LARGE CARNIVORE DEPREDATION ON LIVESTOCK IN EUROPE

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Abstract: One of the most important factors negatively influencing public attitudes toward brown bears (*Ursus arctos*) and other large carnivores is depredation on livestock. This is especially true in Norway, where a small population of 25–55 bears kill about 2,000 sheep annually. In other European countries the re-establishment of large carnivores is planned or underway, and similar problems may arise. As a basis for future large carnivore management in Europe, I compared depredation among 13 European countries having small, medium, or large bear, lynx (*Lynx lynx*), and wolf (*Canis lupus*) populations. I calculated annual per capita losses of livestock (ACLL) as the average annual loss of livestock divided by the estimated predator population in the area of concern. In Norway, the rates of livestock losses from bears, lynx and wolves were among the highest observed in Europe. Assuming predator population estimates are correct, each bear kills an average of 82 sheep annually, each wolf 41, and each lynx 9. Generally, in Europe, lynx were the least important predator on livestock. In all but one area (Cantabrian Mountains, Spain), sheep and goats were the livestock most often taken by all 3 of the large carnivores. Depredation levels were not related to the size of the bear population nor to the number of sheep available, but to differences in local husbandry traditions. Most attacks seemed to occur at night, and sheep were the most exposed on forested range. The high predation level in Norway can be explained by the large number of untended sheep that stay day and night on forested range. There is no example in Europe of extensive sheep farming with low losses and viable populations of bears and wolves on the same range.

Ursus 11:59–72

Key words: brown bear, *Canis lupus*, Eurasian lynx, Europe, large carnivores, livestock depredation, livestock husbandry, *Lynx lynx*, *Ursus arctos*, wolf

Conservation of large carnivores depends greatly on public perception of the species. One of the main factors contributing to a negative attitude is livestock depredation (Linnell et al. 1996). In Norway, depredation on sheep by bears and lynx has resulted in an intense discussion on the future management of carnivores (Aanes et al. 1996, Sagør et al. 1997). In other European countries where large carnivores are recovering, similar problems arise (Kaczensky 1996).

In former times livestock depredation was a serious problem, often threatening the welfare of whole families. Therefore, people were forced to develop efficient guarding techniques. Today, economic, social, and political reasons have altered these traditions. Whereas in the United States the efficiency of livestock guarding techniques has been tested systematically (Wick 1995, Linnell et al. 1996), their efficiency remains scientifically untested in Central Europe.

One should expect that with an increased standard of living, tolerance of livestock losses to large predators would also increase, especially when livestock owners are compensated by the government. Furthermore, a large portion of livestock keepers, especially sheep owners, are subsidized and often keep livestock as an additional source of income (Marty 1996). Yet tolerance is low, especially in areas where the tradition of living closely with bears, lynx, and wolves has been lost (Boitani 1992).

All countries with established or recovering carnivore populations experience some degree of livestock depredation and are trying to cope with the problem in various ways. Compiling data on livestock breeding techniques and livestock damages gives insight into the complexity of the problem and should help to develop strategies to minimize large carnivore–livestock conflicts.

METHODS

Depredation

I selected 13 European countries with large carnivore populations for a comparative evaluation of large carnivore–livestock conflicts (Fig. 1, Table 1). The focus was on bears, but for comparison I included damages caused by lynx and wolves.

I obtained data on depredation by lynx, wolves, and bears from the literature or unpublished data, which I used with the courtesy of the collector. Only depredation on sheep, goats, cattle, and horses (including donkeys and mules) was considered. Predation on pigs, dogs, chicken, geese, rabbits and other domestic animals played a marginal role in some papers.

Annual per Capita Loss of Livestock (ACLL)

A comparison of absolute numbers of livestock killed is difficult to interpret because the size of the predator population and the monitoring periods differed greatly among countries. Therefore, I calculated livestock loss, expressed as the annual per capita loss (ACL), caused by each predator. I also calculated ACLs for all livestock losses (ACLL) and for sheep and goat losses (ACLS):

$$\text{ACLL} = \frac{\text{livestock killed by lynx, wolves or bears /year}}{\text{lynx, wolf or bear population estimate}}$$

I averaged predator population size in the area from the population ranges in the literature. If population estimates changed during the monitoring period, I used mean population estimates.

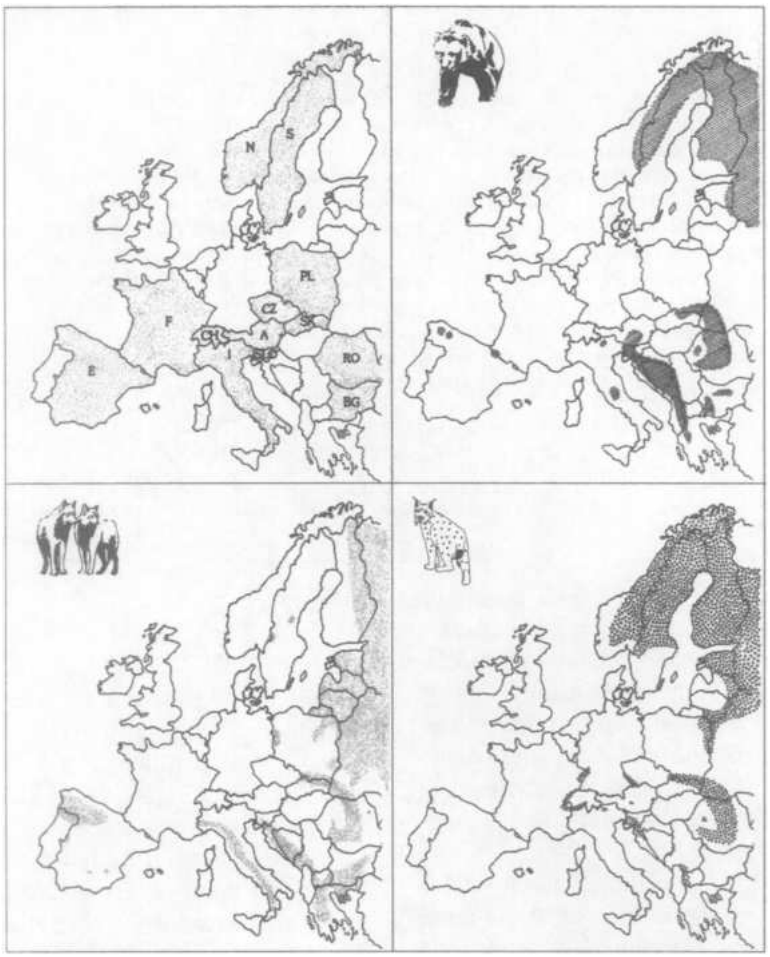

Fig. 1. Countries chosen for evaluation of carnivore depredation on livestock and distribution of bears, wolves, and lynx in these countries. Countries include Austria (A), Bulgaria (BG), Czech Republic (CZ), France (F), Italy (I), Norway (N), Poland (PL), Romania (RO), Slovakia (SK), Slovenia (SLO), Spain (E), Switzerland (CH), and Sweden(S).

RESULTS AND DISCUSSION

Limits of Interpretation

Comparison of depredation from different countries and species can best be done descriptively, comparing the rough magnitude of damage, because of variation in the quality of data.

Different Compensation systems.—Carnivore–livestock problems are systematically monitored in countries with compensation systems (Table 2). The quality of the depredation data highly depends on the experience of people evaluating the claims. In addition, it is almost impossible to distinguish between kills made by a wolf or a dog; therefore, wolf damage might be greatly overestimated in areas with large feral dog populations (Boitani 1982).

When compensation is paid differently for lynx, wolf, and bear depredation, people tend to blame all livestock losses on the predator for which payment is highest or easiest to obtain. For example, in Spain, Poland, and Slovakia, bear damage is readily compensated, but no money is paid for livestock killed by wolves. The real amount of bear damage might be considerably less than the reported bear damage.

In addition, livestock owners might not claim damage if the compensation evaluation procedure is complicated or reimbursement is minimal, as is presently the case in Romania. How well a compensation system works also depends on the attitudes of the local people. In some areas cheating is much more socially accepted than in others. In the beginning of wolf conservation in Italy, some shepherds tried to claim sheep they had slaughtered as wolf kills (Zimen 1988).

Sampling Units.—Damage data are recorded in different units as number of killed animals, attacks, or claims, which typically are not equivalent. During an attack, more

Table 1. Characteristics of countries chosen for evaluation of livestock depredation, 1996.

Country	Area (km²)	Humans/ km²	Urbanization (%)	Forest cover (%)	Population estimates			Livestock husbandry
					lynx	wolves	bears	
Austria	83,850	90	56	45	<10	0	20 30	unguarded
Bulgaria	110,000	81	71	30	0	250	900	guarded
Czech Republic	79,000	130	65	32	100 150	0	8	unguarded
France	550,000	101	73	27	70	12	6 8	unguarded
Italy	301,000	187	67	27	<15	300	50 100	mostly guarded
Norway	323,877	13	73	30	500	5 10	25 55	unguarded
Poland	312,700	116	65	28	200	850	70 80	mostly guarded
Romania	237,500	100	55	27	1,750	2,500	6,300	guarded
Slovakia	49,025	102	59	43	500	450 500	500 600	mostly guarded
Slovenia	200,256	100	64	52	75	10 20	300 400	unguarded
Spain	505,000	76	76	21	0	1,500 2,000	50 70	guarded and unguarded
Sweden	449,964	20	83	56	1,000	40	1,000	unguarded
Switzerland	41,300	160	61	27	100 120	1	0	unguarded

Table 2. Compensation systems for livestock depredation in Europe, 1996.

Country	Bear[a]	Wolf	Lynx
Austria	market price paid by NGOs	no wolves present	same as bears
Bulgaria	not quite market price paid by GO insurance	same as for bears	no lynx present
Czech Republic	no bears present	no wolves present	no compensation
France	market price plus additional fee paid by GO	same as bears	market price plus fee paid by NGO with GO support
Italy	market price paid by GO	market price paid by GO	so far no depredation problems
Norway	100-200% market price paid by GO, lost animals are paid for if predation was previously verified that year	same for bears	same for bears
Poland	market price paid by GO	no compensation	no compensation
Romania	due to inflation very low compensation paid by GO	same for bears	same for bears
Slovakia	marked price paid by GO	no compensation	no compensation
Slovenia	market price paid by GO	same for bears	same for bears
Spain	market price and an additional fee paid by GO; animals have to have tags	market price paid by GO, but only in some communities	no lynx present
Sweden	same as Norway, but farmers are required to have attempted to prevent damage to obtain compensation	same for bears	same for bears
Switzerland	no bears present	no wolves present	market price paid by GO

[a] NGO = non-governmental organization; GO = governmental organization

than 1 animal can be killed, and if the livestock belonged to different owners, more than 1 claim might be processed.

To allow for more consistent comparison among countries, I used numbers of animals killed. When data were given only as claims or attacks, I recalculated the data to the number of animals killed, by multiplying the number of claims or attacks by the average number of animals killed in 1 attack (for Cantabrian Mountains: García-Gaona and Roy 1993, García-Gaona 1997; for Abruzzo: Fico et al. 1993; for French Jura: Office National de la Chasse (ONC), 1989, Bilan de la prédation du lynx sur le cheptel domestique dans le Massif du Jura en 1989, Jura, France; Vandel et al. 1992; Vandel and Stahl 1993).

Another methodical problem was how to compare predation on sheep and goats with predation on cattle and horses. It takes several sheep to equal the biomass and value of a cow or a horse. Conversely, predators are rarely allowed to completely consume a large carcass, because people will more easily find and remove it.

Sampling Periods and Small Populations.—Short sampling periods might result in unusually high or low damage data. Especially with bears, the failure of hard or soft mast in a year might result in high damage statistics (Garshelis 1989). In small populations, single problem animals might easily double average damage in certain years, as occurred with 1 bear in 1991 in the Pyrenees (Camerra et al. 1995), 2 bears in 1994 in Austria, and possibly a few lynx in 1989 in the French Jura Mountains (ONC, 1989, Bilan de la prédation du lynx sur le cheptel domestique dans le Massif du Jura en 1989, Jura, France).

Predator Population Estimates.—Any population estimate of wide-ranging, forest-dwelling and secretive animals is difficult (Kendall et al. 1992, Clevenger 1993,

Camerra 1995). For accurate population estimates, skilled people have to be regularly present in the field. Examples of exaggerated estimates are numerous: a few lynx in Austria gave the impression of an established population (Huber and Kaczensky 1998), a single bear in Vassfaret, south-central Norway, made people believe a small bear population existed (Boekken et al. 1994), and bear numbers in all of Norway except Finmark County were estimated to be 130–194 in 1978–86 instead of the roughly 14 actually present (Swenson et al. 1995). It is important to remember that population estimates are only the best guess at the given time.

Quality of Data Available for Livestock.—Data on livestock available to predators are very heterogeneous. Livestock might be well registered in countries where sheep are subsidized, such as Austria, France, Italy, Norway, Spain, and Switzerland. In other areas it is can be advantageous to misrepresent the number of livestock for tax or grazing right purposes. In addition, livestock are often registered on a large scale, by country or county; therefore, not all of these animals are actually within the range of the predator.

Livestock Husbandry Practices

Throughout Europe, livestock husbandry practices vary with local predators, livestock type, and terrain. This has resulted in a wide range of practices, many of which changed dramatically with the decline of predators. In order to understand possible differences in the amount of damages caused by large carnivores, some basic information on livestock rearing is given for each country.

Austria.—With the eradication of lynx, wolves, and bears, the tradition of guarding livestock was lost. Today sheep graze untended on open range or on fenced pastures. The use of shepherds and dogs has been almost completely abandoned. Electric fences are used to discourage bears from breaking into beehives. In one case an electric fence stopped a bear from breaking into a sheep barn.

Bulgaria.—Sheep are guarded by shepherds with dogs. Normally 1 shepherd collects sheep from a whole village and moves them to the summer range. Flock size is 50–100 sheep/shepherd, and control of the flock is moderate. Shepherds spend the night in small cabins, but the sheep normally stay outside, with the livestock guarding dogs. In winter time sheep stay in barns in or near the village, and damages are rare (a predator has to break into the barn). Cattle and horses are not herded and roam free from spring to late fall.

In some areas of Bulgaria the traditional use of livestock guarding dogs has been lost. There are plans to breed and distribute livestock guarding dogs to local shepherds to encourage their use again (E. Tzingarska, Green Balkans [NGO], Sofia, Bulgaria, personal communication, 1996). Electric fencing to protect livestock or beehives is rarely used.

Czech Republic.—Traditionally, the Bohemian forest has never been a sheep-rearing area. Today ≤2,000 sheep are present. Most are kept in small flocks on fenced meadows. No special care is taken to prevent losses to lynx or other predators like stray dogs or foxes (*Vulpes vulpes*)(J. Cerveney, Czech Ministry of Environment, Praha, Czech Republic, personal communication, 1995).

France.—In former times, shepherds stayed with their herds for the entire summer. Many grazing areas are now reached by car, and sheep are left alone or with livestock guarding dogs and are checked 2–3 times a week. In addition, the number of milk sheep is decreasing in favor of meat sheep. Milk sheep are tended twice a day from spring to late summer and are penned at night; they are much less vulnerable to bear predation than free-ranging meat sheep (Bouvier and Arthur 1995).

Today, traditional methods of livestock grazing are rarely used. In the Jura Mountains, sheep are kept in parks (open meadows intermingled with forest), and in large parts of the French Alps sheep graze freely all summer. Only in the Pyrenees, where sheep milk production is important, is the herding of sheep still occasionally practiced.

In the Mercantour National Park, flocks are large, usually around 1,000–2,000 sheep, and sometimes >3,000 sheep. Few are attended by guard dogs, and almost all remain alone during the night or sometimes for several days (B. Lequette, Mercantour National Park, France, personal communication, 1996). Sheep are kept only for meat and are heavily subsidized (up to 60–70% of the overall income).

Electric fences are used to some extent to protect sheep in areas with depredation problems. In addition, toxic as well as protective collars (thick leather collars) have been tested on sheep to reduce lynx predation in the Jura Mountains (Vandel and Stahl 1993).

Italy.—Traditionally in the Abruzzo region, sheep are guarded by shepherds with dogs and are brought into pens at night. Flocks do not exceed 300 sheep and are always guarded by a minimum of 2 livestock guarding dogs. Sheep are not allowed out at night or during foggy weather (Boitani 1992). According to the sanitary law, all dead sheep have to be buried by the shepherds (Boitani 1992).

Outside traditional wolf range livestock graze untended. Lambs, calves, and foals are born on the pasture (Meriggi et al. 1991). Even if sheep flocks are guarded, guarding is poor. Inexperienced shepherds with an inad-

equate number of dogs look after flocks of 1,000–2,000 sheep (Boitani 1992). In the Abruzzo region, fruit trees have been planted and supplementary food is used to provide bears with high-energy food alternative to livestock (Boscagli 1995).

Norway.—Norway's official policy is to maintain and support settlements in rural areas. Sheep farming is encouraged and heavily subsidized (over 2/3 of a sheep's monetary value), even though most sheep farming is not a full-time occupation for livestock owners. About 2.2 million sheep graze untended on forest and mountain range.

Sheep farming is intensive during winter and extensive during summer. In winter, sheep are confined indoors because of climate. Lambing occurs indoors at the end of April to early May. During May, sheep and newborn lambs are kept in fields close to the farm, and in early June they are released onto forest or mountain range. They are generally left untended, except for occasional visits, until September. Several breeds do not flock, and sheep owners normally patrol their range once or twice a week; however, because of the large range and dispersed nature of the sheep, many are never checked. The use of herding dogs is not common, and livestock guard dogs have never been used.

To reduce the high depredation level in Norway, different protection measures are being tested, including protection collars, taste or smell aversion collars, monitoring, livestock guard dogs (Directorate for Nature Management 1996), shortened grazing seasons, aversive conditioning or translocation of bears (Wabakken and Maartmann 1994), and shooting of problem bears (Sagør et al. 1997). Some farmers have received economic incentives to change to milk or beef production (J. Linnell, Norwegian Institute of Nature Research, Trondheim, Norway, personal communication, 1996).

Poland.—Traditionally livestock has been and still is guarded by shepherds with dogs. At night, sheep are often kept in enclosures or inside barns (H. Okarma, Polish Academy of Science, Bialowieza, Poland, personal communication, 1996).

Romania.—Sheep and cattle are guarded by herders with livestock guarding dogs. The size of sheep flocks varies from 100 to 1,000 animals. At night sheep are brought together on open pastures with the dogs running free and the shepherds sleeping next to the flock. During daytime fences are not used, as by law any fence has to be moved every third day to avoid overgrazing. In the few cases where fences were used, they seemed to be quite effective (C. Promberger, Munich Wildlife Society (NGO), Linderhof, Germany, personal communication, 1996).

Slovakia.—Traditionally, sheep are guarded by shepherds with dogs. At night sheep are brought to large, open pastures and shepherds sleep in cabins nearby. Guard dogs, usually Slovakian cuvac dogs, stay permanently with the sheep (F. Knauer and A. Lampe, Munich Wildlife Society, Linderhof, Germany, personal communication, 1996). This method of sheep grazing is still practiced in the Western Carpathians (Hell 1993). Preliminary data from a wolf telemetry project in the Low Tatra Mountains suggests that traditionally trained livestock guarding dogs are effective in preventing sheep losses (G. Bloch, 1994, Renovation of livestock guarding dog management in Slovakia and the use of livestock guarding dogs as defenders against wolves in southern Poland, Gesellschaft zum Schutz der Wölfe [NGO], Bad Münstereifel, Germany).

Unfortunately, in many areas the use of traditionally trained guard dogs has been lost. Today dogs are often chained to avoid confrontations with tourists or their pet dogs. Chained dogs do not bond with their herd as required for a reliable livestock guard dog, and if turned loose they may even attack sheep. They are fairly aggressive toward people and are not effective in protecting the flocks. Apart from barking to alert the shepherds, their defensive behavior is restricted by the length of the chain (Wick 1995).

Electric fencing has been successfully used to protect beehives, but not to protect sheep. Sheep need to be moved and people are slow to accept the additional work of moving the fence. In addition, for small-scale bee keepers and sheep breeders, the costs of an electric fence are high (Hell 1995).

Slovenia.—Traditional methods of livestock grazing are no longer used. Untended grazing is practiced, especially in the pre-alpine and alpine regions in the north and northwest, or sheep are held in small pens. An analysis of damages showed greater losses when a bear attacked sheep in small enclosures compared to those ranging free (Adamic 1997). In at least 1 instance a greater number of sheep were killed during an attack because sheep could not escape from the fenced area.

In some areas electric fencing is used; however, the success depends on its correct installation (M. Adamic, University of Ljubljana, Ljubljana, Slovenia, personal communication, 1995). Shortening of the grazing season was suggested because the peak damage occurred in spring and autumn. The Ministry of Agriculture offered to cover the additional costs for hay, but the offer was refused by the local farmers (M. Adamic, University of Ljubljana, Ljubljana, Slovenia, personal communication, 1995). In the bear core area, supplementary feeding is

provided to keep bears away from livestock and other human property.

Spain.—Traditional methods included guarding of sheep by shepherds with guard dogs (Spanish mastiff) and taking herds into the village or other shelter at night (Vila et al. 1993). These practices have been abandoned in many areas. To encourage livestock guarding, professional livestock owners are provided with puppies of guard dogs upon request. These dogs are provided free of charge, but are not trained, nor is the use and effectiveness monitored afterwards (J. Naves, Indurot University of Oviedo, Oviedo, Spain, personal communication, 1996).

Switzerland.—Traditionally, livestock was guarded by shepherds with guard and herding dogs. But with the eradication of the large predators, sheep farmers no longer guard sheep. Most sheep roam freely on alpine pastures during the entire grazing period and are checked only once or twice a week. In the Jura Mountains sheep are often held in small enclosures or fields with a small open shed. Most of this farming is done for supplementary income (Marty 1996).

Sweden.—Swedish rural areas and sheep farming are not subsidized as heavily as they are in Norway. Much farmland has been replanted to forest, and mechanization has reduced employment in the forest industry. Therefore, the human population density in rural areas is much lower than in Norway. The 500,000 sheep are kept within fenced pastures and usually near human habitation. Only a small portion of the total sheep population is within predator range, and compensation is provided for loss only if the farmer has used accepted methods to prevent or reduce loss (Swenson et al. 1998).

Magnitude and Composition of Livestock Killed

Bear predation rates, expressed as annual per capita losses of livestock (ACLL) and sheep (ACLS), were rather low in all countries or regions with the exception of Norway. There, bears had a livestock depredation rate 24 times higher than bears in the French Pyrenees, which had the second highest depredation rate (82.2 versus 3.4; Fig. 2, Table 3). The ACLL due to bears in Norway was by far the highest per capita depredation rate of any predator in any country studied.

When comparing equal periods, ACLL due to wolves was 19 times higher than that due to bears in Bulgaria (8.0 versus 0.4), 12 times higher in Abruzzo (17.1 versus 1.4), and 1.5 times higher in Poland (1.3 versus 0.9) (Table 3). ACLL due to bears in Poland and Spain were probably overestimated because of insufficient damage compensation for wolves. To get compensation, livestock owners sometimes claim wolf kills as bear kills. The only country where ACLL due to wolves was lower than for bears was Norway. On average, a Norwegian bear causes twice as much damage as each wolf, but wolves are sporadic visitors.

Values for ACLL and ACLS were almost the same in most countries (Table 3), as sheep were the most important domestic animal prey for all 3 large predators (Fig. 3). Adjusting these figures to a weight or value basis (10 sheep = 1 cow or horse), would only slightly change the damage patterns (Fig. 2, Table 3).

Bear predation was primarily directed at sheep and goats, but in some areas cattle and horses also were attacked frequently and might be locally important (Fig. 3, Genov and Wanev 1992). This was also true for the bear population in parts of the Dinaric Mountain Range. Whereas predation on cattle was minor in Slovenia in 1995, Croatia and Bosnia in 1987 reported 709 cases of livestock depredation, of which 619 (87%) concerned cattle (Huber and Moric 1989). Additional damage statistics from Croatia in 1989 showed 13 cases of livestock depredation, involving cattle in 10 cases and sheep in 3 (Huber and Frkovic 1993).

In Bulgaria bears attacked only cattle and horses that were separated from the herd (Genov and Gancev 1987). In Austria, only calves were attacked (Rauer and Gutleb 1997), but historical data from Switzerland mentions attacks on adult cattle as well as on calves (Metz 1990). In Spain, where predation on cattle and horses was by far the most intensive, cattle rearing was the most important livestock activity in the area (García-Gaona 1997). Adult and yearling cows, and horses were taken about equally in 87 attacks evaluated (Clevenger et al. 1994).

ACLL due to wolves were among the highest observed for the 3 predators but varied between 0.4 - 41.4 (Fig. 2, Table 3). The highest rates were from Norway and Mercantour National Park, 41.4 and 21.0, respectively, where the tradition of livestock guarding was mostly lost. In the Abruzzo region, reported predation was even higher at 43.0 in the period 1974-1978 (Table 2), but Boitani (1982) stated that probably up to 50% of the damage was caused by dogs. From 1980-88 ACLL declined to < 50% of the 1974-78 value (17.1), even though the number of wolves increased. The decrease could have indicated an improvement of herding techniques or a more restrictive damage evaluation. The extent to which stray dogs may account for high ACLL of wolves in other countries or regions is not known.

Wolf predation was aimed primarily at sheep and goats, but some cattle and horses were taken and were locally important (Fig. 3, Genov and Kostava 1993). Data were not usually available on the age of animals killed. In Italy,

Table 3. Magnitude of large carnivore depredation on livestock in Central Europe, 1968-96.

Country/region	Period	Estimated predator population	Annual loss of livestock	ACLL[a]	ACLS[b]	Livestock available on predator range			Available livestock killed (%)	Source
						Sheep and goats	Cattle	Horses		
Bear										
Austria	1990–95	(7–28)[c] 17	35	2.1	2.0					B. Gutleb and G. Rauer 1996
Bulgaria	1984–88	900	379	0.4	0.4					Genov and Wanev 1992
Spain — Cantabria	1973–90	65	57	0.9	0.4					Garcia-Gaona 1997
Spain — RNC Riano	1974–84	6	8	1.3	1.2	15,435	4,767	270	0.04	Purroy et al. 1988
French Pyrenees	1968–91	(35–9)[c] 20	68	3.4	3.2	47,750	12,500	1,000	0.11	Nedelec et al. 1995
Italy — Abruzzso	1980–88	50	71	1.4	1.2	700,000	120,000	30,000	0.01	Fico et al. 1993
Polish Carpathians	1987–91	100	87	0.9	0.7	370,000	524,000		0.01	Bobek et al. 1993*b*
Slovenia — outside core area	1995	70	72	1.0	0.9					Ministry of Agriculture and Foresty 1995[e]
Sweden	1993–95	1,000	62	0.1	0.1					J. Swenson 1995[f]
Norway	1992–95	(15–35)[c] 25	2,055	82.2	82.2	2,200,000			0.09 of total stock	J. Linnell 1995[g]
Lynx										
Switzerland	1984–94	115	50	0.4	0.4	415,000			0.01	Breitenmoser et al. 1998
Czech Republic – Bohemian Forest	1993–94	75	11	0.2	0.2	~2,000			0.55	J. Cerveney and L. Bufka 1995[h]
Frenchy Jura Mountains	1984–92	40	123	3.1	3.1	<74,000			>0.17	ONC 1989[i] Vandel and Stahl 1993
Slovenia	1995	75	67	0.9	0.9					Ministry of Forestry and Agriculture 1995[e]
Sweden	1993–95	1,000	48	0.1	0.1					J. Swenson 1996[f]
Norway	1992–95	500	4,731	9.5	9.5	2,200,000			0.22 of total stock	J. Linnell 1996[g]
Wolf										
Bulgaria	1984–88	250	2,001	8.0	7.8					Genov and Kostava 1993 Blanco et al. 1992
Spain — southwest	1987	1,750	6,818	3.9	3.0				0.65 for Cantabria	Fernandez et al. 1990 Groupe de Suivi Local 1996[k]
France — Merkantour	1993–95	2–12[e]	36–408[e]	21.0	21.0	20,000			0.18–2.04	Lequette et al. 1996
Northern Italy	1988	15	45	3.0	1.7	1,000	1,455	203	1.67	Meriggi et al. 1991
Italy — Abruzzo	1974–78	35	1,490	43.0	39.4					Boitani 1982
Italy — Abruzzo	1980–88	70	1,200	17.1	13.1	700,000	120,000	30,000	0.14	Fico et al. 1993
Poland — West	1993–95	25	11	0.4	0.4	173,000			0.01	Promberger and Hofer 1994
Polish Carpathians	1988–92	350	461	1.3	1.3	370,000	524,000		0.12	Bobek et al. 1993
Slovenia — South	1995	15	67	4.5	4.5					Ministry of Agriculture and Forestry 1995[e]
Sweden	1993–95	40	36	0.9	0.9					J. Swenson 1996[f]
Norway	1992–95	5	207	41.4	41.4	2,200,000			0.01 of total stock	J. Linnell 1996[g]

[a]ACLL=annual per capita loss of livestock [b]ACLS=annual per capita loss of sheep. [c]Increase of decrease of population during period

[d]Because of the dramatic increase of the wolf population and the livestock killed, ACLL and ACLS were calculated for each year and averaged for the whole period.

[e]B. Gutleb and G. Rauer. WWF Austria, Vienna, Austria. personal communication 1996.

[f]Ministry of Agriculture and Forestry. 1995 annual livestock damage statistics. Ljubljana, Slovenia.

[g]J. Swenson. Norwegian Institute of Nature Research (NINA). Trondheim. Norway, personal communication 1996.

[h]J. Linnell. Norwegian Institute of Nature Research (NINA), Trondheim, Norway, personal communication 1996.

[i]J. Cervency, Czech Ministry of Environment, Praha, Czech Republic, and L. Bufka, Susava National Park, Kasperske Hory, Czech Republic. personal communication 1995.

[j]Office National de la Chasse (ONC). 1989. Bilan de la préation du lynx sur le cheptel domestique dans le Massif du Jura en 1989, Jura, France.

predation on cattle and horses was almost exclusively on calves and foals (Meriggi et al. 1991, Fico et al. 1993, Cozza et al. 1996). In Bulgaria wolves preyed on cattle and horses by separating individuals from the herd and chasing them off cliffs; mules and donkeys were attacked while attached to trees with ropes (Genov and Kostava 1993).

Except in Norway, ACLL were generally low for lynx, ranging from 0.15-3.1 (Table 3), an expected pattern for cats (Nowell and Jackson 1996). Information on lynx predation was primarily available from countries and regions where lynx was the only large predator present (Switzerland, Czech Republic, French Jura Mountains), and where wolf and bear numbers were small within the sheep range. In these areas lynx is the largest predator, and people are very sensitive to any kind of loss. In addition, the absence of wolves and bears has allowed to abandon intensive herding techniques without risking high losses.

Predation by lynx is the greatest in Norway, where it is 3 times higher than in the French Jura Mountains. Two factors might encourage lynx predation on sheep: (1) most sheep graze untended in the forest and therefore are easily available, (2) the density of small ungulates (only roe deer (*Capreolus capreolus*), few red deer (*Cervus elaphus*], no chamois [*Rupicapra rupicapra*]) is lower than in most central and eastern European countries, so natural prey numbers are limited.

In Poland, Slovakia, and Romania, where there are large populations of wolves or bears in the same range as lynx, lynx predation is generally considered minimal. Annual livestock losses due to bears and wolves are much higher, and few livestock owners complain about losses caused by lynx (personal communications: O. Ionescu, Romanian Forest Research and Management Institute, Brashov, Romania, 1996; S. Findo, Slovakian Forest Research Institute, Zvolen, Slovakia, 1996; H. Okarma, Polish Academy of Science, Krakow, Poland, 1996). In addition, guarding of livestock against bears and wolves seems to minimize the chance of a lynx killing livestock. Lynx can not fight off dogs as bears do. Similarly, because they are solitary hunters, they can not confuse dogs, the way a pack of attacking wolves do.

Lynx prey almost exclusively on sheep and goats; small calves or foals were rarely taken. Preference for lambs was noted in Norway (Aanes et al. 1996), but not in France or Slovenia (ONC, 1989, Bilan de la prédation du lynx sur le cheptel domestique dans le Massif du Jura en 1989, Jura, France; Ministry of Agriculture and Forestry, 1995, Annual Livestock Damage Statistics, Ljubljana, Slovenia).

Relationship between Depredation Rate and Bear Population

Bear population size and livestock damage is not necessarily correlated (Fig. 4). The few bears in Norway kill far more sheep than do the ~1,000 bears in Sweden (Table 3). Though sheep are the most important domestic prey for bears in areas where more sheep are available/bear, more sheep are not necessarily killed/bear. In the Abruzzo region, Fico et al. (1993) did not observe a significant correlation between numbers of livestock present and numbers of livestock taken by bears when comparing different years. Similarly, Sagør et al. (1997) did not find a significant correlation between ewes present and ewes lost to bears in Norway. From the predator population size or the number of sheep alone, it is not possible to predict expected damage levels. Herding techniques, species of livestock, type of range (forested or open), and alternative prey base all have to be taken into account.

Guarded versus Unguarded Livestock

No European country with large populations of wolves and bears (>50) has sheep and goats grazing untended in the forest (Table 1). Untended grazing of sheep and goats occurs only in areas where there are dwindling populations (bears in the Pyrenees) or where predators are making a recent comeback (bears: Austria, Slovenia outside core area, Norway; wolves: Slovenia, western Poland, northern Italy, Mercantour area of France). The only exceptions seem to be the core area of Slovenia, but so far very few sheep graze within the range of the large predators.

Data from the Cantabrian Mountains and Abruzzo region showed that properly guarded livestock suffered much lower losses (Blanco et al. 1992, Boitani and Ciucci 1993). These successes are masked when combined with areas where guarding techniques are poor or applied inappropriately.

Timing and Location of Predation

Bears and wolves attack livestock primarily at night or during fog, heavy rain, or storms (bear: Genov and Wanev 1992, Nédélec et al. 1995; wolf: Boitani 1992, G. Bloch, 1994, Renovation of livestock guarding dog management in Slovakia and the use of livestock guarding dogs as defenders against wolves in southern Poland, Gesellschaft zum Schutz der Wölfe [NGO], Bad Münstereifel, Germany, C. Promberger, Munich Wildlife Society, Linderhof, Germany, personal communication, 1996). Sheep that were locked into barns or corrals at night were usually safe against wolf and lynx predation but could still suffer bear predation. This seemed to

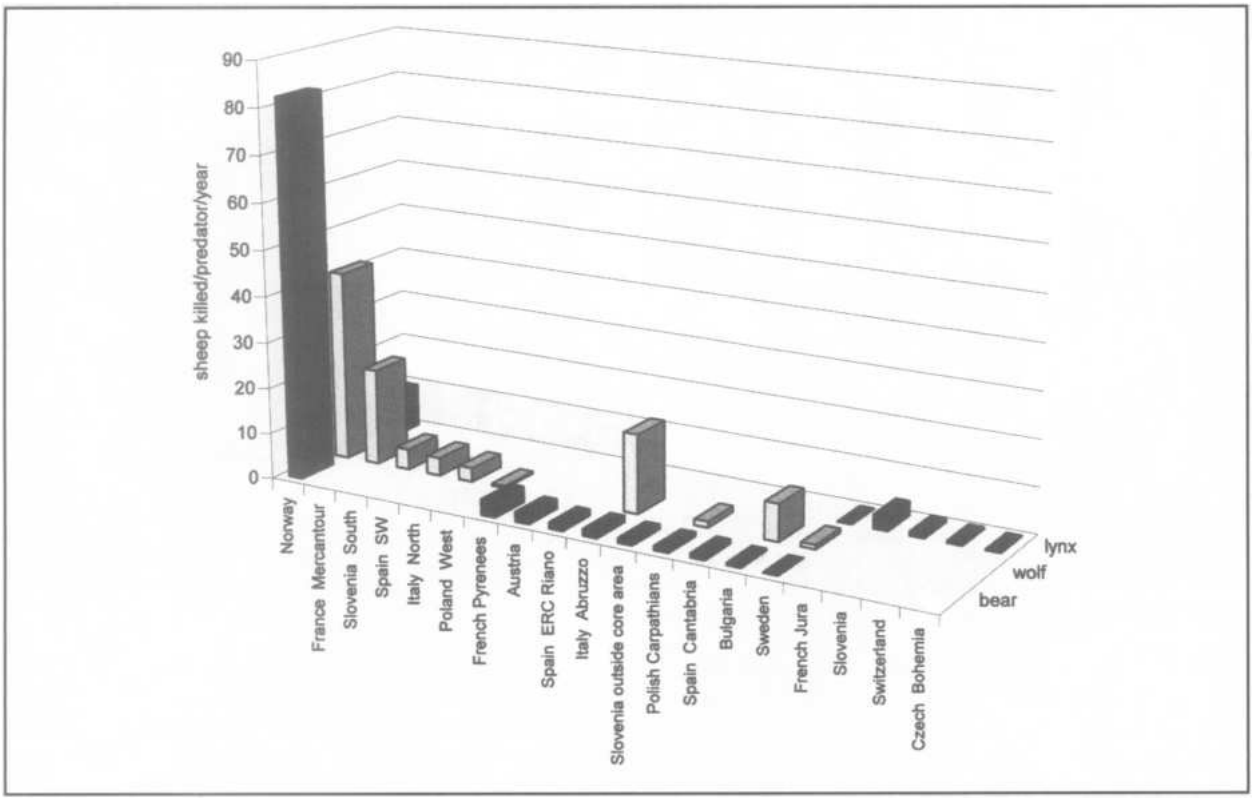

Fig. 2. Annual per capita damage to sheep (ACLS) done by bears, wolves, and lynx in different European regions 1968–95.

be rare, but if bears succeeded in breaking into barns or corrals, they often caused considerable damage because the sheep panicked and suffocated from crowding (Genov and Wanev 1992). The same has been reported for wolves breaking into barns or corrals (Boitani 1992) and bears breaking into enclosures (Adamic 1997).

Today, the distribution of lynx, wolves, and bears in Europe is tightly linked to forest cover, and all 3 predators are rarely present in open country where they are vulnerable to human persecution. Therefore, livestock are most vulnerable in or near the forest (Nass et al. 1984). In Switzerland, lynx predation on sheep was restricted to forested areas; above timberline few losses were reported (U. Breitenmoser, Swiss Lynx Project, Muri, Switzerland, personal communication, 1996). In the French Jura Mountains, the mix of sheep pastures and forests could be one reason for the high predation rates by lynx. A shepherd in Romania who experienced elevated predation by bears and wolves had just a small clearing in the forest available for grazing sheep (S. Klenzendorf, Munich Wildlife Society, Linderhof, Germany, personal communication, 1996). Even historical reports mention that forests were cut down to drive away predators and obtain safe grazing grounds (Eiberle 1972). In Norway, losses of sheep to bears were significantly higher in forested than alpine range (Wabakken and Maartmann 1994).

Economic Loss

The proportional loss any predator species caused among the livestock was very small. In most areas <1% of the overall stock was taken (Table 3), but locally, losses sometimes were significant.

In the Alps, natural losses – not attributed to predators – were estimated at 3–5% for untended sheep. In many areas predation by loose and feral dogs is probably much higher than predation by large carnivores. For example, in 1983 loose dogs killed 667 sheep in the Haute-Savoie, France, while in that year bears killed only 66 sheep in the French Pyrenees (Bouvier and Arthur 1995).

MANAGEMENT IMPLICATIONS

In Norway, per capita losses of livestock due to bears, wolves and lynx are the highest observed in Europe. Untended sheep grazing on forested range are responsible for providing this depredation situation. As the amount of damage and bear numbers seem to be closely correlated (Sagør et al. 1997), losses will further increase as the Swedish bear population spreads into Norway.

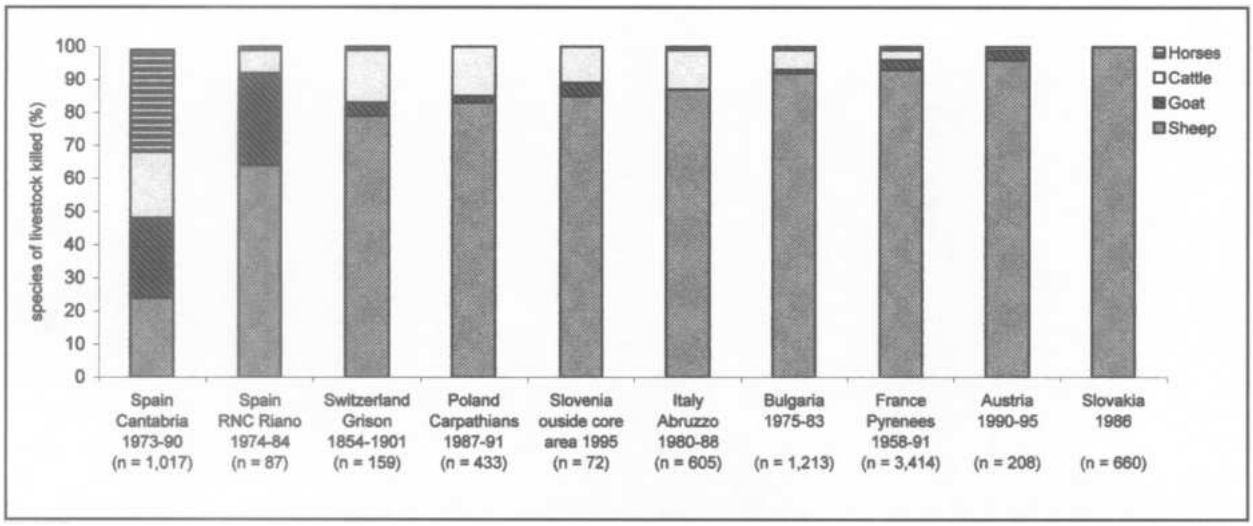

Fig. 3. Composition of livestock killed by bears by region within each country or region (Spain: Purroy et al. 1988, García-Gaona 1997; Switzerland: Metz 1990; Poland: Bobek et al. 1993; Slovenia: Ministry of Agriculture and Forestry, 1995, annual livestock damage statistics, Ljubljana, Slovenia; Italy: Fico et al. 1993; Bulgaria: Genov and Wanev 1992; France: Bouvier and Arthur 1995; Austria: Rauer and Gutleb 1997; Slovakia: Heil and Bevilaqua 1988).

Presently, absolute numbers of livestock losses caused by wolves are small. But with an increasing wolf population, damages have to be expected to be at least as high as losses by bears.

Lynx are minor predators on livestock, including sheep. Inexpensive protection measures against lynx should be further tested (e.g. protection collars, deterring collars). All other countries that plan to re-establish bear or wolf populations should learn from the Norwegian situation: if lynx are causing serious damage to livestock already, problems will greatly increase with the re-establishment of bears or wolves. There is no example in Europe of extensive sheep farming with low losses and viable populations of bears and wolves on the same range.

Experiences from countries with thriving populations of large carnivores show that livestock grazing is possible on predator range given that efficient guarding techniques are applied. Some losses will occur, however. In Norway conditions for re-establishment of large predators are actually good: human population density is very low compared to other European countries, forest cover is about average (Table 1), and the natural prey base is moderate for lynx and high for wolves and bears.

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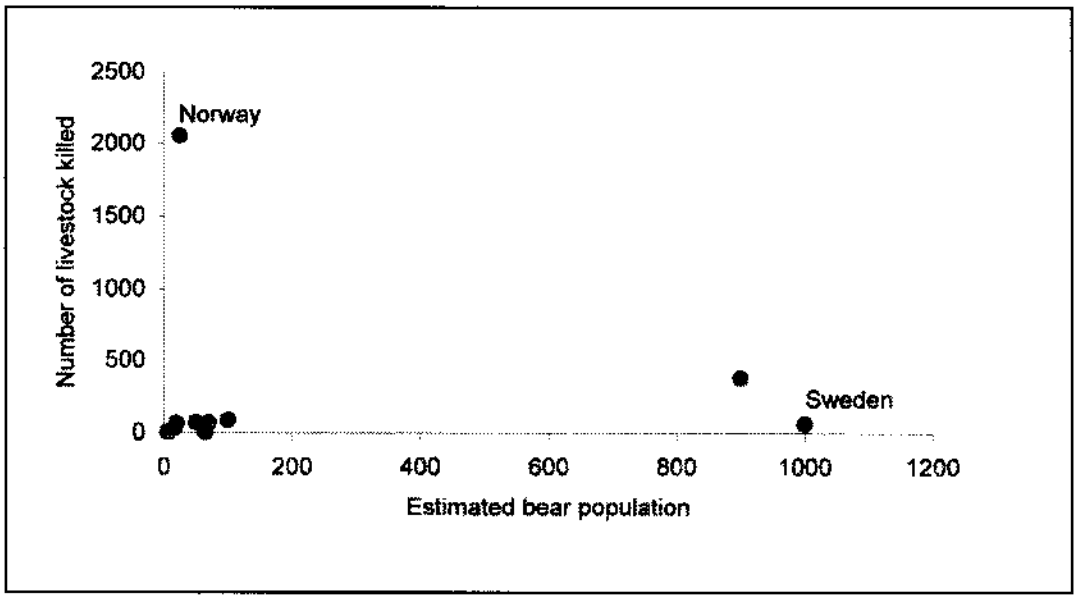

Fig. 4. Correlation of estimated bear population and number of livestock (sheep) killed annually in Europe, 1973–95.

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