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CONSERVATION ISSUES

Small Mammals Vulnerable to Climate Change

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KEY NOTE

Preliminary observations on invasive behaviour of *Ratufa macroura* (Pennant, 1769) (Rodentia: Sciuridae) in traditional home gardens in Sri Lanka.

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Abstract: A study shows that Giant Squirrels (*Ratufa macroura*) have become a serious constraint on various crops in traditional home gardens in Sri Lanka in recent times. Traditional home gardens in Sri Lankan rural villages are essentially mixed cropping with a variety of tree species that provide food, fruits, timber, medicine and spices. Giant squirrel is endemic to southern India and Sri Lanka and considered as a near threatened species in IUCN global list of Threatened Species. We studied the elementary damage caused by Giant Squirrels to home gardens in Anuradhapura, Kandy, Matale, Polonnaruwa and Ratnapura districts of Sri Lanka. Giant squirrels' propensity to chew on various edible and inedible objects caused damage to fruit crops, food crops and spices intensively. Collectively, they damage more than 30 Crop species. They appear to destroy more than they consume and damage fruits, seeds, leaves and branches of trees. Taxa found in dry Zone, intermediate Zone and mid hills cause excessive damage than the taxon found in the low land wet zone. People in rural areas, where we conducted our survey, consider Giant Squirrels as a pest. We assume that the population has increased rapidly within the last two decades. Converting forested areas into mono-crop fields also obsessed them to visit mixed crop home gardens. However, we should conserve these extremely attractive furry creatures essentially, though we consider the animal as pest from our view, in fact, anthropogenic activities has driven them to invade our own home gardens.

Keywords: Giant Squirrel, Animal-human conflict, Pest, Home gardens, Sri Lanka

Introduction

The indigenous architecture of Sri Lanka has its origins in the pre-historic period, dating back over 6000 years [2]. The traditional landscaping and indigenous architecture in Sri Lanka's villages is characterized by traditional home gardens, which comprises a number of species, rendering a natural ecosystem with increased diversity of flora and fauna. Home gardens in Sri Lanka are widespread and vary in species composition and tree density [1]. A survey on the taxonomic composition on plants in traditional home gardens in central Sri Lanka conducted by Hohegger (1998) was able to document 640 species, with a species richness ranging from 22 – 170 (mean: 53 species) species of trees, shrubs and herbs per home garden [3]. The survey conducted by Bambaradeniya (2003) on vertebrate fauna that inhabit and/or visit the traditional home garden-rice field managed landscapes in Sri Lanka was also able to document 250 species, with 37 mammals including the Giant Squirrel (*Ratufa macroura*).

Ratufa macroura is endemic to southern India (Kerala and Tamil Nadu) and Sri Lanka [7]. In India it is known from only five severely fragmented locations [7], while it has an island-wide distribution in Sri Lanka [18]. Moreover, the IUCN global list of Threatened Species listed *R. macroura* as a near threatened (NT) species, while it is listed as Vulnerable (VU) in the 2007 Red List of Threatened Fauna and Flora of Sri Lanka. The species is confined largely to riverine habitats in the rain shadow areas of southern India and feeds primarily on the seeds of immature and mature fruits from trees and climbers [5; 10]. In Sri Lanka, it inhabits forests and woodlands [18], including protected areas and wooded anthropogenic habitats. Clearly distinguished three subspecies of Giant squirrels, varying by color and size probably induced by the prevailing climatic conditions, has been described from Sri Lanka. They are *R. macroura macroura*, *R. macroura melanochra* and *R. macroura dandolena*, respectively distributed in the Lowland Wet Zone, Highland Wet Zone and Dry Zone [18] of Sri Lanka.

Rodents are arguably the most important mammalian pests at the global level [17]. In the recent times in Sri Lanka Giant Squirrel, which is a member of the order Rodentia, is under threat due to being seen as a pest by local villagers in some areas of Sri Lanka. Their propensity to chew on various edible and inedible objects causing damage to fruit crops, food crops and spices intensively, local villagers consider them as vermin. Therefore, in order to document the range of fruit and food crops damaged by *R. macroura* and the extent of the damage we studied home garden habitats in selected areas in Sri Lanka.

Materials and methods

A detailed study conducted on the elementary damage caused by Giant Squirrels in home gardens in Anuradhapura, Kandy, Matale, Polonnaruwa and Ratnapura districts. Visual encounter survey methods and participatory observations in home gardens, agricultural lands and forests were used to conduct the study. Semi-structured interviews and group discussions were conducted in each village. Household questioners and secondary information were also gathered from villagers.

Results

Ratufa macroura feed on fruits, flowers, seeds, young leaves and shoots, and the villagers are not pleased or do not take the ravaging of tasty fruits, food crops, cash crops and spices in their home gardens lightly. According to the study, various perennial home garden species are consumed or damaged by *R. macroura* in Sri Lanka. These plants could be broadly categorized as fruit crops, food crops, cash crops and spices. In addition, they consume or damage several parts of plants such as, the fruit (immature fruit or mature fruit), kernel, flower buds, flowers or inflorescence, tender leaves, mature leaves, sprout, stalks and branches. In the study, we recorded more than 34 plant species belonging to 24 families consumed by *R. macroura* in Sri Lanka. In fruit crops, *R. macroura* always consume the mature fruit whether it is ripe or not. It necessarily wastes the immature fruit by gnawing it. Sometimes mature fruits are also wasted due to gnawing without consumption. It uses the foliage of different crop varieties or other perennial plants as nest materials. People regard *R. macroura* as a vermin when it collects foliage from fruit, food and cash crops or spices in home gardens. In addition, we observed *R. macroura* to gnaw on tender leaves, sprouts and branches of many home garden perennial species. We did not observe violent territorial

behaviors among the individuals of *R. macroura* during the study. They usually visit particular trees in a given area routinely. Habitually it does not gnaw on the entire fruit or branch, instead it partially gnaw them and cast off. Woody shell of some fruits such as *Limonia acidissima* and *Aegle marmelos* (Family: Rutaceae) is peeled off easily by their sharp *incisors*. *Coconut (Cocos nucifera)* (Family: Arecaceae) is the most valued cash crop by villagers, and *R. macroura* damage the inflorescence, aborted fruits, mature fruits, sprouts and branches of the trees. Giant squirrels do not consume any plant part of Coconut tree but they entirely damage the younger plant parts. Because of the extensive damage caused by gnawing on young shoots, buds, sprout, tender leaves and branches of various species of home garden perennial crops the Giant squirrel is considered as a major pest in the Study areas.

According to the results, *R. macroura* mainly feed on and damage fruit crops. Particularly it damages the cash crops *Cocos nucifera* significantly. In addition, in the intermediate zone and lower elevations of hill country areas *R. macroura* cause damage to spices such as *Syzygium aromaticum*, (Family: Myrtaceae), *Myristica fragrans* (Family: Myristicaceae), *Theobroma cacao* (Family: Sterculiaceae), *Piper nigrum* (Family: Piperaceae) and *Tamarindus indica* (Family: Fabaceae). However, people consider the damage caused to Coconut as the major prevailing loss to their income and livelihood.

Discussion and Conclusions

In some areas of Sri Lanka *R. macroura* is considered as a pest of different kinds of commercially valued plant species in home gardens and plantations. Traditional home gardens in Sri Lanka, which comprises a number of plant species, have their special characteristics of species composition and tree density according to the ecological zone and located terrain. These man-made, semi-natural ecosystems are mostly cultivated by perennial species with the prospective of daily use for consumption, cuisine and for use as a medicine. They are also an economically viable form of land use [13, 2]. Invasion of *R. macroura* into home gardens and plantations cause serious livelihood and economic constrains on rural villager's lifestyle.

Table 1. List of plant species consumed and damaged parts of plants by *R. macroura* in Sri Lanka.

Family	Species	Sinhala name	Common English name	Crop type	Plant part damaged
Anacardiaceae	<i>Spondias dulcis</i>	Ambarella	Golden Apple	Fruit crop / Food crop	Immature fruit/ Mature fruit
Anacardiaceae	<i>Mangifera indica</i>	Amba	Mango	Fruit crop / Food crop	Immature fruit/ Ripe fruit/ Tender leaves
Anacardiaceae	<i>Anacardium occidentale</i>	Kaju	Cashew fruit	Fruit crop	Immature fruit / Mature fruit
Annonaceae	<i>Annona muricata</i>	Katu anoda, Katu-attha	Sour sop	Fruit crop	Immature fruit/ Mature fruit
Annonaceae	<i>Annona reticulata</i>	Anoda, Attha	Bullock's Heart	Fruit crop	Immature fruit/ Mature fruit
Annonaceae	<i>Annona quamosa</i>	Geta Attha, Sini-attha	Custard-apple, sweet-sop	Fruit crop	Immature fruit/ Mature fruit
Apindaceae	<i>Nephelium lappaceum</i>	Rambutan	Rambutan	Fruit crop	Immature fruit/ Mature fruit
Arecaceae	<i>Areca catechu</i>	Puvak	Areca-nut, Betel nut palm	Cash crop	Husk/ Sap
Arecaceae (Palmae)	<i>Cocos nucifera</i>	Pol, Thambili,	Coconut, King coconut	Cash crop	Inflorescence/ Aborted fruit/ Mature fruit/ Sprout/ Branches
Bombacaceae	<i>Durio zibethinus</i>	Dooriyan	Durian	Fruit crop	Flower/ Immature fruit/ Mature fruit
Caricaceae	<i>Carica papaya</i>	Gaslabu, Papol	Papaya	Fruit crop	Ripe fruit
Cucurbitaceae	<i>Sechium edule</i>	Chow chow	Chayote	Food crop	Tender leaves/ Immature fruit/ Mature fruit
Clusiaceae	<i>Garcinia mangostana</i>	Mangus	Mangosteen	Fruit crop	Immature fruit/ Mature fruit/ Leaves
Elaeocarpaceae	<i>Elaeocarpus serratus</i>	Weralu	wild olive	Fruit crop	Immature fruit
Euphorbiaceae	<i>Phyllanthus emblica</i>	Nelli	Aamla, Indian gooseberry	Fruit crop	Mature fruit
Fabaceae	<i>Tamarindus indica</i>	Siyambala	Tamarind	Spice	Pod-like fruit
Lauraceae	<i>Persea americana</i>	Aligeta pera	Avacado	Fruit crop	Immature fruit/ Fruit/ kernel/ Tender leaves

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Moraceae	<i>Artocarpus altilis</i>	Rata-del	Breadfruit tree	Food crop	Buds/ Young leaves/ Immature fruit/ Mature fruit
Moraceae	<i>Artocarpus heterophyllus</i>	Kos, Herali	Jack fruit	Food crop	Compound spike/ Ripe fruit
Moringaceae	<i>Moringa oleifera</i>	Murunga	Drumstick tree	Food crop	Drumstick fruit
Musaceae	<i>Musa</i> spp.	Kesel, Kehel	Banana, Plantain	Fruit crop/ Cash crop	Fruit
Myristicaceae	<i>Myristica fragrans</i>	Sadikka	Nutmeg	Spices	Fruit, leaves
Myrtaceae	<i>Syzygium aromaticum</i>	Karabu-neti	Clove	Spices	Leaves/ branches/ Flower buds
Myrtaceae	<i>Psidium guajava</i>	Pera	Guava	Fruit crop	Immature fruit/ Mature fruit
Myrtaceae	<i>Psidium guajava</i>	Kilo pera	Giant Guava	Fruit crop	Immature fruit/ Mature fruit
Myrtaceae	<i>Psidium littorale</i>	Bangali Pera	Strawberry Guava	Fruit crop	Immature fruit/ Mature fruit
Passifloraceae	<i>Passiflora flavicarpa</i>	Val dodam	Passion fruit	Fruit crop	Immature fruit/ Ripe fruit
Piperaceae	<i>Piper nigrum</i>	Gam-miris-wel	Black pepper	Spices	Leaves/ Stalks
Punicaceae	<i>Punica granatum</i>	Delum	Pomegranate	Fruit crop	Mature fruit
Rutaceae	<i>Citrus reticulata</i>	Naran	Mandarin	Fruit crop	Ripe fruit
Rutaceae	<i>Citrus aurantium</i>	Ambul bodam	Sour orange	Fruit crop	Ripe fruit
Rutaceae	<i>Limonia acidissima</i>	Divul	Wood apple	Fruit crop	Immature fruit/ Woody shell/ Kernel
Rutaceae	<i>Aegle marmelos</i>	Beli	Bael	Fruit crop	Immature fruit/ Woody shell
Sapotaceae	<i>Chrysophyllum roxburghii</i>	Lawulu		Fruit crop	Immature fruit/ Ripe fruit
Sterculiaceae	<i>Theobroma cacao</i>	Koko, Kokova	Cocoa	Spices	Immature fruit/ Mature fruit/ Leaves/ Kernel

According to the people interviewed, the problem arose within the last 20 years and before that *R. macroura* was rarely seen around human settlements. Villagers believe a reduction of hunting Giant Squirrels for food and uncommonness of their natural predators in traditional home gardens have caused an extensive population increase within last few decades. It is believed that the conversion of forested areas into mono-crop fields is a major reason for the Giant Squirrels to visit mixed crop home gardens. Presumably, they seem to have adapted well to living in the home garden habitats with the concurrent loss of their natural forest environments.

Giant squirrels appear to destroy more than they consume because of their gnawing habits. Mostly, immature fruits, tender leaves, buds, shoots and branches are subjected to gnawing. This causes a serious problem in propagation and growth of next generation of plants even without considering the economic damage caused by them. Although, only few species of cash crops are damaged or consumed, livelihood of people is intensively affected due to the damage caused to cash crops. A study in Sinharaja Lowland tropical rain forest in Sri Lanka shows that Giant Squirrels choose a wide variety of fruit types [9]. Similarly, they feed on home garden varieties. Since they do not consume the entire fruit and waste immature fruits, people try to control them using several destructive methods such as lighting crackers, setting up noose traps or shotguns.

Eighteen species of rodents are considered as pests in agriculture, horticulture, forestry, animal and human dwellings and rural and urban storage facilities in India [15]. Although *R. macroura* inhabits South Indian forests, records are not available on vermin activities of it. In the study areas of the Sri Lanka where the squirrels cause an irksome damage to home gardens, inhabitants use catapults to scare the squirrels or sometimes shoot them with guns obtained with a government license. As a result, many squirrels are killed especially in the commercial Coconut cultivations.

However, the problem of *R. macroura* invading home gardens is twofold; first, it severely affects the household economy and the livelihood of villagers. Secondly, it may decrease the food security of the villagers. This is because, traditionally villagers in Sri Lanka maintain a home garden for the fundamental purpose of obtaining consumable goods easily such as fruits and for cuisines. The majority of tree species found in home gardens are indigenous with multi-purpose uses [1] and people collect number of varieties of fruits, vegetables, spices and medicines.

However, with the modern socio-economic environment, which is based on financial or monetary assets, an added value has attributed to home gardens. Consequently, people used to harvest various, most essential foods and fruits within their home range without an expense. Moreover, a big economic demand has risen on some varieties of food crops such as Coconut (*Cocos nucifera*), Breadfruit (*Artocarpus altilis*) and fruit crops such as Banana (*Musa spp.*), Durian (*Durio zibethinus*), Mangosteen (*Garcinia mangostana*) and ect. Essentially, economic demand has immensely increased on all valuable home garden - plant varieties with the human population growth. On the other hand, a diverse home garden provides a good supply of year around food and fruits for household consumption. This produce is used by the owners and by the surrounding community, and remainder of the harvest is sold. Therefore, home gardens provide food security, nutrient requirement and economic benefits to the owners. Indirectly, these semi-natural ecosystems, which are full of perennial trees, provide many ecosystem services. These managed landscapes also play a significant role in linking fragmented natural forests and wetlands, as complementary corridors that facilitate the movement of wild animals [4]. Hence, damage on multi-benefit home garden systems by *R. macroura* or any other animal effect severely on household economy and lifestyle of rural villagers.

The general habits of the subspecies of Giant Squirrel found in the Dry Zone of Sri Lanka appear to be very similar to that of the other sub species, with the exception that, in many cases, it appears to be less wary of humans [18]. In our study, we observed a distinguishing behavior between the Giant Squirrel subspecies in the Dry Zone and Highlands of Sri Lanka. Taxa found in the dry Zone, intermediate Zone and mid hills cause excessive damage to home gardens even with the human interference. However, the lowland wet zone subspecies rarely visits home gardens or anthropogenic habitats and seems to be wary of humans.

Threats identified broadly for non-volent small mammals in South Asia, are habitat loss and degradation due to agro-industry farming, small-scale logging, selective logging, increase in human settlements, forest fire, interspecific competition, competition from introduced species, hunting for local consumption purposes and presence of domestic predators [14]. Habitat loss and hunting continue to reduce *R. macroura* numbers significantly throughout most of its ranges in India [11, 12, 14], although it is not properly documented in Sri Lanka.

It is suggested that species such as those occurring in the Indian mainland and in Sri Lanka (e.g. *R. macroura*) needs taxonomic clarification due to their isolated distribution and relatively specialized distribution in the two countries [14]. We presume and that the Sri Lankan subspecies could be upgraded into species level if comprehensive taxonomic research is conducted.

Although, animal-human conflicts are common throughout Sri Lanka, conflicts with elephants (*Elephas maximus*) and mosquitoes (*Aedes aegypti*, *Aedes albopictus*, *Anopheles* spp., *Culex quinquefasciatus*) are only documented at least for a certain extent. Yet, highly localized conflicts between human and other wild animals such as Indian Peafowl (*Pavo cristatus*), Wild boar (*Sus scrofa*), Macaque (*Macaca sinica*), Porcupine (*Hystrix indica*), Giant Squirrel (*R. macroura*) are not yet properly investigated. However, we should not consider *R. macroura* as a vermin since they play an important role in ecosystems such as contributing to seed dispersal and are a food source for predators. It is most likely that anthropogenic activities could have driven them to invade our home gardens.

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