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The possibilities of scent marking in the Mouse-eared bat *Myotis myotis* (Borkhausen, 1797) and the Noctule bat *Nyctalus noctula* (Schreber, 1774) (Mammalia, Chiroptera)

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Abstract

Studied were sebaceous glands on the cranial integument of *Myotis myotis and Nyctalus noctula* by using microanatomical methods. Both species are provided with normal sebaceous glands on the whole snout. Slightly enlarged sebaceous glands, where secretions emerge by pressing the head against an object, are restricted to the lips and the chin in *M. myotis*, and to the rostral part of the snout in *N. noctula*. In enlarged sebaceous glands secretion delivery is caused by contraction of the subcutaneous musculature. In *M. myotis* one of these glands exists on each side of the head and opens into a brush-like hair tuft. Three rows, alltogether consisting of 10 enlarged glands, lie on each side of the snout of *N. noctula*. Only *M. myotis* is equipped with an extremely enlarged sebaceous gland on each side of the snout. This gland expands through the whole dermis into the subcutaneous musculature and opens into a brush-like hair tuft. Although both species are provided with enlarged sebaceous and sudoriferous glands, the microanatomy, number and arrangement of these glands as well as the amount of enlargement diverge. Combined with the different application structures, this shows two completely divergent systems of secretion delivery, application, and distribution.

Introduction

Many studies exist on the olfactory communication in mammals as reviewed in Eisenberg and Kleiman (1972), Johnson (1973), Adams (1980), and Brown and Macdonald (1984). While in the past grossmorphological and microanatomical investigations described a large variety of integumentary glands, recent biochemical studies proved that enlarged sudoriferous and even some enlarged sebaceous glands produce scent (Bereiter-Hahn et al. 1986). In bats, for example, the purpose of a scent gland described by means of histology is often as unclear as is the context of scent marking behaviour. Glands on the head were investigated by means of histology in many vespertilionid bats (Schaffer 1938, 1940; Werner and Dalquest 1952; Dalquest and Werner 1954; Sisk 1957; Fenton 1985; Haffner 1987, 1989; Schmidt et al. 1989; Haffner and Ziswiler 1990) but literature on scent marking behaviour in bats is rare (Buchler 1980; Müller-Schwarze 1983; Lundberg and Gerell 1986; Hoeller and Schmidt 1993).

To fill in some gaps in the knowledge resulting from describing histology I have chosen *Myotis myotis* and *Nyctalus noctula* whose marking behaviour and preening I often had the opportunity to observe, and I used functional morphology on their scent glands.

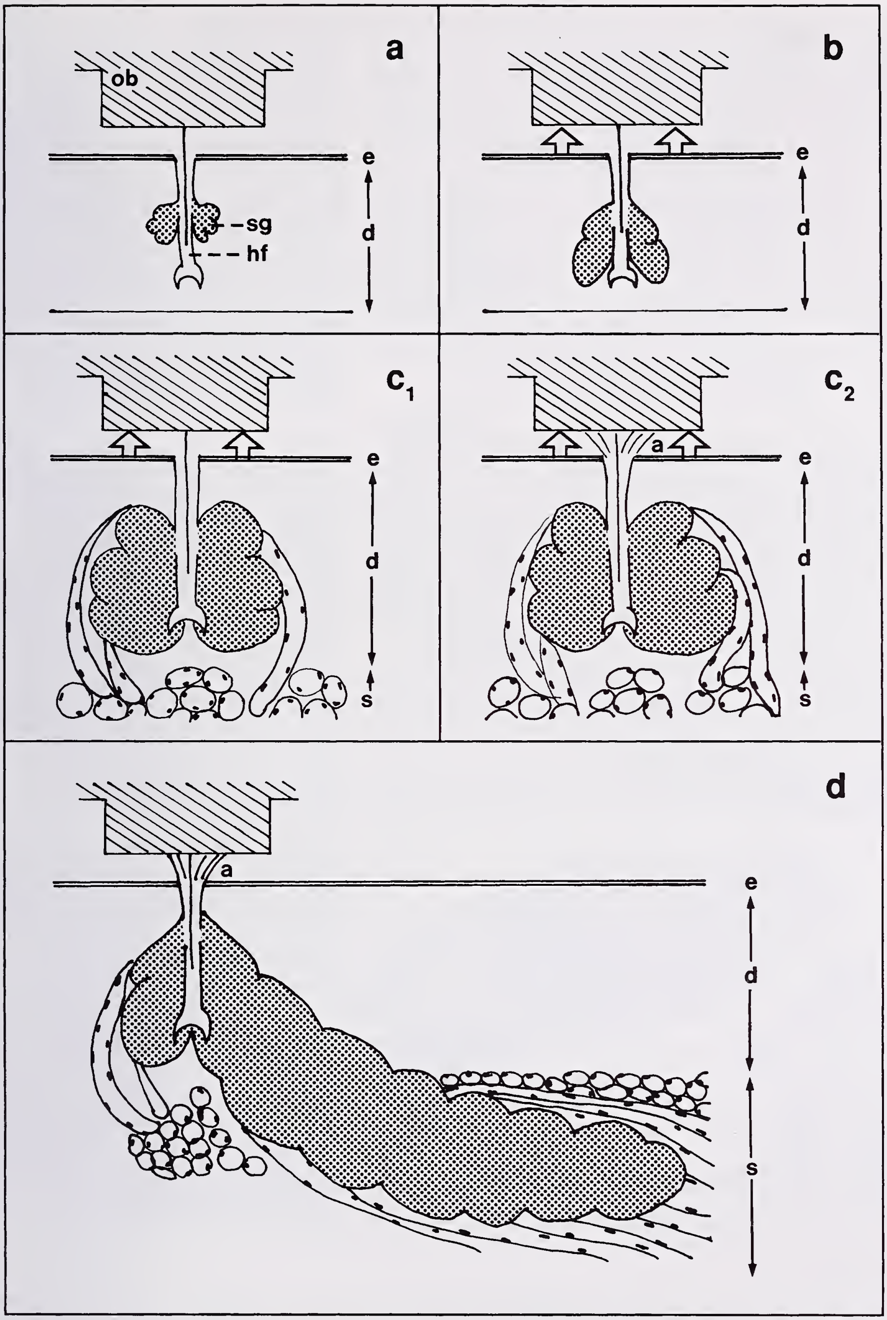

Fig. 1. Four types of sebaceous glands and their secretion. **a**) normal gland / "passive" secretion, **b**) slightly enlarged gland / pressure against object, $\mathbf{c_1}$) enlarged gland / contraction of subcutane muscle, pressure against object, $\mathbf{c_2}$) enlarged gland with application structure / contraction of subcutane muscle, pressure against object, **d**) extremely enlarged gland with application structure / contraction of subcutane muscle

application structure (a), epidermis (e), dermis (d), the hairfollicle (hf) contains hair, object (ob), subcutis (s), sebaceous glands (sg, dotted), pressure against the object (arrow)

Material and methods

The bats were donated by different people to the Zoological Museum. They had been found either dead or badly hurt and had to be killed; they were conserved in 70% alcohol or 10% formalin. 7 adult *M. myotis* (4 males, 3 females) and 37 adult *N. noctula* (21 males, 16 females) were investigated by means of grossmorphology. Ventral or dorsal and lateral views of the snout and chin region were drawn with a WILD drawing apparatus for the binoculars.

4 *M. myotis* (2 males, 2 females) and 7 *N. noctula* (4 males, 3 females) were prepared for histological investigations. For this purpose the skin of the head was dissected and embedded in paraffin, cut in 7–15 µm thick slices and stained with Haemalaun-Eosin using conventional methods (Romeis 1968). From these consecutive slice series the three-dimensional histoarchitecture of integumental structures was reconstructed by using a ZEISS drawing apparatus for the microscope. Based on these investigations a model for secretion delivery, application and distribution was established.

Results

The snout and chin region of both species is sparsely haired. Most of the hairs are thicker than normal body hairs and all of them are connected to sebaceous glands. These glands can be assigned to four types depending on their size, arrangement and relation to muscles:

1. Normal sebaceous glands are proportionally correlated to the thickness of the hair; they do not reach the base of the hairfollicle (Figs. 1 a, 2 a).

2. Slightly enlarged sebaceous glands surround the hairfollicle; their diameter is not much larger than the hairfollicle (Figs. 1 b, 2 b).

3. Enlarged sebaceous glands embed the hairfollicle completely; their diameter is much larger than the hairfollicle, and striated muscle fibres, connected with the subcutaneous musculature, surround the gland like a basket and attach themselves onto its connective tissue covering (Figs. 1 c_1,c_2, 2 c).

4. Extremely enlarged sebaceous glands do not only surround the hairfollicle, but they expand through the whole dermis into the subcutaneous musculature. Near the orifice of the gland the arrangement of muscle fibres is similar to type 3 (Figs. 1 d, 2 d, e).

On each side of the snout of M. myotis a brush-like hairtuft rises up between the rostral Vibrissae mystaciales (Fig. 3 a). The hair in the middle of these hairtufts is supplied with sebaceous glands of type 4 which spread within the integument from the hairtuft to the eye. Another more sparse hairtuft with sebaceous glands of type 3 is situated more dorsad. Except for some slightly enlarged sebaceous glands of type 2 near the lips, all other sebaceous glands are of normal size. On the chin two swellings occur composed of numerous slightly enlarged sebaceous glands and above the symphysis lies a hairless protuberance. Except for the sebaceous glands, nearly all hairs on the snout and only some on the chin are supplied with sudoriferous apocrine glands in the shape of a simple sac which is straight or loosely wound. All these apocrine glands are surrounded by myoepithelial cells.

Based on the histoarchitecture of the glands of *M. myotis* we can distinguish three types of secretion delivery to the orifice of the sebaceous glands:

– "passive" secretion delivery by overflow of the produced secretion: normal sebaceous glands (Fig. 1 a)

– secretion delivery caused by pressure against an object: slightly enlarged sebaceous glands on the chin and near the lips (Fig. 1 b)

– secretion delivery caused by contraction of subcutaneous muscle, probably supported by pressure against an object: sebaceous glands in the minor hairtuft (Fig. 1 c_2). In extremely enlarged sebaceous glands in the larger hairtuft contraction of the subcutaneous musculature, in which the caudal part of the gland is embedded, has the effect of pressing out secretions as if from a tube (Fig. 1 d).

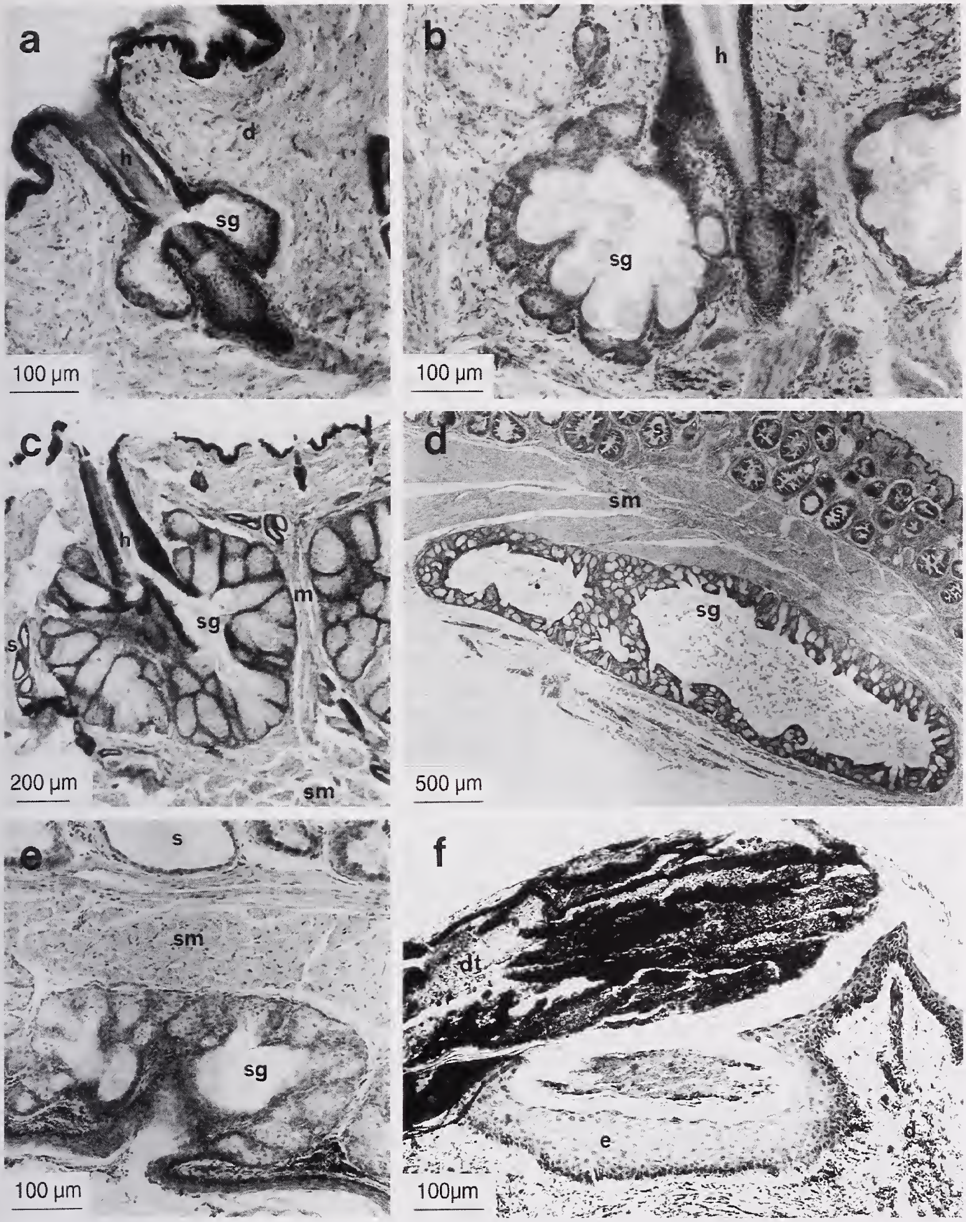

Fig. 2. Micrographs illustrating **a**) a hair with normal sebaceous glands (*N. noctula*), **b**) a hair with sligthly enlarged sebaceous glands (*N. noctula*), **c**) a hair with enlarged sebaceous glands (*N. noctula*), **d**) an extremely enlarged sebaceous gland (*M. myotis*),) a part of an extremely enlarged sebaceous gland (*M. myotis*), **f**) wound healing on the chin of *N. noctula*.
d – dermis, dt – damaged tissue, e – epidermis, h – hair, m – musculature, s – sudoriferous gland, sg – sebaceous gland, sm – subcutaneous musculature

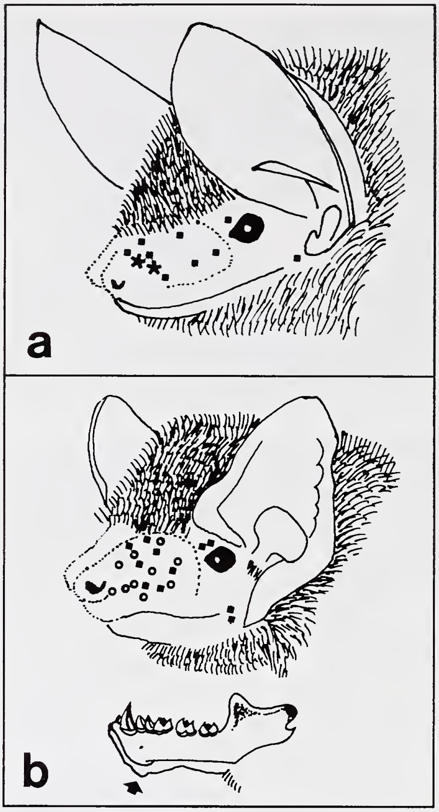

Fig. 3. Schematic drawings of the heads of *Myotis myotis* (**a**) and *Nyctalus noctula* (**b**) and lower jaw of *Nyctalus noctula* with protuberance. Vibrissae mystaciales, V. angulares and V. superciliares (squares), brush-like hairtufts (stars), orifices of sebaceous glands (rings), protruberance (arrow)

The secretion can be applied and distributed directly from the orifice of the gland to the aiming point (Fig. 1 a, b) or indirectly via the application structure, the brush-like hairtuft, as is the case in the four sebaceous glands on the snout (Fig. 1 c_2, d). By means of these hairtufts, secretions applied from other glands onto an object can also be dispersed.

There are three rows of three, five and two hairs, respectively, with enlarged sebaceous glands on each side of the snout between the vibrissae of *N. noctula* (Fig. 3 b). On the chin, four swellings composed of numerous enlarged sebaceous glands are developed. The caudal sebaceous glands are the largest, while the rostral ones are the smallest in both chin and snout. Although all nuances of enlargement can be seen in *N. noctula*, no extremely enlarged sebaceous glands exist, such as those found in *M. myotis*. Exactly above the highest part of the symphysis is a hairless protruberance which is, in contrast to *M. myotis*, often the most prominent part of the chin (Fig. 3 b). The epidermis of this protruberance is thickened, and wounds at different stages of healing can be seen (Fig. 2 f). Nearly all hairs on the snout and a few on the chin have, except for the sebaceous glands, sudoriferous apocrine glands in the shape of a loosely wound or narrowly coiled tube. These glands are smaller in the chin than in the snout but all are surrounded by myoepithelial cells.

Based on the histoarchitecture of the glands I postulate the same two types of secretion discharge for *N. noctula* as described for *M. myotis* (Fig. 1 a, b). In extremely enlarged sebaceous glands secretion delivery is caused by contraction of subcutaneous muscle, probably supported by pressure against an object (Fig. 1 c_1). There are no application structures such as hair tufts found near the orifice of the glands in *N. noctula*. The secretion can be applied and distributed directly from the orifice of the gland (Fig. 1 a–c_1) to the aiming point or indirectly via the application structure, the hairless protruberance on the chin (Fig. 2 f).

Discussion

Most terrestrial mammals can reach almost any part of the body with their extremities or head and therefore take secretions which are produced at any part of the body and distribute them practically anywhere. However, the extremities of bats are integrated into the flying membrane which would be a handicap for the purpose of secretion distribution. So if secretion is to be distributed over the body including the wings and to the nearby surroundings of these flying mammals, it is advantageous to concentrate the glands on the head, which is, due to its movement, best suited for a surface-efficient secretion-dispersion. The high density of enlarged sebaceous glands in the integument of the head of *Myotis myotis* and *Nyctalus noctula* described in this study is typical for many other vespertilionid bats (Schaffer 1938, 1940; Werner and Dalquest 1952; Dalquest and Werner 1954; Sisk 1957; Fenton 1985; Haffner 1987, 1989; Schmidt et al. 1989; Haffner and Ziswiler 1990).

On the one hand both species are able to distribute secretion onto a smooth surface, for example onto the wing membranes, simply by pressing the head into the wings and dragging the flying membrane over the snout. This pressure causes secretion of small and slightly enlarged sebaceous and sudoriferous glands. Sebaceous and sudoriferous secretions probably combine two functions: the grooming and scenting of the flying membranes which could act as a large fan, spreading scent during flight. On the other hand aimed distribution of secretions onto hard surfaces, for example in roosts, is done in a completely different way by each of the two species. As Kulzer et al. (1985) have shown in *Rhinopoma hardwickei*, sudoriferous secretions are produced in large amounts when the animal is excited. The same can be observed in agitated *M. myotis* and *N. noctula*. If these secretions are to be distributed onto a distinct surface it is practical to place the orifices of glands between the organs of orientation to the nearest surroundings, the vibrissae, as is the case in both species. However, if the surface is hard, rubbing the head against it would cause abrasion of the sensitive vibrissae and the orifices of the glands. For this purpose application structures are advantageous to distribute the secretion after it is pressed onto a hard surface. *N. noctula* can, for example, distribute the secretion with the hairless spot on its chin onto the border of a tree hole, and *M. myotis* can spread secretion with the brush-like hairtufts on the snout onto a wooden beam in an attic. By spreading secretions with application structures, products of the sudoriferous and sebaceous glands are mingled. Thereby the sebum could act as a carrier substance for scent produced by the a-glands as postulated by Starck (1982).

Both *M. myotis* and *N. noctula* have enlarged sebaceous and sudoriferous glands. However, the microanatomy, number and arrangement of these glands and the amount of enlargement diverge in the two species and show us, combined with the different application structures, two completely divergent systems of secretion delivery, application, and distribution. These differences in closely related species can be seen as adaptations to different functions.

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Zusammenfassung

Die Möglichkeiten der Duftmarkierung beim Großen Mausohr Myotis myotis (Borkhausen, 1797) und beim Großen Abendsegler Nyctalus noctula (Schreber, 1774) (Mammalia, Chiroptera)

Bei Fledermäusen ist die Verbreitung von Duftdrüsen über die Körperoberfläche durch die Integration von Extremitäten und Schwanz in die Flughaut eingeschränkt. Anhand von vergleichenden mikroanatomischen Untersuchungen am kranialen Integument zweier Fledermausarten wurden Ausscheidung, Auftragung und Verteilung von Sekreten als ein Funktionskomplex interpretiert. Die Talgdrüsen konnten vier Typen zugeordnet werden. Neben normalen haben beide Arten wenig vergrößerte Talgdrüsen.

Bei Kontraktion der subkutanen Muskulatur werden die vergrößerten Talgdrüsen ausgepreßt. Während *N. noctula* pro Schnauzenseite 10 solche Drüsen aufweist, mündet bei *M. myotis* je eine vergrößerte und eine extrem vergrößerte Talgdrüse in einen Haarpinsel. Während beide Arten ein Gemisch aus Sekreten der Talg- und a-Drüsen auf die Flughaut auftragen können, verteilen sie Sekrete auf harten Oberflächen, wie sie in den Tagesschlafquartieren vorkommen, auf unterschiedliche Weise. *N. noctula* verstreicht sie mit dem Kinn und *M. myotis* mit den Haarpinseln auf der Schnauze.

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