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Histological characters of hairs in extant and fossil rhinoceroses

by

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(Plates 12, 13)

Abstract

Observations are submitted upon the structure of hairs in extant and Pleistocene rhinoceroses. From this point of view no differences could be found in any of the rhinoceros forms studied in the present paper. The structure of hairs in these mammals seems to be similar, in spite of the extremely differentiated life, climatic, and environmental conditions of the five extant rhinoceros forms, living mainly in tropical areas, in contradistinction to the Pleistocene woolly rhinoceros of arctic adaptation, and also in spite of the disparate development of the hair coat in the examined rhinoceroses, separated by a geological barrier of thousands of years.

Introduction

The extant rhinoceroses known to lack body hairs may be divided from this point of view into two groups. Three species: *Rhinoceros unicornis*, *Diceros bicornis*, and *Ceratotherium simum* have an almost entirely hairless skin, the two remaining smaller forms: *Rhinoceros sondaicus* and *Didermocerus sumatrensis*, having an extremely sparse hair coat.

Among the fossil *Rhinocerotidae*, the woolly rhinoceros, *Coelodonta antiquitatis*, was characterized by a dense long-haired fur. Probably also the second Pleistocene species, *Dicerorhinus hemitoechus*, contemporaneous with the woolly rhinoceros was similarly hairy.

Since the second half of the nineteenth century hairs of the extant rhinoceroses have been examined by several authors cited by Cave (1969). They were concerned mainly with the hair coat of the rhinoceros body in general and with the distribution of hairs on particular parts of the body, taking into consideration the loss of the body hairs both in the wild state and in captivity. The palpebral vibrissae (eyelashes) in the extant rhinoceros forms were also examined (Cave 1969, Van den Bergh 1970). Now the presence of eyelashes is established for four species. Thus it is probable that eyelid vibrissae are likewise present in the fifth extant rhinoceros form, the now vanishing *Rhinoceros sondaicus* (Cave and Wingstrand 1972). Histological examination of the skin shows that even the totally hairless forms may possess well-developed hair follicles containing the roots and reduced shafts of genuine hairs (Cave and Allbrook 1959, Cave 1962, 1964, 1966).

The hair coat of the fossil rhinoceroses, harder to examine on account of the lack of material, has been considered only on data of one species, the woolly rhinoceros, *Coelodonta antiquitatis*. Studies on the hair coat as a whole, carried out in order to reconstruct the fur, were based particularly on palaeolithic cave paintings, as well as on the general distribution of hair follicles in the skin of the specimen from Starunia (Niezabitowski-Lubicz 1911, Hoyer 1914, 1915). Similar studies were carried out by Schrenck (1880) on the head of the woolly rhinoceros from the Halbuy River of the Yana basin. Only the above mentioned material offers data on this subject. The results of these studies were taken into consideration in later reconstructions, e. g., of the woolly rhinoceros from Almelo (Roding 1954).

No examination of the histological structure of rhinoceros hairs and of the possible differences between the species has yet been undertaken. In the hair atlas by Friedenthal (1911), e. g., rhinoceros hairs are not mentioned. Thus the present examination seems to be useful.

Material

In the present paper guard hairs of the following rhinoceros species were examined:

1. from the ear of *Ceratotherium simum*, the African white, square-lipped rhinoceros. The hairs were taken from a stuffed rhinoceros head from the collection of the Institute of Systematic and Experimental Zoology, Polish Academy of Sciences, Cracow.
2. from the ear of *Diceros bicornis*, the African black, hook-lipped rhinoceros. The material was taken from a stuffed head from the collection mentioned above.
3. from the ear of *Coelodonta antiquitatis*, the Pleistocene woolly rhinoceros (the so-called second rhinoceros from Starunia) from the collection mentioned above. The ear with protruding hairs about 5 cm long is preserved as an alcohol preparation. It originates from the specimen found in Starunia (48°42′ N, 24°30′ E) in 1929 (Nowak et al. 1930). Up to date it is the only woolly rhinoceros in the world preserved entirely with the skin and soft parts of the body (Kubiak 1969). Its age determined by means of radio carbon (^{14}C) (Carbon Dating Laboratory, Smithsonian Institution, Washington, SI-642, 1971) is 23,255±775 years (Kubiak 1971).
4. from *Coelodonta antiquitatis*, the so-called first woolly rhinoceros from Starunia, discovered in 1907, and housed in the Museum of Natural History in Lwów (formerly Dzieduszycki Museum) (Wykopaliska staruńskie 1914). These hairs were also found in Starunia in 1907, in the immediate environment of the partly preserved rhinoceros body.
5. from the head of *Coelodonta antiquitatis*, the woolly rhinoceros from the collection of the Zoological Institute of the Soviet Academy of Sciences in Leningrad. The well-preserved head with yellow-brownish-black hairs was found in 1877 on the bank of the Halbuy River, in the Yana basin about 150 km N from Verhoyansk i. e. about 68°30′ N (Schrenck 1880, Garutt et al. 1970). The radio carbon age determination of this specimen indicates "less than 33,000 years" (Heintz 1966).

Methods

The medulla type, scale pattern, and cross-section of the guard hairs were examined.

These features are usually differentiated and taken into consideration in the identification of hair (Day 1966, Dziurdzik 1973). The techniques used by Day (op. cit.), have been adopted here with a few modifications by Dziurdzik (op. cit.), e. g., to make casts of hairs crystal-cement was used instead of gelatin. The hairs examined were also additionally bleached in peroxide.

Hairs cleaned in hot water, mounted in 70% alcohol, and bleached in peroxide, were laid in a crystal-cement film made on a microscope slide in the same way that a blood smear is made. The medulla type could then be observed under a microscope.

The method of observing the scale pattern is to make a cast of the hair in crystal-cement (see above). After allowing about ten minutes for the crystal-cement to harden, the hairs are peeled off, leaving behind a cast of the scales.

Cross-sections were prepared as follows: in pieces of longitudinally sectioned medulla of elder smeared with thick gelatine a hair was laid. After allowing them to harden, the two adherent halves of the elder medulla with the embedded hair were cut with a razor blade. The cross-sections were observed under magnification ×100.

Observations

1. The hairs from the ear of *Ceratotherium simum* show a lack of medulla, a mosaic pattern, and a circular cross-section (Fig. 1).

2. Hairs from the ear of *Diceros bicornis*: medulla not visible, mosaic pattern, and circular cross-section.
3. Hairs from the ear of *Coelodonta antiquitatis* (the second woolly rhinoceros from Starunia) are thick, reddish, without medulla, and show a mosaic pattern and circular cross-section (Fig. 2).
4. In hairs of *Coelodonta antiquitatis* (the first woolly rhinoceros from Starunia) (Fig. 3) the medulla is not visible, a mosaic scale pattern and a circular cross-section being observed. In the sample many thin yellow fine hairs were present. The guard hairs with yellow pigmentation were lighter, thinner, and more breakable than those of the woolly rhinoceros from the Yana basin.
5. Three samples of hairs taken from different parts of the head of *Coelodonta antiquitatis* from the Yana basin differ in pigmentation. In several hairs examined the medulla is not visible (Fig. 5), and a mosaic scale pattern (Fig. 4) and circular cross-section occur.
   a. hairs from the ear region — macroscopically black, under magnification dark-reddish with heavy pigmentation. The pigment occurs in numerous small dark stripes along the hair. Generally no medulla is visible, though in one short segment of the hair a thin, fragmentary, probably lattice medulla could be observed. However, this fact does not eliminate the possibility that it is only a heavier pigmentation, especially as in other hairs no medulla could be observed.
   b. hairs from the part of the head between the eye and the ear with reddish pigmentation lighter than the hairs described above.
   c. hairs from the throat part of the head: very light, yellow.

Conclusions

I. In the guard hairs of the rhinoceros examined: 1. no medulla is visible, 2. a mosaic scale pattern is present, and 3. a circular cross-section occurs.

II. There are no differences in the histological structure of hairs of extant *Rhinocerotidae* and the fossil woolly rhinoceros.

III. By using the medulla type, scale pattern, and cross-section it is not possible to identify guard hairs of rhinoceroses as to species or even genus.

Discussion

The skin of mammals, fulfilling different vital functions, plays among others an important role in the thermo-regulatory process. The histology of rhinoceros skin indicates this role especially when one compares extant rhinoceroses with the fossil ones. In the woolly rhinoceros the external hair coat was well-developed. Representatives of recent mammals such as elephants, hippopotamuses, and rhinoceroses, characterized by a thick skin and absence of an external hair coat, were formerly treated as one group called pachyderms, though actually they are not closely related. The disappearance of the hair coat in different groups of mammals results, according to Kowalski (1971), from environmental conditions. The loss of even the sparse hair coat, till now without any satisfactory explanation, was also observed in the particularly hairy Sumatran rhinoceros (*Dicerorhinocerus sumatrensis*) both in the wild state (Hubback 1939) and in captivity (Thomas 1901).

The skin in extant rhinoceroses living in tropical environmental conditions is characterized in general by the absence of an external hair coat. The epidermis is extremely thin and delicate. Hairs are confined to roots at the bottom of the hair follicles. No subcutaneous fat is developed. Ordinary sweat glands are replaced by very large and vascular apocrine type sweat glands. The skin is thus structurally designed to facilitate heat loss from the body, not only by passive radiation from the naked external surface but also by mechanical surface heat loss by the active discharge of heat from the body in the form of sweat (Cave 1969). It has been shown by the author cited above that the presence of reduced hairs plays an important role in the morphological cooling mechanism necessitated by the dynamics of the large body.

In the skin of the fossil woolly rhinoceros, *Coelodonta antiquitatis*, living in arctic environmental conditions, the hairs developed maximally into an external dense coat. In this case the skin underwent a modification so as to function as a conservator of body heat. In this species, similarly as in the mammoth, a thick insulating layer of subcutaneous fat was developed as well, and the number and activity of sweat glands became greatly limited.

In spite of the extremely different climatic and environmental conditions of the extant and Pleistocene *Rhinocerotidae* and the various geological periods of their occurrence, there are no differences in the histological structure of the hairs. The hairs of extant rhinoceroses are identical with those of the woolly rhinoceroses living several thousand (about 23,000 and 33,000) years ago. Thus the hairy features of the Pleistocene *Rhinocerotidae* presumable did not change even under the influence of geological conditions during such a long time. Similarly, some tissues of Pleistocene mammals preserved in permafrost conditions seem to be unchanged (Ezra and Cook 1959). Histological investigations on the tissue of Tertiary or even Cretaceous vertebrates living millions of years ago show bone structures not differing from those of recent animals (Pawlicki et al. 1966).

The three features of hairs: scale pattern, cross-section, and medulla type, of taxonomic value in identification of the genus or even species of mammals, seem to be useless within the family of *Rhinocerotidae*. For the identity of these hair characters in the rhinoceroses studied in the course of this work prevented the identification of even the genus of the *Rhinocerotidae*. The lack of medulla in all rhinoceros hairs is characteristic, although hairs without a visible medulla occur (rather rarely) in some mammals. This feature is known in *Chiroptera*, in some races of sheep, and in some kinds of human hair.

Difficulties in identification of the species or even genus of large mammals based on relatively uniform hairs, contrary to the easily identified and more differentiated hairs of small mammals, occur also in the *Rhinocerotidae*.

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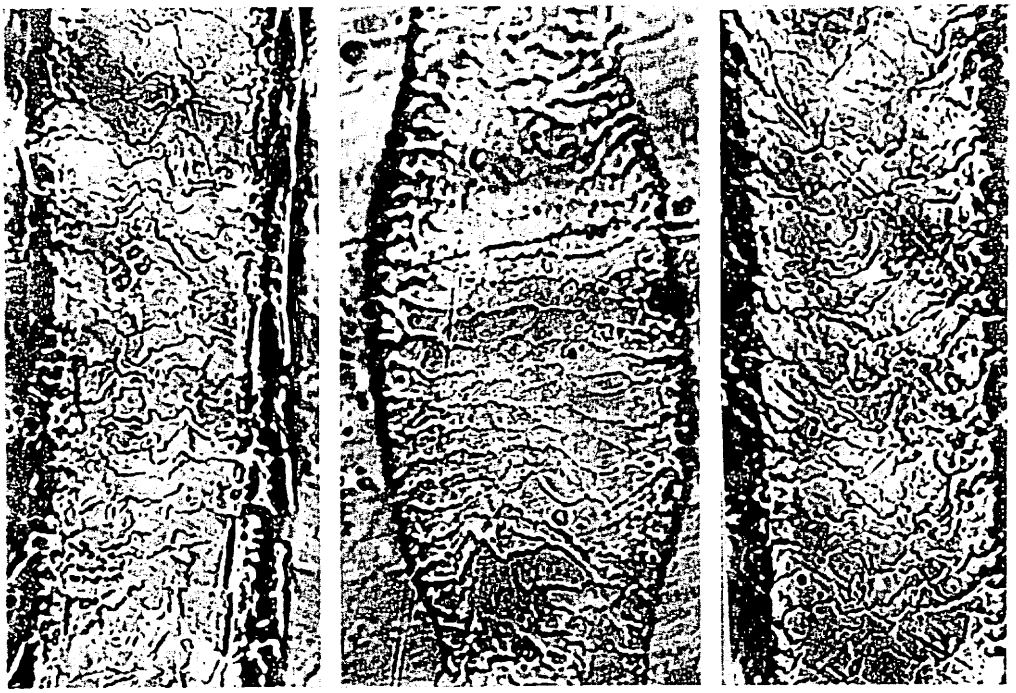
Explanation of Plates 12, 13

Mosaic scale pattern in rhinoceros hairs:

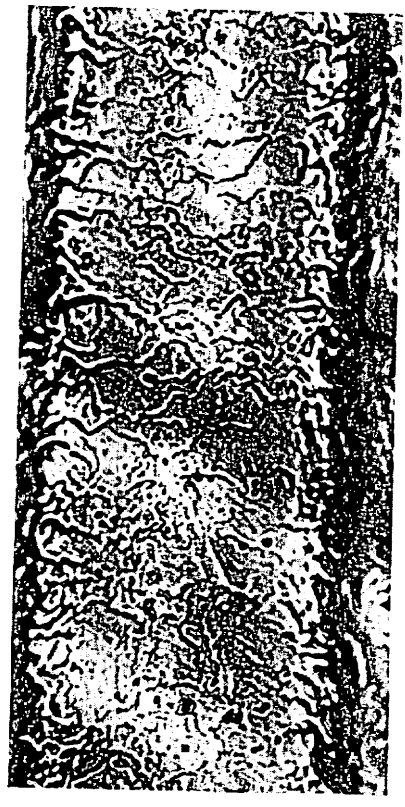
Fig. 1. *Ceratotherium simum*, African white, squate-lipped rhinoceros (extant).
Fig. 2. *Coelodonta antiquitatis*, woolly rhinoceros (fossil) (the second specimen from Starunia).
Fig. 3. *Coelodonta antiquitatis*, (the first specimen from Starunia).

Coelodonta antiquitatis, from the Yana basin:
Fig. 4. Mosaic scale pattern in hair.
Fig. 5. Hair without medulla.



1 2 3

100μ



4

5

100 μ