THE SKIN AND NUCHAL EMINENCE OF THE WHITE RHINOCEROS

BY

A. J. E. CAVE, M.D., D.Sc., F.Z.S.
University of London

AND

D. B. ALLBROOK, M.B., PH.D.
Makerere College Medical School

[Accepted 10th June 1958]

(With 1 plate and 2 figures in the text)

CONTENTS

INTRODUCTION

Rhinoceros skin enjoys a unique and traditional reputation for density, inelasticity and impermeability—so much so that "the hide of a rhinoceros" is the conventional derogatory term applied in stigmatisation of the "thick skinned" individual who is impervious to blandishment and censure equally. Mere thickness of skin cannot explain the adoption of the rhinoceros as exemplar thereof, since other mammals (e.g. elephant, hippopotamus, giraffe) possess skins sufficiently thick. It is the extraordinary density, toughness and almost metallic inelasticity of rhinoceros skin which renders it unique among that of "pachydermatous" mammals.

On mere inspection, and in contrast to the soft, supple, hairy skin of the generality of mammals, rhinoceros skin (of any one species) appears remarkably "dead" or inactive, a dull, wrinkled, rough, dry and hairless armour-plating, more suggestive of oak-bark than of living animal tissue (Plate, fig. 1). Such first impressions are reinforced by the experience of field naturalists, hunters and menagerie keepers, which testifies to the difficulty of penetrating this formidable integument. Upon flaying, the detached hide is found to be tremendously thick, heavy beyond expectation and exceedingly difficult of manipulation. In the adult White or adult Indian Rhinoceros it may weigh a ton and require considerable manpower to drag it over even the smoothest ground. Its consistency is that of a sheet of thin steel (Heller, 1913) and it defies all attempts at folding. Its density and rigidity prevent its being worked, so that it remains without commercial value and (save for the manufacture from it of curios) of service to the taxidermist only.

It is these physical properties of resistance, density and inelasticity which have so impressed naturalists and, in popular opinion, have justified the choice of the rhinoceros as the acme of " thick-hidedness " or integumental imperviousness.

It is the principal purpose of this paper to describe the histological structure of White Rhinoceros skin and thereby to demonstrate the anatomical basis of its obtrusive physical properties. A second purpose is to establish clearly and finally the anatomical nature of the nuchal hump, a curious and distinctive external morphological character of this species.

This hump, *inter alia*, distinguishes the White Rhinoceros (*Rhinoceros simus* Burchell=*Ceratotherium simum* Gray) from the Black Rhinoceros (*Diceros bicornis* (L.)). It is a large, median nuchal prominence, present in both sexes, arising from the continuous surrounding skin upon a fairly well-defined quadrilateral base : it confers a distinctive convexity upon the cervical midline and extends, in the adult, from the occipital crest region almost to the withers, overlying therefore the spinous processes of the second to sixth cervical vertebrae. This notable external character of *Ceratotherium* received remarkably scant attention in the literature prior to Heller's (1913) classical monograph : if mentioned at all, its position was given imprecisely or its structure was left undefined.

Burchell himself, who first (1817) scientifically distinguished the White, or Square-lipped, Rhinoceros from its Black congener, omitted all reference to it, although his familiarity with it is apparent from his field drawings (see Cave, 1947).

Chapman (1868) figured the hump in a dead " Rhinoceros mohogu " and observed that " The back of the mohogu is tolerably straight, but the croop (?hench bone) is as high or higher than the withers ; has a huge square hump, a double navel, and the females a blind pouch near the vagina ". Newton (1903) published photographs of dead specimens with the hump apparent, but gave no textual reference thereto. Trouessart (1909) published an unsatisfactory coloured drawing, showing a hump situated upon the withers, together with photographs of dead specimens wherein the hump (unmentioned in his text) is not distinguishable.

Gray (1867) listed among the external characters of *Ceratotherium* a " shoulder with a well-marked hunch ", but was silent concerning the nature or extent of this " hunch ".

Selous (1881) stressed the edibility of this part of the animal without detailing its position or nature. Bryden (1899), repeating Selous' account, stated that the hump was situated " just in front of the withers " : he said nothing regarding its constitution. Lydekker (1908) merely repeated earlier statements anent hump edibility. Somewhat surprisingly the hump is neither figured nor mentioned in accounts of the White Rhinoceros given by Cumming (1850), Buckley (1876), Drummond (1876), Sclater (1886, 1900), Bryden (1897), Thomas (1901), Beddard (1909) and Lydekker (1910) : the last author indeed gave a bad figure of the living animal devoid of all trace of hump. The classical monograph on mammalia by Flower & Lydekker (1891) merely quotes Selous regarding the succulence of the hump, nothing being said about

its nature or situation. It would seem that neither author was familiar with the living animal or with an accurately-mounted museum specimen. (In this connexion it may be noted that the first mounted example in the British Museum (Natural History) was set up in 1894, being one of two animals shot in Rhodesia in 1892 by R. T. Coryndon, the second specimen going to Tring Museum).

To the present time the nuchal hump of *Ceratotherium* has remained imperfectly known in zoological literature, its position being given either erroneously or but approximately, its constitution never, and its reputed succulence alone implying its non-skeletal nature.

As late as 1910 Roosevelt could comment that " it is a singular thing that scientific writers seem almost to have overlooked, and never lay any stress upon, the existence of this neck hump. It is on the neck, forward of the long dorsal vertebra, and is very conspicuous in the living animal ". Heller (1913) described this feature as " the prominent, rounded, fleshy hump upon the

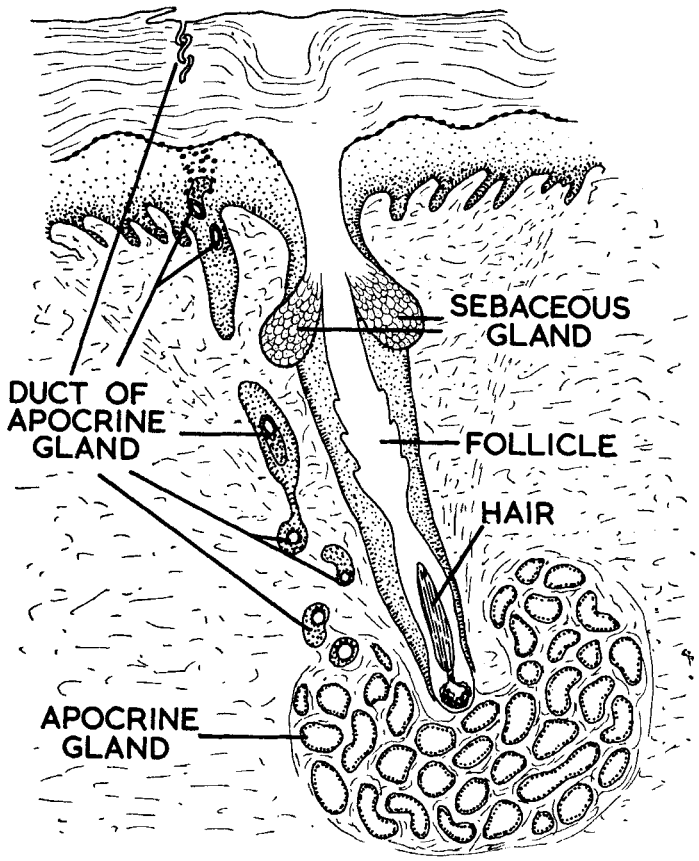


Fig. 1.—*Ceratotherium simum*. Composite histological drawing of epidermis and superficial part of dermis, to show (a) heavily keratinised, pigmented epidermis, (b) hair follicle with contained hair, (c) small paired sebaceous glands, (d) large apocrine sweat gland.

nape of the neck just forward of the withers ", stating that it is " purely a muscular structure and receives no support from the dorsal processes of the cervical vertebrae ". This is the first description (as apart from notice) of the precise location of the hump and a recognition of its non-skeletal or " muscular " nature.

That the hump is not muscular, but dermal, in constitution, was tentatively but correctly deduced by Bigalke *et alii* (1950) from observation of a young captive female animal. They recognised it to be " part of the skin " (because mobile upon palpation and neck movement) and concluded that, while its true nature " remains to be determined by anatomical dissection, there is little doubt that it is not entirely a muscular structure ". Herein the strictly dermal nature of the hump is established.

MATERIAL

The material studied and reported on here was obtained for us, under conditions of considerable difficulty, by Dr E. H. Williams, of Arua, West Nile District of Uganda, from an immature animal dispatched officially following its mutilation by native poachers. The nuchal hump, together with pieces of the skin, liver, kidney and stomach wall, was preserved in the field and

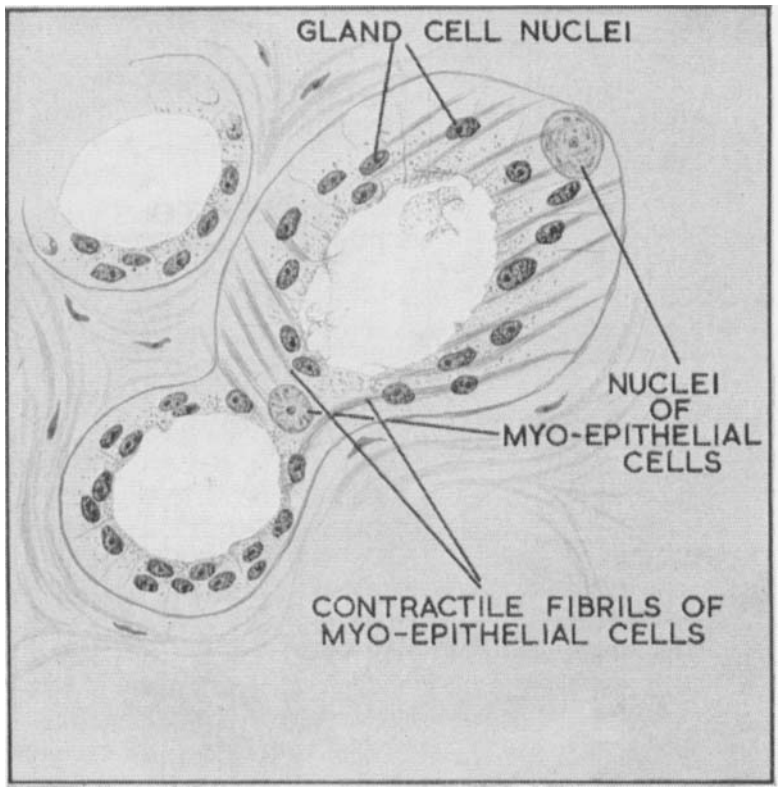


Fig. 2.—*Ceratotherium simum*. High power drawing of apocrine sweat gland to show myoepithelial cells.

reached the laboratory in good state. After due processing, the various tissues stained well (with haematoxylin-and-eosin, Mallory's triple stain, etc.). Macro-sections were made of the nuchal eminence (Plate, fig. 2) and micro-sections of the skin pieces. These last proved difficult to cut, and the best sections obtained varied in thickness from 15μ to 20μ. (As is invariable in this species, the stomach contained nothing save close-cropped grass. An inch-long filarial worm was deeply embedded in the conjunctiva).

The skin micro-sections, by reason of their relative thickness and, often, because of the obliquity of their plane of section, proved unsuitable for direct photographic reproduction. But careful study of successive sections permitted a reliable, if composite, picture of skin-structure (Figs. 1, 2) to be established.

THE SKIN OF *CERATOTHERIUM*

Micro-examination reveals the skin to be of typical mammalian constitution and to be anatomically organised so as to function as a responsive and protective organ subserving sensibility and excretion. It presents two striking specializations in the form of (a) a relatively thick and very dense dermis, and (b) the presence in the superficial layer thereof of large apocrine sweat glands. It is no inert outer wrapping, but a highly modified and physiologically active integument. The whole skin is attached to the deeper structures by non-resistant superficial fascia, which facilitates rapid and easy flaying. The superficial fascia is uniformly fat-laden, the thickness of the fat being as much as one inch on the dorsum of the trunk and as much as two inches on the ventral abdominal wall. So substantial a subcutaneous fat layer provides an ideal insulator for the conservation of body heat, besides topographically obviating that manifestation of costal processes and ridges seen in *Diceros*. (Chapman (1868) noted that *Ceratotherium* "becomes exceedingly fat by grass eating").

The epidermis is generally surprisingly thin (about 1 mm. in thickness) although in body regions not examined (feet, sacral eminence, etc.) it may be thicker : it is everywhere heavily cornified and sends down into the dermis hair-follicles, sebaceous glands and a specialised type of sweat gland. The stratum corneum equals or exceeds in thickness the stratum Malpighii : the cells of its deepest layer contain small discrete granules of melanin. A stratum lucidum is not everywhere apparent. The stratum granulosum averages some two cells in thickness. A section of the " thin " belly skin of our immature animal gave the following relative thickness of component layers :

epidermis = 1 mm.	stratum corneum	0·25 mm.
	,, lucidum	0·5 ,,
	,, granulosum, ,, germinativum	0·25 ,,
dermis = 18 mm.		

The dermis generally is enormously thick (18–20 mm.) and is composed exclusively of densely felted collagen fibres, disposed at all angles (vertical, parallel and tangential) to the surface. The only elastic tissue within this layer is that present in the walls of the dermal arterioles. It may well prove to be

much thicker in parts of the skin not examined : on the nuchal eminence it attains (in this immature animal) a thickness of about 45 mm. Despite the extraordinary thickness of its dermal component, the skin of *Ceratotherium* enjoys a remarkable degree of vascularity : blood-vessels 1 mm. or so in diameter can be observed by naked eye to proceed from the superficial fascia and subcutaneous fat to enter recognizable channels (" dermal foramina ") in the deep aspect of the dermis, wherein they ramify to supply the remarkably large apocrine sweat glands and the bases of the hair follicles.

Hair follicles are present in all the skin micro-sections examined, including the skin of the nuchal eminence. Within the follicles are the stumps of hairs, in some instances confined to the depths of the follicles but in others extending up the follicle towards, or even almost to, the surface. Projecting hairs were not seen, but for a single tuft upon the summit of the nuchal eminence. Save for the eyelashes and the ear- and tail-fringes, hairs are not readily detectable on the body surface and are commonly said to be altogether wanting. Heller (1913) stated that the neonatal *Ceratotherium* is no more hairy than the adult, but Bigalke (1950) was able to detect body hairs in a young female up to the age of fifteen-and-a-half months. Grassé (1955), summarising the relevant literature on the Rhinocerotidae, refers merely to the hirsute form (*D. lasiotis*) of *Didermocerus*, to the ear- and tail-fringes of extant species and to the presence of hairs " dans les plis de peau qui séparent les grandes plaques cuirassées quand celles-ci existent ".

The standard authoritative zoological treatises provide no authentic information nor any histological evidence touching the presence of body-hairs in the Rhinocerotidae. Neuville (1927), in a special study of rhinoceros skin, regarded it as hairless, but stated that hairs may be detected around the horn base in the three Asiatic species : he made no comparable reference to the two African species and he nowhere adduced any histological evidence in support of his general thesis that excessive keratinization (a reaction to external environmental stimulation) was the factor responsible for " depriving " rhinoceros skin of the normal mammalian equipment of glands and hairs.

Present findings suggest that an original sparse external hairy endowment becomes reduced with age, either from the mechanical abrasion of the projecting portions of the body hairs or from natural atrophy consequent upon the development of a substantial layer of subcutaneous fat.

The base of each hair follicle is embedded in the superficial part of the thickened, collagenous dermis and is surrounded by an impressively rich network of sweat gland tubules. Nearer the epidermis, each follicle is provided with a pair of small, piriform, rather feebly developed sebaceous glands (Fig. 1) which appear less numerous in the sections than do the sweat glands.

The ordinary, small type of sweat gland is nowhere apparent in the skin micro-sections studied. Instead, relatively enormous apocrine sweat glands constitute a striking histological feature of the skin. Not over-abundant, these epidermally-developed glands are of uniformly large size and are disposed in open basket fashion around the bases of the hair follicles. The gland cells are arranged in a single layer ; their oval nuclei stain with moderate intensity by haematoxylin and contain coarse granules of chromatin. The sweat ducts

spiral surfacewards, being fairly capacious in their intradermal, but narrower in their intra-epidermal, extent. Both the glands and their ducts are characterised by enormous, ectodermally-developed myoepithelial cells, which provide one of the most striking anatomical characters of the skin. These lie (a) between the gland epithelium and the basement membrane, (b) in helicoidal disposition around the ducts. They furnish the mechanism whereby the large apocrine sweat glands may effect rapid physiological response to sudden functional demands.

The glands are highly vascular, being supplied by relatively large arterioles, which tunnel the dense dermis and branch freely therewithin to reach individual glands.

Thus, on direct histological evidence, the skin of *Ceratotherium* is very much " alive " and singularly well equipped to discharge the several functions of typical mammalian skin. The delicate, pigmented epidermis serves as an external sensorium ; the enormously thickened dermis is mechanically protective ; the substantial layer of subcutaneous fat prevents loss of body-heat, and the remarkably large and well-vascularised apocrine sweat glands provide for the rapid and copious discharge of body-fluid.

In the life of so large an animal, efficient sweating must obviously play an important role, for only by profuse and rapid sweating can any sudden, deleterious rise in body temperature be prevented. Recorded information concerning the sweating capacity of *Ceratotherium* is wanting. Normally the animal seeks cover during bright sunshine and displays its maximal activity in dull daylight or in cool, cloudy or humid weather. When persistently disturbed in hot sunshine it can be observed to sweat freely, as one of us (D.B.A.) has noted.

Its capacity, upon violent exercise, for releasing a sudden and copious discharge of sweat is authenticated by Coryndon, who described (in Bryden, 1899) how a young specimen, roped and struggling on the ground, " began to sweat freely, the moisture dripping off it as though a bucket of water had been thrown over it ".

The machinery for such sudden and copious discharge of body-fluid lies obviously in the huge apocrine sweat glands and their enormous, attendant myoepithelial cells, which constitute a structural adaptation admirably designed to subserve the functional requirements of this animal.

(The total daily volume of body-fluid discharged, either in the form of sweat or of urine, is, of course, unknown. But in this connexion the peculiar mode of micturition in *Ceratotherium* is noteworthy. The animal does not stand and stale by a total contraction of the bladder : instead it effects a discontinuous series of partial badder contractions, spraying small squirts or " puffs " of urine, at irregular intervals during its progress through the bush or around its feeding ground. The animal is prone to return along the trail so " blazed " by means of this discontinuous urine-spraying, for olfaction is its most exquisitely developed and dominant special sense and its principal means of identifying and locating external objects).

THE HUMP (NUCHAL EMINENCE)

The nuchal eminence of our immature specimen (Plate, fig. 2) is revealed by dissection to be a non-fatty, non-muscular, purely cutaneous structure, a dermal node or plaque resulting essentially from an extraordinary, localised and very considerable augmentation of the nuchal dermis. Over the eminence the epidermis is a little thickened. In the middle of the eminence the collagenous dermis virtually doubles its thickness elsewhere and attains an average of 42–44 mm. (In the adult animal the dermal thickness here must be relatively much greater, in proportion to the greater bulk of the eminence). It is this thickened dermis which the older travellers found so palatable. On the summit of the eminence a tuft of hairs is present. The skin of the eminence resembles the skin examined from other parts in its like manifestation of hair follicles, small sebaceous glands and large apocrine sweat glands. No obvious explanation is readily forthcoming concerning the significance of this nuchal dermal node or eminence, so curiously confined to this species of rhinoceros. It is not present at birth but develops shortly afterwards, according to Bigalke (1950), from the gradual coalescence of three cervical midline cutaneous thickenings. These nodules or plaques begin to appear from two to four weeks after birth and their confluence is completed by the sixth month.

SUMMARY

1. The skin histology of an immature White Rhinoceros is described. The thin epidermis has the customary layers, the deepest layer being pigmented. It sends into the dermis hair follicles (containing hair shafts), small sebaceous glands and large apocrine sweat glands characterised by enormous ectodermally-developed myoepithelial cells.

2. The exceedingly thick and well vascularised dermis is exclusively collagenous in composition.

3. The hump or nuchal eminence is merely a local augmentation of the dermis (nuchal node).

ACKNOWLEDGMENTS

Our gratitude is extended to Dr E. H. Williams for his collection, under great difficulties, of the material forming the basis of this study, to Dr John Aumonier for his generous supervision of histological findings, and to the Librarian of the Zoological Society of London and his Staff.

REFERENCES

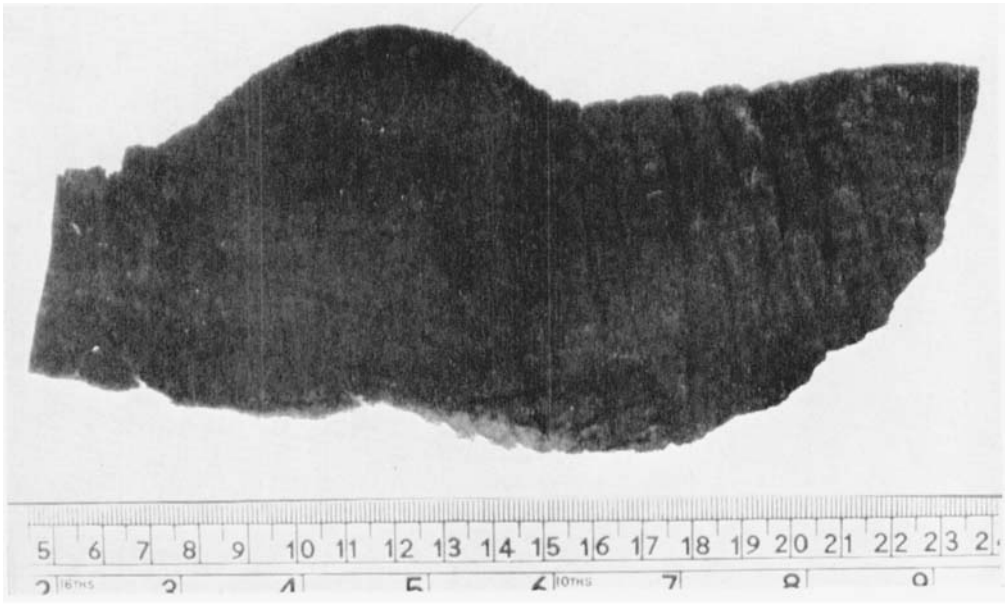
BEDDARD, F. E. (1909). *Cambridge natural history* **10** Mammalia 257–258. London : Macmillan.

BIGALKE, R., *et al.* (1950). Observations on a juvenile female square-lipped or white rhinoceros (*Ceratotherium simum simum* (Burch.)) in the National Zoological Gardens of South Africa. *Proc. zool. Soc. Lond.* **120,** 519–528.

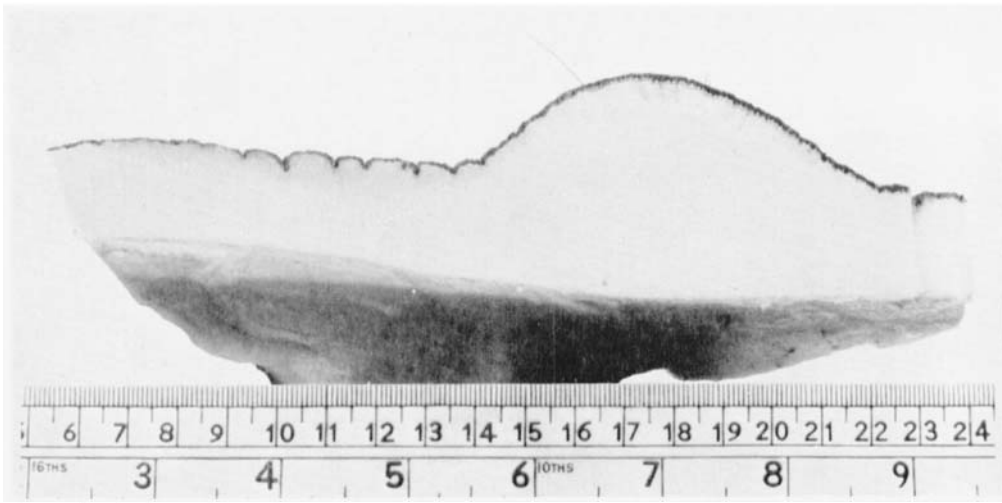
BRYDEN, H. A. (1897). *Nature and sport in South Africa.* 181–190. London : Chapman & Hall.

BRYDEN, H. A. (1899). *Great and small game of Africa.* 52–67. London : Rowland Ward.

BUCKLEY, T. E. (1876). Past and present geographical distribution of large mammals of South Africa. *Proc. zool. Soc. Lond.* **1876,** 277–293.



1



2

The skin and nuchal eminence of the White Rhinoceros.

BURCHELL, W. J. (1817). Note sur une nouvelle espèce de Rhinocérus. *Bull. sci. Soc. philom. Paris* **1817,** 96–97.

CAVE, A. J. E. (1947). Burchell's rhinocerotine drawings. *Proc. Linn. Soc. Lond.* **159,** 141–146.

CHAPMAN, J. (1868). *Travels in the interior of South Africa* **2,** 170–171. London : Bell & Daldy.

CUMMING, R. G. (1850). *Five years of a hunter's life in the far interior of South Africa.* 2nd ed. **2,** 101. London : John Murray.

DRUMMUND, W. H. (1876). On the African rhinoceroses. *Proc. zool. Soc. Lond.* **1876,** 109–114.

FLOWER, W. H. & LYDEKKER, R. (1891). *Introduction to the study of mammals, living and extinct.* p. 409. London : Black.

GRASSÉ, P. P. (1955). *Traité de Zoologie* **17** (1), 1109. Paris : Masson.

GRAY, J. E. (1867). Observations on the preserved specimens and skeletons of the *Rhinocerotidae* in the collection of the British Museum and Royal College of Surgeons including the descriptions of three new species. *Proc. zool. Soc. Lond.* **1867,** 1003–1032.

HELLER, E. (1913). The white rhinoceros. *Smithson. Misc. Coll.* **61,** no. 1.

LYDEKKER, R. (1908). *Game animals of Africa,* 35–46. London : Rowland Ward.

LYDEKKER, R. (1910). in *Harmsworth natural history* **2,** 783–785. London : Harmsworth.

NEUVILLE, H. (1927). Remarques et comparaisons relatives aux phanères des Rhinocéros. *Arch. Mus. nat. Hist. Paris* (6 ser.) **2,** 179–208.

NEWTON, A. (1903). Letter from C. R. Saunders on photographs of the white rhinoceros. *Proc. zool. Soc. Lond.* **1903** (1), 222–224.

ROOSEVELT, T. (1910). *African game trails* (quoted by Heller).

SCLATER, P. L. (1886). Note on the external characters of *Rhinoceros simus.* *Proc. zool. Soc. Lond.* **1886,** 143–144.

SCLATER, P. L. (1900). *Mammals of South Africa* **2,** 297–303. London : Porter.

SELOUS, F. C. (1881). On the South African rhinoceroses. *Proc. zool. Soc. Lond.* **1881,** 725–734.

THOMAS, O. (1901). Notes on the type specimen of *Rhinoceros lasiotis* Sclater ; with remarks on the generic position of the living species of Rhinoceros. *Proc. zool. Soc. Lond.* **1901** (2), 154-158.

TROUESSART, E. L. (1909). Le Rhinocéros blanc du Soudan (*Rhinoceros simus cottoni*). *Proc. zool. Soc. Lond.* **1909** (1), 198–200.

EXPLANATION OF PLATE

Fig. 1.—*Ceratotherium simum.* Nuchal eminence (hump) of immature animal, superficial aspect in lateral view to show appearance of the skin. A hair is visible on the summit of the eminence. Cm. scale.

,, 2.—*Ceratotherium simum.* Nuchal eminence of same animal, longitudinally sectioned to show (a) projecting summit hairs, (b) the relatively thin epidermis, (c) the great depth of the dermis. Cm. scale.