Description of sternal glands in Western Australian *Sminthopsis* and *Ningaui* (Marsupialia: Dasyuridae)

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Abstract

We have identified a cutaneous secretory gland in the gular (throat) area of the small carnivorous marsupials, *Sminthopsis* and *Ningaui* spp, and in all other genera of dasyurid marsupials that occur in Western Australia. The gland is apparent in both sexes of *Sminthopsis* and *Ningaui*, and develops with maturity. It contains both sebaceous and apocrine sudoriferous glands, and is similar in gross and histological structure, and probably function, to the sternal gland previously described for other dasyurid marsupials, although it is located more anteriorly in the gular region.

Keywords: gland, epidermal, sternal, gular, *Sminthopsis*, *Ningaui*, dasyurid, marsupial, histology

Introduction

The skin of marsupials, like that of other vertebrates, has glands of varying functions (Dawson *et al.*, 1989). Scent-producing secretory glands are common, suggesting an important role in olfactory communication. Russell (1985) described scent glands in 63 marsupial species from 40 genera. These include sternal, paracloacal (anal, or paraproctal), pouch, auricular, oral and frontal glands, as well as nasal vestibular glands, sebaceous and serous ocular glands, and lachrymal glands.

Sternal glands are widespread in marsupials; their presence is often indicated in the sternal region by a bare patch of skin, and/or discolouration of the surrounding fur. They typically are larger in adult males, and gland size and secretory activity change seasonally (Dawson *et al.*, 1989). The sternal gland consists of both sebaceous and apocrine sudoriferous cutaneous glands, which are typically larger and more active than the adjacent cutaneous glands. The sternal gland hairs, especially for sexually mature animals, sometimes appear moist with the glandular secretion (*e.g.* Bolliger & Hardy, 1945; Mykytowycz & Nay, 1964; Woolley, 1991). Sternal glands are used during marking behaviour to spread the sternal secretion on objects in the environment (Russell, 1985; Toftegaard & Bradley, 2003) *e.g.* scent-marking by *Antechinus* (Woolley, 1966).

Routine curatorial examination of specimens of *Sminthopsis* species in the Western Australian Museum mammal collection revealed a cutaneous secretory gland in the gular area that develops in both males and females as they become sexually mature. We report here how further systematic examination of specimens has shown that this gland appears to be present in essentially all Western Australian species of *Sminthopsis*, and genera of dasyurids, and is homologous with the previously described sternal gland of other dasyurids.

Methods

We examined specimens of primarily *Sminthopsis* and *Ningaui* spp, but also some individuals from species of all genera of the sub-families of the Dasyuridae that are present in Western Australia, for sternal glands. Observation of Museum specimens was made using a binocular microscope. The fur of spirit specimens (preserved in formalin and then stored in 75% ethanol) was brushed into a natural orientation for examination. We intended primarily to only survey whether or not the gland was present in all species of dasyurid marsupials in Western Australia; this could have been indicated by bare skin or complete gland development. The sex and sexual maturity of specimens with sternal glands were noted. We designate animals as sexually mature when for females there was development of pouches, teats or attached young, and for males from knowledge of season of reproductive activity of species, size of animal and size of testes.

Sections of sternal glands were removed from formalin-fixed, alcohol-preserved specimens of some species for histological study by paraffin sectioning. Sections of 6 μ were examined with a variety of stains, including haematoxylin & eosin, and Heidenhain's azan (Humason 1979), to identify different stages of development of the gland and compare the structure of the gland between sexes and between species.

Results

Examination of specimens of the thirteen *Sminthopsis* and three *Ningaui* species in the Western Australian Museum mammal collection consistently revealed a cutaneous secretory gland in the gular area (Table 1). This gland is apparent in both sexes, and develops as the animal becomes sexually mature. Further examination of other genera of dasyurids that occur in Western Australia revealed a similar gland in all of the species examined (Table 1).

Table 1

Species of Western Australian dasyurid marsupials that have been examined, and location of gland (g = gular, s = sternal, gs = extending from gular to sternal area). Phylogeny after Krajewski *et al.* (1994). Registration numbers are for Western Australian Museum specimens, except SAM is a South Australian Museum specimen.

Subfamily	Genus	Species	Registration Number	Gland location
Sminthopsinae	*Antechinomys*	*laniger*	M36859 ♀	**GS**
	Ningaui	*ridei*	M44971 ♂, M52235 ♀	**G**
	Ningaui	*timealeyi*	M51370 ♂, M45076 ♀	**G**
	Ningaui	*yvonneae*	M47074 ♂, M47199 ♀	**G**
	Planigale	*ingrami*	M52047 ♂	**G**
	Planigale	*maculata*	M30874 ♂	**G**
	Planigale	sp nov	M52212 ♂	**G**
	Planigale	sp nov	M51417 ♀	**G**
	Sminthopsis	*butleri*	M7158 ♀	–
	Sminthopsis	*crassicaudata*	M47112 ♂, M44147 ♀	**G**
	Sminthopsis	*dolichura*	M47230 ♂	**G**
	Sminthopsis	*gilberti*	M1179 ♂	**G**
	Sminthopsis	*granulipes*	M24119 ♂	**G**
	Sminthopsis	*griseoventer*	M52167 ♂	**G**
	Sminthopsis	*hirtipes*	M41983 ♂M21920 ♀	**G**
	Sminthopsis	*longicaudata*	M24530 ♂	**G**
	Sminthopsis	*macroura*	M51361, M23560 ♀	**G**
	Sminthopsis	*ooldea*	M28451 ♂	**G**
	Sminthopsis	*psammophila*	M23229 ♂	**G**
	Sminthopsis	*virginiae*	M21996 ♂	**G**
	Sminthopsis	*youngsoni*	M46745 ♂	**G**
Dasyurinae	*Dasycercus*	*cristicauda*	M48487 ♂	**G**
	Dasycercus	*hillieri*	SAM M15805 ♂	**G**
	Dasyurus	*geoffroii*	M53756 ♂	**S**
	Dasyurus	*hallucatus*	M48847 ♂	**S**
	Dasykaluta	*rosamondae*	M47752 ♂	**G**
	Parantechinus	*apicalis*	M36796 ♂	**GS**
	Pseudantechinus	*ningbing*	M12368	**GS**
	Pseudantechinus	*roryi*	M34304 ♂, M29372 ♀	**GS**
	Pseudantechinus	*woolleyae*	M47636 ♂, 48112 ♀	**GS**
Phascogalinae	*Antechinus*	*flavipes*	M52169 ♂, M52243	**GS**
	Phascogale	*tapoatafa*	M24617 ♂, M11171 ♀	**GS**
	Phascogale	*calura*	M20937 ♂	**GS**

The gland is most obvious in sexually-active males, but it is also present in juveniles and sexually-active females. However, Museum collection specimens of females with a fully developed gland are rarer than are males with a fully developed gland. The gland first appears as a bald area of skin on the throats of juvenile animals, hidden beneath the fur. The skin develops a 'goose-pimply' texture as the gland matures, and is swollen with a folded appearance in the fully mature gland (Fig 1). The gland appears first in the gular area but extends as it develops toward the sternal area. Discolouration of the fur around the gland was often observed.

Histological examination of the gular glands identified both sebaceous and apocrine sudoriferous glands. Early stages of development of the gland showed little or no evidence of hypertrophy of the precursor elements, with small numbers of sebaceous gland cells aggregated around hair shafts. Simple tubular (non-coiled or branching) glands lying deeper in the subcutaneous tissue are putative precursor elements of the sudoriferous glands. Intermediate stages of development of the gland showed thickening of the dermal and subcutaneous layers along with pronounced hair follicle loss. The sebaceous glands were hypertrophied into large simple acinar sacs, which opened directly to the skin surface via the former root sheath of the hair. These accounted for most of the epidermal thickening. The sebaceous glands appeared quite active, with secretion products evident in their lumen. Some hypertrophy of the sudoriferous gland was also evident. For the fully-developed gland, the sebaceous glands were similar in extent to the intermediate stage but in many cases the acini have become lobulated, with each lobe sharing a single opening to the surface of the skin. The sudoriferous glands had hypertrophied and the resultant coiled tubular glands formed discrete cords of glandular tissue oriented deep to the surface. Their secretory cells were truncated pyramidal cells with spherical nuclei that form a single layer. Secretory products of these tubular cords entered ducts located just below the sebaceous gland acini. There was some evidence that these ducts open into the pilo-sebaceous canal.

Discussion

Although Green (1963) did not report any enlarged or specialized sternal gland in *Sminthopsis crassicaudata*, we have identified a cutaneous gland in *Sminthopsis* species, but located in the neck rather than the chest area. With

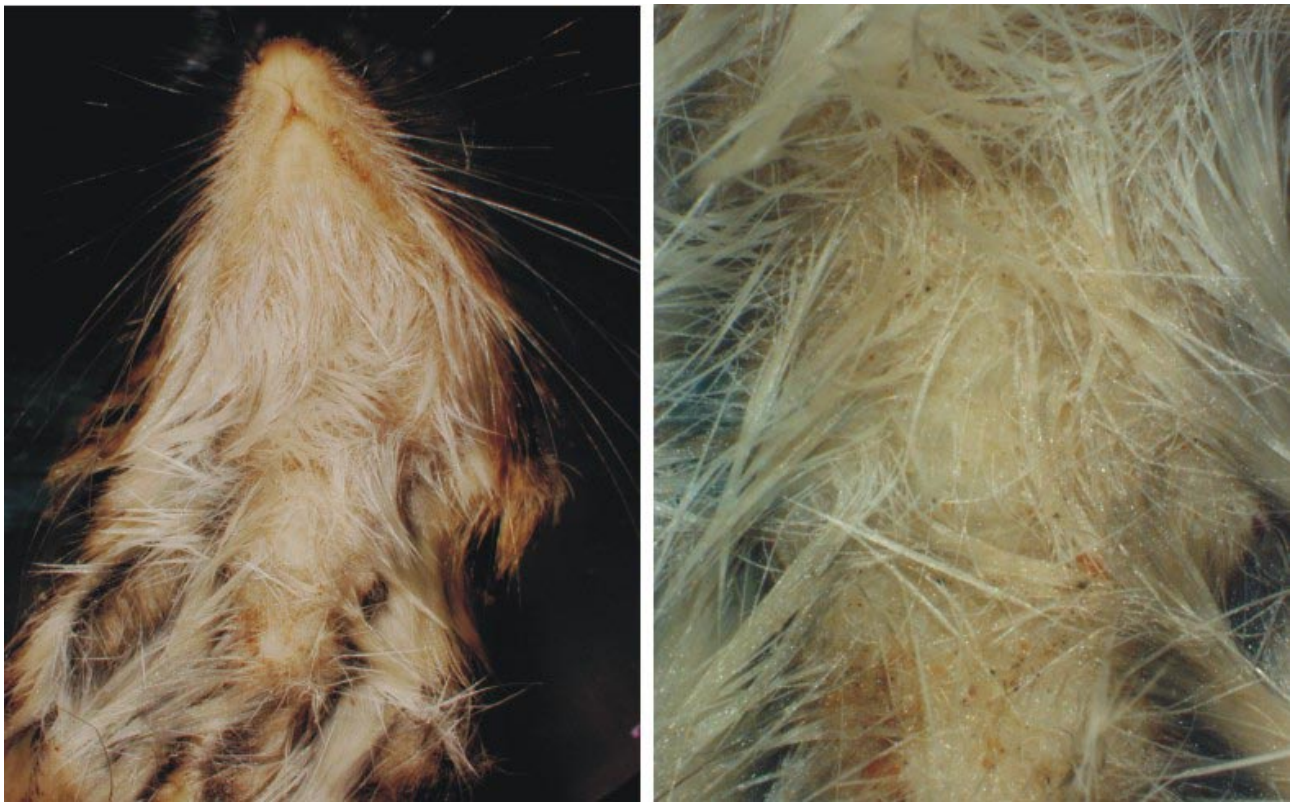

Figure 1. Fully-developed gular gland of a male *Ningaui ridei* (M44971).

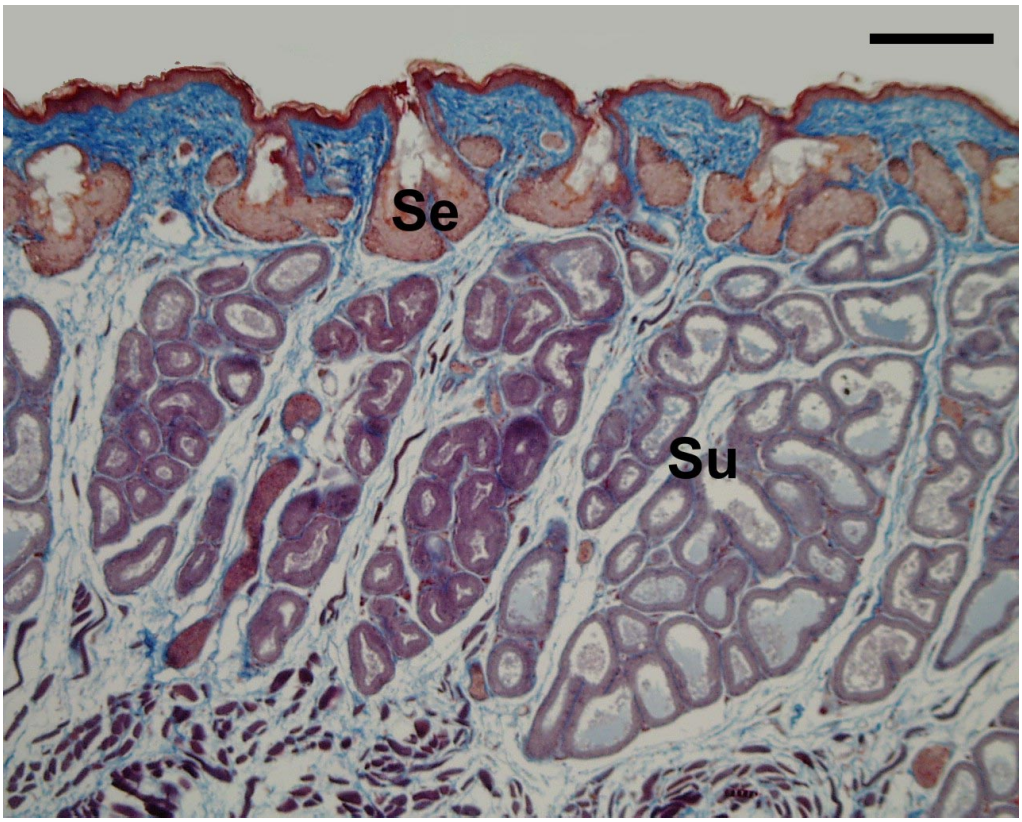

Figure 2. Fully developed gular gland in *Sminthopsis ooldea* (WAM 28451). The subcutaneous layer is thickened, with sebaceous glands (Se) that in many cases have become lobulated, with each lobe sharing the one opening to the surface of the skin, and sudoriferous (Su) glands that have hypertrophied with their resultant coiled tubular glands forming discrete cords of glandular tissue oriented deep to the surface (their ducts appear to open into the pilo-sebaceous canal). Scale bar: 200 μ.

enlargement of the gland it often extends down to the sternal area. We have confirmed that this gland is present in all species of *Sminthopsis* and *Ningaui* found in Western Australia, and it is found in representatives of all of the Western Australian subfamilies within Dasyuridae (Table 1). It would appear to be generally present in both male and female dasyurid marsupials. Previously, sternal glands have been noted in the following dasyurid species; *Phascogale tapoatafa* (Cuttle 1978), *Planigale maculata* (Van Dyck 1979), *Dasyuroides byrnei* (Aslin 1974), *Antechinus stuartii* (Woolley 1966), *Dasykaluta rosamondae* (Woolley 1991) and *Planigale tenuirostris* (Andrew & Settle 1982). Bourne (1934) and Ford (1934) re-described the pre-sternal/sternal gland of the numbat (*Myrmecobius fasciatus*) after Beddard's (1887) original description. Stoddard & Bradley (1991) and Bradley & Stoddard (1993) described the equivalent gland of the sugar glider *Petaurus breviceps* as a gular gland.

The sternal gland that we describe for small dasyurid marsupials is in the gular area rather than on the sternum, and is often obscured by fur. The bald sternal gland of *Sminthopsis* lacks the specialized sternal gland hairs (osmetrichia) of *Antechinus stuartii* (Toftegaard & Bradley 1999). The gland appears to be most fully developed in sexually mature males, and is present in females of most species examined although not so obvious. This may be an artifact of collectors being unwilling to collect females with young, or females with young may be less trappable (if that is the period of full development of the gland), or the gland may atrophy quickly after the reproductive period, or it might not ever develop as fully as in males. However, Aslin (1974) described a well developed sternal gland for female *Dasyuroides byrnei* with unweaned young, in captivity.

The external structure of the sternal gland appears the same for both sexes, for all species of *Sminthopsis* and *Ningaui*, and for all of the other genera in which the gland has been found. Histological study of the sternal glands identified both sebaceous and apocrine sudoriferous glands, as has been reported previously for sternal and some other glands in various marsupials (Bourne, 1934; Ford, 1934; Bolliger & Hardy 1945; Green, 1963; Stoddart 1980; Russell, 1985). The poorly developed system of both sebaceous and sudoriferous glands in immature specimens develops progressively with age. This development of the sternal gland is accompanied by some hair loss, making the glandular area more obvious.

The function of the gular gland of *Sminthopsis* and *Ningaui* is unknown, but like the cutaneous glands of other dasyurids (and other marsupials) it is probably important for olfactory communication between reproductively mature individuals. Woolley (1966) described the development of the sternal gland of sexually mature *Antechinus* and its use for marking objects. Aslin (1974) described scent marking of the substrate and/or objects during sand-bathing for the kowari *Dasyuroides byrnei*. *Planigale maculata* (Van Dyck 1979) has also been described to sternal rub. Sniffing of the neck region by conspecifics has been described for the mulgara *Dasycercus cristicauda*, the kowari *Dasyuroides byrnei*, the Eastern quoll *Dasyurus viverrinus* and the Tasmanian devil *Sarcophilus harrissii* (Aslin 1974; Eisenberg & Golani 1977; Eisenberg *et al*. 1975). Sternal rubbing of objects and the substrate by *Sminthopsis crassicaudata* (Ewer 1968a,b) and *Ningaui* (Croft 1982) presumably deposits secretions of the gland for a similar olfactory identification role. Further study is needed to ascertain the timing of the development of the gland in females, the function of the gland, and whether the presence of the gland is an indicator of reproductive condition in *Sminthopsis* and *Ningaui* spp.

References

Andrew DL & Settle G A 1982 Observations on the behaviour of *Planigale* (Dasyuridae, Marsupialia), with particular reference to Narrow-nosed Planigale (*Planigale tenuirostris*). In: Carnivorous Marsupials (ed M Archer). Royal Zoological Society of New South Wales, Sydney, 311–324.

Aslin H 1974 The behaviour of *Dasyuroides byrnei* (Marsupialia) in captivity. Zeitscrift für Tierpsychologie 35: 187–208.

Beddard FE 1887 Note on a point in the structure of *Myrmecobius*. Proceedings of the Zoological Society of London, 527–531.

Bolliger A & Hardy M H 1945 The sternal integument of *Trichosurus vulpecula*. Proceedings of the Royal Society of New South Wales 78: 122–133.

Bourne G 1934 Glandular areas of some Australian jerboa mice, and remarks on *Nyctinomus* and *Myrmecobius*. Memoirs of the National Museum, Melbourne 7: 90–94.

Bradley A J & Stoddart D M 1993 The dorsal paracloacal gland and its relationship with seasonal changes in cutaneous scent gland morphology in the marsupial sugar glider (*Petaurus breviceps*: Marsupialia: Petauridae). Journal of Zoology London 229: 331–346.

Croft D R 1982 Communication in the Dasyuridae (Marsupialia): A review. In: Carnivorous Marsupials Vol 1 (ed M Archer). Royal Zoological Society of New South Wales, Sydney, 291–309.

Cuttle P 1978 The behaviour of the Tuan, *Phascogale tapoatafa*. MSc Thesis, Monash University, Melbourne.

Dawson T J, Finch E, Freedman L, Hume I D, Renfree M B & Temple-Smith P D 1989 17. Morphology and physiology of the Metatheria. In: Fauna of Australia. Mammalia. Vol 1B (eds D W Walton & B J Richardson). Australian Government Printing Service, Canberra, 451–504.

Eisenberg J F& Golani I 1977 Communication in Metatheria. In: How Animals Communicate (ed T Sebeok). Indiana University Press, Bloomington, 575–599.

Eisenberg J F, Collins L R & Wemmer C 1975 Communication in the Tasmanian devil (*Sarcophilus harrisii*) and a survey of auditory communication in the Marsupialia. Zeitschrifte für Tierpsychologie 37: 379–399.

Ewer R F 1968a A preliminary survey of the behaviour in captivity of the dasyurid marsupial *Sminthopsis crassicaudata* (Gould). Zeitschrifte für Tierpsychologie 25: 319–365.

Ewer R F 1968b Ethology of Mammals. Logos Press, London.

Ford E 1934 A note on the sternal gland of *Myrmecobius*. Journal of Anatomy 68: 346–349.

Green L M 1963 Distribution and comparative histology of cutaneous glands in certain marsupials. Australian Journal of Zoology 11: 250–72

Humason G L 1979 Animal Tissue Techniques. WH Freeman & Co, San Francisco.

Krajewski C, Painter J, Buckley L & Westerman M 1994 Phylogenetic structure of the marsupial family Dasyuridae based on cytochrome b DNA sequences. Journal of Mammalian Evolution 2: 25–35

Mykytowycx R & Nay T 1964 Studies of the cutaneous glands and hair follicles of some species of Macropodidae. CSIRO Wildlife Research 9: 200–217.

Russell E M 1985 The metatherians: Order Marsupialia. In: Social Odours in Mammals (eds RE Brown & DA MacDonald). Clarendon Press, Oxford, 45–104.

Stoddart D M 1980 Observations on the structure and function of cephalic skin glands in bandicoots (Marsupialia: Peramelidae). Australian Journal of Zoology 28: 33–41.

Stoddart D M & A J Bradley 1991 The frontal and gular dermal gland scent organs of the marsupial sugar glider *Petaurus breviceps*. Journal of Zoology London 225: 1–12.

Toftegaard C L & Bradley A J 1999 Structure of specialized osmetrichia in the brown antechinus *Antechinus stuartii* (Marsupialia: Dasyuridae). Journal of Zoology London 248: 27–30.

Toftegaard C L & Bradley A J 2003 Chemical communication in dasyurid marsupials. In: Predators with Pouches (Eds M Jones, C R Dickman & M Archer). CSIRO Publishing, Collingwood, Victoria, 347–357.

Woolley P 1966 Reproduction in *Antechinus* spp and other dasyurid marsupials. Symposium of the Zoological Society of London 15: 281–94

Woolley P A 1991 Reproduction in *Dasykaluta rosamondae* (Marsupialia: Dasyuridae): Field and laboratory observations. Australian Journal of Zoology 39: 549–68

Van Dyck S 1979 Behaviour in captive individuals of the dasyurid marsupial *Planigale maculata* (Gould 1851). Memoirs of the Queensland Museum 19: 413–31.