Histological Variations in Myoepithelial Cells and Arrectores Pilorum Muscles among Caudal, Metatarsal and Preorbital Glands in Hokkaido Sika Deer (Cervus nippon yesoensis Heude, 1884)

Nobuo OZAKI1), Masatsugu SUZUKI1)∗ and Noriyuki OHTAISHI1)

1)Laboratory of Wildlife Biology, The Graduate School of Veterinary Medicine, Hokkaido University, Kita-ku, Sapporo 060–0818, Japan

(Received 1 April 2003/Accepted 15 October 2003)

ABSTRACT. The morphological characteristics of myoepithelial cells and arrectores pilorum muscles were investigated in caudal, metatarsal and preorbital glands of Hokkaido sika deer (Cervus nippon yesoensis Heude, 1884) using immunohistochemistry for α-smooth muscle actin. In the metatarsal, preorbital and general skin glands, myoepithelial cell layers continuously embraced the secretory epithelium, while in the caudal gland, discontinuous myoepithelial cell rows surrounded the apocrine tubules. There was a trend that the widths of the myoepithelial cells of the caudal and preorbital glands appeared to be thinner than those of the metatarsal and general skin glands. In the metatarsal gland, the arrectores pilorum muscles were highly developed and considerably larger than those in other skin glands.

KEY WORDS: arrectores pilorum muscle, myoepithelial cell, sika deer.


The specialized skin glands in the cervid species include forehead, preorbital, tarsal, metatarsal, interdigital and caudal glands [15], most of which contain both apocrine and sebaceous glandular elements [1, 7, 12]. In Hokkaido sika deer (Cervus nippon yesoensis Heude, 1884), the existence of caudal, metatarsal and preorbital glands were confirmed [4]. Some of their histological characteristics have already been reported [4], however, the physiological mechanisms of secretions remain unknown. Since specialized skin glands are considered to work as scent glands [9], their secretory processes and product properties are largely related to ecology and behavior of the species. So in the present study, we investigated the morphological characteristics of myoepithelial cells and arrectores pilorum muscles in caudal, metatarsal and preorbital glands of Hokkaido sika deer using immunohistochemistry for α-smooth muscle actin.

Tissues of those specialized skin glands and general skin glands of the buttocks were collected from four female deer (one year and older) that were humanely and legally shot in Shari District in Hokkaido, Japan, in August 2000. Ages of animals were estimated on deciduous tooth changes [6]. The tissues were fixed in 10% formalin neutral buffer solution (pH 7.4) and embedded in paraffin for light-microscopic immunohistochemistry. The 5 µm thick sections were dewaxed and incubated for 45 min in 3% H2O2-methanol and then in 10% normal rabbit serum (Histfine Kit, Nichirei Co., Tokyo, Japan) for 20 min at room temperature. The sections were then incubated for 20 min at room temperature with a mouse monoclonal antibody against human α-smooth muscle actin (N1584, Dako Co., California, U.S.A.). After three washes (10 min each) in 0.01 M phosphate-buffered saline (PBS, pH 7.2), they were incubated for 15 min at room temperature with a biotinylated rabbit antibody against mouse IgG, IgA and IgM (Nichirei). Then they were rinsed three times (10 min each) in PBS and incubated for 10 min at room temperature in a streptavidin-biotin peroxidase complex (Nichirei). After three rinses in PBS, the peroxidase activity was visualized by incubating in diaminobenzidine solution (Histofine Simple Stain DAB solution, Nichirei). Finally the sections were lightly counterstained with Mayer’s hematoxylin solution (Wako Pure Chemical, Osaka, Japan). The immunohistochemical specificity was tested by replacing the specific antibodies with non-immune serum.

In the apocrine glandular region of all skin glands, immunoreactivity specific for α-smooth muscle actin was found in myoepithelial cells and smooth muscle layer of the blood vessels (Fig. 1). Unlike the infraorbital gland of Japanese serow (Capricornis crispus) [2], variation in the immunoreactivity of myoepithelial cells within each skin gland was not obvious. In the metatarsal and preorbital glands and general skin glands, immunoreactive myoepithelial cell layers continuously embraced the secretory epithelium (Figs. 1a, b, c), while in the caudal gland, discontinuous immunoreactive cell rows surrounded the apocrine tubules (Fig. 1d). There was a trend that the widths of the myoepithelial cells of the caudal and preorbital glands appeared to be thinner than those of the metatarsal and general skin glands (Figs. 1b, d).

In the sebaceous glandular region of all the skin glands, obvious immunoreactivity was detected in the smooth muscle of blood vessels, arrectores pilorum muscles and around hair follicles. It was noticeable that the arrectores pilorum muscles in the metatarsal gland were highly developed and considerably larger than those in the general skin glands, and enclosed the sebaceous glands which were also highly developed (Fig. 2). There were no great differences in the appearance of the arrectores pilorum muscles between the...
Fig. 1. Immunostaining for α-smooth muscle actin of the metatarsal gland (a), preorbital gland (b), general skin gland (c) and caudal gland (d). In the metatarsal and preorbital glands and general skin glands, immunoreactive myoepithelial cell layers continuously embrace the secretory epithelium, while in the caudal gland, discontinuous immunoreactive cell rows surround the apocrine tubules. There is a trend that the widths of the myoepithelial cells of the caudal and preorbital glands appear to be thinner than those of the metatarsal and general skin glands. L: glandular lumina. *: immunoreactive smooth muscle of blood vessels. Bars = 40 µm.

Fig. 2. Immunoreactivity specific for α-smooth muscle actin is seen in arrectores pilorum muscles (arrows). It is noticeable that the arrectores pilorum muscles in the metatarsal gland were highly developed and considerably larger than those in the general skin glands, and enclose the sebaceous glands (SG) which are also highly developed. HF: hair follicles. AG: apocrine glands. *: immunoreactive smooth muscle of blood vessels. Bar = 400 µm.
caudal gland and in the general skin glands except that the distribution of those in the caudal gland were restricted to a shallow portion of the corium and were not seen in the apocrine glandular region. The arrectores pilorum muscles in the preorbital gland appeared to be fewer and smaller than those in the general skin glands.

The present study demonstrated the variations in the degree of development of the myoepithelial cells among the specialized skin glands of Hokkaido sika deer. It has been suggested that the myoepithelial cells of exocrine glands develop better to provide compression pressure for glandular product expulsion, as the viscosity of the glandular product is higher [11, 13]. Therefore, the morphological variations of myoepithelial cells among these glands may reflect the variations in their secretion properties. It is implied that the viscosity of the apocrine products from the metatarsal gland is higher than those from caudal and preorbital glands. It was reported that a sticky secretion, which adhered to the cutis surface of the metatarsal gland of Hokkaido sika deer, was observed [5]. However, we directly observed that the cutis surface of the caudal gland appeared to be dry and smooth. In reindeer (*Rangifer tarandus*), chemical analysis using gas chromatography also revealed that the secretion from the caudal gland consisted of volatiles [10]. These observations are in agreement with our hypothesis about the relationship between myoepithelial cell development and secretion property in specialized skin glands of sika deer. To verify that, detailed chemical and histological analyses of the products from these glands are indispensable.

Our study revealed that the arrectores pilorum muscles in the metatarsal gland were extraordinarily developed. Previous research has indicated that the motion of the skin induced by contraction of this muscle promotes discharge of cell products from the sebaceous gland [8]. This means that the erection of white hair, that covers metatarsal gland region, and discharge of sebaceous products, happen synchronously. It was reported that the hair on or around specialized skin glands stands erect when animals are alerted and act as a visual warning [3]. This visual alarm effect, therefore, is considered to be reinforced by the olfactory effect of metatarsal secretion that discharged simultaneously.

Both sebaceous and sticky apocrine products from the metatarsal region easily adhere to leaves and sprigs of ground cover. In addition, those smells may last longer than that of volatile secretions. This would be of advantage to indicate the trail of an animal to others, and adaptive in maintaining the social group in forest and woodland habitats.

We thank the staff of the Shiretoko National Park Nature Center and members of the Hokkaido Hunting Association in Shari Town for their assistance with the collection of samples. We are grateful to Dr. T. Iwanaga of Hokkaido University for helpful suggestions and support throughout the laboratory analyses.

REFERENCES