effective synthesis of some neuromodulators. On the other hand, neither our results on *dunce*[2], nor those bearing on the *ts*[2] mutant of the gene *Ddc* support an interpretation of the 'sexual perseveration' effect in terms of mnesic deterioration. This is not the first time that the generality of impact of some 'memory mutations' has to be qualified[12-14], especially as far as the *dunce* mutation is concerned.

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## A source of cutaneous maternal semiochemicals in the mink?

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*Summary.* Unique hypertrophic apocrine sweat glands are described in the neck, perineal and inguinal skin of mink kits. These glands enlarge after birth, only to regress rapidly and become vestigal by weaning. No similar phenomenon has been recognized before in mammals. Behavioral studies indicate a possible role for the glandular secretion in maternal recognition of the young.
*Key words.* Mink; apocrine glands; pheromones; maternal behavior; semiochemical.

Maternal care in mammals depends upon the exchange of a variety of sensory stimuli between the mother and her young and is further influenced by the endocrinological status and prior experience of the dam[1-4]. Olfactory cues provided by semiochemicals are likely the most important of the sensory stimuli mediating the mother-young interaction[2-5]. The olfactory cues which mediate the attraction of the young to their mother have been identified in some species; for example, a 'maternal pheromone' has been described in the feces of the female rat[6-9]. Little is known, however, of the source or nature of olfactory cues which emanate from the young to influence maternal behavior and/or offspring recognition. This paper describes hitherto unrecognized hypertrophic cutaneous adnexal glands in the young mink and reports behavioral studies supporting a putative function in chemical communication.

The cervical apocrine glands were first identified upon histological examination of skin from mink kits suffering a fatal staphylococcal dermatitis known as 'pimply kit' disease[10]. The unusual prominence of these glands prompted a histologic and morphometric study of their development during the neonatal period. Four mink kits, 2 of each sex, were sacrificed during the first week of life and at weekly intervals up to 6 weeks (the age of weaning). Mink were skinned and the subcutaneous surface was examined to determine the extent and location of the glands. Skin samples from dorsal neck, inguinal and perianal areas from fetal mink, kits and adults were fixed in 10% buffered formalin. Tissues were processed routinely for histological examination and stained with hematoxylin and eosin (H&E). The area occupied by the cervical glands was measured by tracing the perimeter of all sections of glands lying beneath a standard length of epidermis using a Zeiss Videoplan. Means of total glandular area were calculated for each of 3 sites (cranial, middle or caudal cervical) and for age of mink (newborn, 1, 2, 3, 4, and 5 weeks). The mean areas were log transformed to stabilize error variance and analyzed as a split plot design with the whole units in a completely random arrangement[11].

The cervical region of the newborn mink is very prominent (fig. 1a). The skin is palpably thicker than that of other body regions and is covered by fine, yellow, crusts, presumably dried glandular secretion. The cervical gland is situated on the dorsolateral aspect of the neck and extends from the occiput to the thorax. It is light yellow-brown and the subcutaneous surface is finely nodular (fig. 1b). The gland is present in the fetus. The cervical gland diminishes as the young mink grow and is inapparent macroscopically at 6 weeks.

Histologically, the gland is composed of coiled tubular apocrine glands which show morphological evidence of active secretion (fig. 1c, d). By comparison, at 5 weeks of age, the glands are virtually inactive (fig. 1e). All glands undergo devolution by apoptosis, or programmed cell death (fig. 1f). Morphometric assessment shows that the tubular area of the cervical glands increases markedly over the first 2 weeks of life before decreasing (fig. 2). Glandular area varies significantly with age of mink and site of sampling ($p < 0.0001$). The cervical glands do not exist in the adult, although regular apocrine sweat glands are present throughout the haired skin.

Small foci of hypertrophic apocrine sweat glands, similar to those in the cervical region, occur sporadically in the inguinal and perianal skin of neonatal mink. The latter are not equivalent to the perianal glands associated with scent production in sexually mature animals. These scent glands are rudimentary in neonates.

Behavioral experiments were designed to test the hypothesis that secretion from the glands may function in maternal recognition of the young. Experiments were performed at a commercial mink farm. Secretion from the cervical glands of live 5–15-day-old mink was collected onto unscented absorbent cotton pads by gentle skin massage for 5 min (Neck). Control samples were collected by the same procedure, per-

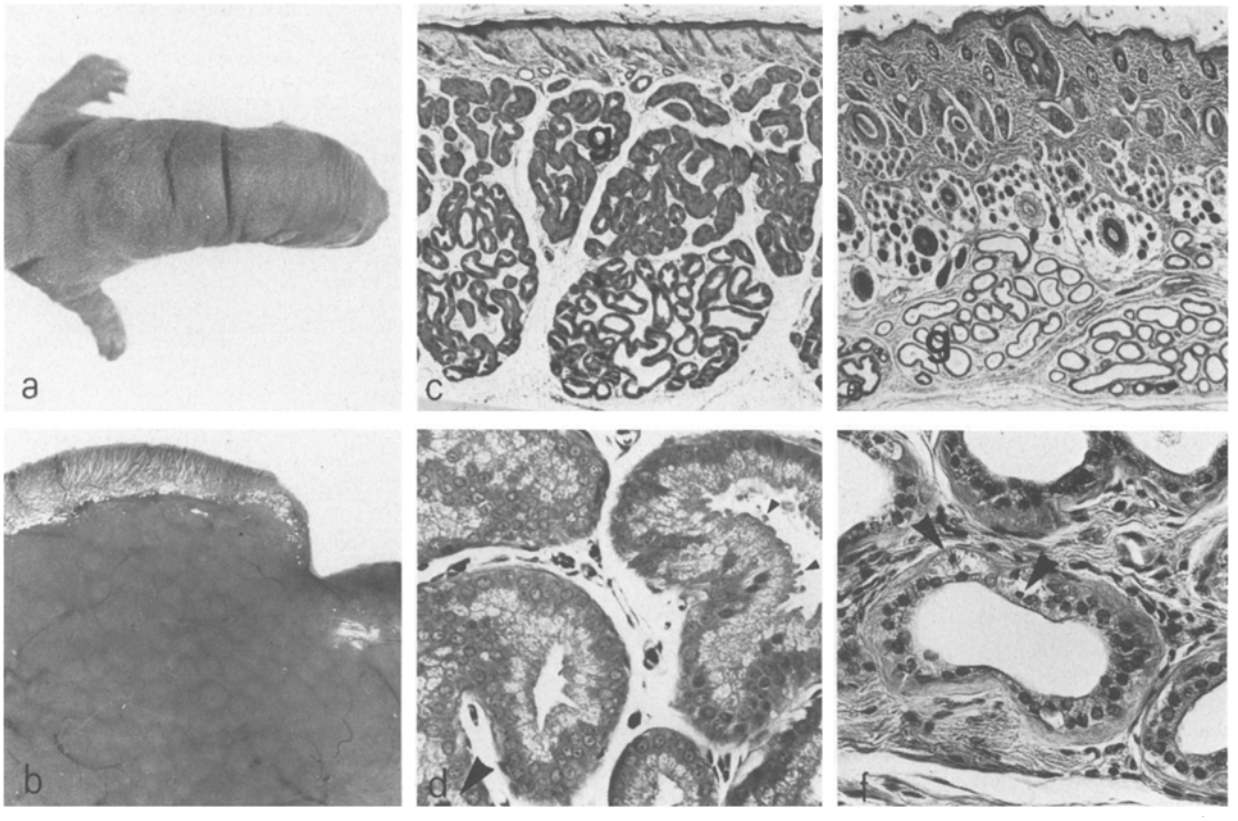


Figure 1. *a* The prominent neck area in a 1-week-old mink kit. *b* The gland from the subcutaneous aspect of the neck skin. *c* Histologic section of neck skin from a neonatal mink showing hypertrophic apocrine glands (g). H & E, × 15. *d* Higher magnification of 1 (*c*) showing hyperplastic secretory units. Small arrows indicate apical blebs and large arrows indicate mitotic figures. Toluidine blue, × 350. *e* Histologic section of neck skin from a 5-week-old kit. The cervical glands (g) have regressed as the hair and other adnexal glands have developed. H & E, ×15. *f* Higher magnification of 1 (*e*) showing atrophic secretory units. Note the thick basement membrane and apoptotic bodies (arrow). H & E, × 220.

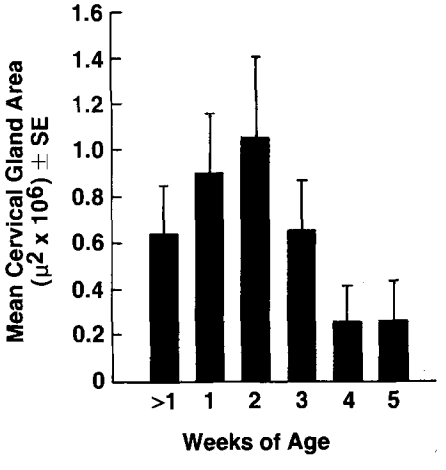


Figure 2. Graph illustrating the changes in the area of secretory units from cervical apocrine glands in mink from birth to 5 weeks of age.

formed on the dorsal trunk skin of the same kit (Back). Clean gloves were used for each operation. Females were tested for their reaction to scent samples collected from one of their own offspring (Own) or from a kit of approximately the same age from another litter (Conspecific). Eleven test females were exposed in random order to the four test samples: 1) Neck-Own, 2) Neck-Conspecific, 3) Back-Own, 4) Back-Conspecific. The test sample was placed in the middle of the open wire cage whilst the female was confined to the closed wooden nesting box. The sample was placed approximately 20 cm from the opening of the nesting box. Removal of a metal slide allowed the female free access to the cage and marked the commencement of the 5-min test period for each sample. The trials were repeated 3 times for each female and results averaged. The following observations were made by an operator unaware of the sample treatment: 1) The number of times the test sample was sniffed (Sniff); 2) The number of times the test sample was picked up (Pick); 3) The number of times the test sample was carried into the nesting box (Box); 4) The time (s) spent with the test sample, including sniffing, carrying and chewing (Total Time); 5) The time (s) spent out of the nesting box (Box Time). Because the female mink spent variable amounts of time in the nesting box, the percentage time spent with the sample of the time spent out of the nesting box, was calculated (% Time). These behavioral data were analyzed as a 2 × 2 factorial. The Sniff response was included as a covariate in the analyses of the remaining data, in order to adjust for disparities in the opportunity the female mink had to spend time with each sample. There was considerable variation in the interest of individual female mink for the samples. There was also a diminution in the interest of most mink as the trials progressed. Randomization of the treatment order, however, prevented any bias in the estimated treatment effects. In order to stabilize the error variance, the following transformations were made: log (Total Time + 1), log (% Time + 100/Box Time), $\sqrt{\text{Pick}} + \sqrt{\text{Pick} + 1}$. Treatment means were computed on the transformed scale, then transformed back to the original scale. Standard errors for these

Table 1. The behavioral responses of lactating female mink to samples impregnated with secretions collected from the neck or back skin of their own or a conspecific kit

| | Neck-Own | Neck-Conspecific | Back-Own | Back-Conspecific |
|---|---|---|---|---|
| Sniff | 5.9 + 0.8 | 4.4 + 0.8 | 4.1 + 0.8 | 5.5 + 0.8 |
| Total Time | 18.1 + 7.0 | 25.1 + 7.0 | 9.0 + 3.3 | 10.2 + 3.3 |
| % Time | 15 + 4.4 | 17 + 4.4 | 6.6 + 1.9 | 6.5 + 1.9 |
| Pick | 1.7 + 0.4 | 2.1 + 0.4 | 0.7 + 0.3 | 0.8 + 0.3 |

means were computed using a Taylor series expansion, assuming the error variance was constant on the transformed scale.

Results are summarized in the table. Female mink approached and sniffed the 4 test samples with equal frequency. The Neck samples elicited significantly greater interest from the lactating females than did the control Back samples, whether measured by Total Time ($p = 0.02$), % Time ($p = 0.003$), or by Pick ($p = 0.02$). The number of trials in which Neck samples were carried into the nesting box (13) was greater than for the Back samples (6) but this difference was not significant statistically (McNammara's test). No evidence was found that the female distinguished between her own and a conspecific kit with either Neck or Back samples.

Despite their prominence, the cervical apocrine glands of the neonatal mink are not a recognized anatomic feature of *M. vison* or other mustelids[12–15]. A study of the development of the hair coat in fetal mink, however, notes 'solitary' sweat glands, which likely correspond to components of the cervical gland[16]. No mention is made, however, of their presence in neonates, although the study was continued up to 120 days post-partum.

Perhaps more unusual than the presence of these hypertrophic cutaneous adnexal glands, is their regression towards the end of the nursing period. We know of no similar phenomenon in mammals[5, 12–15, 17]. The nearest parallel is the uropygidial gland in the hoopoe bird (*Upupa epops*). This gland, which produces a malodorous secretion to deter predators, is maximal in the 12-day-old chick and regresses by the time the bird is a fledgling[17].

Recognizing that presence alone does not predicate a function for a gland, we hypothesized nevertheless that the neonatal mink cervical gland plays a role in maternal recognition of the young. The results of these preliminary behavioral experiments support the hypothesis, indicating that lactating females react more strongly to samples impregnated with secretion from cervical glands than to secretions from other areas of haired skin. The experimental design did not permit the differentiation of positive, i.e., mothering and negative, i.e., aggressive reactions. This may explain why there was no difference in level of interest shown to samples from the female's own kit and that of a conspecific.

The finding that all females approached and sniffed test samples with equal frequency indicates that the putative semiochemicals do not act over distance. Olfactory cues, however, are not necessarily airborne[3]. Many primer semiochemicals are non-volatile, acting by direct contact to stimulate the vomeronasal organ rather than the olfactory mucosa[5, 6, 18, 19]. The anatomic locations of the mink apocrine glands correspond to areas of frequent contact between mother and kit thus facilitating potential transfer of chemical messages. While it would be naive to suggest that maternal behavior in mink depends solely on the secretion of the cervical and associated apocrine glands, secretions of cutaneous adnexal glands act in a variety of odor-guided behavioral responses in mammals, many of which are important in reproduction[2, 5, 6, 19]. We suggest that these glands are adapted for the production of semiochemicals, which have specific effect on maternal interaction with their young.

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