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Fruit gardens enhance mammal diversity and biomass in a Southeast Asian rainforest

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ABSTRACT

Protected areas are frequently inhabited by people and conservation must be integrated with traditional management systems. Cultivation of fruit gardens is a low-impact agroforestry technique which alters the structure and composition of forest stands and has the potential to thereby influence animal communities. This is of particular interest in the rainforests of Southeast Asia, where limited fruit availability between intermittent mast fruiting events results in low mammal densities. We assessed how agroforestry practises of an indigenous community affect terrestrial mammal abundance, diversity and assemblage composition within Krau Wildlife Reserve, Pahang, Malaysia. We used baited camera traps to compare mammal abundance and diversity between seven fruit gardens and eight control sites. Fruit gardens contained similar species richness and abundance levels but higher diversity and almost threefold higher mammal biomass. Fruit gardens contained five times as many fruit-producing trees and a positive correlation was found between the number of fruit trees and total mammal biomass. Mammal community composition differed between the two habitats, with fruit gardens attracting nine species of conservation concern. These results suggest that traditional agroforestry systems may provide additional resources for mammals and therefore their net effects should be considered in conservation policy.

1. Introduction

Rainforests throughout the world have a long history of human occupation (Kareiva et al., 2007). This is often associated with shifting agriculture, which favours particular plant species during both cultivation and the subsequent regeneration (van Vliet et al., 2012). Agroforestry promotes favoured species such as fruiting trees, often with a higher nutrient content than the surrounding vegetation (Miller and Nair, 2006). Similar agricultural practises are widespread among indigenous communities throughout South America (Miller and Nair, 2006) and Southeast Asia (Nyhus and Tilson, 2004). Indigenous peoples have occupied and cultivated Southeast Asian forests for over 11,000 years (Hunt and Rabett, 2013). Conflicts frequently arise between the objectives of reserve managers and these communities, with a lack of understanding of the net effects of traditional practises acting as a barrier to their effective integration into conservation management (Aziz et al., 2013).

The rainforests of Southeast Asia are often described as food deserts due to the relatively low abundance of fruits between infrequent mast fruiting events (Corlett and Primack, 2011). Mast fruiting behaviour is displayed by several hundred tree species throughout the region, and in particular by the dominant Dipterocarp tree family (Curran and Leighton, 2000). Events occur at irregular intervals 2–7 years apart and result in synchronous production of large fruit crops over hundreds of kilometres (Numata et al., 2003). Rainforests elsewhere in the world commonly display annual fruit production (Stevenson et al., 2008) alongside a greater abundance of shrubs and small trees which fruit intermittently in the understory (LaFrankie et al., 2006).

Frugivorous animals therefore occur at relatively lower densities in mast fruiting forests where populations are likely to be highly sensitive to the abundance of fruits between mastings (Ghazoul and Sheil, 2010). This relationship has been well documented in primates whose density is reduced in those forests of Gabon which are dominated by masting trees in the Caesalpinaceae, in South America dominated by Lecythidacaeae, and in Southeast Asia dominated by Dipterocarpaceae (Brugiere et al., 2002). The characteristics of this type of forest therefore present a unique set of challenges for conservation as limited food availability leads to low frugivore densities, making populations intrinsically vulnerable to habitat loss. These challenges are further complicated when conservation management also has to consider the effects of traditional practises by indigenous populations within protected areas.

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Krau Wildlife Reserve was gazetted in 1923. The Chewong are an indigenous group native to central peninsular Malaysia who have been present in the reserve since establishment. They have a small population of approximately 400 individuals, around half of whom still live within the reserve boundaries. The Chewong continue to practise traditional cultivation, hunting, fishing and gathering of wild fruits, herbs and plants for medicines (Howell, 1984). Their cultivation techniques include clearings for planted crops alongside fruit gardens which are enhanced with favoured fruiting trees. Fruit garden cultivation involves the selection of suitable patches of forest, removal of certain tree species within these areas (used for building materials or otherwise unwanted), then the planting of fruiting tree species such as durian *Durio* spp., kepayang *Pangium edule* and rambutan *Nephelium lappaceum*. Fruit gardens are lightly tended and fruit is collected annually during the months of June, July and August for up to 50 years. Fruit gardens are contiguous with old growth forest and involve limited forest clearance, maintaining much of the original vegetation composition and structure (Wiersum, 2004). Since favoured species of fruiting trees are planted among the existing vegetation, it is likely that the long-term effect will be to increase fruit resources through higher densities and seasonal availability of annually fruiting tree species.

Our study aimed to investigate how fruit gardens influence the abundance, diversity and composition of terrestrial mammalian frugivore assemblages at this site. We anticipated that (a) fruit gardens would leave a legacy of greater abundance of fruiting trees than natural forest areas, and (b) this would act as a resource drawing in greater abundance and diversity of frugivores.

2. Methods

2.1. Study area

Krau Wildlife Reserve, Pahang, (3°33′ N 102°30′ E; Fig. 1) is approximately 600 km^2 in size, with a range in altitude from 45 to 2108 m above sea level. Vegetation within the reserve predominantly consists of lowland dipterocarp forest (61%), hill dipterocarp forest (22.5%) and upper dipterocarp forest (9%) with minor components of secondary forest (1.1%) and cultivated/cleared land (0.6%) (Chou and Saw, 2006). Contiguous forests in the mountainous North and lowland South-West combine to a total area of 1100 km^2; however forests outside the reserve are highly fragmented by rubber tree and oil palm plantations. Over the past 50 years defaunation of many large-bodied mammal species has occurred in this reserve, with the total loss of the Asian elephant *Elephas maximus*, gaur *Bos gaurus*, Sumatran rhino *Dicerorhinus sumatrensis* and Javan rhino *Rhinoceros sondaicus*, alongside a reduction in numbers of Malayan Tiger *Panthera tigris jacksoni*, Malayan tapir *Tapirus indicus*, sambar deer *Rusa unicolor* and barking deer *Muntiacus muntjak*.

2.2. Sampling strategy

We surveyed two types of plots: fruit gardens and controls (natural forest). Fruit gardens were identified by local guides as areas currently or previously cultivated for growing fruiting tree species for local consumption. Time since establishment varied from 6 to 55 years according to estimates from local elders (30 ± 8, mean ± SE). Fruit gardens are often situated in close proximity to current or abandoned villages within the forest; those selected for study were 1015 ± 446 m from the nearest active village (mean ± SE). Control plots were chosen based on local knowledge as being natural unmodified forest (no known previous management) with potential for conversion into a fruit garden based on Chewong impressions of suitability. This depends upon existing plant species (trees and understory) along with the suitability of the site for growing fruiting species and accessibility (882 ± 202 m from nearest active village).

A minimum distance of 0.5 km between fruit garden and control plots was used to ensure independent sampling of locations. While a distance of 1–2 km is preferred for terrestrial mammal species (Brodie and Giordano, 2013), we were constrained by the positions of fruit gardens, and aimed to maximise survey effort in line with recommendations by Tobler et al. (2008).

The boundaries of fruit gardens were marked out by local guides and measured in straight line segments. The distance from a central point to each corner was measured and Heron's formula used to calculate area (Colakoglu et al., 2013). A circular plot was placed randomly within each site. Diameter at breast height (dbh, measured at 1.3 m) was measured for all saplings (1–10 cm dbh) within a 9 m radius and trees (>10 cm dbh) within an 18 m radius (~1000 m^2). Specimens were collected for fruit tree identification as determined by local guidance.

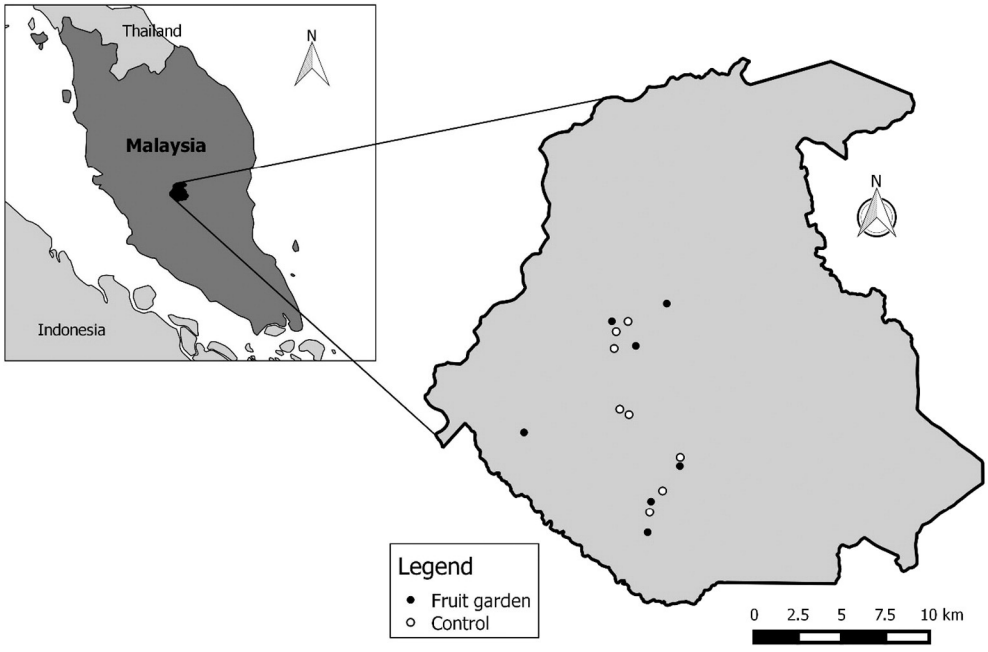

Fig. 1. Map showing locations of fruit garden and control study plots within Krau Wildlife Reserve, Pahang, Malaysia.