Structural and economic aspects of human–bear conflicts in Greece

Alexandros A. Karamanlidis[1,2,5], Angelos Sanopoulos[3], Lazaros Georgiadis[1], and Andreas Zedrosser[2,4]

[1]*ARCTUROS, Roggoti Street 3, 54624, Thessaloniki, Greece*
[2]*Norwegian University of Life Sciences, Department of Ecology and Natural Resource Management, PO Box 5003, 1432 Ås, Norway*
[3]*Vermiou 1, 59100, Veroia, Greece*
[4]*Department of Integrative Biology and Biodiversity Research, Institute of Wildlife Biology and Game Management, University of Natural Resources and Applied Life Sciences, Vienna, Gregor-Mendel Street 33, A-1180 Vienna, Austria*

Abstract: Agricultural damage and the resulting negative attitudes of farmers are major issues in the conservation of brown bears (*Ursus arctos*). We analyzed 3,241 approved compensation claims to gain insight into human–brown bear conflicts in Greece from 1999 to 2006. Damage to livestock was low compared to the number of livestock in an area and affected mainly young cattle and single equids. Damage to sheep was low in Greece in comparison to other countries. Crop damage was recorded mainly in small corn fields and vineyards, while damage to apiaries was associated with their general availability in an area and resulted in considerable economic losses. Bear damage occurred throughout the year, but was most common from May to October, and with the exception of crop damage, was correlated with the current range of the species. To decrease damage levels by bears in Greece and considering the current management and conservation circumstances for the species in the country, we propose the large-scale promotion and use of livestock guarding dogs and electric fencing for small fields of valuable crops as well as apiaries. Reduction of depredation to cattle will require structural changes to the way herds are managed, and compensation for damage should be linked to active damage prevention. On a local scale the livestock husbandry systems may be adjusted by increasing herd size and by penning vulnerable livestock overnight.

Key words: brown bear, compensation system, conservation, damage, endangered species, Greece, human–bear conflicts, livestock management, *Ursus arctos*

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Conflicts with humans are an important reason for the reduction of wildlife and the extinction of species worldwide (Woodroffe 2000, Treves and Karanth 2003). Especially during the 20th century, economic development, human encroachment, and unsustainable land–use patterns have increased dramatically, as has the fragmentation of natural habitats (Chauhan 2003) and human–wildlife conflicts (Fredriksson 2005). Large carnivores in particular are in conflict with humans due to livestock depredation and agricultural damage, and often carnivore populations are endangered due to human persecution (Breitenmoser 1998).

The success of carnivore conservation depends largely on the support of rural people (Rao et al. 2002); however, such support may diminish if conflicts with humans increase (Bowman et al. 2001, Anderson et al. 2002). Compensation programs are popular conservation measures because they alleviate financial losses sustained (Conover 1994). However, they are not always successful in reducing wildlife–agriculture conflicts (Van Eerden 1990) and can, theoretically, even be a step in the wrong direction by triggering wildlife extinctions and reducing human welfare (Bulte and Rondeau 2005, Rondeau and Bulte 2007). In addition, compensation systems are usually expensive, and the monetary allocations for such programs might be better used to subsidize proactive conflict management (Garshelis et al. 1999). Considering the costs and the divided opinions about the efficacy of compensation programs, it is recommended that all agencies carrying out such programs implement a formal review system (Wagner et al. 1997, Boitani et al. 2010).

[5]akaramanlidis@gmail.com

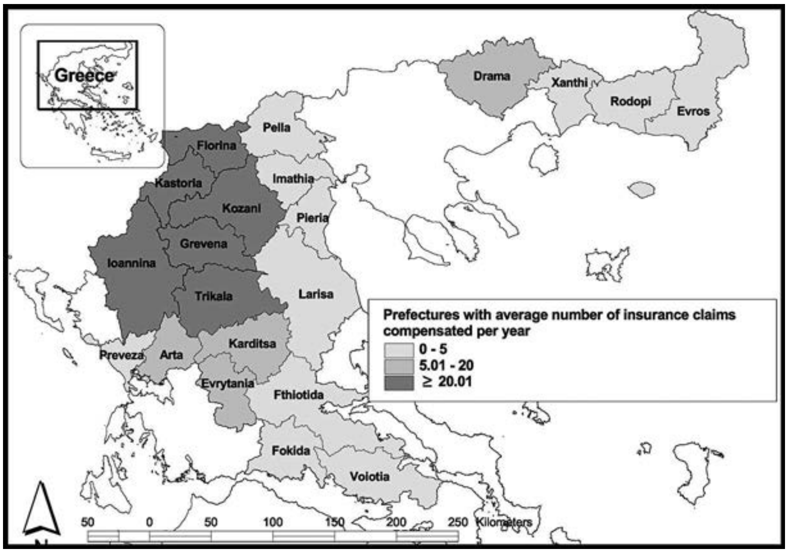

Fig. 1. Average number of insurance claims compensated annually per prefecture in Greece due to damage by brown bears (1999–2006).

Greece is located at the southern tip of the Balkan Peninsula in Europe. Brown bears (*Ursus arctos*) in the country mark the southernmost distribution of the species on the continent and are endangered due to habitat loss and fragmentation, as well as conflicts with humans (Zedrosser et al. 2001, Mertzanis et al. 2009). The species is fully protected, and according to the Greek Forestry Code (Legislative decree 86/1969, article 258; Official Journal of the Government of Greece 1969) the killing, capturing, possession, and exhibition of bears are illegal in Greece. Bears are also listed as a priority species in Annex II of the European Directive 92/43 EEC (European Commission 1992). To support bear conservation in Greece, an official compensation system for agricultural damage by bears was established in the early 1980s. This legal framework has been amended since (i.e., 1988, 1996, 2003, 2004, 2008).

The objective of this study was to analyze the information on agricultural damage by bears to describe human–bear conflicts in Greece. We assessed: (1) the types and levels of damage to livestock, crops, and apiaries by bears, (2) the geographic distribution of damage, (3) the temporal distribution of damage, and (4) the economic magnitude of damage. Based on these results and the current conservation status of brown bears, as well as the socio-economic situation in Greece, we propose management actions to decrease human–bear conflicts with the aim of improving the conservation situation for the species in the country.

Study areas

Brown bears occur in 2 geographically separate areas in Greece (Mertzanis et al. 2009). The core area of the western distribution is in the Pindos Mountains in northwestern Greece (the prefectures of Florina, Kastoria, Kozani, Ioannina, Grevena, and Trikala; Fig. 1). The core area of the eastern distribution is located in northeastern Greece in the Rodopi Mountains (the prefectures of Drama and Xanthi; Fig. 1) (Mertzanis 1994). The western study area extends over approximately 13,500 km^2 of mountainous landscapes, where forests at higher elevations (1,200–2,600 m) are characterized by black pine (*Pinus nigra*), fir (*Abies borisii regis*), and beech (*Fagus* sp.), while at lower elevations oak (*Quercus* spp.) dominates.

Human population density is ~25 people/km^2, and there are 10 municipalities with >5,000 residents in the area. The eastern distribution area extends over approximately 2,400 km^2 of mountainous landscapes (500–2,000 m) along the border with Bulgaria and covers mainly the newly established Rodopi National Park. Main forest types include oak at lower elevations and beech (*Fagus* spp.), spruce (*Picea excelsa*), and Scots pine (*Pinus silvestris*) at higher elevations. Average human population density is ~87 people/km^2, but 89% of the people are concentrated in 3 municipalities with >5,000 residents. This results in low human densities in the rural parts of this area (General Secretariat of

National Statistical Service of Greece 2008). The bear population in Greece is currently considered to be overall stable with indications of population recovery in some areas (Mertzanis et al. 2009). The minimum bear population estimate in the country is 190 individuals; 160 individuals are estimated to live in the western and 30 individuals in the eastern area (Mertzanis et al. 2005, Mertzanis et al. 2009). In recent years several extralimital occurrences of the species have been recorded throughout the country (Karamanlidis et al. 2008); the underlying biological factors, however, of these occurrences are still poorly understood.

The damage compensation system in Greece

Provisions of the regulation of the Hellenic Agricultural Insurance Agency (ELGA) oversee compensation for damage to livestock, crops, and apiaries caused by bears. ELGA is a semi-public body financed mainly by the obligatory insurance fees of farmers (Fourli 1999). When damage by bears occurs, the affected farmer must file a claim for compensation to ELGA accompanied by an inspection fee within 48 hours of the incident. The damage claim is evaluated by a qualified ELGA inspector, who must verify that damage exceeded the minimum damage threshold of 5% of the total crop value to be eligible for compensation. In case of damage to livestock, the farmer must present the damaged livestock. The ELGA inspector decides whether damage was caused by a bear and if the damage should be compensated. The compensation value for each type of agricultural property is determined by ELGA at the beginning of each year and is fixed throughout the country. Damage to apiaries are always fully compensated (Hellenic Agricultural Insurance Agency 2005).

Livestock husbandry, agricultural, and apicultural practices in Greece

Livestock herding as well as agriculture and apiculture are among the most important income sources of rural populations within the range of brown bears in Greece. Transhumance is the main characteristic of the livestock raising practices and herds of livestock, mainly sheep, goats, cattle, and equids (horses, donkeys, mules) are usually moved to higher elevation pastures in late May–June. Sheep and goats are guarded by shepherds with dogs and are brought back to a camp and penned overnight. Cattle and their calves as well as equids usually roam free and are often not protected or penned overnight.

Agriculture is dominated by small- to medium-size corn and wheat cultivations, while orchards, chestnut plantations, and vineyards have decreased in recent years (Godes 1997). Crops are rarely effectively protected against bear damage.

Apiculture is an important economic activity year-round for rural residents within the bear range, but also for seasonally present professional apiculturists from outside of the bear range. Apiaries are generally fenced, and the use of electric fences is increasing.

Methods

Data analysis

ELGA provided upon request an electronic database containing compensation claims. We excluded from analysis data from 1998 (because of incomplete data collection) and data from 2007–09 (because of major changes in the legal framework of the compensation system, which resulted in differences in how data were recorded). We used in the study only claims evaluated as bear damage and compensated as such by ELGA. For each compensated damage claim the database contained information on date, location (on a municipal level), identification number of the affected producer, type and amount of agricultural commodity damaged, the amount of compensation paid, and the total size of the commodity owned by the producer (in case of livestock damage: herd size; in case of crop damage: number of trees or field size; in case of apiary damage: number of beehives and bee colonies). These data were analyzed in relation to data on livestock and apiary availability throughout Greece in the years 1999 and 2005, provided as summary statistics by the General Secretariat of National Statistical Service of Greece (2008). We used descriptive statistics to summarize results and nonparametric tests (i.e., Spearman rank correlation, χ^2-test of independence) for comparisons (Siegel and Castellan 1988). The significance level was set to $P \leq 0.05$. The magnitude of livestock depredation was assessed by calculating the annual per capita loss (ACL; number of livestock killed or apiaries damaged by bears per year/bear population size estimate; Kaczensky 1999), using the minimum population estimates provided by Mertzanis et al. (2009). The geographic distribution of human–bear conflicts was assessed by geo-referencing compensation claims at the municipal level using ArcView 3.1 (Environmental

Table 1. Summary of livestock damage by brown bears in Greece, 1999–2005.

Livestock	Compensation claims (%)	Mean age of herd, years	Mean herd size	Mean number of livestock damaged per attack	Total number of livestock damaged
Cattle	871 (71.9)	4.65	34	1.16	1,015
Sheep	109 (9.0)	3.18	132	7	737
Horses	63 (5.2)	9.84	3	1	63
Mules	65 (5.4)	9.41	3	1	65
Donkeys	45 (3.7)	10.17	1	1	47
Goats	43 (3.6)	3.55	135	5	230
Pigs	13 (1.1)	1.88	20	5	69
Other	2 (0.1)				48

Systems Research Institute [ESRI], Redlands, California).

Results

We evaluated 3,241 claims compensated by ELGA (1999–2006), of which 37.4% (n = 1,211) were damage to livestock, 31.1% to crops (n = 1,009), and 31.5% (n = 1,021) to apiaries.

Types and levels of bear damage

An annual mean of 173 (SD = 37.4) damage claims ($\bar{x}$ = 324.8, SD = 99.8 livestock) were compensated in the study period. Overall, 710 herd owners were compensated an average of 1.7 times from 1999 to 2005. The majority of claims involved cattle (71.9%), equids (14.3%), and sheep (9%), but goats, pigs, and other livestock were damaged (Table 1). The number of livestock damaged increased with increasing herd size of cattle and sheep (Spearman rank correlation; cattle: $r_S = 0.181$, $P < 0.001$, $n = 871$; sheep: $r_S = 0.200$, $P < 0.05$, $n = 109$). We found a negative correlation between the number of individual cattle compensated and their age (young cattle were damaged more often during bear attacks than older cattle; Spearman's rank correlation; cattle: $r_S = -0.208$, $P < 0.001$, $n = 871$), but we did not find this correlation for bear attacks on sheep (Spearman's rank correlation; sheep: $r_S = 0.052$, $P = 0.590$, $n = 109$). Small herds of cattle and sheep were attacked more frequently than large herds (Spearman's rank correlation; cattle: $r_S = -0.455$, $P < 0.001$, $n = 112$; sheep: $r_S = -0.453$, $P < 0.001$, $n = 52$).

Bear depredation affected less than 1% of any type of livestock in any prefecture in bear range in Greece in the years 1999 and 2005. We found no significant correlation between the number of livestock present and the number of approved claims in a given prefecture, except for sheep (Spearman's rank correlation; sheep: $r_S = 0.447$, $P < 0.05$, $n = 20$). ACL was 1.7 livestock/bear/yr throughout Greece, with 2.0 in the western and 0.4 in the eastern core area. Depredation rates in the western bear range were significantly higher than in the eastern range (Wilcoxon signed ranks test $Z = -2.366$, $P < 0.05$).

ELGA compensated an average of 144 (SD = 87.1) claims for damage to crops per year; 524 farmers were compensated an average of 1.9 times during the entire period (1999–2006). The majority of these claims involved corn (47.1%) and grapes (30.8%; Table 2). We found no significant correlation between field size and number of claims compensated, but the proportion of the yield of corn or grapes damaged was negatively correlated with field size: in smaller fields a higher proportion of the yield of corn and grapes was damaged (Spearman's rank correlation; corn: $r_S = -0.264$, $P < 0.001$, $n = 461$; grapes: $r_S = -0.268$, $P < 0.001$, $n = 286$). Farmers experienced damage to 100% of their corn or grape yield in 67 cases.

ELGA compensated on average 67.2 (SD = 30.6) claims for 175.8 (SD = 84.2) beehives and 78.5 (SD = 33.1) claims for 399 (SD = 162.5) bee colonies per year; 387 apiary owners were compensated

Table 2. Summary of compensated insurance claims for crop damage by brown bears in Greece, 1999–2006.

Crop type	Compensated claims (%)	Mean field size (ha)	Mean % yield compensated
Corn	475 (47.1)	5.9	33.2
Grapes	311 (30.8)	2.1	38.2
Walnuts	56 (5.6)	-	26.2
Watermelons	36 (3.6)	1.4	42.4
Melons, other	30 (3.1)	2.2	30.1
Sunflowers	28 (2.8)	8.1	38.6
Other	73 (7.2)		

an average of 2.6 times during the study period (1999–2005). We found a positive correlation between the number of beehives or colonies per apiary and the number of hives or colonies present per claim (Spearman's rank correlation; beehives: r_S = 0.527, $P < 0.005$; bee colonies: r_S = 0.367, $P < 0.005$), as well as between the number of beehives damaged and their number in a given prefecture (Spearman's rank correlation; beehives: r_S = 0.513, $P < 0.05$, n = 20). ACL was 1.0 hives and 2.2 colonies per bear in the western range, and 0.7 hives and 1.7 colonies per bear in the eastern range.

Geographic distribution of bear damage

Compensation claims for bear damage were recorded in 21 prefectures in continental Greece during 1999–2006 (Fig. 1). Claims for damage to livestock and apiaries were filed in both bear areas (Figs. 2a, 2c), whereas crop damage was claimed only in the western area (Fig. 2b). The number of municipalities with claims for livestock depredation by bears increased significantly during the study from 51 municipalities in 1999 to 185 municipalities in 2002 to 132 municipalities in 2005 (F = 11.844, $P < 0.05$). The expansion of bear-related conflicts was recorded mainly in the western range of the species.

Temporal distribution of damage

Damage incidents by bears were recorded throughout the year, but were most common between May and October. Claims for apiary damage peaked in June, whereas crop damage and livestock depredation claims were highest in September (Fig. 3).

Economic magnitude of compensation claims

Overall, ELGA records indicate €864,349 (1€ = $1.43 as of August 2011) paid in compensation to damage caused by bears to crops (15.0%), apiaries (19.7%), and livestock (65.3%) during 1999–2006 (Table 3). The annual compensation for damage to livestock (€80,629, SD = 19,440) increased significantly throughout the study period (F = 35.823, $P < 0.05$), while compensation for damage to crops and apiaries did not (Table 3). Each bear caused an average annual damage of €738 in the western and €178 in the eastern range.

Discussion

Compensation claims for damage by wildlife are considered a good source for evaluating and interpreting human–wildlife conflicts (Cozza et al. 1996). However, the quality of the data depends on the experience of the personnel evaluating the claims as well as on the system itself: damage may not be claimed if compensation procedures are too complicated or if reimbursement is minimal (Kaczensky 1999). Despite indications that small damage to low-cost agricultural properties are sometimes not claimed (A.A. Karamanlidis, personal observation), we are confident that due to the amount of data analyzed, the nature and magnitude of human–bear conflicts in Greece has been captured accurately, and it is therefore possible to draw valid conclusions and propose management recommendations benefiting the conservation of the species.

ACL of livestock in Greece was low and comparable with most other countries with existing data in Europe (Fourli 1999, Kaczensky 1999, Swenson and Andrén 2003), and damage was, with the exception of damage to sheep, not correlated to the number of livestock present in a given area (Fico et al. 1993, Sagor et al. 1997). Herding techniques and type and age of livestock seemed to play an important role in damage frequency in Greece. In contrast to other countries in Europe, where mostly sheep are damaged (Kaczensky 1999, Swenson and Sandegren 2000), small herds of cattle (and less frequently of equids) were attacked in Greece. Cattle and equids usually roam free and unprotected, which may explain their higher damage frequency in Greece in comparison to other countries. Calves were most vulnerable to bear depredation, most likely due to their smaller size in comparison to adult cattle; this has also been observed in other studies (Murie 1948, Swenson et al. 1999, Anderson et al. 2002).

Sheep depredation was positively correlated to the number of sheep in a given area, but was low in comparison with Austria, France, and Norway (Kaczensky 1999, Swenson and Andrén 2003). Larger and thus probably better guarded sheep herds were less frequently attacked. Our findings suggest that Greek livestock husbandry practices are relatively effective in preventing bear-damage to large herds of sheep; in contrast, this seems not to be the case for small herds of sheep (<50 sheep) and cattle, which suffer the highest losses.

Compensation claims for crop damage were mainly for corn (Bowman et al. 2001) and grapes. Damage frequency showed considerable annual variation, which may be related to variation in the total size of cultivated fields or the production of

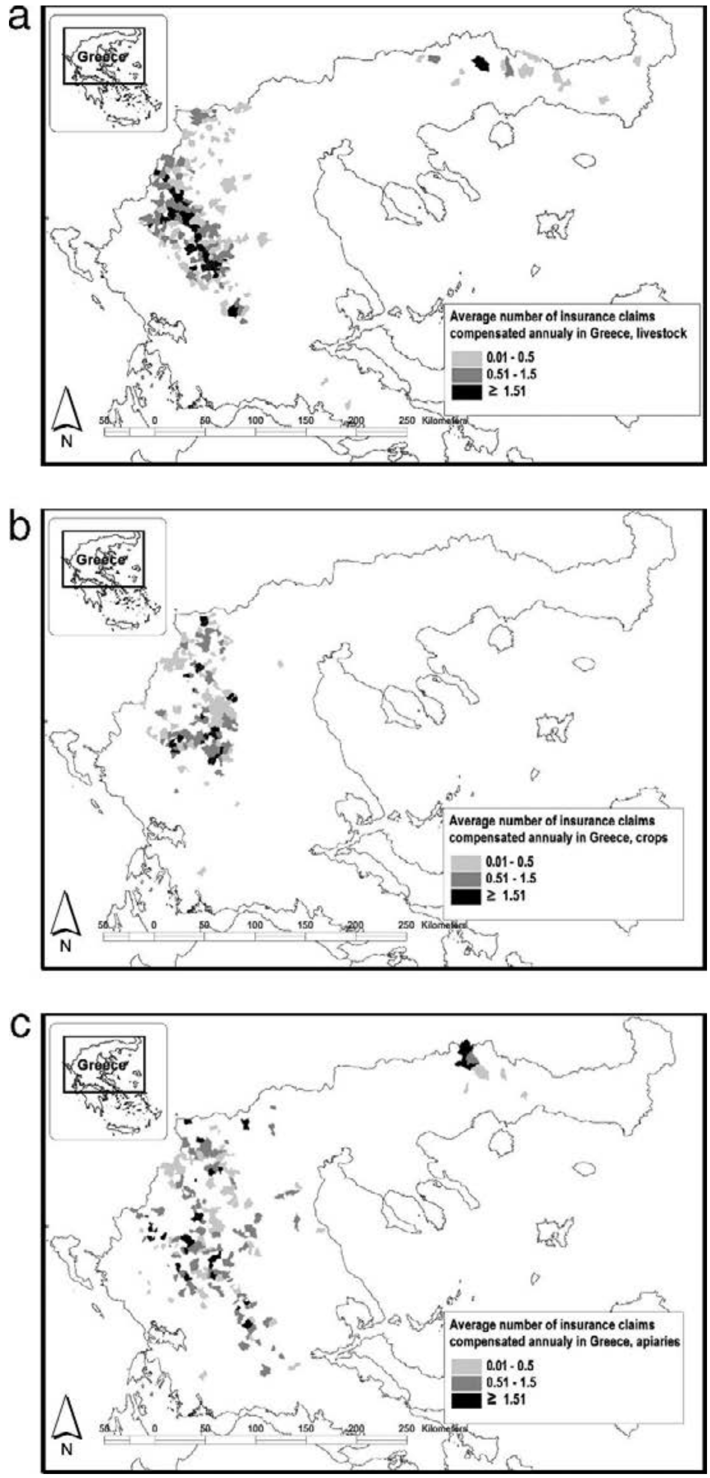

Fig. 2. Average number of insurance claims compensated annually per municipality in Greece for damage by brown bears to (a) livestock (1999–2005), (b) crops (1999–2006), and (c) apiaries (1999–2005).

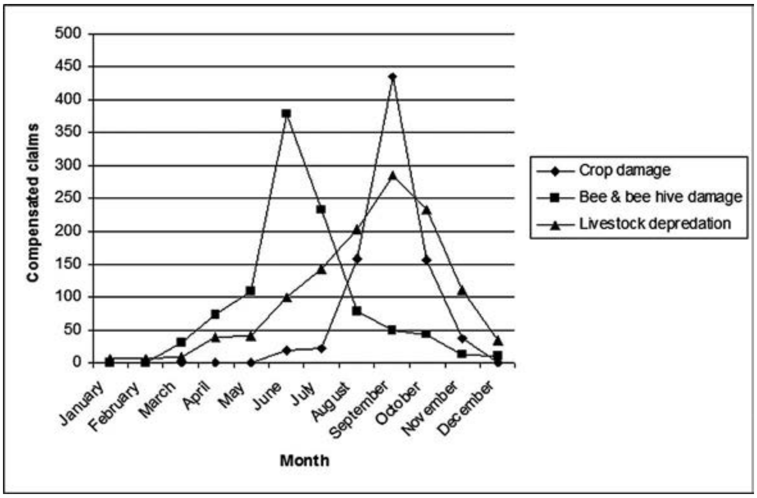

Fig. 3. Temporal distribution of insurance claims compensated annually for damage by brown bears to agricultural crops, beehives and colonies, and livestock in Greece, 1999–2006.

natural bear foods (Garshelis 1989). Bear damage to crops resulted often in substantial financial losses to farmers (Garshelis et al. 1999).

Levels of damage to apiaries were similar to those recorded in North America (Clark et al. 2005) and resulted in considerable economic losses for the affected apiarists (Jonker et al. 1998). However, in contrast to patterns of livestock depredation, damage to apiaries was associated with the number of beehives and colonies present in an apiary, as well as their general availability in a prefecture. This suggests a preference of bears for this highly nutritional food source.

The geographic distribution of damage corresponds with the main distribution of brown bears in Greece (Mertzanis 1994), whereas the increase of areas affected by livestock depredation generally coincides with the extralimital occurrences of the species recorded recently in the country (Karamanlidis et al. 2008). An overall comparison of damage between the western and eastern bear range indicates marked differences between the areas, with damage levels (i.e., ACL) significantly higher in the western range. These differences may be related to a number of reasons, such as differences in public acceptance of bears and differences in agricultural practices or the operational efficiency of the compensation system of ELGA (differences in the operational capacity to record and compensate damage between the western and eastern range of the species). Reasons for general absence of bear damage to crops in the eastern study area remain unclear; this may be related to the smaller size and lower density of the bear population, but also to differences in bear habitat features and agricultural practices and therefore lower crop availability. More detailed information on these factors is needed to better understand the geographic differences in patterns of bear damage in Greece.

Table 3. Compensation (€) per insurance claim due to damage to agricultural crops, apiaries, and livestock by brown bears in Greece, 1999–2006.

Year	Crop damage	Apiary damage	Livestock depredation	Overall
1999	1,974	15,489	53,080	70,543
2000	12,149	19,555	70,369	102,073
2001	not available	32,327	63,533	not available
2002	21,344	37,415	79,228	137,987
2003	8,111	17,982	95,005	121,098
2004	31,973	33,632	105,014	170,619
2005	11,655	13,915	98,172	123,742
2006	42,428	not available	not available	not available
Mean	18,519	24,331	80,629	121,010

The temporal distribution of damage in Greece was similar to that observed in other parts of the world (Garshelis et al. 1999, Chauhan 2003, Ambarli 2006) and reflects primarily availability of livestock, crop, and apiaries and agricultural practices, as well as seasonal-energetic requirements of brown bears. Following hibernation, bear depredation focused on apiaries, the only readily-available, human-related food source. After the ripening of crops and arrival of livestock in late spring and early summer, depredatory behavior shifted toward these food sources. As reported in other studies (Swenson and Andrén 2003), livestock depredation remained high until the end of the grazing season. Not all bears hibernate during mild winters in Greece (Giannakopoulos et al. 2010), and damage is therefore recorded also during late fall and winter.

From an economic view, bears caused the highest damage to livestock breeders, and incidents were more common in the western range of the species, where aggregated damage was 4.1 x more costly than in the eastern range. The underlying reasons for these differences are not clear and further research is needed to understand these patterns and to define and promote the most effective conservation actions. In addition, this also underlines the importance of livestock damage for bear management in Greece and the need to focus on this conflict issue as opposed to crop and apiary damage.

Management and conservation recommendations

The coexistence of people and large carnivores likely will always involve a certain level of damage to human property; therefore, agricultural damage and negative attitudes by affected farmers are important issues for large carnivore conservation (Servheen 1999, Zedrosser et al. 2001, Linnell et al. 2007). Financial compensation of agricultural damage by wildlife is a common management practice (Cozza et al. 1996, Wagner et al. 1997); however, compensation procedures need to be simple and the waiting time until financial compensation is received needs to be short for such programs to be effective (Chauhan 2003, Boitani et al. 2010). According to the data provided by ELGA, damage by brown bears in Greece is compensated within 4.1 months on average, which seems to be a reasonable period compared to other countries in Europe (Fourli 1999); however, there is evidence that the public is still dissatisfied with the perceived complexity of the compensation procedure and the low financial compensation (Garidi 2004). A socio-economic evaluation of the efficiency of the compensation system in Greece is required to identify procedures to simplify and improve the compensation process.

Livestock guarding dogs are an effective tool for preventing livestock depredation by carnivores (Smith et al. 2000), and their use against bear but also wolf (*Canis lupus*) depredation has been successfully promoted in Greece (Bousbouras et al. 2006, Iliopoulos et al. 2009). A large-scale promotion of the use of livestock-guarding dogs seems essential to reduce conflicts with sheep and goat herds, but also to prevent conflicts in expansion areas of bears and wolves in Greece. Such dogs, however, will not solve the conflicts with cattle, because unattended livestock will always be particularly prone to depredation. The solution to this problem will likely require structural changes to cattle herd management (i.e., cattle should be herded). Compensation for damage to cattle should be linked with active damage prevention, which has proven successful in reducing damage levels to livestock in other countries (Swenson and Andrén 2003). For example, in Sweden farmers receive financial support by the state for the use of approved effective prevention measures, and compensation for damage by large carnivores is only paid to farmers using these approved measures (Swenson and Andrén 2003). Following an adjustment period, a similar approach may prove effective in reducing damage levels to cattle in Greece. To make cattle even less vulnerable to depredation and herding more effective and cost-efficient, a temporary increase of cattle herd size (and sheep and goat where necessary) and overnight penning, especially of calves, could be promoted in affected areas; enclosures could be further reinforced by electric fences, which are effective against depredation by large carnivores (Smith et al. 2000).

A high percent of bear damage to high-value crops, such as corn, grapes, and melons, occurred in plantations $\leq$2 ha. Such plantations are small enough that electric fencing may be applied to deter damage (Jonker et al. 1998, Garshelis et al. 1999, Huygens and Hayashi 1999). Most crop damage by bears occur near the edges of fields (Klenner 1987, Maddrey and Pelton 1995), and reducing the availability of crops near forested areas is an effective measure for reducing crop-raiding by primates (Naughton-Treves et al. 1998). Farmers should be encouraged to plant crops attractive to bears ≥250 m from the forest edge (Naughton-Treves et al. 1998) and to remove all harvest remains of crops attractive to bears to deter them from frequenting fields. Electric fences are a successful measure to prevent bear damage to apiaries (Brady and Maehr 1982, Maehr 1984, McKillop and Sibly 1988, Huygens and Hayashi 1999, Bousbouras et al. 2006) that should be used year-around.

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