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Human-Elephant Interaction in Villages Around Manas National Park, Assam, India

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Introduction

As the human population encroaches upon natural habitat, animals find themselves increasingly in competition with people for space and resources (Pimm *et al*. 1995; Balmford *et al*. 2001). Large herbivores and carnivores are particularly affected by this conflict and are either critically endangered or rapidly declining as a result of it (Woodroffe & Ginsberg 1998). Human-elephant conflict (HEC) is a key example of such an interaction. It describes occurrences of elephant crop raiding, infrastructural damage and disturbance of daily activities, which can result in injury or death of people and elephants alike (Hoare 2000). HEC arises in rural areas of both Africa and Asia, posing equally significant problems to local communities, elephants and wildlife managers (Sitati *et al*. 2003).

Assam, which has an Asian elephant (*Elephas maximus*) population of about 5281, as assessed in the year 2008 (source: Assam Forest Department), is a key conservation region of Asian elephants in India (Lahiri-Choudhury 1980). Large herds of wild elephants roamed the forests of the region till the middle of the last century. Clearing large tracts of elephant habitat for tea estates, resettlement of farmers displaced by floods and erosion of the Brahmaputra, and land conversion by politically motivated transmigration of farmers from within and outside the state as well as neighbouring countries, have rapidly dwindled the forests, and wild elephant herds are becoming homeless in their own abode (Sarma 2007). Continuing deforestation and the spread of roads, farms and towns into the former habitats of elephants has threatened the species by restricting their range, cutting off seasonal migration routes and bringing the animal into more frequent conflict with humans (Kirtland *et al*. 2003).

Manas National Park (MNP) is a key elephant habitat and the surrounding area is an important HEC site. No detailed surveys to assess the status of HEC in this area have been carried out previously, due to the decade long socio-political crisis led by the Bodo agitation from the late 80's till the late 90s. The present study was carried out from 2007-2009 to assess the status and patterns of HEC around MNP.

Materials and methods

Study area

MNP (26°35′-26°50′ N and 90°45′-91°15′ E) is located within the Chirang Ripu Elephant Reserve at the foothills of the Bhutan Himalayas in the Baksa and Chirang districts of the Bodoland Territorial Areas District (BTAD), in Assam (Fig. 1). It was declared a National Park in 1990 with an area of 519 km^2. The Park also forms the core area of the Manas Tiger Reserve, which has an area of 2837 km^2. Altitude within the Park ranges from 50 to 200 m above MSL. MNP is one of the prime habitats of Asian elephants within the Bhutan Biological Conservation Complex in the Eastern Himalaya Biodiversity Hotspot (CEPF 2005) and facilitates trans-boundary movement of elephants and other wildlife species. MNP enjoys a tropical climate with rainfall between 3000 and 4000 mm annually.

MNP spans both sides of the Manas River and is bordered in the east and west by Reserve Forests, to the north by Bhutan and to the south by contiguous human settlements. The population in these settlements is dominated by the Bodo tribal community. Due to their traditions and ethno-specific practices they are heavily dependent on forest produce and use which include cattle grazing, timber, firewood, thatch, wild vegetables and fruits, fish and occasionally wild meat.

Sixty one villages bordering the southern park boundary were visited monthly to collect information on elephant depredation. Other villages located further south were also visited whenever any conflict incident was reported. Information was collected through interviews with local people (victims, witnesses and village secretaries, presidents and heads). To verify the authenticity of information and avoid possible exaggeration interviews were conducted separately with a minimum of three different persons.

A conflict event was defined as the raiding of crops or causing house or property damage at a location in a single night. Conflict incidents were defined as individual instances of crop loss, house or property damage and death or injury of humans that took place within a particular conflict event.

Assessment of the extent of HEC

The total number of crop depredation cases, human deaths/injuries, household/structural property damage and elephant deaths/injuries were collected following Varma (2006).

For instances of crop raiding, the following information was collected: name of the village, name of the affected person, GPS location, date and time of raiding, animals responsible (herd/single, tusk-less/tusker), crop type, frequency of raiding a particular crop, crop phenology (pre-reproductive - vegetative stage, reproductive - flowering stage and post-reproductive - yield stage), compensation claimed/not claimed, received/not received.

For cases of house and property damage the following information was collected: type

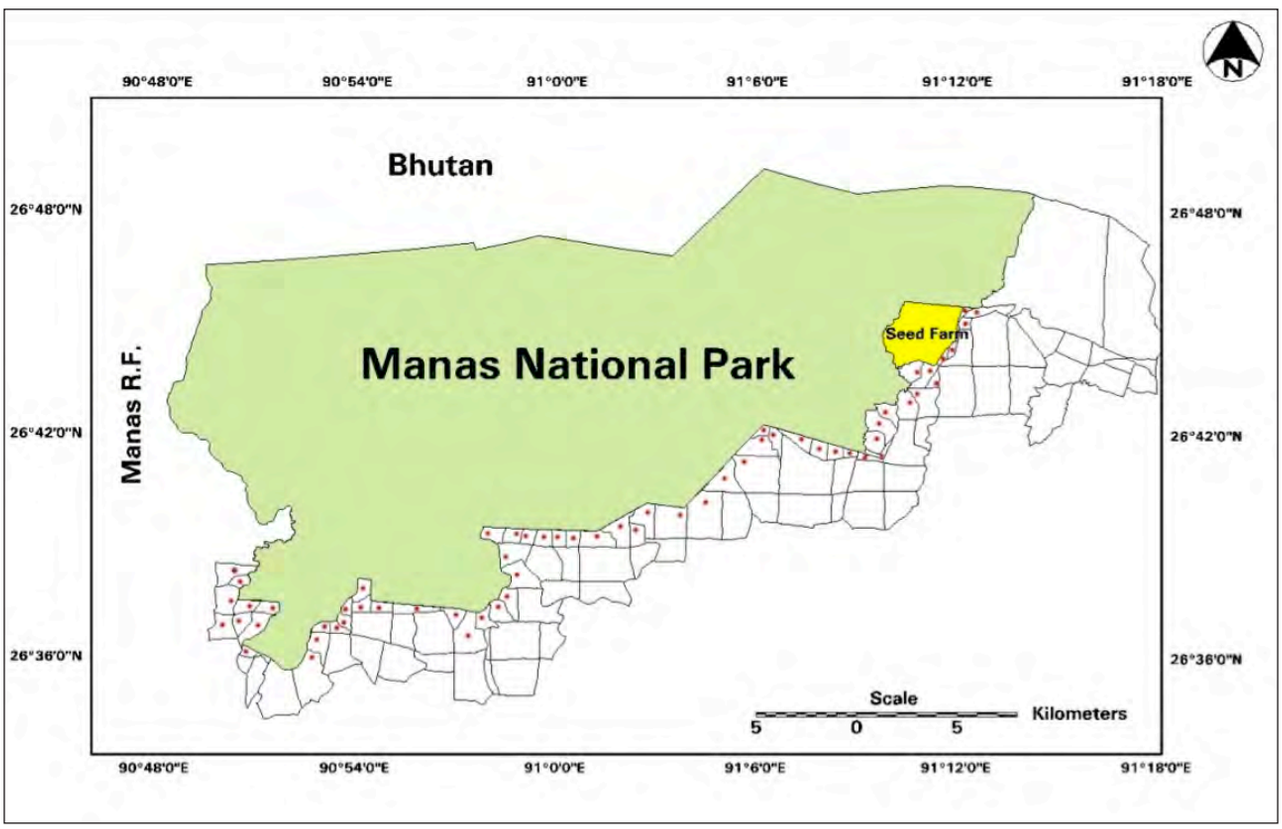

Figure 1. Map of the study area. Red dots indicate monitored villages.

of structure (residential/abandoned house/ temporary shed/granary/pet house/watchtower); building material (concrete/bamboo/wood/ combination of wood and bamboo); nature of damage (complete: totally destroyed/partial: partly destroyed and the structure still standing); cause of damage; date, time and place of damage; owner of the structure; GPS location of the damaged site; compensation claimed/ not claimed, received/not received; animal responsible (herd/single: tusk-less/tusker).

For cases of human death and injury, the following information was collected: name, age, sex and address of the victim; date and time of incident; injury/death (if injured, type of injury: major/minor); GPS location where the incident took place; possible cause of incident; animal responsible (herd/single: tusk-less/tusker); compensation claimed/not claimed, received/not received.

For cases of elephant death and injury, the following information was collected: date and place of the incident; number dead or injured; age and sex of the individual(s); cause of death or injury; method of killing or injury; persons responsible.

Results and discussion

During the study period a total of 1226 conflict events occurred in 93 villages around MNP which included 6331 crop raiding incidents, 136 house and property damage incidents and 19 incidents of human death and injury (Table 1).

Patterns of crop raiding

There was no significant difference in the mean frequency of crop raiding in the affected villages between the years 2007-08 and 2008-09, therefore we clumped both year's data (z-test, n=93). Crop raiding incidents were mostly concentrated along the park boundary and significantly higher depredation occurred in the villages that were adjacent to the park (χ^2_9=13259.35, P<0.001) (Fig. 2). Sukumar (1990) observed a similar pattern and remarked that raiding of agricultural fields by elephants occurs due to proximate

Table 1. HEC events and incidents.

Year	2007-08	2008-09	Total
Conflict events	632	594	1226
Crop raiding	3250	3081	6331
Household & property damage	62	74	136
Human death	3	3	6
Human injury	4	6	10

factors such as contact with cultivation. In MNP, the crop fields are located very close to the forest, which probably resulted in high raiding. Studies conducted in Africa (Bell 1984; Barnes *et al*. 1995; Bhima 1998; Naughton-Treves 1998; O'Connell *et al*. 2000; Parker & Osborn 2001) also showed similar results.

Barengabari village incurred the highest number of crop raiding incidents (2.97%, n=188). The least affected village was Kahitama NC, which incurred only one crop raiding incident during the study period. Both these villages were located at the southern park boundary and Kahitama NC was the smallest among all the fringe villages in terms of both area and population.

Crop raiding in the fringe areas around MNP is mostly a seasonal phenomenon (Fig. 3). Paddy was raided (56.39%, n=3570) significantly more frequently than any other crop (χ^2_{19}=46,544.16, P<0.001). Paddy was found to have the highest damage in Seijosa, Arunachal Pradesh Varma *et al*. (2008) and in most of the study zones of Nath and Sukumar (1998). In comparison to winter paddy, summer paddy was cultivated significantly less in the study area. Farmers used to cultivate summer and winter paddy almost in

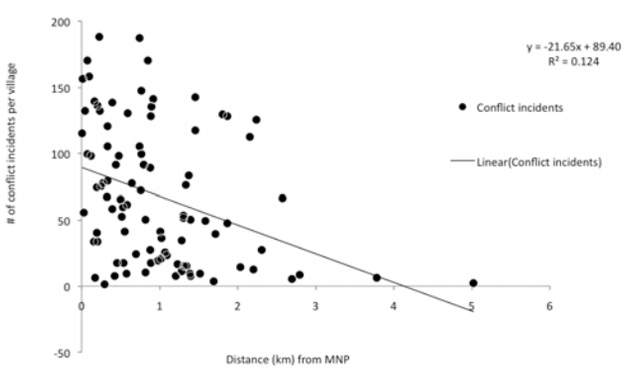

Figure 2. Regression analysis of the number of incidents per village and the distance from MNP.

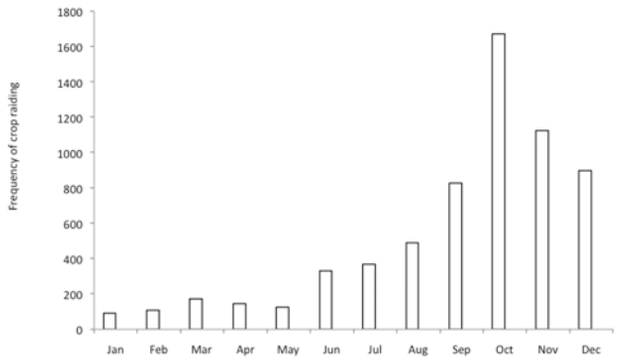

Figure 3. Monthly frequency of crop raiding by elephants in MNP.

equal proportion earlier, but now majority of them do not cultivate summer paddy. This is because summer paddy gets ready for harvest during the peak monsoon months (July-August) when crop guarding is difficult due to bad weather and as a result incurs more damage.

Depredation of paddy occurred in all stages of growth and increased with increasing crop maturity (Fig. 4). Crop maturity and frequency of raiding were positively correlated both for winter paddy (r_s=0.809, n=8, P<0.05) as well as summer paddy (r_s=0.750, n=7, P<0.05) as the crops are most palatable during their mature phase. Studies from Africa showed similar results (Bell 1984; Kangwana 1995; Tchamba 1995; Parker *et al*. 2007). Frequency of raiding of both winter paddy (χ^2_2=616.1, P<0.001) and summer paddy (χ^2_2=2772.38, P<0.001) was significantly more during the post reproductive phase when crops were ready for harvest.

Other economically important crops damaged included 26 different species of plants. Banana was the worst (31.13%, n=1971) affected. Banana is considered a plant with religious importance and its use is widespread in religious ceremonies. Every household in the locality possesses banana trees.

The average group size of elephants in the study area was 7.2 (range 2 to 12). Single bull elephants were involved in crop raiding incidents significantly more frequently (78.72%, n=4984) than female herds (21.28%, n=1347) (χ^2_1= 2088.79, P<0.001; Yates' correction). The higher propensity of adult males to raid crops may be due to the higher variance in male reproductive success in this polygynous mammal, leading to selection favouring a risky strategy by males to obtain better nutrition for enhancing reproductive success (Sukumar & Gadgil 1988). Apart from the single adult males, groups of 2, 3 and 4 adult bull elephants were observed to cause considerable raiding (Fig. 5). Although predominantly solitary while foraging in the forest during day the tendency of male elephants to form groups before raiding crop fields at night was noted by Sukumar (1985).

During the study period, no farmers claimed compensation for their crop losses. When asked about why they did not claim compensation, the farmers said that they do not get any response from the concerned authorities even after repeated follow-ups.

Patterns of property damage

There was no significant difference in median frequency of house damage in different months between the years (Wilcoxon's test for matched pairs), therefore, we clumped the two year's data.

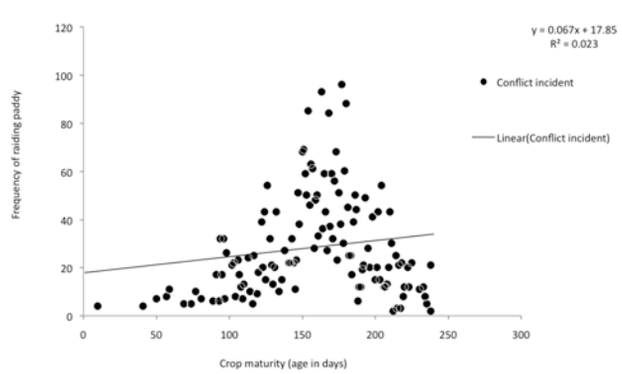

Figure 4. Regression analysis of frequency of raiding and maturity of paddy.

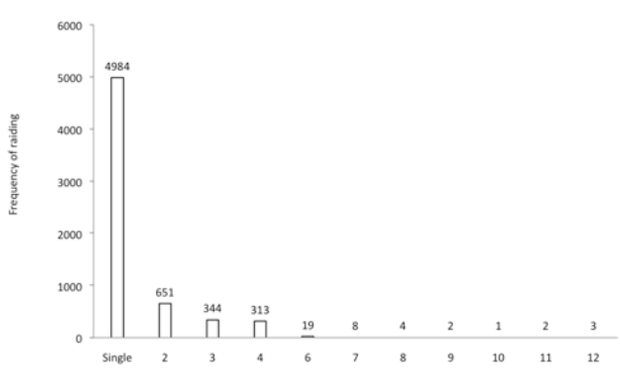

Figure 5. Different herd sizes of elephants and their frequency of crop raiding.

House and property damage incidents occurred in 38 villages. Frequency of damage was highest in Dailong-1 (8.82%, n=12) followed by Lakhijhora (8.09%, n=11) and Barengabai (8.09%, n=11) (χ^2_{37} =94.77, P<0.01).

Damage to kitchens unconnected with living houses was highest (36.03%, n=49), followed by living houses with attached kitchen (23.53%, n=32) and living houses with attached granary store (21.32%, n=29) (χ^2_7=192.35, P<0.01). Other structures damaged included abandoned houses (n=2), cowsheds (n=3), living houses (n=8), grocery shops (n=10), and living houses with both attached kitchen & granary store (n=3). Kitchens generally contain a variety of foodstuff attractive to elephants like stored paddy and other grains, salt, sugar, vegetables such as pumpkin and summer squash, and sometimes rice beer. The greater damage to kitchens was perhaps due to the presence of such foodstuff.

The majority of damages were due to elephants going after stored grain (63.97%, n=87). Other causes were salt (9.56%, n=13), country liquor (6.62%, n=9), vegetables (2.2%, n=3) and provocation by dogs (1.47%, n=2) (χ^2_6=365.18, P<0.01). Around 7.35% (n=10) of the house and property damage incidents were accidental, occurring when elephants tried to go across the structures and in 8.09% (n=11) of incidents the reason was unknown as there was no evidence of raiding.

In 38.24% (n=52) of cases of house and property damage, the structures were completely damaged and in 61.76% (n=84) partially damaged (χ^2_1=7.54, P<0.01; Yates' correction).

Frequency of house and property damage was highest during the non-cropping season, in February and August (14.71%, n=20) and the least number of damages occurred in December (2.21%, n=3). Majority of the house and property damages took place between 00:00 and 03:00 hours (41.18%, n=56) (χ^2_3=39.82, P<0.001) perhaps because human activity in villages is absent and people are mostly asleep at this time.

All house and property damages were caused by single bull elephants. In MNP, tuskers are rare and majority of the bull elephants are tusk less. In 98.53% (n=134) of the house and property damage cases, tusk-less males were involved and tuskers were reported only in 1.47% (n=2) cases (χ^2_1=128.13, P< 0.001; Yates' correction).

Table 2. Human deaths and injuries.

Year	No.	Village	Name of the victim	Age	Death/Injury
2007-08	1	Barengabari	Philip Basumatary	23	Death
	2	Ujan Bahbari	Ranjit Das	40	Minor injury
	3	Milanpara	Gena Boro	33	Major injury
	4	Bishnupur	Putulibala Biswas	15	Death
	5	Bishnupur	Prafulla Mandal	44	Minor injury
	6	Khutipara	Niseswar Das	35	Minor injury
	7	Chourang 1	Nilabhakat Ray	35	Death
2008-09	8	Bamunkhal	Baneswar Basumatary	28	Minor injury
	9	Bamunkhal	Rotiram Basumatary	36	Minor injury
	10	Bamunkhal	Jalgab Basumatary	29	Minor injury
	11	Bamunkhal	Shubhash Basumatary	37	Minor injury
	12	Bargaon	Bhupen Mochahary	55	Minor injury
	13	Garumara	Dali Basumatary	70	Major injury
	14	Chourang 1	Ajay Daimary	12	Death
	15	Lakhijhora 1	Kamakhya Baroi	37	Death
	16	Chourang 1	Ajay Daimary	40	Death

Only 13.97% (n=19) of victims claimed compensation (χ^2_1=70.63, P<0.001; Yates' correction) and 26.31% (n=5) of those who claimed received compensation in the form of in-kind support to reconstruct broken structures.

Human death and injury

There were a total 16 human death and injury cases reported in ten villages out of which six were deaths, eight minor injuries (scratches, sprained leg, back and hand) and two major injuries (injury to head and fracture of limb). Age of the victims ranged from 12–70 years old (Table 2). Among the victims significantly more were males (14 males and 2 females) (χ^2_1=8.13, P<0.01; Yates' correction) and majority of the incidents (n=12) took place during 18:00-21:00 hrs. The local people in this region habitually drink alcohol. The men go to the local market every afternoon and return home drunk in the evening which was a factor in most of the death and injury incidents.

Highest human deaths and injuries occurred in October (43.75%, n=7) and the lowest in February and March (6.25%, n=1). Two major festivals, Durga Puja and Lakshmi Puja are held in October. The movement of local people after dusk increases during this time and the festive atmosphere makes people more negligent, which may have resulted in the increase of death and injury incidents. The animals responsible in all the 16 human death and injury cases were single, tusk-less bull elephants.

Elephant death and injury

According to the Forest Department records there were no elephant deaths due to conflict in the area during the study period. However, we came to know about the death of four bull elephants in MNP. The cause of death was conflict and the elephants were shot dead as retaliation. We tried to gather more information on these death incidents but, unfortunately could not trace any details as the local people were reluctant to give information due to personal safety reasons. We communicated with the Forest Range Officers also, but they denied occurrence of such incidents. This kind of inscrutable deaths of elephants is a bad sign for the future of Asian elephants in the Manas landscape.

Conflict mitigation

Mitigation measures being used in the study area were short term, age old, traditional and improvised, mostly consisting of scaring methods. To address human elephant conflict three long term programs have been initiated during the study period by Aaranyak in collaboration with Awely a French organization, through strengthening traditional crop-guarding systems, experimentation and promotion of alternative cash crops detested by elephants as bio-fences and development and implementation of an effective community education program.

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