Eur J Wildl Res (2008) 54:723–728
DOI 10.1007/s10344-008-0203-x

ORIGINAL PAPER

Factors affecting crop damage by wild boar and methods of mitigation in a giant panda reserve

Jing Cai · Zhigang Jiang · Yan Zeng · Chunwang Li · Benjamin D. Bravery

Received: 21 December 2007 / Revised: 13 May 2008 / Accepted: 29 May 2008 / Published online: 21 June 2008

Abstract In China, following the introduction of protection measures, wild boar (*Sus scrofa*) are returning to forested mountains they previously inhabited and conflict in villages near or within areas under protection has intensified. We studied this phenomenon around a giant panda nature reserve in the Qinling Mountains, China to determine the incidence and frequency of wild boar damage and methods of mitigation. Over a 3-year period, we found that almost half of households in the local village sustained crop damage, that wild boar frequently raided maize (*Zea mays*), potato (*Ipomoea batatas*), and wheat (*Triticum aestivum*) adjoining the reserve, and that boar usually raided croplands at night and preferred the actual crops. The distance between maize fields and mountains or a stream predicted the probability of a field being raided and also the severity of the damage. Local farmers used many methods to protect their crops; however, all were ineffective except increasing the presence of humans in fields.

Keywords Animal–human conflict · Maize · Watching hut · Ecotourism · Qinling Mountains

Communicated by C. Gortázar

J. Cai · Z. Jiang (✉) · Y. Zeng · C. Li
Key Laboratory of Animal Ecology and Conservation Biology,
Institute of Zoology, Chinese Academy of Sciences,
Beijing 100101, China
e-mail: jiangzg@ioz.ac.cn

J. Cai · Z. Jiang · Y. Zeng
Graduate School of the Chinese Academy of Sciences,
Beijing 100049, China

B. D. Bravery
Hainan Datian National Nature Reserve,
Dongfang, Hainan 572600, China

Introduction

Recently, conflict between wildlife and humans has attracted the attention of ecologists, conservationists, and community development researchers (Messmer 2000). Common sources of conflict include wildlife preying upon livestock, the transfer of disease to domestic livestock or people, and damaging crops both directly and indirectly (e.g., Treves and Karanth 2003; Sukumar 1991). Many animal species across the world are known to damage crops, for example, African (*Loxodonta Africana*; Hoare 2000) and Asian elephants (*Elephas maximus*; Zhang and Wang 2003), white-tailed deer (*Odocoileus virginianus*) in North America (Conover and Decker 1991), vervet monkeys in Uganda (Saj et al. 2001), the Eurasian Badger (*Meles meles*) in European (Baker et al. 2005), and wild boar (*Sus scrofa*) in many countries (e.g., Calenge et al. 2004; Choquenot et al. 1996; Fernández-Llario et al. 2003; Fruziński and Poznań 2002; Geisser 1998). Human–wildlife conflict arises for several reasons: (1) human population growth (Nyhus and Tilson 2004; Richard et al. 2004; Vijayan and Pati 2002), (2) habitat encroachment (Balmford et al. 2001; Nyhus and Tilson 2004), (3) changes in patterns of land use (Sukumar 1991; Vijayan and Pati 2002), and/or (4) implementing nature conservation measures (Fall and Jackson 1998; Messmer et al. 1997; Sukumar 1991).

In China, the extent and intensity of conflict between wildlife and humans is increasing (Jiang 2004). Since 1989, wildlife protection and nature conservation laws have been in place and approximately 2,000 nature reserves, covering approximately 14.7% of China's land area, have been established (Jiang 2005). Hunting of wild animals has been banned and the location and distribution of hunting firearms has been nationally controlled since 1994. Consequently,

across many parts of China, populations of wild animals have increased (Jiang 2004) and as a result, the demand on crops and forests from wild animals has also increased leading to conflict with the interests of humans. For some species, this has become a nation-wide issue, such as wild boar (Wu and Chen 2000). This species, usually reaches high densities, also has been attributed to their omnivorous diet (Schley and Roper 2003) and adaptable breeding biology (Schley 2000; Geisser 2000).

Also because of the diet of wild boar which depends mainly on energy-rich plants (Schley and Roper 2003), its large body size and high reproductive output (Fwenández-llario and Maeos-quesada 1998), wild boar usually causes significant damage to agriculture (e.g., Kristiansson 1985; Mackin 1970; Schley and Roper 2004; Herrero et al. 2006; Linkie et al. 2007). In Spain and Portugal, even in years of abundant oak (*Quercus aliena* var. *acuteserrata*) and beech (*Fagus sylvatica*) seeds, crops such as maize still form a large proportion of the diet of wild boar (Fruziński and Poznań 2002; Fournier et al. 1996). In Australia, wild boars are estimated to cause losses to agricultural production in the order of AU $100 million each year (Choquenot et al. 1996). In South America, wild boars are also a significant source of conflict and cause considerable damage to agriculture (Berrutti et al. 1998).

Globally, many techniques have been developed and employed to control this growing problem, such as chasing wild boar with dogs, trapping (Hone 2002), hunting (Geisser and Reyer 2004), and poisoning (Muthmainnah and Supardi 1998). However, these lethal methods are not possible in China due to the protection status awarded wild boar and the strict control on wildlife conservation. Consequently, the number of wild boar in China has exploded, particularly in areas under direct protection and management, such as nature reserves. Conflict between wild boars and humans could threaten the long-term management of protected areas and the stability of wildlife conservation in general. It is essential that legal and proper methods be found to control this emerging problem.

Research on crop damage by protected species in a Chinese context is almost completely absent from the literature (Cai and Jiang 2006). Given the similarities between China and many other developing countries, a case study of wild boar–human conflict in China could shed light on similar situations in other parts of the world. The aims of this study were (1) to determine the factors affecting crop damage by wild boar, (2) to describe methods employed by villagers to prevent and mitigate damage by wild boar, and (3) to examine the interaction, if any, between the benefits of ecotourism and the attitudes of villagers towards crop damage by wild boar. The latter one arose from work by Naughton-Treves (1998) that showed if local people perceive direct benefits from wildlife conservation, they are more likely to accept crop damage.

Materials and methods

Study site

We chose the Laoxiancheng village, which is located inside the Laoxiancheng Nature Reserve (33°43′–33°57′ N, 107°40′–107°49′ E), Shaanxi, China to conduct this study. The reserve was established in 1993, and it formed the center of the nature reserve networks of the Qinling Mountains, designated for the protection of giant panda and sympatric wildlife (Jiang 2006). Streams flowing from the upper mountains gather into the Xushuihe River, which then flows through the focal village.

Laoxiancheng is a small mountain village of only 153 people in 35 households. Farming, livestock production, and beekeeping are the main enterprises among villagers. Another increasingly important source of income for the villagers is ecotourism and there are 13 households owning lodges in this village. Annual per capita income in the village was less than 1,000 RMB (US $125) in 2005, which is much lower than the annual per capita income of China according to the data of State Statistical Bureau. Maize, potato, wheat, and the bean (*Glycine max*) are the primary crops with a peak growing season from April to September.

In Laoxiancheng village, several techniques are used by villagers to protect their crops—setting up straw men, burning plastic or rubber shoes, campfires, guard dogs, and human patrols. The patrols consist of a number of people living in an observation hut each night and walking around the crops several times after dark.

Dominant tree species in the forest include sharp-tooth oak (*Q. aliena* var. *acuteserrata*), poplars (*Populus purdomii* and *P. davidiana*), Chinese red birch (*Betula albosinensis*), Chinese white pine (*Pinus armandii)*, Chinese pine (*P. tabulaeformis*) and hemlock (*Tsuga chinensis*), spruce (*Abies fargesii*), and the Taibai larch (*Larix chinensis*). Wild boars are known to eat the nuts of the sharp-tooth oak, poplar, and all kinds of the pine. Many conservation-dependent species such as the giant panda (*Ailuropoda melanoleuca*), golden takin (*Budorcas taxicolor*), golden monkey (*Rhinopithecus roxellanea*), leopard (*Panthera pardus*), musk deer (*Moschus berezovskii*), golden pheasants (*Chrysolophus pictus*), golden eagle (*Aquila chrysaetos*), and blood pheasants (*Ithaginis cruentus*) inhabit the reserve (Jiang 2006). Of note, the density of giant panda in the reserve is high and increasing (Sun et al. 2005). Due to its central location in the nature reserve networks of the Qinling Mountains, the Laoxian-

cheng Nature Reserve is under strict and comprehensive protection.

Data collection

Data were collected from July 2003 to October 2005. We visited all households in the village once each year during the study period to record all crop damage and to survey their methods of crop protection. We focused on wild boar damage to maize for four reasons. First, maize is the most important crop for the local people. Second, we used data on maize to examine the difference between the levels of damage reported by farmers and what we observed, so as to control for over reporting and exaggeration by farmers (Siex and Struhsaker 1999). Third, we wanted to determine whether topographic factors could predict crop damage by wild boar and this information was readily available for maize and not other crops. Fourth, namely maize has been shown to be the agricultural crop that wild boar prefer (e.g., Geisser 2000; Schley 2000). From August to October 2005, we stayed with local people and recorded each raid by wild boar. The following information was recorded for each raid event: location (using a Global Positioning System receiver), the number of maize plants damaged by consumption and trampling, the part and stage of the plant attacked, and an estimate of the amount of damage obtained by weighing the crops of undamaged maize in the same field and comparing this to the damaged section and crops.

To address our aims, we distributed a questionnaire to survey the attitude of families that owned or did not own a lodge towards damage by wild boar. This questionnaire was part of another research study examining the attitude and knowledge toward wildlife of the local community. Surveys were conducted on families in the Laoxiancheng village. It contained three items designed to measure attitudes towards wild boar. An additional five social demographic questions examined background information about the household. Following methods developed by Ajzen and Fishbein (1980), we measured attitude and behavioral intention based on symmetric five-point scales (1=strongly disagree to 5=strongly agree), with clear and separate alternatives and a central neutral category (Borg and Gall 1989).

Statistical analyses

All spatial data were imported into ArcView3.2 (ESRI, Inc., Redlands, CA) and superimposed onto a grid (10×10 m) map (following Bullock 1996) which spanned all maize fields in the study. A digital map indicating roads, streams, the river, forest, and cropland and associated vector files were provided by the management of Laoxiancheng Nature Reserve. The distances from the center of each grid cell to the nearest road, the nearest building, the nearest boundary of forest, and the nearest stream were calculated by GIS 9.0 (ESRI, Inc., Redlands, CA). Analysis was carried out using SPSS 13 (SPSS, Inc., Chicago, IL). Univariate correlations were conducted using Spearman's rank correlations. Because the intensity of maize raiding by wild boar exhibited a highly skewed distribution among map grid cells, it was not possible to use linear regression to identify multivariate correlates. Instead, maize raiding was coded into presence and absence for each grid cell, and analysis was undertaken using multiple stepwise logistic regressions, with entry and exit of variables determined by the Wald statistic with *P*-values of 0.05 and 0.01, respectively. Of the 1,026 map grid cells, maize raiding by wild boar occurred in 226 cells. Chi-square tests were used to test the difference between the parts of maize which wild boar preferred, the difference between the damage intensity to maize located 60 m or less from the forest edge and maize located more than 60 m from the forest edge, and the different attitude and behavior between the local household with a lodge and ones without lodges. Repeated measures were used to test the difference of the frequency of wild boar damage to different crops from 2003 to 2005.

Results

Crop damage and preference

During the study period, almost half of the households living in the village sustained crop damage by wild boar (2003, n=17; 2004, n=25; 2005, n=26). There was no significant difference between the estimation of crop damage by farmers and our own estimate nor was there a difference in the

Table 1 Frequency of raiding, mean percentage of crops losses per raiding event, and frequency of raid per ha during a period of July to October from 2003 to 2005

Year	Crops	Number of raids	Crops loss per raid (kg)	Frequency of raid per ha
2003	Maize	91	21.8	0.042
	Potatoes	30	11.7	0.05
	Wheat	15	20	0.01
	Bean	10	5	0.017
2004	Maize	141	17.1	0.057
	Potatoes	80	23.2	0.09
	Wheat	21	21.8	0.01
	Bean	0	0	0
2005	Maize	114	10.9	0.04
	Potatoes	95	30.5	0.123
	Wheat	22	36.3	0.011
	Bean	33	4.8	0.05

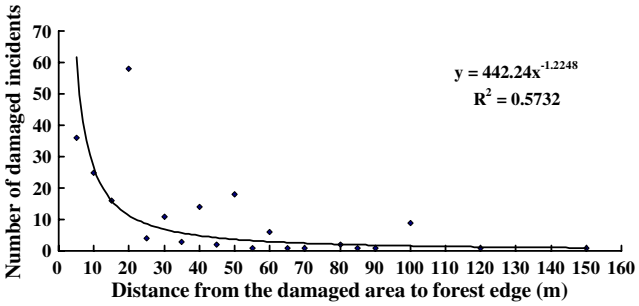

Fig. 1 Frequency of maize damaged by wild boar as a function of the distance of maize field to the nearest forest edge. Most of the maize-damage events occurred within maize fields 60 m from the forest edge and no maize field 160 m or further away from forest edge was raided by wild boar

frequency of wild boar damage between years (Wilks' Lambda=0.121, P=0.347). However, it was found that wild boar preferred maize and potato (P=0.07; Table 1) and, in addition, preferred to eat the crops (root, n=62; stem, n=939; crop, n=2,916; χ^2=3,273.67, df=2, P<0.05).

Topographic factors affecting maize damage

Of the four topographic factors measured, only distance to forest edge (Wald statistic=70.74, df=1, P<0.001) and streams (Wald statistic=14.40, df=1, P<0.01) significantly affected the probability of damage by wild boar. The frequency of a raided maize field by wild boar decreased with increasing distance from the forest edge. Most of the maize-damage events in 2005 occurred within maize fields 60 m from the forest edge and no maize field 160 m or further away from forest edge was raided by wild boar (Fig. 1). Differences between the damage at maize-raiding sites located at 60 m or less from the forest edge and those located more than 60 m away was found to be significant (χ^2=608.68, df=1, P<0.05).

Plausible methods used to alleviate the conflicts

From our results, all strategies employed by the villagers to protect crops failed to work except a human presence in the fields. We also found that maize further away from watching huts tended to sustain greater damage (R=0.247; P=0.08). Based on the results of the questionnaire, we found some differences in the attitudes of villagers towards crop damage depending on their involvement in local ecotourism ventures and the amount of farming they carried out (Table 2).

Discussion

Previous studies have identified a number of main factors affecting the level of damage to crops by wild boar. For example, crop type (Genov et al. 1995; Geisser 1998), the distance of the crops to forest (Genov et al. 1995), the ripening period of a crop (Vassant 1996), density of wild boar population (Spitz and Lek 1999), and the availability of natural foods in the forest (Genov et al. 1995).

Here, we considered two of these factors. For the type of crop, two reasons may explain why wild boar prefers maize and potato. First, from early July to the August, oak is not available and previous research has shown that the absence of natural foods forces wild boar to forage in croplands (Genov et al. 1995; Calenge et al. 2004). Secondly, this period is the ripening season of maize and potato, making it more attractive to wild boar. Our finding that wild boar prefer to eat crops supports this view as presumably, fresh crops are juicy, easy to be digested, and have more energy (Schley and Roper 2003).

Another important factor associated with wildlife damage to crops are topographic factors, such as the proximity of fields to nearby forest (e.g., Genov et al. 1995; Saj et al. 2001; Naughton-Treves et al. 2003; Geisser 2000; Linkie et al. 2007). The distance to the nearest stream was also

Table 2 Opinions towards wild boar of households that have and do not have a family lodge

Opinions	Households owns a guest house				Households do not own a guest house				Pearson chi-square (χ^2)
	Strongly agree (%)	Agree (%)	Disagree (%)	Strongly disagree (%)	Strongly agree (%)	Agree (%)	Disagree (%)	Strongly disagree (%)	
Wild boar caused serious damage to my crops	40.9	59.1	0	0	38.5	61.5	0	0	χ^2=0.02, df=1, P=0.587>0.01
My families spent much time to protect our maize	59.1	40.9	0	0	61.5	38.5	0	0	χ^2=0.02, df=1, P=0.587>0.01
The wild boar damage strongly affected our life	50	45.5	4.5	0	0	44.4	55.6	0	χ^2=18.9, df=2, P<0.01

identified as a significant predictor of crop damage because stream valleys provide a passage for wild boar from the forest to the cropland, especially in summer. In fact, we found many tracks of wild boar along stream channels.

According to local people living in Laoxiancheng Nature Reserve, damage caused by wild boar has historically remained low. After the establishment of the nature reserve, damage to crops caused by wildlife, especially wild boar, became of greater concern. Traditional lethal methods proven to decrease the number of boar were not available because the village is located inside the nature reserve, whereby according to the Nature Reserve Management Ordinance of China, all lethal hunting methods are banned for wildlife conservation inside a nature reserve.

Our study demonstrates that from the nonlethal options available to farmers, only increasing the number of people patrolling a field will reduce the incidence of wild boar damage. Our finding that distance from the cropland to the forest or to a stream affects the probability of raiding by wild boar suggests that people could focus on the cropland that is located close to forest or streams.

Except for traditional methods, it is widely suggested that the creation of alternative sources of revenue to improve local economies, such as ecotourism, is an effective indirect method to alleviate wildlife–human conflict (Pérez and Luis 2006). In our questionnaire, the source of income of villagers affected their attitudes to wild boar mainly because those people who derived income from nonfarming sources experienced little or no conflict with wild boar. For example, we found that some households involved in ecotourism began to decrease there crop planting because of heavy damage from wild boar. Hence, it appears that ecotourism development is a feasible way for alleviating the conflict, to diversify the local economy, and to decrease the local dependence on crops. Gradually, such a trend may result in a restructuring of the local economy.

Conclusion and management implications

Wild boar–human conflict is occurring in many parts of the country and is being in the report of state media. Therefore, finding efficient and nonlethal ways to control wild boar is of great importance. Our analysis of wild boar damage shows that despite the ineffectiveness of most of the methods used to currently protect crops, there are still some options for improving the efficiency of human patrols in the fields. Some studies suggest compensation as a solution; however, given the breadth of the problem in China, the amount of compensation required would be considerably large. If the population of wild boar in China is considered too large, some lethal methods could be reintroduced. For example, one option is to legalize hunting of wild boar by farmers throughout their fields; however, this would have to be strictly monitored to avoid impacts to nontarget species, such as giant panda. In protected areas, we suggest that a way to alleviate the conflict between wild boar and people is to diversify local economies and decrease the dependence on crops by farmers.

Acknowledgements We thank Chinese Academy of Sciences Innovative Research International Partnership Project (CXTDS2005-4), Columbus Zoo and Aquarium, and UAS field conservation funds for financial support. Thank you to staff of Laoxiancheng Nature Reserve for their assistance and to Jing yu, Xueli Lu, and Yankuo Li for their help in the survey. Finally, we thank everyone living in the Laoxiancheng village that participated in the study.

References

Ajzen I, Fishbein M (1980) Understanding attitudes and predicting social behavior. Prentice-Hall, Upper Saddle River, New Jersey, USA

Baker SE, Ellwood SA, Watkins RW, Madonald DW (2005) Non-lethal control of wildlife: using chemical repellents as feeding deterrents for the European badger *Meles meles*. J Appl Ecol 42:921–931, doi:10.1111/j.1365-2664.2005.01069.x

Balmford A, Moore JL, Streams T, Burgess N, Hansen LA, Williams P et al (2001) Conservation conflicts across Africa. Science 291:2616–2619, doi:10.1126/science.291.5513.2616

Berrutti MA, Frade J, Amorin O (1998) Wild Boar status in Uruguay. Third workshop of the European wild boar research group. Insituto Pirenaico de Ecología (CSIC), Zaragoza

Borg WR, Gall MD (1989) Educational research. Longman, New York, USA

Bullock J (1996) Plants. In: Sutherland WJ (ed) Ecological census technique: a hand book. Cambridge University Press, Cambridge, pp 111–138

Cai J, Jiang Z (2006) Human–large mammals conflicts: a new challenge of wildlife conservation. Acta Theriol Sin 26:183–190

Calenge C, Maillard D, Fournier P, Fouque C (2004) Efficiency of spreading maize in the garigues to reduce wild boar (*Sus scrofa*) damage to Mediterranean vineyards. Eur J Wildl Res 50:112–120

Choquenot D, McIlroy J, Korn T (1996) Managing vertebrate pests: feral pigs. Bureau of Resource Sciences, Australian Government, Canberra

Conover MR, Decker DJ (1991) Wildlife damage to crops: perceptions of agricultural and wildlife professionals in 1957 and 1987. Wildl Soc Bull 19:46–52

Fall MW, Jackson WB (1998) A new era of vertebrate pest control? An introduction special issue. Int Biodeterior Biodegrad 42:85–91, doi:10.1016/S0964-8305(98)00058-4

Fernández-Llario P, Mateos-Quesada P, Silvério CA, Évora PS (2003) Habitat effects and shooting techniques on two wild boar (*Sus scrofa*) populations in Spain and Portugal. Z Jagdwiss 49:120–129, doi:10.1007/BF02190452

Fournier CC, Maillard D, Foumi P (1996) Variability of the diet of wild boars (*Sus Scrofa*) in the Montpellier garrigue arrigue (Herault). Gibier Faune Sauvage 13:1457–1476

Fruziński B, Poznań LŁ (2002) Management of wild boar in Poland. Z Jagdwiss 48(Supplement):201–207 doi:10.1007/BF02192409

Fwenández-llario P, Maeos-quesada P (1998) Body size and reproductive parameters in the wild boar. Acta Theriol (Warsz) 43:439–444

Geisser H (1998) The wild boar (*Sus scrofa*) in the Thurgau (Northeastern Switzerland): population status, damage and the influence of supplementary feeding on damage frequency. Gibier Faune Sauvage 15:547–554

Geisser H (2000) Das Wildschwein (Sus scrofa) im Kanton Thurgau (Schweiz): Analyse der Populationsdynamik, der Habitatansprüche und der Feldschäden in einem anthropogen beeinflussten Lebensraum. Thesis, University of Zurich, Zurich, Switzerland

Geisser H, Reyer H (2004) Efficiency of hunting, feeding, and fencing to reduce crops damage by wild boars. J Wildl Manage 68:939–946, doi:10.2193/0022-541X(2004)068[0939:EOHFAF]2.0.CO;2

Genov PV, Tonini L, Massei G (1995) Crops damage by wild ungulates in a Mediterranean area. In: Botev N (ed) The game and the man. Proc IUGB, Sofia, pp 214–215

Herrero J, García-Serrano A, Couto S, Ortuño VM, García-González R (2006) Diet of wild boar *Sus scrofa* L. and crop damage in an intensive agroecosystem. Eur J Wildl Res 52:245–250, doi:10.1007/s10344-006-0045-3

Hoare R (2000) African elephants and humans in conflict: the outlook for co-existence. Oryx 34:34–38, doi:10.1046/j.1365-3008.2000.00092.x

Hone J (2002) Feral pigs in Namadgi National Park, Australia: dynamics, impacts and management. Biol Conserv 105:231–242, doi:10.1016/S0006-3207(01)00185-9

Jiang Z (2004) Behavioral interaction between wild animals and human beings. In: Jiang Z (ed) Animal behavior principles and species conservation methods. Science, Beijing, China, pp 327–339

Jiang Z (2005) On the upper limit of the protected areas in China. Acta Ecol Sin 25:14–21

Jiang Z (2006) Biodiversity in the Shaanxi Laoxiancheng Nature Reserve. Tsinghua University Press, Beijing, China

Kristiansson H (1985) Crop damage by wild boars in Central Sweden. Proceedings of the XVIIth Congress of the International Union of Game Biologists, Brussels, Belgium, pp 605–609

Linkie M, Dinata Y, Nofrianto A, Leader-Williams N (2007) Patterns and perceptions of wildlife crop raiding in and around Kerinci Seblat National Park, Sumatra. Anim Conserv 10:127–135, doi:10.1111/j.1469-1795.2006.00083.x

Mackin R (1970) Dynamics of damage caused by wild boar to different agricultural crops. Acta Theriol (Warsz) 15:447–458

Messmer TA (2000) The emergence of human–wildlife conflict management: turning challenges into opportunities. Int Biodeterior Biodegrad 45:97–102, doi:10.1016/S0964-8305(00)00045-7

Messmer TA, George S, Copsicelli L (1997) Legal considerations regarding lethal and nonlethal approaches to managing urban deer. Wildl Soc Bull 25:424–429

Muthmainnah RH, Supardi (1998) Integrated wild pig (*Sus scrofa*) control in Camming sugar manufacture. Ber Pus Penelit Perkeb Gula Indones 23:20–22

Naughton-Treves L (1998) Predicting patterns of crop damage by wildlife around Kibale National Park, Uganda. Conserv Biol 12:156–158, doi:10.1046/j.1523-1739.1998.96346.x

Naughton-Treves L, Mena JL, Treves A, Alvares N, Radeloff VC (2003) Wildlife survival beyond park boundaries: the impact of slash-and-burn agriculture and hunting on mammals in Tambopata, Perú. Conserv Biol 17:1106–1117, doi:10.1046/j.1523-1739.2003.02045.x

Nyhus P, Tilson R (2004) Agroforestry, elephants, and tigers: balancing conservation theory and practice in human-dominated landscapes of Southeast Asia. Agric Ecosyst Environ 104:87–97, doi:10.1016/j.agee.2004.01.009

Pérez E, Luis FP (2006) Damage by large mammals to subsistence crops within a protected area in a montane forest of Bolivia. Crop Prot 25:933–939, doi:10.1016/j.cropro.2005.12.005

Richard H, Lamprey RH, Reid RS (2004) Expansion of human settlement in Kenya's Maasai Mara: what future for pastoralism and wildlife? J Biogeogr 31:997–1032, doi:10.1111/j.1365-2699.2004.01062.x

Saj TL, Pascale SS, Paterson JD (2001) The conflict between vervet monkeys and farmers at the forest edge in Entebbe, Uganda. African wildlife society. J Afr Ecol 39:195–199, doi:10.1046/j.0141-6707.2000.00299.x

Schley L (2000) The badger *Meles meles* and the wild boar (*Sus scrofa*): distribution and damage to agricultural crops in Luxembourg. Ph.D. Thesis, University of Sussex, Brighton, UK

Schley L, Roper TJ (2003) Diet of wild boar (*Sus scrofa*) in Western Europe, with particular reference to consumption of agricultural crops. Mamm Rev 33:43–56, doi:10.1046/j.1365-2907.2003.00010.x

Schley L, Roper TJ (2004) Distribution and population density of badgers *Meles meles* in Luxembourg. Mamm Rev 34:233–240, doi:10.1111/j.1365-2907.2004.00040.x

Siex KS, Struhsaker TT (1999) Colobus monkeys and coconuts: a study of perceived human–wildlife conflicts. J Appl Ecol 36:1009–1020, doi:10.1046/j.1365-2664.1999.00455.x

Spitz F, Lek S (1999) Environmental impact prediction using neural network modeling: an example in wildlife damage. J Appl Ecol 36:317–326, doi:10.1046/j.1365-2664.1999.00400.x

Sukumar R (1991) The management of large mammals in relation to male strategies and conflict with people. Biol Conserv 55:93–102, doi:10.1016/0006-3207(91)90007-V

Sun C, Zhang Z, Jin X (2005) The division of sub-population of giant panda in Qinling and its quantitative distribution. Chin Wildl 26:51–54

Treves A, Karanth KU (2003) Human–carnivore conflict and perspectives on carnivore managements worldwide. Conserv Biol 17:1491–1499, doi:10.1111/j.1523-1739.2003.00059.x

Vassant J (1996) Evolution of wild boar populations and damage to crops in France between 1978 and 1993. In CIC, Proceeding of Schwarzwild Symposium, Sopron, Ungarn, pp 131–141

Vijayan S, Pati BP (2002) Impact of changing cropping patterns on man–animal conflicts around Gir Protected Area with specific reference to Talala Sub-District, Gujarat, India. Popul Environ 23:541–559, doi:10.1023/A:1016317819552

Wu S, Chen H (2000) Preliminary study on the population structures and reproductive habit in wild boar (*Sus scrofa*) in Dawuling nature reserve. Acta Theriol Sin 20:151–156

Zhang L, Wang N (2003) An initial study on habitat conservation of Asian elephant (*Elephas maximus*), with a focus on human elephant conflict in Simao, China. Biol Conserv 112:453–459, doi:10.1016/S0006-3207(02)00335-X