The Ecology of Urban Squirrels in Singapore

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ABSTRACT

In this study, observational studies were conducted on the population of plantain squirrels on the Kent Ridge campus of the National University of Singapore. Focal animal sampling was used, and activities of squirrels recorded down when they were located. Squirrels were observed to inhabit a range of vegetation types found on the campus, and majority of plant material consumed by the squirrels originated from non-native plants. Few competitors for similar foods were found, and no observations of predation on squirrels were observed. Caching and retrieval of food was also observed. It was concluded that squirrels are pre-adapted in several ways to flourish in a wide variety of habitats, including sparse vegetation. Urban vegetation has lowered the amount of competition from other animals otherwise present in unmanaged vegetation and reduced the risk of predation, allowing for the exploitation of new niches by the squirrels.

INTRODUCTION

The plantain squirrel *Callosciurus notatus* is one of the most prominent native mammals in Singapore, and among few rain forest species that have successfully colonized urban environments. Originating from primary and secondary rain forests, mangroves and scrublands (Medway 1969), its range now includes gardens, parks and urban areas such as housing estates (Baker and Lim 2007). Despite the plantain squirrel's pervasive presence in Singapore's urban landscape, little is known about its ecology, and no in-depth discussion of its successful urbanization exists. However, research done on squirrels in a variety of habitats has often pointed towards the distinct adaptability of the plantain squirrel to different habitats. This may be a crucial trait explaining their ubiquity, when all other squirrel species in Singapore are limited in their range or are extinct.

Such knowledge of the adaptability of plantain squirrels is important to the explanation of its current range in Singapore. However, there is still very little data on urban plantain squirrels, and the purpose of this investigation is therefore to explore the reasons why the plantain squirrel has successfully adapted to a landscape vastly different from its native habitat. While plantations in Southeast Asia generally consist of exotic plants and also differ from natural vegetation, open urban landscapes in Singapore represent an entirely alien habitat as opposed to the denser monocultures of plantations.

The potential use of understanding urban squirrels is its application to the pest control in plantations, where plantain squirrels are destructive to agricultural crops (Duckett 1982). This knowledge can also contribute to a better understanding of invasion capabilities, which appear to be a genus-level trait in *Callosciurus* species. Biological invasion is a significant threat to biodiversity, and while the plantain squirrel itself is not an introduced or invasive species, other *Callosciurus* species exist outside of their natural ranges

MATERIALS AND METHODS

Specific routes were plotted along the Kent Ridge campus of the National University of Singapore. Routes were plotted such that they provided a clear view of as much vegetation as possible. This method was chosen over dividing the campus into regular grids or using straight transect lines, due to the uneven distribution of vegetation and buildings. In total, 106 hours of surveys were carried out along these routes. Focal animal sampling was used. When a squirrel was spotted, it was observed until lost, with the aid of a pair of binoculars where necessary. Its behaviour and elevation was recorded and food items consumed were identified. An observation was considered as one sighting, regardless of the number of squirrels sighted. However, the number of squirrels in each sighting was noted. The ranges of the squirrels were plotted onto a map and all data recordings exceeding five minutes were transcribed and an activity budget created.

RESULTS

Altogether, 31 squirrels were located on the campus, and their ranges can be seen in Appendix 2. Only 12 out of the total 55 sightings were of solitary squirrels. The squirrels were observed in a variety of habitats, though they were invariably found near trees. There appeared to be no preference for the location of trees, and the squirrels were found near main roads and buildings, as well as more isolated areas.

Squirrels were adept at jumping long distances between trees, and the longest jump observed measured 3 m. They were comfortable at all elevations on plants, and were often found on the ground and on artificial surfaces. Out of the total 55 sightings, 18 involved observations of squirrels on the ground and artificial surfaces.

Squirrels were found to consume mostly plant material from exotic plants. Exotic fruits included rain tree exocarps, chiku, Macarthur and *Adonidia merrillii* fruits. Other food included cannonball tree flowers, and insects, bark and leaves from a wide range of native and non-native plants.

Caching behaviour was observed in seven independent observations. Four instances were observed of squirrels picking items off trees and hiding them and three instances of removing food from caches was observed. It was observed that caching or retrieving was never done in the presence of other squirrels, and if any other squirrels were nearby, they were on other trees a distance away.

Although in a constant state of alertness, the squirrels were observed to ignore the presence of many common birds, including Javan mynas, olive-backed sunbirds, and black-naped orioles. Upon hearing the calls of larger birds such as cockatoos and crows, however, the squirrels assumed an alert position.

The activity budget revealed that up to 62% of time was spent on food foraging and eating, 15% spent on movement, and the rest spent on the other categories.

DISCUSSION

The data from this study revealed interesting insights into why the plantain squirrel has flourished in an urban environment. Observations suggested two main explanations for the success of the plantain squirrel; first its adaptability to a wide range of

environments related to traits already observed in its native habitat, and second the accessibility of new niches due to the lack of competitors and predators.

The success of the plantain squirrel in sparse urban vegetation can be attributed to their adaptability to varied vegetation types. In studies comparing presence of mammals in various vegetation types and densities, plantain squirrels are found to thrive in most categories, a trait that is not shared by other squirrels (Tamura and Yong 1993; Saiful et al. 2001; Saiful and Nordin 2004; Nakagawa et al. 2006). Plantain squirrels may therefore be pre-adapted in some ways to survive in a transformed landscape with sparse vegetation.

The human constructions present in an urban environment also appear to be beneficial to the arboreal squirrel, providing clear routes between trees for squirrels to cross. Uncut grass would be difficult for a small mammal to cross, and the squirrels on the campus were rarely seen on grass surfaces at ground level. This preference for artificial surfaces was particularly obvious when squirrels followed a narrow strip of concrete or brick in the middle of a grassy patch.

A prominent discrepancy between data collected in this project and that of previous studies is the range of the squirrels (Saiful et al. 2001, Tamura 1993). However, it is very likely that the ranges of the squirrels in Appendix 2 do not reflect the true range, as squirrels were not tagged and data was based purely on observation.

The caching behaviour observed in this study is a trait seldom discussed in *Callosciurus* species. Although tropical arboreal squirrels are known to cache food when there is a surplus (Becker et al. 1985), little else is known. It is believed that locating of caches by squirrels is achieved through spatial cognition rather than smell, and that squirrels are unable to locate a cache not created on its own (Devenport and Devenport 1998). The squirrels in this study can therefore be assumed to be eating food from their own caches. A possible explanation as to why individuals would search for cached food when there was no shortage of food is the higher intra-species competition arising from increased overlapping of ranges in urban environments.

The absence of competitors in an urban habitat may also explain the plantain squirrel's success. In their natural rain forest environments, the plantain squirrel is likely to co-exist with other species that occupy different niches. In an urban setting, however, competitive species are no longer present, and the plantain squirrel is able to exploit ecological niches previously not available.

The absence of competitors for consumption of exotic plant species may also account for the squirrel's success. Since a significant portion of the managed vegetation on the campus as well as the rest of Singapore is non-native, the natural predators and dispersers of these plants are absent, allowing the plantain squirrel to exploit these resources with reduced competition.

The diversity and quantity of predators that squirrels would encounter is also significantly reduced in an urban setting. Common predators of the plantain squirrel include larger mammals such as leopard cats and snakes, and less common predators include birds of prey (Duckett 1982). No conclusions can be drawn based on predation by snakes due to the fact that no night surveys were conducted. Wild mammals are rare in the urban landscape of Singapore, and birds of prey were rarely sighted within the range of squirrels. This reduced threat from predators may also contribute to the plantain squirrel's apparent ease at the ground level and exposed areas without canopy covering. A difference in the number of alarm calls per unit time between this investigation and that of squirrels in

secondary forest also suggests that urban squirrels are less likely to be threatened by predators. Tamura and Yong (1993) noted that the average number of alarm calls made by plantain squirrels in secondary forests was 10 per 100 hours. In this data set, only one instance of staccato barking was observed in a squirrel out of 33.5 hours of observation.

The activity budget revealed that up 62 % of the squirrels' activity involved food consumption and foraging. This statistic is particularly significant as most of the feeding behaviour is linked to destruction of vegetation rather than beneficial interactions such as dispersal. All fruits eaten were discarded directly below parent trees, effectively reducing the chance of dispersal by other agents, and Cannonball trees were stripped of their unopened flowers before any chance of pollination. Any possible chance of seed dispersal was reduced due to the fact that the squirrels rarely ventured onto grass, and seeds that survived the squirrels' predation and digestion would most likely end up in the tree canopy or on artificial surfaces.

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