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Abstract: **Context.** Compensation programs have become a common tool to mitigate conflicts between farmers and large predators; however, their effectiveness is based on a series of assumptions that should be carefully and continuously assessed within an adaptive management framework. Ex-post compensation programs were adopted in Italy as a financial incentive to aid wolf conservation since the 1970s; however, their implementation has never been monitored nor actively managed in the past 35 years, during which time a remarkable recovery of wolf population and range expansion into more human-dominated landscapes has taken place. **Aims.** We hereby report on wolf-damage compensation programs in Italy and discuss their conservation value. **Methods.** We used data on wolf-damage compensation that we compiled at the national scale for the period 1991–95. Although not recent, these were unfortunately the only available data at the national scale, and were instrumental in supporting our discussion on compensation programs, as these are increasingly becoming a politically and economically sensitive issue. **Key results.** From 1991 to 1995, annual compensation costs represented on average 86% of the alleged losses to farmers, and averaged Euro1'825'440 (+/- 169'760 s.d.), or about Euro 5'150 (+/- 750) per wolf per year. Compensation costs varied markedly from region to region, although local differences were hardly explainable in terms of wolf densities and their trends at the regional scale. On the contrary, they appeared largely affected by inconsistencies in rules and procedures of regional compensation schemes. **Conclusions.** In the light of persistently high occurrence of wolf–livestock conflict, and widespread illegal killing of wolves, we argue that compensation programs in Italy currently provide no evidence of being a functional and cost-effective conservation tool. However, lack of monitoring of compensation costs in Italy at all institutional levels, including nongovernment organisations (NGOs), reveals that compensation policies are not being evaluated, nor is their effectiveness being assessed. **Implications.** We contend this is an unwise and unsustainable strategy to reduce the conflict, especially in the light of the recent increase in wolf numbers and, most importantly, a marked change in livestock husbandry practices. By emphasising the need for a thorough revision of the compensation schemes adopted for wolf conservation in Italy, we advocate new and theoretically sound solutions to current compensation policies.

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Ex-post compensation payments for wolf predation on livestock in Italy: a tool for conservation?

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Abstract

Context. Compensation programs have become a common tool to mitigate conflicts between farmers and large predators; however, their effectiveness is based on a series of assumptions that should be carefully and continuously assessed within an adaptive management framework. Ex-post compensation programs were adopted in Italy as a financial incentive to aid wolf conservation since the 1970s; however, their implementation has never been monitored nor actively managed in the past 35 years, during which time a remarkable recovery of wolf population and range expansion into more human-dominated landscapes has taken place.

Aims. We hereby report on wolf-damage compensation programs in Italy and discuss their conservation value.

Methods. We used data on wolf-damage compensation that we compiled at the national scale for the period 1991–95. Although not recent, these were unfortunately the only available data at the national scale, and were instrumental in supporting our discussion on compensation programs, as these are increasingly becoming a politically and economically sensitive issue.

Key results. From 1991 to 1995, annual compensation costs represented on average 86% of the alleged losses to farmers, and averaged €1 825 440 (±169 760 s.d.), or about €5150 (±750) per wolf per year. Compensation costs varied markedly from region to region, although local differences were hardly explainable in terms of wolf densities and their trends at the regional scale. On the contrary, they appeared largely affected by inconsistencies in rules and procedures of regional compensation schemes.

Conclusions. In the light of persistently high occurrence of wolf–livestock conflict, and widespread illegal killing of wolves, we argue that compensation programs in Italy currently provide no evidence of being a functional and cost-effective conservation tool. However, lack of monitoring of compensation costs in Italy at all institutional levels, including non-government organisations (NGOs), reveals that compensation policies are not being evaluated, nor is their effectiveness being assessed.

Implications. We contend this is an unwise and unsustainable strategy to reduce the conflict, especially in the light of the recent increase in wolf numbers and, most importantly, a marked change in livestock husbandry practices. By emphasising the need for a thorough revision of the compensation schemes adopted for wolf conservation in Italy, we advocate new and theoretically sound solutions to current compensation policies.

Additional keywords: compensation programs, large carnivores, wolf, wolf–livestock conflicts.

Introduction

Similarly to the situation with other large predators, conflicts between wolf (*Canis lupus* Linnaeus) and farmers are common throughout most of the wolf range and represent one of the most relevant problems in wolf conservation programs (Telleria and Saez-Royuela 1989; Bangs *et al*. 1995; Mech 1995; Cozza *et al*. 1996; Breitenmoser 1998; Ciucci and Boitani 1998*a*; Fritts *et al*. 2003; Schwerdtner and Gruber 2007). Wolf predation on livestock has been the primary reason for the eradication efforts that have occurred since the early years of pastoralism (Boitani 1995) and continue to occur today, even in Europe (Kaczensky 1996) and North America (Fritts *et al*. 1992; Boitani 2003).

In Europe, wolf populations and pastoralist economies have always been in conflict, the outcome ranging from complete wolf eradication to tolerance of some level of depredation (Kaczensky 1996). As wolf populations have been gradually protected over their remaining ranges, and ecological conditions have favoured their natural recovery, the problem of wolf–farmer conflict has become ever more compelling in countries such as France, Switzerland, Norway and Italy (Mech 1995; Fourli 1999; Boitani 2000, 2003). In 2000, wolf depredation across Europe

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was estimated to kill ~10 000 heads of livestock per year, for a total loss of Euro €7–9 million (Boitani 2000).

In Europe, before wolves were legally protected, traditional defence strategies against wolf predation included a combination of prevention measures (shepherd, livestock-guarding dogs, night-time enclosures and other grazing practices) and predator control (Kaczensky 1996). Until wolves were abundant, prevention was adopted by farmers without any support by the authorities (Linnell *et al*. 1996). When wolves became protected by either national or European legislation, compensation programs were introduced by governments as a contribution to farmers to mitigate livestock losses to wolves (Fourli 1999). The theoretical and social justification for the compensation programs is obvious, because they respond to the need for equity in sharing the costs of large-predator conservation in human-inhabited areas (Ferraro and Kiss 2002; Nyhus *et al*. 2005; Schwerdtner and Gruber 2007). As such, they are expected to alleviate the burden of losses for farmers and to reduce animosity towards predators and illegal killing. Therefore, compensation programs have often been present in the toolbox of carnivore conservation (Nyhus *et al*. 2005), sometimes being the only tool used by conservation programs. However, schemes that provide compensation to livestock owners for losses to predation can be weakened by theoretical flaws or inadequate legal and social settings (Ferraro and Kiss 2002; Naughton-Treves *et al*. 2003; Zabel and Roe 2009), and their functionality is based on a series of assumptions. Ex-post compensation programs (see below), in particular, assume institutional credibility and effective enforcement of protection laws, reliability and consistency of damage verification and reimbursement procedures, social acceptance of compensation schemes and their long-term economic sustainability. As all these factors are difficult to control and account for, schemes for ex-post compensation are far from being widely accepted as a successful conservation tool, even though they have been implemented in many places around the world (Cozza *et al*. 1996; Naughton-Treves *et al*. 2003; Swenson and Andrén 2005; Gusset *et al*. 2008; Zabel and Holm-Müller 2008).

Compensation for livestock losses to wolf predation has been adopted by several European countries (e.g. Italy, France, Greece, Portugal, Norway, Sweden, Croatia) (Boitani 2000; www.lcie.org, accessed 20 July 2010), although there is a great diversity of approaches, depending on local traditions and socio-economic conditions. In North America, compensation for wolf depredations is less widespread than in Europe (Treves and Karanth 2003). It has been used by the Minnesota Department of Agriculture since 1979 (Fritts 1982; Fritts *et al*. 1992; Mech 1998), and more recently by Defenders of Wildlife, a national wildlife-conservation organisation that established a fund to reimburse livestock owners for livestock losses in the wolf-recovery areas in the Northern Rockies (Fisher 1989; Bangs *et al*. 1998; Treves *et al*. 2002; Stone 2009), Arizona, and New Mexico (Parsons 1998). However, most of these programs are difficult to evaluate in terms of effectiveness for conservation, and they generally lack a strong theoretical framework.

Theoretically, compensation for livestock losses to predators is part of a broader spectrum of incentives for environmental services, a conservation approach increasingly promoted by governmental and non-governmental agencies to contrast declines in biodiversity and ecosystem services (Ferraro and Kiss 2002; Zabel and Roe 2009). Compensation can take many different forms, namely from indirect economic incentives to direct payment for conservation performance (Zabel and Roe 2009). Most commonly, schemes to compensate livestock owners for losses to predators range from ex-post compensation (hereafter, compensation), where the damage is compensated after it has occurred, to ex-ante compensation, where an estimate of the expected damaged is paid conditional on the acceptance of predators in the area (Schwerdtner and Gruber 2007; Zabel and Roe 2009). Payment in the latter form, also referred to as conservation-performance payment (Zabel and Roe 2009), is entirely focused on the conservation outcome which, in the context of carnivore conservation, can be defined as the number of carnivores or carnivore offspring surviving in the area (Zabel and Holm-Müller 2008). Operationally, ex-ante compensation is thought to be a more effective conservation tool whenever damages occur with fairly predictable spatial and temporal patterns (Schwerdtner and Gruber 2007). Whichever compensation program is in place, however, incentives for the adoption of prevention measures and proper husbandry practices also have to play a relevant role (e.g. Woodroffe *et al*. 2007; Gusset *et al*. 2009).

In Italy, the wolf has been legally protected since 1971. Compensation for damages caused by wolves was adopted soon after the species' legal protection, with compensation procedures formally funded by regional governments. The region of Abruzzo was the first, among those hosting wolves, to adopt a compensation program in 1974, following a previous compensation scheme run by the WWF Italy (Boitani 1982).

As wolves recolonised areas from which they had been absent for decades (cf. Cagnolaro *et al*. 1974; Fig. 1), wolf–farmer conflicts expanded nationwide and intensified locally. Especially, in some lowland agricultural areas from which wolves had been absent for decades, compensation paid to farmers increased to the point of becoming economically unsustainable and politically unpopular (Ciucci and Boitani 1998*b*, 2005). The presence of free-ranging domestic dogs, especially in the central and southern regions (Boitani and Fabbri 1983), further exacerbate the problem mostly because of the difficulty in distinguishing between dog- and wolf-caused predations (Boitani 1982; Blanco *et al*. 1990; Fernández *et al*. 1990; Cozza *et al*. 1996). Although the true proportion of predations by dogs is unknown both at the regional and national scales, a considerable share of compensation funds originally meant for wolf conservation are being used to reimburse farmers for damages caused by dogs (Ciucci and Boitani 1998*b*, 2005; Fico *et al*. 2005).

Although compensation has been provided in Italy for more than three decades, knowledge about livestock losses (Fico *et al*. 1993; Boitani and Ciucci 1996), as well as costs, trends and effectiveness of compensation programs is still very limited (Boitani 1982; Guacci 1985; Cozza *et al*. 1996; Ciucci and Boitani 1998*a*, 1998*b*, 2005). No critical analysis on the compensation programs has ever been attempted because they have been designed and implemented during these past 35 years. Such analysis is particularly critical, especially in the light of

Fig. 1. Wolf distribution (grey shade) in Italy in 2010. The internal lines indicate the regional boundaries.

the recent increase in the range and numbers of wolf population, because these changes may not be currently compatible with the premises and assumptions on which compensation programs were originally formulated. More recently, social conflict, locally generated by persistent or increasing compensation costs, has forced some regional administrations to drastically reduce (e.g. Tuscany) or even eliminate (i.e. Calabria) their compensation procedures, without any formal evaluation of previous compensation policies.

Ideally, the data needed for a critical evaluation of compensation schemes should be regularly collected and consistently stored by all regional authorities through standard procedures; however, unfortunately no such data were available for compensation of livestock losses to wolves in Italy. Furthermore, meaningful evaluation of compensation schemes would theoretically entail exploring their causal relationship with ecological and socio-economic correlates; however, this is extremely complex because both environmental and human factors are often difficult to control and occur at random (Zabel and Roe 2009). Accordingly, in the context of carnivore conservation, even a more coarse-grained approach to evaluate compensation programs would be nevertheless feasible, to inform managers and administrators of the potential pitfalls of mismanaged compensation policies (e.g. Cozza *et al*. 1996; Naughton-Treves *et al*. 2003; Swenson and Andrén 2005; Gusset *et al*. 2009). In our case, in particular, we believe this is critical

before compensation policies and schemes are boycotted by interested parties or simply dismissed according to uninformed, political pressures.

On the basis of the above premises, we collected and critically evaluated the costs and structures of the compensation schemes implemented by each regional government in Italy for the years for which these data were available on a national scale (1991–1995). On the basis of these data and drawing from other empirical evidence, our aim is to discuss the strengths and the weaknesses of compensation policies as they have been applied in Italy during these past decades. Unfortunately, no similar data are available for more recent years, as no monitoring program is in place by governmental or non-governmental organisations. However, we believe the patterns we detected are informative of the potential pitfalls that characterise the wolf-compensation policy in Italy also in recent times. In fact, with the exclusion of few exceptions (see above, regions of Tuscany and Calabria), and despite the expanding wolf population and the profound changes in livestock economy and husbandry practices, no major changes in compensation schemes and policies have been attempted in Italy in these past 15 years.

Although our discussion is mainly related to wolf depredations in Italy, we believe it pertains also to the conservation of large carnivore populations elsewhere, especially in countries where traditional, ex-post compensation programs are the main conservation tool to deal with expanding carnivore populations.

Methods

Starting from official files of each regional administration, we collected and tallied compensation costs paid for livestock losses to wolves for the period 1991–1995 from each of the 10 regional governments that were implementing their compensation laws during those years. We distinguished the following two levels of compensation costs for each verified depredation: the total amount claimed by livestock owners in their application and the amount actually refunded by the regional government according to the provisions of the regional law (i.e. full or partial reimbursement).

We compared regional differences in the mean annual compensation costs by using Kruskal–Wallis test, and we tested departure of the distribution of annual costs from a uniform distribution, both at the national and regional scales, by using Kolmogorov–Smirnov (K–S) 1-sample test (Sokal and Rohlf 1995). We used Spearman's r to test the correlation between the mean annual compensation costs by region and the size of the regions, as well as an estimate of wolf abundance by region. We additionally contrasted the regional distribution of compensation costs with the regional extent of the estimated wolf range in Italy by using K–S 2-sample test. In Italy, apart from estimates of wolf numbers at local and restricted scales across the wolf range (cf. Ciucci and Boitani 1998*b*), no accurate estimate of the wolf population nationwide has ever been made. Similar to other European countries (cf. Boitani 2000), gross figures of wolf population size have been obtained by extrapolating densities estimated in sample areas to the known wolf range (Boitani 1992; Boitani and Ciucci 1993; Corsi *et al*. 1999). Therefore, because estimates of wolf numbers by region are too gross an average across space and years for our scope, to explore whether compensation costs had any obvious linear relationship with wolf numbers, we determined the number of wolves in each region that were to be postulated if the linear-relationship hypothesis held true (i.e. we allocated by region the 1991–95 nationwide estimates of 270–380 wolves (Ciucci and Boitani 1998*b*; Corsi *et al*. 1999) in proportion to the average annual compensation costs of each region).

To aid interpretation of compensation costs, we also collected and subjectively evaluated compensation schemes and policies adopted by each regional government, including the most relevant rules and procedures regulating critical phases of the compensation scheme, from verification of the alleged damage to reimbursement. Expectedly unknown inconsistencies in the implementation of some of these rules, however, prevented us to formally attempt to model their causal relationship with compensation costs.

Results

During 1991–1995, the mean (±s.d.) total costs claimed in Italy for wolf depredations were €1 825 440 (±169 760) per year, ranging from €1 513 000 (1991) to €2 070 000 (1995). During the same period, compensation that was actually paid averaged €1 566 070 (±116 000) per year, ranging from €1 445 000 to €1 688 000. Overall, compensation paid by regional governments represented 86% of the alleged losses, ranging from 26% to 100% (Table 1).

We estimated the mean (± s.d.) annual compensation cost in Italy as €5150 (± 750) per wolf per year, ranging from €4450 to €6300. However, the declared losses (i.e. the farmers' perception of the damage) averaged €6050 (±1250) per wolf per year, ranging from €4850 to €7750.

Mean annual compensation costs varied markedly by region (Kruskal–Wallis, $H = 36.2$, $P < 0.001$), ranging from €2500 (region of Liguria) to €727 000 (region of Lazio; Table 1). Total compensation costs during the 5-year period were uniformly distributed, both at the national scale (K–S, $D = 0.0282$, $P > 0.05$), and within each region (K–S, $0.050 \leq D \leq 0.1973$, $P > 0.05$).

Mean annual compensation costs by region did not correlate with the estimated size of the wolf range in each region ($r_s = 0.45$, $n = 9$, $P = 0.22$), and each region's share of the overall national costs was independent from the estimated wolf-range size (K–S, $D = 1.0$, $n = 9$, $P < 0.001$). Under the hypothesis that compensation costs were correlated with wolf numbers, we estimated differences in wolf densities at the regional scale ($n = 9$) up to 94%, ranging from 0.15 to 2.5 wolves per 100 km^2.

We revealed a great variation in the rules and procedures of the compensation programs adopted by the 10 regions. Although the quality and quantity of the data did not allow a formal analysis, it is likely that inconsistency among the following rules would have introduced significant differences among the regional costs (Table 1): (1) the canid for which compensation was provided; only some regions assessed damages separately for wolves and dogs, with separate compensation procedures and dog damages paid from 0 to 100%; (2) the time lag allowed to verify alleged damages by agency personnel (from ≤24 h to several days) and the conditional evidence for a predator attack (from clear

Table 1. Annual mean compensation costs (in €) and programs (main structure) provided by each Italian region for livestock depredations (1991–95)
Although the wolf range in Italy encompassed a total of 13 regions, only 10 regions funded compensation programs in the years of the study. The regions of Puglia and Piemonte, at that time at the fringes of the wolf range, suffered few losses, whereas the region of Basilicata never funded its compensation program since its conception (1974). Data from the regions of Abruzzo and Campania were not available for 1991 and were estimated as averages of the 1992–94 figures to facilitate comparison among regional costs. Costs for the region of Umbria (1993–95) and the regions of Molise and Lazio (1995) do not include losses that occurred inside national parks as they were compensated by the park administrations. Costs for the region of Calabria were available for 1995 only (declared and paid: €226 970) and are not reported in the Table. Costs in Italian Liras were converted in Euros at the exchange rate €1 = Lit 2000. a.s.a.p., as soon as possible

Parameter	Region								
	Lazio	Toscana	Marche	Abruzzo	Umbria	Campania	Molise	Emilia	Liguria
Compensation costs									
Claimed	727 000	299 200	191 900	177 360	109 760	99 860	92 110	80 340	2500
(±s.d.)	(161 880)	(54 121)	(121 390)	(49 430)	(51 270)	(63 290)	(18 170)	(11 100)	(1470)
Paid	727 000	257 440	127 870	156 430	28 430	56 560	92 110	72 310	2500
(±s.d.)	(161 880)	(78 320)	(81 890)	(55 890)	(14 580)	(18 760)	(18 170)	(9990)	(1470)
Compensation program									
Maximum time to verify claimed damages	30 days	7 days	2 days	a.s.a.p.	a.s.a.p.	30 days	a.s.a.p.	a.s.a.p.	a.s.a.p.
% market price compensated	100	100	≤100[A]	100	≤100[A]	≤100[A]	100	90	100
Conditions for reimbursement	Grazing permits	Prevention measures	None	Guarded livestock	Guarded livestock	None	Grazing permits	None	None
Percentage of national wolf range in the region	10.1	12.5	5.9	13	5.2	12.1	4.8	8.2	0.8

[A]Actual proportion paid depends on total amount requested and the availability of the regional budget.

predation signs on the livestock carcass to simple declaration by the farmer); (3) the value compensated, ranging from 60% to 100% of the market price, or lower in case not all funds were available; (4) the rules and the extent of conditionality for a full payment; only few regions required farmers to adopt prevention methods to be eligible for compensation; (5) efficiency of the payment procedure, with only few regions establishing a maximum time lag from claim to actual payment (ranging from 30 days to >2 years, when specified).

Discussion

The annual cost of compensation programs for wolf depredations in the present study in Italy was among the highest of all European countries for the same time period 1991–1995 (Boitani 2000). Only France had comparable costs (€5000 per wolf per year); however, the French farmers, at that time, were facing wolf depredations after decades of livestock husbandry in the absence of wolves. Sweden and Norway had higher annual costs (€14 000 per wolf per year and 10 000 per wolf per year, respectively); however, these included subsidies for prevention measures (Linnell and Brøseth 2003; Swenson and Andren 2005). In Minnesota, by comparison, the average compensation costs (excluding wolf control) during 1990–98 were about €18.5 per wolf per year for a population of ~2000 wolves (Mech 1998). In the same period, compensation costs for wolf recovery in north-western Montana (30–40 wolves) and reintroduction in Yellowstone and Idaho (21–116 and 14–112 wolves, respectively) averaged €61.3 per wolf per year, ranging from €54.5 per wolf per year (north-western Montana) to 73.9 per wolf per year (Yellowstone area: 1996–97 only) (Bangs *et al*. 1998: tables 1, 2). These costs included a fall market value, a potential loss to orphaned livestock, veterinarian bills and probable losses (partial compensation), and excluded relocation and control interventions (Bangs *et al*. 1998).

Absolute figures of compensation costs paid in Italy may appear of economic concern to the public and are often used to weaken public support for conservation programs, especially during times of political confrontation with propagandistic media campaigns at a local level. However, although compensation costs in Italy are among the highest in European countries, they appear almost irrelevant compared with national or regional economies. For example, annual compensation paid in Italy for livestock losses to predators amount, on average, to the cost of building 100 m of a new highway (http://www.regione.toscana.it/regione/export/RT/sito-RT/Contenuti/notiziari/rassegna_stampa/quotidiani_periodici/visualisza_asset.html_892643657.html, accessed 15 February 2010). Moreover, compensation paid to livestock owners for losses resulting from wolf predation was much smaller than that paid to farmers who suffered crop damages to wild boar. In the regions of Umbria and Marche, central Italy, compensation paid for losses caused by wolf depredations in 1991–95 was 17% and 22%, respectively, of the amount paid to compensate wild boar damages to crops (Ciucci and Boitani 1998*b*). By no means, however, are damages caused by wild boar, a highly valued game species, opposed by the public and farmers to the same extent as are damages caused by wolves on livestock (Boitani 1995, 2003).

On a broader perspective, the large differences among compensation costs across Europe (Boitani 2000) do not appear to have any relation to the status of wolf populations. Lower compensation costs do not necessarily represent a measure of better wolf-management policies, lower wolf–livestock conflicts, and/or lower wolf densities. Compensation costs do not appear to be related to the number of wolves in each country (Boitani 2000) and it is difficult to find evidence for, or to speculate on, correlation with ecological or socio-economic variables. Moreover, the same diversity in the design and implementation of the compensation programs we found

across the Italian regions is also found among other European countries, thus making quantitative comparisons among areas difficult to interpret.

Compensation costs and wolf densities

Compensation costs in Italy are often perceived by administrators as a direct index for wolf numbers, and when costs increase, it is more difficult to manage the pressures for wolf control (V. Bossert, Regione Piemonte). Our indirect approach clearly indicates that it is highly unlikely that compensation costs in Italy bear any direct correlation with wolf numbers on a large scale. In fact, we found no meaningful explanation for the high variability in the postulated wolf densities among the regions (i.e. according to regional compensation costs); the 17-fold difference in wolf density, for example, between the regions of Campania and Lazio, adjacently located in the central-southern Apennines, with a continuous wolf range across similar conditions, does not find any reasonable explanation on ecological or management grounds.

Moreover, for the hypothesised correlation between compensation costs and wolf density to hold true, we would need to postulate extreme fluctuations in wolf densities at the regional scale on a yearly basis, with up to two- and three-fold increases in the regions of Abruzzo (1994–95) and Marche (1991–92), respectively, and six-fold decreases in the region of Liguria (1994–95). These variations appear beyond the biological capability of the wolf and certainly have no reasonable explanation in any variation of local ecological conditions, livestock numbers, husbandry methods and numbers of wolves killed illegally.

Many other sources of variation are likely to affect annual compensation costs. Factors related to the ecology of wolf predation and livestock husbandry are likely to be among the most relevant and include wild-prey availability, livestock density and accessibility (e.g. fences, guarding dogs, shepherd, seasonal transhumance patterns), livestock type (e.g. species, breed, age, condition), habitat type and topography of grazing allotments. Unfortunately, most of this information is not available at a national or regional level and, in particular, official censuses of livestock heads are largely unreliable, livestock owners are coded by administrative units and not by grazing allotment, and no information is available on husbandry type (e.g. free-ranging, stables). Each of these factors has independent spatial and temporal distribution patterns and their interaction in the highly interspersed Italian landscape cannot be predicted. In Tuscany, Ciucci and Boitani (1998*a*) found that livestock killed by wolves were not evenly distributed across the regional wolf range, and 8% of the affected municipalities accounted for 32% of sheep lost to canid predators. In the much more uniform landscape of Minnesota, farms with chronic losses were larger, had more cattle, and had herds farther from human dwellings, whereas habitat types and other farm characteristics and management practices were the same around farms with and without losses (Mech *et al*. 2000).

Other sources of variation include all factors related to the rules and procedures of the regional compensation schemes, including proportion of the loss compensated, procedure of damage verification, availability of funds and policies of local governments. The lack of standardisation in the procedures adopted by the regional agencies to verify alleged damages is a common problem, and it markedly affects variability in compensation costs across regions. For example, in the Cilento National Park (Central Italy) compensation costs (€15.500 per wolf per year) are about seven times higher than in the Majella National Park, and on average two times higher than those of all other National Parks of the Apennines (Ciucci and Boitani 2005). Although these differences may in part be accounted for by differences in ecological conditions, wolf and free-ranging dog densities, livestock types and husbandry practices, they rather point at structural and administrative incongruities in the management of the compensation schemes (Ciucci and Boitani 2005). For example, a longer time lag between a predation event and its verification allows for a greater proportion of erroneous certifications and greatly inflates the acceptance of false claims (cf. region of Lazio; Table 1). In addition, an unknown percentage of the compensation costs is due to damages caused by dogs, but is erroneously or falsely attributed to wolves, a distinction difficult to make even though it is required by some regional programs.

Our findings therefore suggest that compensation costs cannot be used locally as an index of wolf numbers or trends, nor to compare wolf–livestock conflicts among different regions. Even though the interaction among factors related to depredation patterns and implementation of compensation programs is complex and may change dramatically through time, it is of critical importance to quantify hard data on the wolves' real or perceived impact on rural economies and to monitor compensation costs through time. In a broader carnivore-conservation context, this type of data are crucial to adequately manage the carnivore–human interface (Naughton-Treves *et al*. 2003; Gusset *et al*. 2009). For example, although compensation costs have never been quantified in Italy before, their perceived figures have often been used in political debates as an argument against wolf conservation.

Compensation programs as a conservation tool

Evaluating compensation programs as a tool to manage carnivore–livestock conflicts is complex and difficult; however, it should nevertheless be a primary concern for all agencies responsible for carnivore conservation (Naughton-Treves *et al*. 2003; Swenson and Andrén 2005). Although compensation programs *per se* were never meant to reduce the extent of depredation, they aim at mitigating the conflict originating from depredations and therefore to increase the social acceptance of carnivores (Schroder and Promberger 1993; Linnell *et al*. 1996; Nyhus *et al*. 2005). Some practitioners and analysts, however, have suggested that ex-post compensation schemes are inadequate and cumbersome (Naughton-Treves *et al*. 2003), and they are thought to be inherently susceptible to moral hazard, problems of trust and transparency, high transaction costs and long time lags (Zabel and Holm-Müller 2008). In addition, in cases where insufficient prevention is adopted, they may even be counterproductive by encouraging a state of permanent conflict (Van Eerden 1990; Cozza *et al*. 1996). As a consequence, ex-post compensation schemes have not proven to be widely successful in changing the attitudes of livestock owners towards carnivores (Zabel and Holm-Müller 2008; Gusset *et al*. 2009). Obtaining

robust experimental data on the effectiveness of compensation programs in reducing illegal killings of carnivores is very difficult. In Italy, despite the high compensation costs, as reported here, there are indications that this approach has not been very effective in achieving its conservation goal, the most obvious being the high number of illegally killed wolves (Ciucci and Boitani 1998*b*, 2005; Lovari *et al*. 2007).

The reasons for this situation can be discussed at three levels. First, we believe the reasons and the ways of illegal wolf killings are largely independent from the rights of farmers to receive the compensation for losses. In Italy, most of the known illegal wolf killings occur in areas of higher livestock densities (Corsi *et al*. 1999), suggesting that livestock owners and their social communities, or even an effective minority of them, do not accept the implicit social agreement which ex-post compensation schemes are based on. Although in Italy, and across most of Europe, compensation programs are generally accepted by the public, the same view is not necessarily shared by many farmers and shepherds who would rather resort to wolf control. For them, acceptance of the compensation programs is a way to legitimate wolf protection; because farmers and shepherds oppose wolf presence, they also oppose compensation programs that support wolf management (L. Boitani, unpubl. data). Especially, in areas where livestock husbandry practices developed during the past decades in the absence of wild predators, wolf recovery and acceptance currently imposes further costs and labour, such as attending livestock, using guarding dogs and other preventive methods, and herding livestock at night into enclosures. With few exceptions, these costs, as well as the indirect costs of a wolf attack (e.g. lost or wounded animals, abortion, loss of condition), are not provided by traditional ex-post compensation schemes. Moreover, transaction costs and long time lags impose further workload on farmers. In Norway, France and Switzerland, in spite of the compensation paid by governments for all damages caused by wolves, farmers fiercely oppose wolf recovery and conservation, and, as a consequence, wolf control has been approved even if the national wolf populations are very small (Breitenmoser 1998; Swenson and Andrén 2005; www.lcie.org, accessed 20 July 2010).

Second, such compensation programs have obvious limits if they are considered the only or primary tool available to manage carnivore–livestock conflicts. When compensation programs were first adopted in the 1970s in Italy, they were welcomed as a fundamental tool in conserving the small and fragmented Italian wolf population, and in promoting changes in social attitudes towards the recently protected predator (Boitani 1992). Old shepherds in central and southern Italy still used traditional husbandry practices and effective prevention methods (e.g. livestock-guarding dogs, assistance of the flock while grazing), and they were happy to accept compensation for the few losses. However, following wolf recovery and range expansion in the successive decades, especially in northern Italy, limitations of the compensation programs as the sole means to mitigate conflicts soon became clear. New generations of farmers have abandoned traditional husbandry in favour of economically more convenient practices, such as grazing free-ranging cattle and horses, and are not willing to resume the old practices (Tropini 2005). In spite of these obvious changes, the Italian national and regional authorities still adopt compensation programs as if they were the only tool available to address wolf–farmer conflicts and to ensure wolf conservation.

Compensation for livestock depredations is expected to have its most positive effects in areas where livestock are killed rarely and irregularly, and this may occur where effective traditional predator-friendly husbandry methods are implemented, or where predators are not living permanently in an area (Schwerdtner and Gruber 2007). This is not necessarily the case, however, where there is an expanding population inhabiting a human-dominated landscape. When wolves live permanently in an area, and when local socio-economic lifestyles are not compatible with traditional husbandry methods (as in most areas recently recolonised by expanding wolf populations), predator attacks are to be expected at rather regular spatial and temporal occurrence (Schwerdtner and Gruber 2007).

Third, to be effective, compensation programs should be thoroughly supported by an effective enforcement system, and a consistently applied, reliable procedure to verify alleged claims. In the absence of credible enforcement and damage-verification procedures, such as is the case of the wolf in Italy (Cozza *et al*. 1996; Ciucci and Boitani 2005; Fico *et al*. 2005), compensation programs may soon become an added bonus to illegal predator killing. Alternatively, practical improvements in livestock husbandry practices may go a long way towards mitigating human–carnivore conflicts, and compensation policies should be designed as to stimulate livestock owners to adhere to minimal standards of responsible husbandry practices (Gusset *et al*. 2009). In this perspective, for a compensation program to be accepted by the local farmers, it needs to be the result of a participatory process among all interest groups, with rules collectively designed and frequently revised (Ostrom 1990). On the contrary, compensation programs for wolf–livestock conflicts in Italy have been traditionally developed and implemented following a top-down approach, with most farmers and shepherds little informed and clearly not participating in the process.

Alternatively to compensation schemes, conservation performance payments have been adopted widely across the world (Zabel and Roe 2009), and similar schemes to aid carnivore conservation have been implemented also in Europe. In Sweden, since 1996 Sami reindeer owners have received carnivore-performance payments contingent on the number of reproductions that are certified on their reindeer grazing areas (Linnell *et al*. 1996; Swenson and Andrén 2005). In this case, the amount of compensation is calculated to offset all potential damage that carnivores are expected to cause to livestock owners, and because of the absence of time lags and transaction costs, incentives are likely to be higher than those for ex-post compensation schemes (Zabel and Holm-Müller 2008). Although this payment system appears to be a promising solution to achieve the goal of reducing conflicts while increasing carnivore acceptance, its design and implementation can be problematic at several stages (Zabel and Roe 2009). Potentially serious drawbacks comprise high transaction costs as a result of the assessment and verification of conservation outcomes (e.g. carnivore offspring), difficulties in reliably measuring the outcome, and induced distortion by scheme participants, with the risk of making payments even

though the conservation goal has not been entirely met (Zabel and Roe 2009). Unfortunately, similarly to ex-post compensation schemes, sparse empirical information is currently available to evaluate the effectiveness of carnivore-performance payments. Similarly to wolves in Italy, the persistently high levels of illegal mortality of wolverines and lynx in Sweden cast some doubt on the success of the Swedish carnivore-performance payment scheme (Zabel and Holm-Müller 2008).

Finally, a similar system of replacing compensation with preventive economic incentives was proposed to the European Union for consideration under the new Common Agricultural Policy (Savelli *et al*. 1998), aiming at expanding the policies on economic subsidies to farmers to include the potential losses to predators. The recent Rule no. 73/2009 of the European Council goes in this direction, and it allows the use of EU funds of the Common Agricultural Policy for direct support schemes to farmers operating in areas of, or in presence of species of conservation concern (http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:030:0016:0099:EN:PDF, accessed 15 February 2010).

In conclusion, our analysis suggests that compensation programs for livestock losses to wolves in Italy are currently fraud with many problems and, despite high costs, do not seem to meet their original goal of increasing wolf acceptance by livestock owners, thereby corroborating studies from elsewhere (Cozza *et al*. 1996; Naughton-Treves *et al*. 2003; Zabel and Holm-Müller 2008; Gusset *et al*. 2009). Even though detailed information on the impact of the persistently high levels of illegal killing on the wolf population in Italy are lacking (Ciucci *et al*. 2007), the recent positive trends in the wolf numbers and range indirectly suggest that total mortality levels are somewhat sustainable at a national scale and in the long-term. Most likely, this is the implicit reason why regional and national authorities, and NGOs, do not attempt to contrast illegal killing and improve the compensation policies. We, nevertheless, stress that it is unwise and counterproductive to persistently address human–wolf conflicts on these premises and to neglect the fact that most illegal killing of wolves originates from unresolved wolf–farmer conflicts, despite costly financial incentives. Contrarily, this is to us a clear indication that ex-post compensation schemes as they have been implemented in Italy in the last 35 years are in an urgent need of a critical revision.

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