountains. In: *People and wildlife: conflict or coexistence?* Abstracts of The Zoological Society of London and Wildlife Conservation Society symposium, London.

Salvatori V., Okarma H., Ionescu O., Dovhanych Y., Finďo S. and Boitani L. (2002). Hunting legislation in the Carpathian Mountains: implications for the conservation and management of large carnivores. *Wildlife Biology* **8(1)**: 3-10.

Samuel M.D. and Fuller M.R. (1996). Wildlife radiotelemetry. In: *Research and management techniques for wildlife and habitats.* 5th ed., rev. Bookhout T.A. ed. The Wildlife Society, Bethseda, Md.: 370-418.

Sathyakumar S. and Viswanath S. (2003). Observations on food habits of Asiatic black bear in Kedarnath Wildlife Sanctuary, India: preliminary evidence on their role in seed germination and dispersal. *Ursus* **14(1)**: 99-103.

Sato Y., Mano T. and Takatsuki S. (2000). Applicability of the point-frame method for quantitative evaluation of bear diet. *Wildlife Society Bulletin* **28(2)**: 311-316.

Savelli B.G., Antonelli F. and Boitani L. (1998). *The impact of livestock support on carnivore conservation*. Large Carnivore Initiative for Europe, Institute of Applied Ecology, Rome. 170 pp.

Savolainen P., Zhang Y., Luo J., Lundeberg J. and Leitner T. (2002). Genetic evidence for an East Asian origin of domestic dogs. *Science* **298**: 1610-1613.

Schaller G.B. (1972). *The Serengeti lion: a study of predator-prey relations*. Univ. Chicago Press, Chicago, Ill. 480 pp.

Schultz R.N., Skuldt L.H., Brett M., Wydeven A.P. and Stewart J.M. (2000). Pilot-testing non-lethal depredation control methods for timber wolves (*Canis lupus*). In: *Beyond 2000 Realities of Global Wolf Restoration. Program and abstracts*. International Wolf Center, Ely, Minnesota: 37.

Scott C. (1961). Research on mail surveys. *Journal of the Royal Statistical Society, A,* **124**: 143-205.

Scott J.P. and Marston M.V. (1950). Critical periods affecting normal and maladjustive social behavior in puppies. *J. Genet. Psychol.* **77**: 25-60.

Scott J.P. and Fuller J.L. (1965). *Genetics and the social behaviour of the dog*. University of Chicago Press, Chicago. 468 pp.

Scott J.M., Temple S.A., Harlow D.L. and Shaffer M.L. (1996). Restoration and management of endangered species. In: *Research and management techniques for wildlife and habitats.* 5th ed., rev. Bookhout T.A. ed. The Wildlife Society, Bethseda, Md.: 531-539.

Sedefchev S. (2003). The oldest livestock protection method, livestock guarding dogs – wolf partners in survival. In: *World Wolf Congress 2003 Bridging Science and Community*. Book of abstracts. Banff, Canada: 79.

Servheen C., Herrero S. and Peyton B. compilers (1999). *Bears. Status survey and conservation action plan*. IUCN Gland, Switzerland and Cambridge, UK: x + 309 pp.

Sharafutdinov I.Y. and Korotkov A.M. (1976). On the ecology of the brown bear in the southern Urals. *Int. Conf. Bear Res. and Manage.* **3**: 309-311.

Sharpe V.A., Norton B. and Donnelly S. eds. (2001). *Wolves and human communities: biology, politics and ethics.* Island Press, Washington, D.C.: 321 pp.

Shideler R. and Hechtel J. (2002). Evaluation of hazing to reduce conflicts between grizzly bears and oil production activities in the Prudhoe Bay oilfields, Alaska. In: *Living with bears. Information, program and abstracts from the 14th International Conference on Bear Research and Management*. Kvam T. and Sørenson O.J. eds. Nord-Trøndelag University College, Steinkjer, Norway: 72.

Shivik J.A., Breck S.W., Treves A. and Callahan P. (2003). Current developments and future directions in non-lethal wolf predation management. In: *World Wolf Congress 2003 Bridging Science and Community*. Book of abstracts. Banff, Canada: 39.

Šíbl J. (in prep.). The forests and state forest management bill from the standpoint of protection of biodiversity and natural forests. In: Proceedings of the 2001 conference on forestry held in Tále, Slovakia.

Sillero-Zubiri C. and Gottelli D. (1995). Diet and feeding-behavior of Ethiopian wolves (*Canis simensis*). *Journal of Mammalogy* **76(2)**: 531-541.

Sillero-Zubiri C. and Laurenson M.K. (2001). Interactions between carnivores and local communities: conflict or co-existence? In: *Carnivore Conservation*. Gittleman J.L., Funk S.M., Macdonald D. and Wayne R.K. eds. Cambridge University Press, Cambridge: 282-312.

Simberloff D. (1998). Flagships, umbrellas, and keystones: is single species management passé in the landscape era? *Biological Conservation* **83**: 247-257.

Šimo J. (1996). Kamziky vo Veľkej Fatre. (Chamois in Veľká Fatra.) *Poľovníctvo a rybárstvo* **48(7)**: 6. (in Slovak.)

Sims D.E. and Dawydiak O. (1990). *Livestock protection dogs: selection, care and training*. OTR Publications, Ft. Payne, AL. 128 pp.

Škultéty J. (1970). Škody spôsobené medveďom na Slovensku. (Damage caused by the bear in Slovakia.) *Lesn. čas.* **16(1)**: 71-86. (in Slovak.)

Slavkovský P. (1997). Traditional agrarian culture. In: *Slovakia. European contexts of the folk culture*. Stoličná R. ed. Veda, Bratislava: 11-59.

Slobodyan A.A. (1976). The European brown bear in the Carpathians. *Int. Conf. Bear Res. and Manage.* **3**: 313-319.

Śmietana W. (2002). Gospodarka łowiecka i pasterska a ochrona wilka i rysia w Bieszczadach. (Game and livestock management in relation to wolf and lynx conservation in Bieszczady.) *Roczniki Bieszczadzkie* **10**: 129-144. (in Polish with English abstract.)

Śmietana W. and Klimek A. (1993). Diet of wolves in the Bieszczady Mountains, Poland. *Acta theriol*. **38**: 245-251.

Smith D., Drummer T., Murphy K. and Guernsey D. (2003). Wolf-prey interactions in Yellowstone National Park. In: *World Wolf Congress 2003 Bridging Science and Community*. Book of abstracts. Banff, Canada: 56.

Somora J. (1965). O medveďovi hnedom (*Ursus arctos* L.) z juhu Tatier. (On the brown bear (*Ursus arctos* L.) from the south of the Tatras.) *Zborník prác o Tatranskom Národnom Parku* **8**: 97-123. (in Slovak with English summary.)

Somorová H. (1997). Kým povolia výnimku. (By the time they permit an exception.) *Poľovníctvo a rybárstvo* **49(10)**: 10-11. (in Slovak.)

Soria M., Palacios F. and Gómez-Sal A. (2003). Wolf trophic function loss in Sierra de la Culebra (NW Spain): relationships with livestock and human perception. In: *World Wolf Congress 2003 Bridging Science and Community*. Book of abstracts. Banff, Canada: 81.

SOSR (1997). *Štatistická ročenka Slovenskej republiky/Statistical yearbook of the Slovak Republic*. Veda, Bratislava. 750 pp.

SOSR (2000). *Štatistická ročenka Slovenskej republiky/Statistical yearbook of the Slovak Republic*. Veda, Bratislava. 720 pp.

SOSR (2002). *Štatistická ročenka Slovenskej republiky/Statistical yearbook of the Slovak Republic*. Veda, Bratislava. 743 pp.

Spaulding R., Krausman P.R. and Ballard W.B. (2000). Observer bias and analysis of gray wolf diet from scats. *Wildlife Society Bulletin* **28(4)**: 947-950.

Sponenberg P. (2000). *Livestock guarding dogs: what is a breed, and why does it matter?* URL: http://www.mindspring.com/~skocher/Sponenberg.htm On Web October 2000

Šprocha J. (1977). Stav medveďov na Slovensku. (The status of bears in Slovakia.) *Poľovníctvo a rybárstvo* **19(11)**: 19. (in Slovak.)

Stahl P., Vandel J.M., Herrenschmidt V. and Migot P. (2001a). The effect of removing lynx in reducing attacks on sheep in the French Jura Mountains. *Biological Conservation* **101**: 15-22.

Stahl P., Vandel J.M., Herrenschmidt V. and Migot P. (2001b). Predating on livestock by an expanding reintroduced lynx population: long-term trend and spatial variability. *Journal of Applied Ecology* **38**: 674-687.

Stahl P., Vandel J.M., Ruette S., Coat L., Coat Y. and Balestra L. (2002). Factors affecting lynx predation on sheep in the French Jura. *Journal of Applied Ecology* **39**: 204-216.

Stirling I. and Derocher A.E. (1990). Factors affecting the evolution and behavioral ecology of the modern bears. *Int. Conf. Bear Res. and Manage.* **8**: 189-204.

Stockmann V. (2001). Majetková ujma predmetom záujmu verejnosti. (Property loss is a concern of public interest.) *Ochrana prírody Slovenska* **2001(2)**: 19. (in Slovak.)

Stockmann V. and Zuskin J. (1998). Forestry, hunting and biodiversity. *Enviromagazín* III (May extra issue): 31.

Stodola M. (2001). Z denníka lesníka o návštevách medveďov. (From a forester's diary on the visits of bears.) *Tatry* **XL(2)**: 10. (in Slovak.)

Stoličná R. ed. (1997). *Slovakia. European contexts of the folk culture.* Veda, Bratislava: 365 pp.

Strickland M.D., Harju H.J., McCaffery K.R., Miller H.W., Smith L.M. and Stoll R.J. (1996). Harvest management. In: *Research and management techniques for wildlife and habitats.* 5th ed., rev. Bookhout T.A. ed. The Wildlife Society, Bethseda, Md.: 445-473.

Stringham S.F. (1986). Effects of climate, dump closure, and other factors on Yellowstone grizzly bear litter size. *Int. Conf. Bear Res. and Manage.* **6**: 33-39.

Stringham S.F. (1990). Grizzly bear reproductive rate relative to body size. *Int. Conf. Bear Res. and Manage.* **8**: 433-443.

Strnádová J. (2000). *Predačný efekt vlka dravého na populáciu diviačej zveri a jeho význam v dynamike výskytu klasického moru ošípaných u diviakov na Slovensku. (The predatory effect of the wolf on the wild boar population and its significance in the dynamics of the occurrence of classical swine fever in wild boar in Slovakia.)* Masters thesis. Prírodovedecká fakulta Univerzity Komenského, Bratislava. 65 pp. (in Slovak.)

Strnádová J. (2002). Potrava vlka dravého (*Canis lupus* L., 1785) v slovenskej časti Karpát. (Diet of the wolf (*Canis lupus* L., 1785) in the Slovak part of the Carpathians.) In: *Ochrana kamzíka. (Chamois protection.)* Janiga M. and Švajda J. eds. TANAP, NAPANT, IHAB: 45-50. (in Slovak with English abstract.)

Strnádová J. (2003). Negatívne prejavy neprítomnosti vlka dravého (*Canis lupus* L.) v lesnom ekosystéme z hľadiska zdravia lovenej koristi. (Negative symptoms of the absence of the wolf *(Canis lupus* L.) in forest ecosystems from the point of view of the health of the prey hunted.) In: *Vlky a rysy v oblasti slovensko-maďarských hraníc.* (*Wolves and lynx in the Slovak-Hungarian border region.*) Gadó G.P. and Pačenovský S. eds. WWF Maďarsko, Budapest: 62-70. (in Slovak.)

Štrumbelj C. and Kryštufek B. (2003). Long-term human impact in core brown bear territory: the Kočevje area of south-central Slovenia. In: *Living with bears: a large carnivore in a shrinking world*. Kryštufek B., Flajšman B. and Griffiths H.I. eds. Ecological Forum LDS, Ljubljana: 173-205.

Šturcel M. (2001). Leto s medveďom. (Summer with a bear.) *Tatry* **XL(6)**: 28-29. (in Slovak.)

Šturcel M. (2002). K niektorým otázkam implementácie Programu záchrany kamzíka vrchovského tatranského. (Notes to some questions of the Tatras Chamois Rescue Programme.) In: *Ochrana kamzíka*. (*Chamois protection.*) Janiga M. and Švajda J. eds. TANAP, NAPANT, IHAB: 99-182. (in Slovak with English abstract.)

Šulgan F. (2002). Medvěd z Brodské. (The bear from Brodská.) In: *Výskum a ochrana cicavcov na Slovensku* **V**. Urban P. ed. Štátna ochrana prírody, Banská Bytrica: 153-155. (in Czech with English abstract.)

Sumiński P. (1976). Postavenie veľkých mäsožravcov (Carnivora) v poľovnom hospodárstve Poľskej ľudovej republiky. (The position of large carnivores (Carnivora) in hunting management in the People's Republic of Poland.) *Folia venatoria* **5-6**: 351-362. (in Slovak.)

Švajda J. (2002). TANAP bude mať nový program starostlivosti. (TANAP will have a new programme of care.) *Ochrana prírody Slovenska* **2002(3)**: 27. (in Slovak.)

Swanson G.A. and Bartonek J.C. (1970). Bias associated with food analysis in gizzards of blue-winged teal. J. Wildl. Manage. **34**: 739-746.

Swenson J.E. and Andrén H. (in prep.). A tale of two countries: large carnivore depredations and compensation schemes in Sweden and Norway.

Swenson J.E., Sandegren F., Söderberg A., Bjärvall A., Franzén R. and Wabakken P. (1997). Infanticide caused by hunting of male bears. *Nature* **386**: 450-451.

Swenson J.E., Sandegren F., Söderberg A. (1998). Geographic expansion of an increasing brown bear population: evidence for presaturation dispersal. *J. Anim. Ecol*. **67**: 819-826.

Swenson J.E., Jansson A., Riig R. and Sandegren F. (1999). Bears and ants: myrmecophagy by brown bears in central Scandinavia. *Can. J. Zool*. **77**: 551-561.

Swenson J.E., Dahle B., Gerstl N. and Zedrosser A. (2000). *Action plan for the conservation of the brown bear in Europe* (Ursus arctos). Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention), Nature and environment, No.114, Council of Europe Publishing, Strasbourg.

Swenson J.E., Sandegren F., Brunberg S. and Segerström P. (2001a). Factors associated with loss of brown bear cubs in Sweden. *Ursus* **12**: 69-80.

Swenson J.E., Dahle B. and Sandegren F. (2001b). Intraspecific predation in Scandinavian brown bears older than cubs-of-the-year. *Ursus* **12**: 81-92.

Szemethy L. and Heltai M. (1996). Néhány védett emlős ragadozó faj helyzete Magyarországon 1987-1994. (Status of some protected carnivore species in Hungary 1987-1994.) *Vadbiológia* **5**: 1-16. (in Hungarian.)

Tardiff S.E. and Stanford J.A. (1998). Grizzly bear digging: effects on subalpine meadow plants in relation to mineral nitrogen availability. *Ecology* **79(7)**: 2219-2228.

Taylor R.A. (1964). Columbian ground squirrel and cambium found in grizzly bear stomachs taken in the fall. *Journal of Mammalogy* **45(3)**: 476-477.

Taylor M. ed. (1994). *Density-dependent population regulation of black, brown, and polar bears*. Int. Conf. Bear Res. and Manage. Monogr. Series No. 3. 43 pp.

Teerink B.J. (1991). *Hair of West-European mammals. Atlas and identification key*. Cambridge University Press, Cambridge. 224 pp.

Temple S.A. (1987). Do predators always capture substandard individuals disproportionately from prey populations? *Ecology* **68**: 669-674.

Teren Š. (1987). *Po stopách vzácnej zveri. (In the tracks of rare game.)* Obzor, Bratislava. 184 pp. (in Slovak.)

Theberge J.B. and Gauthier D.A. (1985). Models of wolf-ungulate relationships: when is wolf control justified? *Wildl. Soc. Bull*. **13(4)**: 449-458.

The Raven (1998). The great wolfian bathtub riddle. Algonquin Provincial Park visitors' newsletter. *The Raven* **39(8)**.

Treves A., Wydeven A. and Naughton-Treves L.C. (2001). Wolves and livestock: problem packs and vulnerable farms. In: *Abstracts from the conference Canid Biology and Conservation, Oxford University*.

Treves A., Wydeven A., Brost B. and Wiedenhoeft J.E. (2003). Characteristics of wolf packs depredating on domestic animals in Wisconsin, USA. In: *World Wolf Congress 2003 Bridging Science and Community*. Book of abstracts. Banff, Canada: 39.

Tsingarska-Sedefcheva E. (2003). School education program about large carnivores. In: *World Wolf Congress 2003 Bridging Science and Community*. Book of abstracts. Banff, Canada: 83.

Tsingarska-Sedefcheva E. and Dutsov A. (2003). Wolf diet and activity towards livestock in conditions of decreased natural prey. In: *World Wolf Congress 2003 Bridging Science and Community*. Book of abstracts. Banff, Canada: 59.

Tsingarska E., Stoev S., Stoeva M., Sedefchev S., Sedefchev A., Todorov Y. and Doutsov A. (1998). *Wolf-man co-existence in Bulgaria*. Unpublished report. 7 pp.

Tubbs N.J. (1997). The wolves of Iberia. *Int. Wolf* **7(4)**: 17-18.

Urban P. (2000). Emerald, Natura a veľké šelmy. (Emerald, Natura and large carnivores.) *Chránené územia Slovenska* **46**: 22-24. (in Slovak.)

Urban P. (2002). Smernica rady európskych spoločenstiev o chrane prírodných biotopov, voľne žijúcich živočíchov a voľne rastúcich rastlín a cicavce Slovenska. (Directives of the Council of the European Community and the protection of habitats, wild fauna and wild flora and mammals of Slovakia.) In: *Výskum a ochrana cicavcov na Slovensku* **V**. Urban P. ed. Štátna ochrana prírody, Banská Bytrica: 9-18. (in Slovak with English summary.)

Urbancová V. (1975). Poľnohospodárstvo a chov dobytka. (Agriculture and livestock breeding.) In: *Slovensko 3 Ľud – II. časť*. (*Slovakia 3 People – 2nd part*.) Filová B. *et al*. eds. Obzor, Bratislava: 755-800. (in Slovak.)

USDA (1998). *Livestock guarding dogs*. United States Department of Agriculture, Animal and Plant Health Inspection Service, Wildlife Services.

Vančura V. (2002). Skúsenosti s participatívnym manažmentom projektu „Zachráňme tatranského kamzíka“. (Tatra Chamois Rescue Project – experience with participative management.) In: *Ochrana kamzíka*. (*Chamois protection*.) Janiga M. and Švajda J. eds.TANAP, NAPANT, IHAB: 241-244. (in Slovak with English abstract.)

Vantara P. (1990). Aby nikdy nevymizol. (So they never disappear.) *Poľovníctvo a rybárstvo* **42(9)**: 10-11. (in Slovak.)

Viestová E. (2003). Slovakia. In: *Progress on preparation for Natura 2000 in future EU member states*. Beckmann A. ed. WWF: 49-52.

Villemure M. (2003). Large predators in small parks: wolves in La Maurice National Park. In: *World Wolf Congress 2003 Bridging Science and Community*. Book of abstracts. Banff, Canada: 35.

Vines G. (1981). Wolves in dogs' clothing. *New Scientist* **10**: 648-652.

Vingada J.V., Eira C., Scheich S. *et al*. (1999). Conservation of the Iberian wolf (*Canis lupus signatus*) in Portugal – the everlasting conflict with man. *Presentation*. 2nd International Wildlife Management Congress. Gödöllő, Hungary. 28th June – 2nd July.

Vološčuk I. (1994). Biodiversity of the forests in Slovakia according to the forest vegetation types. In: *Conservation of forests in Central Europe*. Paulenka J. and Paule L. eds. Arbora Publishers, Zvolen: 39-50.

Vološčuk I. ed. (1999). *The national parks and biosphere reserves in Carpathians – the last nature paradises*. ACANAP, Tatranská Lomnica. 248 pp.

Vos J. (2000). Food habits and livestock depredation of two Iberian wolf packs (*Canis lupus signatus*) in the north of Portugal. *Journal of Zoology* **251(4)**: 457-462.

Voskár J. (1976). Vlk obyčajný (*Canis lupus* L.) a problémy jeho ochrany na Slovensku. (The wolf (*Canis lupus* L.) and problems of its conservation in Slovakia.) *Folia Venatoria* **5-6**: 326-332. (in Slovak.)

Voskár J. (1991a). Vlk v novom svetle. Areál rozšírenia a počet. (The wolf in a new light. Distribution range and number.) *Poľovníctvo a rybárstvo* **42(9)**: 8-9. (in Slovak.)

Voskár J. (1991b). Vlk v novom svetle. Skladba a reprodukčná dynamika. (The wolf in a new light. Structure and reproduction dynamics.) *Poľovníctvo a rybárstvo* **42(9)**: 10-11. (in Slovak.)

Voskár J. (1993). Ekológia vlka obyčajného (*Canis lupus*) a jeho podiel na formovaní a stabilite karpatských ekosystémov na slovensku. (The ecology of the wolf (*Canis lupus*) and its share in the formation and stability of Carpathian ecosystems in Slovakia.) *Ochrana prírody* **12**: 241-276. (in Slovak.)

Wade D.A. and Bowns J.E. (1997). *Procedures for evaluating predation on livestock and wildlife*. URL: http://texnat.tamu.edu/RANCHREF/predators.htm On Web April 2004.

Wasser S.K., Houston C.S., Koehler G.M., Cadd G.G. and Fain S.R. (1997). Techniques for application of faecal DNA methods to fieldstudies of Ursids. *Molecular Ecology* **6**: 1091-1097.

Wasser S., Parker M. and Davenport B. (1999). Noninvasive DNA sampling using scat sniffing dogs. *Society for Conservation Biology Abstracts*. 13th Annual Meeting. College Park, Maryland. URL: http://depts.washington.edu/conserv/programs.html On Web April 2004.

Wayne R.K. and Vilà C. (2003). Molecular genetic studies of wolves. In: *Wolves: behavior, ecology and conservation*. Mech L.D. and Boitani L. eds. The University of Chicago Press, Chicago and London: 218-238.

Weaver J.L. (1993). Refining the equation for interpreting prey occurrence of gray wolf scats. *J. Wildl. Mgmt*. **57**: 534-538.

Weaver J.L. and Hoffman S.W. (1979). Differential detectability of rodents in coyote scats. *J. Wildl. Mgmt*. **43**: 783-789.

Weber P. (1987). Observations of brown bear movements in the Hargita Mountains, Romania. *Int. Conf. Bear Res. and Manage*. **7**: 19-21.

Weber J.-M. (2003). Wolf depredation on livestock in the Swiss Alps, 1999-2002. In: *World Wolf Congress 2003 Bridging Science and Community*. Book of abstracts. Banff, Canada: 59.

Wechselberger M., Rigg R. and Beťková S. (in prep.). *An investigation of public opinion about three large carnivore species in Slovakia – brown bear* (Ursus arctos)*, wolf* (Canis lupus) *and lynx* (Lynx lynx).

Woodroffe R. (2001). Strategies for carnivore conservation: lessons from contemporary extinctions. In: *Carnivore Conservation*. Gittleman J.L., Funk S.M., Macdonald D. and Wayne R.K. eds. Cambridge University Press, Cambridge: 61-92.

Woodroffe R., Thirgood S. and Rabinowitz A. (2002a). How conflict with people affects wildlife populations. In: *People and wildlife: conflict or coexistence?* Abstracts of The Zoological Society of London and Wildlife Conservation Society symposium, London.

Woodroffe R., Thirgood S. and Rabinowitz A. (2002b). The future of coexistence. In: *People and wildlife: conflict or coexistence?* Abstracts of The Zoological Society of London and Wildlife Conservation Society symposium, London.

Wright W.H. (1913). *The grizzly bear. The narrative of a hunter-naturalist*. Charles Scribner's Sons', New York. 274 pp.

Žatkovič J. (2001a). *Ovce: situačná a výhľadová správa*. (*Sheep: situation and perspective report.*) Ministerstvo pôdohospodárstva Slovenskej Republiky a Výskumný ústav ekonomiky poľnohospodárstva a potravinárstva, Bratislava. March. 42 pp. (in Slovak.)

Žatkovič J. (2001b). *Ovce: situačná a výhľadová správa*. (*Sheep: situation and perspective report.*) Ministerstvo pôdohospodárstva Slovenskej Republiky a Výskumný ústav ekonomiky poľnohospodárstva a potravinárstva, Bratislava. September. 37 pp. (in Slovak.)

Zedrosser A., Dahle B., Swenson J. and Gerstl N. (2001). Status and management of the brown bear in Europe. *Ursus* **12**: 9-20.

Žilinec M. (1993). Prehľad metód rozboru potravy prežúvavej zveri. (Review of food analyses methods of ruminant game.) *Folia Venatoria* **23**: 209-219. (in Slovak with English summary.)

Žilinec M. and Hell P. (1995). Poľovné hospodárenie v sezóne 1993/94 v číslach. (Hunting management in the 1993-94 season in figures.) *Poľovníctvo a rybárstvo* **47(9)**: 4-5. (in Slovak.)

Zimen E. (1981). *The wolf – a species in danger*. Delacorte Press, New York. 367 pp.

Zimmermann B., Wabakken P. and Dötterer M. (2003). Brown bear-livestock conflicts in a bear conservation zone in Norway: are cattle a good alternative to sheep? *Ursus* **14(1)**: 72-83.

Zunino F. and Herrero S. (1972). The status of the brown bear (*Ursus arctos*) in Abruzzo National Park, Italy, 1971. *Biol. Cons*. **4**: 263-272.

Zuskin J. (1998). Nature and landscape protection in Slovakia. *Enviromagazín* III(May extra issue): 4-7.

Zuskinová I. (1999). *Ovčiarstvo a salašníctvo v Liptove*. (*Sheep breeding and pasturing in Liptov.*) TeLeM, Liptovský Mikuláš. 142 pp. (in Slovak.)

Appendices

Appendix 1. Estimates of numbers of sheep in Slovakia extrapolated from data in MP SR (2000c) to national herd of 340,000 (SOSR 2002) and proportions surveyed.

Region	Code	Area (km^2)	No. sheep (excluding smallholders)	No. sheep extrapolated total	Sheep in survey *n* flocks	Sheep in survey % of total no. sheep
Bratislava	BA	1,629	700	970		
Banská Bystrica	BB	2,075	19,400	26,879	12	20.5
Bardejov	BJ	1,014	3,600	4,988	6	71.0
Čadca	CA	934	7,500	10,391	5	17.2
Dolný Kubín	DK	1,659	14,000	19,397	14	33.8
Dunajská Streda	DS	1,075	1,600	2,217		
Galanta	GA	965	500	693		
Humenné	HE	1,909	3,200	4,434	6	38.1
Komárno	KN	1,100	3,100	4,295		
Košice	KS	1,777	8,900	12,331	5	34.8
Lučenec	LC	1,304	8,600	11,915	4	12.7
Liptovský Mikuláš	LM	1,968	15,000	20,782	19	49.8
Levice	LV	1,551	5,400	7,482		
Michalovce	MI	1,310	1,800	2,494		
Martin	MT	1,128	7,900	10,945	12	43.3
Nitra	NR	1,443	1,500	2,078		
Nové Zámky	NZ	1,347	1,200	1,663		
Považská Bystrica	PB	1,196	8,800	12,192	3	10.3
Prievidza	PD	960	2,100	2,910	5	80.8
Prešov	PO	1,418	14,200	19,674	6	13.0
Poprad	PP	1,963	14,200	19,674	10	25.0
Rimavská Sobota	RS	1,823	17,100	23,692	12	17.9
Rožňava	RV	1,621	12,500	17,319	11	24.1
Senica	SE	1,691	500	693		
Svidník	SK	862	6,400	8,867	4	19.1
Stará Ľubovňa	SL	624	7,500	10,391	8	48.5
Spišská Nová Ves	SN	1,529	11,600	16,072	9	18.7
Trenčín	TN	1,310	2,800	3,879		
Topoľčany	TO	1,361	600	831		
Trnava	TT	1,390	-	-		
Trebišov	TV	1,322	6,200	8,590		
Veľký Krtíš	VK	848	3,400	4,711		
Vranov nad Topľou	VT	847	4,000	5,542		
Žilina	ZA	1,097	5,200	7,205	5	52.5
Žiar nad Hronom	ZH	1,264	7,700	10,668		
Zvolen	ZV	1,721	16,700	23,138	8	22.8
Total		49,035	245,400	340,000	164	23.0

Appendix 2. Estimates of large carnivore numbers in Slovakia in the years 2000-02 compiled from the Poľov 1-01 national hunters' questionnaire (Kaštier 2004).

	bear			wolf			lynx		
Region	2000	2001	2002	2000	2001	2002	2000	2001	2002
BA									
BB	260	270	237	153	118	105	120	118	104
BJ		1	1	35	19	14	20	14	16
CA	21	22	24	40	37	38	34	25	25
DK	76	81	80	89	90	85	76	73	62
DS									
GA									
HE	26	22	26	123	83	79	63	55	55
KN									
KS	5	2	2	33	23	23	17	13	17
LC	33	35	31	24	19	19	29	36	23
LM	299	238	225	208	229	139	115	110	100
LV									
MI				25	14	9	5	6	9
MT	170	139	123	51	52	50	52	52	55
NR									
NZ									
PB	28	41	33	2		2	30	31	33
PD	75	62	56	6	11	7	31	46	27
PO		1		24	20	14	25	20	19
PP	85	76	61	161	125	103	112	105	83
RS	90	78	67	53	50	38	33	43	40
RV	42	32	31	68	45	38	52	38	37
SE									
SK			1	39	51	49	28	19	21
SL	2	2	2	29	21	27	42	32	30
SN	13	21	6	58	46	33	27	27	17
TN							1	1	1
TO	8	17	14	1			4	3	2
TT									
TV									
VK									
VT				11	12	10	9	8	9
ZA	95	89	59	20	24	23	38	42	42
ZH	52	59	59	8	9	9	29	24	27
ZV	87	62	73	20	15	10	45	27	29
Total	1,467	1,350	1,211	1,281	1,113	924	1,037	968	883

Appendix 3. Recording schedule for survey of farm conditions and alleged losses to predators.

1. Name of interviewer	
2. Date of visit	
3. Livestock owner's name, address, tel. no. (or cooperative, company, etc.)	
4. Head shepherd's name, address, tel. no.	
5. The head shepherd has worked here since ...	
6. Location of flock	
7. How many sheep do they have?	
8. At night the flock is ...	in a sheepfold loose in a barn
9. Does the flock have an electric fence?	yes no
10. How many dogs do they have?	
11. The guarding dogs are ...	chained free-ranging released at night
12. Do they use any other protection methods? (give details)	

13. Have they had any damage caused by wolves or bears this year?

in **2003**	Date, time	Farm location	Circumstances (weather, etc.)	Number of livestock killed	Number of livestock injured
Damage by **wolves**					
Damage by **bears**					

14. Did they have any damage caused by wolves or bears in 2002 or 2001?

in **2002**	Date, time	Farm location	Circumstances (weather, etc.)	Number of livestock killed	Number of livestock injured
Damage by **wolves**					
Damage by **bears**					

in **2001**	Date, time	Farm location	Circumstances (weather, etc.)	Number of livestock killed	Number of livestock injured
Damage by **wolves**					
Damage by **bears**					

15. Are they interested in improving protection measures, e.g. with the help of guarding dogs?

Appendix 4. Recording schedule used for regular health checks of dogs <1 yr. old.

Veterinary checks of LGDs
Veterinárna kontrola psov

Name of observer: Meno kontrolújuceho:	**Date:** Datum:	**Location:** Lokalita:
Name of dog: Meno psa:	**Weight:** Váha psa:	**Age:** Vek psa:

General condition (grade from 1-5*):
Kondícia (stupeň od 1-5**):

Body condition (fat 1-5†):
Kondícia (tuk 1-5††):

Specific (health) problems:
Zistené problémy (zdravotné) u psa:

Other problems:
Zistené iné nedostatky:

Remarks from shepherd/livestock owner:
Poznatky od chovateľa, majiteľa:

Notes:
Poznámky:

*** 5 – Very alert and active, showing enjoyment of life. Well-muscled, without health problems. 4 – Alert, active, movement is brisk, well muscled, minimal health problems. 3 – Less responsive, slower, more weakly muscled, more pronounced health problems. 2 – Slow, reluctant to move, sunken flanks. 1 – Mostly lies, if gets up cannot keep on feet, gaunt, poor health condition.**

** 5 – Veľmi čulý, hyperaktívny, prejavuje radosť zo života. Dobre osvalený, bez zdravotných potiaží. 4 – Čulý, menej aktívny, pohyb je rezký, dobre osvalený, minimálne zdravotné problémy. 3 – Slabšie vnímavý, pomalší, slabšie osvalený, výraznejšie zdravotné problémy. 2 – Pomalý, neochotný sa pohybovať, vpadnuté boky, nemocný. 1 – Prevažne leží, ak sa postaví, neudrží sa na nohách, vychudnutý, zlý zdravotný stav.

† **5 – Skin over ribs moveable, with plenty of fat under the skin, ribs almost undetectable to a gentle touch. 4 – Skin over ribs moveable, slightly less fat under the skin, ribs felt with a gentle touch but the hand does not yet "bounce" over the ribs. 3 – Skin over ribs less moveable, little fat under the skin, protrusion of ribs more clearly felt with a gentle touch. 2 – Skin over ribs barely moveable, no fat under the skin and protrusion of ribs visible at a glance. Pronounced protrusion of hip joints, sunken belly. 1 – Such a dog is just skin and bones and if the dog got into such a state not through long-term illness but through the owner's neglect, such an owner should never raise a dog.**

†† 5 – Koža nad rebrami pohyblivá, podkožie dostatočne postúpené tukom, pohladením rebrá skoro necítiť. 4 – Koža nad rebrami pohyblivá, podkožie postúpené tukom o niečo menej, pohladením rebrá cítiť, ale ruka ešte „neposkakuje" po rebrách. 3 – Koža nad rebrami pohyblivá menej, v podkoží málo tuku, pohladením cítiť výraznešie vystupujúce rebrá. 2 – Koža nad rebrami málo pohyblivá, podkožie je bez tuku aj pohľadom vidno vystupujúce rebrá. Výrazne vystupujúce bedrové kĺby, vpadnuté brucho. 1 – Takýto pes už je kosť a koža a keď pes takto dopadol nie v dôsledku dlhotrvajúcej nemoci, ale nezodpovednosťou majiteľa psa, tak takýto majiteľ by nikdy psa nemal chovať.

Appendix 5. Recording schedule used for focal observations of livestock guarding dog behaviour.

Start time: Date: Location: Pup: Weather: Notes:

Time	Instant state	Instantaneous proximity ov sh he ob lg	Continuous approach	Ins bw	Continuous social	1/0 soc.	Cont. protect	Continuous sheep	Notes

Publications arising from the study

(Works in press and in preparation, reports published on the internet and published conference proceedings are listed as references but have not been reproduced here.)

Rigg R. (2001). *Livestock guarding dogs: their current use world wide*. IUCN/SSC Canid Specialist Group Occasional Paper No 1 [online]. 133 pp.URL: *http://www.canids.org/occasionalpapers* On Web 2001-04

Rigg R. (2002). *The use of livestock guarding dogs to protect sheep and goats from large carnivores in Slovakia.* 2001 report [online]. 25 pp. URL: *http://www.carnivoreconservation.org* On Web February 2002

Rigg R. and Gorman M. (2002). The use of livestock guarding dogs to protect sheep from bears and wolves in Slovakia. In: *Living with bears. Information, program and abstracts from the 14th International Conference on Bear Research and Management*. Kvam T. and Sørenson O.J. eds. Nord-Trøndelag University College, Steinkjer, Norway: 96.

Rigg R. (2003). The use of livestock guarding dogs to protect sheep and goats from bears and wolves. In: *The integrated solution to the problem of nuisance bears* (Ursus arctos). Rigg R. and Baleková K. eds. Conference proceedings, Nová Sedlica, Slovakia 11-12.4.2002: 27-40.

Rigg R. and Baleková K. eds. (2003). *The integrated solution to the problem of nuisance bears* (Ursus arctos). Sloboda zvierat, Bratislava, Slovakia. 142 pp.

Rigg R. (2003). Perceptions and reality in conflicts over large carnivores in Slovakia: who's afraid of what? In: *Carpathian workshop on large carnivore conservation.* Directorate of Culture and of Cultural and Natural Heritage, Council of Europe, Strasbourg: 30.

Rigg R., Gorman M. and Sillero-Zubiri C. (2003). Livestock guarding dogs and their modern role in large carnivore conservation initiatives. In: *World Wolf Congress 2003 Bridging Science and Community*. Book of abstracts. Banff, Canada: 41.

Rigg R. (2003). Pastierske strážne psy a zachovanie populácie vlka na Slovensku. (Livestock guarding dogs and conservation of the wolf population in Slovakia.) In: *Vlky a rysy v oblasti slovensko-maďarských hraníc*. (*Wolves and lynx in the Slovak-Hungarian border region*.) Gadó G.P. and Pačenovský S. eds. WWF Maďarsko, Budapest: 62-70. (in Slovak.)

Goldová M., Ciberej J. and Rigg R. (in press). Medveď hnedý (*Ursus arctos*) a parazitárne zoonózy. (The brown bear (*Ursus arctos*) and parasitic zoonoses.) *Folia Venatoria* **00**: 000-000. (in Slovak.)

Rigg R. (in prep.). Livestock guarding dogs and their modern role in wolf conservation. In: Proceedings of 2003 conference "The wolf in the Carpathians" held in Bystra, Poland.

Wechselberger M., Rigg R. and Beťková S. (in prep.). *An investigation of public opinion about three large carnivore species in Slovakia – brown bear* (Ursus arctos)*, wolf* (Canis lupus) *and lynx* (Lynx lynx).