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COMMUNICATION

Assessment of crop and property damage caused by *Semnopithecus vetulus nestor* (Bennett, 1833) (Mammalia: Primates: Cercopithecidae) in Gampaha District, Sri Lanka

Sunil Wijethilaka [1], Lakshani S. Weerasekara [2], Saumya Bandara [3] & Kithsiri B. Ranawana [4]

[1] Henegama Central National School, Henegama, Gampaha, Sri Lanka.
[2] Department of Zoology, Faculty of Science, Eastern University, Vantharamoolai, Sri Lanka.
[2] Postgraduate Institute of Science, University of Peradeniya, Peradeniya, Sri Lanka.
[3] Science Education Unit, Faculty of Science, University of Peradeniya, Peradeniya, Sri Lanka.
[4] Department of Zoology, Faculty of Science, University of Peradeniya, Peradeniya, Sri Lanka.
[1] sunilwijethilaka@gmail.com, [2] lakshaniw@esn.ac.lk (corresponding author), [3] saumyasnp@gmail.com, [4] kithsiri.r@gmail.com

Abstract: In earlier times, human-monkey interactions were not a severe problem in Sri Lanka, but has recently intensified as a result of habitat fragmentation and urbanization. Due to these changes, *Semnopithecus vetulus nestor* has been listed among the 25 most Endangered primates. The objective of our study was to evaluate the intensity of human-*S.v. nestor* negative interaction by identifying the crop and property damages in villages bordering Danawkanda Forest (7.001N & 80.049E), Gampaha, Sri Lanka. We collected data using structured questionnaires interviewing households (N= 80) bordering the Danawkanda Forest from August 2014 to January 2015. Households were most affected by damage to fruits, leaves, and buds of commercially important trees (93%), followed by damage to roof tiles (76%), and frightful confrontations with the monkeys (43%). Average monthly loss per household from crop and property damage was estimated at between (Sri Lankan Rupees) LKR 2,700 and LKR 1,500. Lighting firecrackers was the most common method used by the residents (99%) to deter monkeys, where as electrified barriers were rarely used (4%). Households in close proximity to Danawkanda Forest experienced a considerable loss to their monthly income due to crop and property damage, compared to households further away. As an alternative, residents now grow ornamental plants and short trees, eliminating the structures that attract and facilitate damage by *S.v. nestor*. Awareness and active participation of residents, authorized government, and non-governmental organizations are needed to manage unplanned construction and agriculture plot extensions into the forest. These two factors trigger the human-wildlife negative interactions in general and are not limited just to monkeys.

Keywords: Danawkanda Forest, deterrent methods, human-primate conflict, human-primate negative interactions, Western Purple-faced Leaf Monkey.

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Author details: Mr. Sunil Wijethilaka is a High School Science teacher who is an enthusiast about nature and especially interaction between langurs and humans. Ms. Lakshani Weerasekara, BSc, is a young graduate major in Zoology and her research interests extend to ecology and wildlife conservation, animal behavior and primatology. Mr. Saumya Bandara, BSc, is a lecturer in the Science Education Unit, Faculty of Science, University of Peradeniya. His research interests are the ecology of land snails and science education of indigenous people. Prof. Kithsiri Ranawana, PhD, is a renowned ecologist in Sri Lanka and an active naturalist. His research interests include ecology and conservation.

Author contribution: Sunil Wijethilaka did the field work, Lakshani Weerasekara & Kithsiri Ranawana prepared the manuscript, and Saumya Bandara did the statistical analysis.

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INTRODUCTION

Crop raiding by animals is a concern for small-scale subsistence farmers (Garriga 2014) in countries around the world like Sri Lanka, where nearly 28.5% of the population depends on agriculture (CBSL 2014). Different animal species cause different problems for farmers when they raid crops (Hill 2005). Not only parasitic invertebrates but also vertebrates like birds (Bruggers et al. 1998; Maurice et al. 2019), rodents (Lathiya et al. 2003; Sarwar 2015), Mouse Deer (Linkie et al. 2007), porcupine (Linkie et al. 2007), Wild Boar (Shafi & Khokhar 1986; Gobosho et al. 2015), Elephants (Sukumar 1990; Barnes 1996; Hill 1998; Chiyo et al. 2012) and non-human primates (Boulton et al. 1996; Pirta et al. 1997; Hill 2000; Dittus et al. 2019) are considered as crop raiding pests responsible for human-wildlife negative interactions. Non-human primates are often considered to be the most destructive crop raiders in many parts of the world (Naughton-Treves et al. 1998; Hill 2000; McLennan 2008; Hill & Wallace 2012; Hockings et al. 2012; Cabral et al. 2018). Members of the genera *Macaca*, *Papio*, and *Cercopithecus* are amongst the most frequently cited non-human primate pest species (Hill 2005). The presence of an organized social hierarchy, co-operative behavior, communication skills, combined with intelligence, dietary and behavioral flexibility, manual dexterity, and extreme agility make these primate species particularly difficult for farmers to prevent from damaging crops (Hill 2005).

The human-monkey interaction in Sri Lanka was not a severe problem in the past, but has intensified in recent decades due to agricultural, irrigational, & industrial projects, increased urban expansion, and fragmentation of natural forested areas due to an increase in the human population (Wickramagamage 1998; Rudran 2007; Marasinghe & Nathaniel 2020). Forest fragmentation in the wet and dry zones is a primary cause of rapid and widespread invasion of primates into farms and agricultural lands in search of alternative food resources (Nahallage & Huffman 2008). As a result, conflicts have intensified. These human-wildlife conflicts affect the survival of many endangered commensal species (Garriga 2014) like *Semnopithecus vetulus nestor*, as well as undermine the local human population's food security and tolerance for wildlife.

S.v. nestor (Bennett 1833) has been listed among the 25 most endangered primates of the world (Schwitzer et al. 2017) due to encroachment into their habitat by unplanned urbanization. Urbanization severely threatens the long-term survival of this endemic species (Molur et al. 2003; Rudran et al. 2009; Mittermeier et al. 2012). While studies on its behaviour and ecology have been comprehensively addressed, reports on human - *S.v. nestor* conflicts are scarce (Molur et al. 2003; Dela 2004, 2007, 2012; Rudran 2007; Mittermeier et al. 2009, 2012; Rudran et al. 2013). Thus, the objective of our study was to evaluate the intensity of human-monkey conflict by identifying the crop and property damages caused by *S.v. nestor*, and to quantify the loss incurred to the households caused by them in villages bordering Danawkanda Forest, Gampaha District in the Western Province of Sri Lanka.

METHODS

Study site

Danawkanda Forest (7.001N & 80.049E) is a secondary wet zone forest encompassing an area of 360ha, located in Gampaha District, Sri Lanka. The forest patch is surrounded by many adjacent villages. Twelve villages bordering Danawkanda Forest were randomly assessed during the study in Mahara Divisional Secretariat (Image 1). Danawkanda Hill is considered a historical land mark in the region, and contains a Buddhist monastery where people interact with the forest. The main habitat type in the study area was village home gardens dominated by the tall fruit tree species *Artocarpus heterophyllus* (Jak) (86%), *Mangifera indica* (Mango) (86%), *Cocos nucifera* (Coconut) (71%), and *Areca catechu* (Arecanut) (34%). The dominant medium-size fruit tree species were *Nephelium lappaceum* (Rambutan) (59%), *Carica papaya* (Papaw) (48%), *Musa paradisiaca* (Banana) (34%), and *Psidium guajava* (Guava) (20%).

Study subject

Semnopithecus vetulus is the only endemic colobine monkey species in Sri Lanka representing four subspecies; namely *S.v. philbricki* (Northern Purple-faced Leaf Monkey), *S.v. vetulus* (Southern Purple-faced Leaf Monkey), *S.v. monticola* (Bear Monkey), and *S.v. nestor* (Western Purple-faced Leaf Monkey) (Rudran et al. 2020). Of which *S.v. nestor* is the smallest subspecies in body size (Dela 2007) (Image 2). Its range extends across the western lowlands of Sri Lanka, in an area of high human population density, very low forest cover (Dela 2012), extensive human settlements, and agricultural activity (Dela 2007).

Survey

A pilot survey was carried out in July 2014 to identify the families that experience *S.v. nestor* raids. Structured questionnaires (N= 80) were then carried

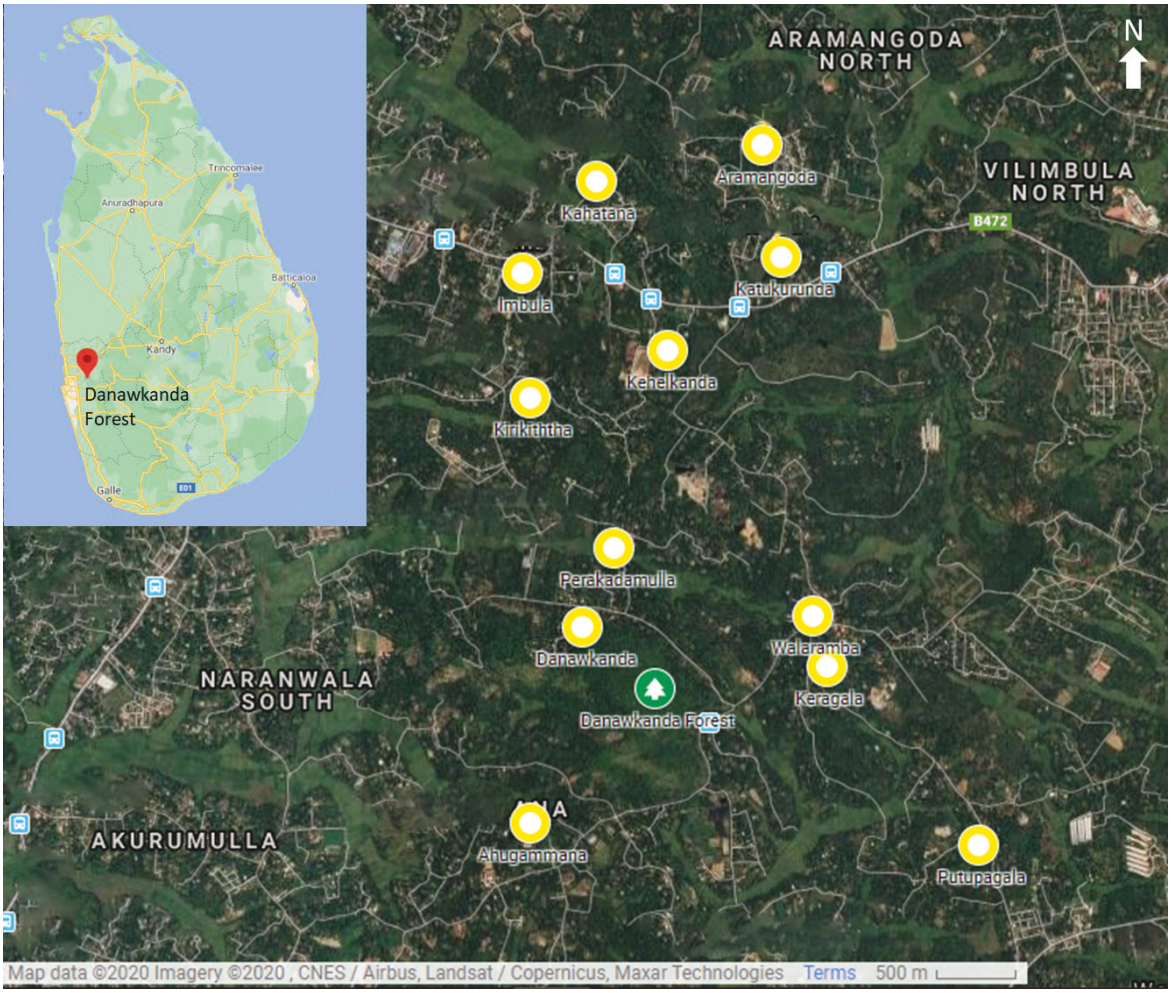

Image 1. Twelve villages bordering Danawkanda Forest, Gampaha, Sri Lanka (Google map source: Image © 2020 Maxar Technologies).

Image 2. One of the 25 most endangered primates of the world, *Semnopithecus vetulus nestor*.

out to collect data by randomly interviewing families in 12 villages bordering Danawkanda Forest from August 2014 to January 2015. The head of each household was interviewed in the relevant native language, Sinhalese or Tamil, to avoid omission of vital information. The questionnaire was composed of both closed- and open-ended questions and binary (yes/no) questions.

Data analysis

The data collected from interviews were presented as percentages of respondents given for each response (Marchal & Hill 2009). Crop and property damages, financial loss to the household, and expenditures for deterrent methods were calculated. Pearson's correlation test was performed to analyze the relationship between the money spent on firecrackers and the distance to the forest. Minitab (Version 14.0) Statistical Software was used and the level of statistical significance was set at $p \leq 0.05$.

RESULTS

Economic structure of the households in villages bordering Danawkanda Forest

Residents in the study area led a typical Sri Lankan lifestyle, of which 61% were employed (21% in the government, and 40% private sector) and 39% were unemployed, being involved in horticulture and a very few were daily-based laborers. Despite their employabiltiy, the majority were involved in friut plant (N= 78), crop plant (N= 55), and ornamental plant cultivation (N= 12). Monthly income was recorded as follows: 64% of residents earned less than LKR 25,000, 19% of residents earned LKR 35,000–50,000, and 3% of residents earned more than LKR 50,000.

Crop and property damage caused by *S.v. nestor*

Damages were categorized as crop damages, property damages, and others (Table 1). The highest number of households was affected by damages done to fruits, leaves, & buds (93%) of commercial value, breaking of roof tiles (76%), and frightful encounters (43%). The most preferred fruit species of the monkeys were *M. paradisiaca* and *C. papaya* (99%) (Table 2). The average losses per household by crop and property damages ranged between LKR 2,700 and LKR 1,500. This loss to the household caused by crop and property damage was higher in the dry season than the wet season (Fig. 1).

In addition to losses to the household caused by crop and property damages, residents spend money to buy firecrackers for chasing monkeys away. There was a strong negative correlation between the distance to the village and the average amount of money spent on firecrackers (r^2= -0.78 p= 0.0410).

Deterrent methods for *S.v. nestor* raids in villages bordering Danawkanda Forest

Deterrent methods for chasing away *S.v. nestor* were categorized as currently used methods, and proposed alternative methods (Table 3). Lighting firecrackers were the most common method used by the residents to chase away *S.v. nestor* (99%). Electrified barriers were rarely used (4%). Now most of the residents prefer to grow ornamental plants and short trees to develop an aesthetic appearance around the home and to eliminate the structures that attract and facilitate *S.v. nestor* approaching the home and property as proposed alternative methods.

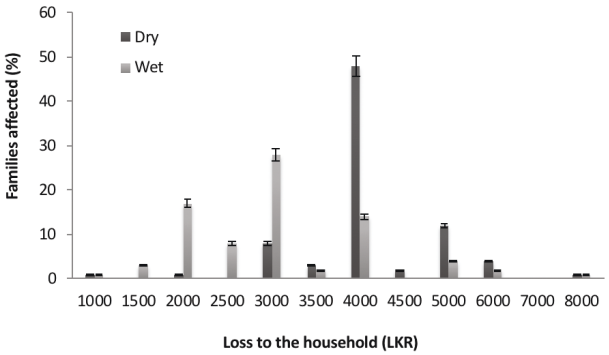

Figure 1. Approximated loss to households caused by crop and property damages during dry and wet season by *Semnopithecus vetulus nestor* with 5% error bars.

Table 1. Damage caused by *Semnopithecus vetulus nestor* in villages bordering the Danawkanda Forest, Sri Lanka.

Damage type	Number of families affected (%)
Crop damage	
Damage fruits, leaves and buds (leaf and flower buds)	93
Consume ripe and raw fruits	29
Consume crop and flowers of vegetable plants	13
Uprooting plants	13
Property damage	
Break the roof tiles	76
frightful encounters	
Scaring adults and children	43
Biting adults and children	31
Noise annoyance	41

Table 2. Fruit species ingested by *Semnopithecus vetulus nestor* in home gardens bordering the Danawkanda Forest, Sri Lanka.

Family	Species	Common name	Reported frequency of use (%)
Musaceae	*Musa paradisiaca*	Banana	99
Caricaceae	*Carica papaya*	Papaw	99
Sapindales	*Nephelium lappaceum*	Rambutan	44
Anacardiaceae	*Mangifera indica*	Mango	31
Arecaceae	*Cocos nucifera*	Coconut	20
Euphorbiaceae	*Manihot esculenta*	Manioc	08
Dioscoreaceae		Yams	08
Arecaceae	*Cocos nucifera* "king"	King coconut	05
Malvaceae	*Durio kutejensis*	Durian	04
Dipterocarpaceae	*Dipterocarpus zeylanicus*	Kiripalu	02

Table 3. Deterrent methods for raiding by *Semnopithecus vetulus nestor* into home gardens bordering the Danawkanda Forest, Sri Lanka.

Deterrent method	Households (%) employing these techniques
Currently practiced methods	
Lighting fire crackers	99
Throwing and/or thrashing stones	41
Shooting by pellet guns and catapults	18
Creating noises/shouting	26
Electricity fence/wires	04
Proposed alternative methods	
Growing decorative plants	99
Addition of short trees	99
Creating an esthetic landscape	99
Growing ornamental plants instead of crop plants	98
Elimination of structures that attract and facilitate monkeys	92
Reducing the food sources	84
Removal of tall trees	78

DISCUSSION

Crop raiding by wildlife is not a new phenomenon. It has been occurring since humans first settled down and started practicing agriculture (Sillero-Zubiri & Switzer 2001); however, the intensity of this problem is particularly problematic in areas where humans are encroaching onto once undisturbed wildlife habitats (Rudran 2007; Nahallage & Huffman 2008). It is challenging to conduct a comprehensive assessment of the damage caused by wildlife (Garriga 2014). Farmers' perceptions of loss are often greater than the actual loss, and this becomes more accentuated if the plantations are in close proximity to a protected wildlife area (Hill 2004). In the present study, we found that residents near the Danawkanda Forest are experiencing a considerable financial loss due to crop and property damage by *S.v. nestor* compared to their monthly income. Twelve villages are located within a 4km radius of Danawkanda Forest, of which 75% are located within a radius of 2km. Hence, *S.v. nestor* can easily exploit the available food resources of these villages via continuous arboreal pathways that connect the villages to the forest (Rudran 2007). Villages that are located relatively close to the forest largely experience a high frequency of crop and property damages compared to more distant villages. Similarly, previous studies have also shown that *S.v. nestor* is involved in the exploitation of human modified habitats, and that often results in crop damage and consumption and other forms of property damage (Rudran 2007; Dela 2012). Similarly, studies carried out in African countries like Uganda and in some regions in India show that farms closer to forests do actually suffer significantly more crop raiding than farms situated further away (Saj et al. 2001; Baranga et al. 2012; Karanth et al. 2013).

The vegetation structure of home gardens was the key element in attracting *S.v. nestor*. They mostly preferred taller fruit-trees that facilitated their arboreal movements, hence, home gardens with more tall trees were raided more frequently. Food sources like fruit plants were very common in home gardens in the study sites. Dela (2012) stated that *S.v. nestor* living in environments modified by humans and with abundant sources of cultivated fruits had actively adopted a more frugivorous dietary strategy, unlike that of any other colobine monkeys. Though fruits vary widely in biochemistry and quality, they are in general easily digested and contain energy-rich sugars and nonstructural carbohydrates (Kay & Davies 1994; Waterman & Kool 1994). Human edible fruits from cultivars seem to have these features (Dela 2007). Similar to Rudran (2007) in the present study, *S.v. nestor* commonly preferred fruits such as banana and papaw over other available fruits, and this might be due to their availability throughout the year, unlike most seasonal fruits. Chimpanzees are also known to cause significant damage to banana plantations (Naughton-Treves 1996). In the present study, the highest percentage of damage is done to leaves, fruits and their buds (93%), because mature leaves are generally high in fiber and protein, are more nutritious, and have lower processing costs (Oates et al. 1980; Waterman & Kool 1994). *S.v. nestor* commonly preferred both raw and ripe fruits (29%), and vegetable crops and their flowers (13%). On the other hand, roof tiles (76%) and roof sheets (13%) were frequently damaged by removing and destroying them. On occasion, they jump down on the roofs from tall trees as they move and chase one another, causing substantial damage to the roof. Unrepaired damages can lead to roof degradation.

Fear of *S.v. nestor* was common in the study area. Small children are the most common victims. Some monkeys were relatively more aggressive than others, with a few reports of people being bitten. Other primates like chimpanzees have even been known to kill children on more than 10 occasions in the Kibale Forest of western Uganda (Naughton-Treves pers. comm. 1996; Hill 2005) and baboons have caused injury and death to humans (Hill 2000; Nchanji 2002). Other prevailing problems include breaking fences, spoiling water in storage tanks and food, and the carrying off of small household items.

More than two-thirds of the residents interviewed face financial difficulties and the majority find selling of horticulture as a good remedy. They cultivate fruits and vegetables in their home gardens. Monkey foraging incursions into their home gardens cause a direct economic impact to the household. Damage to crops and property was higher in the dry season compared to the wet season. The wet season triggers flushing and fruiting of food sources in the forest, so the monkeys are able to get enough natural food at this time of year within the Danawkanda Forest. But in the dry season, food sources are scarce inside the forest. This might be the reason for intensified foraging in the adjacent home gardens, resulting in high crop and property damages at this time of the year. Conversely, many colobine species in other parts of the world feed selectively on seasonal plant parts (Davies 1991; Stanford 1991).

Most of the deterrent methods used are not harmful to the monkeys, but electrocution, shooting, poisoning, and hitting with stones are injurious. More traditional protection strategies used against other species such as creating barriers (electric fences, living fences, walls, and ditches) between wildlife and farming areas are ineffective where primates are concerned (Garriga 2014). Lighting firecrackers was the most common deterrent method used by the residents near the Danawkanda Forest. As the distance from the forest to the villages increases, the amount of money that had to be spent on firecrackers to deter *S.v. nestor* decreased. This is because the villages located more closely to the Danawkanda Forest are more frequently raided by *S.v. nestor* than the villages further away.

Apart from the currently used methods, we recommended seven alternative methods to residents in the area (see Table 3). The majority (99%) preferred to grow shorter trees instead of taller trees, because they give an aesthetic appearance to the home garden, and grow more ornamental plants instead of crop plants. This will, however, reduce the opportunities for growing valuable timber species and crop plants that can increase the monthly income of these residents.

Our study can be regarded as a baseline survey, which provides an initiative to address this rising problem in the area. We propose that *S.v. nestor* causes crop and property damages in the villages bordering Danawkanda Forest as a result of their search for nutritious food sources in home gardens at times of food scarcity in the forest. Residents who are living in close proximity to the forest, having low income, experienced a considerable economic loss to the household, leading to conflicts between humans and *S.v. nestor*. Perhaps compensatory mechanisms can help alleviate the financial losses to households. Awareness can play a vital role in encouraging villages to tolerate and mitigate crop and property damages caused by *S.v. nestor*. More efforts are needed to educate people on the importance of biodiversity and effective ways of mitigating the wildlife problem without engaging in constant conflict with them. Importantly, active participation of authorized government and non-governmental organizations needs to be involved to manage unplanned construction and agriculture extensions into the forest, which triggers negativity towards not only monkeys, but many other wildlife species as well.

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