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Human-Elephant Conflict in Kerala, India: a Rapid Appraisal Using Compensation Records

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Abstract

Human-wildlife conflict (HWC) is a major challenge for conservation biologists worldwide. To counter negative attitudes of people towards wildlife species, government agencies or non-governmental organizations (NGOs) frequently provide monetary compensation for losses due to crop damage or livestock depredation by wildlife. While much has been written about the challenges of using compensation schemes as a wildlife conservation tool, there has been little investigation into alternative potential benefits of compensation records. We suggest that compensation records can be used to obtain a summary overview of wildlife conflict instances that occur in a region and thereby provide an understanding of the distribution of HWC across a landscape. Further, these records provide insights on the economic prioritization given to each of the species involved in HWC and the kind of damage they cause. We tested this premise through a case study of human-elephant conflict (HEC) in districts of Kerala in southern India using state government-maintained compensation records. To this end, we constructed a conflict index and found Wayanad, Palakkad, and Kannur to be the districts most affected by HEC. An overall distribution map of HEC in any region is crucial to formulating mitigation policies for conflict management. Findings from our study, based on the compensation records, present a holistic view of conflict occurrences in Kerala and thus provide data that can be used to develop basic management strategies for HEC in the state.

Keywords Human-wildlife conflict · Human-elephant conflict · Compensation records · Conservation management · Kerala, Southern India

Introduction

Human-wildlife conflict (HWC) is an existential challenge for conservation biologists worldwide (Madden and McQuinn 2014). People sharing spaces with wildlife incur costs such as physical injuries, disease transmission, crop/kitchen/garden damage, livestock depredation, and opportunity costs (Karanth *et al*. 2013; Redpath *et al*. 2015). Such costs can influence people's attitudes and tolerance towards wildlife and generally make them averse to wildlife conservation measures, thereby giving rise to further conflict (Dickman 2010). HWC is particularly of concern in less developed nations where Protected Areas (PA) designated for wildlife protection have zones of overlap with human settlements (Ogra and Badola 2008). India, the seventh largest country in the world geographically and yet second in terms of population, is no exception; there are human settlements within and in the vicinity of ~65% of the PAs in the country and occurrences of HWC are common (Kothari *et al*. 1989; Ogra and Badola 2008). Moreover, with increasing population pressures and consequent land-use changes, HWC are not confined to forested areas alone but are also encountered in rural and urban regions (Distefano 2005).

While wildlife conservationists have instituted many measures including physical and behavioural barriers to prevent wild animals from entering human habitations (Karanth and Kudalkar 2017; Ravenelle and Nyhus 2017), conflicts continue to occur (Karanth and Madhusudan 2002; Madhusudan 2003). To counter negative attitudes of people towards

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wildlife species, government agencies or non-governmental organizations (NGOs) frequently provide monetary compensation for losses due to crop damage or livestock depredation by wildlife (Mishra *et al.* 2003; Agarwala *et al.* 2010). It has been suggested that this practice can secure local support for wildlife conservation, curb retaliatory actions, and help reduce HWC while more appropriate management plans are formulated (Madhusudan 2003; Agarwala *et al.* 2010; Persson *et al.* 2015).

Studies on wildlife-related compensation payments typically address the merits of compensation schemes (Madhusudan 2003; Nyhus *et al.* 2005; Bulte and Rondeau 2007), debate the effectiveness of compensation payment procedures (Karanth *et al.* 2018), investigate factors that affect people's participation in compensation schemes (Mmopelwa and Mpolokeng 2008; Ogra and Badola 2008), and assess people's attitudes towards wildlife and compensation programs (Naughton-Treves *et al.* 2003). While there has been much research into the challenges of using compensation schemes as a wildlife conservation tool (e.g., Nyhus *et al.* 2005), little investigation has been made into potential alternative benefits of compensation records. Compensation records maintained by State Forest Departments provide information regarding the presence and frequencies of HWC instances in a region and the wildlife species involved in these scenarios. Thus these records can be used to provide a summary overview of wildlife conflict instances that occur in a region and thereby improve understanding of the distribution of HWC across a landscape. Further, these records provide insights on the economic prioritization assigned to each of the species involved in HWC and the kind of damage they cause. We tested this premise through a case study of human-elephant conflict (HEC) in the state of Kerala in southern India using state government-maintained compensation records.

Elephants (*Elephas maximus*) are recognized to be a major conflict species in India as they are responsible for high economic losses as well as the loss of human lives (Gubbi *et al.* 2014). Local retaliatory killings of 'errant' elephants are also common (MOEF 2010). Although HEC is a key conservation and social concern in India, very few studies have quantitatively assessed the distribution of reported incidences (Gubbi 2012; Gubbi *et al.* 2014). However, such assessments are important as the levels of HEC are not consistent across areas and information in this regard can assist in the development of region-specific mitigation/management strategies (Lenin and Sukumar 2011; Gubbi *et al.* 2014). The state of Kerala is located along the Malabar Coast in peninsular India. Although its geographical extent consists of only 1.18% of

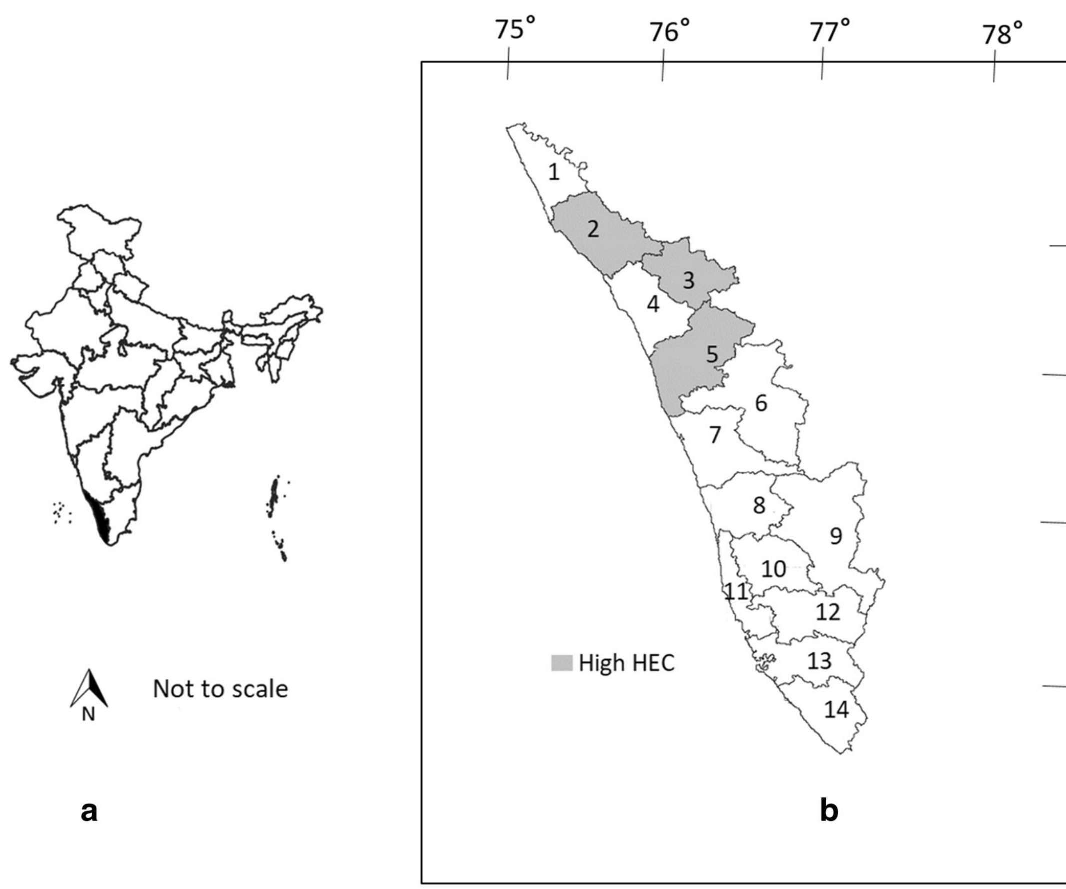

Fig. 1 Map showing **a** position of Kerala within India and **b** districts of Kerala: 1. Kasargod 2. Kannur 3. Wayanad 4. Kozhikode 5. Malappuram 6. Palakkad 7. Thrissur 8. Ernakulam 9. Idukki 10. Kottayam 11. Alappuzha 12. Pathanamthitta 13. Kollam 14. Thiruvananthapuram

the land area of the country, it is one of the top three states of the country in terms of the density of its elephant population (Gubbi *et al.* 2014). In 2010, the estimated wild elephant population of the state was 3520 and 6026 as per the block count method and dung survey respectively (Kerala Forest Research Institute 2010).

In India, the responsibility for wildlife management lies with the respective State Forest Departments, and at least 27 states in the country, including Kerala, have initiated compensation programs (Karanth *et al.* 2018). The Departments maintain records of compensation claims made and the amounts disbursed against them. We used compensation records maintained by the Kerala State Forest Department to identify districts where HEC is high and which thus require immediate intervention. HWC can be a function of various socio-ecological factors such as density of conflict wildlife species, natural resource availability, extent of forest cover. Hence, we also addressed the potential correlation of area under forest cover, annual rainfall, human population density, and elephant population density to HEC across Kerala.

Methods

Kerala, located in peninsular India, has an area of 38,860 km^2, of which 27.84% is under forest cover (Forest Survey of India 2017). The state is divided into 14 districts: Alappuzha, Ernakulam, Idukki, Kannur, Kasaragod, Kollam, Kottayam, Kozhikode, Malappuram, Palakkad, Pathanamthitta, Thrissur, Thiruvananthpuram, and Wayanad (Fig. 1). While Wayanad has the highest percentage of its geographical area under forest cover (74.18), Alappuzha has the least (4.81) (Forest Survey of India 2017). The compensation records of the Kerala Forest Department typically enumerate the following information: name of the complainant, place, the name of the forest range in which damage occurred, wild animal(s) involved, mode of damage, and compensation amount granted. We obtained compensation data for all districts for the years 2009 to 2015, although there were no records of compensation for Alappuzha. The compensation records were often incomplete; for instance, the wildlife species against which compensation claims were made were often not systematically logged. Out of the total 17,216 compensation cases registered, the name of the species was absent for 904 records, the generic term 'wild animal' was used for 642 records, and multiple varied species were entered for 2153 records. For example, between 2009 and 2015, there were three cases in which compensation was given for damages caused by 'elephant, boar, deer, macaque.' We constructed a HEC index (C_i) for each district using the following formula:

$$C_i = \frac{No.of\ cases\ registered\ against\ elephants\ in\ district\ i*Total\ area\ of\ state}{Total\ no.of\ cases\ registered\ against\ elephants\ in\ state*Area\ of\ district\ i}$$

We considered districts with $C_i > 1$ to be those with high HEC and vice versa.

In order to assess the influence of forest cover on HEC, we collected data from the State of Forest Report 2015 (SFR) (Forest Survey of India 2015). We obtained human population density data from Census of India 2011 (censusindia.gov.in), and elephant population density data from the 'Wild elephant census of Kerala state 2010' report (Kerala Forest Research Institute 2010), which enumerates number of direct sightings and elephant densities for various forest divisions of Kerala based on the block count method. From the counts and the population densities, we estimated the areas over which the sampling was done. For Thenmala and the Agasthyavanam Biological Park (ABP) Special Division, there were no direct sightings. Hence, we could not estimate the sampled area from the provided densities (0/km^2 in these cases). For these two divisions, we used their areas (which we obtained from the Kerala Forests and Wildlife Department 2018) as proxies for the areas of the sampled blocks. We then added the number of direct sightings for all the divisions in a district and divided the figure by the sum of the areas of the sampled blocks to estimate district-wise elephant population densities. Annual rainfall data for 2009 to 2012 were obtained from Venkatesan *et al.* (2015), while for 2013 to 2015, the data were obtained from Rainfall Statistics of India reports of the respective years (Kaur and Purohit 2015). The average annual rainfall figures for these years was considered to be the mean rainfall for the districts. Pearson's correlation coefficients were used to assess the relationship between C_i and (a) mean annual rainfall, (b) forest area, (c) human population density, and (d) elephant population density. All statistical analyses were done in R version 3.5.1 (R Core Team 2018).

Results

Spatio-Temporal Patterns

Between 2009 and 2015, a total of 16,312 records of compensation were registered for which the animals were specified. Elephants accounted for 48% of these. Elephant-related compensation records accounted for 43.2% (± SD 9.3) of the total number of cases across the years on an average. The highest number of cases were registered against elephants in 2010 (50.2% of the cases, $N = 1862$) and 2013 (54.0%, $N = 3660$; Fig. 2).

All the districts had compensation records against elephants. Across all the districts except Kottayam elephants were among the top three wildlife species against which compensation claims had been made (Table 1). Palakkad (66.6%, $N = 1536$), Kannur (58.5%, $N = 1905$), Malappuram (57.1%, $N = 898$), and Wayanad (55.1%, $N = 7343$) had the highest percentage of cases registered against elephants.

Across the districts, crop damage accounted for 44% of the complaints registered for which the mode of damage was specifically mentioned (Table 2). In Wayanad, Palakkad, and Kannur, crop damage accounted for 95%, 94%, and 82% respectively of the cases registered. Elephants were cited as the cause for over 50% of these cases in Wayanad (57.2%), Malappuram (61.1%), Palakkad (68.2%), and Kannur (70.6%). In Wayanad and Palakkad, high percentages of cases reporting human mortality were also attributed to elephants (Table 2).

Compensation for Damage Caused by Elephants

Compensation was paid for 16,948 cases and amounted to INR 217,756,915. The mean amount paid per year was INR 31,108,131 (±SD 16470297; range: INR 966,104 to 58,186,365). Compensation paid for damage caused by elephants accounted for 13% of the total. Crop damage accounted for 84% of these cases and 67% of the compensation amount. Human death accounted for 2.2% of these cases and 20% of the compensation amount. In Palakkad, Malappuram, Wayanad, and Kannur, compensation for damage attributed to elephants amounted to 73%, 65%, 59% and 55% of the total sum respectively.

HEC Index (C_i) and Correlates

C_i ranged from 0.01 (Kottayam) to 9.45 (Wayanad). We identified Wayanad, Kannur (1.87), and Palakkad (1.14) as the districts having high HEC (Fig. 1). The percentage of area under forest cover ranged from 29.3% in Ernakulam to ~80% in Wayanad (mean: 50.6 ± SD 15.5%, $N = 13$; Table 3). The mean elephant population density across the districts was 0.39 (± SD 0.28) individuals/sq.km (range: 0.07 in Kottayam to 1.08 in Ernakulam, $N = 12$; elephant population density data were not available for Kasargod; Table 3). Human population density was the highest in Thiruvananthapuram (1508 individuals/sq.km) and the lowest in Idukki (254 individuals/sq.km; mean: 858 ± SD 0.28 individuals per sq.km, $N = 13$; Table 3). C_i was not correlated with percentage of district area under forest cover ($r^2 = 0.26$, $p = 0.07$), rainfall ($r^2 = 0.09$, $p = 0.29$), elephant density ($r^2 = 0.13$, $p = 0.25$), or population density ($r^2 = 0.16$, $p = 0.29$; Table 3).

Discussion

We found that while HEC was recorded across all the districts in Kerala with the exception of Alappuzha, it was high in Palakkad, Kannur, and Wayanad. These districts were also the ones in which the highest number of compensation claims against wildlife damage had been registered. Higher conflict was reflected both in the number of cases that were registered against elephants in these districts as well as the amount of compensation paid for elephant damages. Elephants were also among the top three wildlife species causing damage in all the districts except one. In fact, our calculations of these figures may be underestimations because many compensation records did not specify the identity of the wildlife species. Crop-foraging was found to be the most frequent cause of damage. In the districts with high HEC, crop-foraging by elephants

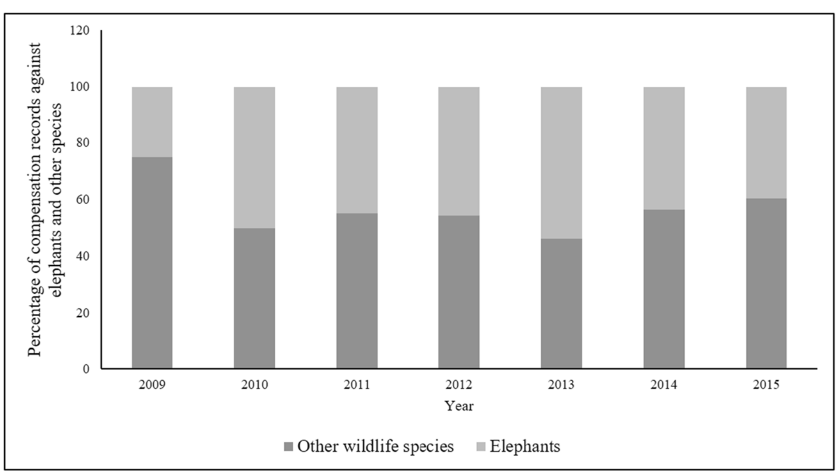

Fig. 2 Compensation records against elephants and other wildlife species

accounted for 57–71% of the total number of cases documented. Thus, we suggest that Palakkad, Kannur, and Wayanad districts in Kerala should be prioritised in the reformulation of HEC mitigation measures and that these should be targeted towards curbing crop-foraging by elephants.

While C_i was >1 for both Kannur and Palakkad, it was notably higher for Wayanad (9.45). The intensity of crop-foraging by elephants is known to be proportional to the length of the perimeter of the forest-agricultural land boundary (Sukumar 1989). However, we did not find any relation between percentage of area under forest cover and number of cases reported against elephants in this study. Our results may have been influenced by using area under forest cover as a proxy of forest perimeter. However, Gubbi *et al.* (2014) also found no relation between HEC and forest perimeter in the state of Karnataka in southern India, similar to our results. We

Table 1 Top three wildlife species against which cases have been registered

District	Wildlife species against which highest number of compensation claims have been made	Number of cases registered
Wayanad	Elephant (*Elephas maximus*)	4048
	Bonnet macaque (*Macaca radiata*)	733
	Wild boar (*Sus scrofa*)	611
Kannur	Elephant	1114
	Wild boar	285
	Snake	280
Palakkad	Elephant	1023
	Wild boar	251
	Tiger (*Panthera tigris*)	35
Pathanamthitta	Elephant	46
	Snake	22
	Wild dog (*Cuon alpinus*)	6
Idukki	Elephant	344
	Wild boar	132
	Wild buffalo (*Bubalus arnee*)	45
Ernakulam	Elephant	85
	Snake	75
	Tiger	10
Malappuram	Elephant	513
	Wild boar	207
	Bonnet macaque	94
Kozhikode	Elephant	319
	Wild boar	110
	Chital (*Axis axis*)	10
Thiruvananthapuram	Snake	41
	Wild boar	39
	Elephant	20
Kollam	Wild boar	40
	Tiger	36
	Elephant	24
Kottayam	Snake	60
	Wild boar	39
	Bonnet macaque	11
Thrissur	Wild boar	223
	Snake	191
	Elephant	159
Kasargod	Snake	139
	Bonnet macaque	114
	Elephant	113

Table 2 Percentage of crop damage and human death cases attributed to elephants

District	No. of cases for which mode of damage is recorded	Percentage of crop damage incidents attributed to elephants	Percentage of human death cases attributed to elephants
Ernakulam	264	42.3	10.3
Idukki	919	45.5	30.8
Kannur	1903	70.6	7.1
Kasargod	533	29.1	0.0
Kollam	375	7.7	0.0
Kottayam	131	6.1	6.3
Kozhikode	739	44.9	18.2
Malappuram	938	61.1	20.0
Palakkad	1429	68.2	60.9
Pathanamthitta	488	13.9	0.0
Thiruvananthapuram	520	24.0	2.3
Thrissur	938	3.1	8.8
Wayanad	7329	57.2	66.7

also did not find any relationship between number of cases reported against elephants and elephant and human population densities. While it is possible that the lack of relationship between elephant population density and number of cases reported against elephants in our study is an artefact of the way we calculated elephant population densities, our results are supported by Gubbi *et al*. (2014), who also reported no relationship between HEC and elephant density in Karnataka.

In addition, we found no relationship between the number of cases reported against elephants and rainfall. This result is in contrast with that observed at the Nagarhole National Park in southern India, where occurrence of HEC was negatively correlated with rainfall patterns (Gubbi 2012). The disparity may be attributed to the particular kinds of crops that are grown in different regions. Around the Nagarhole National Park, most of the villagers practice rainfed agriculture and incidents of crop foraging by elephants increase when crops mature (Gubbi 2012). This finding is similar to that of Chen *et al*. (2016) in China, where they reported that HEC became more intense during the rainy season when crops such as paddy, corn, beans, peanuts, and sugarcane matured. More information about the cropping patterns across the districts of Kerala would shed more light in this regard. Also, it would be useful to see if examining the correlation between seasonal rainfall (instead of annual average rainfall) and the number of cases filed against elephants for crop-foraging would yield different results. We however were constrained by the lack of detail in this regard in the dataset we had access to.

The lack of correlation with any of the variables we used as parameters in this study shows that HEC may be a function of

Table 3 District-wise number of cases registered and those registered against elephants

District	No. of complaints against elephants	Total no. of records	Elephant density (no./sq.km)	Percent of area under forest cover	Population density (no./sq.km)	Average annual rainfall (mm)	Ci
Ernakulam	85	263	1.08	29.33	1069	2891.5	0.18
Idukki	344	802	0.42	75.11	254	2866.4	0.34
Kannur	1114	1905	0.15	45.11	852	2980.6	1.87
Kasargod	113	533	NA	43.02	654	2745.8	0.28
Kollam	24	375	0.26	56.28	1056	2336.5	0.05
Kottayam	4	131	0.07	40.08	896	3004.2	0.01
Kozhikode	319	739	0.25	44.88	1318	2870.1	0.68
Malappuram	513	898	0.21	41.56	1058	2487.5	0.72
Palakkad	1023	1536	0.29	39.31	627	1985.2	1.14
Pathanamthitta	46	488	0.39	65.96	453	2890.2	0.09
Thiruvananthapuram	20	345	0.31	60.05	1509	2252.2	0.05
Thrissur	159	954	0.52	37.09	1026	2594	0.26
Wayanad	4048	7343	0.78	79.73	383	2282.6	9.45

other factors (Gubbi 2012; Chen *et al.* 2016). For example, the amount of crop damage may be a result of individual variation in elephant behaviour; some individuals in the population may forage on crops more regularly than the others. It has been reported that due to intense mating competition, male elephants may engage more in crop-raiding than females (Chiyo and Cochrane 2005; Ekanayaka *et al.* 2011). Thus, rather than elephant population density, data on the number of adult male elephants present in a district may be more useful in accounting for the frequency of HEC. There is currently no such published data available. Elephant movement patterns are also influenced by their high water requirements. They often encounter crops when seeking water from ponds and irrigation reservoirs located within and around cultivated fields (Sukumar 1989). Further analysis to identify the location of large and small water bodies in the agricultural areas where complaints are lodged will contribute a better understanding of HEC in Kerala. The intensity of HEC may also be a consequence of certain crop-guarding techniques. For example, in the Tsavo ecosystem in Kenya, HEC was found to be much less intense in fenced areas (Smith and Kasiki 2000). Future studies need to assess if crop protection techniques vary among the districts in Kerala and whether the type used is reflected in the frequency and intensity of HEC.

The primary step in devising HWC mitigation measures is to identify areas in which conflict is heightened and which require immediate attention (White and Ward 2011). Compensation records provide a fast and effective way of assessing levels of conflict. There is little published information on district-wide HEC in Kerala and available literature provides data only about specific regions in the state (Jayson and Christopher 2008; Govind and Jayson 2013; Rohini *et al.* 2016). An overall distribution map of HEC in the state is crucial to formulate mitigation policies for conflict management. Our findings based on compensation records present a holistic view of conflict occurrences in the state and thus provide data that can be used to develop basic management strategies for HEC in Kerala. More importantly, on comparing the results of our study with others addressing the correlates of HEC, we found that the frequency and intensity of HEC may be highly variable and be a function of several different factors. Hence, it may not be possible to make generalizations from specific regional observations. However, an understanding of the spatial patterns of HEC is a prerequisite for identifying priority areas and planning region-specific mitigation strategies that serve the interests of elephants and humans alike.

We do recognize that compensation records may not always completely reflect differing scenarios on the ground (Karanth *et al.* 2018). While compensation rules can vary from state to state, generally the application procedure is similar (Sekhar 1998; Agarwala *et al.* 2010; Karanth *et al.* 2018). Victims needs to file an immediate complaint with the appropriate Range Forest Officer and provide valid documents proving their rights over lands on which they have incurred losses. Claim verification involves a formal investigation report, local witnesses' accounts, and an assessment of the loss by a designated Forest Officer. Following this, the claim is ratified, examined, and endorsed by several officials of the Forest Department before the Deputy Conservator sanctions the order (Madhusudan 2003). The act of filing a complaint for compensation can be tedious. Forest offices are often hard to reach, entailing difficult travel arrangement for villagers in remote areas. Getting formal documents to claim land rights can also be problematic (Madhusudan 2003). Bureaucratic apathy, alongside the many steps involved in the sanction of the order also ensures that the process is extremely time-consuming (Mishra 1997). Most importantly, compensation schemes only cover a small percentage of the monetary losses incurred (Mishra 1997; Madhusudan 2003). Thus, victims of HEC do not always file complaints and these incidents go unrecorded. Also, people often may name elephants as the culprit species in the hope that compensation will be higher. Gubbi (2012), for instance, points out that it is easier to get compensation against elephants as it is easier to provide evidence of extent of damage by elephants. In addition, complaints filed against some wildlife species may be made as a consequence of people's negative attitudes towards the species. For example, in both Solapur, India, and Wisconsin, USA, people recorded more complaints about wolves because of their inherent negative perceptions although other species caused much more damage (Agarwala *et al.* 2010). By quantifying the actual damage caused by red colobus monkeys to coconut plantations in Zanzibar, Siex and Struhsaker (1999) demonstrated that the farmers incorrectly perceived the primates to be detrimental to their harvest. Moreover, damage caused by Sykes monkeys on banana plantations were often attributed by farmers to red colobus monkeys as the latter were more conspicuous. Similarly, at the Nagarhole National Park, the higher number of complaints made against elephants as opposed to sambars or wild pigs indicates people's bias towards elephants (Gubbi 2012).

Assessing HWC usually entails time consuming studies involving rigorous collection of spatial data, information on ecological correlates, socioeconomic variables, and demographic characteristics of both human and wildlife species, alongside interviews to understand attitudes, perceptions, and tolerance levels of local people (Agarwala *et al.* 2010; Karanth *et al.* 2012, 2013). While such robustly designed studies are preferred, rapid assessments of conflict scenarios are often required to devise and urgently implement region-specific mitigation measures. Despite all the limitations we have noted above, compensation records can indeed be very useful for such appraisals, especially at larger scales. We recommend the use of compensation records for preliminary studies about HWC scenarios before attempting ground-truthing. These will not only help in understanding the extent and level of HWC, but data on the distribution of HWC obtained in such rapid appraisals can also help in monitoring distributions of wildlife species.

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Compliance with Ethical Standards The study used compensation records from the Kerala State Forest Department for which the authors had permission.

Conflict of Interest The authors declare they have no conflict of interest.

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