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Review article

Investigating trends in human-wildlife conflict: is conflict escalation real or imagined?

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ABSTRACT

Human–wildlife conflict (HWC) has a history that is as old as human civilization; yet currently the phenomenon poses a serious environmental challenge for human society. Both due to their bio-geographical and social characteristics, developing regions of the world such as South and Southeast Asia are particularly vulnerable to this problem. Although the popular perception is that HWC intensity has escalated over the past few decades, there is little published literature to support this view. We argue that insights into the historical trajectories of HWC are important to comprehend past trends and set up future priorities. As a case study, we review conflict literature from India to analyze trends in HWC in the country over the past four decades. Our analysis reveals that there has been a consistent increase in the number of HWC publications, and that nearly 90% of the country is currently afflicted by HWC. A total of 88 species belonging to nine taxonomic groups are involved in HWC. Yet, research has been limited to select species and geographical locations. We discuss potential causes for this bias and set out research directions for efficient management of this issue.

Introduction

The existence of human–wildlife conflict (HWC) dates to human prehistory; the earliest forms of conflict occurred in the form of predation of ancestors of prehistoric man and early hominoids (the Taung Child, *Australopithecus africanus;* Berger and McGraw 2007; Lee-Thorp et al 2000). This later extended to crop and livestock depredations, first recorded around 10,000 years ago, in the current Cenozoic era (Gordon 2009). Today, HWC occurs in several different contexts and spans a range of animal taxonomic groups and countries (Baruch-Mordo et al 2008; Davison et al 2011; Hoffman and O'Riain 2012; Okello 2005; Walpole et al 2003). Although, HWC has a long historical existence, its increasing severity and complex nature has made it a central issue to wildlife management. The increase in severity of HWC has been attributed to a number of factors, such as expansion of human activities into wildlife habitats, recovery, and expansion of a few wildlife populations and large scale environmental changes (reviewed in Treves 2008). Previously, human wildlife conflict was considered a "rural or agricultural problem" (Messmer 2000), that mainly affects communities living in close proximity to forests. However, with increase in human population and expansion of human developmental activities, HWC incidences are now common in urban and suburban areas (Soulsbury and White 2015). Urban/suburban HWC incidents typically involve wildlife species that have a history of coexistence with humans or the ability to survive in human-dominated environments.

Currently, HWC is a global issue that encompasses a wide range of events that have adverse consequences for both humans and wildlife. With its far-reaching impacts in the domains of species conservation, protected area management and sustainable livelihoods (Bowen-Jones 2012; Dickman 2010), it is increasingly acquiring the attention of ecologists, wildlife biologists, and wildlife managers across the globe (Messmer 2000). Unmitigated conflict levels deplete local support for conservation (Hill et al 2002) and result in retaliatory killing of wildlife species (Inskip and Zimmerman 2009; Mateo-Tomás et al 2012), thus threatening the long-term survival of wildlife species. Declines in wildlife population levels tend to be associated with areas that show a high degree of conflict between humans and wildlife (Michalski et al 2006; Woodroffe et al 2005). Thus, unmitigated conflict presents a very real, perceivable threat to the long-term survival of species. It also poses a danger to human lives and is a challenge for the

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sustainability of human livelihoods (Gillingham and Lee 2003; Rao et al 2002; Sahoo and Mohnot 2004). Concomitantly, resultant economic loss due to crop and livestock damage (Brara 2013; Mackenzie and Ahabyona 2012; Schön 2013) and management of HWC drains the affected countries of financial and human resources (Lamarque et al 2009). In addition to direct, observable impacts, HWC, particularly in developing countries, creates a larger conflict of values and class, which weaken the effectiveness of state institutions (Anthony and Wasambo 2009).

Though the need for HWC mitigation is well-established, a number of factors make it an extremely complex challenge: (1) traditional methods of lethal elimination to deal with problem-wildlife is no longer a desirable option due to increasing concerns over species conservation (Sillero-Zubiri et al 2009, more examples reviewed in Treves et al 2006) or social opprobrium (Jones and Thomas 1999). This means that HWC needs to be managed in a way that is publicly acceptable and does not jeopardize wildlife conservation goals; (2) people's perception regarding conflict is not only dependent on the actual damage by wildlife but is also shaped by a number of socio-cultural factors. In such cases, conflict continues to exist even after damage-control measures have been put in place; and (3) implementation of any mitigation intervention without a comprehensive understanding of species behaviors and human social factors often fails to achieve its desired result, and in some cases, may even increase the level of conflict.

Although HWC is a global phenomenon, there are certain differences in its manifestation and magnitude across the developed and developing regions of the world. Developed regions of the world exhibit low dependency on forest ecosystems and an exclusionary management approach for wilderness areas. This essentially limits interactions between humans and wildlife to selected areas and consequently, HWC incidences tend to occur only in areas where there is a significant degree of interaction between humans and wildlife (Pack et al 2013), such as urban and suburban areas (Gompper 2002; Jones and Thomas 1999; Lay et al 2001; Poessel et al 2013). HWC in the developed world is also less about competition for limited resources (Engeman and Sterner 2002; Tzilkowski et al 2002), and instead more about the nuisance activities of wildlife that interferes with the lifestyles of residents (Towns et al 2009; Wambuguh 2008). As opposed to this, developing regions of the world such as south and south-east Asia exhibit great propensity for HWC due to their rich biodiversity and human developmental characteristics (Madhusudan and Karanth 2002). A high degree of dependence on forest ecosystems and prevalent poverty has led to unsustainable extraction of forest resources and conversion of forests into agricultural land. (Chao 2012; Sodhi et al 2010; The World Bank 2015). Data for south-east Asia shows that 14.5 million hectares of forest were lost during 2000–2010, primarily due to cash crop plantation (Sodhi et al 2010). Overlapping resource use increases interactions between humans and wildlife leading to high incidences of conflict (Treves et al 2006). The existing state of HWC in the developing world is most likely to increase in the future due to several factors such as "expanding human settlement, growth of outdoor recreation, and the increase of species adapted to living in human dominated landscapes" (Manfredo 2015).

The HWC scenario in India may be considered representative of the conflict situation in south and south-east Asia. Incidences of HWC involving numerous species have been widely reported from different parts of the country. Although the popular perception is that HWC has increased in intensity over the past few decades (Sinu and Nagarajan 2015, Sundriyal and Dhyani 2014), there is no published literature to support this view. There is also little information on the geographical distribution of conflict or the total number of species involved in conflict currently. To address this research gap, we analyzed HWC literature from India, to assess: (1) changes in the geographical distribution of HWC over time; (2) the number of species involved in conflict and changes in their relative representation over time; and (3) prominent themes in HWC research and any changes in such concerns over time. Additionally, we also aimed to analyze the magnitude of conflict intensity over time in order to substantiate/disprove the popular perception regarding increasing level of HWC in India.

Materials and methods

We conducted an internet-based search of online cross-reference databases namely Web of Science, Scopus, Google Scholar, JStor, and Springer to obtain literature for our review. We used different combinations of keywords such as "human-wildlife conflict" AND India, "wildlife damage" AND India, "animal damage" AND India, "crop depredation" AND wildlife AND India, "crop depredation" AND animal AND India, "crop loss" AND wildlife AND India, "crop loss" AND animal AND India, "crop depredation" AND wildlife AND India, "crop depredation" AND animal AND India, "livestock depredation" AND wildlife AND India, "livestock depredation" AND animal AND India, "livestock mortality" AND wildlife AND India, "livestock mortality" AND animal AND India, "human attack" AND wildlife AND India", "human attack" AND animal AND India", "human injury" AND wildlife AND India", "human injury" AND animal AND India", "human mortality" AND wildlife AND India", and "human mortality" AND animal AND India". The time period for the search was limited from 1900 to present. Types of resources searched for were limited to journal articles, conference proceedings, reports, and magazine articles. The minimum requirement for a literature resource to be included in the analysis was the presence of a fully accessible abstract. Obtained search results were included in the analysis, only if the study was based in India and it focused on at least one wildlife species. Approximately 37% of our total search results referred to crop damage caused by insects; these were not included in the analysis. We excluded insects from our analysis primarily because insect damage to crops comes under the domain of crop pest management, where the entire focus in on the lethal elimination of damage-causing species. Management of crop loss due to larger vertebrates, however, is a rather more complex issue due to differing human perceptions regarding animal species and varying wildlife conservation and management practices across the globe. In order to check for changes with respect to time, we classified available records into two time periods of 20 years each (1976–1995 and 1996–2015) and then carried out our analysis. The date of publication could not be established for a small percentage of the search records ($n = 8$). We categorized search records in terms of geographical distribution of conflict incidences, taxonomic identity of conflict species, forms of conflict, and focus areas of study investigation. In order to assess changes in geographical distribution of conflict incidences over time, we extracted study location/area of focus for each record, listed the parent state, and identified if conflicts occurred in sites formally protected/not protected by the forest department. We also calculated the total (unique) number of times a state was mentioned as a conflict location in a search record or a wildlife species was mentioned as a conflict species. To evaluate changes in conflict intensity over time, we listed all reported instances of livestock depredation and human injury or death and plotted it across the years. However, a similar analysis could not be carried out for crop depredation, as various studies differed in their measurement of crop damages.

Results

Characteristics of conflict literature

We obtained a total of 204 records from our literature search, all of which were considered for the analysis. The first available record was from 1976 and the latest was from 2015. The majority (88.2%, $n = 180$) were published during the past two decades (1996–2015), although only 7.8% ($n = 16$) were from the earlier time period (1976–1995). Date of publication could not be established for 3.9% of studies ($n = 8$). Nearly half the publications (42.6%, $n = 87$) appeared during the current decade (2011–present). HWC publications consistently increased across each decade and maximum (333%) decade-on-decade increase was from 1976–1985 to 1986–1995 (Figure 1A). HWC was reported from 32 states and union territories. Published records discussed three aspects of HWC, namely crop depredation, livestock depredation, and attacks on humans. The most commonly discussed topic was crop depredation (60%); 34% of the studies focused exclusively on this subject. Nearly half the publications (47%) recorded attacks on humans; however, only 5% of all studies dealt exclusively with human attacks as a form of HWC. Similarly, although 24% of the studies mention livestock depredation, only 6% were exclusively on this theme. Based on the structure of the study, existing conflict literature fell into two broad categories; the majority of the studies (76.5%, $n = 156$) used a case-study approach, providing details on species involved, type of depredation, spatio-temporal patterns of conflict instances, and people's perception. A smaller subset of studies (23.5%, $n = 48$) dealt with the determination of possible causative factors for the initiation of conflict, existing mitigation measures in place and their efficacy.

Geographical distribution of HWC

Although HWC was reported from 32 states and union territories of India (out of a total of 36), some states namely Karnataka in southern India ($n = 25$), Assam in North-Eastern India ($n = 22$), and Gujarat in western India ($n = 16$) were the three top most reported locations of conflict (Figure 1B). Although HWC in Karnataka is primarily due to elephant crop depredation and human causalities by elephant and large carnivores (mainly tiger and leopard), Assam reported crop depredation by primates and elephant, and Gujarat, crop depredation by ungulates (mainly blackbuck and blue bull).

The geographical distribution of conflict also showed a dramatic increase over time; during the period 1976–1995, HWC was reported only from 11 states and union territories in India; whereas the number increased to 31 regions in the period 1996–2005 (Figure 2). In the period 1976–1995, Gujarat in western India ($n = 4$), Kerala in southern India ($n = 4$), and Haryana in northern India ($n = 2$) were the top three HWC locations (Figure 2A) with crop depredation due to elephant, primates, and ungulates, being the major form of conflict. During 1996–2005 though, Karnataka ($n = 22$) in southern India, Assam ($n = 21$), and Arunachal Pradesh ($n = 21$) in north-eastern India were the top three HWC locations (Figure 2B), and the main forms of conflict were human injuries and causalities by large carnivores (mainly tiger and leopard) in Karnataka and crop depredation by elephant and primates in all three locations.

Overall, 69% of conflict incidences were reported from non-protected forest areas, although less than onethird were reported from forests with some level of government protection (such as National Parks, wildlife sanctuary, elephant and tiger reserves, and reserved forests).

Wildlife species involved in HWC

A total of 88 species (Table 1) belonging to nine different taxonomic groups were reported to be involved in conflict. Most of the species were carnivores ($n = 21$) followed by rodents ($n = 19$) and ungulates ($n = 17$). The number of taxonomic groups involved in conflict varied across India and the highest number (8) of unique taxonomic groups were reported from Kerala in southern India (Figure 1C) Most of the studies focused on a single taxonomic group (72%). Out of the total 88 species in conflict, the top four species in terms of number of reports were Asian elephant *Elephas maximus*: 16.5%, leopard *Panthera pardus*: 7.00%, tiger *Panthera tigris*: 7.00%, and rhesus macaque *Macaca mulatta* 5.25%. As with conflict instances and geographical regions, the number of species involved in HWC also doubled from 38 in 1976–1995 to 76 during 1996–2015 (Figures 3 and 4). The main conflict species during 1976–1995 were Asian elephant, blackbuck *Antilope cervicapra,* and Indian gerbil *Tatera indica.* This changed to Asian elephant, Indian tiger, and common leopard during 1996–2015.

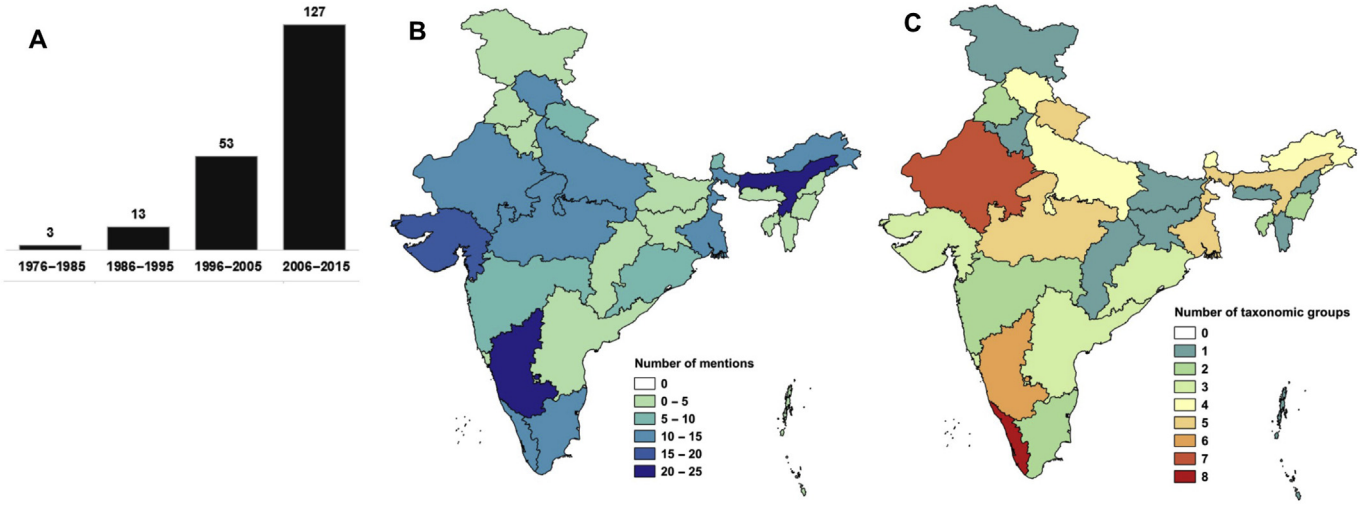

Figure 1. Characteristics of conflict literature: A, Number of HWC publications over time; B, Number of HWC reports across regions; C, Number of taxonomic groups involved in HWC. HWC = human–wildlife conflict.

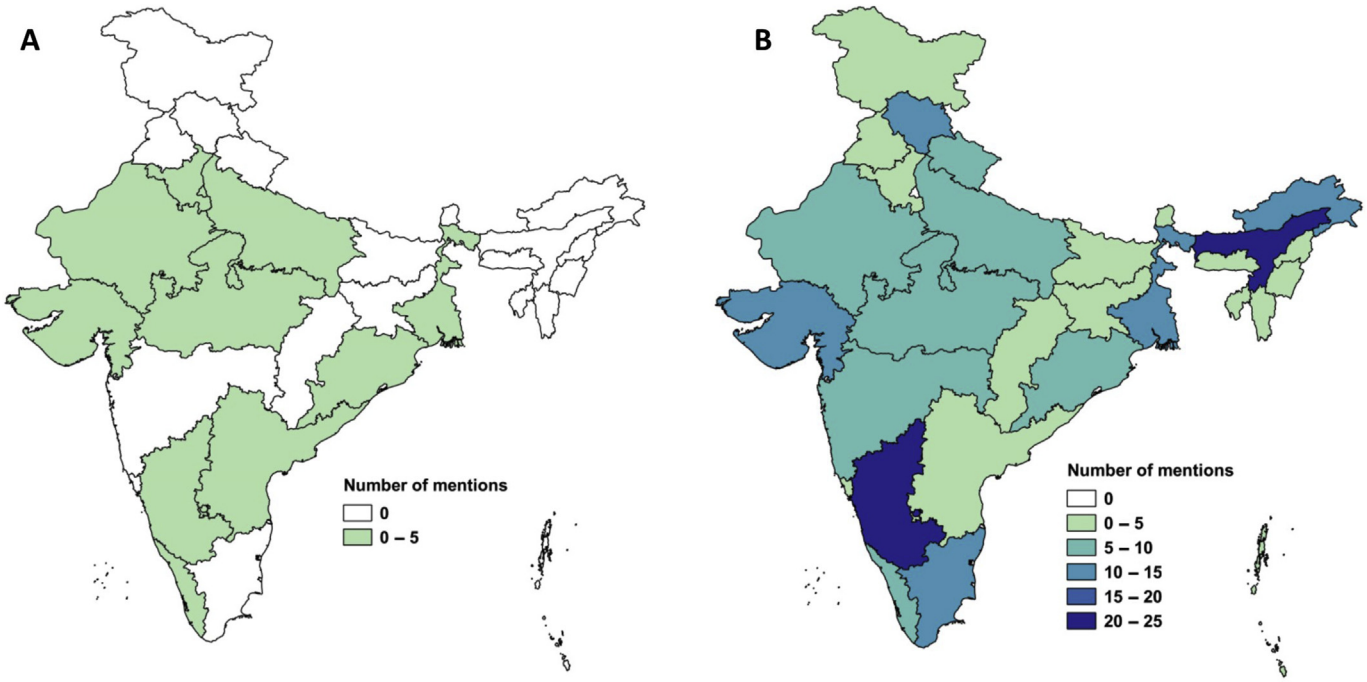

Figure 2. Geographical distribution of HWC: A, Based on records published between 1976 and 1995; B, Based on records published between 1996 and 2015. HWC = human–wildlife conflict.

Table 1. List of species involved in human–wildlife conflict.

(1) Species	(2) Common name	(3) Species	(4) Common name	(5) Species	(6) Common name
Bats		Carnivores		Rodents	
Cynopterus sphinx	Greater nosed fruit bat	*Viverricula indica*	Small Indian civet	*Meriones hurrianae*	Indian desert jird
Pterous giganteus	Indian flying fox	*Vulpes vulpes*	Red fox	*Mus booduga*	Indian field mouse
Birds		Elephants		*Bandicota indica*	Large Bandicoot rat
Grus antigone	Sarus crane	*Elephas maximus*	Asian elephant	*Funambulus palmarum*	Three-striped palm squirrel
Acridotheres ginginianus	Bank myna	Hares		*Funambulus tristriatus*	Jungle palm squirrel
Corvus macrorhynchos	Jungle crow	*Lepus nigricollis*	Indian hare	*Gerbillus gleadowi*	Indian hairy-footed gerbil
Lonchura spp	Munia	*Caprolagus hispidus*	Hispid hare	*Golunda ellioti*	Indian bush rat
Passer domesticus	House sparrow	*Primate*		*Mus musculus*	House mouse
Pavo cristeasus	Indian peafowl	*Macaca mulatta*	Rhesus macaque	*Mus platythrix*	Spiny field mouse
Ploceus spp	Weaver birds	*Semnopithecus entellus*	Northern plains langur	*Nesokia indica*	Short-tailed bandicoot rat
Psittacula spp	Parakeet	*Macaca assamensis*	Assamese macaque	*Rattus nitidus*	White-footed Himalayan rat
Streptopelia spp	Dove	*Macaca arctoides*	Stump-tailed macaque	*Rattus norvegicus*	Brown rat
Turdoides spp	Common babbler	*Macaca munzala*	Arunachal macaque	*Suncus murinus*	Asian house shrew
Carnivores		*Macaca nemestrina*	Pig-tailed macaque	Ungulates	
Panthera pardus	Common leopard	*Macaca radiata*	Bonnet macaque	*Sus Scrofa*	Indian wild pig
Panthera tigris	Tiger	*Trachypithecus geei*	Golden langur	*Boselaphus tragocamelus*	Blue bull
Melursus ursinus	Sloth bear	*Macaca fascicularis*	Long-tailed macaque	*Bos gaurus*	Gaur
Canis lupus	Grey wolf	*Hoolock leuconedys*	Eastern hoolock gibbon	*Antilope cervicapra*	Blackbuck
Canis aureus	Golden Jackal	*Macaca thibetana*	Tibetan macaque	*Cervus unicolor*	Sambar
Panthera uncia	Snow leopard	*Semnopithecus hypoleucos*	Black-footed gray langur	*Muntiacus muntjak*	Indian or red muntjac
Cuon alpinus	Wild dog	*Trachypithecus pileatus*	Capped langur	*Axis axis*	Spotted deer
Panthera leo	Asiatic lion	Reptiles		*Equus hemionus*	Asiatic wild ass
Hyaena hyaena	Striped hyena	*Chelonia mydas*	Green sea turtle	*Gazella bennettii*	Chinkara
Paguma larvata	Himalayan palm civet	*Crocodylus porosus*	Saltwater crocodile	*Rhinoceros unicornis*	Greater 1-horned rhinoceros
Ursus thibetanus	Asiatic black bear	*Crocodylus palustris*	Mugger crocodile	*Axis porcinus*	Hog deer
Canis bengalensis	Indian fox	Rodents		*Bubalus arnee*	Wild buffalo
Felis chaus	Jungle cat	*Hystrix indica*	Indian crested porcupine	*Cervus duvaucelii*	Swamp deer or barasingha
Helarctos malayanus	Sun bear	*Bandicota bengalensis*	Lesser bandicoot rat	*Lynx lynx*	Eurasian lynx
Martes flavigula	Yellow throated marten	*Rattus rattus*	House rat or black rat	*Moschiola indica*	Indian chevrotain
Paradoxurus hermaphroditus	Common palm civet	*Tatera indica*	Indian gerbil	*Moschus chrysogaster*	Alpine musk deer
Paradoxus hamiltonis	Hamilton's Civet	*Millardia meltada*	Soft-furred rat	*Naemorhedus goral*	Himalayan goral
Viverra zibetha	Large Indian civet	*Funambulus pennanti*	Five-striped palm squirrel	*Tetracerus quadricornis*	4-horned antelope

HWC = human–wildlife conflict.

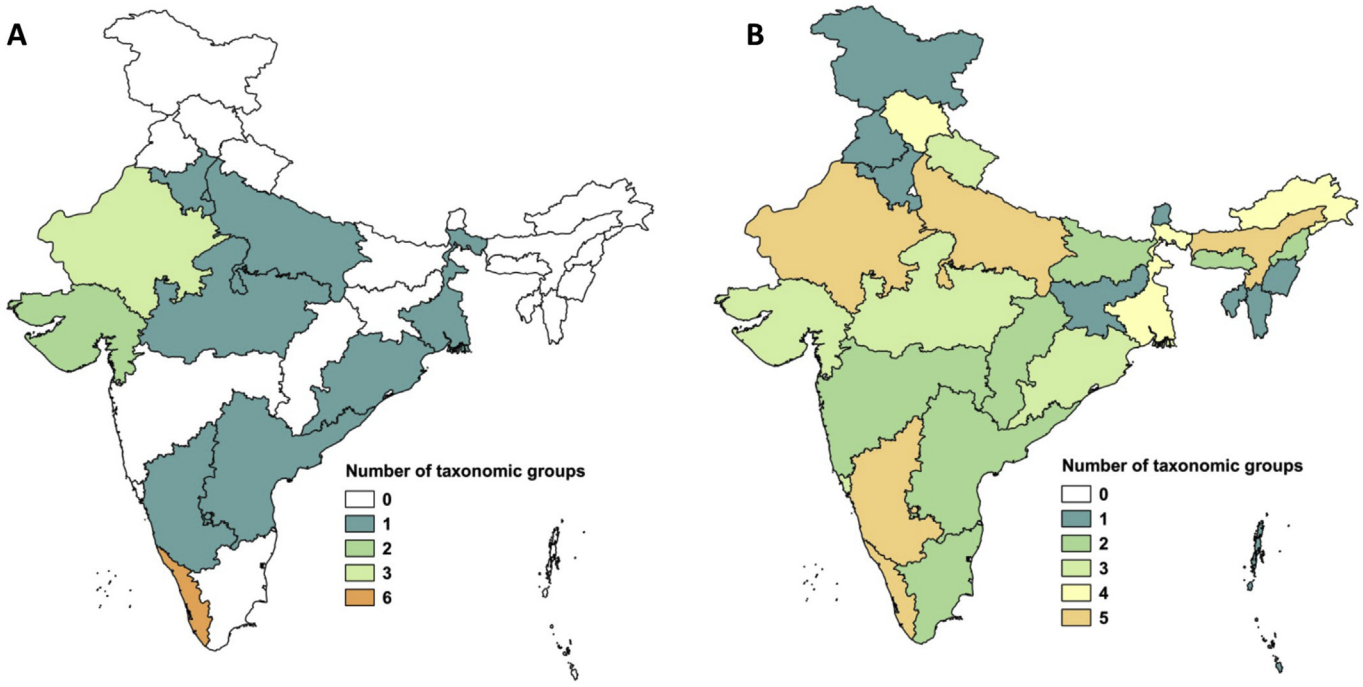

Figure 3. Number of taxonomic groups involved in HWC: A, Based on the records published between 1976 and 1995; B, Based on records published between 1996 and 2015. HWC = human–wildlife conflict.

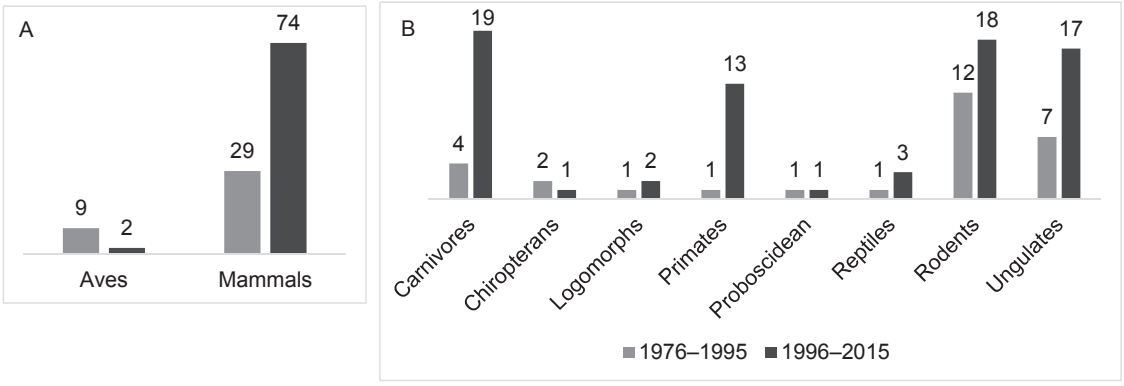

Figure 4. Number of species involved in HWC: A, Classification based on vertebrate class; B, Classification based on order. HWC = human–wildlife conflict.

Intensity of conflict

Human injuries and death due to HWC steadily increased until 2005 after which both declined. After a brief decline period, the number of cases of human injuries shot up in the year 2010. Livestock depredations showed an irregular pattern, with two distinct peaks in 1995 and 2010 (Figure 5). A similar analysis could not be carried out on crop depredation as intensity of crop depredation was reported in various ways by different studies. For example, although some studies referred to conflict intensity in terms of number of crop-raiding events, others evaluated it as total area raided, fraction of produce lost, and/or monetary loss experienced by farmers.

Discussion

The results of our study accord several interesting insights into the nature of HWC in India. The first of these concerns the apparent rapid spread of HWC to a greater proportion of the country's geographical area. Increased reporting of conflict instances from various parts of the country could genuinely reflect newer conflict areas or they could be the result of a new upsurge of research interest in HWC. Increased reporting of HWC from new areas has been previously linked to changes in land use and livelihoods and intensification of agricultural activities (Henle et al 2008; Knight 2000). It has also been observed that areas that were recently brought under formal institutional protection mechanisms, such as creation of protected areas (PAs), tend to report increased rates of HWC (Hazzah 2006). This is primarily because protected areas are seen as being controlled by outside forces, which are devoid of any resource extraction rights, where wildlife enjoy protection and cause damage (Knight 2000). India has witnessed a significant transformation with respect to both land use changes and increase in the land area under protection. Total area under cropland has increased from 120.4 million hectares in 1970 to 140.1 million hectares in 2010 whereas the total built-up area has increased from 1.02 million hectares to 2.04 million hectares (Tian et al 2014). Similarly, there has been a significant increase with respect to the

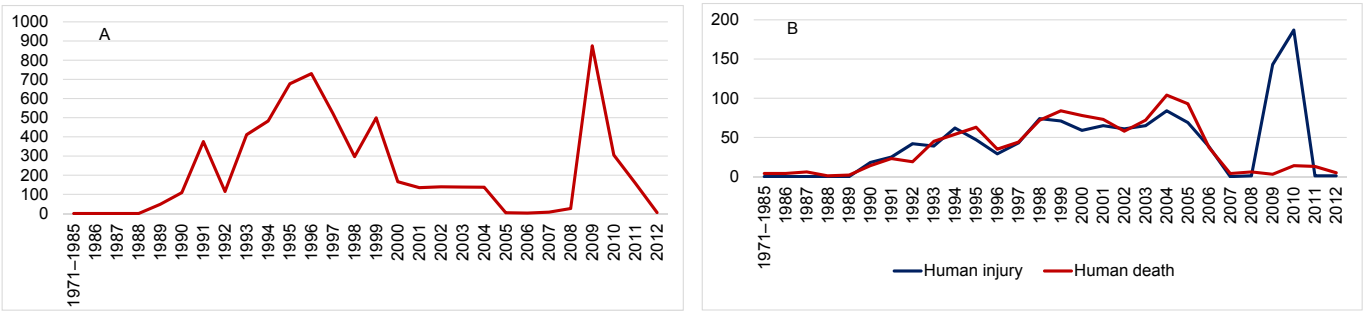

Figure 5. Intensity of conflict measured in terms of number: A, Livestock depredation; B, Human injury and human death.

area under institutional protection. Starting with just six national parks and 59 wildlife sanctuaries in 1970 (Badola 1999), there are 103 national parks, 537 wildlife sanctuaries, and 26 community reserves as of January 2017 (ENVIS Centre on Wildlife & Protected Areas, 2017). It is likely that both these factors play important roles in the increased reporting of conflict in India.

The second set of interesting findings are with respect to the wildlife species involved in conflict. It is significant that more than half (54%) of the total number of species that are currently involved in the conflict were recognized as conflict species only during the past two decades. It is also noteworthy that although the total number of species involved in conflict has increased, research efforts have been limited to a few selected species. This is illustrated by the fact that although 88 species are involved in conflict, only three species (belonging to mega-herbivore and charismatic carnivores) are predominantly reported.

The attention focused on elephants, tigers, and leopards may reflect the high damage caused by these species relative to other wildlife species. However, some recent decisions made by the Government of India with respect to wildlife conflict management in several parts of the country suggest a different scenario. In an attempt to curb damage to standing crop, rhesus macaques, blue bulls, and wild boars were identified as problem wildlife and declared vermin in the states of Himachal Pradesh (March 2016), Bihar (December 2015), and Uttarakhand (February 2016), respectively (Ministry of Environment, Forest and Climate Change 2015, 2016a, 2016b). This means that these wildlife species are no longer protected by forest department laws and can be culled at will by affected citizens. Declaration of these species as vermin suggests that conflict caused due to damage by these species was exceptionally high in recent years. If conflict literature accurately reflected ground realities, these species, should have figured prominently in discourses of human–wildlife conflict. Yet, except for a handful of studies on the rhesus macaque (Radhakrishna and Sinha 2011; Sahoo and Mohnot 2004; Saraswat et al 2015; Singh and Thakur 2012), none of the other species or the state where they have been declared vermin has attracted significant attention in literature. It is also notable that HWC studies on birds and bats have decreased in recent years. It is unlikely that this means conflict incidents involving birds or bats have actually reduced in number, for in 2016, the Goa state government debated declaring the peacock, the national bird of India, as vermin so that it could be culled in retaliation for its crop raiding activities (The Guardian 2016, The Telegraph 2016). These observations suggest that conflict research studies may not always present true ground realities due to inherent bias in the choice of study species and study location.

Studies on HWC suggest that people's perception of conflict species are not always driven by the quantum of damage caused by the species (Hazzah 2006; Knight 2000; Naughton-Treves 1997). Morphological characteristics such as large body size and menacing vocalizations, ecological characteristics such as generalist feeding nature and large social group and chronic raiding frequency, coupled with socio-cultural symbolism can lead to elevated risk perception of a species (Anthony and Wasambo 2009; Hazzah 2006; Kansky and Knight 2014; Knight 2000) Often, people tend to focus on sporadic, catastrophic damage events rather than the frequent low level damage by smaller mammals, which can cumulatively outweigh the damage caused by large mammals (Naughton-Treves 1997). Additionally, people are less tolerant of species that have the potential to harm humans (Kellert 1980). People may also report exaggerated claims of damage (Chardonnet et al 2010; Knight 2000), either as a way to maximize compensation or as an aversive reaction to institutional constraints on coping strategies (Kansky and Knight 2014; Knight 2000; Naughton-Treves 1997; Nyhus et al 2003; Wagner et al 1997). We suggest that in India, as in many other countries (Kandel et al 2016), a mega-herbivore such as the elephant and large carnivores such as tigers and leopards tend to attract disproportionately large attention due to their potential to cause human fatality and large-scale destruction.

One of the goals of our study was also to evaluate changes in HWC intensity over time. However, the majority of the studies (80%) did not attempt to measure conflict intensities, and when they did (20%), varied widely in their techniques of measurement. For example, intensity of conflict due to crop damage was reported in a number of ways such as total area damaged, frequency of crop-raiding events, fraction of total produce lost, and amount of compensation paid. Hence, we were unable to concretely evaluate changes in intensity of conflict, with respect to crop depredation.

Finally, we would like to raise the issue of research bias in HWC studies. All the HWC publications that we accessed focused exclusively on the adverse impacts of wildlife on humans. This highlights our anthropocentric approach in dealing with this issue, for HWC is a phenomenon which by its very definition equally impacts both humans and wildlife (Conover 2001). Crop and livestock depredation and attacks on humans are well-known examples of actions by wildlife that have negative impacts on humans (Inskip et al 2014; Riley 2007), and these subjects have attracted a lot of research attention in the field of HWC. A number of human activities such as hunting, pet trade, habitat degradation and modification have adverse impacts on wildlife (Kanagavel et al 2016; Nijman 2010). However, these topics are typically evaluated under the field of wildlife conservation or conservation biology. They are rarely examined as a part of HWC studies. Human actions related to conflict management such as translocation, sterilization, and selective culling also have negative impacts on wildlife. Again, the impacts of these activities have not been systematically evaluated. This constitutes a major research gap in this area which needs to be urgently addressed.

Our study on HWC trends in India reveals a number of crucial pointers for further research in this area: (1) there is an urgent need to develop and implement a standardized system for reporting intensity of conflict. This would greatly facilitate a spatio-temporal analysis of conflict intensity. Spatial analysis of conflict locations would also reveal similarities and differences with respect to location specific factors that influence the intensity of conflict; (2) we must adopt a cautious approach and systematically evaluate the actual damage caused by wildlife species, so that we can actually tease apart the actual damage and perceived damage. This will also facilitate us in eliminating any preformed biases toward a particular taxonomic group or species; (3) research on development, testing, and implementation of mitigation measures is really scarce in India (and indeed elsewhere in Southeast Asia), and this should be a priority area for future research, involving a greater number of taxa and geographical locations; (4) existing management strategies that are used for conflict mitigation need to be more nuanced, research driven and must take into account the behavior and ecology of the species concerned. Hence, there is a need to understand various aspects of habitat use by species and assess factors that influence it; and (5) there is a pressing need to eliminate the existing bias in HWC research by initiating research on impact of conflict and its mitigation on wildlife species.

The intensity of HWC is predicted to increase in the future (Madden 2004) and we need to be better prepared for this eventuality. Insights from our study are valuable starting points not just for India, but for other countries facing similar developmental concerns in south and south east Asia.

Conflicts of interest

The authors declare that there is no conflicts of interest.

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References

Anthony BP, Wasambo J. 2009. *Human–wildlife conflict study report: Vwaza Marsh Wildlife Reserve, Malawi. Report prepared for Malawi Department of National Parks and Wildlife*. Budapest, Hungary: Central European University.

Badola R. 1999. People and protected areas in India. *Unasylva* 50.

Baruch-Mordo S, Breck SW, Wilson KR, Theobald DM. 2008. Spatiotemporal distribution of black bear–human conflicts in Colorado, USA. *Journal of Wildlife Management* 72:853–1862.

Berger LR, McGraw WS. 2007. Further evidence for eagle predation of, and feeding damage on, the Taung child. *South African Journal of Science* 103:496–498.

Bowen-Jones E. 2012. *Tackling human–wildlife conflict: a prerequisite for linking conservation and poverty alleviation, Poverty and Conservation Learning Group Discussion Paper No 6, International Institute for Environment and Development*.

Brara S. 2013. *Invaded by simians*. The Hindu. pp. 1–2. Available at: http://www.thehindu.com/news/national/other-states/invaded-by-simians/article4702837.ece [Date accessed: 4 August 2014].

Chao S. 2012. *Forest Peoples: number across the world, Forest Peoples Programs United Kingdom*. Available at, http://www.forestpeoples.org/sites/fpp/files/publication/2012/05/forest-peoples-numbers-across-world-final_0.pdf [Date accessed: 1 July 2016].

Chardonnet P, Soto B, Fritz H, et al. 2010. *Managing the conflicts between people and lion. Review and insights from the literature and field experience, Wildlife Management Working Paper Number 13*. Rome: Food and Agriculture Organization of the United Nations.

Conover MR. 2001. *Resolving human–wildlife conflicts: the science of wildlife damage management*. 1st ed. Boca Raton: CRC Press.

Davison J, Roper TJ, Wilson CJ, et al. 2011. Assessing spatiotemporal associations in the occurrence of badger–human conflict in England. *European Journal of Wildlife Research* 57:67–76.

Dickman AJ. 2010. Complexities of conflict: the importance of considering social factors for effectively resolving human–wildlife conflict. *Animal Conservation* 13:458–466.

Engeman RM, Sterner RT. 2002. A comparison of potential labor-saving sampling methods for assessing large mammal damage in corn. *Crop Protection* 21:101–105.

ENVIS Centre on Wildlife & Protected Areas. 2017. *Protected Areas of India*. Available at: http://www.wiienvis.nic.in/Database/Protected_Area_854.aspx [Date accessed: 15 January 2017].

Gillingham S, Lee PC. 2003. People and protected areas: a study of local perceptions of wildlife crop-damage conflict in an area bordering the Selous Game Reserve, Tanzania. *Oryx* 37:316–325.

Gompper M. 2002. Top in the carnivores suburbs? Ecological by colonization of North-eastern North America by coyotes. *BioScience* 52:185–190.

Gordon IJ. 2009. What is the future for wild, large herbivores in human-modified agricultural landscapes? *Wildlife Biology* 15:1–9.

Hazzah LN. 2006. *Living among lions (Panthera leo): coexistence or killing? Community attitudes towards conservation initiatives and the motivations behind lion killing in Kenyan Maasai land*. Masters dissertation. University of Wisconsin-Madison.

Henle K, Alard D, Clitherow J, et al. 2008. Identifying and managing the conflicts between agriculture and biodiversity conservation in Europe—A review. *Agriculture, Ecosystems and Environment* 124:60–71.

Hill C, Osborn FV, Plumptre AJ. 2002. *Human–wildlife conflict: identifying the problem and possible solutions*, In: *Albertine Rift Technical Report Series*, Vol. 1. Wildlife Conservation Society.

Hoffman TS, O'Riain MJ. 2012. Monkey management: using spatial ecology to understand the extent and severity of human–baboon conflict in the Cape Peninsula, South Africa. *Ecology and Society* 17:13–28.

Inskip C, Fahad Z, Tully R, et al. 2014. Understanding carnivore killing behaviour: exploring the motivations for tiger killing in the Sundarbans, Bangladesh. *Biological Conservation* 180:42–50.

Inskip C, Zimmermann A. 2009. Human–felid conflict: a review of patterns and priorities worldwide. *Oryx* 43:18–34.

Jones DN, Thomas LK. 1999. Attacks on humans by Australian magpies: management of an extreme suburban human–wildlife conflict. *Wildlife Society Bulletin* 27:473–478.

Kanagavel A, Parvathy S, Nameer PO, et al. 2016. Conservation implications of wildlife utilization by indigenous communities in the southern Western Ghats of India. *Journal of Asia-Pacific Biodiversity* 9:271–279.

Kandel P, Gurung J, Chettri N, et al. 2016. Biodiversity research trends and gap analysis from a transboundary landscape, Eastern Himalayas. *Journal of Asia-Pacific Biodiversity* 9:1–10.

Kansky R, Knight AT. 2014. Key factors driving attitudes towards large mammals in conflict with humans. *Biological Conservation* 179:93–105.

Kellert SR. 1980. American attitudes toward and knowledge of animals—an update. *International Journal for the Study of Animal Problems* 1:87–119.

Knight J. 2000. Introduction. In: Knight J, editor. *Natural enemies: people–wildlife conflicts in anthropological perspective*. New York: Routledge. pp. 1–35.

Lamarque F, Andreson J, Fergusson R, et al. 2009. Human wildlife conflict in Africa - Causes, consequences and management strategies. In: *FAO Forestry Paper 157*. Rome: FAO.

Lay GL, Clergeau P, Hubert-Moy L. 2001. Computerized map of risk to manage wildlife species in urban areas. *Environmental Management* 27:451–461.

Lee-Thorp J, Thackeray JF, Van der Merwe N. 2000. The hunters and the hunted revisited. *Journal of Human Evolution* 39:565–576.

Mackenzie CA, Ahabyona P. 2012. Elephants in the garden: financial and social costs of crop raiding. *Ecological Economics* 75:72–82.

Madden F. 2004. Creating coexistence between humans and wildlife: global perspectives on local efforts to address human–wildlife conflict. *Human Dimensions of Wildlife* 9:247–257.

Madhusudan MD, Karanth KU. 2002. Local hunting and the conservation of large mammals in India. *Ambio* 31:49–54.

Manfredo MJ. 2015. Essays on human–wildlife conflict 10 years after the Durban world parks congress: an introduction. *Human Dimensions of Wildlife* 20:285–288.

Mateo-Tomás P, Olea PP, Sanchez-Barbudo IS, et al. 2012. Alleviating human–wildlife conflicts: identifying the causes and mapping the risk of illegal poisoning of wild fauna. *Journal of Applied Ecology* 49:376–385.

Messmer TA. 2000. The emergence of human–wildlife conflict management: turning challenges into opportunities. *International Biodeterioration & Biodegradation* 45:97–102.

Michalski F, Boulhosa RLP, Faria A, et al. 2006. Human–wildlife conflicts in a fragmented Amazonian forest landscape: determinants of large felid depredation on livestock. *Animal Conservation* 9:179–188.

Ministry of Environment, Forest, and Climate Change. 2015. *Gazette Notification No. S.O.3318(E) dated 01.12.2015 regarding listing of Nilgai and Wild Boar in Schedule-V of Wild Life (Protection) Act, 1972 in the State of Bihar*. Available at: http://www.moef.nic.in/sites/default/files/BIHAR-BLUE%20BULL%20AND%20WILD%20BOAR_1.pdf [Date accessed: 15 September 2016].

Ministry of Environment, Forest, and Climate Change. 2016a. *Gazette Notification No. S.O. 374 (E) dated 03.02.2016 regarding listing of Wild Boar in Schedule-V of the*

Wild Life (Protection) Act, 1972 in the State of Uttarakhand. Available at: http://www.moef.nic.in/sites/default/files/UTTARAKHAND-WILD%20BOAR.pdf [Date accessed: 15 September 2016].

Ministry of Environment, Forest and Climate Change. 2016b. *Gazette Notification No. S.O. 1922 (E) dated 26.05.2016 regarding listing of Rhesus Macaque in Schedule-V of the Wild Life (Protection) Act, 1972 in the State of Himachal Pradesh*. Available at: http://www.moef.nic.in/sites/default/files/HIMACHAL%20PRADESH-RHESUS%20MACAQUE-2.pdf [Date accessed: 15 September 2016].

Naughton-Treves L. 1997. Farming the forest edge: vulnerable places and people around Kibale National Park, Uganda. *The Geographical Review* 87:27–46.

Nijman V. 2010. An overview of international wildlife trade from Southeast Asia. *Biodiversity Conservation* 19:1101–1114.

Nyhus P, Fischer H, Madden F, et al. 2003. Taking the bite out of wildlife damage: the challenges of wildlife compensation schemes. *Conservation in Practice* 4: 37–40.

Okello MM. 2005. Land use changes and human–wildlife conflicts in the Amboseli Area, Kenya. *Human Dimensions of Wildlife* 10:19–28.

Pack S, Golden R, Walker A. 2013. *Comparison of national wildlife management strategies: what works where, and why?*. 1st ed. Maryland: University of Maryland, Heinz Center for Science Economics & Environment.

Poessel SA, Breck SW, Teel TL, et al. 2013. Patterns of human–coyote conflicts in the Denver Metropolitan Area. *The Journal of Wildlife Management* 77:297–305.

Radhakrishna S, Sinha A. 2011. Dr Jekyll and Mr. Hyde: the strange case of human–macaque interactions in India. *Current Conservation* i:39–40.

Rao KS, Maikhuri RK, Nautiyal S, et al. 2002. Crop damage and livestock depredation by wildlife: a case study from Nanda Devi Biosphere Reserve, India. *Journal of environmental management* 66:317–327.

Riley E. 2007. The human–macaque interface: conservation implications of current and future overlap and conflict in Lore Lindu National Park, Sulawesi, Indonesia. *American Anthropologist* 109:473–484.

Sahoo SK, Mohnot SM. 2004. A survey of crop damage by Rhesus Monkeys (*Macaca mullata*) and Hanuman Langur (*Semnopithecus entellus*) in Himachal Pradesh, India. *Tigerpaper* 31:1–6.

Saraswat R, Sinha A, Radhakrishna S. 2015. A god becomes a pest? Human–rhesus macaque interactions in Himachal Pradesh, northern India. *European Journal of Wildlife Research* 61:435–443.

Schön T. 2013. *The cost of having wild boar: damage to agriculture in South-Southeast Sweden*. Master's dissertation. Sweden: Swedish University of Agricultural Sciences.

Sillero-Zubiri C, Sukumar R, Treves A. 2009. Living with wildlife: the roots of conflict and the solutions. In: Macdonald D, Service K, editors. *Key topics in conservation biology*. Oxford: John Wiley & Sons. pp. 255–272.

Singh V, Thakur M. 2012. Rhesus macaque and associated problems in Himachal Pradesh-India. *Taprobanica: The Journal of Asian Biodiversity* 4:112–116.

Sinu PA, Nagarajan M. 2015. Human–wildlife conflict or coexistence: what do we want? *Current Science* 108:1036–1038.

Sodhi N, Posa M, Lee T, et al. 2010. The state and conservation of Southeast Asian biodiversity. *Biodiversity and Conservation* 19:317–328.

Soulsbury CD, White PCL. 2015. Human–wildlife interactions in urban areas: a review of conflicts, benefits, and opportunities. *Wildlife Research* 42:541–553.

Sundriyal RC, Dhyani PP. 2014. Human–wildlife conflicts. *Current Science* 107:346–347.

The Guardian. 2016. *Is it a bird? No, it's vermin: Goa reclassifies the peacock*. Available at: https://www.theguardian.com/world/2016/feb/12/bird-vermin-goa-reclassifies-the-peacock-india [Date accessed: 8 January 2017].

The Telegraph. 2016. *Goa attempts to classify India's treasured peacocks as vermin*. Available at: http://www.telegraph.co.uk/news/worldnews/asia/india/12155192/Goa-attempts-to-classify-Indias-treasured-peacocks-as-vermin.html [Date accessed: 8 January 2017].

The World Bank. 2015. *The World Development Indicator*. Available at: http://data.worldbank.org/indicator [Date accessed: 15 March 2016].

Tian H, Banger K, Bo T, et al. 2014. History of land use in India during 1880–2010: large-scale land transformations reconstructed from satellite data and historical archives. *Global and Planetary Change* 121:78–88.

Towns L, Derocher AE, Stirling I, et al. 2009. Spatial and temporal patterns of problem polar bears in Churchill, Manitoba. *Polar Biology* 32:1529–1537.

Treves A, Wallace RB, Naughton-Treves L, et al. 2006. Co-managing human – wildlife conflicts: a review. *Human Dimensions of Wildlife* 11:383–396.

Treves A. 2008. Human–wildlife conflicts around protected areas. In: Manfredo M, Vaske JJ, Brown P, et al., editors. *Wildlife and society: the science of human dimensions*. Washington: Island Press. pp. 214–228.

Tzilkowski WM, Brittingham MC, Lovallo MJ. 2002. Wildlife damage to corn in Pennsylvania: farmer and on-the-ground estimates. *Journal of Wildlife Management* 66:678–682.

Wagner KK, Schmidt RH, Conover MR. 1997. Compensation programs for wildlife damage in North America. *Wildlife Society Bulletin* 25:312–319.

Walpole M, Karanja GG, Sitati NW, et al. 2003. Wildlife and people: conflict and conservation in Masai Mara, Kenya. *IIED Wildlife Development Series* 14: 17–56.

Wambuguh O. 2008. Human–urban wildlife interface: interactions around Tilden Regional Park, San Francisco Bay area, California. *Human Dimensions of Wildlife* 13:71–72.

Woodroffe R, Thirgood S, Rabinowitz A. 2005. The impact of human–wildlife conflict on natural systems. In: Woodroffe R, Thirgood S, Rabinowitz A, editors. *People and wildlife: conflict and coexistence*. New York: Cambridge University Press. pp. 1–12.