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## COMMUNICATION

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## Negative human-wildlife interactions in traditional agroforestry systems in Assam, India

Yashmita-Ulman<sup>1</sup> , Manoj Singh<sup>2</sup> , Awadhesh Kumar<sup>3</sup> & Madhubala Sharma<sup>4</sup>

<sup>1</sup> Department of Silviculture and Agroforestry, College of Horticulture & Forestry, Acharya Narendra Deva University of Agriculture and Technology, Ayodhya, Uttar Pradesh 224229, India.

<sup>2</sup> Department of Zoology, Kalinga University, Near Mantralaya, Naya Raipur, Chhattisgarh 492101, India.

<sup>3,4</sup> Department of Forestry, North Eastern Regional Institute of Science and Technology, Nirjuli, Arunachal Pradesh 790109, India.

<sup>1</sup> yashmita2018@gmail.com (corresponding author), <sup>2</sup> msingh.zooku@gmail.com,

<sup>3</sup> tpileatus@gmail.com, <sup>4</sup> mbs\_madhu@yahoo.co.in

**Abstract:** Traditional agroforestry systems are designed to provide maximum and diverse yield (ranging from agricultural crops, forest trees, livestock and fish) to people. They also act as sources of food and shelter to wild animals leading to crop destruction, livestock depredation and injuries to people giving rise to negative human-wildlife interactions. The present study was carried out in three different agroforestry systems namely tea gardens, homegardens, and agrisilvicultural systems in Assam to document the attitude of people towards wild animals which damage the crops and livestock, through questionnaire surveys. In agroforestry systems, 13 animals were reported as destructive; rodents at 13% followed by Indian Hare at 12%. The least destructive were birds and bats with 4% each. In tea gardens majority of the people killed animals for meat (95%) and the most common method for killing was the use of catapults (77%). In homegardens and agrisilvicultural systems, owners chased the animals away (82%) by using catapults (68%). Hunting of animals and intolerance of people towards crop destruction and livestock depredation done by wild animals were the two main reasons causing negative human-wildlife interactions in agroforestry systems. The present study concludes that wildlife species found in the agroforestry system in Assam were threatened by local inhabitants and thus, a suitable conservation awareness and policy action plan should be developed in consultation with the owners of agroforestry systems by considering the ecological significance of the wildlife species found therein.

**Keywords:** Agrisilvicultural systems, agroforestry systems, crop destruction, destructive wildlife species, homegardens, tea gardens.

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**Author details:** DR. YASHMITA-ULMAN, works as Assistant Professor in Department of Silviculture & Agroforestry, ANDUAT, Ayodhya, on agroforestry systems. Her research interests include plant-animal interactions, forest ecology and wildlife conservation. DR. MANOJ SINGH works as Assistant Professor in Department of Zoology, Kalinga University, Chhattisgarh. He is working on bird acoustics and wildlife conservation using GIS. DR. AWADHESH KUMAR works as an Associate Professor in Department of Forestry, NERIST (Deemed-to-be-University), Nirjuli, Itanagar, Arunachal Pradesh. He works on population and behavioural ecology of threatened mammalian species and other wildlife of northeast India. His interest lies in ecological process related to wildlife conservation and forest management under the umbrella of forestry research. PROFESSOR (MRS.) MADHUBALA SHARMA also works in the Department of Forestry, NERIST (Deemed-to-be-University), Arunachal Pradesh. She is specialized in the field of wood science & technology and non-timber forest products.

**Author contribution:** Y-U did the fieldwork and wrote the article. MS helped with the data compilation and analysis. AK and MS edited and finalized the manuscript.

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## INTRODUCTION

Agroforestry system is a traditional cultivation practice carried out in Assam, a northeastern state of India (Yashmita-Ulman et al. 2018). This system includes growing of agricultural crops along with trees. Agroforestry systems are also frequently used by wild animals either as food resources (Lees & Peres 2008; Lenz et al. 2011; Mueller et al. 2014) or for shelter or as a corridor (Kumar et al. 2004; Yashmita-Ulman et al. 2020). As these systems are close to human habitations and mainly human-centric as a product of centuries, decades or years of destruction of natural forests or wilderness areas, they are prone to negative human-wildlife interactions, usually inappropriately called 'conflicts'. The two main threats to wildlife in agroforestry systems are: (i) killing of animals as revenge for crop damage or livestock depredation and (ii) hunting for subsistence or as a part of culture and tradition or for trade. Conover & Chasko (1985) found that 89% of farmers in Kansas, USA, were of an opinion that wildlife caused damage in the farms. There are many such reports on crop predation. Elephants are known to be the most destructive wild animals (Shrivastava 2002). They feed on ripened paddy, banana, coconut, corn (Nyhus et al. 2000; Bandara & Tisdell 2002; Santiapillai et al. 2010; Bal et al. 2011; Chartier et al. 2011), maize, millet, sorghum, green gram, soyabean, cowpeas, mustard, beans, green chillies (Bandara & Tisdell 2002), vegetables (Kumar et al. 2004), and cashew nut (Varma et al. 2008). The macaques feed on maize and wheat (Wang et al. 2006). In cacao plantations of Cameroon, squirrels, primates (Chimpanzee, Agile Mangabey, Moustached Guenon) and Sitatunga Antelopes destroy ripen pods of cacao causing very serious damage (Arlet & Molleman 2010). They also reported that the cacao growers either hunted or used passive methods like making noise, guarding, and using scarecrows to drive away these animals and thus prevent or reduce the damage caused. So, in most cases, the wild animals like elephants (Nyhus et al. 2000; Kushwaha & Hazarika 2004; Santiapillai et al. 2010) and primates (Wadley et al. 1997; Hill 1997) are killed by people in revenge for crop destruction.

Hunting in northeastern India has both economic and cultural importance (Aiyadurai 2007; Velho & Laurance 2013). There are many studies in northeastern India which suggest that hunting is a serious threat to many wild species (Pawar & Birand 2001; Datta 2002; Mishra et al. 2006). Hunting has a more negative effect on the abundance and diversity of mammals than the vegetation disturbance (Naughton-Treves et al. 2003; Datta et al. 2008). Naughton-Treves et al. (2003) in Tambopata, Peru

observed that the farmers living near forests experienced crop raiding and livestock losses and to offset these losses, they resorted to hunting. So, all these are some of the threats that wild animals face in most agroforestry systems which might otherwise act as a second home or refuge for wild animals. This study is designed to identify the reasons for negative human-animal interactions in agroforestry systems and the methods used for killing these wild animals. Questionnaire surveys were conducted to 1) document the factors responsible for such human-wildlife interactions (types of crops destroyed or livestock killed, attitudes of people and their response in form of tolerance or retaliation by killing), 2) identify the most destructive wild animal in different agroforestry systems, and 3) document the methods used to kill, chase or avoid wild animals in different agroforestry systems.

## STUDY AREA

Two districts of Lakhimpur and Sonitpur (undivided) located on the north bank landscape of Brahmaputra River were selected for the documentation of human-wildlife interactions in agroforestry systems in Assam (Fig. 1). Homegardens and agrisilvicultural systems were chosen from both the districts while the tea gardens were chosen only from Sonitpur District. Lakhimpur district is situated approximately between 26.800–27.883 °N & 93.700–94.333 °E. Sonitpur lies between 26.500–27.167 °N & 92.267–93.717 °E covering an area of around 5,324 km<sup>2</sup>. Tea garden tribes, Mishing, Bodos, Assamese, Nepalis, and Bengalis are some of the predominant ethnic groups living in the study area (Namsa et al. 2011).

## METHOD

A questionnaire survey was conducted from September 2016 to February 2017 in the selected study areas. A total of 148 respondents, which included 54 agrisilvicultural system owners, 54 homegarden owners and 40 tea gardens labourers were interviewed. All these 148 respondents interviewed were the ones who worked in these agroforestry fields (homegarden and agrisilvicultural system owners themselves worked in their respective lands but in tea gardens, labourers were employed and therefore, tea garden labourers were interviewed and not the tea garden owners). All the respondents were well aware of the wild animals causing destruction and the type of destruction caused. Information was collected on the wildlife species sighted, crops destroyed by wildlife species

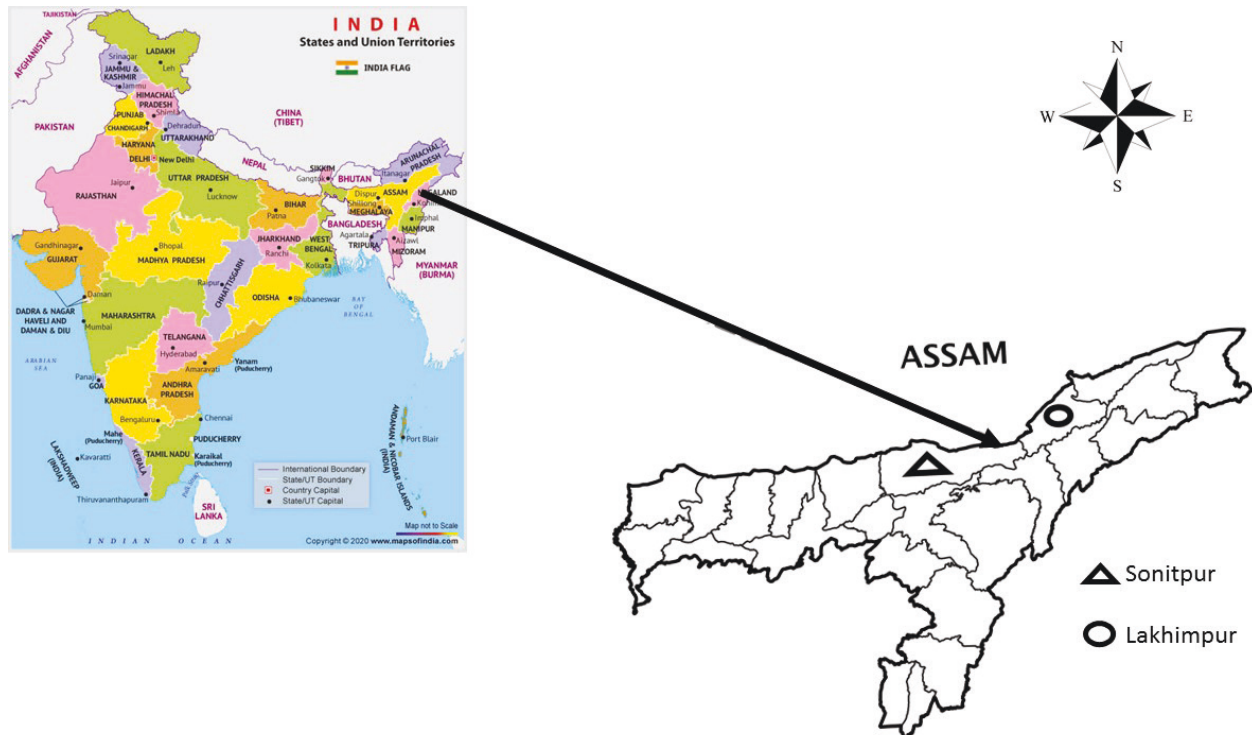


Figure 1 . Districts surveyed for understanding negative human-wildlife interaction in agroforestry systems practiced in Assam.

in the agroforestry system and the preventive measures adopted to control the loss. They were questioned over the prevalent techniques used for hunting and killing of wild animals (Mishra et al. 2006). Any wild animal product like skin, bone, trophy, and hunting tools kept in their houses were photographed for identification and confirmation of threat. To find out the most destructive animal for the crops and livestock in agroforestry systems as per owners'/labourers' opinion, the method used by Ahire & Kumar (2006) was followed. In this method, the owners were asked to give a score (1–13) to each animal they viewed as destructive for their crops and livestock in their agroforestry system. The most destructive animal had the highest score and the rest of the animals got the score in descending order.

## RESULTS

The major destruction done by wild animals inhabiting the agroforestry systems was crop damage. The details of the crops destroyed by the various wildlife species in the different agroforestry systems are presented in Table 1. In all the three agroforestry systems combined, 13 animals were reported as destructive for the crops and livestock present in the agroforestry systems (Fig. 2). The most destructive wildlife species were rodents (13%) followed

by Indian Hare *Lepus nigricollis* (12%) (Fig. 2). The least destructive were birds and bats (4% each) (Fig. 2).

Homegardens recorded the highest number of destructive animals (13) (Fig. 3), followed by agrisilvicultural systems (8) (Fig. 4) and the lowest was found in tea gardens (7) (Fig. 5). Out of the 13 animals viewed as destructive in homegardens, Hoary-bellied Himalayan Squirrel *Callosciurus pygerythrus* (15%) was reported to be the most destructive followed by Indian Grey Mongoose *Herpestes edwardsii* (13%) (Fig. 3). The least destructive was Indian porcupine *Hystrix indica* (2%) (Fig. 3). Among the eight wildlife species recorded as destructive in agrisilvicultural systems, the most destructive animal was rodent (29%) followed by birds (23%) and the least destructive was Indian Porcupine (6%) (Fig. 4). Out of the seven destructive wildlife species reported in tea gardens, Asian Elephant *Elephas maximus* (24%) followed by Wild Boar *Sus scrofa* (19%) were the most destructive animals in tea gardens (Fig. 5). The least destructive was the Rhesus Macaque *Macaca mulatta* (5%) (Fig. 5).

In all the three agroforestry systems as a whole, majority (59%) chased the wild animals away followed by killing of the animals (37%) and the least tolerated the presence of wildlife in their agroforestry systems (4%) (Fig. 6). Among the chasing techniques, the most common was use of catapults (49%) followed by use of scarecrow (7%)



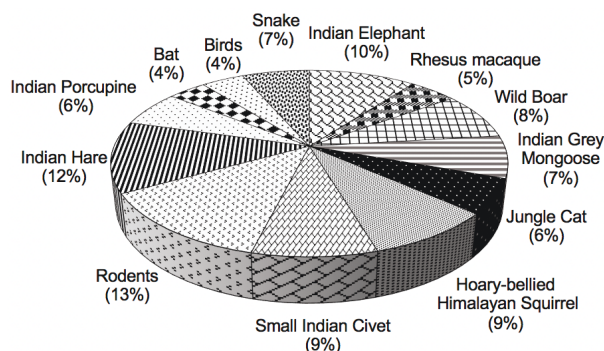


Figure 2. Destructive wildlife species as ranked by the respondents of agroforestry systems.

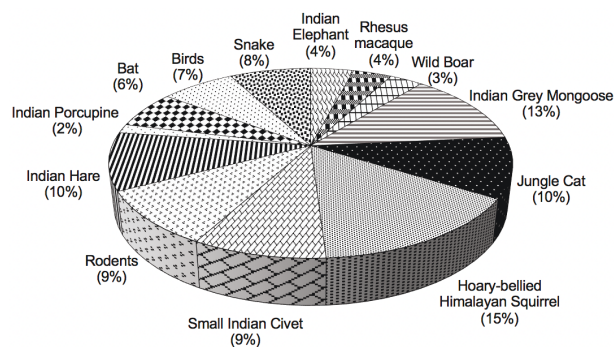


Figure 3. Destructive wildlife species as ranked by the respondents of homegarden.

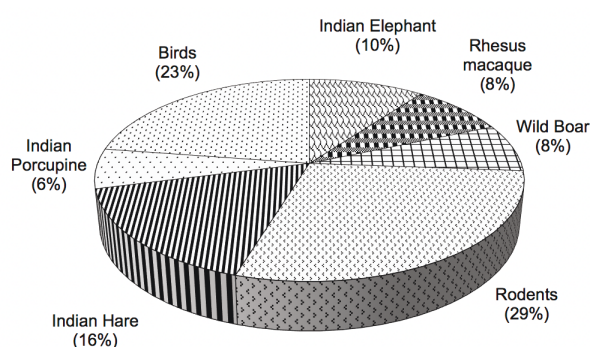


Figure 4. Destructive wildlife species as ranked by the respondents of agrisilvicultural system.

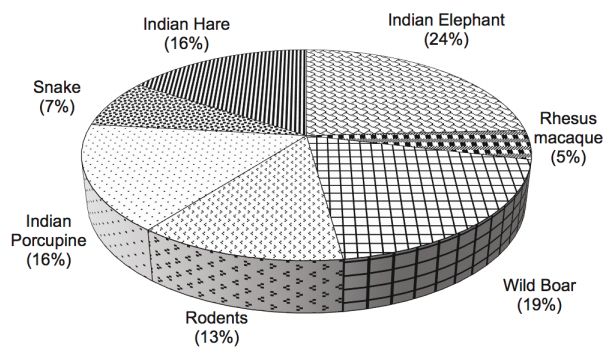


Figure 5. Destructive wildlife species as ranked by the respondents of tea garden.

and the least common was the use of drums and noise to chase the animals away (3%) (Fig. 7). The most frequently used killing methods was the use of catapults (28%) followed by leg traps, bows and arrows (3% each) and the least used methods were sticks, air rifles and poison (1% each) (Fig. 7). About 4% respondents chose to ignore the presence of wildlife in their agroforestry systems (Fig. 7). It was observed that 82% of the respondents in both homegardens and agrisilvicultural systems chased the animals away, 13% killed the animals for meat as well as a kind of retaliation for livestock depredation and the remaining 5% ignored the menace caused by wildlife (Fig. 6). The highest number of respondents (68%) used catapults to chase the animals, 10% made use of scare crows, 8% killed the animals with catapult, 5% ignored the presence of animals, 4% used drums or other forms of noise to scare away the animals, 3% used leg traps, and 2% used poison to kill the animals (Fig. 7). The trend was different in tea gardens. It was observed that in the tea gardens, majority of the respondents (95%) killed the animals for meat, 3% chased the animal away and 2% chose to ignore the presence of the animal (Fig. 6). Among the various methods used to kill the animals the most common was the use of catapults (77%) followed

by use of bows and arrow (9%) and leg traps (5%) (Fig. 7). The least used method was use of stick and air rifles (2%) each (Fig. 7). The pictographic representation of the animals killed by the agroforestry system owners and the methods used by them are shown in Plate 1 & 2.

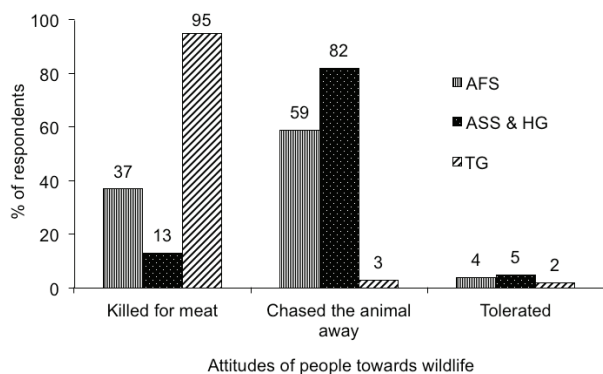
## DISCUSSION

In the current study, animals like elephants, wild pigs, porcupine, hare, rodents, rhesus macaque, jungle cats, birds and bats were reported as destructive animals in agroforestry systems. Squirrel was recorded as top most destructive animal in homegardens and rodents in agrisilvicultural systems. The squirrels were notorious for damaging the cash crop yields of Areca nut *Areca catechu*, Coconut *Cocos nucifera*, Pepper vines *Piper* spp., etc. The rodents and birds were known to destroy paddy crops, bamboo seeds, etc. and the bats were observed feeding on the fruits of Lychee *Litchi chinensis*, Wax Jambu *Syzygium samarangense*. Yashmita-Ulman et al. (2017) observed flocks of Baya Weaver *Ploceus philippinus* feeding on mature paddy grains in agroforestry systems. Similar observations of crop depredation by rabbits (Conover

Table 1. Record of wildlife species for crop destruction in selected agroforestry systems.

	Name of animal	Crops destroyed/other problems		
		ASS	HG	TG
1.	<i>Elephas maximus</i> (Asian Elephant)	<i>Oryza sativa</i> (Rice), <i>Zea mays</i> (Maize), <i>Bambusa</i> spp. (Bamboo)	<i>Musa</i> spp. (Banana), <i>Bambusa</i> spp. (Bamboo), <i>Areca catechu</i> (Areca nut), <i>Cucurbita moschata</i> (Squash), <i>Cocos nucifera</i> (Coconut)	Uprooted shade trees and <i>Camellia sinensis</i> (Tea) plants
2.	<i>Macaca mulatta</i> (Rhesus Macaque)	<i>Oryza sativa</i> (Rice), <i>Mangifera indica</i> (Mango), <i>Artocarpus heterophyllus</i> (Jackfruit)	<i>Oryza sativa</i> (Rice), <i>Vigna unguiculata</i> (Cowpea), <i>Vigna mungo</i> (Black gram), <i>Moringa oleifera</i> (Drumstick), <i>Areca catechu</i> (Areca nut), <i>Mangifera indica</i> (Mango), <i>Artocarpus heterophyllus</i> (Jackfruit), <i>Carica papaya</i> (Papaya), <i>Citrus</i> spp., <i>Musa</i> spp. (Banana), <i>Psidium guajava</i> (Guava), <i>Piper</i> spp. (Pepper), <i>Luffa cylindrica</i> (Sponge gourd), <i>Luffa acutangula</i> (Ridge gourd), <i>Cucurbita moschata</i> (Squash), <i>Lagenaria siceraria</i> (Bottle gourd), <i>Abelmoschus esculentus</i> (Okra), <i>Daucus carota</i> (Carrot), <i>Allium cepa</i> (Onion), <i>Pisum sativum</i> (Peas), <i>Phaseolus lunatus</i> (Lima bean), <i>Saccharum officinarum</i> (Sugarcane), <i>Solanum tuberosum</i> (Potato), <i>Ananas comosus</i> (Pineapple)	
3.	<i>Sus scrofa</i> (Wild Boar)	<i>Oryza sativa</i> (Rice)	<i>Oryza sativa</i> (Rice), <i>Vigna unguiculata</i> (Cowpea), <i>Vigna mungo</i> (Black gram), <i>Solanum tuberosum</i> (Potato), <i>Manihot esculenta</i> (Cassava), <i>Daucus carota</i> (Carrot), <i>Allium cepa</i> (Onion), <i>Ananas comosus</i> (Pineapple)	Uprooted shade trees and <i>Camellia sinensis</i> (Tea) seedlings
4.	<i>Herpestes edwardsii</i> (Indian Grey Mongoose)		<i>Gallus gallus domesticus</i> (Chicken) eggs, <i>Anas</i> spp. (Duck), <i>Columba livia domestica</i> (Pigeon) and fish	
5.	<i>Felis chaus</i> (Jungle Cat)		<i>Gallus gallus domesticus</i> (Chicken) eggs, <i>Anas</i> spp. (Duck), <i>Columba livia domestica</i> (Pigeon) and fish	
6.	<i>Callosciurus pygerythrus</i> (Hoary-bellied Himalayan Squirrel)	<i>Oryza sativa</i> (Rice), <i>Mangifera indica</i> (Mango), <i>Artocarpus heterophyllus</i> (Jackfruit), <i>Syzygium cumini</i> (Jamun)	<i>Cocos nucifera</i> (Coconut), <i>Musa</i> spp. (Banana), <i>Citrus grandis</i> (Pomelo), <i>Carica papaya</i> (Papaya), <i>Citrus reticulata</i> (Madarin orange), <i>Pyrus communis</i> (Pear), <i>Syzygium cumini</i> (Jamun), <i>Terminalia chebula</i> (Myrobalan), <i>Elaeocarpus floribundus</i> (Indian olive), <i>Phaseolus lunatus</i> (Lima bean), <i>Luffa acutangula</i> (Ridge gourd), <i>Trichosanthes anguina</i> (Snake gourd), <i>Cucurbita moschata</i> (Squash), <i>Cucumis sativus</i> (Cucumber)	
7.	<i>Viverricula indica</i> (Small Indian Civet)		<i>Musa</i> spp. (Banana), <i>Gallus gallus domesticus</i> (Chicken) eggs, <i>Anas</i> spp. (Duck), <i>Columba livia domestica</i> (Pigeon)	
8.	<i>Vulpes bengalensis</i> (Indian Fox)		<i>Capra</i> spp. (Goat), <i>Gallus gallus domesticus</i> (Chicken) eggs, <i>Anas</i> spp. (Duck)	
9.	Rodents	<i>Oryza sativa</i> (Rice)	<i>Oryza sativa</i> (Rice), <i>Vigna unguiculata</i> (Cowpea), <i>Vigna mungo</i> (Black gram), <i>Solanum tuberosum</i> (Potato), <i>Manihot esculenta</i> (Cassava), <i>Daucus carota</i> (Carrot), <i>Allium cepa</i> (Onion), <i>Ananas comosus</i> (Pineapple), <i>Cucurbita moschata</i> (Squash), <i>Lagenaria siceraria</i> (Bottle gourd)	Cuts shade trees and <i>Camellia sinensis</i> (Tea) plants roots
10.	<i>Lepus nigricollis</i> (Indian Hare)	<i>Oryza sativa</i> (Rice)	<i>Musa</i> spp. (Banana), <i>Brassica juncea</i> (Mustard), <i>Brassica oleracea</i> (Cabbage), <i>Abelmoschus esculentus</i> (Okra), <i>Solanum tuberosum</i> (Potato), <i>Cucurbita moschata</i> (Squash), <i>Lagenaria siceraria</i> (Bottle gourd), <i>Pisum sativum</i> (Peas), <i>Raphanus sativus</i> (Raddish), <i>Spinacia oleracea</i> (Spinach), <i>Solanum lycopersicum</i> (Tomato), <i>Daucus carota</i> (Carrot)	Uprooted shade trees and <i>Camellia sinensis</i> (Tea) plants seedlings
11.	<i>Hystrix indica</i> (Indian Porcupine)	<i>Oryza sativa</i> (Rice)	<i>Solanum tuberosum</i> (Potato), <i>Alocasia</i> spp.	Uprooted shade trees and <i>Camellia sinensis</i> (Tea) plants seedlings
12.	Bat	<i>Syzygium samarangense</i> (Wax Jambu), <i>Mangifera indica</i> (Mango), <i>Artocarpus heterophyllus</i> (Jackfruit)	<i>Mangifera indica</i> (Mango), <i>Artocarpus heterophyllus</i> (Jackfruit), <i>Citrus</i> spp., <i>Musa</i> spp. (Banana), <i>Litchi chinensis</i> (Lychee), <i>Psidium guajava</i> (Guava), <i>Syzygium samarangense</i> (Wax Jambu)	
13.	<i>Varanus bengalensis</i> (Bengal Monitor)		<i>Gallus gallus domesticus</i> (Chicken) eggs, <i>Anas</i> spp.	
14.	Birds	<i>Oryza sativa</i> (Rice), <i>Terminalia chebula</i> (Myrobalan), <i>Syzygium samarangense</i> (Wax Jambu), <i>Mangifera indica</i> (Mango), <i>Artocarpus heterophyllus</i> (Jackfruit)	<i>Oryza sativa</i> (Rice), <i>Vigna unguiculata</i> (Cowpea), <i>Vigna mungo</i> (Black gram), <i>Terminalia chebula</i> (Myrobalan), <i>Musa</i> spp. (Banana), <i>Psidium guajava</i> (Guava), <i>Averrhoa carambola</i> (Star fruit), <i>Phaseolus lunatus</i> (Lima bean), <i>Capsicum</i> spp., Fish	
15.	Snakes		<i>Gallus gallus domesticus</i> (Chicken) eggs, fish	-

ASS=Agrisilvicultural system, HG=Homegarden, TG=Tea garden.



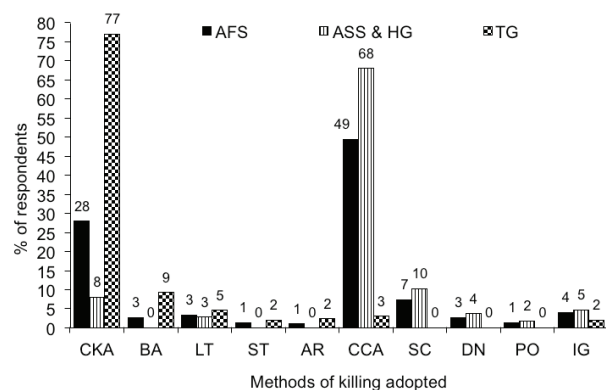
**Figure 6.** Attitudes of people towards wildlife present in selected agroforestry systems. AFS—agroforestry systems | ASS—agrisilvicultural systems | HG—homegarden | TG—tea garden

1994) and by birds (Gillingham & Lee 2003; Naughton-Treves & Treves 2005) have been reported. Some other small mammals like mongoose and Small Indian Civet were also reported to be destructive in the homegardens of the current study area. These were reported to depredate upon the livestock (hens, ducks, pigeons, and goats) reared by the homegarden owners. Similar results were obtained by Weladji & Tchamba (2003).

In the current study, animals like elephants, wild pigs, porcupine, rabbits, rodents and rhesus macaques were recorded to destroy the young tea seedlings and uproot the shade trees in tea gardens. Similarly, elephants are reported to damage the coffee bushes, fruit trees and associated pepper vines (Bal et al. 2011) and roots of shade tree Indian Coral Tree *Erythrina mysorensis* in coffee agroforests of southern India (Kumar et al. 2004). The Wild Boars and porcupines are reported to dig the root systems of tea plants causing damage to the tea gardens (Kumara et al. 2004) in the Western Ghats of India.

Conover & Chasko (1985) in Kansas, USA observed that 56% of the farmers reported that the losses incurred due to wildlife were higher than they were willing to tolerate. Similar results were found in the present study where it was observed that in the tea gardens, 95% of the respondents killed the animals for meat and 13% of the respondents in homegardens killed wildlife in retaliation and for meat. Only 2% respondents in tea gardens and 5% in homegardens choose to ignore or tolerate the presence of the wild animals. Killing small carnivores in retaliation for depredation of livestock is similar to other studies by Datta et al. (2008) and Lyngdoh et al. (2011). All these factors may explain such high rate of killing of wildlife in the current study area.

In the present study, methods like making sounds through clapper and drum, using catapults, scarecrows were usually employed by the local people to chase



**Figure 7.** Methods adopted for avoiding or killing of wildlife species in selected agroforestry systems. CKA—catapults to kill animals | BA—bows and arrows | LT—leg traps | ST—sticks | AR—air rifles | CCA—catapults to chase away animals | SC—scarecrow | DN—drums and noise | PO—poison | IG—ignore.

the wild animals away from their agroforestry systems. Similar methods were also used to control wildlife damage in Bhutan (Wang et al. 2006), Indonesia (Marchal & Hill 2009) and Rajasthan (Chhangani et al. 2010). The homegarden and agrisilvicultural system owners belong to the Kalita caste who usually neither indulge in hunting nor is it a part of their tradition. As a result, these people either tolerated the animals or tried to deter the wildlife species present in the agroforestry systems to protect their crops. Only very few killed the wild animals in doing so. Whereas, the labourers in tea gardens are tribes and indulge in hunting as a part of their culture and food habits. The tea tribes used primitive hunting techniques like catapults, bows & arrows and leg traps to hunt the animals for bush meat. Similar hunting techniques were observed in Arunachal Pradesh (Aiyadurai 2011) and the Western Ghats (Gubbi & Linkie 2012).

## CONCLUSION

The main cause of negative human-wildlife interactions is the lower rate of tolerance of humans to crop and livestock depredation by wild animals in the agroforestry systems of Assam. Another major factor which contributes to killing of wild animals is the practice and tradition of people. The fact that majority of the people in tea gardens resorted to hunting of wild animals primarily for subsistence or as a tradition and also killed them as a revenge for livestock depredation and crop destruction is a matter of concern. But the brighter side is that the homegarden and agrisilvicultural system owners prefer to chase the animals using catapults which shows positive signs for their conservation. Understanding people's





Image 1. Photographs showing threats to wildlife in selected agroforestry systems a—captured *Nycticorax nycticorax* (Black-crowned Night Heron) | b—killed *Lepus nigricollis* (Indian Hare) | c—killed *Phaenicophaeus tristis* (Green-billed Malkoha) | d—killed *Zosterops palpebrosus* (Oriental White-eye) | e—Turtle shell used for medicinal purpose | f—skull of *Varanus bengalensis* (Bengal Monitor) used for medicinal purpose | g—skin and bones of *Varanus bengalensis* (Bengal Monitor) used for medicinal purpose. © Yashmita-Ulman.





Image 2. Photographs showing different traps used to kill wildlife in selected agroforestry systems a—wire trap | b—bows and arrows | c—leg trap | d—spearheads | e—rodent trap | f—catapult | g—gun. © Yashmita-Ulman.

attitude towards wild animals in their agroforestry systems helps to develop wildlife conservation strategies in agroforestry systems which otherwise provides refuge to wild animals in the current scenario of deforestation and habitat loss.

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## Editorial

**Pakshirajan Lakshminarasimhan: a plant taxonomist who loved plants and people alike**  
– Mandar N. Datar, Pp. 16195–16203

## Communications

**The worrisome conservation status of ecosystems within the distribution range of the Spectacled Bear *Tremarctos ornatus* (Mammalia: Carnivora: Ursidae) in Ecuador**  
– José Guerrero-Casado & Ramón H. Zambrano, Pp. 16204–16209

**Living with Leopard *Panthera pardus fusca* (Mammalia: Carnivora: Felidae): livestock depredation and community perception in Kalakkad-Mundanthurai Tiger Reserve, southern Western Ghats**  
– Bawa Mothilal Krishnakumar, Rajarathinavelu Nagarajan & Kanagaraj Muthamizh Selvan, Pp. 16210–16218

**An updated checklist of mammals of Odisha, India**  
– Subrat Debata & Himanshu Shekhar Palei, Pp. 16219–16229

**Negative human-wildlife interactions in traditional agroforestry systems in Assam, India**  
– Yashmita-Ulman, Manoj Singh, Awadhesh Kumar & Madhubala Sharma, Pp. 16230–16238

**Prevalence and morphotype diversity of *Trichuris* species and other soil-transmitted helminths in captive non-human primates in northern Nigeria**  
– Joshua Kamani, James P. Yidawi, Aliyu Sada, Emmanuel G. Msheliza & Usman A. Turaki, Pp. 16239–16244

**Detection of hemoparasites in bats, Bangladesh**  
– Shariful Islam, Rakib Uddin Ahmed, Md. Kaisar Rahman, Jinnat Ferdous, Md. Helal Uddin, Sazed Akter, Abdullah Al Faruq, Mohammad Mahmudul Hassan, Ausraful Islam & Ariful Islam, Pp. 16245–16250

**Ecology of the Critically Endangered Singidia Tilapia (Teleostei: Cichlidae: *Oreochromis esculentus*) of lake Kayanja, Uganda and its conservation implications**  
– Richard Olwa, Herbert Nakiyende, Elias Muhumuza, Samuel Bassa, Anthony Taabu-Munyaho & Winnie Nkalubo, Pp. 16251–16256

**Length-weight relationships of two conservation-concern mahseers (Teleostei: Cyprinidae: *Tor*) of the river Cauvery, Karnataka, India**  
– Adrian C. Pinder, Rajeev Raghavan, Shannon D. Bower & J. Robert Britton, Pp. 16257–16261

**The identity and distribution of *Bhavana annandalei* Hora, 1920 (Cypriniformes: Balitoridae), a hillstream loach endemic to the Western Ghats of India**  
– Remya L. Sundar, V.K. Anoop, Arya Sidharthan, Neelesh Dahanukar & Rajeev Raghavan, Pp. 16262–16271

**Records of two toads *Duttaphrynus scaber* and *D. stomaticus* (Amphibia: Anura: Bufonidae) from southeastern India**  
– S.R. Ganesh, M. Rameshwaran, Naveen A. Joseph, Ahamed M. Jerith & Sushil K. Dutta, Pp. 16272–16278

**Some rare damselflies and dragonflies (Odonata: Zygoptera and Anisoptera) in Ukraine: new records, notes on distribution, and habitat preferences**  
– Alexander V. Martynov, Pp. 16279–16294

**Floristic diversity of Anjaneri Hills, Maharashtra, India**  
– Sanjay Gajanan Auti, Sharad Suresh Kambale, Kumar Vinod Chhotupuri Gosavi & Arun Nivrutti Chandore, Pp. 16295–16313

**A checklist of macrofungi (mushroom) diversity and distribution in the forests of Tripura, India**  
– Sanjit Debnath, Ramesh Chandra Upadhyay, Rahul Saha, Koushik Majumdar, Panna Das & Ajay Krishna Saha, Pp. 16314–16346

## Short Communications

**A threat assessment of Three-striped Palm Squirrel *Funambulus palmarum* (Mammalia: Rodentia: Sciuridae) from roadkills in Sigur Plateau, Mudumalai Tiger Reserve, Tamil Nadu, India**  
– Arockianathan Samson, Balasundaram Ramakrishnan & Jabamalainathan Leonaprinay, Pp. 16347–16351

**Impact of vehicular traffic on birds in Tiruchirappalli District, Tamil Nadu, India**  
– T. Siva & P. Neelamarayanan, Pp. 16352–16356

**Ichthyofaunal diversity of Manjeera Reservoir, Manjeera Wildlife Sanctuary, Telangana, India**  
– Kante Krishna Prasad, Mohammad Younus & Chelmala Srinivasulu, Pp. 16357–16367

**New distribution record of the endemic and critically endangered Giant Staghorn Fern *Platynerium grande* (Fee) Kunze (Polypodiaceae) in central Mindanao**  
– Cherie Cano-Mangaoang & Charissa Joy Arroyo Gumban, Pp. 16368–16372

## Notes

**First photographic record of the Dhole *Cuon alpinus* (Mammalia: Carnivora: Canidae) from the Sirumalai Hills in Tamil Nadu, India**  
– B.M. Krishnakumar & M. Eric Ramanujam, Pp. 16373–16376

**Tracing heavy metals in urban ecosystems through the study of bat guano - a preliminary study from Kerala, India**  
– Jithin Johnson & Moncey Vincent, Pp. 16377–16379

**Population dynamics and management strategies for the invasive African Catfish *Clarias gariepinus* (Burchell, 1822) in the Western Ghats hotspot**  
– Kuttanellloor Roshni, Chelapurath Radhakrishnan Renjithkumar, Rajeev Raghavan, Neelesh Dahanukar & Kutty Ranjeet, Pp. 16380–16384

**First records of the black widow spider *Latrodectus elegans* Thorell, 1898 (Araneae: Theridiidae) from Nepal**  
– Binu Shrestha & Tobias Dörr, Pp. 16385–16388

**First report of the assassin bug *Epidius wangi* (Heteroptera: Reduviidae: Harpactorinae) from India**  
– Swapnil S. Boyane & Hemant V. Ghate, Pp. 16389–16391

**Observations of the damselfly *Platylestes cf. platystylus* Rambur, 1842 (Insecta: Odonata: Zygoptera: Lestidae) from peninsular India**  
– K.J. Rison & A. Vivek Chandran, Pp. 16392–16395

***Herminium longilobatum* (Orchidaceae), a new record for Bhutan**  
– Ugyen Dechen, Tandin Wangchuk & Lam Norbu, Pp. 16396–16398

**Recent record of a threatened holoparasitic plant *Sapria himalayana* Griff. in Mehao Wildlife Sanctuary, Arunachal Pradesh, India**  
– Arif Ahmad, Amit Kumar, Gopal Singh Rawat & G.V. Gopi, Pp. 16399–16401

**Eleven new records of lichens to the state of Kerala, India**  
– Sonia Anna Zachariah, Sanjeeva Nayaka, Siljo Joseph, Pooja Gupta & Scaria Kadookunnel Varghese, Pp. 16402–16406

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