Available online at www.sciencedirect.com
ScienceDirect
Forest Ecology and Management 255 (2008) 1595–1603
Forest Ecology and Management
www.elsevier.com/locate/foreco

Frugivory and seed dispersal by a small carnivore, the Chinese ferret-badger, *Melogale moschata*, in a fragmented subtropical forest of central China

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Received 5 September 2007; received in revised form 15 November 2007; accepted 17 November 2007

Abstract

The capacity for the Chinese ferret-badger (*Melogale moschata*), a small carnivorous mustelid mammal, as a frugivore and endozoochorous seed disperser was evaluated over the main fruiting period during 2 years of study in a fragmented subtropical forest of central China. Seeds of eight plant species were dispersed by *M. moschata*, based on the analysis of the 163 faecal samples. Three forest types were sampled; one subject to commercial clear-cut logging, the second a selectively logged site and the third a natural primary forest habitat. The proportion of seed-bearing faecal samples was greatest amongst those collected from the primary forest, with the selectively logged and clear-cut habitats having a lower frequency of seed-bearing faeces, respectively. Ferret-badgers mainly defecated in open habitats, however the proportion of seed-bearing faeces did not differ according to the type of cover present at the deposition sites. Ferret-badgers selected fleshy-fruited and seed-pulp rich species. Significantly, selection was found for the large-seeded species, *Diospyros lotus*, however, they chose to consume the smaller seeds from this plant. Seed passage time through the gut ranged between 0.8 and 5.9 h. No significant individual-specific differences were detected in the passage time for the different fleshy fruits. Five out of six dominant species had seeds germinate successfully from faecal samples. Only the germination of *D. lotus* seeds were lower than expected by comparison to the control seeds. By contrast, ingested seeds of *Hovenia dulcis* had higher germination rates than in control samples, but no statistical differences were detected. These findings indicated that ferret-badgers were legitimate (they defecated viable seeds), but inefficient dispersers (seeds in faeces were mainly deposited on open sites which were regarded as ''unsafe microsites'' for seed germination and seedling establishment). In order to fully understand the role of *M. moschata* in forest recruitment and regeneration, quantitative research on their efficiency as endozoochorous seed dispersers and the effects of their digging activities on the seed bank and seedling survival should be undertaken, focusing on sites degraded by forestry operations, especially in badly affected sites.

Keywords: Carnivore; *Melogale moschata*; Forest recruitment; Endozoochorus; Fruit selection; Germination; Seed dispersal; Seed passage time

1. Introduction

That many mammalian carnivores ingest large quantities and varieties of fruits is well established (Herrera, 1989; Willson, 1993). With larger foraging ranges, longer seed passage times in their gut, and selection for particular defecation microsites (e.g. faecal marking behaviour, see a review by Hutchings and White, 2000), their role as seed-disperser is significant and important for maintaining and establishing the floristic diversity and species composition of forested habitats. However, quantitative studies of the role frugivores play in forest ecosystems are limited (Aronne and Russo, 1997; Campos and Ojeda, 1997; Motta-Junior and Martins, 2002). Here we consider the role of *M. moschata*, a small carnivore weighting 1.07 ± 0.30 kg ($n = 14$), as a frugivore and seed disperser in a subtropical forest of central China. Ferret-badger are very

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doi:10.1016/j.foreco.2007.11.018

important for forest conservation, due to their multi-faceted role in forest recruitment (Gao and Sun, 2005).

Successful seed dispersal consists of removal from a parent plant and deposition into suitable microsites for germination, such as a recently opened clearing in a forested area (termed a ''seed shadow'') (Howe and Smallwood, 1982; Fowler, 1988; Willson and Traveset, 2000). Fruit morphology and the behaviours of disperser are important factors for contributing to this successful seed dispersal process (Janson, 1983; Herrera, 1989; Debussche and Isenmann, 1989; Corlett, 1996; Westcott et al., 2005; Russo et al., 2006). The morphological characteristics of fruits and seeds chosen by frugivores limit the number of animal species which can disperse seeds effectively (Jordano, 1995). Disperser feeding behaviour (e.g. mastication, regurgitation), fruit processing (e.g. gut passage effects), post-feeding movements, as well as deposition site characteristics affect seed dispersal pattern, germination and seedling establishment (Hickey et al., 1999; Willson and Traveset, 2000; Traveset and Verdú, 2002; Westcott et al., 2005; Russo et al., 2006; Weir and Corlett, 2007). These mechanisms have been well documented for birds (e.g. Westcott et al., 2005; Weir and Corlett, 2007), bats (e.g. Janzen et al., 1976) and monkeys (e.g. see a review by Chapman and Russo, 2006).

The Chinese ferret-badger inhabits a wide variety of habitats including tropical and subtropical forests, secondary habitats, cultivated habitats and the rural outskirts of villages over a large range stretching from Assam to central China and northern Indochina (Zheng, 1987; Seefeldt, 2003; Nowak, 2004). Ferret-badgers are nocturnal and live in pre-dug holes (e.g. rodent dens) rather than digging new ones themselves (Wang, 1999). Ferret-badgers have an omnivorous diet that includes a significant fruit component (Seefeldt, 2003). Although it is a widespread species, little is known about its natural history and ecology, especially about its ecosystem role. Only a few studies have been conducted on its diet and feeding behaviour (Qian et al., 1976; Chuang and Lee, 1997; Wu, 1999), ranging behaviour (Wang, 1999; Wang and Fuller, 2003), activity patterns (Sheng, 1982; Pei, 1998, 2001; Wang, 1999; Wang and Fuller, 2003) and reproductive biology (Pei and Wang, 1995). A recent study has indicated that *M. moschata* is more closely related to a musteline-lutrine clade than to the badger clade, Melinae (Sato et al., 2004).

We studied the dispersal of seeds by *M. moschata* in a fragmented subtropical forest of central China. Data were collected during the main period of fleshy fruit dispersal in 2004 and 2005. Additionally, we tested the legitimacy of *M. moschata* as seed disperser, that is the occurrence of apparently undamaged seeds in the faeces (cf. Herrera, 1989; Reid, 1989). We also tested the effects of ingestion on seed germination by comparing the germination proportion in defecated versus control seeds. The focus of this study was to establish: (1) How many seeds and species are transported? (2) Do ferret-badgers contribute to the dispersal of forest plants? (3) Does fruit morphology affect the fruit choice made by *M. moschata*? (4) How long is the gut passage time, once ingested, of seeds through the digestive tract of the Chinese ferret-badger? (5) What effects does gut passage time have on germination?

2. Study site

The study was conducted in Hubei Houhe National Nature Reserve (NNR) (30°2′45″–8′40″N, and 110°29′25″–40′45″ E), central China (Fig. 1). The reserve covers 10,340 ha and lies at the transitional belt between the middle subtropical zone and north subtropical zone, with four distinct seasons, a cold winter and a hot, humid summer (Song and Liu, 1999). Mean annual rainfall was in the region of 1814 mm with mean air temperature around 11.5 °C. The main fruiting plants are members of the families Rosaceae, Lauraceae, Actinidiaceae and Cornaceae, which mature between August and November; outside these months, fruits are scarce (Song and Liu, 1999; Wang et al., 1997), although there are some fruits which are mature such as *Elaeagnus henryi*, *Cerasus dielsiana*, *Fragaria orientalis* and *Hovenia dulcis*. The reserve consists of primary forest, selectively logged forest, logged forest, forest plantation (primary species: *Davidia involucrata*, *Aesculus wilsonii*, *Cunninghamia lanceolata*, *Pinus massoniana* and *Cunninghamia lanceolata*) and farmland. Most logging occurred before 1998. In the logged forest all commercially valuable trees with a diameter at breast height (dbh) >20 cm were harvested for construction while trees with a dbh of 10–20 cm were harvested for firewood. Approximate one tree (with a dbh >20 cm) per 100 m^2 was taken for the construction of local residences in the selectively logged forest from 1996 to 1998. After logging, a mosaic of vegetation types persisted, dominated by pioneer tree species, shrubs, vines, climbers and herbs.

3. Methods

3.1. Faecal analysis and morphological characteristics of fruits

Ferret-badgers faeces were collected every two weeks along twenty chosen transects between August and November 2004, and August 2005 and January 2006 in conjunction with a study on the Chinese ferret-badger and the masked palm civet (*Paguma larvata*) behavioural ecology. Ferret-badger faeces

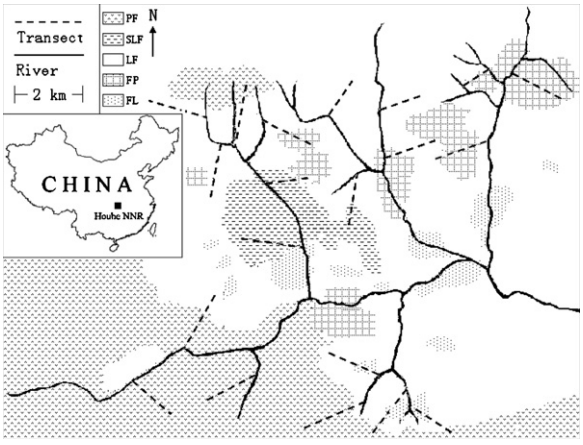

Fig. 1. Map of the study area, location of the five habitat types and twenty transects in Houhe National Nature Reserve, China. PF, primary forest; SLF, selectively logged forest; LF, logged forest; FP, forest plantation; FL, farmland.