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HISTOLOGICAL STUDIES OF GLYCOGEN IN THE HAIR OF DOMESTIC ANIMALS WITH SPECIAL REFERENCE TO REPLACEMENT OF HAIR

By

Yoshiyuki TORYU

*Department of Animal Husbandry, Faculty of Agriculture
Tohoku University, Sendai, Japan.*

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Introduction

It has been generally thought that the hair may contain glycogen or a substance related to it in more or less amount. As far as I know, however, there are few who have given reliable evidence of the existence of glycogen in the hair. In 1949 Bolliger and McDonald studied the glycogen in the skin and hair of man, sheep, rabbit and phalanger and stated that granules containing glycogen were observed in the outer root sheath of the hair follicle.

In the present investigation I have dealt with the distribution of glycogen in the hair of domestic animals with especial reference to the relation of it to the replacement of hair, as the first step of investigation concerning the physiological significance of glycogen in the hair.

Materials and Methods

Pieces of skin were taken from horses, cattle, goats and pigs during from November, 1947 to September, 1949. Alcohol-formalin saturated with magnesium sulphate was used as fixing fluid. All materials were embedded in celloidin and sectioned 20μ thick. Best's carmine fluid was used for glycogen staining. Identification of glycogen was made by means of salivary test.

Results

1. *Result Obtained for the Existence of Glycogen in the Hair.*

Stained by the method as above mentioned, red colored granules appeared in the cells of the outer root sheath of the hair follicle, located in the lower half of the sheath up to about the level where the sebaceous glands

are connected with the hair follicle, as has already been stated by Bolliger and McDonald (1949) in man, sheep, rabbit and phalanger. In these cells glycogen granules are irregular, roundish in form, of large size and closely packed in the cytoplasm, so that the whole body of the cells assumes an intense red color (Fig. 1). No glycogen was found in any other structures of the hair.

It was also found that there was no difference in the amount of glycogen in different kinds of hairs, though a relatively less amount of it was found in the hair of the pig than other animals.

Since the glycogen above mentioned was found to resist pepsin, but easily digested by saliva, the time required for the complete digestion being about 3 hours in saliva diluted 4 times with buffer solution of a moderate pH, the nature of the glycogen may be considered as the same as that of the glycogen in the liver and in the His's bundle, where the glycogen exists as pure element.

To obtain further data concerning the evidence that the glycogen is contained in the outer root sheath of the hair follicle, pieces of skin were obtained from 10 healthy pigs and analysed for the determination of glycogen by Pflüger's method and the total amount of glycogen was estimated about 0.09 per cent on the average. From the result above obtained it seems probable that some part of the total glycogen is contained in the outer root sheath of the hair follicle.

2. *Result Obtained for Glycogen in the Replacing Period of Hair.*

To obtain physiological significance of glycogen in the outer root sheath of the hair follicle, further histological investigation of skin in the replacing period of hair was made. Pieces of skin were obtained from horses and cattle at 15 to 30 days intervals during from October, 1948 to November, 1949. The materials were also occasionally obtained from goats. Microscopic preparations were made by the method as already mentioned. The observations are as follows:

The hair follicle, after the hair became detached from the papilla, atrophies and the inner root sheath almost disappears. The club hair is often located in the atrophied follicle at the level of the entrance of the sebaceous duct. In the outer root sheath of these follicles glycogen was greatly diminished or completely disappeared (Fig. 4).

The formation of a new hair starts with the proliferation of cells of the outer root sheath in the middle region of the atrophied follicle, not in the region of the old papilla, forming a cell mass connected with the old hair follicle. The new hair germ thus formed grows down obliquely in to the

derma forming a new papilla at the lower end of the germ and finally a new hair follicle containing a replacing hair is formed. In the cells of the new hair germ and of the outer root sheath of the new hair follicle a great amount of glycogen was observed (Fig. 5, 6 and Text-Fig. 1), namely the whole body of the cells showed an intense red color stained selectively with Best's carmine fluid.

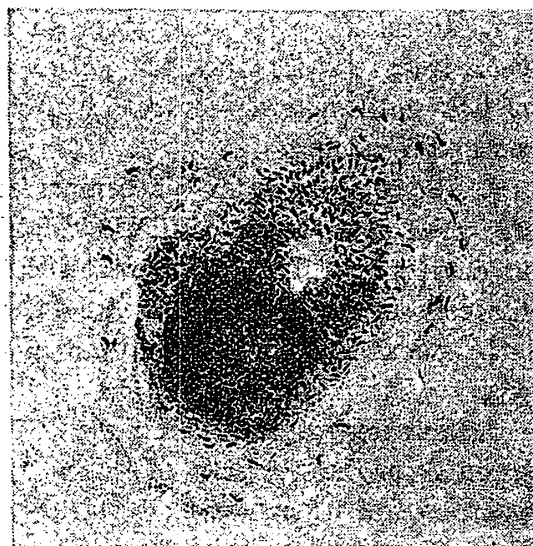
From the result above obtained it will be noticed that the outer root sheath of the hair follicle contains glycogen throughout the entire duration of life of hair, but not in the shedding period, suggesting that the glycogen is intimately related to the processes of metabolism of hair.

It is generally known that shedding of hair takes place in most animals at regularly recurring periods. According to the present investigations on the glycogen in the hair of domestic animals, such as horses, cattle and goats, it takes place one time in a year, in spring; succeeding periods show gradual death and replacement of hairs until autumn, when the hairs increase in length and in dimension without more shedding. To support the view just stated I noticed the following relations; first, in spring, from March to April, a great number of follicles became atrophied and no glycogen was observed in their cells and the hairs became detached from the atrophied follicles (Fig. 4), showing an active shedding process of hair; second, in summer, from May to September, a small number of atrophied follicles containing no glycogen in their cells were found scattered among the normal follicles, showing gradual death and replacement of hairs; third, from October to February of next year, most hair follicles contained glycogen, showing almost no shedding of hairs as already mentioned.

Summary

The results obtained in this investigation may be summarized as follows:

1. In horses, cattle, pigs and goats, glycogen is contained in the outer root sheath of the hair follicle, located in the lower half of the sheath up



Text-Fig. 1. Hair germ attached to the atrophied follicle (From the goat).
Enlarged 100 times.

The cells of hair germ are filled with glycogen granules.

to somewhere about the level where the sebaceous glands connect with the hair follicle.

2. In horses, cattle and goats, shedding of hair takes place one time in a year, in spring; the succeeding period shows gradual death and replacement of hair until autumn, when the hairs increase in length and in dimension without shedding.

3. Shedding of hairs is accompanied by the disintegration of glycogen in the outer root sheath of the hair follicle, but when the hair germ begins to develop from the outer root sheath glycogen also begins to appear in the cells of the germ and is found throughout entire duration of life of hairs.

4. About 0.09 per cent of total glycogen is contained in the skin of the pig.

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Literature Cited

Bolliger, A and McDonald, N. D. 1949. *Austr. J. Exp. Biol. and Med. Sci.*, Vol. 27, Part 2, pp. 228—233.

Explanation of Figures

- Fig. 1. Longitudinal section through roots of hairs of the horse. $\times 100$. (Glycogen is contained in the outer root sheath of hair follicles).
- Fig. 2. Transverse section through roots of hairs of the horse at the level where the sebaceous glands connect with the hair follicles. $\times 100$. (No glycogen is contained in the outer root sheaths of hair follicles).
- Fig. 3. Transverse section through roots of hairs of the horse, when no shedding nor replacing of hairs are taking place. $\times 100$. (All follicles contain a great amount of glycogen in their outer root sheaths).
- Fig. 4. Transverse section through roots of hairs of the horse in the shedding period. $\times 100$. (Glycogen is contained in the outer root sheaths of the hair follicles, from which the hairs were already detached).
- Fig. 5. Longitudinal section through roots of replacing hairs of the cow. $\times 80$. (A new hair containing glycogen in the outer root sheath of the hair follicle is seen attached to the atrophied follicle).
- Fig. 6. Longitudinal section through roots of hairs of the goat. $\times 100$. (A new hair is also seen in the same manner as the above).

Toryu: Glycogen in the Hair



Fig. 1

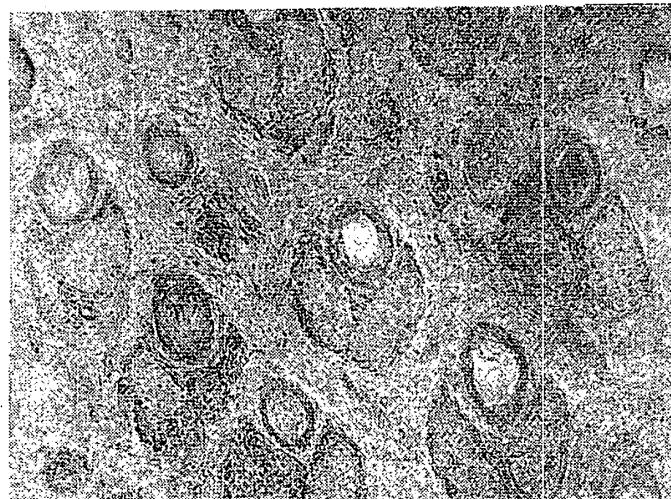


Fig. 2

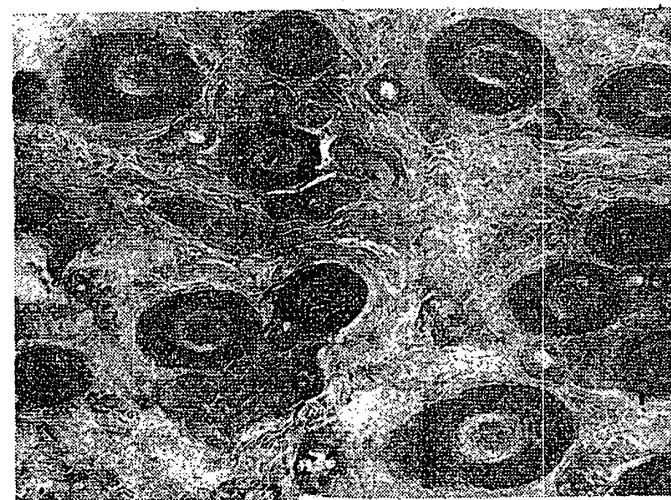


Fig. 3

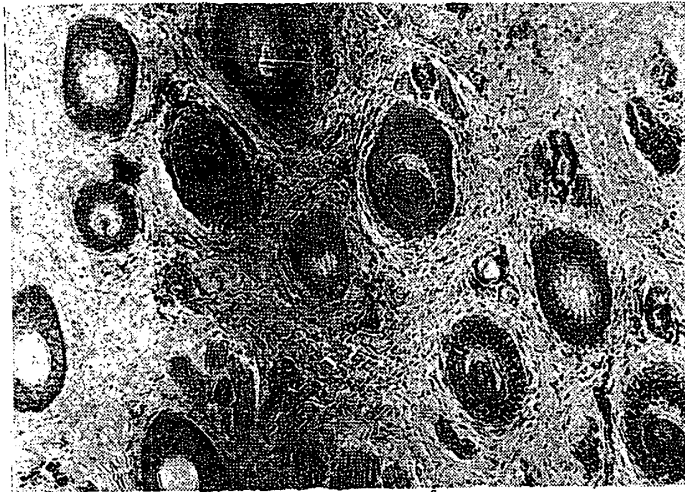


Fig. 4

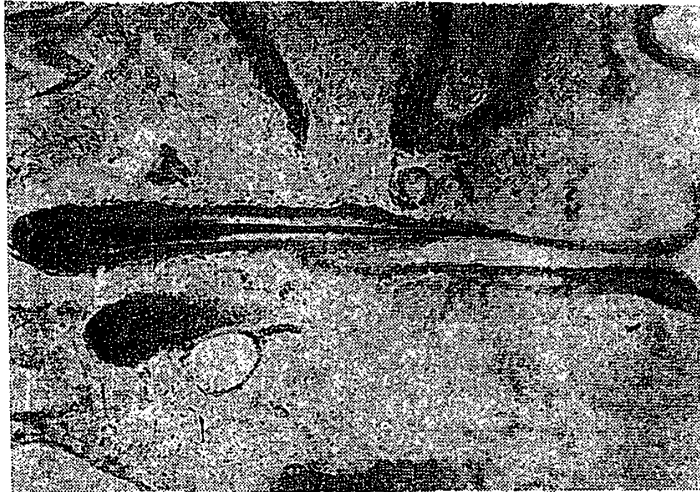


Fig. 5

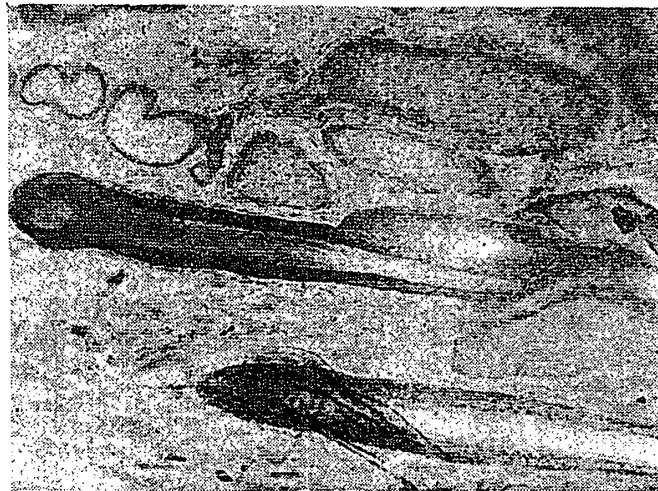


Fig 6