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10.11609/jott.2022.14.1.20311-20538 www.threatenedtaxa.org

> 26 January 2022 (Online & Print) 14(1): 20311-20538 ISSN 0974-7907 (Online) ISSN 0974-7893 (Print)



Publisher

Wildlife Information Liaison Development Society www.wild.zooreach.org

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Caption: Cyrtodactylus myintkyawthurai, endemic to Myanmar. Medium: Water colours on watercolor sheet. © Aakanksha Komanduri

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Journal of Threatened Taxa | www.threatenedtaxa.org | 26 January 2022 | 14(1): 20478-20487

ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print) https://doi.org/10.11609/jott.7560.14.1.20478-20487 #7560 | Received 08 July 2021 | Final received 21 October 2021 | Finally accepted 06 December 2021



OPEN

(cc)

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Utilization of home garden crops by primates and current status of human-primate interface at Galigamuwa Divisional Secretariat Division in Kegalle District, Sri Lanka

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Abstract: Many humans coexist with non-human primates (NHP), and as human populations have increased so have the pressures on natural habitats. For example, deforestation results in habitat loss and food scarcity for NHPs. In response, NHPs sometimes enter human habitats in search of food, which can result in negative interactions between humans and NHPs. This study focused on human-NHP interactions in three Grama Niladhari divisions in Kegalle District, Sri Lanka. We used interviewer-administered structured questionnaires to collect data from 500 randomly selected informants. The majority stated that they could not obtain sufficient harvests from home gardens for their own consumption owing to crop damage and losses caused largely by NHPs and other wild animals. This has led many people to abandon home gardening. Toque Macaques caused the most damage to crops, followed by Wild Boars, porcupines, and Purple-faced Leaf Langurs. Damage was caused to coconuts, vegetables, bananas, and yams. NHPs also caused property damage, with Toque Macaques causing more damage than langurs. People commonly used firecrackers, catapults and air rifles, and wore wooden or plastic face masks, in attempts to control crop damage by NHPs, with little success. People are of the opinion that the NHPs should be relocated to other forested areas or sterilized to control their numbers. In conclusion, to address the issues pertaining to human-primate interactions in terms of conflict due to crop utilization of primates, an integrated management plan should be developed in cooperation with the relevant stakeholders.

Keywords: Crop raiding, deforestation and habitat loss, economic loss, forest edge home gardens, human-primate conflict, integrated management plan, *Macaca sinica, Semnopithecus vetulus*.

Abbreviations: DSD—Divisional Secretariat Division | GN divisions—Grama Niladhari divisions | NHP—Non-human primate.

Editor: Honnavalli N. Kumara, Salim Ali Centre for Ornithology and Natural History, Coimbatore, India. Date of publication: 26 January 2022 (online & print)

Citation: Nahallage, C.A.D., D.A.M. Dasanayake, D.T. Hewamanna & D.T.H. Ananda (2022). Utilization of home garden crops by primates and current status of human-primate interface at Galigamuwa Divisional Secretariat Division in Kegalle District, Sri Lanka. *Journal of Threatened Taxa* 14(1): 20478–20487. https://doi. org/10.11609/jott.7560.14.1.20478-20487

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Funding: This research was funded under the mini research grants of the Multidisciplinary Research Centre of the Faculty of Humanities and Social Sciences, University of Sri Jayewardenepura.



Competing interests: The authors declare no competing interests.

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Author contributions: CADN wrote the manuscript and DTHA, DAMD, and KKDTH contributed to data entering, analysis, and reviewing of the manuscript. DAMD, KKDH, and CADN collected field data.

Acknowledgements: The authors thank the dean of the Faculty of Humanities and Social Sciences, University of Sri Jayewardenepura and the director of the Multidisciplinary Research Center for their support. This research was funded under the mini research grants of the Multidisciplinary Research Centre of the Faculty of Humanities and Social Sciences. Also, we are grateful to the reviewers for the constructive suggestions and recommendations. The manuscript benefitted greatly from the inputs of the reviewers. We also thank Prof. M.G. Lalith Ananda for reading through the manuscript and correcting the language errors.

INTRODUCTION

Humans, macaques, and langurs are members of the sub-order Anthropoidea in the Order Primates. The three species share many physiological, anatomical, and behavioral characteristics and thus have similar requirements to sustain themselves. As a result, when they share the same environment a variety of interactions between them become inevitable. Sometimes these interactions have negative impacts on species when they share similar food resources (Houle 1997; Peiman & Robinson 2010). The intensity of the interactions increases with the similarity of shared resources, creating competition within or between species, which at times can be detrimental to one or both.

Non-human primates and humans maintain both positive and negative interactions. The positive interactions include deploying primates for economically beneficial activities such as harvesting coconuts, as can be seen in Thailand and also as performers to entertain humans (Nahallage & Huffman 2013; Nahallage 2019). In both instances, humans gain economic benefit by employing primates in various activities, which in turn creates a positive attitude towards them. Most crucial for the survival of the primates and their conservation is mitigating adverse interactions that create negative attitudes toward primates, primarily in the form of human and non-human primate competitions over common resources.

One of the main reasons for escalating humanprimate negative interactions in Sri Lanka is the loss of natural primate habitat due to various development projects (Nahallage et al. 2008; Cabral et al. 2018; Dittus et al. 2019). Primates become isolated in small forest patches because of the fragmentation of forests they inhabit, which leads to an increase in competition for food and space. When resources become depleted in the natural habitat, primates frequent villages in search of food, which intensifies human-primate interactions (Dela 2007; Rudran 2007; Nahallage et al. 2008; Dittus 2012; Rudran & Kotagama 2016, Dittus et al. 2019; Nahallage 2019). Other reasons monkeys are attracted to nearby settlements include improper garbage disposal, feeding by humans, cultivation of large-scale cash crops, and scarcity of food & water in the natural habitats during the dry season (Dittus et al. 2019).

In Sri Lanka, the three diurnal primate species are mainly involved in human-primate interactions: Toque Macaquea Macaca sinica, Purple–faced Leaf Langurs Semnopithecus vetulus and Gray Langurs Semnopithecus priam (Nahallage & Huffman 2013; Dittus et al. 2019). No conflicts have been reported with two resident nocturnal Loris spp., which have little interaction with humans. Macagues are sociable animals that interact frequently with humans and prefer to stay close to human settlements, while langurs prefer more natural habitats and foods (Nahallage & Huffman 2013; Dittus et al. 2019; Nahallage 2019). Purple-faced Leaf Langurs are strictly arboreal folivores and have the least interaction with humans in many places. This relationship, however, varies in different parts of the country (Rudran 1973, 2007; Dela 2007; Dittus 2012; Dittus et al. 2019; Nahallage 2019), with Purple-faced Leaf Langurs in the Western Province considered the most prominent species living close to humans causing crop and property damage. Food selection by Gray Langurs depends on their habitat; in natural environments they depend mainly on plant material, while those in urban environments and temple areas tend to consume food given to them by pilgrims, such as leftover offerings (Nahallage et al. 2008; Nahallage & Huffman 2013; Dittus et al. 2019). During periods of food scarcity, both Gray Langurs and Toque Macaques obtain food forcibly from people or directly from houses or shops, leading to intense human-primate negative interactions.

Human-primate interactions is not a recent occurrence in the country. Robert Knox, an English traveler who was imprisoned on the island by the Kandyan King but allowed to live in various places freely for about 20 years, described how macagues invaded corn fields and home gardens despite their being heavily guarded (Knox 1681). There were even folk poems written regarding the crop raiding of primates (Ananda 2000). At present, crop raiding occurs in all 25 districts of the country. Crop raiding by primates generally depends on the types of crops grown, seasonality, distance to the village from the forest, availability of natural foods, and the methods of crop guarding (Hill 2000; Marchal & Hill 2009; Fungo 2011). In Sri Lanka, macaques inflict more damage to crops than langurs, but all are considered pests to varying degrees in the provinces where they are found (Nahallage at al. 2008; Nahallage & Huffman 2013; Prasad et al. 2016; Nahallage 2019; Dittus et al. 2019). In places where all three diurnal primates exist, Toque Macaques damage crops the most, followed by Gray Langurs (Nahallage et al. 2008), however, in some parts of the North Central Province, Gray Langurs cause more damage than Toque Macagues (Perera & Vandercone 2016).

The main objective of this study was to determine the present status of human-primate interactions in relation to home garden crop damage in selected



Image 1. Study area: A—Kegalle District | B—Galigamuwa Divisional Secretariat Division | C—Three GN divisions (Hathnapitiya, Karagala, and Aruggammana).

areas in Kegalle District. This study looks into the wild animals in the selected study area and their impact on home garden crops. Home garden cultivations are very important to these low-income rural villagers, as they supply food to meet their daily needs and allow them to earn additional income by selling the excess harvest. The specific objectives were to find out the extent of crop damage by non-human primates and other wild animals, the types of crops that are mostly affected by crop raiding primates, the types of property damage they do, the control measures used by humans to prevent or reduce crop damage and the people's perception of the type of mitigative actions that should be taken to control conflicts.

METHODS

The selected study area was in the Galigamuwa Divisional Secretariat Division (DSD) in the Kegalle district, Sabaragamuwa Province. Out of the 51 Grama Niladhari Divisions (GN divisions), three GN divisions namely Aruggammana, Hathnapitiya, and Karagala were purposely selected as they recorded higher incidents of human primate interactions according to the Galigamuwa DSD office (Image 1). This was a descriptive cross-sectional study.

Galigamuwa DSD is located in the wet zone, and receives more than 2,500 mm annual average rainfall, and has a mean temperature of 22–27 °C. Agriculture is the main economic sector in the area. The land extent is 127 km². Hapudeniya is the highest parish in the division at 366 m above sea level and the lowest is Helamada at 27m. The two primate sub-species present in the area are *Macaca sinica aurifrons* and *Semnopithecus vetulus nestor*.

Location of the home gardens

Of the home gardens, 48% in Hathnapitiya, 32% in Aruggammana, and 80% in Karagala are located less than 50 m from the forest. Most of the home gardens in Karagala are located at the edge of the forest. Compared to Karagala GN divisions, most home gardens in Hathnapitiya and Aruggammana are located more than 100 m away from the forest edge (52% in Hathnapitiya and 68% in Aruggammana).

A total of 500 households were surveyed (Table 1). The electoral registers lists were obtained from Grama Niladhari officers in the respective GN Divisions to randomly select the houses for the survey. In instances where the people were not willing to participate in the survey or had vacated these houses, the next address was selected. The study was conducted between October and December 2018.

We used an interviewer-administered questionnaire method to collect data from each household for the survey. We obtained the required information from the head of the house or an adult (wife, parents or inlaws of the head of the house) present in each house at the time the data collectors visited the house. The structured questionnaire included 19 closed and open-ended questions on such topics as: occupation of the informant; the size of the home garden; types of crops cultivated; average monthly income; types of wild animals frequenting the home garden; the types of crops consumed or damaged by the animals; the extent of property damage; the measures taken to control the damage, and the peoples' perceptions on

Table 1. Selected sample sizes in each GN Division.

| GN Division | Total No. of houses in each GN Division | Number of houses surveyed |
|--------------|--|------------------------------|
| Aruggammana | 368 | 214 |
| Hathnapitiya | 303 | 136 |
| Karagala | 232 | 150 |

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how to control the damage caused by primates. Before collecting these data, we explained the purpose of the survey to the participants. Those who were willing to provide information were then given enough time to ask questions regarding the survey, and their written consent was obtained with a signature at the bottom of each questionnaire. On average, it took about 20 minutes to fill the questionnaire. In addition, we conducted field observations as well.

The collected data were entered into a Microsoft Excel sheet and analyzed using SPSS package (version 16).

RESULTS

Occupation of the informants

Except for Aruggammana GN Division, the majority of the informants were housewives (Table 2). Aruggammana and Karagala have more self–employed informants than Hathnapitiya.

Size of the Home Garden

All three GN divisions had many home gardens of less than 1.0 acre (4047 m²) in size, representing 93% of home gardens in Hathnapitiya, 66% in Aruggammana and 82% in Karagala (Table 3). When compared with the other two GN divisions, 33% of the home gardens in Aruggammana were larger, ranging from 1 to 5 acres.

Types of crops cultivated in the home gardens

The most common home gardening crops grown in all three GN divisions were coconuts (15%), Jack fruits (13%), areca nuts (13%), pepper (10%), and bananas (9%). More people grow coconuts in Hathnapitiya than Aruggammana and Karagala, while tea was cultivated more in Aruggammana and Karagala areas (Table 4).

Economic loss due to crop damage

During the time of data collection, the informants of Hathnapitiya (50%), Aruggammana (23%), and Karagala (21%) stated that they could not get sufficient harvest from home gardens for their consumption. All of the Hathnapitiya, 94% of Aruggammana, and 62% of Karagala respondents informed us that at present they cannot get sufficient additional income from home garden crops. Of the informants, 4% from Aruggammana and 33% from Karagala said that they get less than SLR 10,000 income per month and only 1% of Aruggammana and 6% of Karagala informants said they receive more than SLR 10,000 income per month (Table 05).

Reasons for not engaging in cultivation

In all three GN divisions people gave various reasons for not cultivating crops in home gardens, however, the majority of the informants stated the main reason was crop damage caused by wild animals, mainly primates (Hathnapitiya 87%, Aruggammana 92%, Karagala 94%). The other reasons were not enough manpower (Hathnapitiya 5%, Aruggammana 4%, Karagala 6%), inadequate land area (Hathnapitiya 5%, Aruggammana 2%), inadequate water (Hathnapitiya 2%, Aruggammana 2%), and infertility of the soil (Hathnapitiya 1%).

Animals responsible for crop damage

In all three respective GN divisions, the main species identified as responsible for crop damage were Toque Macaques, Wild Boars, porcupines, and Purple-faced Leaf Langurs (Table 6).

According to informants the NHPs frequent home gardens irrespective of the time of the day (Table 7).

The crops utilized by animals

The three main crops that the NHP utilized most were coconuts, bananas, and different types of yams. In addition, they consumed garden vegetables including brinjal *Solanum melongina*, winged beans *Psophocarpus tetragonolobus*, snake gourds *Trichosanthes cucumerina*, long beans *Vigna unguiculata*, lady'sfingers *Abelmoschus esculentus* (Table 08).

Consequences of crop damage by animals

Decreases in harvests (Hathnapitiya 59%, Aruggammana 51%, Karagala 43%) and income (Hathnapitiya 16%, Aruggammana 22%, Karagala 28%) were the main effects of crop damage by animals. As a result, people have discontinued home garden cultivation (Hathnapitiya 25%, Aruggammana 26%, Karagala 27%), and some have abandoned all or parts of their lands as they cannot control animal visits (Aruggammana 1%, Karagala 2%).

Property damage caused by Toque Macaques and langurs

In addition to crop damage, Toque Macaques and langurs also damage property. Toque Macaques caused the most property damage by entering houses and damaging household furniture and utensils (Table 9).

Langurs were not reported to cause much property damage, which was only reported in 2 GN divisions where langurs caused damage to roofs (Table 9). There were no reports of other wild animals causing property damage.

| 0 | Hathnapitiya | | Aruggammana | | Karagala | |
|----------------------------|--------------|-----|-------------|-----|-----------|-----|
| Occupation | Frequency | % | Frequency | % | Frequency | % |
| No occupation (housewives) | 67 | 49 | 54 | 25 | 72 | 48 |
| Government sector | 27 | 20 | 60 | 28 | 21 | 14 |
| Private sector | 24 | 18 | 33 | 15 | 21 | 14 |
| Commercial farming | 3 | 2 | 1 | 0.5 | 2 | 1 |
| Self-employment | 13 | 10 | 66 | 31 | 31 | 21 |
| Security service | 2 | 2 | 0 | 0 | 3 | 2 |
| Total | 136 | 100 | 214 | 100 | 150 | 100 |

Table 2. Occupation of the informants in each GN divisions.

Table 3. Size of the Home garden.

| GN Division | Hathn | apitiya | Arugga | ammana | Kar | agala |
|---|-------|---------------|--------|---------------|-----|---------------|
| Size of home garden | N | Valid Percent | N | Valid Percent | N | Valid Percent |
| Less than 1 acre (less than 4,047 m ²) | 103 | 93 | 126 | 66 | 116 | 82 |
| Between 1.1 to 5 acres (4,047–20,234 m ²) | 5 | 5 | 63 | 33 | 22 | 15 |
| More than 5 acres (more than 20,234 m ²) | 3 | 3 | 3 | 2 | 4 | 3 |
| Total | 111 | 100 | 192 | 100 | 143 | 100 |
| Not responded | 25 | | 22 | | 8 | |
| Total | 136 | | 214 | | 150 | |

Methods used by people to control crop damage by primates

Methods used to prevent primates from entering gardens are described in Table 10. The most common methods used to chase away monkeys were firecrackers, catapults, and wooden or plastic face masks. During the study period some people had been using air rifles to chase monkeys from their gardens, a new addition to control methods.

Recommendations to control crop damage by primates.

Suggestions by informants to reduce primate crop damage were: 46% wanted monkeys relocated into other areas; 30% suggested sterilizing them to control population growth; 9% think government authorities should provide mitigative strategies; 10% wanted permission to use guns; and 5% suggested killing monkeys (5%).

DISCUSSION

Crop damage by primates and other wild animals

Although most studies on human-primate negative interactions were concentrated on commercial farming,

the present study mainly focused on the human-primate interactions occurring due to crop raiding of primates on home gardens. In the semi urban and rural areas in Sri Lanka, local people grow crops such as coconuts, banana, jack fruits, areca nuts, vegetables, and different kinds of spices in their home gardens to meet their daily food needs. Before the intensification of crop raiding, people have been able to obtain their daily food needs and an additional income from their home gardens. This way, they do not have to spend much money to buy food items. Home gardening has been a very important means of maintaining their economic status for generations.

However, at present, people are facing many problems as wild animals have started to frequently raid home gardens to take food (Nahallage & Huffman 2013; Cabral et al. 2016; Dela et al. 2016; Perera & Vandercone 2016; Prasad et al. 2016; Rudran & Kotagama 2016; Cabral et al. 2018; Dittus et al. 2019). The majority of home gardens in the study area are comparatively small (less than 1 acre) and primates cause extensive damage to these small-scale garden cultivations. The majority of the informants of all three GN divisions complained that they cannot get adequate harvest for their daily needs and that they had to buy coconuts and vegetables from the market. This is creating a new economic burden

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Table 4. Types of home garden crops cultivated in the respective GN divisions.

| Types of crops | Hathanapitiya (%) | Aruggammana (%) | Karagala (%) |
|----------------|----------------------|--------------------|--------------|
| Coconut | 18 | 14 | 13 |
| Banana | 12 | 9 | 7 |
| Jack Fruit | 11 | 14 | 13 |
| Areca nut | 11 | 13 | 13 |
| Pepper | 8 | 11 | 10 |
| Avocado | 5 | 6 | 4 |
| Vegetables | 5 | 1 | 3 |
| Теа | 4 | 8 | 11 |
| Clove | 3 | 8 | 6 |
| Rubber | 2 | 3 | 3 |
| Yams | 2 | 2 | 3 |
| Pineapple | 1 | 1 | 1 |
| Durian | 1 | 2 | 1 |
| Breadfruit | 1 | 1 | 1 |
| Magnus | 1 | 0 | 2 |
| Betel | 1 | 1 | 2 |
| Nutmeg | 0 | 0 | 1 |
| Cardamon | 0 | 0 | 0 |
| Other | 12 | 7 | 7 |

as these people are in the low-income group and face economic hardships because of the crop damage. The crops that are mainly affected by primates and other wildlife were coconuts, bananas, and vegetables, the key food varieties of these communities. The animals that are causing considerable damage to coconuts were Toque Macagues in all three study areas. According to informants, macaques visit the gardens daily and drop the young coconuts to the ground and also peel off the mature coconuts and eat the soft flesh inside. This way, many immature nuts get destroyed resulting in a decrease in the total harvest. During the field visits the authors were able to observe these young coconuts piled up by the side of the garden. Furthermore, the macaque visits were not limited to a particular time of the day, and they stayed for a long time which escalated the scale of damage. This situation has led some people to abandon growing and tending coconut trees, as they believe that it was a waste of time and money. At present, people are buying coconuts from the nearby markets for their own consumption. Coconuts have been one of their main additional income generating crops. Therefore, currently the people not only have to spend money to buy coconuts but have lost their additional income as well. However, Purple-faced Leaf Langurs were not

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Table 5. Monthly income obtained from home gardening.

| GN Division | Hathna | apitiya | Arugga | ammana | Karaga | la |
|----------------------|---------|---------|---------|--------|---------|-----|
| | Present | | Present | | Present | |
| Income | N | % | N | % | N | % |
| No income | 136 | 100 | 202 | 94 | 92 | 62 |
| Less than SLR 10,000 | 0 | 0 | 9 | 4 | 49 | 32 |
| More than SLR 10,000 | 0 | 0 | 3 | 2 | 9 | 6 |
| Total | 136 | 100 | 214 | 100 | 150 | 100 |

| GN Division | Hathnapitiya (%) | Aruggammana (%) | Karagala (%) |
|--------------------------|---------------------|--------------------|-----------------|
| Toque Macaque | 40 | 34 | 29 |
| Wild Boar | 25 | 30 | 25 |
| Porcupine | 14 | 23 | 21 |
| Purple-faced Leaf Langur | 18 | 7 | 16 |
| Giant Squirrel | 1 | 2 | 3 |
| Rat | 0 | 1 | 1 |
| Snail | 0 | 1 | 1 |
| Coconut Beetle | 1 | 0 | 0 |
| Peacock | 1 | 1 | 1 |
| Parrot | 0 | 0 | 1 |
| Grey Hornbill | 0 | 0 | 1 |
| Other | 0 | 1 | 1 |

Table 6. Animals that are responsible for crop damage.

| GN Division | Hathnapitiya (%) | Aruggammana (%) | Karagala (%) |
|--------------------|---------------------|--------------------|--------------|
| Moring only | 6 | 1 | 3 |
| Evening only | 6 | 1 | 3 |
| Night only | 15 | 0 | 5 |
| Anytime of the day | 67 | 96 | 82 |
| Cannot say | 6 | 2 | 7 |

reported to damage coconut trees in the study area.

The other home garden crop that was mostly affected by the primates was banana. Both Toque Macaques and Purple-faced Leaf Langurs raid banana trees. They not only eat the banana fruits but damage the trees which reduces future harvests as well. Of the two primates, langurs consume the banana most. Informants stated that langurs mostly consume the unripe fruit while the macaques eat the ripe yellow fruit. However, in a separate study, Purple-faced Leaf Langurs were reported to eat ripe fruits in some districts of the country (Dela 2012). Other than bananas, both primate species

Human prímate ínterface ín Srí Lanka

Table 8. The crops utilized by animals.

| GN Division | Hathnapitiya (%) | Aruggammana (%) | Karagala (%) |
|----------------------------|---------------------|--------------------|--------------|
| Coconut | 22 | 29 | 21 |
| Vegetables | 19 | 4 | 9 |
| Banana | 15 | 12 | 12 |
| Yams (kiri ala, casava) | 12 | 16 | 15 |
| Pepper | 4 | 9 | 10 |
| Areca nut | 3 | 6 | 8 |
| Jack Fruit | 4 | 6 | 5 |
| Pineapple | 2 | 1 | 1 |
| Теа | 1 | 4 | 5 |
| Avocado | 1 | 1 | 1 |
| Rubber | 1 | 2 | 1 |
| Bread Fruit | 1 | 1 | 1 |
| Betel | 1 | 2 | 3 |
| Durian | 1 | 1 | 0 |
| Nutmeg | 1 | 0 | 1 |
| Cardamom | 1 | 0 | 0 |
| Clove | 0 | 0 | 1 |
| Other | 11 | 6 | 6 |

were reported to consume jack fruit, pineapple, other available fruits, vegetables, and yams, depending on the season. In general, macaques cause more damage to crops than langurs in all the districts in the country. The omnivorous macaques consume a diverse range of food items including fruits, leaves, bark, flowers, seeds, roots, cereals, insects, other invertebrates, eggs, small mammals, birds, and food prepared by humans. Owing to these diverse food habits and larger group sizes, macagues can adapt to any environmental condition and hence cause more damage than the two langur species. According to the study conducted by Prasad et al. (2016), of the complaints received by the Wildlife Department, 54% were against macaques and 29% against Purplefaced Leaf Langurs. Out of these, 70% were related to crop damages; however, the primate species responsible for crop damage was different in different parts of the country. According to the study of Perera & Vandercone (2016), in Mihintale Kaludiyapokuna forest edge farms, Gray Langurs and Toque Macaques were responsible for 78% and 22% of the reported crop damages, respectively. Purple-faced Leaf Langurs were not recorded to damage crops in that area. A study carried out by Dittus et al. (2019) in Polonnaruwa reported similar results indicating that macaques and Gray Langurs were responsible for human-primate interactions rather than the Purple-

| Table 9. Types of property | damage caused | by Toque | Macaques | and |
|----------------------------|---------------|----------|----------|-----|
| Purple-faced Leaf Langur. | | | | |

| Type of Damage | Hathnapitiya (%) | Aruggammana (%) | Karagala (%) | | |
|---|---------------------|--------------------|--------------|--|--|
| Macaques | | | | | |
| Damage household goods | 15 | 25 | 27 | | |
| Consume foods that are inside the house | 35 | 31 | 37 | | |
| Defecate inside the house | 25 | 22 | 23 | | |
| Damage roofs | 24 | 17 | 10 | | |
| Other types of damages | 1 | 5 | 3 | | |
| Purple-faced Leaf Langur | | | | | |
| Damage roof | 15 | 1 | 0 | | |
| No damage | 85 | 99 | 100 | | |

Table 10. Methods used to reduce the crop damage by Toque Macaques.

| GN Division | Hathnapitiya (%) | Aruggammana (%) | Karagala (%) |
|---------------------|---------------------|--------------------|--------------|
| Catapult | 21 | 33 | 30 |
| Firecrackers | 42 | 36 | 30 |
| Masks | 10 | 7 | 10 |
| Hanging tin cans | 1 | 0 | 0 |
| Nets to cover crops | 2 | 3 | 6 |
| Boards | 1 | 1 | 6 |
| Shouting | 11 | 4 | 4 |
| Black cloth | 1 | 1 | 1 |
| Air rifles | 0 | 1 | 1 |
| Use of dogs | 0 | 1 | 1 |
| Clapper board | 0 | 1 | 1 |
| Others | 11 | 12 | 10 |

faced Leaf Langurs. In Western province, it is the Purplefaced Leaf Langurs that cause the most damage to home garden crops (Dela 2007; Rudran 2007; Nahallage et al. 2008; Cabral et al. 2016; Prasad et al. 2016; Nahallage 2019). The other factors that are responsible for crop damage are the availability of natural foods, the variety of crops grown, seasonality, distance from the forest and the people's perceptions (Hill 2005). According to some informants in Hathnapitiya GN division, the frequency of primate visits was less during the months of January to July as it was the fruiting season and monkeys could find food in the forests where they live.

In addition to primates, the other wild animal species that are responsible for crop damage in the study area are the two nocturnal mammals: the Wild

Boars and porcupines. These animals mainly damage the vegetables and the yams that people grow. Next to macaques, Wild Boars caused the most damage to cultivations followed by porcupines. Most of the people in the three GN divisions have stopped cultivating home garden crops due to the crop damage caused by wildlife resulting in the decrease of the harvest and income as well.

In addition to crop damage, primates were the only wildlife species reported to damage property. Macaques were reported to have damaged the household goods such as pots, pans, plates, rice cookers, and furniture. When they are able to enter into a house in an unguarded moment, they consume the foods stored inside cupboards and racks, runaway with the cooked and other types of dry foods, defecate inside the house and damage roofs as well. Similar incidence was reported in Kandy district where macagues were responsible for taking food by force, damaged the roof, and damaged the infrastructure (Cabral et al. 2016). Compared to macaques, langurs cause less property damage and the only reported damage by the langurs (PFL - present study and Gray Langur – Dittus et al. 2019) was to roofs due to their large body size. In the study area, people used wire meshes and wood planks to cover their windows and spaces between the roof and the walls. This successfully cut down the multiple entry points of the monkeys to one's house (CN personal observation). This leaves the monkeys to come into the house either from the back or front door, which only the boldest ones would try.

Methods used by people to reduce crop damage

People believe that over the years the primate populations have increased and many now consider them as pests due to crop damage. The methods used by people in the study area to reduce primate crop damage were similar within the country as well as in other countries. The most common methods were the use of stones, firecrackers, shouting, and catapults to chase the primates away from their properties with very little success (Nahallage et al. 2008; Hill & Webber 2010; Dittus et al. 2019). The monkeys get used to or learn to avoid these methods and with time the methods become less effective. People abstain from hunting, killing or poisoning monkeys due to their religious beliefs and most of the time are tolerant of their behaviors (Nahallage & Huffman 2013), or they employ methods just to chase the monkeys from their home gardens. The people in the study area wear long black cloths with a wooden or plastic face mask and carry a stick to scare the monkeys, or point a gun shaped wooden stick at them.

This seems to work better compared to other methods. In the study area, the most effective technique was air rifles. The monkeys were afraid of them. However, since the air rifles were expensive most people cannot afford to buy them. In addition, people wrap thorny branches of jackal jujube Ziziphus oenoplia and lime Citrus aurantifolia around banana bunches or on the fronds to prevent monkeys from getting to the fruits or they cover the banana bunches with nylon nets or bags. To protect coconuts, they wrap aluminium sheets around coconut trees to prevent macaques climbing the trees. Further they sprinkle cow dung mixed with water on coconuts and the informants believed that macaques dislike the smell of cow dung. During a survey in the Northwestern province CN observed that in some coconut plantations, people covered the young coconut bunch with iron mesh so macaques could not reach the coconuts. However, the owner of the plantation informed this was both time consuming as well as costly and that they must increase the mesh size when the coconuts increase in size (CN personal observation). This is not practical to implement in large coconut estates. The use of dogs to chase the monkeys has not been much in practice in the present study areas. The most effective method the informants used to protect crop damage by wild boar was to cover the vegetable beds with sarees to keep the wild boars away. To protect the vegetables from porcupines, people sprinkled human hair around the vegetable beds. They reported that the porcupines dislike this and try to evade such vegetable beds. This method too was not practical in the long run because the hairs get blown away with the wind and the rain dampens it reducing its effectiveness.

Mitigative actions to control the damage caused by monkeys

To reduce the damage caused by primates to home garden crops, the majority of people wanted the monkeys to be relocated to another area or sterilized them to control population growth. Relocation of monkeys has detrimental effects to the monkeys if not managed properly. For the relocation to be effective, the monkeys have to be transported to a similar environment or ecological zone that they were used to. Otherwise, it will not be possible for them to adapt to the new environment successfully and will have trouble finding necessary food sources and might die of starvation. Therefore, effective post translocation monitoring mechanisms should be implemented. Further, translocation of monkeys who were used to living close to human settlements (and utilize human grown crops) to remote areas also will not be effective as the monkeys will go in search of nearby human habitats. Thus, relocation might temporarily solve the problem in one location but will spread the problem to other parts of the country (Nahallage 2019; Dittus et al. 2019).

Sterilization of the monkeys will be effective to some extent. Though sterilization requires manpower, veterinary expertise, and money, it is a permanent solution for population control (Jayalath & Dangolla 2011). In addition, some countries use birth control as an effective strategy of fertility control (Shimizu 2012). This is most applicable to monkeys that are seasonal breeders, making the process reversible, allowing them to resume their normal cycles and normal pregnancies later. With further studies and investigations there is a high possibility to apply this method successfully in Sri Lanka as well.

Further, the informants want the government to take some initiatives for control and advise them on how they could best control the situation. So far, the authorities have not conducted awareness programs for the villagers. According to the discussions the authors had with the villagers during data collection and field visits, it was obvious that they do not know much about the primates in their area or even that the primate species are endemic to the country. Thus, it is important that the villagers understand the behaviors, life histories and the factors that drive these primates to the villages. This awareness would give them an insight into the issue and help them to act accordingly. During the field visits, intentional provision of food to primates and keeping primates as pets were not observed in the study area. However, garbage dumping sites and macaques feeding on garbage dumping sites were observed in all three divisions

Therefore, the authors recommend the following mitigative actions to control the situation; conduct awareness programs, introduce proper garbage disposal mechanisms, enrichment of the natural habitats of the primates and to facilitate long term research to gather more information.

CONCLUSION

For decades, scientists and primatologists across the world have been conducting research studies related to human primate interactions to find ways to minimize damage to both parties concerned, such as damage to crops and properties of humans and killing and wounding of primates. Though these studies provide many useful

recommendations, none of them were able to provide plausible long-term solutions to mitigate this problem. Nahallage et al. (2018), proposed to use an integrated management plan (IMP) to minimize the damage to the conflicted parties. The integrated management plan is mainly based on the: a) biology and the behavior of the primate; b) occurrence and the level of damage; c) habitats; and d) interaction between the primates and the humans. With this method, the local authorities, with the help of the experts have to decide the control strategies for each of the above-mentioned components and select control methods that are suitable to local conditions and implement them with the cooperation of relevant stakeholders. However, future research is needed to test this plan with different primate species and under different environmental conditions.

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ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

January 2022 | Vol. 14 | No. 1 | Pages: 20311–20538 Date of Publication: 26 January 2022 (Online & Print) DOI: 10.11609/jott.2022.14.1.20311-20538

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