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COMMUNICATION

AN ASSESSMENT OF HUMAN-ELEPHANT CONFLICT AND ASSOCIATED ECOLOGICAL AND DEMOGRAPHIC FACTORS IN NILAMBUR, WESTERN GHATS OF KERALA, SOUTHERN INDIA

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An assessment of human-elephant conflict and associated ecological and demographic factors in Nilambur, Western Ghats of Kerala, southern India

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Abstract: Elephant conservation carries cost in the form of human-elephant conflict and affects the wellbeing of people living near ecologically important areas. Conflicts impart serious challenges towards the survival of Asian Elephants, which are categorized as Endangered in the IUCN Red List of Threatened Species. Issues of wildlife conservation are least addressed in areas with less restricted categories of protection. Hence an attempt was made to evaluate the intensity of elephant conflict and factors associated with its occurrence in villages with forest fringes of North and South Forest Divisions of Nilambur, Kerala, southern India. It was hypothesized that variables such as number of houses, area of village, livestock population, forest frontage, and presence of water source along the forest boundary abutting the village to be the underlying correlates of conflict. Field studies were conducted fortnightly from June 2014 to May 2015, by visiting farms and households of 17 selected forest fringe villages. Observational methods, questionnaire surveys and secondary data collection were employed for this purpose. A total of 277 incidents of crop depredation, 12 incidents of property damage, three human injuries, and one human death due to conflict were recorded during this period. Crop raiding was highest during post monsoon season and it was low during pre-monsoon and monsoon seasons. Multiple linear regression results suggest that forest frontage and livestock population were significant predictors of conflict incidence. Information regarding the prime causes of conflict will be helpful for planning strategies for the establishment of appropriate mitigation methods. The present study serves as baseline information which will be helpful for formulating prospective management plans.

Keywords: Conservation, human-elephant conflict, crop damage, Nilambur, Western Ghats.

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INTRODUCTION

Human-wildlife conflict (HWC) involves any interaction between man and wildlife that has harmful effect on either human or wildlife populations (Madden 2004). 'Interaction' with wildlife will be perceived as 'conflict' whenever people experience negative impacts (Reilly & Reilly 2003) economically, socially, or psychologically while sharing boundaries with forests. Intensity of HWC is evidently increasing (Perera 2009) in the context of growing habitat loss and fragmentation over the last century. Conflict with elephants is widespread across Asia and Africa, and a key threat to the survival of Asian Elephants, which has endangered status (Williams et al. 2001).

Elephants are one of the least tolerated crop raiding wildlife species as the intensity of damage per conflict incident is much higher than with any other species (Naughton-Treves 1998). Effects of human-elephant conflict (HEC) such as crop damage, injury or death, spread rapidly leading to fear among people (Ngure 1995). This in turn has negatively influenced the local support for the elephant conservation which threatens the survival of elephants especially outside protected areas (Wilson et al. 2015). The present conservation challenge is to maintain viable populations of elephants with minimum negative impacts on humans (Kangwana 1995). This has become a tremendous task while considering the large home range requirement of elephants.

Working towards suitable mitigation methods is significant for achieving the conservation goal. Relying on any single method alone makes it almost impossible to mitigate HEC (Sitati & Walpole 2006). As conflict shows geographically specific patterns, understanding underlying causes will help in establishing appropriate mitigation methods (Sitati et al. 2005) that are site-specific.

In southern India, elephant populations spread along the Western Ghats form the largest among Asian elephant populations (AERCC 1998). However, earlier research on elephant conflict in Kerala was either concentrated around protected areas (Jayson 1998; Veeramani & Jayson 1995; Easa & Sankar 2001) or was short term studies. Wildlife conservation issues are least addressed in areas outside Protected Areas (Macura et al. 2011). In Kerala, losses due to crop damage and human casualty are still low when compared to the national average (Sinu & Nagarajan 2015). Retaliatory responses and agitations following conflict incidents were previously observed in the Nilambur region (Rohini et al. 2015). Hence an attempt was made to evaluate the intensity of elephant conflict and factors associated with its frequency of occurrence in villages with forest fringes of North and South Forest Divisions of Nilambur, Kerala. It was hypothesized that factors such as forest frontage (length of forest boundary abutting a village), presence of water source along forest boundary, cattle population, number of houses, and area of the village as the underlying causes of conflict. These variables were chosen as key correlates of conflict based on literature review (Hoare 1999; Karanth & De Fries 2010; Nyhus 2000; Smith & Kasiki 2000; Gubbi 2012). The occurrence of seasonal variation in the intensity of conflict incidents was also investigated. Results of this study will possibly help in planning conservation and the development of mitigation plans in this region.

STUDY AREA AND METHODS

The study area comes under the administration of North and South Forest Divisions, Nilambur, part of Nilgiri Biosphere Reserve (NBR). The study area includes 17 forest fringe villages of Vazhikadavu Range (11.45525^{0}N & 76.27142^{0}E) and Karulai Range (11.28179^{0}N & 76.3241^{0}E). New Amarambalam Reserve Forest (NARF), which is a part of the Nilambur South Forest Division, forms a core area of the NBR and supports a good population of elephants and also several endemic mammals of the Western Ghats. This region has been identified as a High Value Biodiversity Area by the Kerala Forest and Wildlife Department and proposed to upgrade the protection status (Sharma et al. 2002). The forests of the lower slopes and the plains have been cleared for monoculture teak plantations. Large tracts of teak plantations are interspersed with thickly populated rural villages and the evergreen forests.

Extensive cultivation of perennial and cash crops were more common than seasonal crops in the study area. Rubber plantations dominate in the total cultivated area of the forest fringe villages, which was evident from records obtained from agriculture department. Though large scale cultivation of banana is present in the study area, was not widespread in forest fringes. Small scale cultivation of shrubby crops such as ginger, turmeric, and colocasia was present. Cultivation of paddy was observed as very limited in these forest fringe regions.

To record conflict incidents, a field visit was done fortnightly, from June 2014 to May 2015, by visiting farms and households of the forest fringe villages. Data

collection was done by direct evaluation of damage caused by elephants and with questionnaire surveys among villagers about each incident (Easa & Sankar 2001). Conflict incidents due to elephants such as crop damage, property damage, injury or human death in the villages were recorded systematically. Information about the date and time of conflict incidents (i.e., crop damage, property damage, injury or death caused by elephants in each village) was collected from villagers during each visit. The information such as whether an elephant herd or an individual elephant caused the damage were also noted. If direct or indirect evidence of the presence of elephant calves was found in the field, the raiding was considered as that of a herd (Easa & Sankar 2001). Crop damage was assessed in all the study villages by counting the number of plants damaged. This assessment was done for perennial and cash crops such as Coconut *Cocos nucifera*, Arecanut *Areca catechu*, Rubber *Hevea brasiliensis*, Teak *Tectona grandis*, and for seasonally cultivated crops such as Banana *Musa paradisiaca*. As the damage to other crops such as Ginger *Zingiber officinalis*, Turmeric *Curcuma domestica*, Colocasia *Colocasia esculenta* and vegetables was negligible these crops were not included in this study to calculate the intensity of damage. The locations of each damaged plot were marked using hand held GPS (global positioning system). Demographic and other information of the affected villages such as number of houses and area were collected from the village offices. Livestock population records were obtained from the database of the Animal Husbandry Department. The length of the forest boundary abutting the village was calculated using Arc 9.3 (GIS software) and termed "forest frontage" for the village.

Seasonal variation in the number of conflict incidents was investigated using χ^2-test to find out the association of conflict in relation to season. Wilcoxon signed rank test was used to examine the association between growth stages of the crops and crop raid. Linearity was examined by plotting the relationship between response variable (crop raiding incidence) and each predictor variable (environmental covariates) using Minitab's Lowess plot. To investigate multicollinearity between the environmental covariates, a correlation analysis was conducted before using multiple regressions to assess the relationships between the response variable and predictor variables, thereby providing valid parameter estimates and P values. The data was analyzed using SPSS, 16 (IBM SPSS Inc., Illinois, USA). Prior to analysis, conflict incidence data was normalized using natural logarithm transformation on the number of livestock and forest frontage.

RESULTS

During the study period 277 incidents of crop depredation, 12 incidents of property damage, three human injuries, and one human death were recorded. The human death happened inside the forest. Of the three injuries, one of the incidents occurred by direct encounter with a tusker elephant which was raiding crops at night. The other two cases took place while farmers were trying to deter elephants from their farms. Property damage included damage to solar fences, pillars of barbed wire fences, surveillance shelters, pipelines, water tank, well slab, and partial damage to a house. Property damages were mostly caused by solitary elephants.

Among the total 17 villages considered, 12 of them had no mitigation measures, or if any barriers were present they were found damaged and unrepaired for years. In the study site people deter elephants by traditional methods such as crackers, flashlights, or by making loud noise. Though solar fencing was present in three villages (Malachi, Balamkulam, and Nellikuthu) it was not continuous and did not cover the entire forest boundary abutting the village. Solar fencing and elephant proof trench were found in working condition along the entire boundaries of two villages (Paalad and Randampadam).

Raiding seasons and crop preferences

Though crop raiding instances were reported throughout the year, they were significantly higher during post monsoon period (30±7.07) and low during pre-monsoon (21.7±14.9) and monsoon (17.5±6.5) periods (χ^2=14; df=2; p=0.00) (Fig. 1). Crop damage varied considerably according to growth stage in different crop species. The stage at which the plant with inflorescence was considered as reproductive stage and those prior to this stage was termed as vegetative stage. Arecanut and coconut were significantly damaged more at reproductive stage than at vegetative phase (Table 1). Though it was not statistically significant, banana was also damaged more at reproductive stage. Only rubber was damaged more at early stage of growth, however it is not a fodder plant and was found statistically insignificant. In cases of damage to teak plantations, the numbers of damaged plants observed in the study villages (n=18) were too low to calculate the difference in damage between vegetative and reproductive stages.

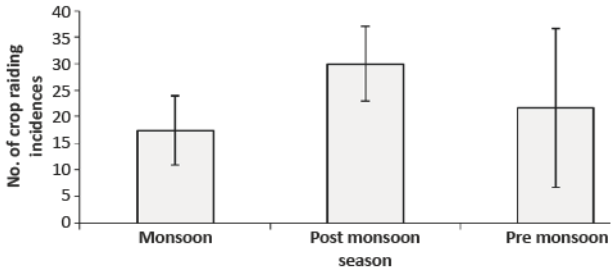

Figure 1. Seasonal variation in the mean elephant crop raiding incidences (n=290) (χ^2=14; df=2; p=0.00)

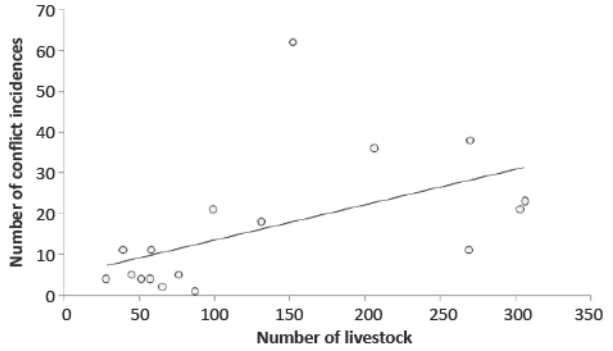

Figure 2. Relation between the number of livestock and number of conflict incidences

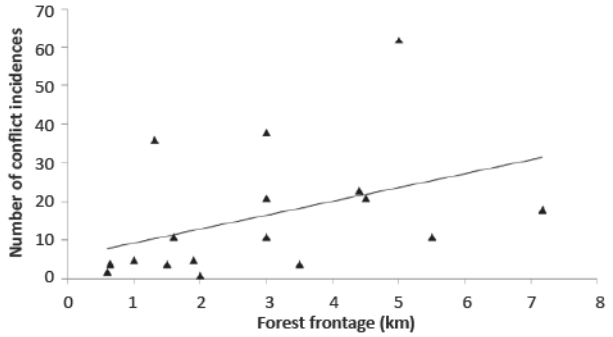

Figure 3. Relation between forest frontage (village boundary bordered with forest area) and the number of conflict incidences

The majority of conflict incidents (70%) were caused by solitary elephants, whereas herds were responsible for 30% of conflict incidents.

Correlates of conflict

In order to predict conflict incidences, the variables such as number of houses, number of livestock, forest frontage, area of village, number of conflict incidents, and presence or absence of water source in boundary were loaded in multiple regression. Among these, variables such as number of livestock and forest frontage significantly predicted conflict incidences (F=9.06; df=16; p<0.05; Table 2). The model was significant and explained 56% of overall conflict incidence. From the standardized partial regression co-efficient it was inferred that the number of livestock (Fig. 2) has a primary influence on conflict followed by forest frontage (Fig. 3) (Table 2).

Table 1. Variation in crop damage by elephants with respect to different growth stage of crops

Crop name	Growth Stage	Mean	SD	Z	P
Arecanut	Vegetative	14.90	14.16	-2.70	<0.05
	Reproductive	35.50	25.33		
Banana	Vegetative	14	16.07	-1.59	>0.05
	Reproductive	33.27	44.21		
Coconut	Vegetative	14	16.07	-2.49	<0.05
	Reproductive	33.27	44.21		
Rubber	Vegetative	46.2	106.53	-1.47	>0.05
	Reproductive	10.17	12.92		
Teak	Vegetative	4.5	4.95	Inadequate samples	
	Reproductive	1.8	1.30		

DISCUSSION AND CONCLUSION

During this study it was observed that crop raiding by solitary elephants was more frequent than raiding by elephant herds; this may signify the presence of habituated crop raiders in this area, as observed in other studies (Sukumar 1990; Easa & Sankar 2001; Das et al. 2012). It is not easy to drive away habitual crop raiders from agricultural fields by using traditional methods such as crackers, flashlights or by making loud noise, whereas elephant herds were mostly driven away by such methods (Nath et al. 2009).

In the study site it was observed that elephants raid mostly palatable crops such as coconut, arecanut, and banana. In mixed cropping areas, damage to rubber plants occurred by trampling while elephants move towards palatable crops. But in monoculture rubber plantations, apart from damage to the rubber trees by trampling, elephants scrape and remove the outer layer of the bark of rubber trees without uprooting them. An attempt by elephants to modify their feeding strategy can be expected with respect to the changing cultivation pattern. Jayson (1998) reported that elephants uprooting rubber plants and feeding on the basal portion in Peppara Wildlife Sanctuary, Kerala.

Studies illustrate that crop raiding is associated with

Table 2. Results of multiple regressions that explain the factors that influence conflict incidences around North and South Forest Divisions of Nilambur

Independent variable	Predictor	Unstandardized Coefficients		Standardized Coefficients	T	p	Model (r^2)	Model (p)
		β	SE	β				
Conflict	(Constant)	0.705	0.423		1.668	0.118	R^2=56% F=9.06; df=16	0.006
	Number of livestock	0.006	0.002	0.547	3.061	0.008		
	Forest frontage (km)	0.259	0.107	0.433	2.421	0.030		

palatability and presence of nutrients in the growth stage of cultivated crops (Sukumar 1990). The tendency to raid crops in the reproductive phase is generally higher when compared to the vegetative phase (Easa & Sankar 2001). Similar to this, it was observed that coconut, arecanut, and banana were damaged more in their reproductive stage in the study area. In the case of rubber plants, damage occurred more in vegetative stage rather than in reproductive stage. Though the reason is unknown, this may be due to the presence of less latex in the bark of rubber plants during early stages of growth. However, it has been observed that the presence of latex in plants belonging to Moraceae and Anacardiaceae does not prevent elephants from feeding on them (Olivier 1978; Sukumar 1990). In the case of banana plantation, crop damage occurs irrespective of its maturity, indicating a higher susceptibility for this crop to be raided by elephants. Hence it is risky for the farmers to sustain a cultivation of banana in forest fringes without proper mitigation methods.

The present results indicate that crop raiding by elephants occurs throughout the year in the study area, which is comparable to an observation (Mehta & Kulkarni 2013) in northwestern Maharashtra. This was due to the presence of plantation crops that are available year-round which made the conflict at high intensity throughout the year. During earlier periods, the large scale cultivation of paddy, tapioca, banana, coconut, and arecanut was practiced in the forest fringe areas of Nilambur. The repeated crop damage by elephants for years is one of the reasons that made many farmers for crop shift towards monoculture rubber plantations (personal discussion with agricultural officers and farmers) in the study area. The shift in cultivation was also due to the perception that the probability of elephant crop raiding would be less for rubber plants when compared to other crops, apart from the low maintenance with higher revenue (personal observation and discussion with agricultural officers). But, at present, considerable damage to rubber plantations occurs by trampling and destruction of the trees by peeling off the bark during the growing stages. The economic loss experienced by damage to cash crops were remarkably high compared to seasonal crops (Easa & Sankar 2001). It was observed in the present study area that frequent damage to these crops leads to negative approach from farmers towards elephants and also towards forest officials.

Previous studies (Hoare 1999; Sitati et al. 2005; Prasad et al. 2011; Webber et al. 2011; Gubbi 2012) indicate that ecological, spatial, and geographical factors influencing elephant conflict vary according to different habitat. For example, the influence of rainfall on the intensity of conflict was found to be positive, neutral, or negative depending on the area under study as observed in Cambodia, southern India and North Western Zimbabwe, respectively (Hoare 1999; Webber et al. 2011; Gubbi 2012). In the present study, although crop raiding occurs throughout the year, it was observed that significantly higher damage occurred during the post monsoon period, and the damage was low during pre-monsoon and monsoon periods. This result corresponds with the peak damage period mentioned in other studies in Asia by Sukumar (1989) and Campos-Arceiz et al. (2009).

Negative correlation was observed between conflict frequency and number of houses in the forest fringes in this study, i.e., lesser the number of houses in the fringes, higher will be the conflict, probably due to the tendency of elephants to avoid human dominated regions. However, Wilson et al. (2015) observed low human population density areas with lesser conflict in Assam. Factors such as human population density, livestock population and area of the village have shown non-linear correlation with frequency of elephant conflict around Nagarahole National Park, India (Gubbi 2012). Here it was observed that the cattle population in the forest fringe villages was one of the important predictors of higher conflict. Livestock populations degrade the vegetation around the villages due to continued grazing.

Thus poor availability of grass in the forest could have resulted in the higher conflict incidences around the villages with high livestock populations. Pressure from cattle grazing results in competition between cattle and wildlife for limited resources and deteriorates habitat quality; this will further add to the intensity of conflict (Madhusudan 2003).

The present study shows that forest frontage is a significant predictor of the occurrence of conflict, concordant with results observed in other studies (Sukumar 1990; Hoare 1999). As the length of the forest boundary abutting a village increases, the probability of conflict also increases. This signifies the need for efficient maintenance of physical barriers to reduce crop raiding by elephants.

There may be several other factors which influence conflict including type of mitigation methods adopted, type of vegetation adjacent to the village, encroachment and habitat fragmentation. Further studies are needed to understand the influence of other factors on the occurrence of conflict.

The only available corridor between Nilambur North and South Forest Division is through Gudallur-Nilambur Ghat road (Sukumar & Easa 2006). In few other areas of Nilambur North Division, the elephant route was blocked by rubber plantations of Plantation Corporation of Kerala together with seed farms owned by the Agriculture Department of Kerala. Here power fences were preventing animal movement through their original routes (Joju 2015). By considering all these factors related to habitat fragmentation and movement pattern of elephants, a broader understanding for the management of elephant conflict in the study area can be achieved through further research.

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