# TAIL FAT STORAGE IN ARID ZONE BANDICOOTS

G. GORDON AND L.S. HALL

IN Australia, storage of fat deposits in the tail occurs in some dasyurids, the burramyid genus *Cercartetus* and the rodent genus *Zyzomys* (Morton 1980; Morton, Dickman and Fletcher 1989; Watts and Kemper 1989). In other countries, caudal fat storage in small mammals is found in the Marsupialia, Insectivora, Rodentia and Primates. It occurs in two main groups of small mammals, species that characteristically undergo extended torpor, and desert-dwelling insectivores (Morton 1980). These are cryptic small mammals that avoid high temperatures and range from 10-120 g body weight.

Because of their extreme fragility, Begg (1988) suggested that the swollen tails of *Zyzomys* may function as an escape mechanism rather than a fat store. Pond (1978) suggested that storage of fat in the tail is related to "adaptations for short bursts of rapid running and a high degree of maneuverability in a confined space," occurring in species that "rarely stray a long way from shelter," and catch their prey by stalking and pouncing rather than by running it down. It is thought that fat located in the tail does not "interfere with rapid running or manoeuvrability" (Morton 1980). Pond's (1978) suggestion does not, however, account for the strong correlation between tail fat storage and two modes of life (desert dwelling insectivores and species that undergo torpor respectively), stating that it is not "specifically related to the diet ... or to desert dwelling per se"

Morton (1980) proposed that where smaller body size is favoured due to, eg., predation, and fat storage is also advantageous, storage may take place in the "only organ that can be increased in size without changing the bulk of the body, ie., the tail". In open habitats in arid areas, there may be considerable short term fluctuations in insect numbers resulting from short periods of adverse weather. Insectivores may then undergo severe short term food shortage and require supplementary fat reserves. In *Sminthopsis crassicaudata*, the amount of fat in the tail is less than that in the body and is only sufficient to provide a supplement over short periods. Hence, it is thought to serve as "a partial buffer against unpredictable periods of food shortage" (Morton 1978). For the second group of small mammals, those that undergo torpor, tail fat may provide sustenance during their inactivity (Morton 1980).

In this paper, we report the discovery of tail fat storage in bandicoots (Marsupialia: Peramelidae). The presence of tail fat storage in bandicoots may necessitate some modification of previous hypotheses about its evolution. We examined the tails of spirit specimens of bandicoots from the Australian Museum, the Museum of Victoria and the South Australian Museum and asked staff of the British Museum of Natural History to examine bandicoots held in their collection and record whether the tail was swollen into a spindle shape. Maximum tail width of Australian spirit specimens was measured in a lateral plane. Width at the base of the tail is given for some specimens also. Tissue samples were taken from two bandicoots and sectioned to confirm the presence of fat.

Fattened tails were found in some specimens of *Perameles bougainville bougainville*, *P. b. myosura*, *P. b. notina* and *P. eremiana*, (Table 1). Some of these specimens were collected around the turn of the century (Table 1) and undated specimens are thought to be of similar age. In Australian museum specimens, fat tails were absent in *Macrotis leucura* (four specimens examined: SAM - M3166, M3925, M3933, M3465), *Chaeropus ecaudatus* (one: SAM M3971), *Isoodon auratus* (six: SAM M3078, M3968, M3969, M3974, M3995, M4734) and *I. obesulus* (three: SAM M4702, M5119, M6271). They were also absent in many specimens of *I. macrourus*, *P. nasuta* and *M. lagotis* that have been handled live by the authors during other work.

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*G. Gordon, Queensland Department of Environment and Heritage, PO Box 42, Kenmore, Brisbane, Qld, Australia 4069. L. S. Hall, Department of Anatomical Sciences, University of Queensland, Brisbane, Qld, Australia 4072.* *Manuscript received 17 May, 1994.*

| Species | Mus. | Reg. No. | Sex | Max. wid. (mm) | Bas. wid. (mm) | Date | Location |
|---|---|---|---|---|---|---|---|
| P. eremiana | SAM | M3946 | M | 7.5 | 5 | 8.1899 | Oolarinna-Everard Ra., SA |
| | MV | C488 | F | 8.1 | 5.5 | 23.3.1916 | no data |
| P. b. notina | SAM | M3927 | F | 7.5 | * | no data | no data |
| | SAM | M3973 | F | 5.2 | * | no data | Ooldea-Talarinna, SA |
| | SAM | M3982 | F | 5.6 | * | no data | no data |
| | SAM | M3984 | F | 7 | * | no data | no data |
| | SAM | M3987 | F | 11.5 | * | no data | no data |
| P. b. myosura | BMNH | 6.8.1.328 | M | * | * | 5.4.1906 | East Pingelly, WA |
| | BMNH | 7.7.18.10 | no data | * | * | no data | Darton, WA |
| P. b. bougainville | BMNH | 10.12.25.7 | F | * | * | 12.8.1910 | Dorre Is., WA |

*Table 1.* Museum specimens of bandicoots with fattened tails. "MV" = Museum of Victoria, "SAM" = South Australian Museum, "BMNH" = British Museum of Natural History. "Reg. No." = museum registration number. "Max. wid." and "Bas. wid." = maximum and basal width of tail, respectively. "*" = width not measured. "Date" and "Location" show the data on the specimen label, with states shown as South Australia ("SA") and Western Australia ("WA").

Fattened tails were spindle shaped, with narrow bases followed by a swollen proximal portion that then tapered gradually to the tail tip (Figure 1). The maximum diameter was 11.5 mm (Table 1). Fattening was slight in relation to body size, with tail widths of 5.2-11.5 mm (Table 1) in species weighing possibly 200-250 g or greater. *S. crassicaudata*, in contrast, has tail widths of 3.6-4.9 mm for body weights of 11.6-19.6 g (Morton 1978, p. 197).

A wedge of tissue 1 cm long and approximately 2-3 mm wide was excised from the ventral side of the tail of *P. eremiana* (specimen C488) and *P. bougainville* (specimen M3927). The tissue sample extended from surface epidermis to tissue immediately adjacent to caudal vertebrae. Tissue blocks were stored in 10% buffered formalin for several weeks. For each species, the sample was divided into two. One was processed for Haematoxylin and Eosin via wax embedding to show general histological features and the other was stained with Oil Red O as frozen sections to identify neutral fats (Vacca 1985).

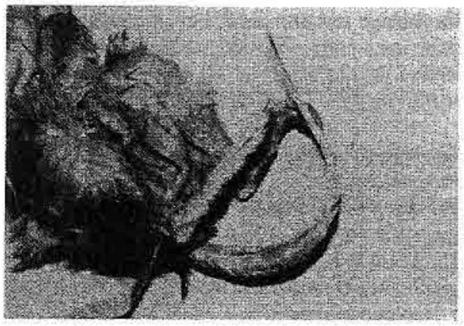

*Fig. 1.* Tail of *Perameles eremiana* (specimen C488) showing the swollen basal half and the site of the tissue sample

Hairs follicles on the tail were arranged in different patterns in the two species. In *P. bougainville*, the epidermis contained ridges running transversely around the tail. Between the ridges hair shafts emerged from follicles whose base was located deep in the hypodermis. The hairs were arranged in characteristic linear groups of three with the central one largest. The linear pattern of hair was aligned with the lateral arrangement of ridges. In *P. eremiana*, lateral ridges were less apparent in the epidermis and the hairs were arranged singly.

In both species the dermis was thick and composed of dense irregular connective tissue. Underlying the dermis was an extensive area of areolar tissue composed principally of large unilocular polygonal adipocytes with scattered arteries, capillaries and connective tissue septae. The Oil Red O showed only a slight amount of neutral fat in the adipocytes, but this could be due to fixation over a long period.

The base of the tissue block was composed of skeletal muscle. Between the epidermis and the base of the skeletal muscle the areolar tissue comprised approximately 70% of the tissue thickness.

Among bandicoots, tail fat storage was only found in species of *Perameles* from arid and semiarid areas. Although possibly largely insectivorous, at least some of these bandicoots (*P. b. bougainville*, *P. b. myosura* and *P. b. notina* [= *P. fasciata* of Gould 1974]) are omnivores, including seeds and other plant parts in their diet (Gould 1974; Burbidge 1988). Aboriginal accounts of *P. eremiana* describe it as insectivorous (Burbidge, Johnson, Fuller and Southgate 1988); there are no other reports of its diet. Other arid zone bandicoots are also omnivorous: *Macrotis lagotis* (Southgate 1990), *M. leucura* (Burbidge et al 1988; Johnson 1988), *Isoodon auratus* (McKenzie 1988) and *Chaeropus ecaudatus* (Aitken 1988).

It is difficult to apply Pond's hypothesis (see above) directly to bandicoots, as it appears to relate to species that require short bursts of speed for, eg., predation from an ambush, and to species that "rarely stray a long way from shelter". However, tail fat storage may yield other locomotory advantages to bandicoots, such as manoeuvrability for the purpose of predator avoidance. *P. b. myosura* was said to be an animal of astonishing activity with remarkable powers of jumping and movements "more reminiscent of those of birds than those we usually associate with mammals" (Jones 1968). When alarmed, it may jump vertically into the air and then appear to vanish (Jones 1968).

Tail fat storage in bandicoots does not concur with Morton's (1980) observation (see above) that it is found in species that undergo extended torpor (no bandicoots are known to undergo torpor).

Morton (1980) also found tail fat storage in small insectivores with an undependable short term food supply. The fat-tailed bandicoots do not seem to fit this pattern either as (a) some or all species may have a large component of seeds and other plant material in their diet, and (b), bandicoots may have a significant advantage in feeding on invertebrates and plants below the soil surface. Seeds are not affected in the short term by adverse weather and sub-soil invertebrates are at least partly protected from extremes of weather. The abundance of the latter are likely to be relatively more stable over a short term than surface insects; thus, it is unlikely that the short term abundance of soil invertebrates such as termites would be greatly affected by short periods of severe weather. If this is correct, it does not lend support to the idea that tail fat storage in bandicoots is related to short term severe food shortage (Morton 1980).

However, seeds in particular may not form a stable alternative food source for a bandicoot as there may be considerable variation in the production of seeds through time and there may also be competition from other more efficient granivores (Morton and Baynes 1985). Bandicoot foraging patterns appear to consist of slow onward movement in search of dispersed food sources (*Isoodon macrourus*, Gordon 1974) and they may not be adapted to take maximum advantage of more clumped food sources. In addition, other more specialised insectivores would probably outcompete bandicoots in finding surface insects. Such factors might mean that bandicoots also are subject to "severe short term food shortages", and could possibly favour caudal fat storage.

These bandicoots also differ from the other small mammals with caudal fat storage in their greater body weight, approximately 190-250 g in *P. b. bougainville* (Morton 1980, Burbidge 1988), and possibly slightly greater in other taxa. However, it may be significant that these are among the smaller species of bandicoots. Most other species (of *Perameles* and of other genera) are much larger. Tail fat storage in bandicoots may be an adaptation that has developed as part of an evolutionary reduction in body size in arid areas.

It is difficult, therefore, to fully explain tail fat storage in bandicoots in terms of previous explanations of this phenomenon and current hypotheses about the occurrence and functions of tail fat storage require some modification to encompass fat-tailed bandicoots. The characteristics of bandicoot food supply in the arid zone, in relation to this discussion, also require further study.

These ideas do not explain why tail fat storage has developed in *Perameles* spp and not in other arid zone bandicoots. However, this finding is an indication of differences in ecology and adaptive strategies among these poorly known bandicoots.

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