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Research Note

Long-nosed potoroo (*Potorous tridactylus*) behaviour and handling times when foraging for buried truffles

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Abstract. Truffles represent an important food resource for many small mammals, but because most mycophagous mammals are difficult to observe in the wild, behavioural observations of mammals handling and consuming truffles are almost non-existent. Using camera traps, we observed the behaviour of long-nosed potoroos (*Potorous tridactylus*) foraging for buried truffles, and recorded the rate at which truffles were excavated and consumed. Potoroos excavated buried truffles rapidly (2.4 ± 0.2 s) with synchronous drawing strokes of their forepaws, then gathered the excavated truffles with forepaws and/or mouth and cleaned away adherent debris before consuming the truffle. When potoroos were unsuccessful at recovering a truffle, they spent significantly more time digging (4.8 ± 0.6 s) before giving up. Potoroos were successful at recovering a truffle in 76% of digging attempts, and once they had located a cache of buried truffles, achieved a rate of recovery of ~2.4 truffles per minute.

Additional keywords: hypogeous, marsupial, mycophagy, potoroid, sporocarp, Tasmania.

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Introduction

Many of the ectomycorrhizal fungi that form important symbiotic associations with forest trees give rise to underground (hypogeous) spore-bearing fruiting bodies commonly known as 'truffles' (Claridge and May 1994; Smith and Read 1997; Claridge 2002) that emit strong odours to attract mycophagous mammals (Fogel and Trappe 1978; Donaldson and Stoddart 1994; Blaney 1996; Johnson 1996). Ingested truffle spores remain viable on passage through the gut, and the resultant spore-laden faeces represent a source of inoculum for new tree hosts (Johnson 1996; Claridge 2002; Caldwell *et al*. 2005).

Because most mycophagous mammals are relatively small, cryptic and therefore difficult to observe in the wild, and because foraging events occur non-randomly over large spatial-scales, direct observation of mycophagy is usually impracticable. Consequently, the foraging behaviour of mycophagous mammals has received very little attention, and no data exist on the rates at which mammals can detect, uncover, and consume truffles. Among Australian mycophagous mammals, truffle foraging behaviour has been observed only in captive Tasmanian bettongs (*Bettongia gaimardi*) (Donaldson and Stoddart 1994). Similarly, in North America, Zabel and Waters (1997) observed northern flying squirrels (*Glaucomys sabrinus*) feeding on different fungal species as part of a captive laboratory trial. However, with the notable exception of Thysell *et al*. (1997), who reported opportunistic sightings of radio-tracked northern flying squirrels foraging for a wide range of food types, few published observations of wild foraging by mycophagous mammals have been reported anywhere in the world.

We aimed to fill this data gap by using camera traps to record long-nosed potoroos (*Potorous tridactylus*) foraging for truffles we buried but under wild conditions. These are the first direct observations of truffle foraging by an Australian mycophagous mammal in the wild, and complement other aspects of the mycophagous habits of the species determined through routine dietary assays or other indirect measures of foraging activity (see Claridge and May 1994; Johnson 1996; Claridge 2002; Garkaklis *et al*. 2004).

Methods

Study site and design

The study was conducted at the Peter Murrell Reserves (centre: 43°00′S, 147°18′E) in Tasmania, Australia. The study area was dominated by black peppermint (*Eucalyptus amygdalina*) woodland with a low heath understorey. Vernes and Jarman (2011) describe the mammal community at the site.

Our camera trapping observations ran over a two-week period from 23 October to 2 November 2010. Because of our difficulty in finding truffles, it was necessary for us to use a mix of truffle species most commonly fruiting in the reserve at the time of the study. Thus, truffles from a random mix of native species in the genera *Hysterangium* and *Descomyces* as well as several genera from the family Russulaceae were collected from within the reserve, or from native woodland adjacent to the reserve, at the start of the study. All truffles, regardless of species used, were small (5–15 mm diameter), with a soft peridium, and all are palatable to, and known to be consumed by, mycophagous mammals (see Claridge and May 1994). This collection was then subdivided into 10 equal subsamples of 10 truffles, with each subsample having an equal representation of large (10–15 mm diameter) and small (5–10 mm diameter) truffles. A Scoutguard 550-v infrared motion-activated camera set to record 1-min-long video files at each activation (and set at 'high sensitivity') was placed at each of 10 random locations within the study area and a subsample of collected truffles was buried 1 m from each camera, with all truffles at each camera station randomly buried within a circular area of ~30-cm radius to mimic the occurrence of a small patch of truffles. Truffles were pressed into the loosened sandy soil until flush with the soil surface and covered with a light scattering of soil and leaves to mimic the typically observed positioning of these truffles at the soil–litter interface. Because ground-level vegetation was at times quite dense, some clipping of herbage in front of cameras was required to minimise false triggers from vegetation moving in windy conditions. Cameras were deployed at 14 locations for 3–6 nights each. For other details regarding the survey design used see Vernes and Jarman (2011).

Data collection

We examined each 1-min-long video file for truffle foraging by long-nosed potoroos. At each appearance at a camera, we recorded whether the animal (a) dug for food, (b) recovered a truffle, and (c) consumed the truffle. Each digging and consumption event was timed with a stopwatch to the nearest 0.1 of a second. The entire time spent foraging (digging and consuming truffles, but also engaged in unsuccessful diggings, sniffing at the ground etc.) was also timed for each video file. Details of the animal's behaviours when foraging for and consuming truffles were also recorded.

Results

Truffle foraging behaviour

The cameras recorded 144 1-min-long video files of long-nosed potoroos; 29 of these showed potoroos foraging for truffles (for an example, see Video S1, available as supplementary material to this paper). Potoroos typically sniffed at the ground in a side-to-side motion while meandering slowly in the vicinity of buried truffles before targeting a truffle for excavation. Before excavation, the animal positioned itself so that the buried truffle was in line with the region beneath its chin. The animal then proceeded to excavate the truffle with a few (typically 2–4) synchronous drawing strokes of its forepaws that pulled soil and litter towards itself and exposed the truffle. In some cases, probing at the ground with the snout preceded digging. For 37 truffle excavations, we could clearly see how the truffle was plucked by the potoroo once it was unearthed. For 16 (42%) of these observations the truffle was picked up directly with the forepaws, on seven (18%) occasions the truffle was gathered first in the mouth and then transferred to the forepaws, and on a further 15 (40%) occasions the animal used mouth and forepaws simultaneously to gather the truffle. Prior to eating a truffle, the potoroo moved it rapidly from side to side in its forepaws while simultaneously rotating it to (presumably) remove adherent debris with its mouth.

Truffle handling times

Up to 6 truffles were observed being excavated per video, for a total of 47 truffle excavations. In each case in which a potoroo excavated a truffle, digging was considered to have commenced when either the nose or forepaws were used to disrupt the ground surface (leaf litter or soil), and to have ceased when a truffle was gathered in the mouth or paws. By these criteria, digging to recover a truffle averaged (±s.e.) 2.4 ± 0.2 s. In 24% of cases ($n = 15$) digging did not yield a truffle. When potoroos did not succeed in recovering a truffle, digging was maintained significantly longer (4.8 ± 0.6 s) than when a truffle was recovered ($t = -3.9$, d.f. = 19.05, $P < 0.001$). Once a truffle was recovered, it was rapidly consumed. Consumption of a truffle (beginning with the manipulation of the truffle in the paws or mouth, and ending with cessation of chewing movements of the jaw) averaged (±s.e.) 9.6 ± 0.7 s ($n = 47$).

The time elapsed between consuming a truffle and starting to dig for a new truffle varied from 0.1 to 25.5 s (mean ± s.e. = 4.5 ± 1.0; $n = 38$). The animal used much of this time to move to a new area in front of the camera, position itself for a new digging, or to sniff at the ground. Sometimes an animal stood motionless for several seconds in an alert posture before resuming foraging.

For each appearance at a camera point, the time the animal was actively foraging (digging and consuming truffles, but also engaged in unsuccessful diggings, sniffing at the ground, etc.), divided by the number of successful excavations in each video ($n = 22$ videos) yielded a truffle encounter rate of ~1 truffle recovered for every 25.2 ± 2.8 s of foraging (range = 12–57 s), or ~2.4 truffles per minute.

Discussion

Few mammals have been observed foraging for hypogeous truffles, and our observations are the first to document the foraging behaviour and truffle handling times of an Australian mycophagous mammal. As would be expected of a truffle specialist, the long-nosed potoroo was highly proficient at detecting and unearthing truffles. Once detected, excavation of a truffle took only a few seconds, followed by a further few seconds of cleaning adherent debris from the truffle before it was consumed. In ~76% of cases, digging by potoroos resulted in a successful truffle excavation, but when digging continued for twice the time in which a potoroo would normally be successful at recovering a truffle, digging was abandoned. Using this approach – rapid recovery, handling and consumption of truffles, or conversely, rapidly giving up on unsuccessful ventures, potoroos could consume ~2.4 truffles per minute when foraging at a truffle patch (by 'patch' we mean one to several fruiting truffles at a single point, similar to what we attempted to replicate in this study).

Truffles occur patchily or non-randomly in Australian forests (Taylor 1992; Claridge *et al*. 1993) so mycophagous potoroids usually have large home ranges and travel extensively during a night of foraging (Taylor 1993; Green *et al*. 1998; Vernes and

Pope 2001). Because of the large interpatch distances that must be travelled to access truffles upon which to feed (see Vernes and Haydon 2001), much of the night is probably spent travelling between truffle patches. However, when discovered, a patch of truffles can be depleted within minutes, so it should be possible for an individual potoroo to visit and deplete many such patches during a night of foraging. Furthermore, in a related study we showed that most artificial truffle patches established in the field were discovered by long-nosed potoroos in the first 12 h (roughly a full night) of foraging (Vernes *et al.* in press), suggesting that once truffles mature and become attractive to mammals, they are discovered quickly. Garkaklis *et al*. (2004) deduced that another potoroid, the woylie (*Bettongia penicillata*), made an average of 38–114 diggings per night. If woylies have a similar success rate at recovering truffles at each attempt as potoroos achieved in our study (i.e. 76%), they would be able to consume between 30 and 90 truffles per night.

We acknowledge that the type of substrate and the depth at which a truffle is fruiting will both affect the rate at which a potoroo can unearth a truffle. Thus, further work that takes these factors into account is needed if we are to more fully understand foraging rates by potoroids. To this end, our use of infrared cameras demonstrates a novel approach that can lead to a deeper understanding of the foraging behaviour of potoroids and other cryptic mammals by allowing observations that would otherwise not be feasible in a free-ranging situation.

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