Fungal diet of the Long-nosed Bandicoot (*Perameles nasuta*) in South-eastern Australia.

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Abstract

Information on fungi in the diet of the Long-nosed Bandicoot (*Perameles nasuta)* at two sites in south-eastern Australia is presented. Many of the fungi identified in bandicoot faecal pellets from this study are presumed to form mycorrhizal relationships with trees and shrubs. As a potential disseminating agent for these fungi, *P. nasuta* may help in the long-term health and vigor of native forests. The implications of this habit for forest management should not be overlooked.

Introduction

The ecology of many of Australia's marsupial families remains poorly understood relative to that of other taxa. One such family is the Peramelidae, or bandicoots. Many of the species within this family have been inadequately studied in their native habitats. For example, the ecology of the Long-nosed Bandicoot *(Perameles nasuta)*, a common inhabitant of the rainforests, eucalypt woodlands and eucalypt forests of eastern mainland Australia (Stodart 1983), remains largely undescribed. In one of the few studies of relevance, Claridge *et al.* (1991) described the diet and habitat requirements of a small population of *P. nasuta* in a dry sclerophyll forest site near Eden, New South Wales. At that site, animals were found to consume invertebrates, plant material and some fungi, while preferentially inhabiting gully sites with an open ground cover. The preference of *P. nasuta* for moist (gully) sites was later re-confirmed by Opie *et al.* (1990). Here, I present some additional information on the fungal diet of *P. nasuta* from two other forest sites in south-eastern Australia. This data, while sparse, is the best currently available for the species.

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Methods

Study Sites

The diet of *Perameles nasuta* was monitored in two forest sites in south-eastern Australia. The first site (here referred to as Cabbage Tree Creek) was located near the settlement of Cabbage Tree Creek, East Gippsland, Victoria (148°47'25E, 37°04'40S), while the second site (here referred to as Bruces Creek) was located in Nadgee State Forest in far south-eastern New South Wales (149°49'20E, 37°23'30S).

Details of the Cabbage Tree Creek study site have been described in another paper (Claridge *et al.* 1992). Briefly, the site comprises a forested catchment with a series of slopes of predominantly easterly-facing aspect, and slopes with a more exposed predominantly westerly-facing aspect, divided by a tributary of a small creek. Mean annual rainfall for Cabbage Tree Creek is 1113 mm, and is distributed evenly throughout the year, with slight peaks in late autumn and early winter and relatively low rainfall in summer. The highest mean monthly maximum temperature is 25.1°C (January), the lowest mean minimum temperature is 3.9°C (July) (Stuwe and Mueck 1990). Overstorey vegetation is dominated by mature Silvertop Ash (*Eucalyptus sieberi* L. Johnson), Yellow Stringybark (*E. muelleriana* Howitt) and White Stringybark (*E. globoidea* Blakely) on the slopes and ridges, and by Mountain Grey Gum (*E. cypellocarpa* L. Johnson) and Southern Mahogany (*E. botryoides* Sm.) in the gullies. Trees on the site are from a variety of age classes. Understorey vegetation is dense and species commonly contributing the cover layer to this stratum include Handsome Flat Pea (*Platylobium formosum* Sm.), Forest Wiregrass (*Tetrarrhena juncea* R.Br.), and a variety of ferns and sedges (see Stuwe and Mueck 1990).

The Bruces Creek site shares some features of the Cabbage Tree Creek site, comprising slopes with a predominantly easterly-facing aspect, slopes with a predominantly westerly-facing aspect, divided by a small creek. Mean annual rainfall recorded at Greencape Lighthouse (approx. 16km north-east of site) is 751 mm, being distributed irregularly throughout the year with peaks in January and March, and lows in winter-early spring (July and August). The highest mean monthly temperature is 22.2°C (February), the lowest mean minimum temperature 8.3°C (July) (Bureau of Meteorology 1988). The Bruces Creek study site was burned by severe wildfire in 1972-73, subsequently salvage logged and then burned again in another wildfire in 1980 (P. Moore, Forestry Commission of New South Wales, pers. comm. 1992). The predominant overstorey vegetation resulting from this disturbance regime is a regrowth stand of Silvertop Ash *(E. sieberi).* Below the eucalypt canopy, a thicket of wattle *(Acacia floribunda* (Vent.) Willd. and *A. terminalis* Salisb.) forms a dense midstorey. The understorey is also dense, with Wiregrass *(T. juncea),* a variety of ferns and sedges and large burned logs forming much of the ground cover.

Sampling of Bandicoots

Bandicoots were sampled at both sites using wire cage traps baited with a mixture of peanut butter, oats and pistachio essence (Scotts and Seebeck 1989). To avoid contamination of faeces, baits were held within a wire tea infuser suspended from the roof of each trap. Faecal pellets were collected from the floor of the traps on the first night that any individual was trapped. Bandicoots were sampled at irregular intervals during the period January 1990 to February 1992.

Faecal Analysis

Faeces collected for dietary analysis were divided into a coarse fraction containing fragments of fungal tissue, plant matter and invertebrates, and a fine fraction containing fungal spores, by washing crushed pellets through a soil sieve with mesh openings of 0.125 x 0.125 mm. Coarse material retained on the mesh was suspended in approximately 20 ml of 70% ethanol in a glass vial. For analysis, a pair of smooth-sided tweezers were placed in each vial and closed. Materials held by the closed tweezers were placed on a slide, to which a drop of glycerol was added. The fragmentary nature of the coarse fraction precluded quantitative analysis, so the abundance of different food items were estimated under light microscope (X 100 magnification), using the following subjective scoring system: 1 = item covering less than 25% of a field of view, a few small fragments; 2 = item covering between 25 and 50% of field of view; 3 = item covering between 50 and 75% of field of view; 4 = item covering greater than 75% of field of view. For each sample, fragments of food in 40 random fields of view were scored. The percentage occurrence of each food item was calculated according to the methods of Bennett and Baxter (1989). This involved adding up all scores for each food category, respectively, and then dividing that value by the total score for all food categories in the sample. These values were added, then divided by 10 (the total number of samples), to derive the average percentage occurrence of that food category.

Methods of analysis of fine fraction materials (containing fungal spores) have been described in Claridge *et al.* (1992). Briefly, a small portion of the remaining sediment from each sample was extracted and placed on a microscope slide. A drop of Melzer's reagant (McIntyre and Carey 1989) and a drop of glycerol were then added to the slide and a coverslip placed over the entire suspension. The suspension was examined using a light microscope (X 1000 magnification).

Where possible, spore types were identified to species using the descriptions of Beaton and Weste (1982, 1984) and Beaton *et al.* (1984 a; 1984 b; 1985 a; 1985 b; 1985 c; 1985 d). However, one spore type was placed into a category called 'other' (Table 1) because it did not agree with any known hypogeal taxa. The relative abundance of all spore types in each of 20 fields was assigned to one of the following categories: 1 = sparse, one or two spores; 2 = uncommon, three to five spores or; 3 = common, more than five spores present in the field of view. For all the samples, the percentage occurrence of each spore type was calculated according to the methods of Bennett and Baxter (1989) for all samples. This involved adding up all scores for each species, respectively, and then dividing that value by the total score for spores in the sample. These values were added, then divided by 10 (the total number of samples), to derive the average percentage occurrence of that spore type.

Results

A total of 10 faecal samples, from 10 individual bandicoots, were analysed for food items. In order to describe the diet of *P. nasuta,* results were pooled (averaged) from samples from both sites (9 from Cabbage Tree Creek and 1 from Bruces Creek). For the coarse fraction analysis, *P. nasuta* was found to consume mainly plant vascular material, invertebrates and plant seeds. Items of additional dietary importance were fungi, monocot leaf material and dicot leaf material (Fig. 1). For the fine fraction (fungal spores) component of the diet, 25 fungal taxa were identified from spores in faeces (Table 1). Most of these taxa were attributed to species of hypogeal (underground-fruiting) basidiomycetes that produce complex sporocarps (fruiting-bodies). On an average percentage occurence basis, the most commonly found spores were of two

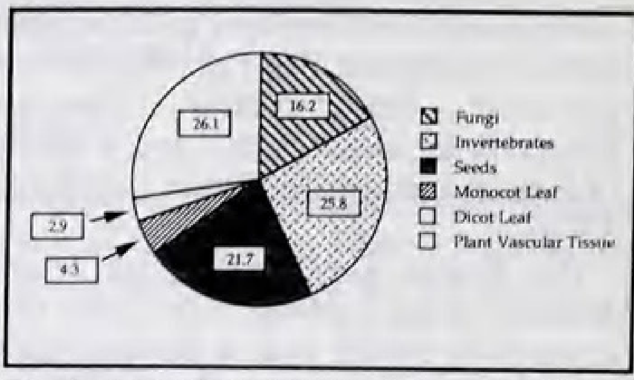

Fig. 1. Average percentage occurrence of food items in coarse fraction faeces of *Perameles nasuta* at Cabbage Tree Creek and Bruces Creek.

Table 1. Average percentage (%) occurrence of fungal taxa identified from spores in faeces of *Perameles nasuta* at Cabbage Tree Creek and Bruces Creek.

Species	Average % occurrence
Ascomycetes	
Jafneadelphus sp.	0.50
Labyrinthomyces varius	1.20
Basidiomycetes	
Gasteromycetes	
Castoreum sp.	5.80
Chamonixia vittatispora	12.90
Chamonixia sp.	0.40
Gautieria monospora	0.50
Gautieria sp. 1	1.00
Gautieria sp. 2	0.20
Hydnangium sp. (U)	0.20
Hymenogaster albus	0.40
H. atratus	8.60
H. nanus	3.30
H. zeylanicus	0.50
H. inflatum	3.70
Hymenogaster sp.	2.10
Hysterogaster sp. 1 (U)	1.50
Hysterogaster sp. 2 (U)	0.40
Mesophellia sp.	22.50
Octavianina tasmanica	4.00
Richionella pumila	6.80
Thaxterogaster scabrosus	4.10
Zelleromyces daucinus	5.20
Zelleromyces sp.	1.30
Zygomycetes	
Endogonaceae	
Endogone sp. (spore walls single layered)	2.50
Other	
Opaque black, spherical spore	5.70

Fruiting habit was either hypogeal or sub-hypogeal, except for *Jafneadelphus* sp. which was epigeal and the 'other' category, for which fruiting habit was unknown. (U) indicates uncertainty in identification of that genus.

species, *Mesophellia* sp. (22.5%) and *Chamonixia vittatispora* (12.9%). Spores of remaining species contributed less than 10% of the total of spores counted.

Discussion

The use of faecal analysis, as I used, in the qualitative and quantitative estimation of animal diet has been widely criticized on the basis of differential digestibility of food items (Calver and Wooller 1982; Ford *et al.* 1982; Batzli 1985). Soft-bodied food items, for example, are liable to complete digestion (Stoddart 1974; Bradbury 1983), whereas other items may be crushed into fragments beyond recognition. Samples are therefore likely to be biased in favour of less digestible items, precluding any accurate reconstruction of diet. Nevertheless, despite these limitations in technique, confirmation of the omnivorous feeding habit of *P. nasuta* in this study is in general agreement with the dietary habits of other bandicoot species (see Heinsohn 1966; Watts 1974; Opie 1980; Lobert 1985; Quin 1985; Claridge *et al.* 1991). In addition, I have identified that *P. nasuta* feeds on a variety of fungi. At least one other peramelid species, the Southern Brown Bandicoot *(Isoodon obesulus),* is also known to feed on fungi. In a Victorian heathland, Lobert (1985) found *I. obesulus* consumed fungi mainly in the winter months. However, Lobert (1985) was unable to describe the species of fungi being consumed. In Tasmania, Quin (1985) found that *I. obesulus* consumed the sporocarps of unidentified gasteromycete and zygomycete fungi throughout the year. More recently, Claridge *et al.* (1991) identified at least three species of fungi in the faeces of *I. obesulus* at a dry sclerophyll forest site in south-east New South Wales. One of the species found in the diet was from the genus *Mesophellia. Mesophellia* was abundantly represented by spores in the faeces of *P. nasuta* in the current study, and is a prolific sporocarp-producer in the eucalypt forests of south-eastern Australia (A. Claridge, unpubl. data 1990-2).

At Cabbage Tree Creek and Bruces Creek, *P. nasuta* is not the only medium-sized ground-dwelling marsupial known to feed on fungi. Long-nosed Potoroos *(Potorous tridactylus)* are very common at both study sites, and feed heavily on fungi throughout most times of the year (A. Claridge, unpubl. data 1990-2). Moreover, the range of fungal species consumed by *P. nasuta* and *Potorous tridactylus* show complete overlap (see Claridge *et al.* 1992; A. Claridge, unpubl. data 1990-2).

This suggests that there may be some competition for food resources between the two sympatric marsupial species. However, destructive competition may be avoided, in this case, because *P. nasuta* appears to consume far less fungi (as a proportion in faeces) than does *Potorous tridactylus.* In addition, *P. nasuta* exists at much lower population densities than *Potorous tridactylus.* A combination of these two factors (as well as other factors), may allow for two ecologically similar species to co-exist.

The consumption of fungi by *P. nasuta* is noteworthy, since many of the species found as spores in its faeces are thought to form mycorrhizal associations on the roots of a variety of trees and shrubs (see Bennett and Baxter 1989). These fungal associations are vital, among other functions, for the uptake and transfer of nutrients and water from the soil to the plant host (Trappe and Maser 1977). *P. nasuta* may play a role in the dissemination of mycorrhizal fungi by depositing spores in faeces. This role has already been attributed to at least two other species of marsupial, the Brush-tailed Bettong *(Bettongia penicillata)* and the Long-nosed Potoroo *(Potorous tridactylus)* (Lamont *et al.* 1985; Claridge *et al.* 1992).

The role of *P. nasuta* as an agent for beneficial fungi in native forests emphasises that all species within an ecosystem perform some vital role. These roles need to be fully appreciated by forest managers. Acknowledgement of the current example should take the form of practices designed specifically to enhance habitat for *P. nasuta,* and habitat for the fungi that it consumes. Such measures do not currently exist.

Acknowledgements

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The Mountain Brushtail Possum (*Trichosurus caninus* Ogilby): Disseminator of Fungi in the Mountain Ash Forests of the Central Highlands of Victoria ?

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Abstract

Faeces collected from the Mountain Brushtail Possum (*Trichosurus caninus* Ogilby) at a forest site in the Central Highlands of Victoria contained fungal spores. Some spores were from hypogeal (underground-fruiting) fungi that form a symbiotic mycorrhizal relationship on the roots of a variety of trees and shrubs. When in symbiosis, these fungi absorb nutrients and water from the soil and donate them to the host plant, and protect its root system from deleterious root pathogens. Mycorrhizal fungi are thus integral to the survival, establishment and growth of plants. The possible functional role of *T. caninus* in dispersing the spores of mycorrhiza-forming fungi needs to be recognized formally in management practices designed to conserve the species in areas subject to land-uses such as logging. The conservation of *T. caninus* may be particularly important in the mountain ash forests of Victoria because other ground-dwelling mycophagists such as bandicoots and potoroos are rare or absent.

Introduction

The Mountain Brushtail Possum, *Trichosurus caninus,* is a species of arboreal marsupial that is largely confined to forest habitats in eastern Australia (How 1983; Lindenmayer *et al.* 1990). It is common in the montane ash forests of the Central Highlands of Victoria (Lindemayer 1989) where the major eucalypt species are Mountain Ash *(Eucalyptus regnans)* and Alpine Ash *(E. delegatensis)* (Lindenmayer *et al.* 1991). Despite its status within this region, the general ecology of *T. caninus* remains poorly understood although there have been studies of its diet (Seebeck *et al.* 1984) and habitat requirements (Lindenmayer *et al.* 1990).

Seebeck *et al.* (1984) found that fungi was an important seasonal component of the diet of *T. caninus,* but did not specify which species were consumed. Here, we describe for the first time some of the fungal taxa consumed by *T. caninus* at

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