Skin glands

Deer have the same five senses that humans do but place very different importance on each of them. We rely primarily on sight to gather information about our environment and on sound to communicate with other humans. Deer, on the other hand, use their sense of smell as the primary means of both gathering information and communicating with other deer.

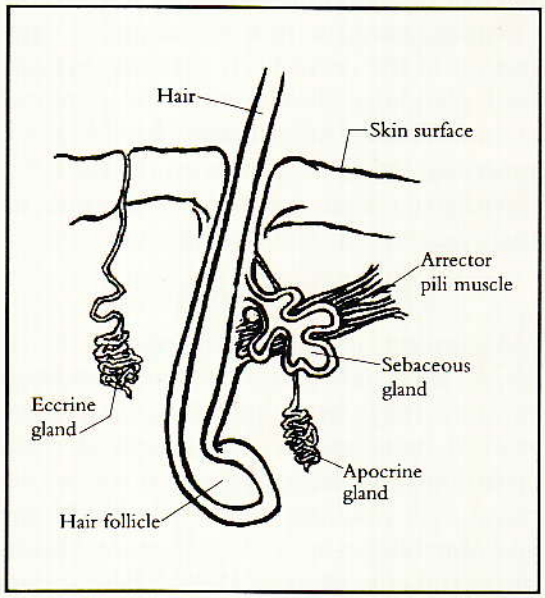
Chemical signals that are part of an olfactory vocabulary may be produced by a number of sources, including the reproductive tract, urine, feces, the respiratory system, and specialized skin glands. Although the other sources of scent are undoubtedly important in conveying information among deer, the skin glands are notable because of their wide distribution over the deer's body and their variability in structure and function.

All odocoileids—mule deer, black-tailed deer, and white-tailed deer—are richly endowed with scent-producing skin glands. As early as 1877, the presence of some of these glands was reported by Canton. Since these deer are closely related, they have essentially the same glands, which serve similar functions, although there are some differences among the species.

Skin Gland Histology

Each of the specialized skin glands is composed of one or both of two basic types of glandular tissue: sebaceous and sudoriferous. Both types are found distributed over the skin surface, but they tend to be greatly concentrated and enlarged in the specialized skin glands.

Sebaceous gland tissues are usually associated with a hair follicle, although this is not always the case. Commonly, sebaceous glands are connected to a hair follicle by a short duct. When viewed under a microscope, a group of sebaceous glands looks like a tiny cauliflower. The secretory product of the sebaceous glands is always oily and rich in fatty materials called lipids. The sebaceous glands themselves apparently do not produce any scent important in communication, but their secretions appear to be vital for holding substances—produced elsewhere in the body—that do convey information. This lipid material then can either be trans-



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Both sebaceous and sudoriferous glands lubricate the skin and waterproof the hair. The lipids they produce, though they have no scent of their own, are a vehicle for olfactory messages.

ferred to a tree branch or some other object in the environment or be held on the deer's body to allow bacteria to change it into an odor important for communication.

There are two types of sudoriferous or tubular sweat gland tissue: eccrine and apocrine. Both consist of a secretory coil located deep in the skin and a duct leading to the skin surface. The duct of eccrine glands opens directly at the skin surface; that of apocrine glands generally leads to a hair follicle. Eccrine glands are responsible for thermoregulatory sweating in humans, but they typically are not very important in other animals. Apocrine glands, on the other hand, are confined to the pubic, perineal, and axillary regions of the human body but are widely distributed over the skin of most other mammals. Apocrine glands are much more important than eccrine glands in chemical communication; they can produce airborne odors or, more commonly, a material that is altered through microbial action into a scent.

Several of the specialized skin glands of deer are associated with areas of specialized hairs. These hairs are important in odor transmission. They can control air circulation to the skin surface, increase the area for evaporation of odors, provide a substrate for the growth of odor-producing bacteria, and serve as a brush for transferring materials to objects in the environment. In addition, each hair is connected to an arrector pili muscle, which, when contracted, can cause the hair to "stand on end."

Researchers have thus far identified eight regions of the deer's body that have specialized glandular development of potential communicative importance: the forehead, preorbital, and nasal glands on the head; the interdigital, tarsal, and metatarsal glands on the legs; the caudal and preputial regions.

The Forehead Gland

According to Müller-Schwarze (1971, 1972), black-tailed deer rub their foreheads on dry twigs and branches, and these marked branches become centers of social attention. Similar observations of white-tailed deer marking were made by Moore and Marchinton in 1974 and later by Marchinton and coworkers in 1990. These studies found that in both species, scent marking with the forehead gland is done by both males and females, although males mark more often than females.

In black-tailed and mule deer, a microscopic anatomy (or histology) of the forehead skin reveals that the sebaceous and sudoriferous gland tissues here are only slightly, if at all, larger than those in the skin of other parts of the deer's body. In their studies conducted in the 1970s, Quay and Müller-Schwarze did not observe any differences in the activity of these glands according to the age or sex of the animal. Nonetheless, behavioral observations do indicate that this is an important scent-producing region in these deer.

A slightly different situation exists with white-tailed deer. Microscopic examination of the forehead region reveals greater numbers of tubular apocrine sudoriferous gland tissues than are found in other areas of the deer's skin. During summer, these glands exhibit little activity in either male or female deer. During breeding season, however, glandular activity increases somewhat in females and greatly in males. These glands are most active in dominant males and least active in young fawns.

The Preorbital Gland

The preorbital gland—also called the antorbital gland, preocular gland, suborbital pit, or lachrymal sinus—consists of a shallow, hairless pocket that opens to the surface through a slit. It is located in front of the corner of the eye. This pocket is essentially aglandular in black-tailed and mule deer. The edges, or lips, of the pocket in both sexes have sebaceous and sudoriferous gland tissues that are only slightly larger than those occurring elsewhere on the body surface. The histology of this gland in white-tailed deer has not been investigated, but there is little reason to suspect that it differs substantially from that of the other two species.

In all species, the preorbital gland is under muscular control; bucks commonly flare theirs open during dominance displays, does often do so while their fawns are nursing. Inside the preorbital sac there is often an accumulation of material that likely consists of dead skin cells, drainage from the eye, and

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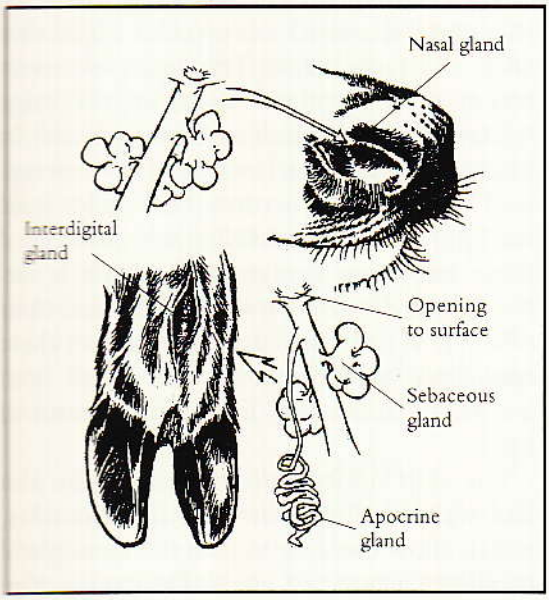
Bucks often rub the preorbital gland, which is just in front of the eye, on overhanging twigs. Passing deer may react to the scented twig, but the exact message remains unknown.

foreign matter. Investigations by Volkman and his coworkers demonstrated that black-tailed deer react to the scent from the preorbital gland. This reaction indicates that the scent conveys some information to other deer, but exactly what information is not yet known. The researchers suggested symbiotic bacteria inhabiting the sac as a possible source of this scent.

The Nasal Gland

Nasal glands were first reported in both mule and white-tailed deer by Atkeson and his coworkers in 1988, and it is very likely that black-tailed deer also have them. These glands, consisting of oval cavities located just inside the nostril, connect to the nostril by a short duct. The glands are hairless and contain many sebaceous gland tissues but no sudoriferous ones.



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The function of the nasal gland is unknown, but it does not appear to be involved in scent communication. It is similar to the nasal gland reported by Jacob and van Lehmann in 1976 in the closely related marsh deer from South America. Secretions from this gland were shown to consist primarily of lipid material that has a very low volatility. Because the molecules do not readily pass into the air, it is unlikely that these secretions emit a behaviorally important scent. It seems that their primary purpose is to lubricate the nose, although their possible role in signpost communication should not be ignored. Additional research may someday clarify the importance of the nasal gland.

Two glands whose communicative significance has not yet been determined are the nasal gland, which exudes lipids, and the interdigital gland, which contains sebum.

The Interdigital Gland

Between the toes on all four feet are invaginations, or saclike folds, called interdigital glands. For all three types of deer these glands probably serve to leave a scent trail–depositing a telltale odor with each step. There are, however, differences among the species in the anatomy of this gland; therefore the source and type of scent produced likely differs also.

In white-tailed deer, the interdigital pockets are characterized primarily by greatly enlarged sebaceous gland tissues, although sudoriferous gland tissues do occur. There is

a tendency for the sebaceous gland tissues to enlarge as the deer ages, according to Quay. Often a yellowish, waxy material called sebum is present in the interdigital sac.

In mule and black-tailed deer, in contrast, the interdigital contains both enlarged sebaceous and sudoriferous gland tissues. In the blacktail, at least, the sebaceous and sudoriferous layers also appear to be thicker.

The Metatarsal Gland

The metatarsal gland is located on the outside of the deer's hind foot, or metatarsus. It is a curious structure consisting of a central, oval patch of highly cornified, hairless skin surrounded by an oval tuft of white hair. There is considerable variation in its size among the species of deer. In mule deer this gland is 100 to 150 millimeters (4 to 6 inches) long; in black-tailed deer it is considerably smaller, 60 to 100 millimeters (2.5 to 4 inches). In whitetails the gland is even smaller—just 20 to 35 millimeters (.75 to 1.5 inches)—and interestingly, it varies in size among the different whitetail subspecies. In the northern United States and Canada, the gland is fairly large. In the southern states, the gland is smaller, and in subspecies inhabiting parts of Central and South America, the gland may be completely absent.

The central, hairless ridge contains no glandular elements. Quay hypothesized that this structure has a sensory function, such as circulatory thermoregulation, although experimental evidence is lacking. The fact that this gland is larger in colder climates does support his suggestion, however.

The skin underlying the oval ring of hair contains both enlarged sebaceous and sudoriferous gland tissues. The sudoriferous tissues are much more highly developed in black-tailed and mule deer than in the whitetail. Müller-Schwarze has demonstrated that the metatarsal of black-tailed deer produces a garliclike odor that serves as an alarm signal, but his studies, and later those of Atkeson, failed to demonstrate that the whitetail metatarsal produces an alarm scent. These findings are consistent with the differences in the histology of the organ between the two species.

The Tarsal Gland

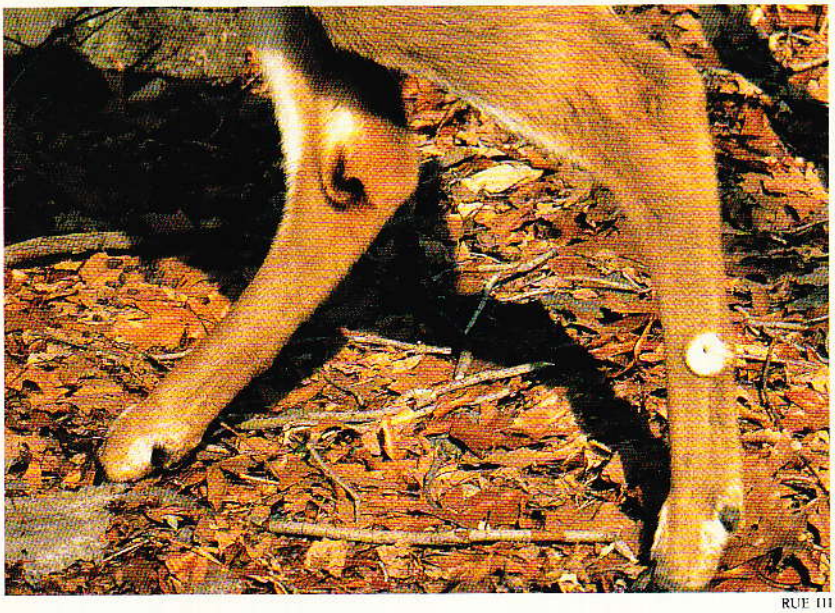
The tarsal gland is probably the most important gland in all three types of deer. It is used to identify other deer and likely also contains information on dominance position, physical condition, and reproductive status.

The gland consists of a tuft of elongated hair on the inside of the hind leg at the tarsal joint, or ankle, and large numbers of enlarged sebaceous and sudoriferous gland tissues in the skin underneath this tuft. Though these skin glands likely contribute to the odor of the tarsal gland, the primary source of the tarsal odor appears to come from urine.

All deer commonly urinate onto their tarsal glands in a behavior called rub urination or scent urination. The sebaceous gland tissues under the tarsal tuft produce a lipid that coats the tarsal hairs. This lipid selectively retains certain compounds from the urine while permitting other materials to pass. In black-tailed deer, the tarsal hairs have specialized comblike structures that help hold the lipid on the hair. Müller-Schwarze called these structures osmetrichia, which is derived from the Greek *osme* ("odor") and *thrix* ("hair"). White-tailed deer do not have these specialized structures, but the tarsal hairs are still capable of holding large amounts of lipid.

The skin underneath the tarsal tuft also has well-developed arrector pili muscles, which allow the deer to flare the tarsal gland to release a burst of scent. Deer often flare

The tarsal gland, on the inside of the hind leg, grows a brush of hair that the deer can wash with urine. Certain chemicals (lactones) in the urine interact with the lipids from the gland to produce significant scents.



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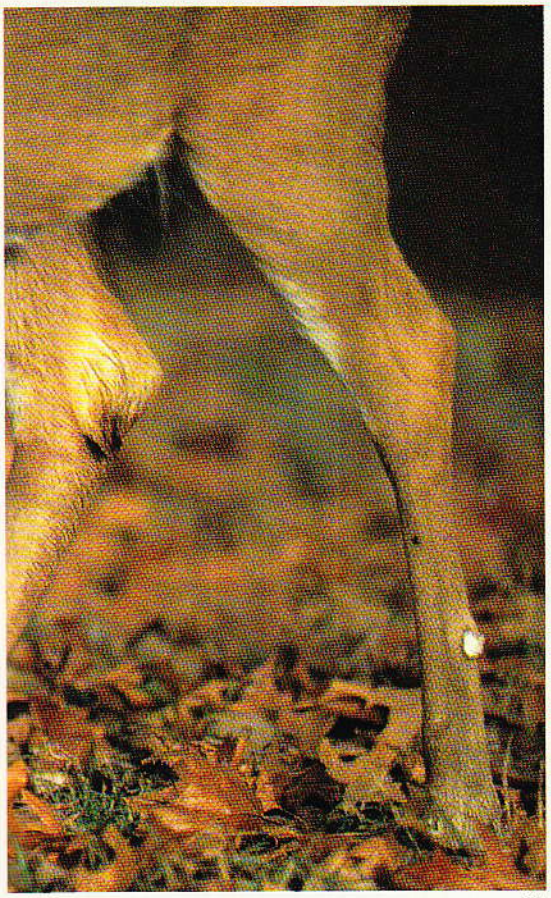

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The role of the metatarsal, on the outside of the hind leg, is only partially known, but its size differs greatly between the species. The whitetail's gland is small, round, and white; the mule deer's may be 6 inches long.

this gland in response to physical or social trauma—a painful injury, harassment from other deer.

In black-tailed deer, the main component of the tarsal scent was identified by Brownlee and his coworkers in 1969. They found that a compound called *cis*-4-hydroxydodec-6-enoic acid lactone, which originates from the deer's urine, is present on the tarsal glands of males. Subsequent studies indicated that this compound is effective in eliciting approach, sniffing, and licking responses from other deer, although it must be accompanied by several other tarsal constituents for maximal response.

Although the compounds that provide the scent to the tarsal gland in white-tailed deer have not yet been identified, they certainly have their origin in the deer's urine and are likely similar to those of black-tailed deer.

Caudal Glands

Caudal glands have been described for black-tailed and mule deer only. These glands are located on the dorsal and lateral areas of the tail and consist of moderately enlarged sebaceous and sudoriferous gland tissues. As with the tarsal gland, the skin in the caudal area contains enlarged arrector pili muscles. Müller-Schwarze reported that blacktail fawns produce a peculiar odor from their tails when excited. This odor can also be found in adult males. The caudal area of white-tailed deer also may function as a scent gland, but it has not been examined histologically nor have any behavioral observations suggested it as a source of scent.

Preputial Glands

The existence of preputial glands in white-tailed deer was reported in 1991 by Oden'hal and his coworkers, but their function has not yet been determined. They consist of greatly enlarged sebaceous gland tissues and a few long hairs that protrude from the penal sheath. These long hairs become covered with a lipid material in the same manner as the tarsal hairs.

The preputial area in black-tailed and mule deer has not yet been investigated.

—Karl V. Miller and R. Larry Marchinton