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THE PELAGE DEVELOPMENT IN YOUNG MINK (*Mustela vison*)*

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Introduction

Most mammals are well coverd with hair. There are two distinct types of hair in the mink pelt : the outer guard hair and the underfur. In turn, there are two types of guard hair termed "straight" and "intermediate". These are nearly equal in length, but the basal portion of the intermediate guard hair is fine and wavy like the underfur[1)3)].

Hair emerges from the hair follicle, which is formed by down growths of the basal cells of the epidermis into dermis. The hair bulb is formed at the basal portion of the hair follicle.

The hair growth cycle is divided into three phases, anagen, catagen and telogen[2)]. In the anagen phase, the follicles and hair bulbs are largest and hair growth is most active. There is also a medulla in the hair in the follicles at this time. In the next phase, catagen, a period of decline, the proliferation of cells in the hair bulb ceases and the end of the hair root becomes club shaped and hence is known as club hair. The club hair moves to the upper part of the follicle and at the same time the follicle shortens[4)]. In telogen, the resting phase, the completely grown hair lies in the follicle and a medulla can not be seen in the hair in the follicle. Having passed through these three stages the hair goes into anagen again and the hair growth cycle is repeated.

This is a report of a histological study of pelage development in Sapphire mink from birth to pelting. Sapphire mink are a major strain of mink raised in Japan.

Materials and Methods

Animals

Male Sapphire mink, all sired by the same sire but different dams, born around May 8, and raised under identical conditions were selected and sacrificed at the rate of one animal per week, the first being killed immediately after birth. The animals were frozen immediately after sacrifice in order to prevent as much

* An outline of this paper was read at 4th International Scientific Congress in Fur Animal Production in Tront, 23rd August, 1988.

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as possible changes in the structural elements of the skin that body temperature might cause.

Sectioning and staining

Hair was cut from the mid-dorsal region, and then an approximately 5 by 5 mm sample of skin was taken. Each sample was wrapped separately in aluminium foil and again in plastic wrap to prevent dehydration, then preserved by freezing (−20°C).

The frozen samples were mounted with Compound (Miles Co. Ltd.) and sectioned to thicknesses of 8-12 μm by a freezing microtome, fixed with 10 % formalin and stained with the Hematoxylin-Eosin and mounted in Canadian balsam.

Observation by a light microscope

Samples were sectioned both parallel to the hair follicle and perpendicular to it. The parallel sections were used for observation of the epidermal and dermal thickness, and the length and depth of the follicle. The samples sectioned perpendicularly at the sebaceous gland level, which will be called the follicle group level, were used to determine the number of underfur and to observe the activity phase, whether anagen, catagen or telogen, of the individual underfur. The active phase (anagen) was judged by the existence of a medulla.

Using the results of the above observations the ratio of activity of underfur at the follicle group level was measured.

All the values are shown at the average obtained from the measurment at n= 100. The ratio of activity was calculated using the following formula :

$$\text{Ratio of activity (\%)} = \frac{\text{Number of underfur in active phase} \times 100}{\text{Total number of underfur}}$$

Results and Discussion

Table 1 shows the number of underfur and the ratio of activity of the underfur. Table 2 gives the thickness of the epidermis and dermis, and the variation in hair follicle length and depth. The values shown in Table 1 and 2 are plotted in Figures 1-5, which clearly show the major changes in skin demensions.

Number of underfur per follicle group

The variation in number of underfur per follicle group is shown in Fig. 1.

Initially there was only neonatal hair, a form of guard hair in the follicles of the mink sacrificed immediately after birth. The existence of underfur in follicles was confirmed at week 4. From week 4 to week 10 the underfur increased in number dramatically and reached about 14 per follicle group. The values remained rather constant in the summer coat at 12-14 (S.E. 0.05-0.17) between weeks 10 and 16. At week 16 moulting began. After moulting the summer coat the number of underfur per follicle group increased rapidly and reached 22-23 (S.

Table 1. Number of underfur and ratio of activity of underfur in young mink

Weeks	Number of underfur $\overline{X}\pm$S.E.	Ratio of activity of underfur(%)
0		
2		
4	1.56±0.05	78.8
6	3.76±0.06	87.5
8	6.12±0.10	72.8
9	11.25±0.15	54.1
10	14.58±0.17	47.1
12	13.68±0.20	31.4
14	13.06±0.17	2.1
16	13.79±0.22	0.8
18	22.76±0.30	28.6
20	24.01±0.25	51.6
22	23.08±0.37	72.3
23	23.42±0.49	72.9
24	24.62±0.58	64.2
25	23.87±0.38	17.7
26	23.47±0.47	1.7
28	22.60±0.37	0.1
30	22.15±0.22	0

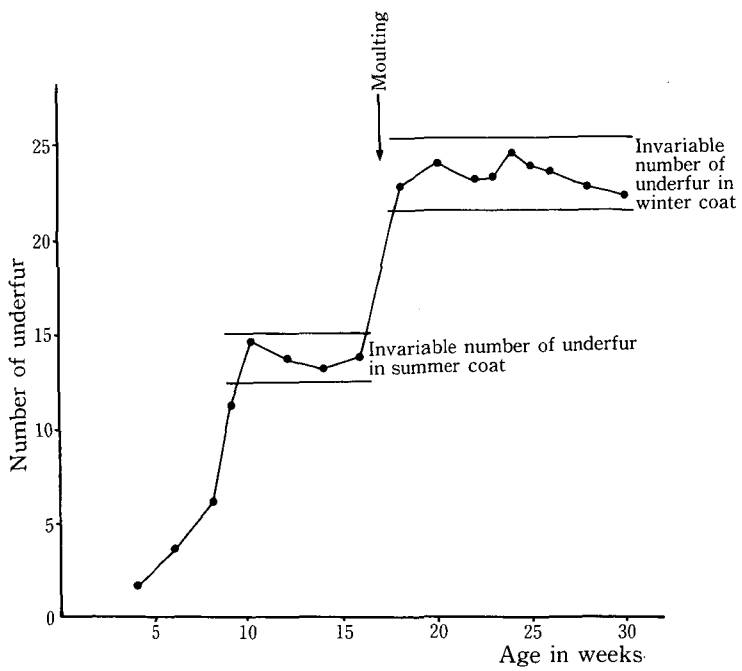

Fig. 1. Changes in the number of underfur per follicle group in mink

Table 2. Epidermal and dermal thickness together with the variation in hair follicle depth and length througout the hair cycle in mink skin

Weeks	Epidermal thickness $\bar{X}$ ±S.E. (μm)	Dermal thickness $\bar{X}$ ±S.E. (mm)	Hair follicle length $\bar{X}$ ±S.E. (mm)		Hair follicle depth $\bar{X}$ ±S.E. (mm)	
			Guard hair	Underfur	Guard hair	Underfur
0	35.0±3.1	0.23±0.01	0.81±0.04	0.41±0.03	0.55±0.02	0.28±0.03
2	21.3±2.1	0.30±0.02	1.44±0.04	0.89±0.05	0.89±0.04	0.56±0.07
4	21.1±1.4	0.45±0.02	1.55±0.08	1.23±0.08	1.15±0.06	0.85±0.04
6	21.0±1.9	0.68±0.04	2.22±0.12	1.62±0.04	1.26±0.06	0.93±0.03
8	24.2±1.8	0.88±0.01	2.78±0.06	1.93±0.07	1.69±0.03	1.18±0.03
9	26.6±1.4	1.02±0.04		1.63±0.05		1.07±0.03
10	26.8±1.7	1.04±0.02	2.46±0.07	1.65±0.07	1.45±0.07	1.05±0.04
12	25.2±1.6	0.89±0.04	1.58±0.30	1.41±0.05	0.98±0.11	0.92±0.03
14	20.1±1.4	0.89±0.04	1.12±0.05	0.91±0.05	0.78±0.05	0.66±0.04
16	17.9±0.8	0.91±0.03	0.93±0.05	0.87±0.01	0.77±0.04	0.67±0.01
18	17.6±0.6	1.33±0.05	2.70±0.06	1.54±0.03	1.95±0.05	1.17±0.03
20	16.3±0.8	1.13±0.05	2.47±0.06	1.74±0.03	1.79±0.03	1.29±0.03
22	15.4±1.0	1.24±0.03	2.42±0.04	1.99±0.02	1.65±0.04	1.44±0.02
23	16.7±0.7	1.37±0.05		2.14±0.02		1.56±0.02
24	17.7±0.7	1.11±0.03	1.90±0.26	1.70±0.02	1.32±0.24	1.25±0.01
25	16.8±0.7	0.96±0.03		1.39±0.02		0.87±0.01
26	16.8±0.6	0.75±0.02	1.08±0.05	1.04±0.02	0.72±0.04	0.64±0.01
28	15.0±0.6	0.72±0.01	1.06±0.02	0.76±0.004	0.70±0.02	0.56±0.003
30	15.2±0.5	0.70±0.01	0.86±0.02	0.70±0.003	0.60±0.01	0.52±0.003

E. 0.30) by week 18 and then remained between 22-26 (S.E. 0.30-0.58) until week 30.

Several quantitative studies on underfur have been published. Dolnick[3] reported 8 underfur per follicle group by day 30 (about 4 weeks), and 9-14 by day 42 (6 weeks) ; by day 88 (12.5 weeks) the underfur was all club hair. Rougeot et al.[5] have reported that the number of underfur was between 12-14 in the summer coat and between 19-22 in the winter coat. A third report[6] stated the values at 8-12 in the summer coat and 25-40 in the winter coat. The values resulting from this experiment were close to those of reports made by Rougeot and others. However the strain of mink, the climate and feeding conditions, and the part of the body from which samples were obtained were different.

Variations in the ratio of activity of the underfur at the follicle group level

The changes in the ratio of activity of underfur at the follicle group level are presented in Fig. 2.

As is shown from weeks 4-8, the ratio of activity of the summer coat is high at 70-90% (anagen). Between weeks 8-14 the ratio of activity decreased dramatically (catagen) and became 0-3% during weeks 14-16 (telogen). The ratio of activity of the underfur for the winter coat reached its highest percentage at 70-75% between weeks 22 and 23. It then decreased suddenly from week 25 and

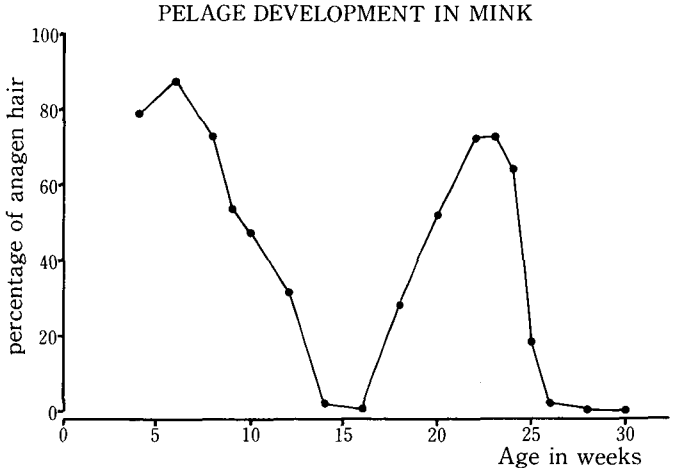

Fig. 2. Changes in the ratio of hair activity in mink

dropped to almost 0% by week 26. As mentioned above, the ratio of activity of the summer coat gradually decreased over a period of six weeks while that of the winter coat showed a rapid decline in just two weeks. The duration of anagen of the winter coat was shorter than that of the summer coat and the ratio of activity of the winter coat was lower than that of the summer coat. Compared with the approximate two weeks duration of telogen in the summer coat, telogen of the winter coat was much longer, more than one month.

Variations in the skin thickness

The changes in the epidermal and dermal thickness are shown in Fig. 3.

As is clear from Fig. 3 the epidermis of the mink killed immediately after birth was thick, about 35 μm. Over the next two weeks it decreased to approximately 20 μm and remained at that value until week 6. The epidermis then began to thicken again and became about 25 μm between weeks 8 and 12. When the resting phase of the summer coat started (by week 14) the epidermal thickness decreased. In the period of the winter coat, from week 18 to 30, the epidermal thickness was about 15 μm. It remained fairly constant at this value, but between weeks 23 and 25 a slight increase (17-18 μm) was noted.

The development of the dermis is charted in Fig. 3. It was 0.2 mm at birth and by weeks 9 and 10 had increased to 1.1 mm. It then thinned to 0.9 mm by week 12 and stayed at that value until week 16. Between weeks 16-18 the dermis again rapidly thickened to 1.3 mm during the moulting period and then again thinned slightly to values between 1.1 and 1.4 mm by week 24. Weeks 24-26 showed a rather sudden decline in dermal thickness to 0.7 mm at which time the resting phase began.

Though the epidermis was thickest at the time of birth, and thinned considerably in the two weeks after birth, there was little change thereafter. On the other hand the dermis thickened with the growth of the mink until weeks 8-10. At the same time the interweaving of the collagen fibers became dense. The epidermis of the summer coat was thick from weeks 8-12 and that of the winter

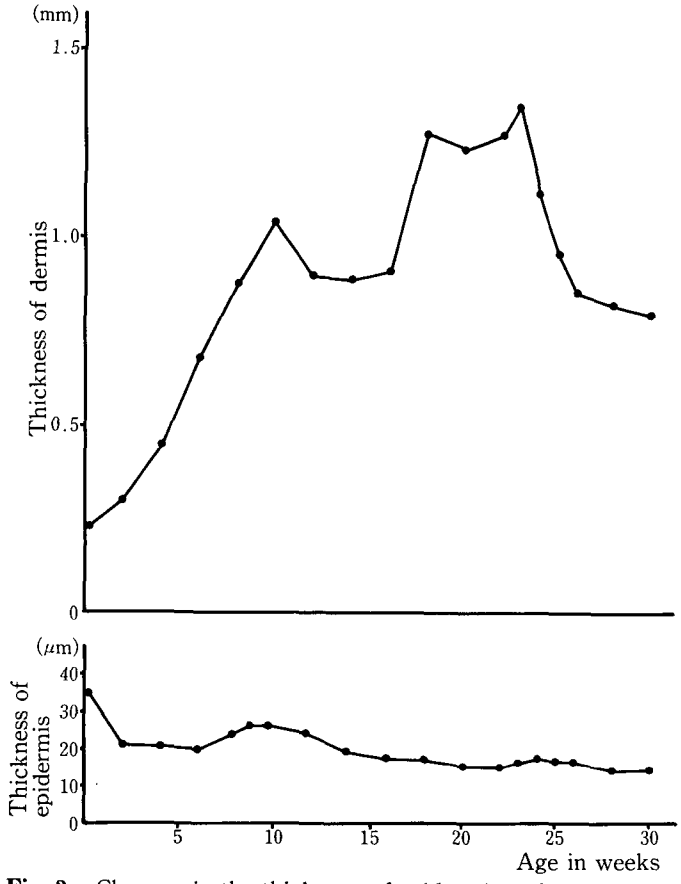

Fig. 3. Changes in the thickness of epidermis and dermis in mink

coat was thick between weeks 23 and 26. During the resting phase it became somewhat thinner. The epidermis of the summer coat was somewhat thicker than that of the winter coat. It is not understood if this is caused by a seasonal factor or whether there is some relationship to the growth process. More investigations are needed to clarify this possibility. It was noted, however, that in the summer coat the epidermis thickened corresponding to the follicles in the active phase. Although the same results had been expected for the dermis, the difference between the active phase and inactive phase of the winter coat was larger than that observed for summer coat.

The resting phase in November, considered the prime period, is the best for pelting, not only because the quality of the hair is the best, but also because the dermal thickness was the thinnest and the length of the follicles, which will be discussed later, is the shortest.

Variations in the follicle length

As to the length of the follicles of guard hair and underfur, not only the real follicle length in the skin, but also the vertical depth of the follicles were

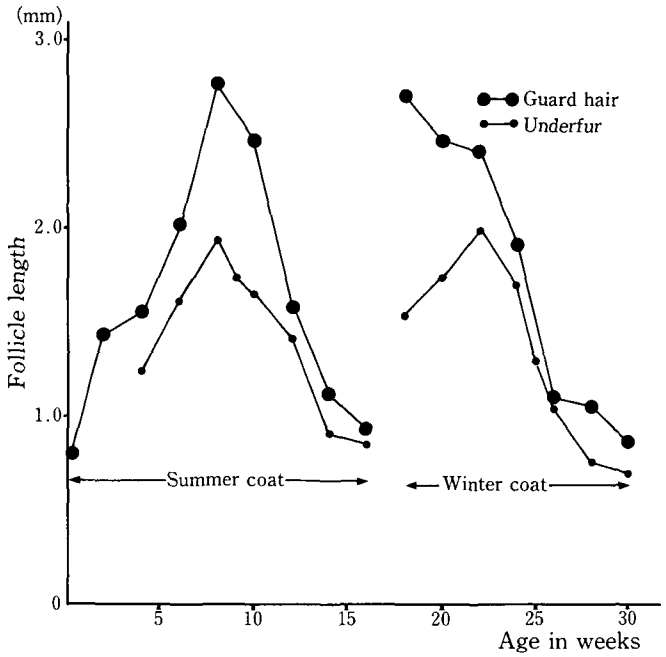

Fig. 4. Changes in the follicle length in mink

measured to compare with skin thickness. These values were plotted in Fig. 4 and 5.

The length of the guard hair follicles was 0.8 mm immediately after birth and afterwards it grew to 2.8 mm by week 8 during the active phase (Fig.4). During the catagenic phase, the follicle length shortened corresponding to an increase in the ratio of the follicles in catagen and telogen and became about 1.0 mm between weeks 14 and 16. Soon after moulting into the winter coat, by week 18, the guard hair follicles reached their greatest length for the winter coat at 2.7 mm and afterwards shortened to 0.9-1.1 mm between weeks 26-30. Though the length of the underfur follicles varied in the same way as that of the guard hair follicles, they never became longer than the length of the guard hair follicles.

The length of the underfur follicles increased to 2.1 mm by week 8, corresponding to the growth cycle of the hair and afterwards shortened to 0.9 mm between weeks 14 and 16. Also the length of the underfur follicles was 2.1-2.2 mm at week 18 when moulting had just finished. Afterwards this length, like that of the guard hair follicles, decreased to 0.8−0.9 mm between weeks 28 and 30.

Though the range of differences in the length of the underfur follicles was smaller than that of the guard hair follicles, both the length of the guard hair follicles and the underfur follicles in telogen were about 1/3 of those in anagen. Dolnick[4], using American mink, reported that the follicles in telogen shortened to the sebaceous gland level. The results obtained from this experiment using Sapphire mink were the same as Dolnick[4].

The finding that both the follicles of the guard hair and the underfur were long immediately after moulting demonstrated that the winter coat follicles had

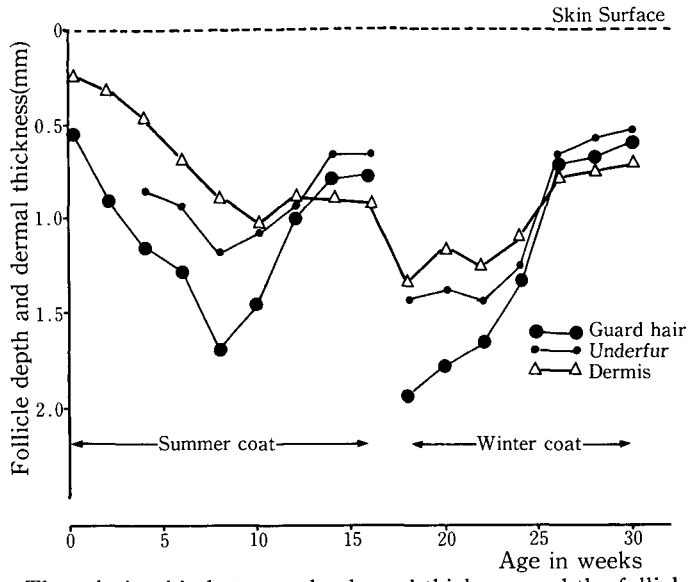

Fig. 5. The relationship between the dermal thickness and the follicle depth

already been developing before moulting. After initiation of the winter coat phase, the guard hair follicles immediately began to shorten but the underfur follicles remained long until week 22. From this fact it was concluded that the guard hair follicles entered into catagen earlier than the underfur follicles.

Fig. 5 plots the changes in depth of the follicles.

The depth of the guard hair follicles was 0.6 mm at birth and increased to 1.7 mm by week 8, when the depth of the underfur follicles reached 1.4 mm. Afterwards the depth of both the guard hair follicles and the underfur follicles decreased (the former was 0.8 mm and the latter 0.6-0.7 mm between weeks 14 and 16). In the winter coat the depth of the guard hair follicles was greatest at 1.9 mm immediately after moulting at week 18 and that of underfur follicles was 1.6 mm between weeks 18 and 22. The former started to become shallow immediately after week 18 and the latter from week 22. Both of them were shallowest between weeks 26 and 30 : the former was 0.6-0.7 mm and the latter was 0.5-0.6 mm.

The depth of the follicles varied in the same way as the length of the follicles while the depth of the underfur follicles never became deeper than that of the guard hair follicles. Also, just like the lengths of the follicles, the depth of the guard hair follicles started to decrese immediately after moulting. While the depth of the underfur follicles started to decrease from week 22, 2 weeks later than the guard hair follicles.

When comparing the changes of the follicle depth with those of the skin thickness, the follicles of both the guard hair and the underfur in anagen reached deep into the subcutis but during telogen neither extended below the dermis. Also the change in the depth of the follicles was quicker than the change in the

thickness of the skin and it was recognized that when the follicles became shallow the skin became thin. Around week 28 the follicle depth was the shallowest, about 0.1-0.2 mm shallower than the thickness of the dermis and the skin was thinnest. This is called the prime period of the mink.

Judging from the above results it can be said that the prime period which is known to mink producers from experience as the best time for pelting, is the most appropriate time for sacrificing the animals from the point of view of the histological changes in the mink skin.

Summary

This study was carried out in order to clarify the relationship between the hair cycle and the histological parameters of the skin in young mink, i.e. the number of underfur hairs, the ratio of hair activity, the skin thickness, and the follicle length and depth.

Male Sapphire minks from new born to 30 weeks of age were used in this experiment. Samples were taken from the mid-dorsal region and were sectioned into 8-12 μm slices with a freezing microtome and stained with Hematoxylin-Eosin. From this study the following results were obtained. 1) In the summer coat the number of underfur hairs per follicle group increased until week 10 and remained at 12-14 between weeks 10 and 16. As for the winter coat the number of underfur hairs dramatically increased just after the begining of moulting at week 18, and remained at 22-26 afterward. 2) The hair activity of underfur of the summer coat was highest (90%) at week 6 and was lowest (0-3%) between weeks 14-16. On the other hand, that of the winter coat was highest (80%) at week 22 and was lowest (0%) between weeks 26-30. 3) The dermis of both the summer and the winter coats was thick in anagen, and thin in telogen. But the dermis of the winter coat in telogen was thinner by 0.2 mm than that of the summer coat (0.7 mm as opposed to 0.9 mm). 4) In telogen the hair follicles of both guard hair and underfur decreased to about 1/3 the length of those in anagen, did not invade the subcutis and shortened to the sebaceous gland. Guard hair follicles started catagen two weeks earlier than underfur follicles.

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