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THE DIET OF THE HONEY POSSUM TARSIPES ROSTRATUS

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Summary

The diet of the honey possum has been studied in the field and laboratory. In the field, animals were associated with plant assemblages having overlapping flowering phenologies which resulted in a continuous local supply of nectar and pollen. Nectar provides the animals with a carbohydrate source whilst other nutritional requirements probably come from pollen. The contents of most pollen ingested is either fully or partly digested during its 8-12 hour transit through the gut.

I. INTRODUCTION

The honey possum Tarsipes rostratus is a small marsupial (7-15 g) found only in the sandplain heathlands of south-western Australia. It lives entirely on a diet of nectar and pollen which it obtains from the very diverse plant communities which are found in these areas (George et al. 1979). Tarsipes is dependent on a suite of proteaceous plants, particularly the many species of banksias and dryandras. The overlapping flowering phenologies of these Proteaceae result in both nectar and pollen being available throughout the year. However, the abundance of these food sources varies considerably in space and time. Honey possums are most numerous at those times of year when proteaceous flowers are most abundant i.e. July to September (Wooller et al. 1984). Despite their floristic richness, Australian heathlands have a relatively low productivity due to the extremely poor nutrient status of their substrate (Kikkawa et al. 1979). The plentiful sunlight of this region allows abundant production of sugars (e.g. nectar) but the nutrient limitations imposed by the soil may restrict protein production (e.g. pollen) in these heathlands.

Nectar is an excellent source of energy and in many proteaceous plants commonly reaches a concentration of 20-25% w.w. sucrose equivalents. Multiple flower heads, such as banksia cones, may produce nectar with an energy content of more than 2 kJ daily. The energy requirements of an adult Tarsipes have been assessed as the equivalent of the nectar available from between 5 and 8 cones each day (Wooller et al. 1984).

As nectar contains little other than carbohydrates (Baker and Baker 1983), the sources of nitrogen, fats and essential vitamins for nectarivores require further investigation. There is little evidence that Tarsipes eat insects. The most likely source for these nutrients is pollen. Pollen typically contains 20% protein, 37% carbohydrates, 4% lipid and 3% minerals (Knox 1979). Fatty acids (e.g. palmitic, linoleic and linolenic acids) are common and all essential amino acids are present in pollen. Many vitamins known to be essential in insect and mammalian nutrition are present as enzyme co-factors in pollen (Heslop-Harrison 1973).

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II. MATERIALS AND METHODS

(a) Field observations

As part of a long-term ecological study, Tarsipes were trapped in the Fitzgerald River National Park. Faecal deposits were collected for microscopic examination to determine the species of pollen grains and the state of their digestion. When released, animals were frequently observed as they fed from pollen presenters or the nectaries of various plant species.

(b) Anatomical structures

A few animals were taken for gross morphological and microscopic examination of alimentary tract structures. Careful anatomical dissection was followed by routine histological procedures. Gut contents were examined.

(c) Laboratory experiments

(i) Maintenance Two female and five male Tarsipes were maintained in captivity on a liquid mixture which consisted of water (150 ml), honey (130 g), milk-based invalid health food ("Complan") (12.5 g) and pollen (4.5 g). Animals were kept individually in cages and fed 2 ml of this mixture three times daily from a syringe dispenser. Since the small, moist faeces of Tarsipes adhere to mesh, each animal was kept in a cage, the floor of which was lined with absorbent paper. Animals were accustomed to the feeding regime for at least one week prior to any dietary manipulation.

(ii) Experiment 1 - pollen transit times A pulse dose, consisting of 2 ml of the normal mixture but with the addition of a small amount of highly distinctive pollen (Acacia sp.) not present in the normal mixture, was supplied in the usual manner. For the next 8 hours, all faeces deposited during each 2 hour period were marked. Then each animal was transferred to a clean cage and collection of faecal matter continued at 4 hour intervals. Samples from each individual and each time period were examined microscopically after staining with basic fuchsin dye. Marker pollen grains, when present, were readily distinguishable from all other pollen types in the faeces. In each sample, 100 pollen grains were identified and the percentage which consisted of marker pollen was calculated.

(iii) Experiment 2 - pollen digestibility A large, simple pollen type (Banksia coccinea) was added to the normal mixture to study pollen digestibility. Faecal samples were collected in the manner described previously, stained with acid fuchsin and malachite green, and examined microscopically for the presence or absence of their contents.

III. RESULTS

(a) Field observations

Tarsipes has often been seen to glean pollen from flowers, particularly myrtaceous species, even before it probes for nectar. The considerable manipulative ability of its hands, coupled with its great agility, allow it to harvest effectively the available pollen. Individuals have been seen to exploit groups of flowers in a clearly systematic way, passing from one inflorescence to the next without revisiting flowers already harvested. Tarsipes has several modifications associated with its unusual diet. In addition to its grasping hands and prehensile tail, it has an elongate and extremely protrusible tongue, which is poked into nectar sources or passed over the surfaces of pollen presenters.

(b) Anatomical structures

The tongue has a brush-like upper surface with particularly long filiform papillae on the tip. Nectar is probably taken up by capillary action along these papillae and squeezed from the tongue when it is returned to the mouth. Pollen caught on the tongue's papillate surface is combed off by transverse ridges on the hard palate. Since some of these combs point forwards and some backwards, pollen is removed from the tongue during its protrusion and its retraction. When offered a 20% sugar solution, the tongue was observed to move in and out of the mouth at least 2-3 times each second during feeding. Prehension of pollen appears to occur at a slower rate.

The ingested pollen is passed directly to the bi-lobed stomach and thence to the intestine. The stomach has a J-shaped main chamber, which has an ovoid-shaped diverticulum of approximately two thirds the capacity of the main chamber. The inter-chamber connection occurs adjacent to the cardia. The stomach is lined by acid- and mucous-secreting cells whilst the diverticulum is lined with mucous-secreting cells. Pollen was found in the main chambers, particularly near the pylorus, of all animals taken from the field but was never seen in their diverticula. The intestine is a simple convoluted tube without a caecum. Pollen was found in the intestine of all animals examined.

(c) Pollen transit times

The percentage of marker pollen grains of the bulk of pollen in the pulse dose voided in the faeces is illustrated in Figure 1.

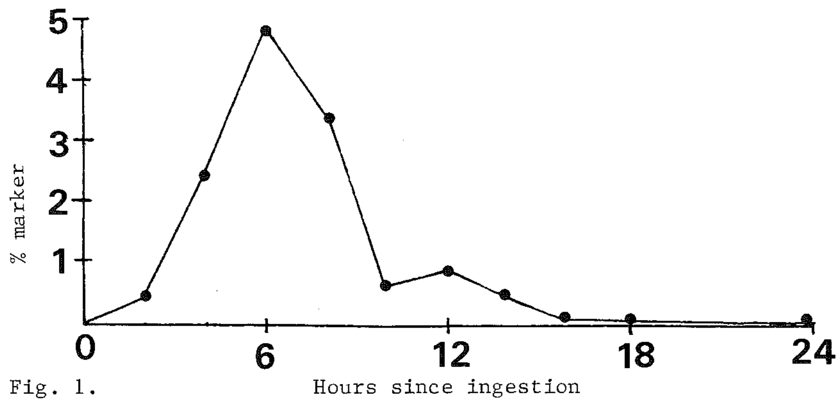

Fig. 1.

(d) Pollen digestibility

In the field and morphological studies, pollen grains were found in the main stomach chambers of all the animals dissected. Pollen was never found in the diverticula. Most of the pollen grains (90%) found in the pyloric region of the stomach were undigested. The intestine is a simple coiled tube, without a caecum. Fewer pollen grains in the proximal part of the intestine were digested (10-50%) than those in the distal region (50-100%). Faecal masses from both animals caught in the field and those maintained in the laboratory consisted of large numbers of pollen grains, most without their contents.

In experiment 2 the percentage of grains voided which were without their contents was linearly related to the length of time that the grains had spent in passage through the alimentary tract ($r = +0.97$; $p < 0.001$).

IV. DISCUSSION

The differential loss of contents by pollen grains along the alimentary tract suggests that little digestion occurs in the stomach and that most, if not all, occurs in the intestine. Pollen from some plant species, such as Calothamnus, appears not to be readily digested. In contrast the large pollen grains of Banksia and Dryandra species which have large germinal apertures appear to be much more effectively digested.

To date, no attempt has been made to determine which pollen types have a high protein content, as has been done in dietary studies of bees (Dietz 1975). Differences between plant species may have a profound effect on the survival of an individual in times of nitrogen stress, such as during lactation and periods of low pollen availability.

Several workers have suggested that pollen may play an important role in the diet of Tarsipes (Wiens et al. 1979; Hume 1982; Turner 1984; Wooller et al. 1984). A number of different mechanisms for pollen digestion have been proposed (Simpson and Neff 1983):

a) enzymatic cracking of the grain
b) mechanical rupture of the grain
c) initiation and digestion of pollen tubes
d) microbial digestion
e) direct digestion of the pollen grain through the pores in the exine coat.

In our work, the exine coat of all grains voided were intact and no pollen tubes were observed. Tarsipes appears to have no morphological adaptations for microbial digestion. The most likely mode of digestion is therefore direct enzymatic action. Details of this process are currently under investigation.

Finally, it is interesting to note that the growth rate of Tarsipes is markedly slower than more insectivorous marsupials of similar size (Wooller et al. 1984). This difference may reflect the dietary constraints associated with the collection and digestion of sufficient amounts of suitable pollen.

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