MEMOIRS

OF THE

American Museum of Natural History.

NEW SERIES, VOL. I, PART IV.

IV.—ONTOGENETIC AND OTHER VARIATIONS IN MUSKOXEN, WITH A SYSTEMATIC REVIEW OF THE MUSKOX GROUP, RECENT AND EXTINCT.

BY J. A. ALLEN.

March, 1913.

(*Continued from 3rd page of Cover.*)

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NEW SERIES, VOLUME I, PART IV.

ONTOGENETIC AND OTHER VARIATIONS IN MUSKOXEN, WITH A SYSTEMATIC REVIEW OF THE MUSKOX GROUP, RECENT AND EXTINCT.

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BY J. A. ALLEN.

PLATES XI–XVIII AND 46 TEXT FIGURES.

CONTENTS.

I. ONTOGENETIC AND OTHER VARIATIONS.

Introduction.

During the last ten years this Museum has acquired a large amount of material illustrating variations in Muskoxen due to age, sex, environment, and individual differentiation, mainly through the many years of Arctic exploration by Commander (now Rear Admiral) Robert E. Peary, which culminated in 1909 in his discovery of the North Pole. This material comprises nearly 140 specimens, presented to the American Museum by the Peary Arctic Club, and others from the Barren Grounds of northern Canada and Melville Island, obtained partly by purchase and partly through loans from other museums.

In 1901 a report was made by the writer[1] on the series of Muskoxen collected by Peary on Bache Peninsula, Ellesmere Land, in October, 1898, with reference to their relationship to those of the Barren Grounds and East Greenland. Since then several notable contributions have been made to the history of this interesting species and its immediate progenitors. Lönnberg published in 1900 his second contribution to the anatomy of *Ovibos*,[2] which includes a discussion of the affinities of the genus and the development of the horns. Elliot, in 1905,[3] described a new subspecies of *Ovibos* from Wager Inlet, northwest of Hudson Bay, and Preble, in 1908,[4] gave an important and detailed account of its distribution. Kowarzik, in 1910, contributed[5] an elaborate memoir on the Muskox and its races (referred to more at length later), in which he recognized five subspecies, to which in 1911 he gave the rank of full species, and divided them into two genera.

Also of special interest in this connection are several papers on fossil forms allied to *Ovibos*, respectively by Osgood,[6] Gidley,[7] and Brown.[8]

Material Examined.

The material examined in the preparation of the present paper includes 8 mounted specimens, about 140 skins, about the same number of skulls, and 5 skeletons in the American Museum of Natural History; 6 living animals in the New York Zoölogical Society's Park, and 2 skulls and 3 mounted heads in its 'Heads and Horns' collection; 3 skulls from the Barren Grounds

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[1] Allen, J. A. The Muskoxen of Arctic America and Greenland. Bull. Amer. Mus. Nat. Hist., Vol. XIV, pp. 69–86, pll. xii–xvi, text figs. 1–7, March 27, 1901.

[2] Lönnberg, Einar. On the Structure and Anatomy of the Musk-Ox (*Ovibos moschatus*). Proc. Zool. Soc. London, 1900, pp. 686–718, text figs. 1–10.

[3] Elliot, D. G. Descriptions of apparently new Mammals of the genera *Ovibos*, *Cynomys* and *Mustela*. Proc. Biol. Soc. Washington, Vol. XVIII, pp. 135–140, April 18, 1905. *Ovibos niphœcus* sp. nov., p. 135.

[4] Preble, Edward A. A Biological Investigation of the Athabaska-Mackenzie Region. North Amer. Fauna, No. 27, pp. 1–574, with 25 plates and 16 text figures. Oct. 26, 1908. Musk-ox (*Ovibos moschatus*), pp. 150–155, with map.

[5] Kowarzik, Rudolf. Der Moschusochs und seine Rassen. Fauna Arctica, Bd. V, 1910, pp. 87–126, 1 pl. and 16 text figs.

[6] Osgood, Wilfred H. *Scaphoceros tyrrelli*, an extinct Ruminant from the Klondike Gravels. Smithsonian Misc. Coll. (quart. issue), Vol. 48, Part 2, No. 1589, pp. 173–185, pll. xxxvii–xlii, July 1, 1905.

See also, by the same author: *Symbos*, a substitute for *Scaphoceras*. Proc. Biol. Soc. Washington, Vol. XVIII, p. 223, Oct. 17, 1905.

[7] Gidley, James Williams. A new Ruminant from the Pleistocene of New Mexico. Proc. U. S. Nat. Mus., Vol. XXX, 1906, pp. 165–167, 3 text cuts. April 4, 1906. *Liops zuniensis* gen. et sp. nov.

Gidley, James Williams. Descriptions of two new Species of Pleistocene Ruminants of the Genera *Ovibos* and *Bootherium*, with notes on the latter Genus. Proc. U. S. Nat. Mus., Vol. XXXIV, pp. 681–684, pll. lvii–lix, 1 text fig. Sept. 15, 1908. *Ovibos yukonensis*, *Bootherium sargenti*, spp. nov.

[8] Brown, Barnum. The Conard Fissure, a Pleistocene Bone Deposit in Northern Arkansas: with Descriptions of two new Genera and twenty new Species of Mammals. Mem. Amer. Mus. Nat. Hist., Vol. IX, Part IV, pp. 155–208, pll. xiv–xxv, text figs. 1–3. February, 1908. *Symbos australis*, sp. nov., p. 203, pl. xxii.

north of Great Slave Lake, and 4 skulls from Wager Inlet, Hudson Bay (the type and 3 topotypes of *Ovibos moschatus niphœcus* Elliot), borrowed from the Field Museum of Natural History of Chicago; and 3 skulls from Melville Island (topotypes of *O. moschatus melvillensis* Kowarzik), borrowed from the Victoria Memorial Museum at Ottawa, Canada.

The American Museum material was collected, as already stated, mainly by the Peary Arctic Expeditions (1898–1909), but includes in addition 10 specimens from the Barren Grounds (among them 2 fœtal specimens), and 9 from the head of Wager Inlet (topotypes of *O. moschatus niphœcus*), collected by Captain George Comer in 1892. The Peary material consists of about 20 specimens from northern Ellesmere Land, 26 from Cape Morris K. Jesup, the most northern point of Greenland and hence also the most northern known land, while the remainder were taken in Grant Land, from the vicinity of Fort Conger and Lake Hazen northward to the Arctic coast. It includes specimens of all ages, from young calves to senile adults, of which 40 are adult males and 30 are adult females, the others representing almost every stage of immaturity. They were nearly all killed either in the spring (in March, April, and May) or in the fall (chiefly in September and October), the greater part, however, in the autumn, to furnish the winter supply of meat for the men and dogs of the expeditions.

The specimens brought in by Peary from his several expeditions represent but a small part of those killed, which probably aggregate more than 600. They were received in excellent condition as regards both skulls and skins, but unfortunately, in many instances, the skins and skulls cannot be associated as belonging together, owing to lack of care in labelling, and had to be entered separately in cataloguing. Only about one half of the skins and skulls can be positively identified as belonging the one to the other. A further misfortune is that definite dates are lacking, leaving much to be inferred in respect to the actual date of capture. In my account of the growth of the horns, the stages of development are based primarily on the teeth and the general size and condition of the skull, checked by a few skulls of known date of capture for each stage of growth, by the six living specimens of known age in the New York Zoölogical Park, and on the fact that nearly all of the specimens sent to the Museum were killed either in April and May or in September and October. The series of photographic illustrations of skulls carry their own evidences of age, since they include not only dorsal, lateral, and occipital views, as each case may require, but a view of the crown surface of the maxillary teeth to show their condition in each skull illustrated.

The fossil material includes the types of *Bootherium* and *Liops*, and a nearly complete skull of *Symbos*.

ACKNOWLEDGEMENTS.

I am especially indebted to Dr. W. D. Matthew, Curator of the Department of Vertebrate Palæontology, for the use of the most nearly complete skull thus far known of *Symbos* (*Bootherium*, part, Leidy), opportunely received at the Museum while the preparation of this paper was in progress. I have also received from Dr. Matthew an imperfect adult female skull of *Ovibos* from Alaska, which is of interest for comparison with female skulls of *Ovibos* from Grant Land; also several imperfect skulls of *Ovibos* from various Pleistocene localities in the United States, and the type material of *Symbos australis* Brown.

Dr. William T. Hornaday, Director of the New York Zoölogical Park, has afforded me every facility for the study of the six muskoxen at present living in the Zoölogical Park, and has also

furnished me with full data respecting the date and place of capture of not only these but the full history of such other muskox specimens as have lived for a time in the Park and now form part of the material available for study in the present connection. He has also kindly sent me photographs taken from time to time of the living specimens, especially valuable as representing animals of known age.

I am indebted to the Field Museum of Natural History of Chicago, through Mr. Charles B. Cory, Curator of Zoölogy, for the loan of several skulls of muskoxen from the Barren Grounds north of Great Slave Lake, and for topotype skulls of *Ovibos moschatus niphœcus* Elliot. Mr. Roy C. Andrews, Assistant Curator of Mammals in this Museum, and Mr. Wilfred H. Osgood, Assistant Curator of Mammals and Birds in the Field Museum, have kindly examined for me the series of skins of *Ovibos moschatus moschatus* and *O. moschatus niphœcus* in the Field Museum in reference to certain diagnostic points respecting which I desired information.

Through the kindness of Mr. J. W. Gidley of the Palæontological Department of the U. S. National Museum, I have been able to study at first hand the unique type of his remarkable genus *Liops*. I am also under great obligations to Mr. Percy A. Taverner, Curator of Zoölogy in the Victoria Memorial Museum at Ottawa, Canada, for the loan of three muskox skulls from Melville Island.

Valued information has been given me by Mr. V. Stefansson and Dr. R. M. Anderson, of the Museum's recent expedition to Arctic America, and by Captain George Comer, who for the last twenty years has prosecuted whaling voyages to Hudson Bay, regarding the present range of muskoxen respectively west of Coronation Gulf and the adjoining Arctic coast, and in the region northwest of Hudson Bay. They have each given me detailed statements which are here inedited in their proper connection. I am also indebted to Mr. Frank C. Hennessey, of Winona Lake, Indiana, for valued notes on the habits and external appearance of the Muskoxen on Melville Island, where he passed the winter of 1908–09 as an assistant to Captain J. E. Bernier of the Canadian Government exploring steamer 'Arctic', and who helped capture the specimen now living in the New York Zoölogical Park. I am also under obligations to Mr. Donald B. MacMillan of the last Peary Expedition, for important notes on muskoxen made by him at the most northern extremity of Greenland in 1909.

Mr. H. E. Anthony, Assistant in Mammalogy, has greatly aided me in handling the large amount of unwieldly material involved in this investigation, to whom I am also indebted for the measurements of the large series of skulls presented in Tables I–IV, and for supervising the photographing of the skulls used in illustrating the present paper. The photographs were taken by the Museum photographer, Mr. Julius Kirschner, and speak for themselves. •

Ontogenesis of the Horns in Ovibos.

The development of the horns in the muskox is a subject possessing special interest on account of their position and structure, and their changes in form and direction during growth. The first and only special investigation of the subject, so far as known to the present writer, was published by Einar Lönnberg in the 'Proceedings' of the London Zoölogical Society for the year 1900 (*l. c.*, pp. 687–694, figs. 1–4). Owing to the scantiness of his material his conclusions, based largely on hypothetical grounds, are open to correction in several quite essential details, as will be noticed later in this paper.

The following notes on the condition of the horns at intervals of about six months, for the period from birth to full maturity, and the illustrations accompanying the text, show in detail, from actual specimens, the ontogenetic changes presented by the skull, teeth, and horns in *Ovibos*.

1. *Fœtal* (probably about 8th month). Fig. 1. Two specimens. Deciduous premolars: dp^2 about even with the alveolus; dp^3 about two-thirds up; dp^4 about one-third up.

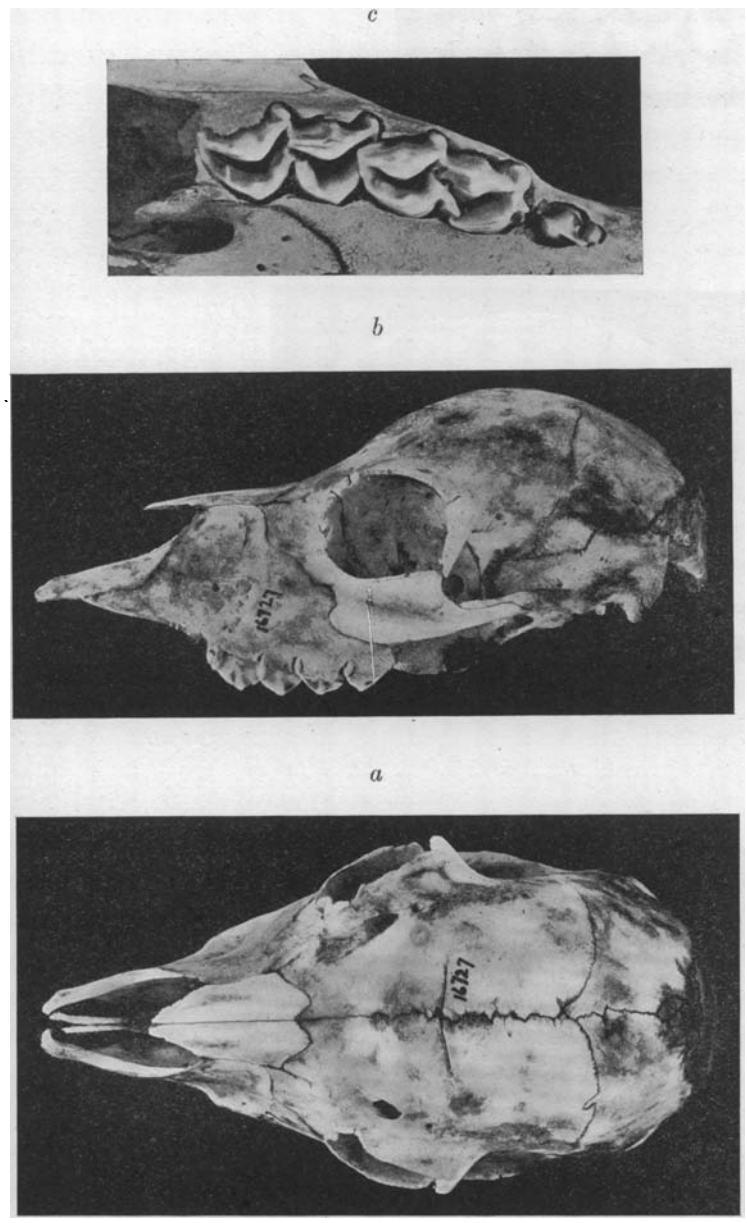


Fig 1. No. 16727, fœtal (about 8th month), Barren Grounds, east of Mackenzie River. *a*, dorsal view, ½; *b*, lateral, ½; *c*, crown view of maxillary teeth, 1/1.

There is no indication of horncores nor of their future position on the skull. Size of skull: total length, 168 mm.; least postorbital breadth (between eye-sockets and base of horncores), 66 mm. Locality: Barren Grounds east of Mackenzie River. Two skulls, Nos. 16726 and 16727 (figured).

2. *About one week old.* Fig. 2. Two specimens. Deciduous premolars fully developed but not worn; m^2 concealed in alveolus. Position of horncores not yet indicated. Size of skull: total length, ♀ 200, ♂ 209; postorbital breadth, ♀ 75, ♂ 76. Locality: No. 15597, ♀, Fort Conger, Grant Land, May 18, 1889; No. 29939, ♂ (figured), Cape May, Greenland, about May 20, 1909.

3. *Five to seven months old.* Fig. 3, No. 35346, ♀. Represented by numerous skulls of animals killed in northern Grant Land from the last week in August till late in October. The sex is positively known for only a few of them, but judging by these, about one half of them should be males and the other half females.

In the younger specimens (probably killed in late August and early September) the anterior half of m^2 projects above the alveolus about 4 mm., while the top of the posterior half is about even with the alveolar border. In the others (probably mostly October specimens) m^2 is slightly more advanced.[1] The deciduous premolars are considerably and about equally worn in all of the skulls. The horncores vary in development, usually forming a slight prominence or 'hillock' about 10 to 20 mm. in breadth at base and 3 to 10 mm. in height.

The size of the skull at the age of from about five to eight months is shown in the following

[1] The development of the mandibular dentition parallels that of the maxillary and only requires mention where the incisors are involved. For figures of the mandibular teeth see Plate XVI.

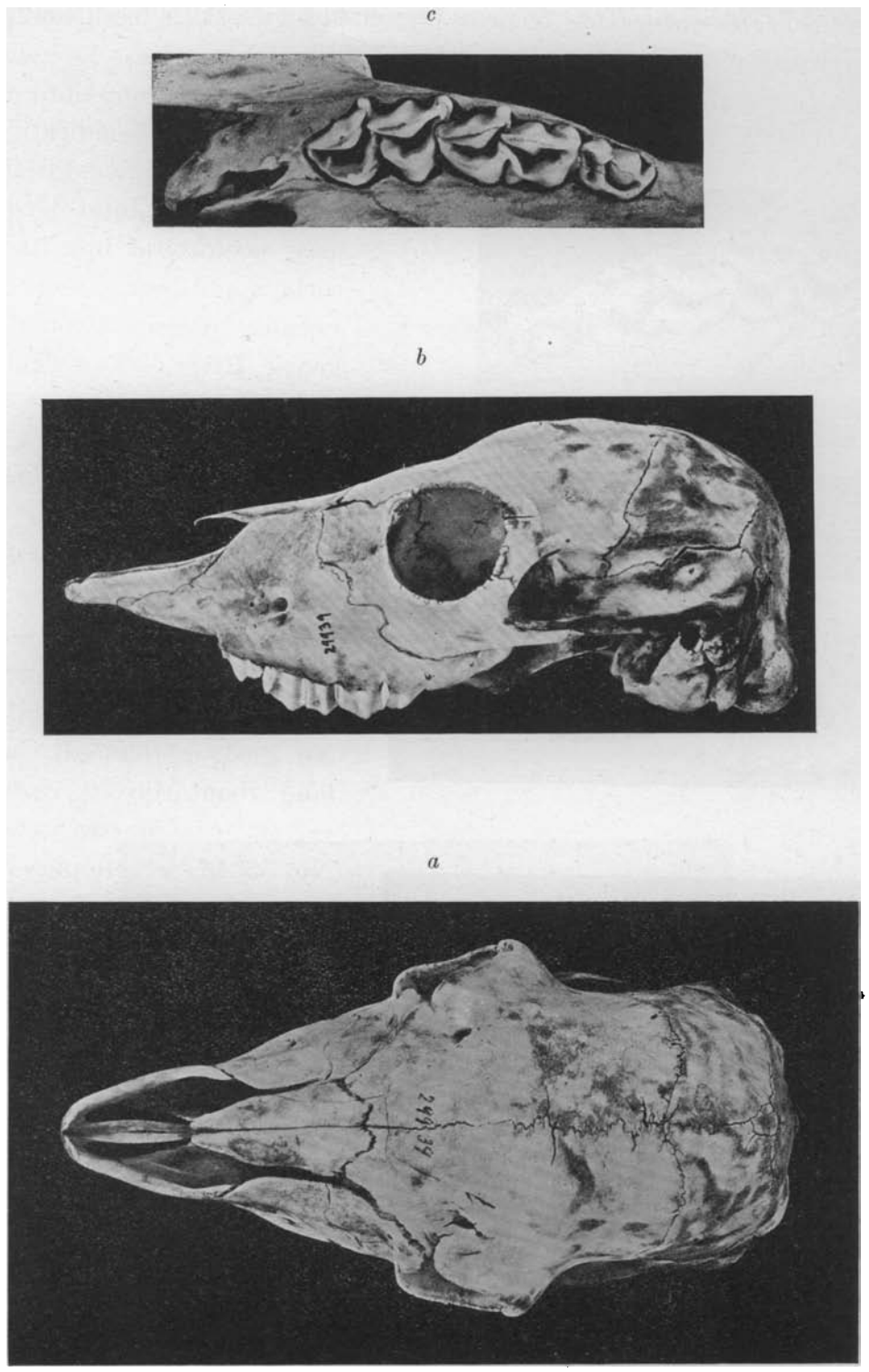


Fig. 2. No. 29939, ♂, about 1 week old, Cape May, Greenland, May 20, 1909. *a*, dorsal view, $\frac{1}{2}$; *b*, lateral view, $\frac{1}{2}$; *c*, crown view of maxillary teeth, $\frac{1}{1}$.

table of measurements. All the skulls are from northern Grant Land, from the vicinity of Lake Hazen and north to the coast, except one (No. 35346), of an animal brought alive from Ellesmere Land, by Mr. Paul J. Rainey, and presented by him to the New York Zoölogical Society; it died in the Zoölogical Park October 27, 1902.

Measurements of young Muskox Skulls, Five to Seven or Eight Months old.

	Total length	Postorb. breadth	Horncores Diam. at base	Horncores Length
No. 28033 ♂	300	84	20	10
" 29913 ♂	290	83	22	12
" 35346 ♀	283	81	10	3
" 28070 ♀	278	79	10	3
" 28035 ♀	288	84	14	4
" 28037 ♀	294	82	15	4
" 29914 ♂	287	82	16	8
" 29915 ♂	284	83	16	5
" 29928 ♂	283	81	15	5

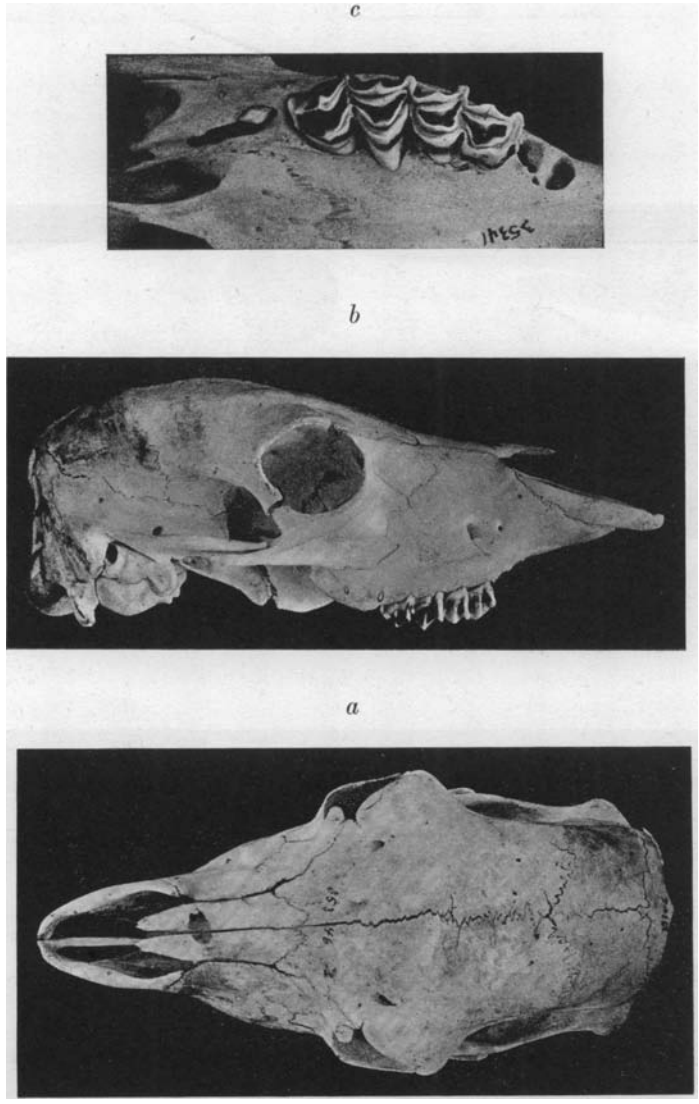


Fig. 3. No. 35346, ♀, 5 months old, Ellesmere Land; died in New York Zoölogical Park, October 27, 1902. *a*, dorsal view, ⅓; *b*, lateral view, ⅓; *c*, crown view of maxillary teeth, ½.

4. *One year old.* Fig. 4, No. 28108, ♀ (?), Grant Land. Several of the skulls in the collection are almost unquestionably skulls of yearlings, though not positively known to be of this age. In these the deciduous premolars are much worn, and m^2 is fully grown and functional, the anterior half sometimes showing slight wear. In m^3 the anterior half projects slightly above the alveolus, and the posterior half is about level with the alveolar border. All of the deciduous incisors are still present. The horncores have a diameter of base of about 18 to 25 mm. in the males, and about 10 to 15 mm. in the females. The horn sheaths must still be rudimentary; none are available for examination.

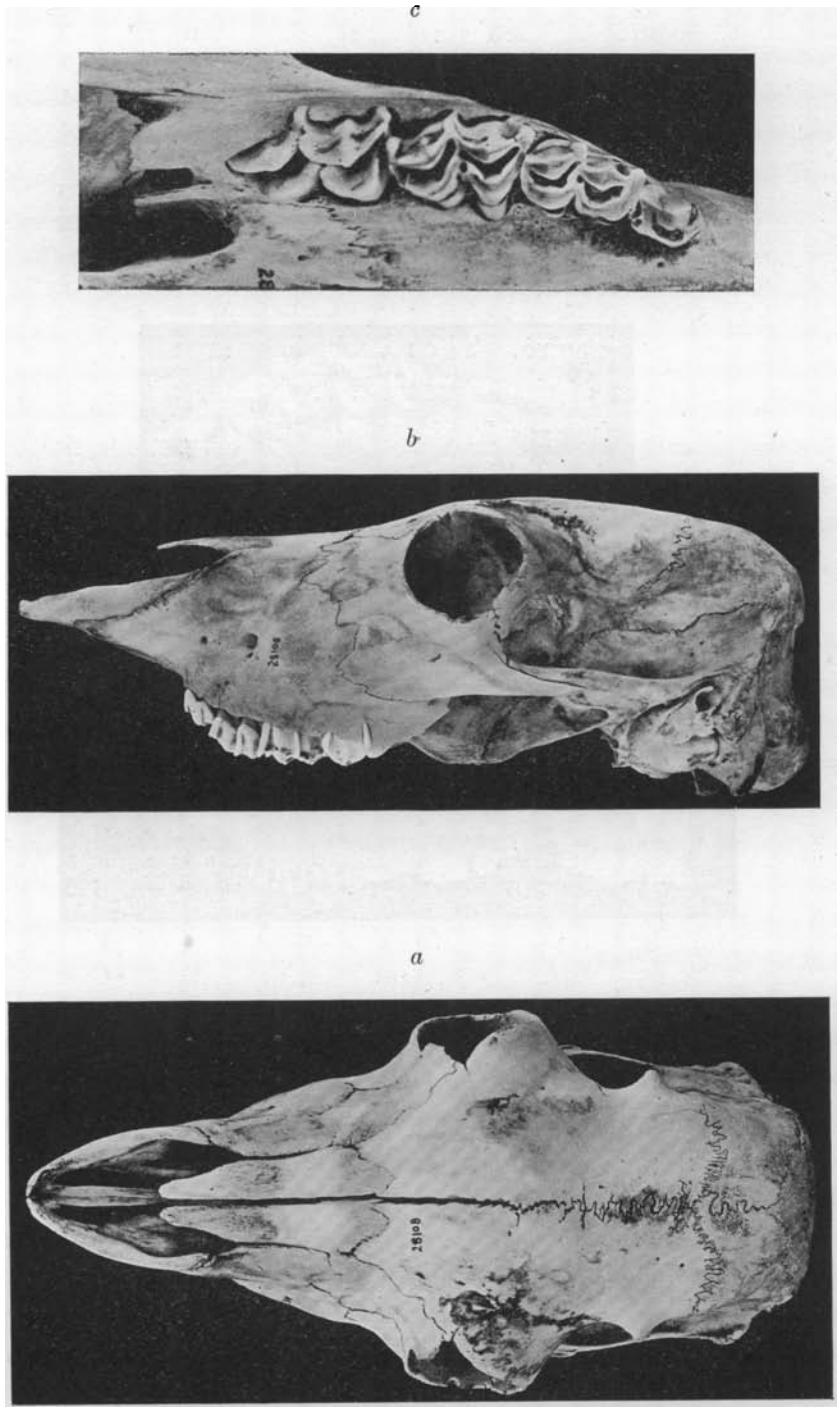


Fig. 4. No. 28108, ♂, about 1 year old, northern Grant Land. *a*, dorsal view, ⅓; *b*, lateral view, ⅓; *c*, crown view of maxillary teeth, ⅔.

Measurements of young Muskox Skulls, presumably about One Year old.

	Total length	Postorb. breadth	Horncores Diam. at base	Horncores Length
No. 28011 ♂	305	87	18	8
" 28108 ♂	317	91	22	10
" 28009 ♂	288	87	22	10
" 28079 ♂	308	85	25	18
" 28034 ♂	300	87	22	15
" 28032 ♂	295	85	18	9
" 28010 ♀	315	88	25	17
" 28106 ♀	300	82	14	4

5. *Eighteen months old.*[1] Figs. 5 and 6, Nos. 29916, ♀, and 27995, ♂, Grant Land. Specimens, as follows: No. 15678, ♀, 15684, ♀, Bache Peninsula, October, 1898; Nos. 27995, 28077, 29950, males, and 28078 and 29916, females, northern Grant Land, September and October, 1908.

The deciduous premolars are much worn; m^1 is fully grown and functional; the anterior half is a little worn in some specimens, in others the posterior half is also beginning to wear; in m^2 the anterior half rises to just above the edge of the alveolus in the younger (September) specimens, and is a little more advanced in the older (October) specimens, in which the posterior half is level with the edge of the alveolus. The milk incisors are all still present.

The anteroposterior diameter of the horncores at base in males is 41 to 46 mm., in females 32 to 34. Their length in males ranges from 103 to 115 mm., in females from 59 to 63; the deflection of the axis from the horizontal is slight — about 7°. The length of the horn sheaths, in a straight line from base to tip, is about 165 mm. in males and about 107 in females. The horncores begin to show a slight dorso-ventral flattening. They consist now of a short, smooth pedicel 10 to 13 mm. in length, surmounted by the rugose sheath-covered portion. The sheaths are about twice the length of the rugose portion of the core, and are curved forward and slightly upward, the tips rising a little above the dorsal plane of the skull.

Measurements of young Muskox Skulls, about Eighteen Months old.

	Total length	Postorb. breadth	Horncores Diam. at base	Horncores Length
No. 28077 ♂	360	119	46	115
" 27995 ♂	355	103	41	103
" 29950 ♀	350	97	—	—
" 28078 ♀	338	97	33	63
" 29916 ♀	340	94	32	59
" 15684 ♀	340	93	34	61

6. *Two years old.* Figs. 7 and 8. Five specimens, 3 males and 2 females, all from northern Grant Land, represent a slightly more advanced stage of growth, and are hence believed to be about two years old.

The deciduous premolars are greatly worn, in dp^2 and dp^3 the crown pattern being obliterated; m^1 is much worn; in m^2 the anterior half is fully up but not worn or only slightly worn; m^3 is

[1] The present collection of skulls of muskoxen consists of specimens taken mainly in the fall of the year (late in August to early November, and hence contains few that can be referred to even years of age, as two years, three years, four years, etc., hence their division as below to correspond with the actual season of capture. The date of capture for some of the specimens in each of the divisions is known to have been in October.

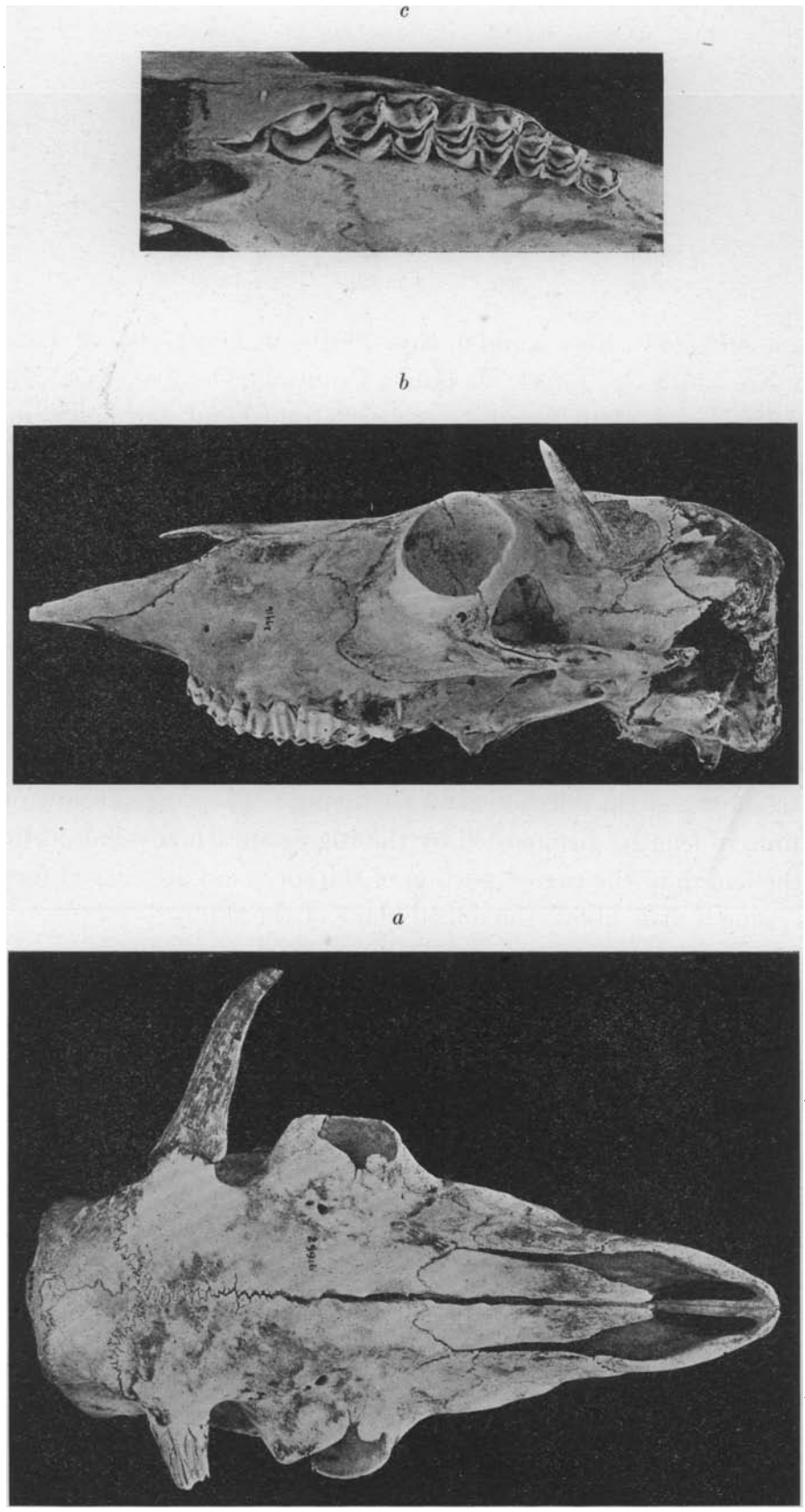


Fig. 5. No. 29916, ♀, 18 months old, northern Grant Land. *a*, dorsal view, $\frac{1}{3}$; *b*, lateral view, $\frac{1}{3}$; *c*, crown view of maxillary teeth, $\frac{3}{5}$.

Fig. 6*a*

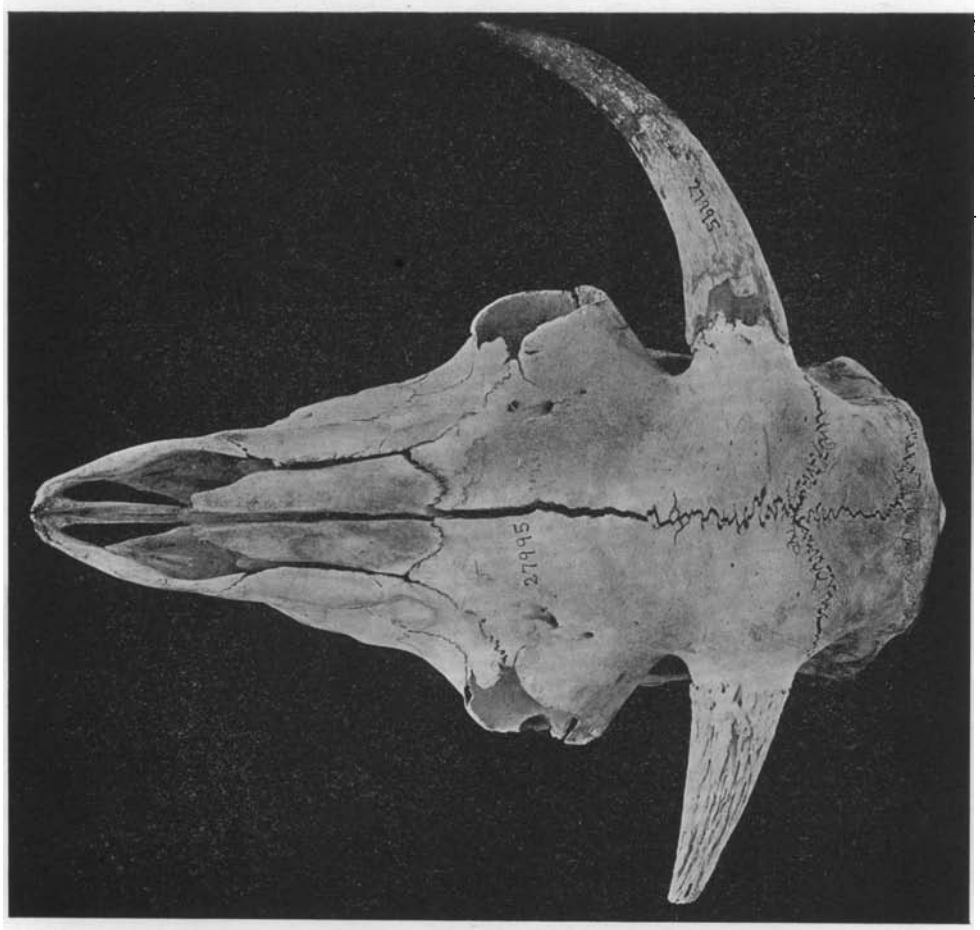


Fig. 6*b*

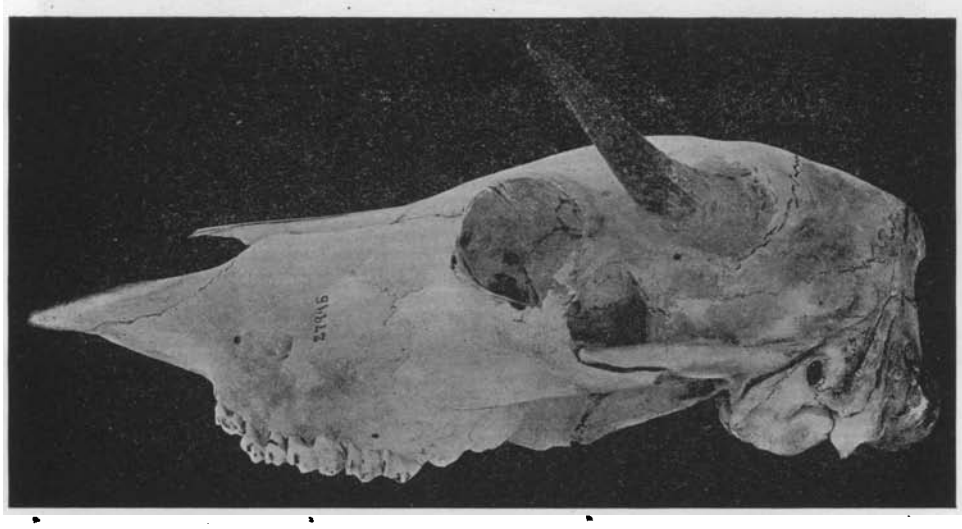


Fig. 6*e*

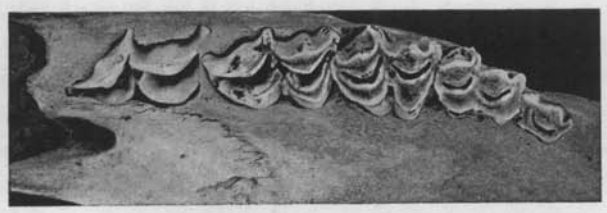


Fig. 6*c*

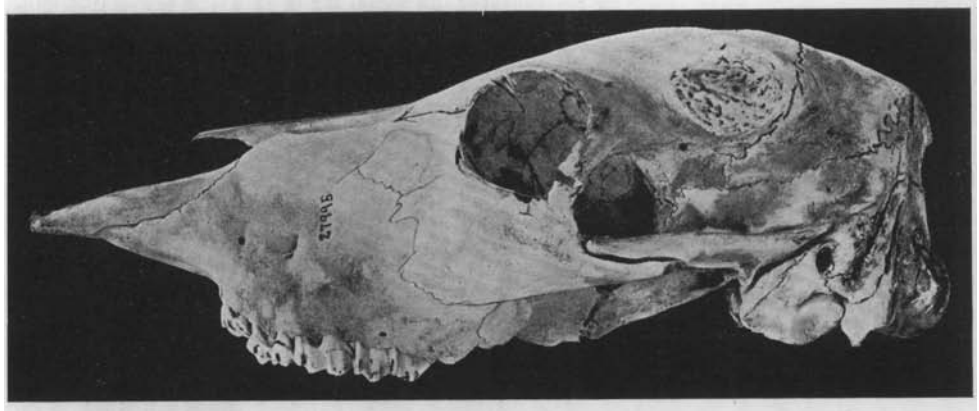


Fig. 6*d*

Fig. 6. No. 27995, ♂, 18 months old, northern Grant Land. *a*, dorsal view, one horn sheath removed, $\frac{1}{3}$; *b*, lateral view with horn sheaths, $\frac{1}{3}$; *c*, lateral view with horn sheaths removed, $\frac{1}{3}$; *d*, occipital view with one horn sheath in place and one removed, $\frac{1}{3}$; *e*, crown view of maxillary teeth, $\frac{3}{5}$.

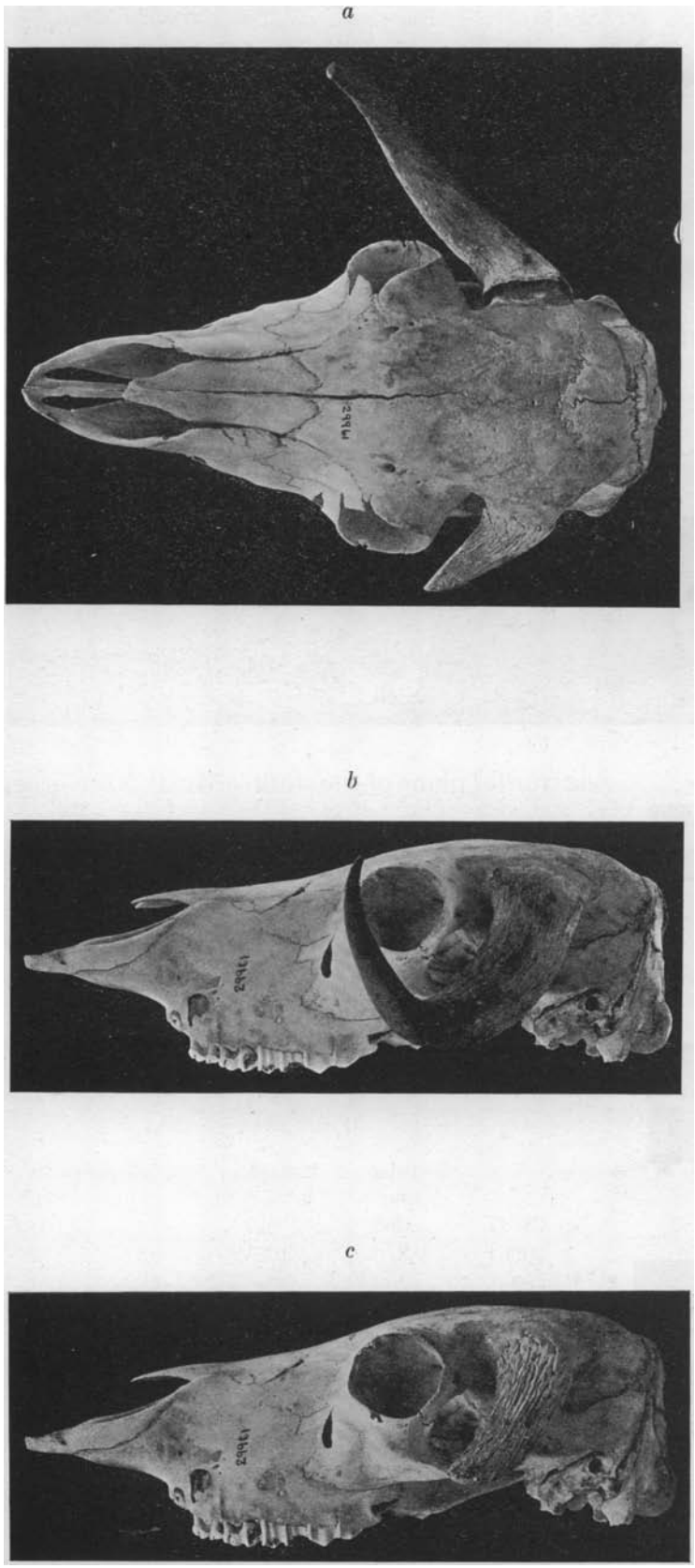


Fig. 7. No. 29961, ♀, 2 years old, northern Grant Land. *a*, dorsal view, ½; *b*, lateral view with horn sheath, ½; *c*, lateral view without horn sheath, ½; *d*, occipital view, ½; *e*, crown view of maxillary teeth, ⅝.

still enclosed in the alveolus; the middle pair of permanent incisors have the tip just above the alveolar border.

The horncores in females are greatly flattened dorso-ventrally, less so and much more robust in males; the deflection of the axis in females is about 33°, much greater than in the males (about 20°), with the apical third curved slightly forward and outward. The pedicel is smooth, about 10° to 15° mm. long in different specimens; the rugose portion of the horncore is slightly broader at base than the pedicel, projecting a little beyond it on both the anterior and posterior borders, the projection being greater in males than in females.

The length of the horn sheaths in a straight line from base to tip is about 150 mm. in females, and about 180 in males. The sheaths present a rapidly increasing curvature on the apical third, measuring over the convexity, ♀ 285, ♂ 310 mm. The tips do not usually extend much above

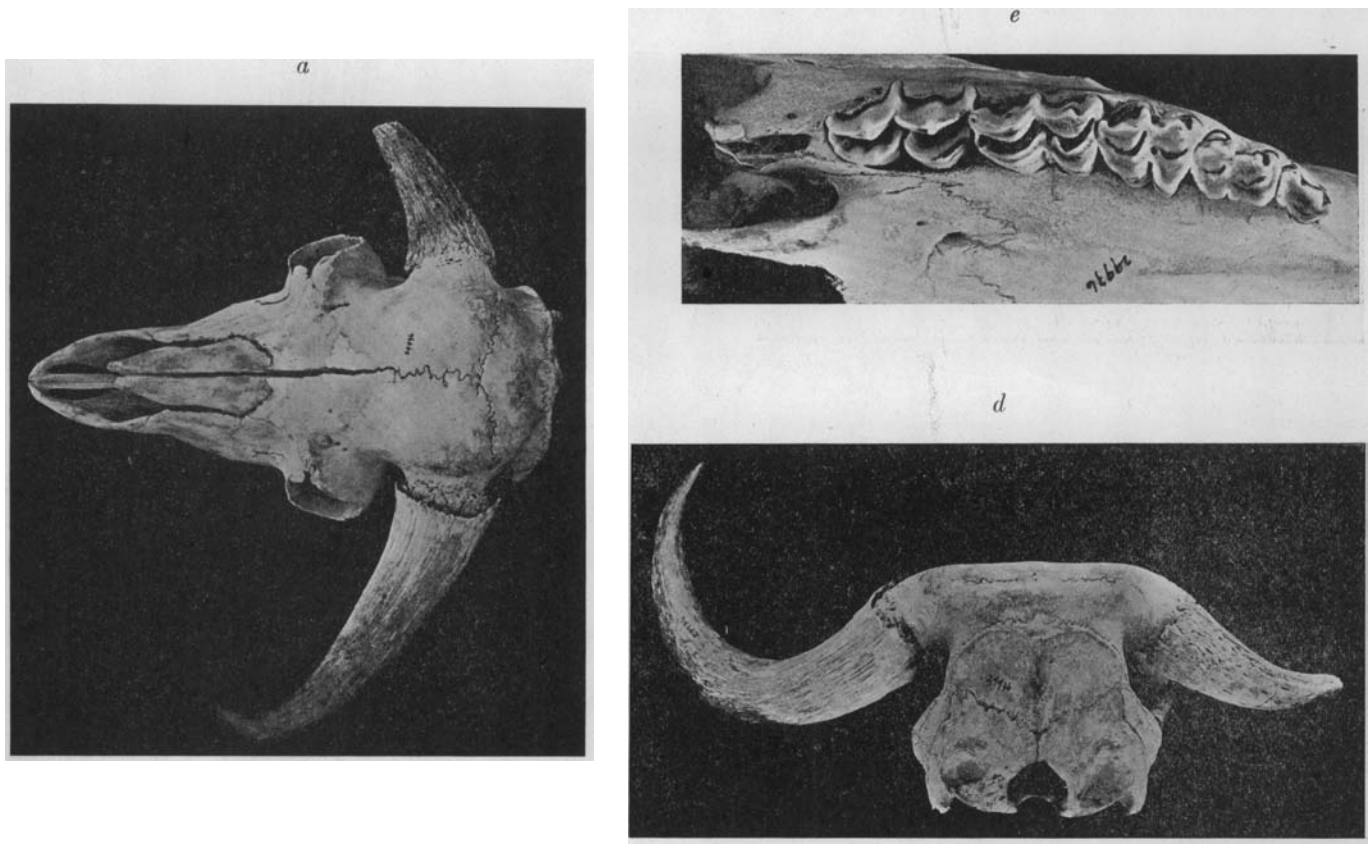


Fig. 8. No. 29936, ♂, 2 years old, northern Grant Land. *a*, dorsal view, $\frac{2}{9}$; *b*, lateral view with horn sheaths, $\frac{2}{9}$; *c*, lateral view without horn sheaths, $\frac{2}{9}$; *d*, occipital view, $\frac{2}{9}$; *e*, crown view of maxillary teeth, $\frac{1}{1}$.

the frontal plane of the skull. Mr. B. McEnroe, keeper of the muskoxen in the New York Zoölogical Park, informs me that he has found, by measurement, that the rate of growth in one of the specimens averaged about one-half inch each month, his observations being carried through one year.

Measurements of Skulls of young Muskoxen, about Two Years old.

	Total length	Postorb. breadth	Horncores Diam. at base	Length
No. 28017 ♀	363	99	44	105
" 29961 ♀	370	102	43	132
" 28081 ♂	353	104	48	126
" 19559 ♂	355	104	49	112[1]
" 28076 ♂	363	109	54	146

7. *Twenty-eight to thirty months old.* Eight skulls may be cited as referable to this stage, namely, 4 males and 4 females. Nos. 15678, 15589, 15679, 15682, are from Bache Peninsula, Oct. 14, 1898; Nos. 19562, 27966, 28011, 29943, are from northern Grant Land, October, 1908.

[1] Slightly abraded at tip.

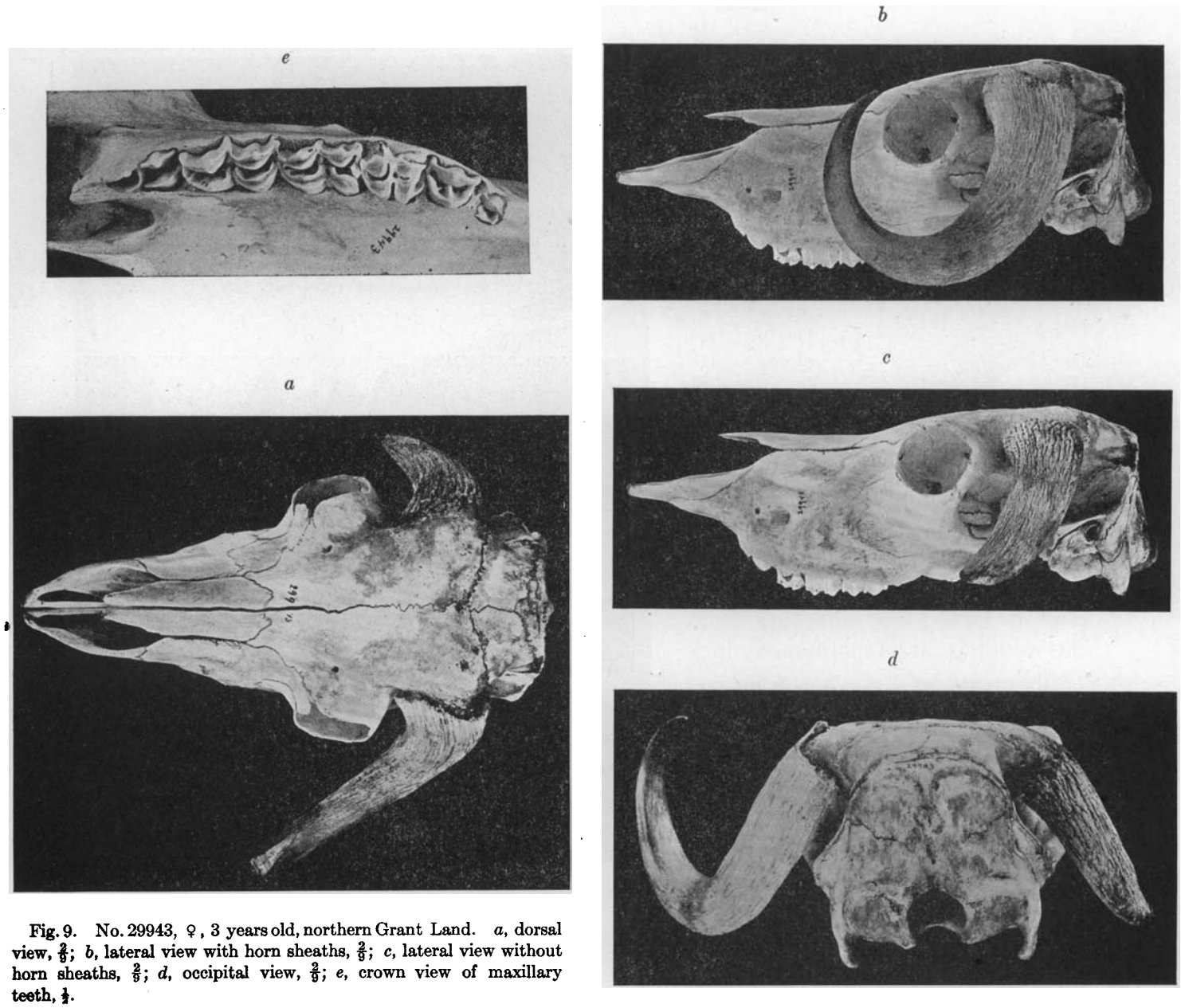


Fig. 9. No. 29943, ♀, 3 years old, northern Grant Land. *a*, dorsal view, $\frac{2}{3}$; *b*, lateral view with horn sheaths, $\frac{2}{3}$; *c*, lateral view without horn sheaths, $\frac{2}{3}$; *d*, occipital view, $\frac{2}{3}$; *e*, crown view of maxillary teeth, $\frac{1}{2}$.

The deciduous premolars are worn down nearly to the roots; m^1 is much worn; m^2 is functional and worn on the front half, and slightly worn on the posterior half; m^3 is wholly enclosed in its capsule. The middle pair of permanent incisors (i_1) is fully grown, while i_2 is enclosed in its capsule; di_{2-4} are not yet shed.

The horncores are much deflected (in females about 50°, in males about 45°), much flattened dorso-ventrally in males as well as females, curved forward apically, and in males also outward. The rugose basal part projects anteroposteriorly over the smooth pedicel, in males about 6 to 8 mm. on each side.

The length of the horn sheaths, in a straight line from the base to the tip, is about 177 mm. in females and about 190 in males; they measure along the convexity about 315 mm. in females and about 425 in males. They are strongly recurved at the tips, which rise often considerably above the frontal plane. In this and the next stage the tips rise higher above the frontal plane than at any other stage, either earlier or later, but none rise quite as high as represented by Lönn-

berg in his hypothetical sketch of "the horns at the end of the first summer (*l. c.*, p. 688, fig. 1 A.), or (as stated on p. 689), "of a young bull in the second autumn of its life."

Measurements of young Muskox Skulls, about Twenty-eight to Thirty Months old.

	Total length	Postorb. breadth	Horncores Diam. at base[1]	Length
No. 15678 ♀	372	106	44	121
" 27966 ♀	372	109	46	123
" 15682 ♂	385	110	42	127
" 15679 ♂	380	113	58	145
" 28011 ♂	400	106	55	130
" 19562 ♂	372	113	59	140[2]

8. *Three years old.* Figs. 9 and 10. Two males, Nos. 28011 and 29938 (both figured), from northern Grant Land have been selected as representing this stage.

The middle pair of permanent incisors is fully grown, and i_2 is partly grown; dp^2 and dp^3 have been shed, but dp^4 still surmounts p^4; p^3 and p^4 are about half their mature height (p^3 is most advanced), and p^2 is above the alveolus. M^1 is already much worn; m^2 is beginning to wear; m^3 is breaking through the alveolus.

The horncores are much larger than in stage 7 (28–30 months), and more depressed (57° to 60°), but the change is mainly in increased size. The sheaths are still easily separable from the horncores by maceration and have not begun to thicken at the base.

9. *Four years old.* Figs. 11 and 12, and Plate XII, fig. 5. Nos. 15588 (♀, deflection of horns 64°) and 19558 (♂), the former from Bache Peninsula, the other from northern Grant Land, are the specimens here figured, selected from a series referable to this stage.

[1] Base of pedicel; wider at base of the rugose portion.
[2] Tip slightly abraded.

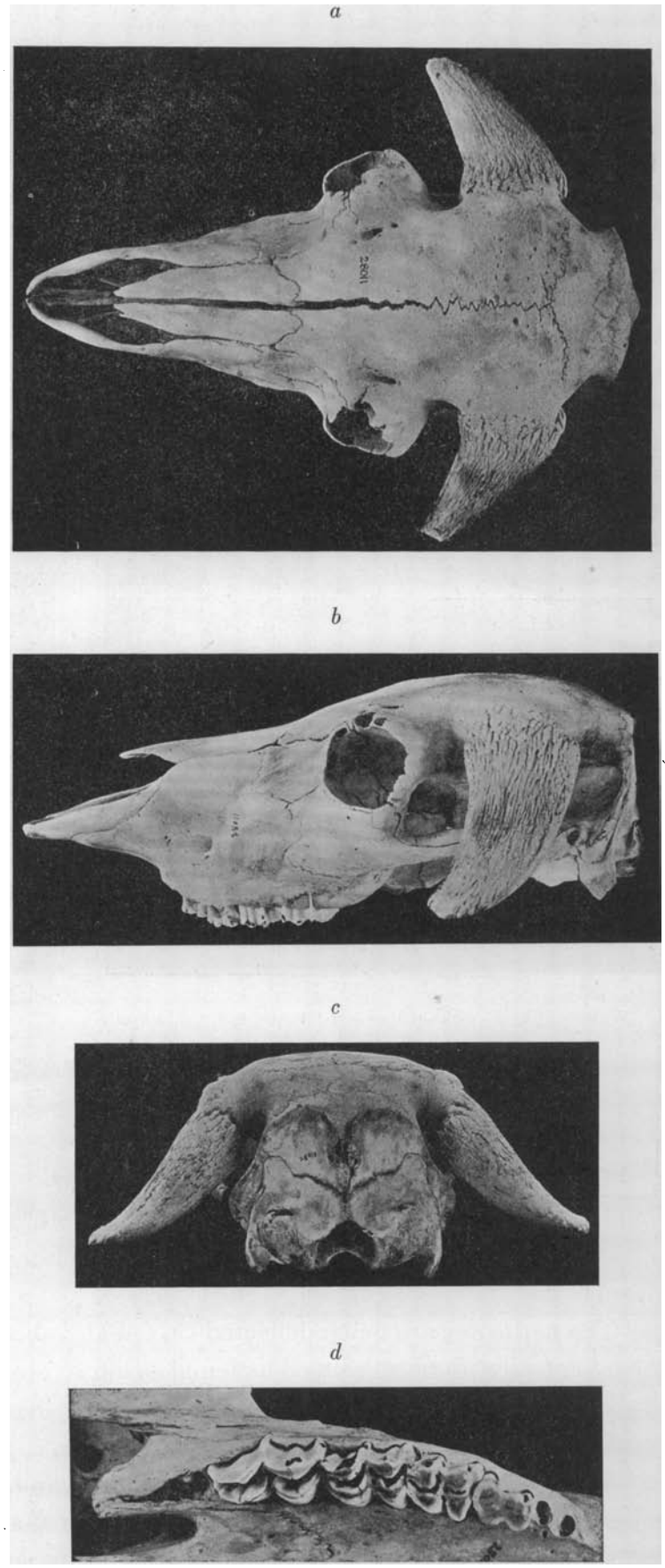


Fig. 10. No. 28011, ♂, 3 years old, northern Grant Land. *a*, dorsal view, $\frac{2}{5}$; *b*, lateral view, $\frac{2}{5}$; *c*, occipital view, $\frac{2}{5}$; *d*, crown view of maxillary teeth, $\frac{1}{2}$.

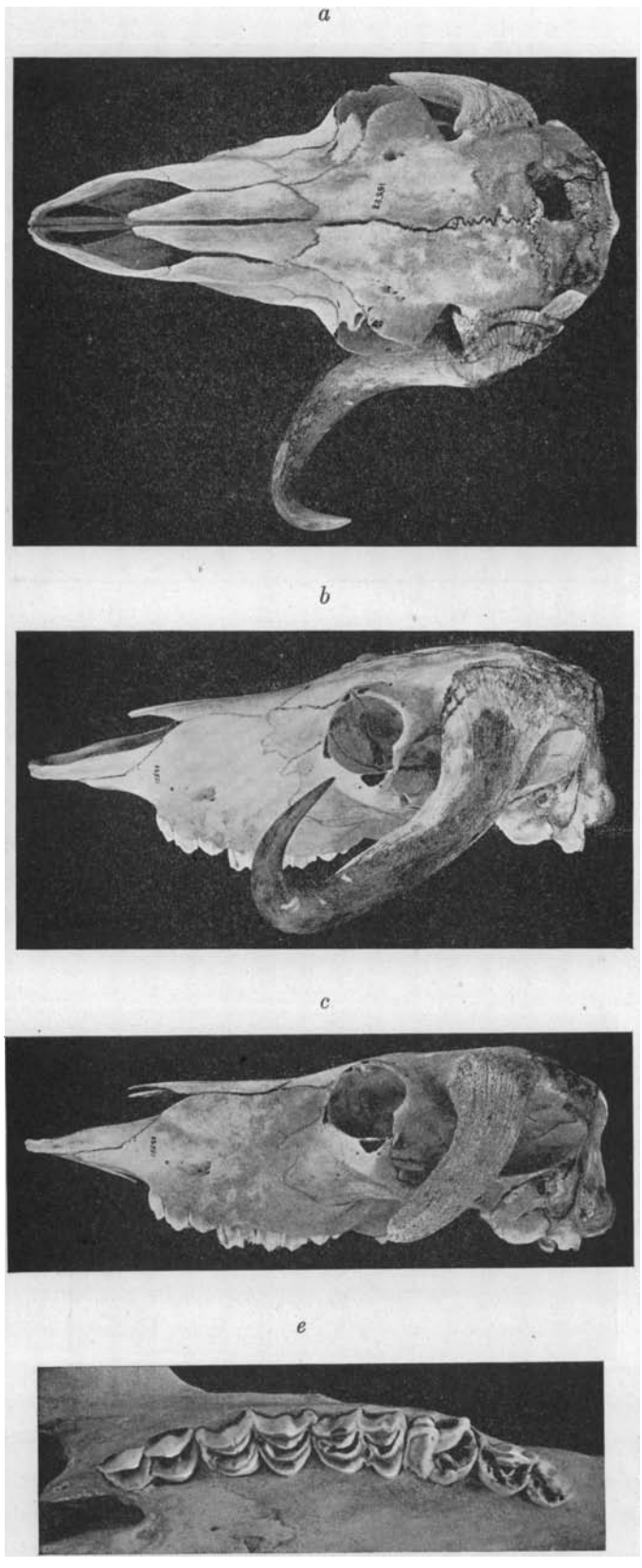
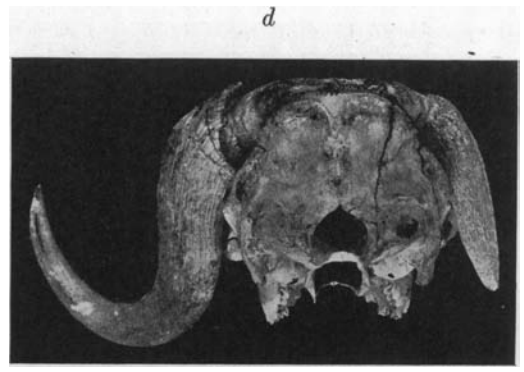


Fig. 11. No. 15588, ♀, 4 years old, Bache Peninsula, Ellesmere Land. *a*, dorsal view, $\frac{1}{5}$; *b*, lateral view with horn sheaths, $\frac{1}{5}$; *c*, lateral view without horn sheaths, $\frac{1}{5}$; *d*, occipital view, $\frac{1}{6}$; *e*, crown view of maxillary teeth, $\frac{1}{2}$.



All of the premolars and m^3 are almost fully grown, but they show little or no trace of wear; i_{1-3} are fully grown, but di_4 has not been shed, although i_4 is forming beneath it. The sheaths now so firmly adhere to the horncores in the males that they do not become loosened by maceration, but are often thus separable in the females. The base of the horncores is rapidly increasing in breadth by extension inward over the frontal region through exostosis, and the sheaths are beginning to thicken at base on the outer or dorsal surface. The depression of the horns has reached the maximum, leaving a space of only about 10 mm. in the female and about 15 mm. in the male between the horncore and the cheek bone for the skin of the face and the horn sheath. The horn tips are now sharply recurved (Figs. 11 and 12). In the female (No. 15588) the chord of the curve is 197 mm., while the chord from the base to the point of greatest outward curvature is 230 mm. The sheath at base extends 23 mm. inward over the frontal bone beyond the original base of the core. In the male (No. 19561) the chord of the curve is only 170 mm., while the chord from the base of the horn to the point of greatest outward curvature is 287 mm.

10. *Five years old.* Figs. 13, ♀, and 14, ♂, both from northern Grant Land. The outer or caniniform incisor has become functional and all the other teeth show increased wear. The horns have continued to increase in size, with the basal thickening greatly accelerated through the simultaneous deposition of bone and of keratin.

11. *Six to twelve years old.* Figs. 15 to 19. Skulls of six years and thence on to old age can be determined only approximately and relatively, through the amount of wear shown by the teeth and the general condition of the skull. Nor is it known to what age the muskox lives. Only a few of the skulls in the present large series show advanced senility and these are presumably at least twelve years old, while some of them are possibly much older. The oldest skulls are females, several of which bear marks of greater age than the oldest male skulls.

In an old female (No. 29963, northern Grant Land) the crown pattern has almost wholly disappeared in all the teeth except the posterior two molars, in which it is still distinct although the crowns of the teeth are greatly worn. The horn sheaths nearly meet on the midline of the skull (they are separated by a space of only 15 mm.), and exostosis from the base of the horncores covers the lateral third on each side of the postero-frontal and parietal regions. The horns descend so close to the sides of the head that a space of only 5 mm. separates them from the malar bone. The horns are not different in size or form from those of females five or six years old. The total length of the skull is 440 mm., the postorbital breadth 115 mm.

An old male (No. 28009), from the same locality, has the teeth similarly worn, but the skull is of course far more massive, having a total length of 516 mm. and a postorbital breadth of 145 mm. The horn sheaths have a basal breadth of 220 mm. and project 17 mm. beyond the plane of the occiput and extend forward to the posterior fourth of the eye-sockets.

The oldest skulls, whether male or female, are not always the largest of the series, there being a wide range of individual variation independent of sex and age. Some obviously very old skulls are below the normal or

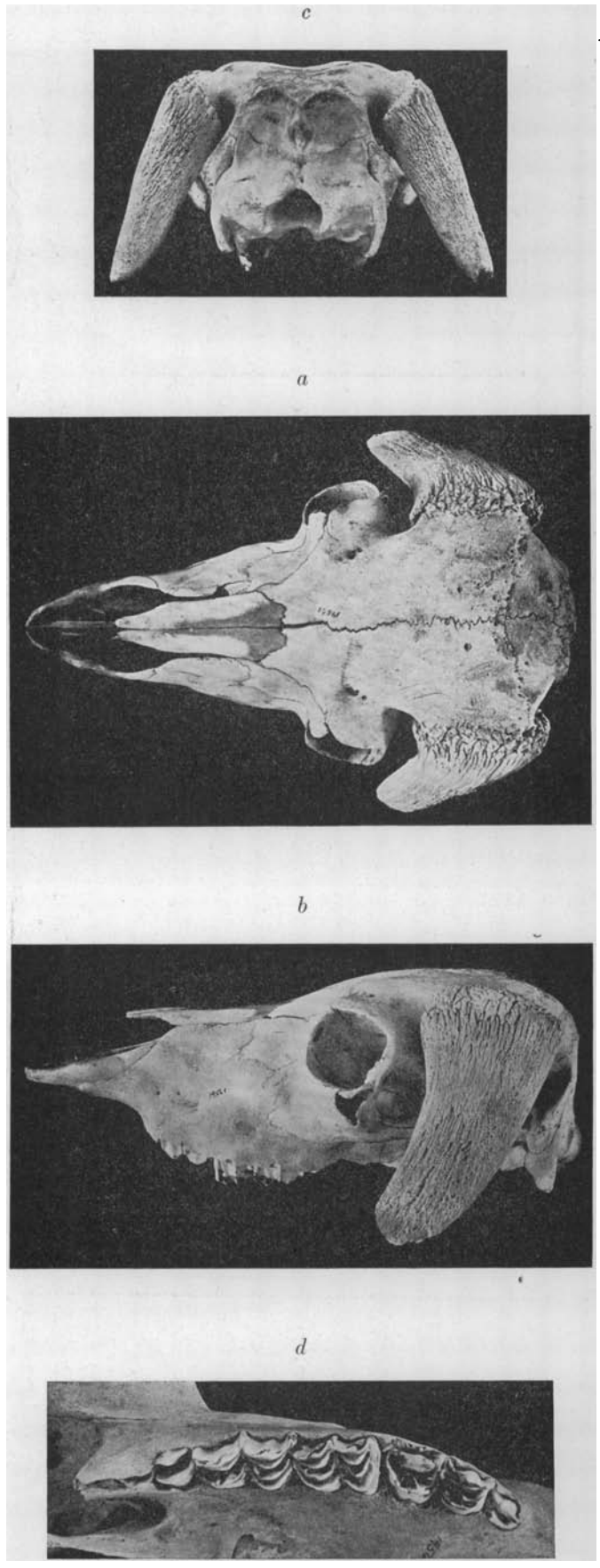


Fig. 12. No. 19561, ♂, 4 years old, northern Grant Land. *a*, dorsal view, $\frac{1}{5}$; *b*, lateral view, $\frac{1}{5}$; *c*, occipital view, $\frac{1}{5}$; *d*, crown view of maxillary teeth, $\frac{1}{2}$.

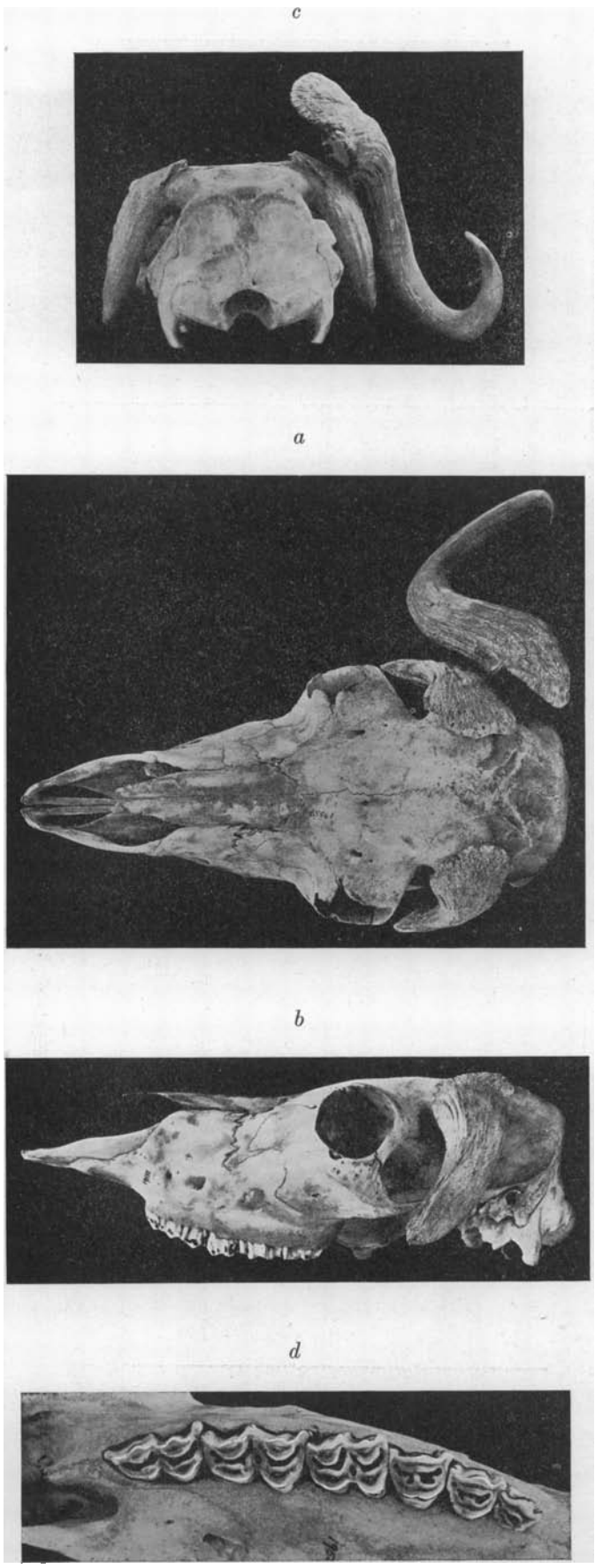


Fig. 13. No. 19558, ♀, 5 years old, northern Grant Land. *a*, dorsal view, $\frac{1}{5}$; *b*, lateral view, $\frac{1}{5}$; *c*, occipital view, $\frac{1}{5}$; *d*, crown view of maxillary teeth, $\frac{1}{3}$.

average size of the series. (See below under 'Individual Variation'.)

The changes beyond the age of about six years consist (1) in the wearing down of the teeth; (2) the closing of the sutures, many of which become wholly obliterated in old age; (3) the increased density of the bones; (4) marked exostosis on various parts of the skull; (5) the development of large sinuses at the base of the horncores. The nasals often become solidly anchylosed on the median line, thickening on their dorsal contour and becoming thus arched in transverse section. The lacrymals in males of ten to twelve years or older become anchylosed with the frontals and squamosals, the lacrymo-frontal suture becoming obliterated first and the lacrymo-squamosal a little later. In old age in males the orbital tubes become more or less roughened by exostosis, especially on the outer border. The extension inward and laterally of the horncores at base in both sexes with increase in age has already been noted.

The striking changes in the form and structure of the horncores during the earlier years of maturity are well shown in Figs. 20–24 and in Plates XI, XII, XIII, and XIV. These illustrations show that the period of greatest growth of the basal third of the horns is the period of from four to six years of age. They also show much individual diversity in growth conditions in males of the same age. Thus Figures 20, 21, and 22, are taken from males of the same age, the condition of the teeth being the same in each, the premolars and the last molar having just reached full development, indicating a probable age of five or five and a half years. These occipital views were taken looking obliquely upward at an angle of about 15 to 20 degrees from the vertical, thus giving the best view possible of the sheaths and exostosis at the posterior base of the horns. Plate XII, Fig. 2, presents a still earlier stage, taken from a pair of horns

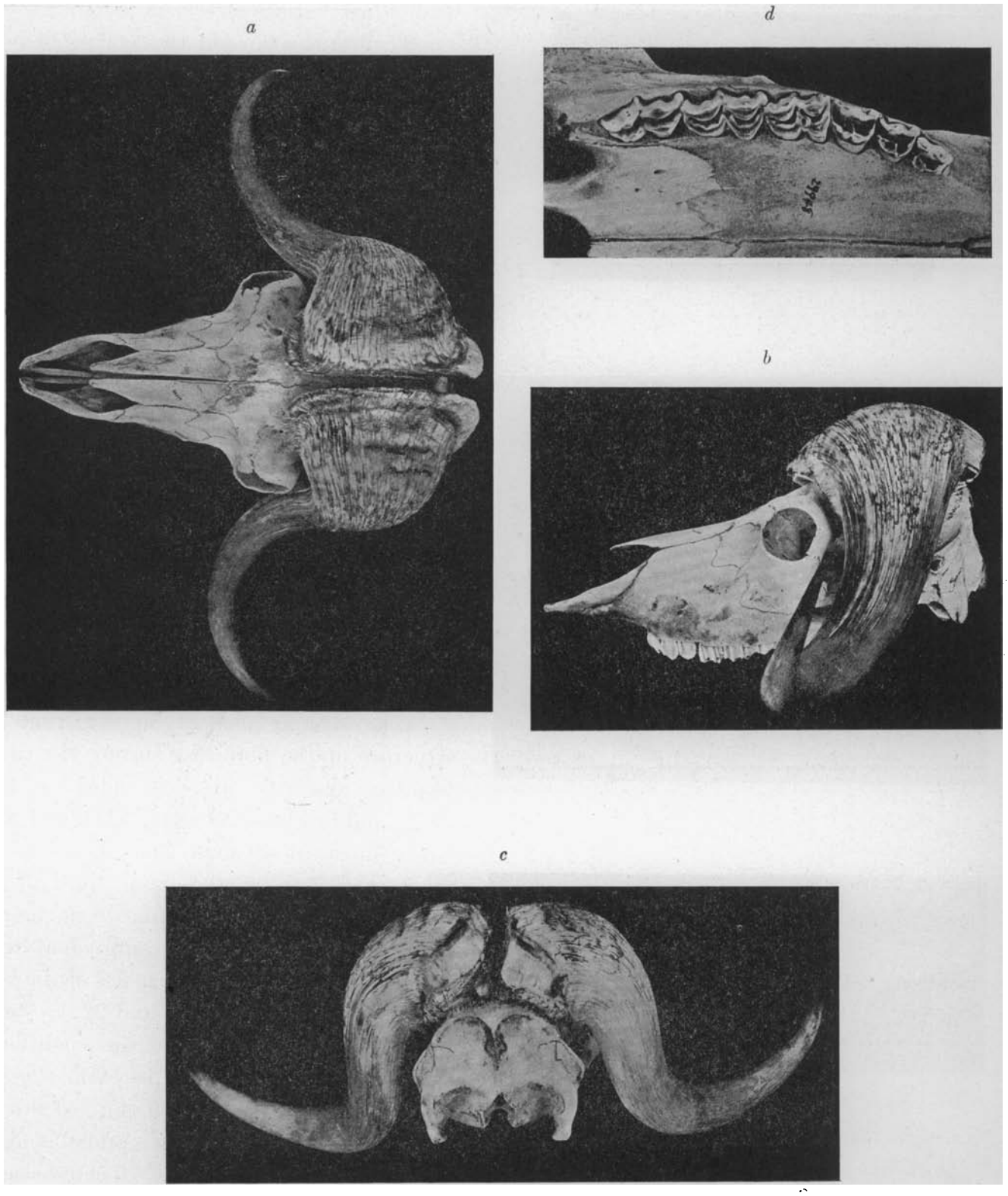


Fig. 14. No. 29948, ♂, 5 years old, northern Grant Land. *a*, dorsal view, $\frac{1}{5}$; *b*, lateral view, $\frac{1}{5}$; *c*, occipital view, $\frac{1}{5}$; *d*, crown view of maxillary teeth, $\frac{1}{2}$.

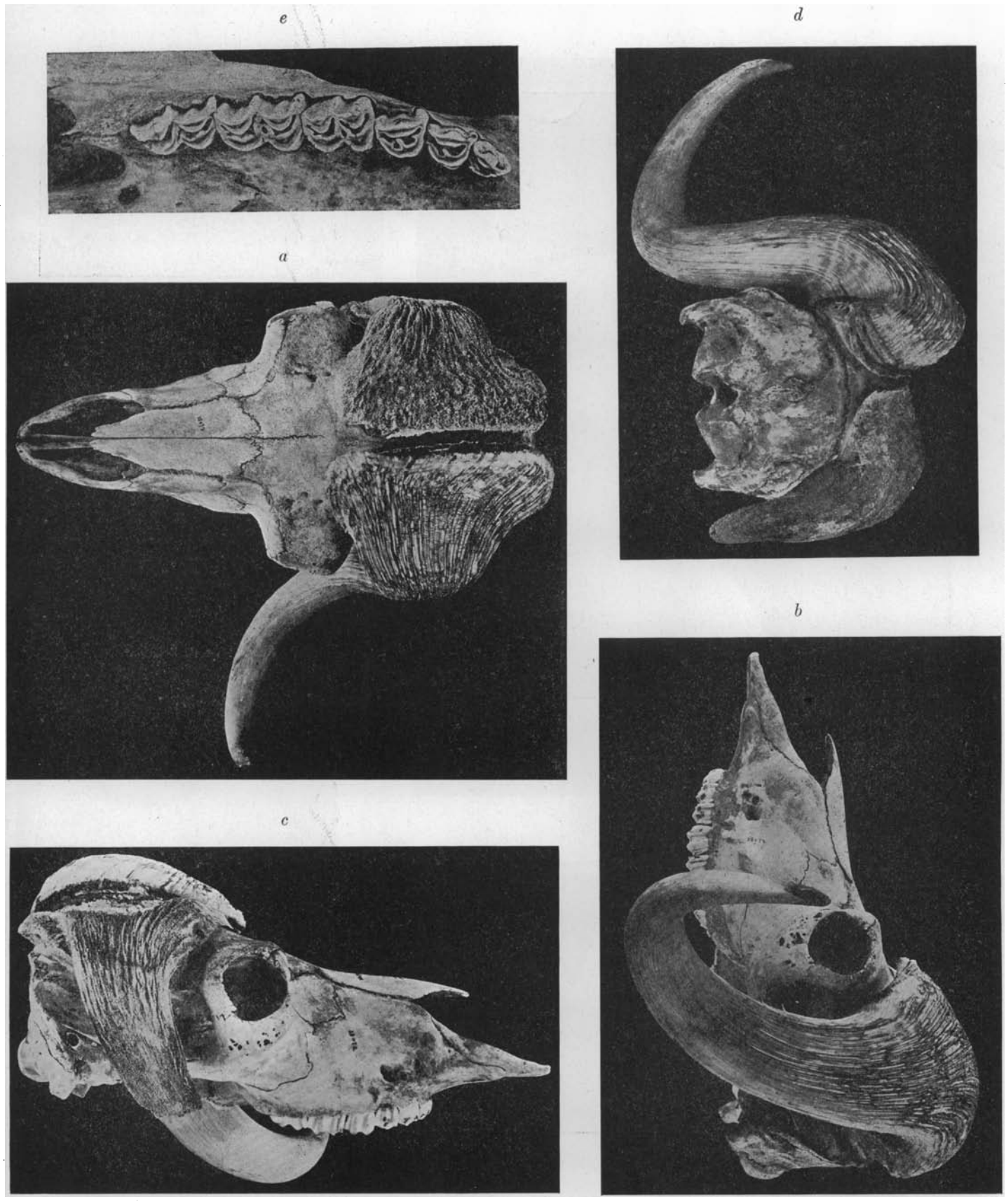


Fig. 15. No. 28072, ♂, 6 years old, northern Grant Land. *a*, dorsal view, $\frac{1}{5}$; *b*, lateral view with horn sheaths, $\frac{1}{5}$; *c*, lateral view without horn sheaths, $\frac{1}{5}$; *d*, occipital view, $\frac{1}{5}$; *e*, crown view of maxillary teeth, $\frac{1}{2}$.

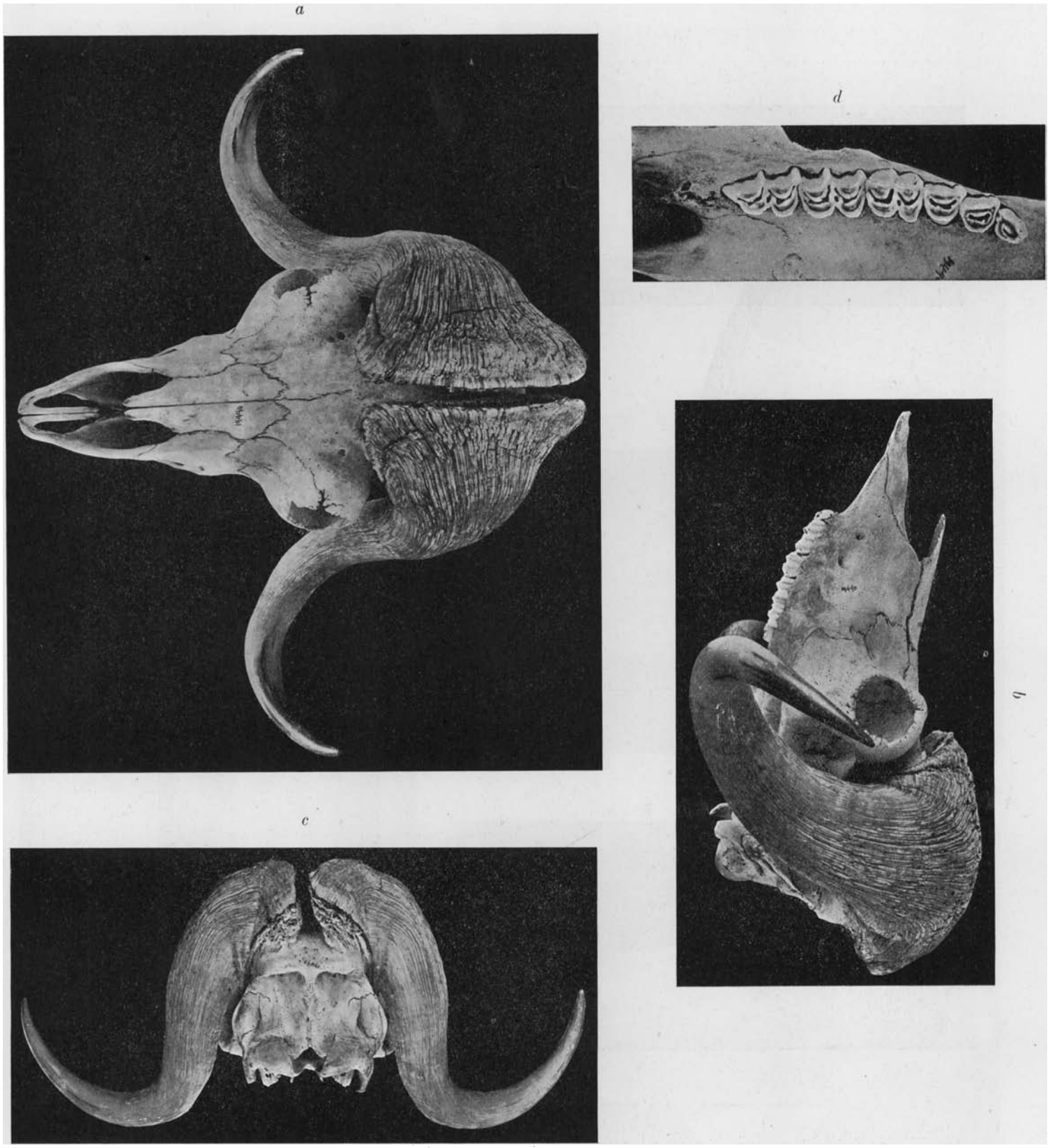


Fig. 16. No. 19490, ♂, about 7 years old, near head of Wager Inlet, Hudson Bay. *a*, dorsal view, $\frac{1}{5}$; *b*, lateral view, $\frac{1}{5}$; *c*, occipital view, $\frac{1}{5}$; *d*, crown view of maxillary teeth, $\frac{1}{3}$.

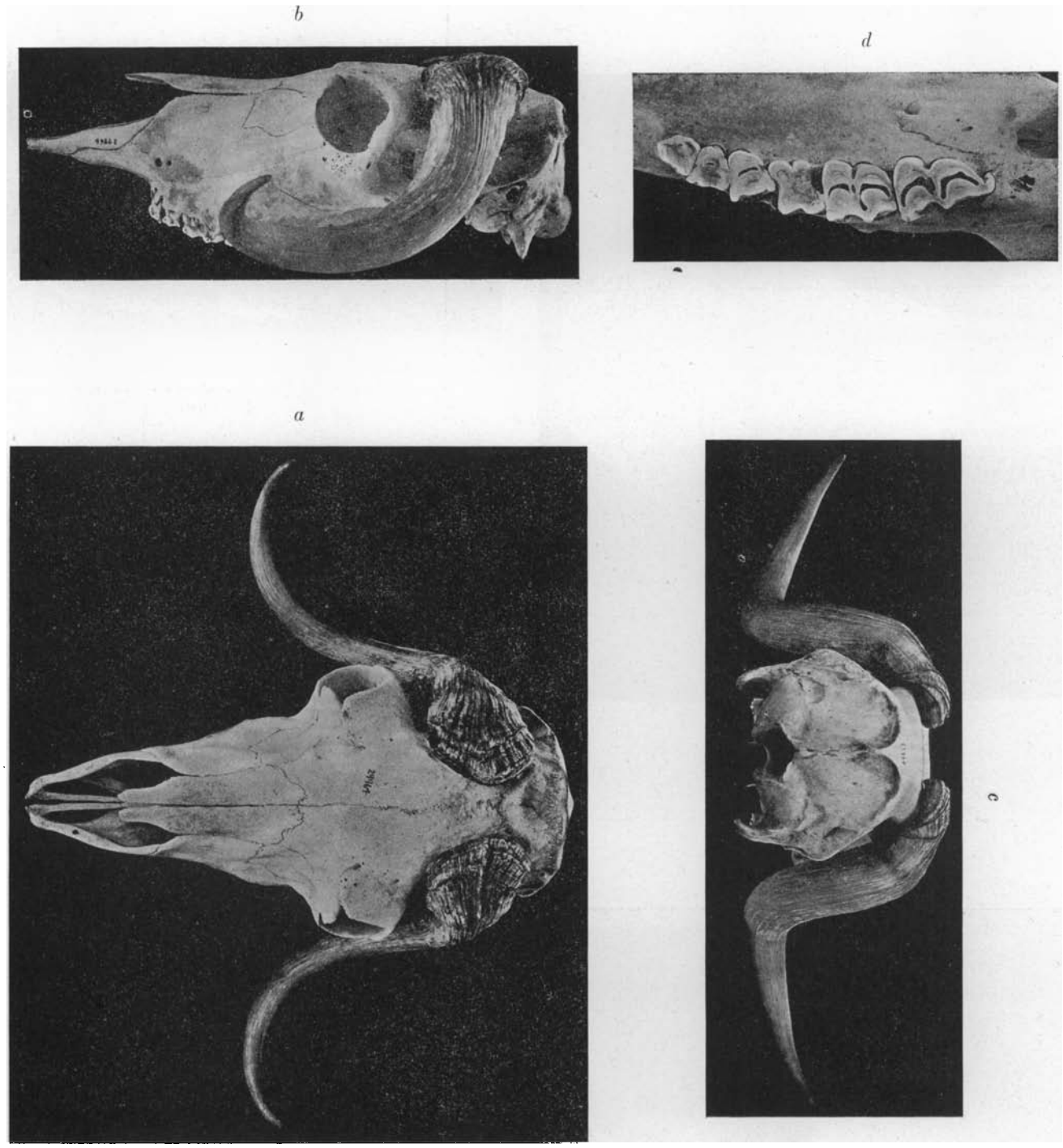


Fig. 17. No. 29964, ♀, probably 12 years old, northern Grant Land. *a*, dorsal view, $\frac{1}{5}$; *b*, lateral view, $\frac{1}{5}$; *c*, occipital view, $\frac{1}{5}$; *d*, crown view of maxillary teeth, $\frac{1}{2}$.

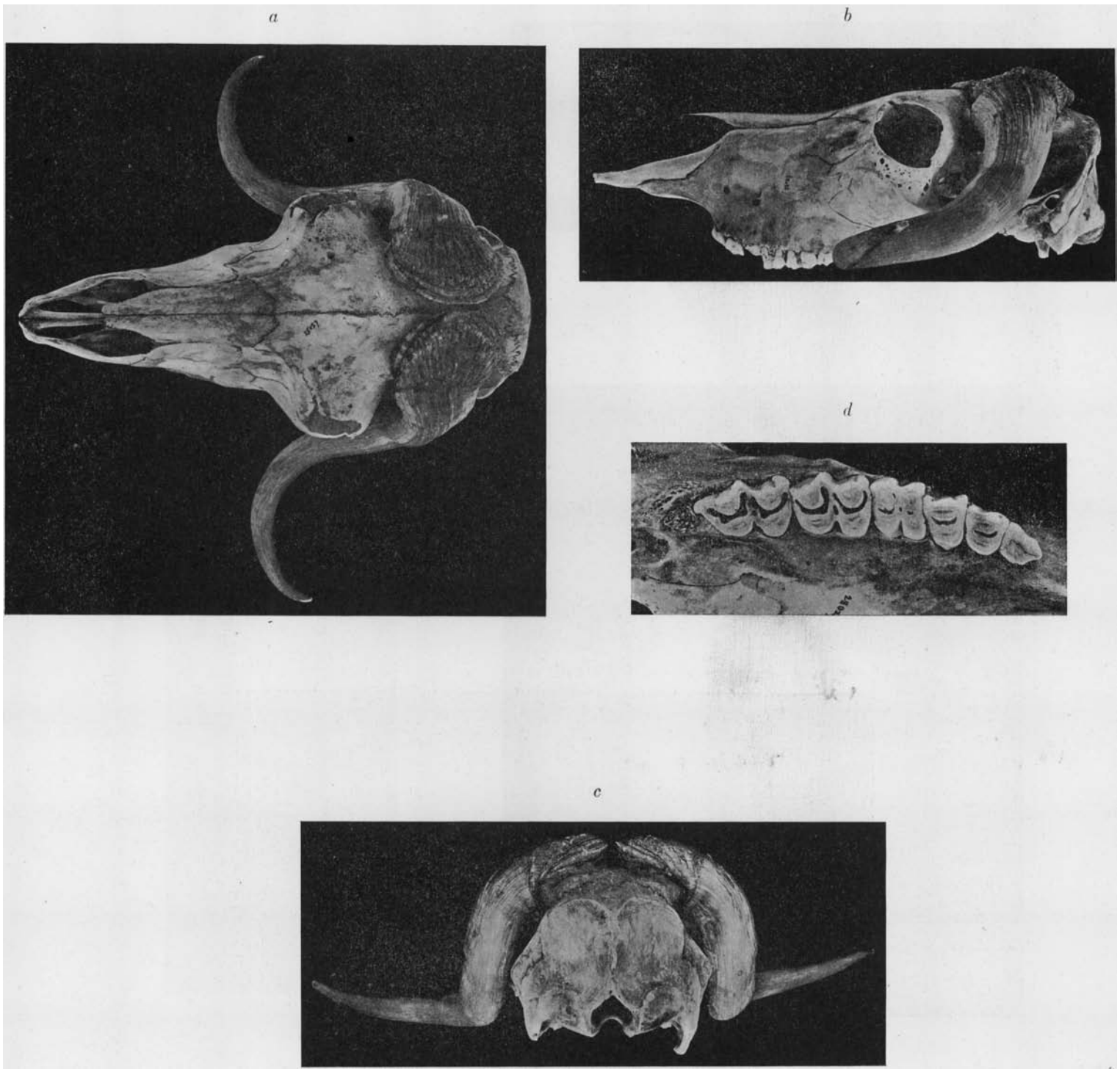


Fig. 18. No. 28027, ♀, probably about 12 years old, northern Grant Land. *a*, dorsal view, $\frac{1}{5}$; *b*, lateral view, $\frac{1}{5}$; *c*, occipital view, $\frac{1}{5}$; *d*, crown view of maxillary teeth, $\frac{1}{2}$.

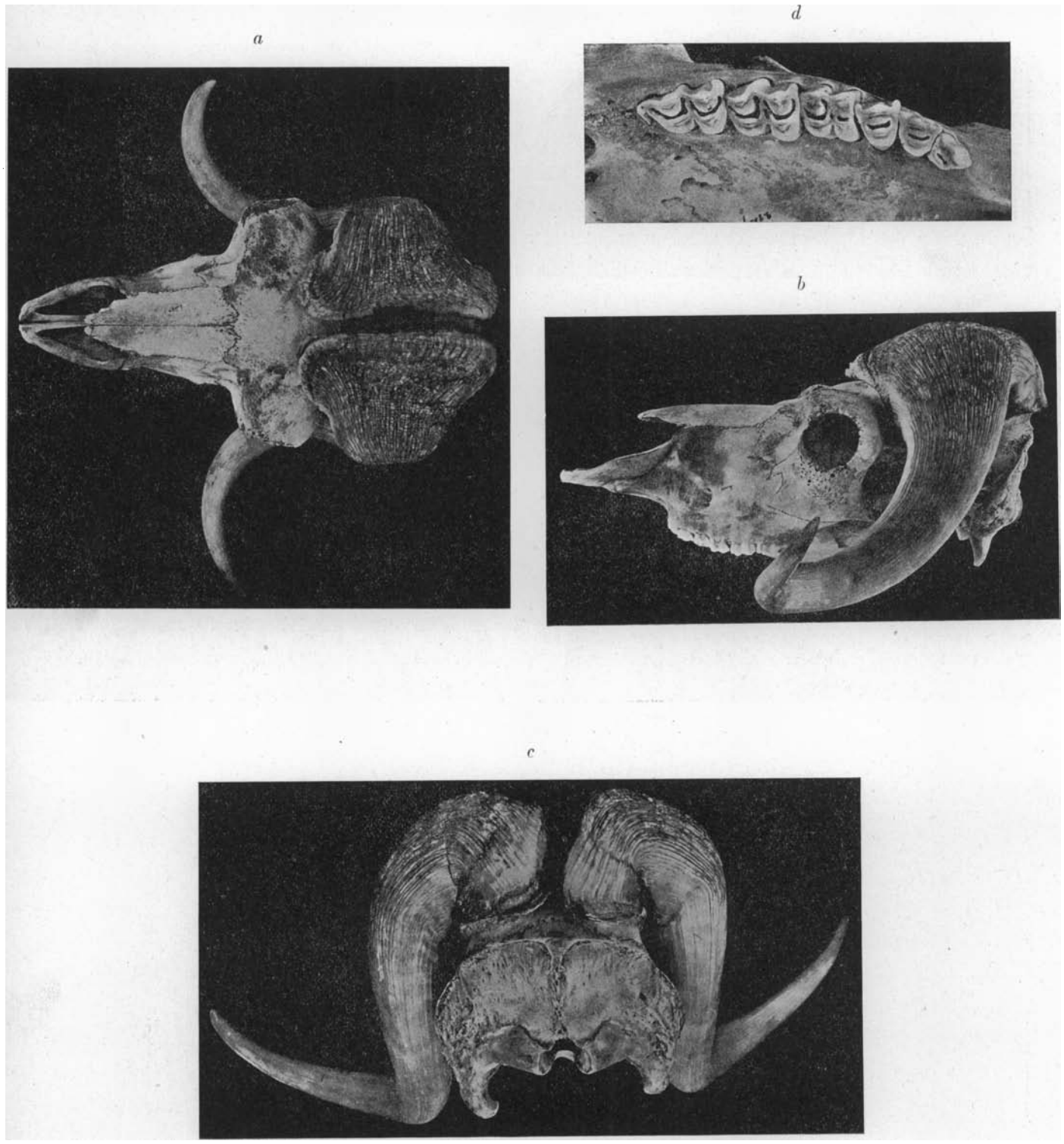
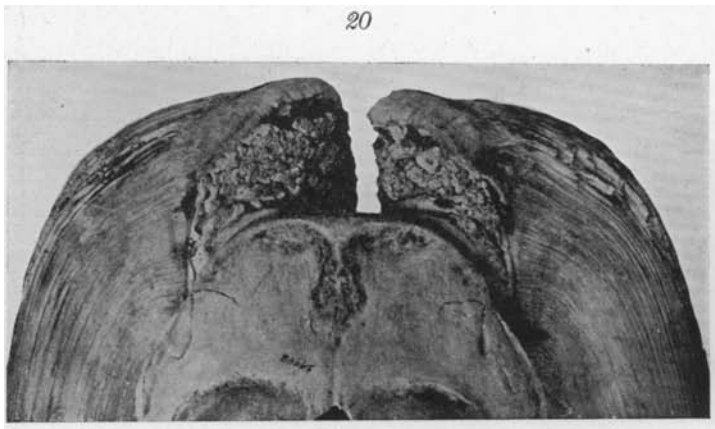
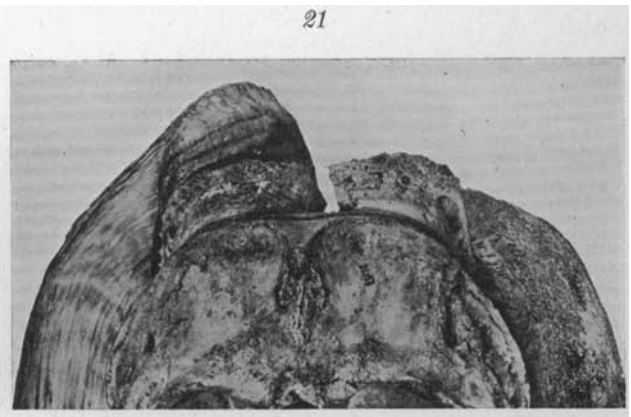


Fig. 19. No. 28009, ♂, about 10 years old, northern Grant Land. *a*, dorsal view, $\frac{1}{6}$; *b*, lateral view, $\frac{1}{6}$; *c*, occipital view, $\frac{1}{6}$; *d*, crown view of maxillary teeth, $\frac{1}{2}$.





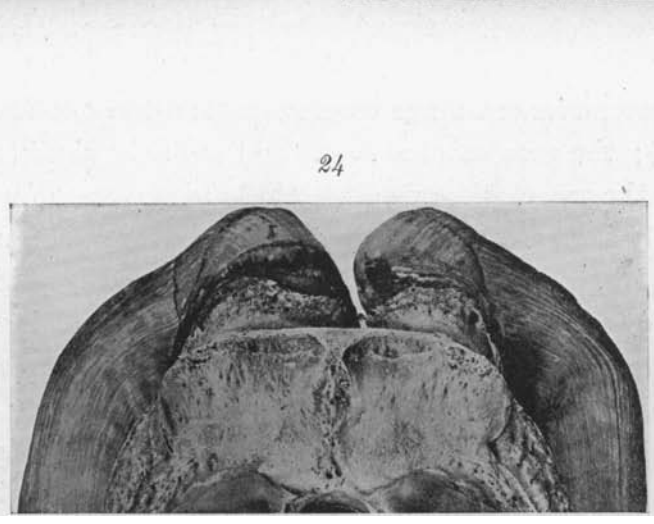


Fig. 20. No. 29948, ♂, 5 years old, northern Grant Land. Occipital view, looking obliquely upward, to show exostosis and base of horn sheaths, $\frac{3}{5}$.

Fig. 21. No. 28072, ♂, about 5 years old, northern Grant Land. Occipital view, $\frac{3}{5}$. One horn sheath removed to show horncore. Teeth only slightly more worn than in Fig. 20. (*Cf.* Figs. 14 *e*, and 18 *d*.)

Fig. 22. No. 28005, ♂, six years old, northern Grant Land. Occipital view, to show base of horncores and horn sheaths, $\frac{3}{5}$.

Fig. 23. No. 19490, ♂, 7 years old, near Wager Inlet, Hudson Bay. Occipital view, to show base of horncores and horn sheaths, $\frac{3}{5}$.

Fig. 24. No. 28009, ♂, about 10 years old, northern Grant Land. Occipital view, to show base of horncores and horn sheaths, $\frac{3}{5}$.

(a hunter's trophy) detached from the skull of a male (No. 28093) killed when about four years old.

In this four-year-old male the conditions may be described as follows: The exhibit is a right horn with the right frontal bone and an adjoining part of the right parietal. A thin layer of exostosis covers the top of the skull from nearly to the median suture outward to the base of the horncore, which rises abruptly from the middle of the right fronto-parietal region to an average thickness of about 20 mm. Above this is a vacuity over the whole dorsal surface of the horncore, about 10 mm. in vertical extent on the inner border and extending outward between the sheath and the horncore for about 23 mm., narrowing gradually outward to the point where the sheath and the core are in contact. In life this vacuity must have been filled with blood vessels and secreting tissue. Above the vacuity the sheath extends 35 mm. beyond the horncore, or nearly to the midline of the skull, ending in a thin edge. The under surface of this free portion of the sheath is covered with deep pits directed obliquely upward parallel to the axis of the sheath. They have a depth of 7 to 10 mm. and vary in diameter at the orifice from 2 to 5 mm., each pit narrowing to a point at the bottom. The base of the horncore exposed beneath the overhanging sheath consists of very open porous bone, presenting a mammillate or warty surface permeated irregularly by fissures. The facing surfaces of the horncore and sheath thus give indication of active deposition of new matter — bone on the horncore and keratin on the sheath — by the intervening layer of secreting tissue.

A longitudinal section of the left horn of this pair (Plate XIII, fig. 1) shows the relation of the sheath to the horncore, the intervening space between them at the extreme base of the horn, and the very large sinuses at the base of the horncore.

The deposition of bone and the thickening of the sheaths at the base of the horns go on together from the same matrix of secreting tissue, as evidenced by the large series of skulls before me showing the development of the basal portion of the horns from the age of four and five years onward to old age (see text Figs. 20 to 24 and Plates XI–XIII). No. 29948, a five-year-old male (Fig. 20), presents a more advanced stage of growth than the one above described (illustrated in Plates XII and XIII); the exostosis between the top of the skull and the sheath has greatly thickened, and presents the same soft, open, mammillate structure found in No. 28093, but the sheath has not materially increased its thickness at and near its basal edge. In No. 28005, a male of the same age as No. 29948, the sheath has become greatly thickened on its basal border and has already begun to cover the growth of spongy bone beneath it, a condition usually found only in much older animals. In this specimen growth seems to have been greatly accelerated through individual differentiation.

In No. 28072 (text Fig. 21 and Plate XI) the condition is intermediate between the conditions presented in the two specimens last described: the deposit of bone is thicker and more dense, and the base of the sheath has begun to extend downward over the exostosis, as shown in Fig. 21. In this illustration the left horn has the sheath in situ; the sheath of the right horn has been removed, to show the relation of the exostosis to the horncore proper. An oblique dorso-lateral view of the same skull (Plate XI, fig. 1, about $\frac{1}{2}$ nat. size) shows the upper (dorsal) surface of the right horncore and the basal border of the left horn. The sheath as seen in the illustration appears to cap the median border of the horncore, but in reality the sheath only meets the upper surface of the exostosis, the real capping being a thin vertical lamella of bone which forms the inner boundary of the exostosis and rises to meet the base of the sheath. In other words, the

sheath does not extend downward beyond the upper edge of the exostosis, and does *not* cap nor overlap the basal edge of the horncore.

This view also illustrates the porous structure of the horncore and its grooved upper surface. Plate XI, fig. 2, natural size, shows the inner (ventral) surface of the apical third of the same horncore, which is finely pitted and thickly set with thin, short, bony spines, pointing obliquely toward the base of the horncore, reminding one of a thick-set, stiff, bony beard, the free points being from 1 to 5 mm. long and .5 to 1 mm. thick at base. The inner surface of the base of the sheath is covered with longitudinal ridges fitting the grooved surface of the horncore.

A seven-year-old skull (No. 19490) is illustrated in text Fig. 23, in which the conditions of growth and the relation of the sheath to the exostosis is essentially the same in every respect as in the five-year-old skull shown in Fig. 20. The exostosis is a little thicker but the overlying sheath is of the same character and has the same relation to the exostosis. There is, however, no vertical lamella, as in the other five-year-old skull already described (No. 28072). Indeed the development of such a lamella is exceptional; while present in several of the skulls of the present series, there is no trace of such a development in about 90 per cent. of them. Figure 24, illustrating a ten-year-old skull (No. 28009), shows conditions quite similar to those found in the five-year-old No. 28005, as regards the base of the horns. The lower edge of the sheath is equally thickened, and is rounded and smooth in both; but in the older skull the texture of the exostosis is more compact and dense and smoothly laps over the base of the rounded edge of the thickened sheath. The sheath, neither in this nor in any other skull of the series, "caps" or overlaps the exostosis.

The extension of the exostosis at the posterior base of the skull beyond the plane of the occiput varies in 30 adult male skulls, all from northern Grant Land, from 20 to 44 mm. in males of five to six years old, and from 20 to 35 mm. in males of about ten to twelve years old. The basal edge of the sheath does not usually adhere closely to the base of the horncore till about the age of nine years or older, or till the horn is fully developed and the deposition of both bone and horn has practically ceased, in comparison at least with the great activity of these functions during the period of adolescence. As soon as growth practically ceases the exostosis may extend up as a thin layer of bone to enclose the basal border of the sheath, the sheath being in this way capped by the exostosis instead of the exostosis being capped by the sheath.

In order to study the internal structure of the horn, transverse and longitudinal sections have been made of several horns of males of four, eight, and twelve years. They show that the horn-layer is much thinner on the inner (convex) or ventral side of the horn than on the outer (concave) or dorsal side. In a transverse section taken close to the inner base of the horn at a right angle to the axis (Plate XII, Fig. 1), the horn layer on the ventral side has a thickness of 6 mm., while the horn layer of the dorsal side has a thickness of 26 mm. In a section near the tip of the same horncore (Plate XII, Fig. 3) the thickness of the horn layer on the two opposite sides is respectively 7 and 20 mm. This difference is clearly shown in the longitudinal sections (Plate XIII). Strength is secured by the great thickness of the horny layer on the convex side of the horn.

The osseous core early reaches its ultimate length, size, and form, usually by the third or fourth year of the animal's life, except that the basal third continues to broaden and increase in mass till a much later period. The growth of the horn layer of course takes place exclusively by the deposition of keratin from the matrix of secreting tissue between the sheath and the bony

core, while bone is added at the same time to the core from the same source of deposit. The horn as a whole may thus be compared to the trunk of a tree, the core corresponding to the solid wood and the horny covering to the bark, the point of growth being in the one case at the junction of the wood with the bark and in the other at the contact surface between the core and the sheath. As the tree trunk expands through growth the outer surface of the bark (in most trees, as oaks, walnuts, pines, etc.) becomes ruptured with longitudinal fissures, and the outer layers are often shed to a greater or less extent, according to the species. In the horns of the muskox the horny covering thickens by accretion on its inner surface; the outer and intermediate layers undergo structural change, so that the outer surface becomes ribbed, very finely in the earlier years, more coarsely in later life, and most heavily ribbed where the expansion is greatest, as at the base, where often not only is the surface of the horn longitudinally strongly ribbed but the outer layers are also often transversely fractured and the surface roughened by the irregular shedding of some of the broken filaments of horn, as shown in Text Figures 5–24.

There is nothing in the structure of the horns of the *male* muskox, either on the surface or internally, to indicate periods of growth, and hence nothing that is comparable with the rings of growth in trees, or even the supposed rings denotive of age in domestic cattle. Neither is there evidence that the growth of the horns is materially checked during winter, as supposed by Lönnberg (*l. c.*, pp. 687, 689). The condition of the animals at the end of winter doubtless varies in different years and at different localities. Thus Peary refers, on one occasion, to the lean condition of muskoxen killed by him in spring in northern Ellesmere Land. On other occasions muskoxen were killed on his expedition for food in April in northern Grant Land, with no intimation in his narratives of exploration that the 'beef' thus obtained was not in satisfactory condition. Mr. Donald B. MacMillan, who was one of Peary's assistants on his last expedition, killed numbers of muskoxen in March, 1909, at Cape Morris K. Jesup, the most northern known land (in Lat. 83° 40′), and assures me that the animals were found to be in excellent condition, although there had been no melting of snow, the conditions in this respect remaining the same as they had been throughout the winter.

The apical portion of the horn permanently retains its shape, size, and color throughout the life of the animal, except that in adults it becomes slightly worn and polished, and sometimes blunted at the tip, through abrasion. The growth accretions are of course added only where the sheath is in contact with the core. The small horns developed by the yearling calf increase in length in the two-year-old through the growth of the horncore and the lengthening of the sheath at the base, its diameter increasing with the lengthening and thickening of the core, and only in that portion through which the horncore extends. The sheath in the yearling is hollow to its tip. Later the core, while increasing rapidly in length and thickness by additions to its exterior, becomes shortened at the tip by absorption, the bony matter being here replaced by keratin. In this way the solid tip of the horn increases in length, in three-year-olds it about equaling the length of the horncore, and later forming one half to two thirds of the total length of the horn. As shown in longitudinal sections of the horns of mature animals (Plate XIII), the former site of the horncore is indicated by a narrow fissure, the surrounding walls of keratin failing to unite or coalesce as the tip of the horncore recedes, with its blood vessels and secreting surface. In horns sectioned longitudinally along the midline this fissure is found to extend to the extreme tip of the horn, as clearly shown in Plates XIII and XIV.

Up to about the fourth year the sheath, while increasing in length, does not materially

increase in thickness at its basal extremity. In five-year-olds and six-year-olds, thickening of the dorsal side of the sheath at the base proceeds rapidly and continues at a decreasing rate till past middle life, when the maximum thickness of the sheath at base in the males is attained, the thickness varying in different individuals from about 40 to 70 mm.

In adult males, as in the young, the tip of the horn for 60 to about 100 mm. is black or blackish; this color is not superficial but pervades the whole substance of the horn, often extending proximally further in the interior of the horn tip than at the surface. The rest of the sheath, as shown in longitudinal section, varies in color from a light pearl gray to nearly white, the central part in front of the horncore being usually distinctly lighter (yellowish white) than the outer portions, except at the thickened base, where the outer layers are much lighter than the inner ones. The line of demarkation in color, as shown in Plate XIII, is usually sharp but irregular, and does not follow the grain of the horn.

As further shown in the sections (Plate XIII), there is a semblance of a stratified structure in the superficial layers at the thickened base of the sheath, while the texture of the rest of the sheath is practically homogenous. Under a strong lens it seems to be made up of solidly agglutinated fine longitudinal fibres. The superficial layers on the outside of the base of the sheath can not well be assumed to indicate periods of growth, since they are irregular and too numerous to indicate either annual or semiannual periods.

In old females there are usually well-defined concentric half-circles at the base of the horn sheath, made up of accretions added through the extension of the sheath inward over the frontal region beyond the line of the base of the sheath, as seen in three-year-old females. These sometimes have a striking resemblance to the lines of growth seen in the valves of lamellibranch mollusks. They undoubtedly indicate periodic additions of horn at the base of the sheath, as they increase in number with age. Their regularity, and their number being correlated with age, seems to indicate that they are not only periodic but annual. The first half-ring is much broader (30 to 40 mm.) than the second, usually several times the width of the second, while the second is much wider than any that follow. The later half-rings are very narrow, and often indistinct and difficult to recognize, being only a millimeter or two in width and compactly superimposed one above another. In old females eight to ten of these rings can be clearly recognized. In advanced senility one or two more can be doubtfully distinguished. As the first (outermost) of these half-rings is not formed till about the fifth year, and as ten or more can often be easily distinguished, it seems pretty certain that the female muskox often attains the age of fifteen years or more. It is to be noted, however, as already said (p. 132), that no similar half-rings or other indications of age are present in the horns of the males.

Résumé. To recapitulate briefly the foregoing notes: The first trace of horncores appears at about the age of six months, as a very slight prominence ('hillock') on the side of the frontal near its posterior border, a few millimeters below the plane of the forehead. Six months later, or at the age of one year, they form a distinct prominence about 12 mm. broad at base and about 3 mm. in length in females, and about 20 mm. in breadth and about 12 mm. in length in males, with the axis horizontal.

During the next six months (at the age of about 18 months) the base has broadened and the length increased to about 40 to 60 mm., and the axis is slightly deflected from the horizontal. The posterior border of the base extends to the fronto-parietal suture. The sheaths have a length

about twice that of the horncores and are gently curved from base to tip, the concavity being dorsal.

At two years the horncores have a basal breadth of 50 mm. and a length (in different individuals) of from 110 (♀) to 135 mm. (♂); the deflection of the axis at base is about 30°, with the apical third of the horn curved upward. The horns in the males have become much thicker and longer than in the females.

At two years and a half (30 months) the size of the horncores has further greatly increased, as has the deflection of the axis (now 45°–50°); the breadth at base in a male is 61 mm. antero-posteriorly by 44 dorso-ventrally, the corresponding measurements in a female being 44 and 29 mm.; the horncores have now become flattened (in cross-section) instead of being circular as in earlier stages.

At three years the same general conditions prevail, with further increase in size, greater deflection of the axis (now about 55° to 60°), and the base of the horncore projects posteriorly considerably beyond the fronto-parietal suture. The horn sheaths are still easily detachable by maceration, but at four to five years old they become permanently fixed to the bony cores, so that they are not readily separated by maceration alone.

At about three years in the female and four years in the male, the deflection of the horncores has reached its maximum, they then almost touching the side of the head at the malar region; in the female the space between the sheath of the horn and the malar bone in the cleaned skull is often only 4 to 6 mm., which in life must be nearly filled by the skin; in the male it is slightly greater but seemingly affords scant space for the skin and tissues at the zygoma. This stage usually precedes the complete maturation of the dentition.

The deposition of bone at the base of the horncores continues throughout the life of the animal but is most active from five to seven years old. It is restricted in the female to a semi-oval space on the antero-outer third of the parietal, while in the male it ultimately covers the whole of the dorsal area of the parietal, and also of the frontal posterior to the postorbital constriction. This basal expansion of the horncore is covered by a correlated expansion and thickening of the horny sheath. In middle-aged and old males the space between the bases of the horns along the midline of the skull is often narrowed to less than 10 mm. (usually 10 to 15 mm.), but the bases appear never to quite meet, and thus do not coalesce as in *Symbos*.

Lönnberg's 'The Development of the Horns in the Muskox.' — In concluding this account of the ontogenesis of the horns of the muskox it seems necessary to review briefly Dr. Lönnberg's paper on this subject,[1] which was based on scanty and quite inadequate material (see *antea*, p. 10), so that his conclusions were necessarily more or less hypothetical. The more important points respecting which his results differ from mine (as above given) are here noticed *seriatim*.

(1) His figure 1 (p. 688), entitled 'Schematic sketches showing different stages of development of the horn of the Musk-ox,' purports to represent: "A, the horn at the end of the first summer; B, an intermediate stage when the exostoses are at the height of their development; and C, a quite full-grown horn." These "schematic sketches," he informs us, were based on "a skull of a young calf and several skulls of adult bulls and cows" from East Greenland, and

[1] Lönnberg, Einar. 'On the Structure and Anatomy of the Musk-Ox (*Ovibos moschatus*). Sect. I. The Development of the Horns in the Muskox.' Proc. Zool. Soc. London, 1900, pp. 687–694, fig. 1–4.

"Sir John Richardson's description and fine figure of the skull with the horn-cores of a yearling or '16 months' old bull." [1]

As shown by the abundant material now available in the present connection (some 60 specimens for the period from birth to four years old), Richardson [2] was in error in respect to the age of his "16 months old bull," which was unquestionably an animal in its third year. This figure was the basis of Lönnberg's fig. 1, A, which he says, in the explanation of the figure, "represents the horn at the end of the first summer," but in the text on the following page (p. 689) he says it "should represent the horn of a young bull in the second autumn of its life," or at the age of about eighteen months. This horn is represented as having a sheath extending much too far above the frontal plane for even an average three-year-old bull, at which age the horns rise highest above the frontal plane (see *antea*, p. 118).

(2) Lönnberg has interpreted certain irregularities of structure seen in his longitudinal section of an adult horn (*l. c.*, pp. 689–691, fig. 2) as indicating periods of growth. I have made longitudinal sections of three adult horns and find somewhat similar irregularities of growth, which occur differently in degree and position in the three horns, while none agree with Lönnberg's figure. These irregularities seem clearly due to pathological conditions occurring in the horn during its growth, and to have no relation to any regular "periods of growth."

(3) I am unable to understand Lönnberg's references (*l. c.*, p. 691, footnote) to "exostoses.... pre-formed independently of the horncores"; in my 136 skulls of muskoxen, the exostoses are in all cases extensions of the bony deposit at the original base of the horncore.

Lönnberg further says: "By-and-by the horny sheath encroaches in a median direction over these exostoses [at the base of the horn], and when it has come so far that it *caps over them* [3] it cannot be driven out any more or be prolonged, because its shape hinders it. Fig. 1 B (p. 688) is a schematic figure representing such a stage. The horn is, however, not yet fully formed although its length has reached its maximum. The continued growth tends to thicken the horny sheath, especially its upper layers. The bony substance of which the exostoses consist *is reabsorbed and replaced by horny layers.*[3] It may be said metaphorically that the *horny sheath eats down into the bony mass*,[3] which thus gets a rugged and pitted surface as seen on figs. 3 and 1 C" (*l. c.*, pp. 691, 692).

In the scores of young skulls in which the sheaths are easily removed from the cores by maceration there is nothing to suggest any reabsorption of bone by horny layers, or that the "horn sheath eats down into the bony growth." The growth of the core and the increase in the thickness of the sheath overlaying it are simultaneous and reciprocal, resulting in the interlocking or dovetailing of the two surfaces thus in contact, and the firm attachment, after the fourth or fifth year, of the sheaths to the horncores.

(5) The horn sheaths are described, in the above-quoted passage, as finally extending in a median direction over the exostoses at the base of the horn and capping over them, when the sheath "cannot be driven out any more or be prolonged, because its shape hinders it." I have already called attention to and illustrated the varying conditions at the base of the horn in adult

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[1] On Richardson's plate the age is given as "16 months old"; in the description of the plate (p. vii), as "thirteen months old"; in the text (p. 67) the specimen is referred to as "a bull more than *a year old*, but which when killed had not ceased to follow his mother." The last clause has doubtless less weight than Richardson supposed, as the hunter who killed it may easily have been mistaken as to which female in the herd was the mother of this particular calf.

[2] Voyage of the Herald, Zoology, 1854, p. 67, pl. iv, fig. 4.

[3] Not italicised in the original.

males (*antea*, pp. 122, 130, Figs. 20–24). In only one instance have I seen a condition in which the base of the horn sheath extends below the upper margin of the exostosis in such a way that it could be properly described as *capping* the inner face of the base of the horn. Almost without exception the horn sheath in old males extends only low enough to meet the exostosis and is in no way prevented from pushing forward through further growth, should such occur.

(6) He further says (p. 693): "The reabsorption of the bony mass continues until the horny substance has reached down nearly to the fronto-parietal surface, but on the median and partly posterior side there remains a vertical lamella, thin as a leaf and perforated. . . . This thin crest lies close to the surface of the base of the horn, the base of which thus rests in a thin basket of bone *constituting the remains* [1] of the former exostoses. These facts, especially the presence of the thin median lamella, which hardly could have been produced in any other way, proves that the formation of the basal parts of the horns has taken place exactly in the manner described above, and that thus the greatest exostoses belong to comparatively young though just full-grown animals, *but that in old bulls the exostoses are more or less completely reabsorbed.*" [1]

Here again there seems to be a misinterpretation of conditions and of the process giving rise to them. A careful examination of many specimens, from the age of four years onward to old age, indicates (1) the steady deposit of bony matter at the base of the horn, extending the base of the horncore gradually inward over the frontal aspect of the skull until in old age the bases of opposite horncores nearly meet on the median line; (2) that the exostosis over the skull gradually thins out as it extends inward, the thinnest part being on the border toward the median line; and (3) that there often develops in middle-aged and old bulls a vertical lamella that (as described by Lönnberg) rises abruptly as a thin plate or network of bone to a height of 10 to 20 mm. above the base of the horncore of which it forms the boundary, and clasps or 'caps' the lower border of the *sheath*, instead of the sheath capping the exostosis. The base of the sheath at the same time thickens enormously in that portion that overlies the skull, sometimes attaining a vertical thickness of more than 60 mm. and occupying space at no time ever occupied by the exostoses.

As said by Lönnberg, the period of greatest activity in the deposit of bony matter at the base of the horncore is in "comparatively young though just full-grown animals," or during the period of from four to six years of age. But, as already noted and illustrated (*antea*, pp. 121–133, Figs. 20–24), males of this period, even when of the same age, present a diversity of conditions at the inner base of the horns. The secreting tissue or matrix between the sheath and the core occupies much more space and the newly deposited bone is also softer, more porous, and more fissured in some cases than in others, and later there seems to be a drawing together of the sheath and core as the deposition of bone and horn on the opposing surfaces becomes less active and the matrix shrinks. The recently deposited bony matter hardens by becoming more dense and apparently shrinks in volume; but, as already said, there is nothing to suggest that "in old bulls the exostoses are more or less completely reabsorbed" and "replaced by horny layers." The deposition of bony matter and the superimposed horny layers proceeds coincidently and not the one at the expense of the other.

(7) Lönnberg's explanation (p. 690) of the change in the direction of the axis in the horncore of the muskox with growth, from horizontal in the young to an almost vertical direction downward in the adult, through "reabsorption and apposition," seems entirely reasonable, and the only hypothesis suggested by the conditions. I had reached the same conclusion before

[1] Not italicised in the original.

meeting with his paper. While the method seems obvious, it is not so clear that his theory of the immediate cause of the reabsorption of the upper surface of the horncore by the pressure of the thickening sheath is applicable or necessary.

He says: "During the second period of growth (third summer) the upper side of the horn is thickened by more rapid growth than that which takes place on the under side. Through this a pressure is effected by the horny sheath on the upper side of the horn-core, and this causes a reabsorption on the upper side of the same. On the lower side, on the contrary, the pressure is diminished and, therefore, the horn-core is thickened below by apposition. In such a manner the direction of the main axis is lowered.... Next period (fourth summer) the growth is continued mostly in the same way...." The examination of numerous sheaths (removed from the horncore by maceration in cleaning the skulls) of animals of the age here indicated fails to confirm the above statement that the sheaths are thickened more on the upper side during these periods than on the lower. In fact the sheaths prove, without exception, to be *thinner*, during this stage of development, on the upper side than on the lower. The thickening of the upper side of the sheath, seen in older animals, *does not begin* until the axis of the horn has attained its full amount of deflection. Longitudinal sections of adult horns, which display a complete record of the growth of the horn, also show that the horn forming the *upper* wall of the sheath apical to the tip of the horncore is uniformly about one-fifth *thinner* (see Plate XIII) than the ventral wall. The thickening of the upper wall of the sheath does not begin, as already said, till the axis of the horncore has reached a nearly vertical direction. The thickening of the upper side of the sheath does not usually begin till the fifth summer, and the thickening is then and later confined almost wholly to the portions of the sheath which have been added *since* the deflection of the horns was nearly completed. Clearly, the deflection of the horncore cannot be caused by the *pressure* of a non-existent thickening of the sheath at the time the axis of the horn begins to turn downward.

Ontogenesis of the Teeth.

Plates XV and XVI and Text Figures 1–19.

Muskoxen present no features in the ontogenesis of the teeth not shared by other types of the Bovidæ. The structure of the teeth and the modifications by growth and wear are so well shown in the illustrations (Plates XV and XVI) that extended descriptions are unnecessary. The principal changes due to age and attrition are, in outline, as follows:

Milk dentition. In a fœtal specimen (No. 16727), at about the eighth month of pregnancy, dp^3 and dp^4 have attained about one-half of the mature height, while the point of the main cusp of dp^2 projects about 5 mm. above the alveolus. M_1 is still wholly enclosed in its capsule. The lower premolars present a corresponding condition of growth. The inner incisiform tooth (di_1) is nearly full grown; di_2 and di_3 are about half grown, and the tip of di_4 is barely above the alveolus.

At about the age of one week (Nos. 15597 and 29939), the crown surface of all the premolars is well above the alveolar border, but the third and fourth, both above and below, are not fully grown, although the front half of dp^4 shows slight wear on the outer side. Dp^3 is fully grown and distinctly worn on the outer edge of both halves and slightly on the inner edge of the posterior half. The crown of m^1 is visible through a wide slit in the capsule, the tip of the anterior cusp

being level with the border of the opening. The lower milk premolars are at a corresponding stage, dp_3 showing slight wear. The outer milk incisors are not quite fully grown.

At six months (No. 35346) the premolars are not only all full grown, but all are more or less worn, except dp^2 in each jaw. The milk incisors have attained full development.

At the age of one year (No. 28108) the premolars are extensively worn, the crown surface having lost at least a millimeter or more in height. The incisiform teeth are all in place, and permanent i_1 has not begun to form.

At the age of three years (No. 28011) the milk premolars are all still in situ, but dp^2 and dp^3 have lost all trace of the enamel pattern, being worn down nearly to the roots; a part of the enamel pattern in dp^4, however, still remains. All the milk incisors are also worn down to their roots; the tips of the permanent middle pair have reached the level of the alveolar border, but their predecessors still remain (at least in No. 29936), with the permanent tooth (i_1) coming up behind di_1 and di_2.

At four years old (Nos. 19561, ♂, and 15588, ♀) the deciduous premolars have all been shed, crowded out by their successors, now about one-half grown; another pair of incisors (i_2) has appeared, while only the roots of the two outer deciduous incisors (i_3 and i_4) remain. The deciduous premolars all fall out at about the same time, but not till their successors are well advanced, their crowns being already considerably above the alveolar border; the formation and exclusion of these three teeth is, unlike that of either the molars or incisors, simultaneous.

Permanent dentition. Premolars. At four years old the permanent premolars become fully functional and at six years old show considerable wear, as do also incisors i_1 and i_2; i_3 is slightly worn and i_4 is fully grown and functional.

At seven years old (No. 19490) the crochets in the premolars begin to disappear through wear; and at ten years the crown pattern in these teeth has almost wholly disappeared by attrition, so that a little later only the fangs remain. The incisors have also become worn down to the roots, the enamel-covered portion having wholly disappeared. Thus the cycles of growth, by change and wear, of the two sets of incisiform and premolar teeth are completed.

Molars. The crown portion of the *first molar* (m^1 and m_1) is already formed at the time of birth, and can be seen through the partly open top of the capsule. At six months the anterior half projects slightly above, and the posterior half is about even with the alveolar border. At one year old this tooth is still not fully grown, although the crests of the anterior half begin to show slight traces of wear. At eighteen months it is fully grown, with the front half considerably worn and the posterior very slightly worn. From this point on there is constant change through wear. At three years the crown is worn down so far that the accessory cusp is included in the worn surface. At about the age of nine years (when the frontal bones anchylose in males), the enamel pattern has become practically obliterated, and in old age the tooth becomes worn down so that only the roots remain. As this is the first of the molar teeth to become functional it is likewise the first to wear out, m^2 and m^3 remaining in good condition after the greater part of the crown of m^1 has disappeared through wear. The wearing off of the enamel pattern usually slightly preceded the disappearance of the enamel pattern in p^4. The lower teeth wear more rapidly, at least in many instances, than the corresponding teeth of the upper jaw.

The *second molar* does not appear above the alveolus until m^1 has reached maturity and begins to show marked wear on the front half and slight wear on the posterior half, or till about the end of the second year of the animal's life, and does not reach maturity till about the end of the third year.

The *third molar* breaks through the alveolus at about the beginning of the fourth year, and is not fully mature till the beginning of the fifth year. Its appearance is simultaneous with that of the permanent premolars, which it parallels in rate of growth, the premolars and m^3 beginning to wear by use at the same time. Neither are fully developed till the beginning of the fifth year. On the other hand, as age advances, m^3 continues to be the least worn tooth of the molar series, remaining, even in old age, in good condition after the premolars and m^1 have lost the last vestige of the enamel pattern. In extreme old age (see Plate XVI, Fig. 11), however, m_3 finally becomes greatly worn, though still retaining at least remnants of the enamel pattern, while m^3 remains in good condition. At this stage i_4 retains the lower part of the enamel covering of the crown, while only the roots of the other incisiform teeth remain.

Ontogenesis of the Skull.

Text Figures 1–19.

In very young skulls the dorsal contour, from a point a little behind the base of the nasals to the occiput, is evenly convex, the highest point in a fœtal skull of about the eighth month of pregnancy being just posterior to the middle of the frontals, and at birth near the beginning of the posterior third of the frontals; later at the ages of six months, one year and two years, and at still later stages, the highest point remains very nearly in this position, but in the meantime the whole dorsal contour has become much less convex, through the accelerated development of the facial and occipital portions of the skull. The general form of the skull thus elongates, as in all young mammals, relatively to its breadth. In a fœtal specimen of eight months the percentage of the zygomatic breadth to the occipito-nasal length is 50; at birth it has become reduced to 45, at six months to 41, at one year to 38, and at two years to 36, which is also about the normal ratio in adults.

The muskox has no interparietal; there is, however, a strong tendency to the formation of small, irregularly-shaped interpolated bones at the principal sutures, and when one of these chances to have the position of an interparietal it might easily be interpreted as that bone.

The various bones that form the outer surface of the skull change very little in form or relative size during growth. The parietals are about one third as long on the median line as the frontals, and maintain their relative size and position throughout life, as in *Bison* and *Buffelus;* in other words, there is no tendency to their obliteration as in *Bos.*[1] There is also no change whatever in the position of the horncores; the point on the frontals where they first appear is permanently the central point of the horncore, but through growth the base expands from this point in all directions, mainly forward and backward, until in old bulls the base of the horncore extends posteriorly over the whole breadth of the parietal and anteriorly over about the posterior half of the frontal.

The sutures in the skull of the female remain open, or at least distinctly traceable, throughout life; in the male anchylosis of some of the bones begins at about the age of seven or eight years and extends until there is often complete anchylosis of the basal half of the nasal bones with each other, of the frontals with each other, of the supra-occipital with the exoccipitals, of

[1] *Cf.* Osborn, Henry Fairfield. The Continuous Origin of Certain Unit Characters as observed by a Paleontologist. Amer. Naturalist, Vol. XLVI, pp. 185–206, 249–278, April and May, 1912.

these with the basioccipital, and the latter with the basisphenoid. The orbital portion of the lacrymal often coalesces with the frontal and squamosal, sometimes so completely as to leave no trace of the former sutures.

The orbital tubes are a conspicuous and specialized feature of the skull. At birth they are far more developed than in any other bovine type at this age; with the general growth of the skull they increase in massiveness, and in old males protrude to such an extent that they form nearly two thirds of the orbital breadth of the skull, while the lower or squamosal wall of the orbit attains a thickness of 30 to 35 mm., with a corresponding thickening of the frontal segment. At this stage, however, the walls of the orbit, particularly the greatly thickened portions, are vesicular, consisting largely of an aggregation of vacuities bound together and covered externally by a framework of bone. Thus their increase in size with age adds, relatively, very little to the weight of the skull. Their special function is to give the eye sufficient lateral prominence to overcome the restriction of the field of vision that would otherwise occur by the descending massive horns and the long hair that clothes the sides of the head.

Another striking ontogenetic feature of the skull is the change of direction of the axis of the horncores from the original horizontal plane of the early stage of development to the nearly vertical direction downward attained during the third and fourth years of growth. This phase of the subject has already been considered at length under 'Ontogenesis of the Horns' (*antea*, pp. 107–137).

Ontogenesis of the Pelage and Coloration.

First Pelage. In a calf killed when only a few days old (No. 19251, Ellesmere Land, "June") the pelage consists, as in adults, of underfur and overhair. The underfur is thick, soft and woolly, about 20 to 25 mm. in average length on most parts of the body, shorter and less abundant on the head and nearly wanting on the limbs. It is mixed with fine, soft, woolly hairs, of an average length of about 40 to 50 mm., thickly interspersed with long slender hairs, about 60 to 80 mm. in length, forming the outer surface of the coat. (See Fig. 36, p. 197.)

This coat appears to be molted early. In a calf killed when about two or three months old (No. 19258, Payer Harbor) the underfur had become detached from the skin, and in places had been shed, but over the greater part of the body it adhered in loose masses to the overhair by which it is still suspended midway between the roots and the tips of the hair. The base of the pelage in this specimen thus consists wholly of rather coarse hairs, above which is the suspended mantle of underfur. The underfur, however, had entirely disappeared from a considerable area on the middle of the back, from a portion of the mid-ventral surface, from the greater part of the head, and from the limbs.

A large series of specimens taken in September and October in Grant Land show that the natal coat is wholly replaced by a new pelage, differing in color as well as in texture from that of the young calf, before the first winter. There is a new and much thicker covering of underfur, and the overhair is very much longer and more abundant, at least twice as long as in the young calf, averaging about 90 to 100 mm. in length. (The changes in color are described below under 'Coloration.')

As shown by numerous specimens in the present collection taken at different stages of the first molt, the underfur separates *en masse* from the skin and moves outward in felted masses to the tips of the hairs, from which it is probably finally dislodged by winds or by the animal rubbing

itself against rocks or bushes. For a time there is only the coarse roots of the overhair next to the skin, but the loosened underfur still forms a protecting mantle from cold while the new coat of underfur is growing.[1]

For the following account of the annual molt as observed in living animals at the New York Zoölogical Park I am indebted to Mr. Bernard McEnroe, one of the animal keepers at the Park who has the muskoxen in special charge. In a reply to my letter of inquiry, dated Sept. 24, 1912, he states: "My observations lead me to believe that the outer long hair of the musk-ox is shed something after the manner of the hair in man. It falls out and is replaced by a young growth throughout the year. The under growth of wool is shed each year, like that of the bison, in large bunches or sheets. I have comed out large quantities of the fine wool."[2]

Adult Pelage. The present series of muskox skins includes many of animals from five or six months to three years old, as well as of adults. An examination of these shows that the long coarse overhair so conspicuous in adults is acquired gradually. In the first autumn (October) the pelage is very thick and heavy, about 120 to 150 mm. in length over most parts of the body, of which the superficial one fifth to one fourth consists wholly of the crinkled, frizzled tips of the longer hairs, the basal two thirds to three fourths forming a compact dense mass of fine grayish brown wool. As yet there are no long, coarse, straight, drooping hairs such as in adults constitute the superficial or outer covering of the pelage. In the second autumn the pelage is similar in general character to that of the first autumn, but thicker and longer. During the second winter the long, straight, coarse overhair increases in length and by the third winter the superficial covering of coarse overhair is fully developed.

In adults the basal zone of soft woolly underfur is, on most parts of the body, about 2½ to 3 inches (about 60 to 75 mm.) in thickness, terminating apically rather abruptly and evenly; it is heavily covered by an outer coat of coarse hair, varying in length on different parts of the body, being much longer on the sides than on the middle of the back; in full winter coat the long hairs from the sides of the body, breast, and limbs nearly reach the ground. A large area on the middle of the back, known as the 'saddle,' narrowly oval in outline, about 20 inches in length and about 8 inches in breadth at the widest part, is without the long overhair that clothes the rest of the body, the pelage of this part consisting of the underfur covered with short, woolly hair. At the borders of the saddle the long coarse overhair begins, increasing in length and coarseness from the 'saddle' area outward to the flanks. At the edge of the saddle the overhair has a length of about five or six inches; lower down on the sides of the body it gradually increases in length to 12, 15, and even 18 inches at the flanks, on the thighs, rump, and breast, some of the longest hairs frequently attaining a length of 2 feet (about 600 mm.).

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[1] Since writing the above I have found that all this was well known to Hearne nearly a century and a half ago, from observation of the living animal on the barren-grounds of northern Canada. His account is as follows:

"In winter they [the muskoxen] are provided with a thick fine wool, or furr, that grows at the root of the long hair, and shields them from the intense cold to which they are exposed during that season; but as the summer advances, this furr loosens from the skin, and, by frequently rolling themselves on the ground, it works out to the end of the hair, and in time drops off, leaving little for their Summer clothing except the long hair. This season is so short in those high latitudes, that the new fleece begins to appear, almost as soon as the old one drops off; so that by the time the cold becomes severe, they are again provided with a "Winter-dress."— HEARNE, A Journey from Prince of Wale's Fort in Hudson Bay to the Northern Ocean, 1795, p. 139. The observations were made 1770–1772.

[2] The following excerpt from Hanbury is of interest in the present connection. He says: "I was surprised to notice how little difference there was between the summer and winter coats of the muskox. At this date, August 12, one would naturally expect the robes to be worthless, but they were quite handsome. The fact is that the long black hair, which often reaches nearly to the ground, is never shed. Once the undercoat of wool has been rubbed and scraped off, the robes are good and certainly worth preserving. The trees and bushes along the river were loaded with this wool, which is very fine in texture, much resembling the pashmina of Kashmir. Bags of this wool could be collected from the bushes. It would be a novelty to have a shawl made of it." — HANBURY, David T. Sport and Travel in the Northland of Canada, 1904, p. 40.

Coloration.[1] In the first pelage (No. 19251) the general coloration is nearly uniform dark brown suffused with a tone of chestnut. The ventral surface and the upper part of the limbs are darker than the sides and back, and there is a median blackish stripe from the top of the head to the shoulders, bordered conspicuously on either side by light-tipped hairs. The middle of the dorsal region is lighter than the sides of the body, and a mixture of light yellowish hairs occupies the position of the future saddle area. The muzzle and the feet are yellowish white, in contrast with the general coloration. There is no mixture of black, gray or white hairs on the face or head. The first pelage is essentially the same in all of the subspecies of *Ovibos*.

After the first molt (in No. 34346, Ellesmere Land) the general coloration becomes much darker, except that over the whole dorsal region the hairs are broadly tipped with yellowish rufous. The whole head in front of the eyes (except the white nose-patch) is blackish. There is a broad triangular area of white on the middle of the face, extending back nearly to the ears and terminating medially in a point somewhat in advance of the eyes. This white face patch extends laterally to the cheeks where it becomes gray through the admixture of black hairs with the white. The saddle area of the adult is indicated by light bases to the hairs covering this region, but the pelage here is otherwise much like that of the adjoining parts, being long and broadly tipped with pale rufous. This is the pelage of the first autumn, after the first general molt, and differs in coloration from that of adults in the long fulvous or rufous tips of the hairs over most of the body.

There is, however, much variation in the coloration at this stage, as in another specimen (No. 19351, Grant Land) there is much less white on the face, and less yellowish tipping on the hairs of the dorsal area. Both of these specimens were brought alive to the New York Zoölogical Park, where both died in October at the age of about six months. Other specimens of the same age from Grant Land, killed in the wild state, agree with the Ellesmere Land specimen (No. 34346) already described.

At the age of eighteen months, or in the second autumn, the general coloration and markings are nearly as in the adults. The sides of the body, neck, and underparts are very dark or blackish brown; the whole mid-dorsal region is lighter and browner, with usually the long tips of the hairs pale yellowish brown; the saddle area is still lighter, often with the tips of the hairs distinctly whitish or yellowish white. The nose patch and the feet (superficially) are white, and there is a broad transverse band of white on the front of the head, occupying most of the space between the eyes and horns, varying from nearly clear white to grayish white, sometimes more gray than white. This extends laterally to the cheeks, which are blackish more or less strongly mixed with white, often giving an ashy gray effect. The face in front of the eyes is usually iron gray, through the profuse mixture of white with blackish brown, and a strong gray suffusion extends to the base of the pelage.

There is apparently no sexual variation in color at any age, except that with the growth of the horns the original area of white in the males becomes restricted by the encroachment of the base of the horns upon the white frontal area. There is, however, a wide range of individual color variation at all ages. This is conspicuously manifested in the amount of white on the face and head, which sometimes covers the greater part of the face and is sometimes reduced to a slight intermingling of white hairs in the areas usually white or gray. The 'saddle' varies from

[1] This description is based on Ellesmere Land and Grant Land material, or the white-faced form of the muskox group. Departures from this type will be noted below in the systematic review of the species and subspecies.

nearly white to pale yellowish brown; the dark long hairs on the lower back, usually slightly brownish, are sometimes conspicuously pale chestnut brown. The back may be superficially washed with brown through the hairs being tipped with some shade of fulvous or rufous, or nearly uniform dark brown like the sides. The white on the feet varies in extent proximally, and in the length of the white on the individual hairs, the white sometimes extending nearly to the base of the pelage and sometimes being limited to the apical half or third, particularly on the upper two thirds of the white area. Doubtless some of this variation is due to season.

Individual Differentiation, as indicated by the Skull.

The subjoined measurements [1] (Tables I–IV) of 73 adult skulls — 41 males and 32 females — afford excellent data for the study of individual variation in the size of the skull, the size of different parts in relation to the basal length of the skull, the length of the toothrow, etc. In selecting the skulls for measurement, only those of mature animals were taken, or those five years old or older, as indicated by the teeth. At five years the premolars and m^3 are fully grown and functional, but are either unworn or so slightly worn that the crown pattern has not been altered by attrition. The permanent incisiform canine does not become functional until the age of six years; at five years its temporary predecessor is still in situ, although the permanent tooth is forming beneath it.

In order to eliminate as much as possible the influence of locality, the present discussion is restricted to 57 specimens (31 males and 26 females, Tables I and II) killed in northern Grant Land, from the vicinity of Lake Hazen north to the Arctic coast, an area of comparatively small extent.

Males. The male skulls included in Table I, are all from northern Grant Land. It is sufficient for present purposes to divide these into two categories on the basis of age; the first, comprising 15 skulls, consists of specimens ranging from five to about seven or eight years, in which the premolars and m^3 in the youngest skulls are practically unworn, while in the oldest the crown pattern of the premolars still retains the cross-bar or crochet in p^4. The second division includes 16 skulls, in the youngest of which the crochet of p^4 has nearly or quite disappeared by wear, while in the oldest skulls the teeth are greatly worn, with the crown pattern effaced in at least the premolars and in m^1.

In the first series of 15 skulls, the extremes depart widely from the mean, one being far below

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[1] *Explanation of Measurements.*

Total length = front border of intermaxillaries to occipital spine.
Basal length = front border of intermaxillaries to anterior border of foramen magnum.
Mastoid breadth = at lateral borders of mastoid processes.
Orbital breadth = at extreme lateral borders or orbits.
Postorbital breadth = at point of least breadth between orbits and base of horns.
Nasals, length = greatest length.
Nasals, breadth = greatest breadth.
Maxillary toothrow = length at alveolar border.
Lower jaw, length = incisive border to posterior border of condyle.
Lower jaw, height = angle to condyle. The 'angle' as here used is the angle made by the plane of the lower border of the mandible at m^3 projected to meet a line perpendicular to it from the posterior border of the ascending ramus.
Lower jaw, height = angle to top of condylar process.
Horns, length = along outer curvature of a single horn, usually the right.
Horns, spread at tips = distance in a straight line from tip to tip.
Horns, breadth at base = antero-posterior breadth in a straight line.
Horns, distance apart at base = distance between basal edges of sheaths.

Table I. Measurements of 31 adult male skulls of Muskoxen from Northern Grant Land.[1]

	♂ 29948	♂ 29952	♂ 29949	♂ 29912	♂ 29965	♂ 29956	♂ 29966	♂ 29967	♂ 29968	♂ 29930	♂ 29971	♂ 29933	♂ 29970	♂ 28072	♂ 28016	♂ 28014	♂ 28030	♂ 28074	♂ 28005	♂ 28829	♂ 28026	♂ 28028	♂ 28031	♂ 28073	♂ 28022	♂ 28015	♂ 28019	♂ 28082	♂ 28021	♂ 28018	♂ 28009
Total length	485	491	496	453	422	440	452	482	459	494	490	446	486	492	426	474	461	489	470	480	463	463	503	498	474	492	488	503	508	496	516
Basal length	454	464	455	420	403	406	420	443	428	454	456	426	451	465	390	436	426	450	431	446	427	434	461	456	438	451	448	470	470	461	472
Mastoid breadth	172	184	190	166	156	159	166	172	166	176	179	166	175	177	149	166	168	177	167	177	165	165	184	180	171	181	176	196	195	179	198
Orbital breadth	252	265	265	241	231	232	248	255	252	269	267	254	257	258	220	242	234	253	239	253	241	239	267	260	246	261	263	277	272	265	277
Postorbital breadth	140	142	138	128	118	121	132	139	131	143	141	130	140	142	125	133	128	141	135	145	129	134	140	143	134	140	139	149	145	141	145
Nasals, length	155	157	165	140	123	137	140	149	136	151	161	140	153	159	129	147	142	154	145	150	143	146	162	158	147	153	155	165	166	159	169
" greatest breadth	71	70	75	59	60	56	67	65	61	70	74	68	70	73	55	62	61	69	63	68	58	63	72	70	59	68	68	82	82	70	83
Maxillary tooth-row, length	150	144	143	134	133	130	135	138	136	138	133	135	140	148	140	145	141	145	142	144	145	142	143	147	148	144	144	141	134	144	130
Breadth of palate opposite m^2	82	86	83	73	68	70	72	73	74	78	79	74	79	78	70	80	77	80	76	—	75	76	77	78	74	80	77	81	81	78	80
Lower jaw, length	383	396	400	353	348	351	361	391	358	396	395	—	391	397	350	380	367	390	371	383	380	—	400	—	377	391	391	—	—	401	410
Lower jaw, height, angle to condyle	131	137	136	123	127	120	133	133	131	138	139	—	140	138	121	122	122	133	129	137	128	—	137	—	132	136	141	—	—	136	140
" " " " cond. proc	176	179	184	162	167	160	165	168	162	187	188	—	177	178	157	163	166	176	167	183	166	—	188	—	170	178	177	—	—	182	185
" " tooth-row, length	155	149	145	142	137	135	137	141	142	141	139	—	142	150	147	151	145	147	146	150	152	—	144	—	146	144	147	—	—	147	134
Horns, distance between tips	706	671	615	—	460	550	491	642	657	629	625	547	564	—	577	648	645	665	625	646	646	560	543	652	636	671	671	686	596	655	587
" breadth at base	210	206	205	167	142	131	136	177	162	184	189	166	219	205	146	213	199	224	200	207	190	198	199	208	192	200	190	204	216	195	217
" length on outer curvature	635	556	573	355	540	606	625	582	548	624	578	602	648	627	595	612	628	651	561	653	582	554	635	651	614	637	664	594	602	654	646
" distance between bases of sheaths	19	11	14	11	10	13	15	6	10	11	11	15	12	—	16	17	15	14	21	14	12	13	10	15	13	15	15	10	8	14	9
Weight of skull	15½	18	16½	—	10¼	10½	13¾	15⅛	12½	17	16	14	18½	17⅝	11½	16	13⅝	18	14	17⅝	12⅝	13¾	17⅜	18	14⅝	17⅛	16¾	19⅜	23½	16⅜	21
" of lower jaw	1⅞	2	2	1½	5½	1½	1¾	2⅛	2	2	1⅛	—	2⅛	2	1½	1⅞	2	2	1⅞	2¼	2	—	2¼	—	1¾	—	2	—	—	2¼	2⅜
Total weight of skull	17⅛	20	18½	—	15¾	12	15½	17⅝	14½	19	17⅞	—	20⅝	19⅝	13	17⅞	13⅝	20	15⅞	19⅞	14⅝	—	19⅝	—	16⅜	—	18¾	—	—	18⅝	23⅜

[1] The mean, maximum, and minimum averages are given in Table V, p. 182.

Table II.—Measurements of 26 adult female skulls of Muskoxen from Northern Grant Land.[1]

	♀ 19560	♀ 28024	♀ 29947	♀ 27997	♀ 28012	♀ 27998	♀ 28010	♀ 28003	♀ 29946	♀ 29960	♀ 29929	♀ 29932	♀ 29959	♀ 29957	♀ 29953	♀ 28013	♀ 29969	♀ 29931	♀ 28007	♀ 29958	♀ 29963	♀ 28008	♀ 28004	♀ 28075	♀ 29962	♀ 28027
Total length	423	415	406	429	440	432	429	441	441	446	447	459	440	440	429	457	433	435	437	450	440	447	434	451	420	460
Basal length	398	389	385	402	409	400	405	412	416	404	421	426	411	413	410	422	410	406	401	422	416	423	406	418	402	430
Mastoid breadth	151	144	144	157	153	151	151	154	156	150	160	157	156	158	154	160	156	152	158	155	—	162	155	160	151	159
Orbital breadth	202	205	201	215	213	211	211	216	211	214	223	223	211	220	212	220	217	214	222	218	220	222	217	226	211	222
Postorbital breadth	111	110	110	119	113	120	120	121	114	114	117	120	114	119	114	121	119	115	115	124	115	123	115	122	108	119
Nasals, length	140	133	140	132	146	145	140	147	150	138	151	150	143	149	148	149	138	148	146	146	144	141	141	151	139	151
" greatest breadth	54	47	53	54	54	53	58	57	60	59	58	57	60	60	56	57	50	60	50	53	55	58	50	54	55	58
Maxillary tooth-row, length	137	136	140	142	140	144	143	140	140	136	134	133	136	136	132	146	139	133	129	135	133	138	133	130	122	130
Breadth of palate at m^2	70	68	65	72	64	67	68	69	68	70	69	72	68	74	67	71	70	68	70	69	72	72	70	71	72	73
Lower jaw, length	341	344	340	354	306	350	353	358	360	355	373	—	360	360	357	365	—	355	356	368	366	370	350	362	351	370
" " height, angle to condyle	126	123	116	127	125	117	116	123	128	129	128	—	121	118	118	121	—	125	124	128	121	129	128	120	124	129
" " " " cond. proc	164	160	156	159	155	155	154	163	167	168	167	—	157	160	160	161	—	156	162	167	163	163	165	157	161	166
" " tooth-row, length	142	142	143	150	142	149	147	144	144	141	138	—	141	139	137	143	—	134	131	139	134	139	135	133	125	130
Horns, distance between tips	—	439	—	492	471	519	480	480	380	430	554	516	451	504	412	512	—	368	482	505	472	398	425	502	—	499
" breadth at base	68	81	73	89	87	85	92	91	91	80	90	83	88	80	74	76	82	84	81	91	81	91	74	93	72	103
" length on outer curvature	380	377	420	468	428	452	468	488	505	392	435	475	440	447	412	437	391	470	398	440	435	434	406	474	355	466
" distance between bases of sheaths	—	47	52	22	23	34	31	21	10	15	18	24	8	30	30	48	22	13	20	27	13	14	45	28	24	4
Weight of skull	$4\frac{5}{8}$	$5\frac{1}{8}$	$4\frac{3}{8}$	$6\frac{1}{8}$	$6\frac{1}{8}$	6	$6\frac{2}{8}$	$5\frac{7}{8}$	$5\frac{3}{4}$	$5\frac{3}{8}$	$6\frac{1}{4}$	$5\frac{1}{2}$	$5\frac{5}{8}$	$6\frac{5}{8}$	$4\frac{5}{8}$	7	$6\frac{1}{2}$	$6\frac{1}{2}$	5	$6\frac{5}{8}$	$5\frac{3}{4}$	$5\frac{7}{8}$	$5\frac{3}{4}$	$6\frac{1}{8}$	4	$6\frac{1}{2}$
Weight of lower jaw	$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{3}{4}$	$1\frac{7}{8}$	$1\frac{7}{8}$	$1\frac{5}{8}$	$1\frac{1}{2}$	$1\frac{5}{8}$	$1\frac{3}{4}$	$1\frac{3}{4}$	—	$1\frac{1}{2}$	$1\frac{7}{8}$	—	$1\frac{7}{8}$	—	$1\frac{5}{8}$	$1\frac{5}{8}$	$1\frac{7}{8}$	$1\frac{3}{8}$	—	$1\frac{3}{4}$	$1\frac{5}{8}$	$1\frac{1}{4}$	$1\frac{5}{8}$
Total weight of skull	$6\frac{1}{2}$	$6\frac{5}{8}$	$5\frac{5}{8}$	$7\frac{7}{8}$	8	$7\frac{7}{8}$	$7\frac{7}{8}$	$7\frac{3}{8}$	$7\frac{3}{8}$	$7\frac{1}{8}$	8	—	$7\frac{1}{8}$	$8\frac{1}{2}$	—	$8\frac{1}{8}$	—	$8\frac{1}{8}$	$6\frac{5}{8}$	$8\frac{1}{2}$	$7\frac{1}{8}$	—	$7\frac{1}{2}$	$7\frac{3}{4}$	$5\frac{1}{4}$	$8\frac{1}{8}$

[1] The mean, maximum, and minimum averages are given in Table V, p. 182.

the average and much below the next in size, and the other far above the average and much above the next in size, although the smaller of the two is slightly older than the larger one. These represent, respectively, the dwarf and the giant of the series. In the second series of 16 older skulls the extremes are respectively much below and much above the average; there are others of nearly the same size which grade into the series without a marked hiatus between the extremes and the series as a whole.

Basal length. In the first 15 the basal length of the skull averages 439.2 mm., with the minimum (a dwarf) at 390 and the maximum (a giant) at 464. In this instance the extremes are represented by skulls of the same age, both being six years old, as nearly as can be determined. This difference of 74 mm. between the extremes — equal to 17% of the mean — is therefore purely individual.

In the second series of 16 skulls the basal length averages 444.7 mm., with the extremes at 403 and 472 mm. In this instance also the largest and smallest skulls are of practically the same age, both being well past middle age with all the teeth much worn. The difference between the extremes is 69 mm. or 15.5 %, and of course is purely individual.

The mean of the two series is 442 mm., with the minimum at 390 and the maximum at 472, the difference being 82 mm., or 18.6 % of the average of both series. These statistics indicate a slight average increase in size between maturity and old age, and also that the normal range of individual variation in the basal length of the skull in full-grown males is about 17 % of the mean.

Maxillary toothrow. The maxillary toothrow in the first division of 15 skulls has an average length of 143.5 mm., with the minimum at 134 and the maximum at 150. The range of individual variation is 16 mm. or a little over 11 % of the mean.

In the second series of 16 older skulls the average is 137.7 mm., with the extremes at 130 and 144, giving a range of variation of 14 mm. or 10.2 % of the mean. A comparison of these statistics for the two series shows an average slight loss in the length of the toothrow in the older animals, due to absorption and the crowding together of the teeth — a condition well known to result from senility.

Mastoid breadth. In the first division of 15 skulls the average mastoid breadth is 172 mm., the minimum 149, and the maximum 190. The difference, 41 mm., is 23.8 % of the mean. Throwing out two skulls, respectively the dwarf and the giant of the series, already referred to, both of the same age, leaves the average as before, but the extremes are only 165 and 184, with the difference 19 mm. and the range only 11 % of the mean.

In the second series of 16 older skulls the mean is 176 mm., the extremes being 156 and 198; the difference is 42 mm., or 23.9 % of the mean. In this series, as already stated, no skull stands out from the rest as either a giant or a dwarf.

Postorbital breadth. Average in the first series of 15 skulls, 135.7; extremes 125 and 145; difference, 20 mm., or 14.8 % of the mean. Average of the second series of 16 skulls, 137.3 mm., the extremes 118 and 149; difference, 31 mm., or 22.7 % of the mean.

The range of individual variation in postorbital breadth is exceptionally great in comparison with that for most of the measurements of other parts of the skull. In the second series of 16 skulls the postorbital breadth in the four narrowest is, respectively, 118, 121, 131 and 132, the next narrowest being 139 and 140 (two in each case, which are slightly above average). On the other hand there is one at 149 and two at 145 mm.

It may be noted that the minimum postorbital breadth in the series of 15 younger skulls is 125 mm., and that the next are 128 (two) and 129 (one), while the maximum is 145. The average difference between the two series is less than 2 mm., showing that the range of variation is almost strictly individual.

Orbital breadth. Owing to the specialization of the orbital tubes, it is natural to expect a wide range of individual variation in this feature. This anticipation is, however, not supported by the table of measurements.

In the first series of 15 skulls the average orbital breadth is 246.5 mm.; extremes 220 and 267, the minimum being due to the before mentioned 'dwarf' of the series. The difference between the extremes is thus 47 mm., or 19 % of the mean. In the second series of 16 skulls the mean is 250.4 mm.; the extremes 231, and 277; the difference is 46 mm. or 18.5 % of the mean.

Palatal breadth at m^2. In the first series the average is 75 mm.; extremes 70 and 80; range of variation, 10 mm., or 13.3 % of the mean. In the second series the average is 76 mm.; extremes, 68 and 81; range of variation, 13 mm., or 17 % of the mean.

Lacrymal. The lacrymal bone varies greatly in individuals of the same age and sex, but owing to its concave surface and irregular outline these variations cannot be readily expressed in measurements. In outline, in the ratio of breadth at both the narrowest and widest parts to length, the variation is marked. Age affects size and measurements through exostosis on the orbital border. The sutures of the portion entering into the formation of the orbit are often wholly obliterated in males in old age, on one or both borders, that on the anterior border being the first to become completely obliterated. The point of deepest depression of the surface, the so-called 'lacrymal pit,' is often sharply deepened in old age by the heavy exostosis of its dorsal and ventral borders.

In average adult male skulls the least width of the lacrymal is slightly more than one third, and the greatest width is almost exactly one half, of the total length, but the variations from this norm are considerable, due partly to individual variation and partly to age.

These variations are so similar in the two sexes that the present description is as applicable to the females as to the males, except that in the females the depressions is less than in the males, and often entirely absent.

Nasals. The nasals, as in most mammals, and especially in the Ruminants, are one of the features of the skull most subject to individual variation as regards both size and form. They also vary with age in respect to form and massiveness. In *Ovibos* they are apt to become greatly thickened and arched through excessive osseous deposition in middle-aged and senile males.

Length: In the first series of 15 skulls, ranging in age from maturity to the middle period of life, the nasals have an average length on the mid-line of 149.3 mm., with the extremes at 127 and 165; difference, 36 mm., equal to 24.1 % of the mean. In the second series of 16 older skulls the average is 151 mm., with the extremes at 123 and 169; range of variation, 46 mm., or 30.5 % of the mean.

Breadth: In the first series of 15 skulls the mean breadth is 65 mm., the extremes, 55 and 75; the difference is 20 mm., or 37.7 % of the mean. In the second series of 16 skulls the mean breadth is 70 mm., the extremes, 56 and 83; the difference is 27 mm., or 38.6 % of the mean.

In the case of the nasals, the wide range of variation here shown is to be ascribed in part to individual variation, but is in part orthogenetic. The measurements do not, however, indicate the large amount of variation in the dorsal arching and thickening of the nasals, which is mainly orthogenetic and progressive with age.

Horns. The horns are naturally the most variable element of the skull structure, and the one most affected by age after the permanent dentition has reached mature development. There is, however, a wide range of individual variation that may be easily recognized in respect to length and curvature, as expressed in the measurements given in Tables I and II.

Length: In the first series of 15 skulls the horns have an average length along the curvature of 603.7 mm.; extremes 554 and 653; range, 99 mm., or 16.6 % of the mean. In the second series of 16 skulls the average length is 611.2 mm.; extremes 540 and 664; range 124 mm., or 20.3 % of the mean. The average greater length in the older series of 16 skulls is due mainly to the accretions at the base, which extend the horn inward toward the mid-line of the skull.

The length of the horns proves not to be closely correlated with the general size of the skull. Thus, in the first series, the skull with the longest horns has a basal length of 446 mm. while the skull with the shortest horns has a basal length of 434 mm.; the skull with the greatest basal length has horns 98 mm. shorter than the maximum horn length. In the second series the largest skull (basal length 470) has horns only 594 mm. long, while the skull with the longest horns (664 mm.) has a basal length of only 448 mm.

Distance from tip to tip: The variation in the distance in a straight line from the tip of one horn to the tip of the other has not necessarily any bearing on the length or size of the horns, but indicates variation in their curvature, particularly the relative amount of inward curvature toward the tip.

In the first series the average distance between the horn tips is 613 mm., or a little more than the length of the horn measured along the curvature. The extremes of variation are 543 and 671, the range of variation is 128 mm., or 20.9 % of the mean. In the second series the mean is 609.9 mm.; the extremes are 460 and 686, the range of variation being 226 mm., or 37 % of the mean. The skull presenting the least distance between the horn tips in the second series has also the smallest and shortest horns of the series, while the skull with the tips widest apart has also the longest horns of the series.

Breadth at base: This is the total breadth of the horn at the base on the mid-line of the skull, and proves to average actually less in the older of the two series of skulls. In the younger series of 15 skulls this measurement averages 198 mm., with the extremes at 146 and 224; range 78 mm., or 39.4 % of the mean. In the older series of 16 skulls the average is 183 mm. and the extremes 131 and 219, a range of 88 mm., or 45.9 % of the mean.

The diameter of the horn at the base is thus extremely variable, approaching a range well toward 50 % of the mean. As shown by the table (Table I) of measurements, it cannot be greatly affected by age but must be almost entirely individual. It is surprising that the younger series of skulls show both a higher average and a larger maximum than the series of older skulls.

Distance between sheaths at base: Average distance between the bases of the sheaths in the first series, 14.3 mm.; extremes, 10 and 21; range of variation, 11 mm., or 76.9 % of the mean. Average in the second series, 11.6 mm.; extremes 8 and 15; variation 7 mm., or 60.3 % of the mean. This wide variation range is due to the variable amount of horn growth formed by accretions at the base of the horn over the parietal region.

Weight of Skull. The weight of the skull, including the lower jaw, in the first series of 15 skulls averages 17.3 lbs.; extremes, 13 and 20.2 lbs.; range of variation, 7.67 lbs., equal to 44.3 % of the mean.

In the older series of 16 skulls the average is 17.8 lbs.; the extremes are 12 and 26 lbs.; range of variation 14 lbs., or 86.13 % of the mean.

In the first series the lightest skull (13 lbs.) is the smallest (the 'dwarf') of the series; three attain a weight of 20 lbs. (heaviest, 20.2 lbs.); these three skulls are among the five largest of the series, in which the basal length ranges from 450 to 464 mm.

In the second series (older skulls) the average weight is only half a pound greater than in the first series, while the range of variation in weight is nearly 90 %, or twice the range in the first series. This is due to the fact that the minimum (12 lbs.) in the second series is 3.5 lbs. less than the next lowest in weight, while the maximum (26 lbs.) is 4.5 lbs. greater than any other in the series except one, with a weight of 23.2 lbs. The 12-pound skull is the dwarf of the series, while the two heaviest are the largest of the series.

The small skulls are as old as the large skulls, and in some instances older, so that the range of variation shown in the weight is mainly individual and only to a small extent due to differences in age. With increase in age most of the sutures of the skull close, and the texture of the bones becomes more compact and dense, without a very marked increase in the weight of the skull. This may be due to increase in the number and size of the vacuities in the walls of the skull, through absorption.

FEMALES. As in the case of the male skulls, the 26 female skulls (see Table II) are all from northern Grant Land, and range in age from five years old to old age. Also, as in the case of the males, they are divided into two categories on the basis of age, the first series of 11 skulls including those of five to about eight years of age, the second series of 15 skulls, those of about eight years to old age.

Basal length. In the 11 skulls forming the younger series the basal length averages 405 mm., with the minimum at 385 and the maximum at 421; the range of variation is 36 mm., equal to 8.8 % of the mean. In the second or older series comprising 15 skulls, the basal length averages 414.4 mm., with the minimum and maximum respectively at 401 and 430; the range of variation is 29 mm., equal to 7 % of the mean. The mean of the two series is 406.1 mm.; the extremes are 385 and 430; the range of variation, 45 mm., is equal to 10.58 % of the mean of the whole series.

These statistics indicate a slight increase in size with age, with a decrease in the individual range. They also indicate a much smaller range of individual variation in the females than in the males.

Maxillary toothrow. In the first division of 11 skulls the maxillary toothrow has an average length of 139 mm.; extremes, 134 and 144; range of variation, 10 mm., equal to 7.2 % of the mean.

In the second series of 15 older skulls the average is 133.3 mm.; extremes, 122 and 146; range of variation, 24 mm., equal to 18 % of the mean. This wide range, however, is due largely to two skulls: one, very old, with a toothrow length of only 122 mm.; the other, middle-aged, with a toothrow length of 146 mm. Excluding these two skulls the range of variation for the other 13 skulls is from 125 (with only one other below 130) to 139, or only 14 mm., which is 12.3 % of the mean, or 4 % greater than the range of variation in the younger series.

Here, as in the males, there is a marked decline in the length of the toothrow in the older as compared with the younger series, due to senility.

Mastoid breadth. The average mastoid breadth in the younger series of 11 skulls is 152 mm.; the minimum is 144, the maximum, 160; range of variation, 16 mm., or 10.4 % of the mean.

In the older series the average is 157 mm., with the extremes at 151 and 165; range of variation, 14 mm., or 9 % of the mean,— about 1.5 % less than in the younger series.

Postorbital breadth. Average in the younger series, 115.4 mm.; extremes, 110 and 121; range of variation, 11 mm., equal to 9.6 % of the mean.

Average in the older series, 118 mm.; extremes, 108 and 134; range of variation, 26 mm., or 22 % of the mean. The wide range is here due to the same two skulls that so greatly extended the range of variation in the length of the maxillary toothrow already noted.

Orbital breadth. Average in the younger series, 211 mm.; extremes 201 and 223; range of variation, 21 mm., or 10 % of the mean. Average in the older series, 218.3 mm.; extremes, 211 and 226; range of variation, 15 mm., or 6.9 % of the mean.

Palatal breadth at m^2. In the first series of 11 skulls the average is 68.2 mm.; extremes, 64 and 72; range of variation, 8 mm. or 13.2 % of the mean; in the second series of 15 skulls, the average is 70; extremes, 67 and 74; range of variation, 7 mm., or 10 % of the mean.

Nasal bones. Length: Average in the first series, 142 mm.; extremes, 132 and 151; range 19 mm., or 13.4 % of the mean. Second series, average, 145.7 mm.; extremes, 138 and 151; range of variation, 13 mm., equal to 8.23 % of the mean.

Breadth: Average in the first series, 55 mm.; extremes, 47 and 60; range of variation, 13 mm., equal to 23.6 % of the mean. Second series, average, 55.5 mm.; extremes, 50 and 60; range of variation, 10 mm., or 18 % of the mean.

Horns. Distance between tips: The average distance between the tips in a straight line in the first series is 475 mm.; minimum, 380, maximum, 554; range of variation 174 mm., or 36.6 % of the mean. The average for the same measurement for the second series (older skulls) is 465 mm.; extremes, 368 and 516; range of variation, 148 mm., or 31.83 % of the mean.

The great excess of variation in the first series is due to two abnormal skulls, in one of which the spread of horns is far below (25 mm.) the spread of horns in the next lowest, while in the other the spread is far above (35 mm.) that of the next highest, and 38 mm. greater than the maximum in the second series. Excluding the two extremes of the first series reduces the average spread to 434.6 mm., the extremes to 360 and 519, and the range of variation to 159 mm., or 36.6 % of the mean, giving the same range of variation as when they were included, which is much above that of the second series.

Length: The average length of the horns, measured along the curvature from the extreme base of the sheath, in the first series is 437.5 mm., with the extremes at 380 and 505, and the range of variation 125 mm., equal to 30 % of the mean. The same measurement in the second series averages 432 mm., with extremes of 355 and 475, and a range of variation of 120 mm., or 27.44 % of the mean. The range of variation is thus less in the older than in the younger series, due in part to the fact that in some of the younger skulls the sheath at base had not reached its ultimate expansion inward over the frontal region of the skull.

Breadth at base: The average in the first series is 83.3 mm., the extremes 68 and 92, and the range of variation 24 mm., or 29 % of the mean. In the second series the average is 85.5 mm., the extremes 72 and 103, and the range of variation 31 mm., or 35.9 % of the mean.

Distance between sheaths at base: The sheath is extended by growth at the base over the frontal region of the skull after the animal has reached maturity, thus leaving the distance between the horn sheaths at base much less in old individuals than in those of five or six years of age. In a series of 11 females of five to eight years old the average distance between the bases of the horn sheaths is 27.3 mm., with a range of variation from 18 to 52 mm., or 138 % of the mean. In 14 skulls of females of eight years or older, the same average is 14 mm., with a varia-

tion in range of 8 to 30 mm., or 157 %. Although much of the variation in this feature is obviously due to age, there is also a wide range of variation in skulls of practically the same age, the difference being often 20 mm., or more than 50 % of the mean; much greater than in the males (see *antea*, p. 148).

Weight of skull. The average weight of the skull, including the lower jaw, in the first series is 7 lbs.; extremes 5 and 8; variation, 3 lbs., or 43 % of the mean. The average in the second series of older skulls is 7.34 lbs.; extremes, 5.1 and 8.5; range of variation 3.4 lbs., or 46.3 % of the mean.

Conclusions. (1) As shown in the subjoined tabular presentation, based on the foregoing statistics, the range of individual variation in cranial characters in *Ovibos* is greater, in both males and females, during the period of from five to eight years of age than in those that have passed the eighth year.

(2) It is also considerably greater in males than in females of corresponding ages.

(3) It is relatively less in the length of the toothrow than in the basal length of the skull.

(4) It is greater in the mastoid breadth of the skull than in the postorbital or orbital breadth.

(5) The nasal bones are among the most variable elements of the skull, and therefore among the most unreliable features for use in diagnosis, as regards their length, breadth, and general form.

(6) The highest ratio of variability is shown in the horns, as would be expected speaking generally, but especially so in *Ovibos* on account of their peculiar form and long period of growth.

(7) The weight of the skull varies greatly in animals of practically the same age and of the same sex.

The foregoing statistics are summarized in the following table:

Tabular Summary.

Basal length	15 ♂♂, 5 to 8 years	av. 439.2	min. 390	max. 464	var. 74 = 17 %
" "	16 ♂♂, 8 " 14 "	" 444.7	" 403	" 472	" 69 = 15.5 "
" "	31 ♂♂, 5 " 14 "	" 442	" 390	" 472	" 82 = 18.6 "
" "	11 ♀♀, 5 " 8 "	" 405	" 385	" 421	" 36 = 8.8 "
" "	15 ♀♀, 8 " 14 "	" 414.4	" 401	" 430	" 29 = 7 "
" "	26 ♀♀, 5 " 14 "	" 406.1	" 385	" 430	" 45 = 10.6 "
Max. toothrow	15 ♂♂, 5 to 8 years	av. 145.5	min. 134	max. 150	var. 16 = 11 %
" "	16 ♂♂, 8 " 14 "	" 137.7	" 130	" 144	" 14 = 10.2 "
" "	11 ♀♀, 5 " 8 "	" 139	" 134	" 144	" 10 = 7.2 "
" "	15 ♀♀, 8 " 14 "	" 133.3	" 122	" 146	" 24 = 18 "
Mastoid breadth	15 ♂♂, 5 to 8 years	av. 172	min. 149	max. 190	var. 41 = 23.8%
" "	16 ♂♂, 8 " 14 "	" 176	" 156	" 198	" 42 = 23.9 "
" "	11 ♀♀, 5 " 8 "	" 152	" 144	" 160	" 16 = 10.4 "
" "	15 ♀♀, 8 " 14 "	" 157,	" 151	" 165	" 14 = 9 "
Postorb. breadth	15 ♂♂, 5 to 8 years	av. 135.7	min. 125	max. 145	var. 20 = 14.8%
" "	16 ♂♂, 8 " 12 "	" 137.3	" 118	" 149	" 31 = 22.7 "
" "	11 ♀♀, 5 " 8 "	" 115.4	" 110	" 121	" 11 = 9.6 "
" "	15 ♀♀, 8 " 12 "	" 118	" 108	" 134	" 26 = 22 "
Orbital breadth	15 ♂♂, 5 to 8 years	av. 246.5	min. 220	max. 267	var. 47 = 19 %
" "	16 ♂♂, 8 " 14 "	" 250.4	" 231	" 277	" 46 = 18.5 "
" "	11 ♀♀, 5 " 8 "	" 211	" 201	" 223	" 21 = 10 "
" "	15 ♀♀, 8 " 14 "	" 218.3	" 211	" 226	" 15 = 6.9 "

Tabular Summary — Continued.

Palatal breadth	15 ♂♂, 5 to 8 years	av. 75	min. 70	max. 80	var. 10 = 13.3%
" "	16 ♂♂, 8 " 14 "	" 76	" 68	" 81	" 13 = 17 "
" "	11 ♀♀, 5 " 8 "	" 68.2	" 64	" 72	" 8 = 13.2 "
" "	15 ♀♀, 8 " 14 "	" 70	" 67	" 74	" 7 = 10 "
Nasals, length	15 ♂♂, 5 to 8 years	av. 149.3	min. 129	max. 165	var. 36 = 24.1%
" "	16 ♂♂, 8 " 14 "	" 151	" 123	" 169	" 46 = 30.5 "
" "	11 ♀♀, 5 " 8 "	" 142	" 132	" 151	" 19 = 13.4 "
" "	15 ♀♀, 8 " 14 "	" 145.7	" 138	" 151	" 13 = 8.23 "
Nasals, breadth	15 ♂♂, 5 to 8 years	av. 65	min. 55	max. 75	var. 20 = 37.7%
" "	16 ♂♂, 8 " 14 "	" 70	" 56	" 83	" 27 = 38.6 "
" "	11 ♀♀, 5 " 8 "	" 55	" 47	" 60	" 13 = 23.7 "
" "	15 ♀♀, 8 " 14 "	" 55.5	" 50	" 60	" 10 = 18 "
Horns, length	15 ♂♂, 5 to 8 years	av. 603.7	min. 554	max. 653	var. 99 = 16.4%
" "	16 ♂♂, 8 " 14 "	" 611.2	" 540	" 664	" 124 = 20.3 "
" "	11 ♀♀, 5 " 8 "	" 437.5	" 380	" 505	" 125 = 30 "
" "	15 ♀♀, 8 " 14 "	" 432	" 355	" 475	" 120 = 27.4 "
Horns, spread at tip	15 ♂♂, 5 to 8 years	av. 613	min, 543	max. 671	var. 128 = 20.9%
" " "	16 ♂♂, 8 " 14 "	" 610	" 460	" 686	" 226 = 37 "
" " "	11 ♀♀, 5 " 8 "	" 475	" 380	" 554	" 174 = 36.6 "
" " "	15 ♀♀, 8 " 14 "	" 465	" 368	" 516	" 148 = 31.8 "
Horns, breadth at base	15 ♂♂, 5 to 8 years	av. 198	min. 146	max. 244	var. 98 = 49.4%
" " "	16 ♂♂, 8 " 14 "	" 183	" 131	" 219	" 80 = 45.9 "
" " "	11 ♀♀, 5 " 8 "	" 83.3	" 68	" 92	" 24 = 29 "
" " "	15 ♀♀, 8 " 14 "	" 83.7	" 72	" 103	" 31 = 35 "
Horns, separated at base	15 ♂♂, 5 to 8 years	av. 14.3	min. 10	max. 21	var. 11 = 76.2%
" " "	16 ♂♂, 8 " 14 "	" 11.6	" 8	" 15	" 7 = 60.3 "
" " "	11 ♀♀, 5 " 8 "	" 38	" 22	" 66	" 44 = 103 "
" " "	15 ♀♀, 8 " 14 "	" 14	" 8	" 30	" 22 = 157 "
Weight of skull	15 ♂♂, 5 to 8 years	av. 17.3	min. 13	max. 20.2	var. 7 = 41.6%
" " "	16 ♂♂, 8 " 14 "	" 17.5	" 12	" 26	" 14 = 80 "
" " "	11 ♀♀, 5 " 8 "	" 7.	" 5	" 8	" 3 = 43 "
" " "	15 ♀♀, 8 " 14 "	" 7.34	" 5.1	" 8.5	" 3.4 = 46 "

RATIOS. The amount of individual variation in the more important dimensions of the skull, expressed in ratios to the basal length, is not striking, as shown in the subjoined table, where the ratios of the following six measurements to the basal length are given, namely: (1) total length of the skull to the basal length; (2) mastoid breadth to the basal length; (3) orbital breadth to the basal length; (4) postorbital breadth to the basal length; (5) palatal breadth to the basal length; (6) length of the maxillary toothrow to the basal length.

The ratio variation in these measurements for 31 adult males and 26 adult females from northern Grant Land ranges, for these different measurements, from about 3 to 8 %, the highest being for the length of the maxillary toothrow. It is noteworthy that while these ratios relate to purely individual variation they exceed, as will be shown later, the average differences between the subspecies of the muskox group (see *infra*, pp. 154, 155).

RATIOS: BASAL LENGTH OF SKULL = 100.

31 Males, Northern Grant Land.

		Total length.	Mastoid breadth.	Orbital breadth.	Postorbital breadth.	Palatal breadth.	Maxillary tooth row.
5 to 8 years old.	28016	109	38	56.4	32	18.2	36
	28014	108.3	38	55.5	30.5	18.3	33.3
	28030	108	39.3	55	30	18.1	33.1
	28074	109	39	56.2	31.3	18	32.2
	28005	109	38.5	55.5	31.3	17.6	33
	28029	108	39.7	56.8	32.5	—	32.3
	29026	108.5	38.7	56.4	30.2	18	34
	28028	106.7	38.6	55.3	30.9	17.5	32.7
	28031	109	40	58	30.4	16.5	31
	28073	109	39.5	57	31.4	17.3	34.4
	28022	108	41.3	56	30.6	17.1	33.8
	28015	109	40.1	57.9	31	17.7	31.9
	28019	109	39	58.7	31.2	17.2	32.1
	28082	107	41.7	58.9	30.2	17.2	30
	28021	107	41.5	56.5	30.8	17.2	29
8 to 14 years old	28018	108	38.3	57.5	30.6	17	31.2
	28009	109.4	41.9	58.3	30.8	17	28
	28072	106	38	56.5	30.2	17	31.9
	29948	106.6	38	55.5	30.8	18	32.9
	29952	105.8	39.5	57	30.3	18.5	31
	29949	109	41.8	58	31.2	19.1	31.4
	29912	108	39	57	30.5	17.4	31.9
	29965	104.7	38.9	57.4	29.3	16.9	33
	29956	108	39.1	57	30	17.2	32
	29966	107.7	39.5	59	31.2	17.1	32.1
	29967	109	39	58	31.4	16.5	31.1
	29968	107.2	39	59	30.6	17.3	31.3
	29930	109	39	59.2	31.5	17.2	30.4
	29971	107.7	39.2	59.4	30.9	17.1	29
	29933	104.9	39	59.6	30.5	17.4	31.7
	29970	107.8	39	57	31	17.5	31
	Minimum	104.7	38	55	29.3	16.5	28
	Maximum	109.4	41.9	59.6	32.5	19.1	36
	Average	107.9	39.4	57.3	30.8	17.5	31.9

RATIOS: BASAL LENGTH OF SKULL = 100.

26 Females, Northern Grant Land.

		Total length.	Mastoid breadth.	Orbital breadth.	Postorbital breadth.	Palatal breadth.	Maxillary tooth row.
5 to 8 years old.	19560	106.4	37.2	50.8	27.6	17.9	34.4
	28024	106.4	37	52.7	28.3	17.5	34.2
	29947	105.4	37.8	54.8	28.6	16.3	35.2
	27997	106.7	39.1	53.5	27.1	17.9	35.3
	28012	107.6	37.4	52.1	27.6	15.6	34.2
	27998	108	37.8	50.3	30	16.8	36
	28010	105.9	37.3	52.1	29.6	16.8	35.3
	28003	107	37.4	52.4	29.1	16.7	34
	29946	106	37.5	50.7	27	16.3	33.7
	29960	105.5	37.1	53	28.2	17.3	33.7
	29929	106.2	38	53	27.8	16.4	31.8

RATIOS: BASAL LENGTH OF SKULL = 100—*Continued.*

26 Females, Northern Grant-Land—Continued.

		Total length.	Mastoid breadth.	Orbital breadth.	Postorbital breadth.	Palatal breadth.	Maxillary tooth row.
8 to 14 years old.	29932	107.7	37	52.3	28.2	16.9	31.2
	29959	107.1	38	51.3	27.7	16.5	33.1
	29957	106.5	38.3	53.3	28.8	17.9	32.9
	29953	104.6	37.6	51.7	29.5	16.3	32.2
	28013	108.3	38.2	52.1	28.7	16.8	34.6
	29969	105.6	38	52.9	29	17.1	33.9
	29931	107.1	37.4	52.7	28.3	16.7	32.8
	28007	109	39.4	54.9	28.7	17.4	32.2
	29958	106.6	36.7	51.2	29.4	16.4	32
	29963	105.8	—	52.9	27.6	17.3	31.9
	28008	105.7	38.2	52.5	29.1	17	32.6
	28004	107	38.2	53.4	28.3	17.2	32.8
	28075	107.9	38.3	54.1	29.2	17	31.1
	29962	104.5	37.6	52.5	26.9	17.9	30.3
	28027	107	37.2	51.6	27.7	16.7	30.2
	Minimum	104.5	37	50.3	27	15.6	30.2
	Maximum	109	39.4	54.9	30	17.9	36
	Average	106.7	37.7	52.1	28.3	17.3	33.1

RATIOS: BASAL LENGTH OF SKULL = 100.

3 Males and 5 Females, Bache Peninsula.

	Total length.	Mastoid breadth.	Orbital breadth.	Postorbital breadth.	Palatal breadth.	Maxillary tooth row.
♂ 15599	107	39.4	57.5	31.5	17.6	33.4
♂ 15596	105.7	39.1	56.6	28.4	17.5	31.8
♂ 15583	106.4	40.3	56.3	28.8	18.3	33.2
Minimum	105.7	39.1	56.3	28.4	17.5	31.8
Maximum	107	40.3	57.5	31.5	18.3	33.4
Average	106.4	39.6	56.8	29.9	17.8	32.6
♀ 15680	106.4	39	51.6	29.5	17	35
♀ 15590	105.8	37.7	51.5	27.6	17.6	33.9
♀ 15681	105.4	38.3	50	28	17	33.7
♀ 15592	105.6	38.4	51.2	28.3	15.5	34
♀ 15683	105.3	38.8	—	26.2	17.2	33
Minimum	105.3	37.7	50	26.2	15.5	33
Maximum	106.4	39	51.6	29.5	17.6	35
Average	105.7	38.5	51.1	27.9	16.9	33.9

RATIOS: BASAL LENGTH OF SKULL = 100.

2 Males, Barren Grounds.

	Total length.	Mastoid breadth.	Orbital breadth.	Postorbital breadth.	Palatal breadth.	Maxillary tooth row.
♂ 16604	106.7	40.7	58.3	29.8	18	28.5
♂ 29042	108.4	39.1	57.3	31.3	17.1	29
♂ 11743	110.3	38.2	53.3	31	17.1	31.2
♂ 11744	111	38.8	56.8	32	18.3	32.7
♂ A	112.4	37	60.6	—	18	31.6
♂ B	111.1	40	—	—	16.9	29
Minimum	106.7	37	53.3	29.8	16.9	28.5
Maximum	114.4	40.7	60.6	32	18	32.7
Average	110.6	38.8	56.9	30.9	17.6	30.6
♀ 11746	107.7	36.6	51.3	30.1	18	33

RATIOS: BASAL LENGTH OF SKULL = 100.

5 Males and 2 Females, Wager Inlet, Hudson Bay.

	Total length.	Mastoid breadth.	Orbital breadth.	Postorbital breadth.	Palatal breadth.	Maxillary tooth row.
♂ 19346	110	39	57	30.2	16.8	29
♂ 19488	110	39	57.7	31.2	18	29.6
♂ 19487	109.4	39.2	58	31.4	17.9	31.2
♂ 19490	109	30.7	57	27.6	16.5	30.6
♂ 19489	107	37.6	56	27	16	27.3
Minimum	107	30.7	56	27	16	27.3
Maximum	110	39	58	31.4	17.9	31.2
Average	109	37.1	57.1	29.5	16.8	29.5
♀ 19345	104.3	36	51.6	28.5	17	30
♀ 1261	107	36.8	52.5	27.7	17.6	27.9

RATIOS: BASAL LENGTH OF SKULL = 100.

Averages for 31 males of Ovibos moschatus wardi, 6 males of O. m. moschatus, and 5 males of O. m. niphœcus.

	No. of specimen.	Total length.	Mastoid breadth.	Orbital breadth.	Postorbital breadth.	Palatal breadth.	Maxillary tooth row.
O. m. wardi Grant Land	31	107.9	39.4	57.3	30.8	17.5	31.9
O. m. moschatus Barren Grounds	6	109.1	38.8	56.9	30.9	17.6	30.6
O. m. niphœcus Wager Inlet	5	109.1	37.1	57.1	29.5	16.8	29.5

Secondary Sexual Differentiation.

Secondary sexual differentiation in muskoxen is manifested in the much smaller size of the female in comparison with the male, but especially in the less development of the horns and the correlated differences in the skull thus entailed.

Size. In the absence of external measurements, the present comparison is necessarily based on the skull. The skull is much smaller, and also weaker in structure, in the female than in the male. In total length the difference is not great, amounting to about 9 %, and to about 8 % in basal length, computed on the basis of the average size of the skull in the female. The sexual difference in the length of the toothrow is markedly less, being only 3.4 %; but the teeth are narrower and less massive in females. The nasal bones, while nearly as long in the female as in the male, are nearly 23 % narrower. The lower jaw is relatively, as well as absolutely, shorter and much slighter in structure than in the male, although the length of the toothrow is relatively greater.

The development of the orbital tube is far less in the female than in the male, the ratio of the orbital breadth of the skull to total length being about 7 % less in the female, due mainly to the less protrusion of the orbits.

The most striking sexual divergence is naturally in the horns, which are not only shorter and more slender in the female, but lack the enormous breadth at the base which forms so striking and exceptional a feature in the male. The average length of the horn, measured along the outer curvature, is in the male 127 % of the total length of the skull; in the female only 60 %. The breadth of the horn at its junction with the skull averages in the male 60 % of the total length of the skull; in the female only 20 %.

In consequence of the great development of the horns in the male the weight of the skull is much increased. The average weight of 23 adult skulls of females from northern Grant Land is 7 pounds; of 29 skulls of adult males from the same localities, 18 pounds, or about 266 % greater.

There are no available statistics regarding the entire weight of the animal in the two sexes, but in all probability it is about one third greater in the adult male than in the adult female.

Pelage. In adults the hair in both sexes grows to an enormous length, but it is relatively rather longer and heavier on the head and throat in the male than in the female. In other respects the pelage is similar in both sexes.

Coloration. The coloration is similar in both sexes up to about three years of age, but later in the white-faced forms the males become darker on the head than the females, through the enlargement of the horns at the base, which gradually thus encroach upon the white frontal area till often little of it is left.

II.— SYSTEMATIC REVIEW OF THE OVIBOS GROUP.

Historical Summary.

Discovery of Muskoxen.

The first account of the muskox was published in 1720, by Jérémie, a French officer who was in charge of Fort Bourbon, on the west coast of Hudson Bay at the mouth of Hayes River, from 1697 to 1714, when this French post was transferred to the English and renamed York Factory.[1] From this point (about latitude 57°) he made journeys northward and westward, and found muskoxen inhabiting the country between the Churchill River and Seal River (in latitude 58° to 60°). His account of the Hudson Bay country, in which he gives a description of the muskox, first appeared in a collection of voyages published at Amsterdam by Jean-Frédéric Bernard, and is entitled 'Relation du Détroit et de la Baye de Hudson.'[2] His account of the 'bœuf musqué,' or muskox, being the first published description of the animal, and the only one for the next seventy-five years based on actual observation, is here transcribed[3] in full, as follows:

"A 15. lieues de la riviére Danoise, se trouve la *Riviére du Loup-Marin*, parcequ'effectivement il y en a beaucoup dans cet endroit. Entre ces deux riviéres, il y a une espéce de bœuf que nous nommons *Bœufs-musquez;* à cause qu'ils sentent si forte le musc, que dans certaine saison de l'année il est impossible d'en manger. Ces animaux ont de très belle laine: elle est plus longue que celle des moutons de Barbarie. J'en avois apporté en France en 1708., dont je m'étois fait faire des bas qui étoient plus beaux que des bas de soye: j'ai même encore ici un petis reste de cette laine, que j'aurois l'honneur de vous envoyer, si je croyois que cela vous fit plaisir, pour en faire faire l'essai par d'habiles ouvriers.[4]

"Ces bœufs, quoique plus petits que les notres, ont cependant les cornes beaucoup plus grosses & plus longues. Leurs racines se joignent sur le haut de la tête, forment comme un gros bourlet, & descendent à côté des yeux presqu'aussi bas que la gueule. Ensuite le bout remonte en haut, qui forme comme un croissant. Il y en a de si grosses, que j'en ai vu, étant séparées du crane, qui pesoient les deux ensemble 60. livres.[5] Ils ont les jambes fort courtes, de maniére que cette laine traine toujours par terre lorsqu'ils marchent; ce que les rend si difformes, que l'on a peine à distinguer d'un peu loin de quel côté ils ont la tête. Il n'y a pas une grande quantité de ces animaux; ce qui feroit que les Sauvages les auroient beintot détriuts, si on en faisoit faire la chasse: joint à ce que, comme ils ont les jambes tres courtes, on les tue lorsqu'il y a bien de la neige, à coups de lance, sans qu'ils puissent fuir."

Jérémie's account of the muskox was republished nearly in full by Charlevoix[6] in 1744, from which source Jérémie's description of the muskox has usually been quoted.

Dobbs,[7] also in 1744, gave an abridged version of Jérémie's account of the muskox, which, as he omitted to give Jérémie as his authority, has passed current as based on original observation, whereas it evidently rests wholly on Jérémie. Ellis, who is also cited as an original source of information, merely made, in 1748, an incidental reference[8] to the habit of the Eskimos of

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[1] Dobbs, Arthur. An Account of the Countries adjoining to Hudson's Bay, etc., 1744, p. 18.

[2] Bernard's Recueil de Voyages au Nord, Vol. VI, 1720, pp. 1–52; nouvelle éd., Vol. III, 1732, pp. 305–356. Bœuf musqué, 1720 éd., pp. 9, 10; 1732 éd., 314, 315.

[3] From the 1732 edition, the 1720 edition not being at hand. A plate, facing p. 313, gives two figures, entitled "Bœuf Sauvage du Mississipy & de la Baie de Hudson." They show no feature of the muskox, but suggest the American bison.

[4] He appears, however, not to have taken either a skin or a skull of the muskox to France; at least he makes no reference in any part of his 'Relation' to having done so, nor is there any evidence that any skin or skull reached Europe before 1770.

[5] The average weight of a pair of horns, *with the skull*, in an adult male is about 18 pounds, and the maximum weight of skull and horns is about 26 pounds. Yet Jérémie's erroneous statement was repeated by most subsequent compilers, without question, for a century! The weight of an old male skull, in the flesh, with the horns, might approximate the weight given by Jérémie for the horns alone.

[6] Charlevoix, P. F. X. de. Journ. d'un Voyage dans l'Amérique septentrional, Vol. III, 1744, p. 132.

[7] Dobbs, Arthur. Account of the Countries adjoining to Hudson's Bay, etc., 1744, pp. 18 and 29.

[8] Ellis, Henry. A Voyage to Hudson's Bay, by the Dobbs Galley and California, in the years 1746 and 1747, etc., p. 232.

the Hudson Bay region of wearing a cap "made of the skin of a Buffalo's Tail" to "keep off the Musketoes." [1]

The narrative of the voyage of the ship 'California,' published in 1749,[2] states that a hunting party from the ship saw "three Buffaloes, a Bull Buffalo with two Cows," in August 1747, on the west coast of the northern part of Hudson Bay. They apparently killed some of them, as they took some of the flesh to the ship, and considered it "remarkable that the flesh of the Buffalo tasted Musk, and the Heart especially so very strong, that few could eat it." The animals are described as "much lower than a Deer, but larger bodied," and as having short legs and very long hair; and "the Bull's horns resembled an *English* Rams; they run a good pace, and climbed nimbly up the Rocks."

The second important contribution to the history of the muskox is the account by Hearne,[3] who, during the years 1769–1772, traversed the range of the muskox from the mouth of the Churchill River westward and northward to the mouth of the Coppermine River. His observations on its habits, distribution and molt are still of the highest interest and are quoted more or less fully in the present paper (see pp. 141, 163).

Through the continued prosecution of the search for the Northwest Passage during the first quarter of the nineteenth century much additional information was acquired respecting the range and life history of the muskox, so that Richardson,[4] in 1829, was able to give a good description of its external characters, and a quite full account of its habits and geographical distribution, as the latter was then known.

Its occurrence in Greenland was first established by Kane,[5] who found its recent remains in the vicinity of Rensselaer Bay, in about latitude 78°, in 1853, and later by Hayes,[6] who reported that two were killed near Wolstenholme Sound in the winter of 1859. They were found by the German Arctic Expedition of 1869–70 on the east coast of Greenland in about latitude 74°, and by Peary at Independence Bay, on the north coast in 1899. Subsequent explorations have established for it a continuous distribution on the Greenland coast from about latitude 78° on the west coast northward and eastward to about latitude 74° on the east coast. Its range on the east coast of North America has been found to extend from northern Ellesmere Land to the Arctic Ocean.

Introduction into Natural History Literature.

The first introduction of the Muskox into the literature of natural history as a distinct species was made by Pennant [7] in 1781, under the name 'Musk Buffalo,' primarily [8] on the basis of Jérémie's account, given above. Pennant's account is accompanied by a plate (pl. ii) in

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[1] Hearne corrects Ellis's statement by saying: "It is the hair from this part [throat and chest] that the Esquimaux make their musketto wigs, and not from the tail, as is asserted by Mr. Ellis; their tails and the hair which is in them, being too short for this purpose." HEARN (*l. c. infra*), p. 138.

[2] An Account of a Voyage for the Discovery of a Northwest Passage by Hudson's Streights, to the Western and Southern Ocean of America,....in the Years 1746 and 1747, in the Ship California, etc. By the Clerk of the California, Vol. II, 1749, p. 260. Cited as 'Clerk's Voyage,' by Pennant, in 1781, and later, by Pennant and others, as 'Drage's Voyage,' or 'Dragge's Voyage,' Dragge being the name of the 'Clerk of the California.'

[3] Hearne, Samuel. A Journey from Prince of Wale's Fort in Hudson Bay, to the Northern Ocean....in the Years 1769, 1770, 1771, and 1772. 4to, 1795, pp. 4, 31, 135–139.

[4] Richardson, John. Fauna Boreali-Americana, Vol. I, 1829, pp. 275–278.

[5] Kane, Elisha Kent. Arctic Exploration in the Years 1853, '54, '55, Vol. I, 1856, pp. 80, 81, 456.

[6] Hayes, I. I. The Open Polar Sea, 1867, p. 260.

[7] Pennant, Thomas. History of Quadrupeds, 1781, p. 71, pl. ii, fig. ii.

[8] There is also a reference to "Clerk's voy. ii, 260," which is the "Account of the Voyage of Discovery," etc., of the Ship California in the Years 1746 and 1747, by "the Clerk of the California" (= Dragge), as stated above, footnote 2.

which the lower figure (fig. 2) is designated "Musk B." [1] The text is a confused account of the American bison, and the figure was doubtless intended to represent that animal. It is obviously a fancy sketch; the general form is suggestive of a bison, but the head is surmounted by horns that strongly suggest those of the muskox; but they may be those of the Cape Buffalo, adapted from Buffon's figure of the horns "d'un buffle du cap Bonne-espérance." [2] Three years later, however, Pennant gave [3] a much fuller and better description of the muskox, founded in part (as before) on Jérémie, Dobbs, "Clerk" (now cited as Drage), and Ellis, but mainly, so far as its external appearance is concerned, on the skin of a female collected by Hearne and sent by him to Samuel Wegg, an officer of the Hudson's Bay Company in London. This was probably the first specimen of the muskox to reach Europe, and served as the basis of Pennant's plate of the female of this animal in the 'Arctic Zoölogy,' which was copied by many subsequent authors during the next half century. In this plate the female is in most respects properly represented and is the principal figure, the head and shoulders of the bull appearing in the left foreground, the bull being drawn as partly concealed by a cliff. The species is here designated 'Musk Buffalo,' and most of the information regarding its habits he obtained, as well as the skin, indirectly from Hearne through Wegg, and was previously unpublished.[4] Although Pennant's account contains irrelevant references to other species, under the impression that they were the same or closely related to the muskox, it is on the whole a very good description of the external characters of the female and of the general habits of the species.

Introduction into Systematic Zoölogy.

The Muskox was introduced into systematic zoölogy by Zimmermann [5] in 1780, under the name *Bos moschatus*. His diagnosis and synonyms are strictly pertinent to the muskox, being based entirely on Jérémie, though at second hand through Charlevoix and Dobbs. The type locality of the species is therefore the region adjoining Hudson Bay between the Seal and Churchill rivers (about latitude 59°).

In 1816 the muskox was first removed from the Linnean genus *Bos* by Blainville [6] who made it the exclusive basis of a new genus *Ovibos*. By many writers, however, it was still retained in *Bos* for many years, but for the last three fourths of a century the muskox has been known almost exclusively as *Ovibos moschatus*.

Pallas discovered comparatively recent remains of muskoxen in Siberia in the latter part of the eighteenth century, for which Hamilton-Smith,[7] in 1827, proposed the name *Ovibos pallantis*, and for which DeKay, a year later, proposed the name *Bos pallasi*, to which he also referred specimens from the United States that were later made the basis of a new genus *Bootherium* by Leidy in 1852. *Bootherium* was for many years referred by various writers to *Ovibos*, but in recent years American fossils of this type have been made the basis of two additional genera, *Symbos* Osgood, and *Liops* Gidley, while fossil muskox remains from Germany have been made

[1] The same plate appeared originally in 1771, in Pennant's 'Synopsis of Quadrupeds,' facing p. 8, and there designated "American B[ison]," with a passing reference (3 lines on p. 9) to the 'Musk ox,' with citations of "Dobb's Hudson's Bay 19.25," and "Clerk's Voy. II. 260," with the remark "seems to be the same with the above" (*i. e.*, American bison).

[2] Buffon, Compte de G. L. Leclerc, Hist. nat., XI, 1754, pl. xli.

[3] Arctic Zool., I, 1784, pp. 8–11, pl. vii.

[4] See Hearne, as cited above, p. 158. Hearne's work did not appear till 1795, eleven years later than Pennant's 'Arctic Zoölogy.'

[5] Zimmermann, F. A. W. Geogr. Gesch. des Menschen und der vierfusigen Thiere, Vol. II, 1780, pp. 86–88

[6] Blainville, H. M. Ducrotay de. Bull. Soc. Philom., May, 1816, p. 76.

[7] Griffith's Anim. Kingd., Vol. IV, 1827, p. 375.

the basis of a new genus *Præovibos*. A few years since the genus *Ovibos* was raised to the rank of a family, and the former *Ovibos moschatus* separated into five species and two genera, as will be noted in detail later.

Since 1899 young muskoxen have been taken alive on several occasions to Europe and to the United States, and quite a number of them still survive in confinement, there being six now living and in excellent condition in the New York Zoölogical Park, and others in different zoölogical gardens in Europe.

Geographical Distribution, Past and Present.[1]

Pleistocene.— During the Pleistocene the immediate progenitors of the existing muskoxen were distributed over a large part of northern Eurasia and Alaska, their remains having been found in England, France, and Germany and thence northward to the New Siberian Islands, and also at various points in northern Alaska and in northern Greenland and Grant Land. The earliest known of these remains, comprising two imperfect skulls, were discovered on the River Ob (or Obi) in Siberia by Pallas, and described by him [2] in 1773. The next earliest known were also found in Siberia, having been discovered at the mouth of the Lena River by Count Rouminatzow, and described and figured by Ozeretskovsky [3] in 1811. The genus *Ovibos* was thus first made known to science from fossil skulls found in northern Siberia, Pallas's description of these remains antedating Pennant's formal introduction of the Hudson Bay animal into natural history literature, on the basis of an actual specimen, by eleven years, while Pallas's and Ozeretskovsky's figures of the Siberia skulls long precede the first illustrations of the skull of the living *Ovibos moschatus*.[4]

According to Kowarzik,[5] remains of muskoxen had been found and recorded from 70 different localities in Europe and Asia prior to the end of the year 1908, as follows: Germany, 29; Siberia, 14; England, 11; European Russia, 7; Austria, 6; France, 3. These finds include, in some instances, more than a single piece, and collectively represent not only many skulls (always more or less incomplete), but numerous other parts of the skeleton, as vertebræ, ribs, bones of the extremities, teeth, and even horn-sheaths and hair. The richest finds have been at the New Siberian Islands and in Jana-Lande,[6] where 47 skulls and parts of skulls, 15 horn-sheaths, 5 lower jaws, numerous vertebræ and bones of the extremities, and hundreds of teeth have been obtained. It is also stated by Bunge, on the authority of a native, that the whole body of a muskox was once found on Laikhof Island after a landslide.

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[1] This outline is supplemented (*infra*) by annotated references in the bibliographic citations under the several species and subspecies.

[2] Pallas, Peter Simon. De Reliquiis Animalium exoticorum per Asiam borealem repertis complementum. Novi Comm. Acad. sci. imper. Petropolitanæ, Tom. XVII (pro anno 1772), 1773, pp. 576–606, tab. xvii. Tauri feri, pp. 601–606, description with measurements and three figures of the skull, pl. xvii.

[3] Ozeretskovsky, Nicol. "Rémarques sur le crâne du Bison musqué. Mém. de l'Acad. des. Sci. de St. Pétersbourg, Tom. III, 1811, pp. 215–219, pl. vi."

[4] Cuvier, in 1812 (Rech. Ossem. foss., IV, pt. 3, p 62), knew of the existence of neither a skin nor a skull in Europe, and appealed to English naturalists to secure skins of this animal, "et à donner des figures exactes de son crâne osseux, avec les dimensions."

[5] Kowarzik, Rudolf. Der Moschusochs im Diluvium von Europe und Asien. Verhandl. des naturf. Vereines in Brünn, Vol. XLVII, 1909, pp. 44–59.

Other earlier lists of localities where muskox remains have been found in Europe are: (1) Beyer, E., Zur Verbreitung der Tierformen der arktische Region in Europe während der Diluviumzeit, 1894 (muskoxen, pp. 28, 29). (2) Gréve, C. Situngsb. naturf. Gesel. Universität Dorpat, Vol. XII, 1901, pp. 371–374. (3) Staudinger, W. Centralbl. f. Min., Geol., u. Palaeont., Jahrg. 1908, pp. 498–502 (remains found in Germany).

[6] Bunge, A. Berträge zur Kentniss des russischen Reiches und der angrengenden Länder Asiens, Dritte Folge, Bd. III, St. Pétersbourg, 1887, p. 253, 254.

In Alaska muskox remains have been found at a number of widely scattered localities, as at Eschscholtz Bay (numerous specimens), where they were first discovered by Captain Beechey in 1826; in the Yukon Valley and near Point Barrow, where skulls have been found in such excellent preservation as to suggest the presence there of living animals within comparatively recent times, or that the skulls have been transported there from the Arctic coast east of the Mackenzie River by the natives on trading expeditions.

According to good authorities, the deposits in Europe which contain muskox remains indicate the presence of this animal in early, middle, and late Pleistocene times, and the condition of the remains varies at different localities from a highly mineralized state to a wholly fresh condition, with sometimes even the horn-sheaths well preserved. Owing to variations inevitably resulting from sex, age, and individuality, to the fragmentary condition of most of the skull material and the small number of skulls known, added to the difficulty of bringing any considerable part of the material together for direct comparison, it must for a long time render it difficult satisfactorily to differentiate the several forms or races that in all probability existed during the long period of time between the beginning and close of the Pleistocene period.[1] Prior to 1908 it was customary to refer all of the Eurasiatic and Alaskan Pleistocene remains of the muskox type to the existing *Ovibos moschatus*, although as early as 1827 Hamilton-Smith proposed the name *Ovibos pallantis* for the Siberian skulls described many years before by Pallas and Ozeretskovsky, on which DeKay one year later also based the name *Bos pallasii* (not *Bos pallasii* Baer, 1823). In 1830, Fischer de Waldheim based the name *Bos canaliculatus* on other muskox skulls found later near Moscow.

Subsequent authors have generally consigned these names to synonymy. Even the American forms for which Leidy in 1852 proposed the generic name *Bootherium* have frequently been referred to *Ovibos*. During the last few years, however, new names, both generic and specific, have been proposed for extinct forms of both the *Ovibos* and *Bootherium* groups (as noted below, p. 169).

RECENT.— Living muskoxen have been met with only in northern North America and Greenland. In North America the range of the muskox formerly nearly coincided with the southern border of the arctic tundra or barren-grounds, exending from the west coast of the northern half of Hudson Bay west to Great Slave Lake, and thence northward to the eastern arm of Great Bear Lake and the arctic coast eastward of Mackenzie River.[2] They were found by Parry in 1824 at Melville Island, and they have since been found to inhabit most of the known insular land areas thence eastward to Smith Sound, and northward from Ellesmere Land as far as land extends, including Heiberg Land, Grinnell Land, and Grant Land. They have never been found on Southampton Island, in Baffin Land, in Labrador, nor in Melville Peninsula.[3]

The first positive evidence of the presence of muskoxen in Greenland was discovered by Kane in 1853, when he found their recent remains near Rensselaer Bay, on the west coast, in about latitude 78°.[4] A few years later Hayes[5] confirmed their recent presence in this vicinity

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[1] Reference is made *infra*, p. 178, to Kowarzik's recent attempt to classify fossil muskoxen.

[2] The evidence of their recent occurrence along the Arctic coast of Alaska is considered in detail later. See *infra*, p. 188.

[3] See *infra*, under 'Species and Subspecies,' for more detailed statements, and map, facing p. 185.

[4] "The observations of our parties extended the range of the musk-ox (*Ovibos moschatus*) to the Greenland coast. None of us saw a living specimen; but the great number of skeletons, their state of preservation and probable foot-tracks, when taken in conjunction with the information of the Esquimaux, leave me no room to doubt but that these animals have been recent visitors." — KANE, ELISHA KENT, Arctic Explorations, Vol. 1, 1856, p. 456.

[5] Hayes, Isaac Israel. The Open Polar Sea, 1867, p. 390.

by finding a part of the head of a muskox that had apparently been used for food by the Eskimos, and was informed by his Eskimo hunter that they had formerly been numerous, and that the previous winter (1859–60) two had been seen and one killed near Wolstenholme Sound. They appear to have been soon after exterminated along this part of the coast, but have since been found further north along the west coast from Polaris Bay, latitude 81° north, to the most northern point of land on the Greenland coast. Their discovery by Peary at Independence Bay, in 1892 and 1895, saved the life of himself and party from starvation.

Muskoxen were first discovered on the east coast of Greenland, in latitude 74°, by the Second German North Pole Expedition in 1869, and their presence along the whole coast thence northwestward to Independence Bay has since been established. Their passage from Ellesmere Land, Grant Land, and Grinnell Land to the Greenland coast is practically uninterrupted, Smith Sound, Kennedy and Robeson Channels, which are very narrow and closed by ice in winter, offering no barrier to the movements of these hardy animals.

It is of interest to note that while the muskox in Greenland has been exterminated within the last seventy-five years from the southern part of its former range on the west coast, it has within about the same length of time extended its range southward along the east coast, having been found as far south as Scoresby's Sound, in about latitude 70°. A. G. Nathorst in 1899 found numerous herds, where in 1822 the Scoresbys, father and son, found none, although they made considerable journeys into the interior.[1] The following year Sabine found no muskoxen at Sabine Island, some four degrees further north where he spent two weeks, but where they have since been found in abundance. Hence it appears that the animal extended its range southward in the course of seventy or eighty years from latitude 75° to latitude 70°, due, it is thought, to the extinction of the Eskimos along this part of the coast during this interval.

The mainland range[2] of muskoxen has undergone considerable restriction during the last hundred years, on both its southern and western borders, and its numbers everywhere have likewise become much fewer through persecution by man. Formerly their chief enemies were the wolves and the Eskimos within its general range, and the Indians along its southern and western borders. Owing to the small number of their human foes the inroads upon the herds were usually not serious, although it was the custom of both the Eskimos and the Indians to annihilate the small herds which they attacked, the habit of the animals of huddling together for defense till the last member of a herd was killed rendering this easy of accomplishment. The white man, however, has proved their most deadly foe, thousands of these helpless animals having been necessarily killed for the support of the various Arctic exploring expeditions which have penetrated their range during the last three fourths of a century. The herds of Ellesmere Land, Grinnell Land, Grant Land, and East Greenland have suffered especially from these visitations, while along the Arctic Coast of the main land many have been killed by whalers, or by the natives in their interest.[3] In recent years enterprising sportsmen have considered their game

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[1] Conwentz, H. Zur Verbreitung des Muschusochsen und anderer Tiere in Nordost-Grönland. Verhandl. der Gesells. für Erdkunde zu Berlin, Bd. XXVII, 1900, pp. 427–432.

[2] Maps of the distribution of muskoxen in North America and Greenland have been published, as follows: Kartenskizze der jetzigen Verbreitung des Moschusochsen, by A. G. Nathorst in Conwentz's 'Zur Verbreitung des Moschusochsen und anderer Tiere in Nordost-Grönland'. Verhandl. der Gesels. f. Erdkunde zu Berlin, Bd. XXVII, No. 8, 1900, pp. 427–432 (map, p. 428).

Hornaday, William T. American Natural History, 1904, pp. 103–107, with map.

Preble, Edward A. North American Fauna, No. 27, 1908, pp. 150–155, with map (p. 151). Preble gives a summary of observations on the localities of occurrence of muskoxen as noted by explorers of the Canadian barren-grounds, mostly in chronological sequence.

[3] See *infra*, pp. 185, for details.

list incomplete without the inclusion of a few muskox heads among their trophies, either from the barren-grounds of the interior or from inhospitable Ellesmere Land.

Even in the eighteenth century, muskoxen, owing to the barren nature of their habitat, appear to have been nowhere very numerous and of rather local occurrence. Hearne, who in the years 1769 to 1772, made a journey from Prince of Wales Fort, on the west side of Hudson Bay, to the mouth of the Coppermine River, and thus travelled throughout this long distance through muskox country, thus speaks of their numbers at this early date:

"Early in the morning we crawled out of our holes, which were on the North side of the Stony Mountains [shown by his map to have been in the Coppermine River country], and walked about eighteen or twenty miles to the North West by West. In our way we crossed part of a large lake on the ice, which was then far from being broken up. This lake I distinguished by the name of Buffalo, or Musk-Ox Lake, from the number of those animals that we found grazing on the margin of it; many of which the Indians killed, but finding them lean, only took some of the bulls' hides for shoe-soles.... This was the first time we had seen any of the musk-oxen since we left the Factory [Prince of Wales Fort]. It has been observed that we saw a great number of them in my first unsuccessful attempt, before I had got an hundred miles away from the Factory; and indeed I once perceived the tracks of two of those animals within nine miles of Prince of Wales's Fort. Great numbers of them also were met with in my second journey to the North: several of which my companions killed, particularly on the seventeenth of July one thousand seven hundred and seventy. They are also found at times in considerable numbers near the sea-coast of Hudson's Bay, all the way from Knapp's Bay to Wager Water [Wager Inlet of modern maps], but are most plentiful within the Arctic Circle. In those high latitudes I have frequently seen many herds of them in the course of a day's walk, and some of those herds did not contain less than eighty or an hundred head. The number of bulls is very few in proportion to the cows; for it is rare to see more than two or three full grown bulls with the largest herd: and from the number of the males that are found dead, the Indians are of opinion that they kill each other in contending for the females[1]. ... They delight in the most stony and mountainous parts of the barren ground, and are seldom found at any great distance from the woods. Though they are a beast of great magnitude, and apparently of a very unwieldly inactive structure, yet they climb the rocks with great ease and agility, and are nearly as sure-footed as a goat; like it too, they will feed on anything; though they seem fondest of grass, yet in Winter, when that article cannot be had in sufficient quantity, they will eat moss, or any other herbage they can find, as also the tops of willows and the tender branches of the pine tree."—HEARNE, *l. c.*, p. 136.

As already stated (*antea*, p. 157) muskoxen were first met with by Europeans on the west coast of Hudson Bay, between the Churchill and Seal Rivers, but they seem, judging from the various accounts of that region that have come down to us, never to have been very numerous there and rarely seen in the country immediately bordering Hudson Bay, nor do their products often appear in the lists of the Hudson's Bay Company's shipments of peltries. Furthermore, this seems to have been about the southern limit of their range in this region, from which they have long since been extirpated. They are rarely found now in the Hudson Bay region south of Chesterfield Inlet, at the northwest corner of Hudson Bay. The most southern recorded limit of their range in the interior seems to have been about latitude 60°, in the region of Great Slave Lake.

Muskoxen appear to be perfectly adapted to their arctic environment, where there is seemingly a limited supply of food for their nourishment, and for half the year the temperature is far below zero (Fahrenheit). Their abundant coat of long overhair with its thick lining of the softest wool evidently forms ample protection for them against the combined effect of protracted gales of wind and a temperature of even — 50°. In winter they are always found in good condition, but sometimes become very lean in summer. Even in winter food in sufficient quantity seems to be readily accessible to them. Says Peary, after many years of experience in muskox country in Grinnell Land and Grant Land: "I am often asked how the wild herbivorous animals,

[1] This has not been the experience of later observers although it has been noted that at certain seasons of the year the bulls leave the herds to a considerable extent and wander singly or a few together.

like the musk-ox and the reindeer, survive the winter in that snow-covered land. By a strange paradox, the wild winds that rage in that country help them in their struggle for existence, for the wind sweeps the dried grasses and scattered creeping willows bare of snow over great stretches of land, and there the animals can graze." [1]

Muskoxen are not in a true sense migratory, but wander more or less in search of suitable feeding grounds, although they were found at Melville Island on Parry's First Voyage [2] only in summer, and were observed to arrive from the south in May and depart in September.[3] Peary found them along the northern coast of Grinnell Land both in winter and in summer, and in March, 1910, some of his party killed muskoxen in Andrup Land, the most northern point of Greenland, and also the most northern known land.

Classification and Relationships.

The affinities of few mammals have given rise to so much discussion as have those of the muskoxen. Most early writers, and particularly the many explorers who have seen them alive in their native haunts, have noted their resemblance to cattle, as implied by such names, chosen for their designation, as Bœuf musqué, Buffle musqué, Bison musqué, Musk-ox, Musk Bison, and Musk Buffalo, while the name Musk Sheep seems never to have been used for them till so employed by Dawkins in 1867. Systematists formerly always referred them to the Linnæan genus *Bos*, and never to *Ovis*, many of them till long after Blainville, in 1816, provided them with the special genus name *Ovibos*, in recognition of certain sheep-like resemblances that he, in part erroneously, ascribed to them. They have, however, often been referred to as an intermediate type between sheep and oxen, while generally recognized as most nearly allied to the latter.

Blainville is in large part responsible for the belief that muskoxen are more nearly related to sheep than to oxen. His misleading diagnosis of *Ovibos* [4] is as follows:

"g. XI. *Ovibos*. Car. Cornes simples lisses, à double coubure, dans les deux sexes, larmiers nuls, brosses nulles, pores inguinaux? queue courte, 2 mammelles, poiles longs, laineux, point de mufle.

"Esp. B. Moschatus."

This is followed on a later page by a description "d'un individu mâle du Bœuf musqué, conservé dans la collection de M. Bullock," in which he says ". . . . il a en général plus de resemblance avec un gros mouton qu'avec un bœuf. . . . il n'y a aucune trace de mufle, c'est- a-dire de partie nue a l'extrémité du museau, en sorte que par cette disposition cet animal des moutons que des bœufs." There are thus in his diagnosis and description two alleged sheep characters ascribed to the muskox which it does not possess, namely, (1) "2 mammelles" instead of 4; (2) no trace of a muffle, whereas a portion of the muzzle is naked, not wholly clothed as in the sheep. Notwithstanding Blainville's dictum, most systematists continued for nearly fifty years to classify the muskox with the oxen and not with the sheep.

Owen, in 1856, in his description of a fossil cranium "of the Musk-Buffalo" found at Maidenhead, England,[5] referred the muskox to the genus *Bubalus* (*Buffelus*), regarding it as merely

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[1] Peary, Robert E. The North Pole, 1910, p. 183.

[2] Sabine, Edward. Parry's First Voyage, 1824, App., p. clxxxix.

[3] They are now known to pass the winter there. See *infra*, p. 201.

[4] Blainville, H. de. Sur plusiers espèces d'animaux mammifères, de l'ordres des ruminans. Bull. des Sci. par la Soc. Philomat. de Paris, année 1816, pp. 73–82. *Ovibos*, p. 76; Bœuf musqué, pp. 81, 82.

[5] Owen, Richard. Description of a Fossil Cranium of the Musk-Buffalo (*Bubalus moschatus*, Owen). . . . from the 'Lower-Level Drift' at Maidenhead, Berkshire, England. Quart. Journ. Geol. Soc. London, Vol. XII, 1856, p. 124.

specifically different from the Cape buffalo, but this conclusion did not receive the approval of subsequent authors. His view of its affinities is thus expressed: "....the Musk-Buffalo seems to have been subgenerically separated without due grounds from the *Bubali*, and especially from the Cape Buffalo (*Bubalus caffer*), under the misguiding term *Ovibos;* its peculiar affinities amongst the Ox-tribe to the Sheep being by no means obvious: for the woolly covering beneath the coarser hair of the Musk-buffalo is a purely adaptive modification for an arctic climate, like that which the extinct northern Elephant and Rhinoceros presented." Owen was quite justified in speaking of *Ovibos* as a "misguiding term."

In 1867, Dawkins [1] claimed that the position assigned it by Blainville and others, as "intermediate between *Ovis* and *Bos*, is proved both by the natural history and the osteology of the animal," and proceeded to enumerate the characters which he thought allied it on the one hand to *Bos* and on the other to *Ovis*. Most of the osteological characters he gave as allying it to the sheep prove, however, to have been erroneously assigned, they being equally present in the genus *Bison*. Later,[2] on the basis of further erroneous assumptions, as the possession of two teats and no trace of a muffle, he decided to "relegate it to the ovine or caprine group of mammals" (*l. c.*, p. 2). His opinion, however, was not generally accepted, and *Ovibos* has since been commonly associated with the Bovinæ [3] as before.

Turner,[4] as early as 1850, was impressed with the distinctness of *Ovibos* from its nearest affines, thus foreshadowing the exaggerated valuation of the really slight differences that separate it from some of the other Bovidæ. In regard to its relationships he says it is "as nearly, if not more allied to the Sheep [than to the Ox], but should most properly stand alone." Rütimeyer, in 1867,[5] placed it next to *Bubalus* and *Bison*, but in 1878 [6] he seemed inclined to agree with Dawkins and place it among the sheep. Milne-Edwards, in 1868–70,[7] found certain analogical resemblance, between *Ovibos* and *Budorcas*, but he evidently based his comparison of *Budorcas* with *Ovibos* on figures of the latter and not upon a direct comparison with specimens. But Matschie,[8] in 1898, claimed that *Budorcas* bears a close relationship to *Ovibos*, and proposed for these two genera "eine besondere Gruppe Ovibovinæ," to consist exclusively of *Ovibos* and *Budorcas*, stating that they have certain characters in common, as the flat and broad form of the metacarpus, the shape of the skull and form of the horns, the small size and unusual shape of the ears, the character of the muzzle, the short tail, the thick, short limbs and large dew-claws. Although there is a superficial resemblance between the two forms in a few details, a careful comparison of the two fails to establish, in the opinion of the present writer, any near relationship, either in external or osteological characters.

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[1] Dawkins, W. Boyd. *Ovibos moschatus* (Blainville). Proc. Roy. Soc. London, Vol. XV, 1867, pp. 516–517; Ann. and Mag. Nat. Hist., 3d Ser., Vol. XX, 1867, pp. 139, 140.

[2] British Pleistocene Ovidæ. *Ovibos moschatus* Blainville. Palaeont. Soc., Vol. XXV, pt. 5, 1872, pp. 1–20, pll. i–iv.

[3] I have been unable to trace the source of Dawkins's misinformation that muskoxen have only two teats, unless he took it from Blainville, as above. Ogilby (Proc. Zool. Soc. London, 1836, p. 137) gave the following diagnosis of *Ovibos:* "Sinus lachrimalis nulla.... Mammæ quatuor." And the number of teats has since repeatedly been given as four, on the basis of first-hand knowledge. Yet, as will be noticed below, the statement has been made that the Barren Ground animals have only two and all others four. When Ogilby wrote, muskoxen were known only from the Barren Grounds and Melville Island, which latter locality they were supposed to visit only on their summer journeys north.

[4] Turner, H. N., Jr. On the generic subdivisions of the Bovidæ, or Hollow-horned Ruminants. Proc. Zool. Soc. London, 1850, pp. 164–178. (*Ovibos*, p. 177.)

[5] Rütmeyer, L. Verhandl. naturf. Gesel. Basel, Vol. IV, 1867, p. 328.

[6] Abhandl. der schwitz. paläont. Gesel., Vol. V, 1878, p. 104.

[7] Milne-Edwards, H. and A. Recherches pour servir à l'Hist. nat. des. Mamm., 1868–74. Genus *Budorcas*, pp. 367–377, pll. lxxiv–lxxix.

[8] Matschie, Paul. Die systematische Stellung von *Budorcas* Hodg. Sitzungsb. d. Gesel, naturf. Freunde Berlin, Jahrg. 1898, pp. 30–31.

An important contribution to our knowledge of the anatomy of the muskox was made by Lönnberg in two papers published in the 'Proceedings' of the Zoölogical Society of London, which deal with its soft anatomy as well as with its osteology.[1] He also is deeply impressed with the morphological isolation of *Ovibos*, but he fails to find any near relationship to *Budorcas*. He says: "Taken together, all seem to prove that the soft anatomy of the Musk-ox not only does not speak for its affinity with the Sheep, but even plainly prohibits its inclusion in the same group ....But, to judge from its soft anatomy, the Musk-ox is entitled to form a subfamily of its own, at least *pro tempore*, as well defined as the Caprinæ or the Bovinæ" (*l. c.*, pp. 166, 167). He adds later (*l. c.*, pp. 717–718); "The resemblance between *Budorcas* and *Ovibos* is only superficial.... Under these circumstances....I suppose that Matschie's attempt at classing *Ovibos* and *Budorcas* together in one and the same group '*Ovibovinæ*' must be regarded as a failure. A subfamily with such a name can, of now living animals, only include *Ovibos* alone."

Regarding the number of teats in *Ovibos* Lönnberg states that "both males and females, normally have four well-developed teats....The alleged presence of only two teats has been regarded as an evidence for allying *Ovibos* with the Ovine Ruminants. The opposite view is perhaps, proved by the existence of four teats" (*l. c.*, p. 163).

In 1907, Knotterus-Meyer[2] constructed his "Fam. XXII, Obovidæ," of the genera *Ovibos* *Budorcas*, and *Connochætes*, each genus being awarded the rank of a subfamily, respectively, as follows: Ovibovinæ, Budorcatinæ, Connochætinæ (*l. c.*, pp. 81–85, 95, 96, and 142, 143). He also proposed a new classification of the order Artiodactyla, based primarily (in large part exclusively) on the os lacrymale! As an indication of his valuation of characters it may be noted that the Ruminants alone are divided into 23 families and 40 subfamilies, and that, in addition to the revival of many hitherto obsolete genera, 8 new ones are proposed for antelopes. Furthermore, the North American pronghorn (*Antilocapra*), usually ranked as a family without close alliances, is made a subfamily of the family Giraffidæ!

The three genera *Ovibos*, *Budorcas* and *Connochætes* have not many characters in common that are not shared by other genera of Ruminants, and have others, of far higher importance, that are not shared mutually. Figures of the skulls of each of these genera are shown in Knotterus-Meyer's pl. V, and these alone serve to show how widely the structure of the facial portion of the skull differs in each, to say nothing of the diverse types of horn structure they each present. *Budorcas* and *Connochætes*, as well as *Ovibos*, are well represented in the American Museum by not only mounted specimens but by skeletons and by both young and adult skulls. An examination of this material seems to warrant the assumption that *Ovibos* does not find a near affine in *Budorcas*, and much less in *Connochætes*. Indeed, Owen was not so far astray as some of his critics have assumed when he found what he supposed to be a near ally of *Ovibos* in *Bubalus* (*Buffelus*), but he was of course quite wrong in referring the Cape buffalo and the muskox to the same genus.

It seems very strange in going over the literature on the relationships of *Ovibos* to find nowhere a direct comparison of this genus with *Bison*, and rarely the faintest allusion to *Bison* in any such connection. Osgood (*l. c.* p. 178) is the only author known to me who has made any very direct comparison between *Ovibos* and *Bison*. As regards the skull of *Ovibos*, the horns excepted, there is a close resemblance at all ages between it and the skull in *Bison*. In young animals up

[1] Lönnberg, Einar. (1) On the Soft Anatomy of the Musk-Ox (*Ovibos moschatus*). Proc. Zool. Soc. London, 1900, pp. 142–173, text cuts 1–14. (2) On the Structure and Anatomy of the Musk-Ox (*Ovibos moschatus*). *Ibid.*, pp. 686–718, text cuts 1–10.

[2] Knotterus-Meyer, Theodor. Über das Tränenbein des Huftiere. Vergleichend-Anatomischer Beitrag zur Systematik der rezenten Ungulata. Arch. fur Naturgeschichte, Jahrg. LXXIII, Bd. 1, 1907, pp. 1–152, pll. i–v, text figs. 1–34.

to about two years of age, or before the horns in *Ovibos* begin to turn downward, there is not only a striking resemblance in the general form and proportions of the skull in these two genera but in the structure and relations of its component bones, a resemblance far closer even than between *Bison* and *Bos*, which groups, however, Knotterus-Meyer proposes to arrange in separate subfamilies. The dentition is also practically the same — as nearly so as can be found between any two recent genera of the Bovidæ. The general form of the body and limbs in *Ovibos* and *Bison* is strikingly similar, so much so that non-scientific observers have many times regarded the muskox as a small bison rather than a sheep; and this external resemblance is borne out by the internal structure. Among the distinctive features of the muskox are the protruding orbits, which are nearer those of a bison than of any other Ruminant, and may be regarded as differing in the two only through greater specialization in *Ovibos*. The horns in the old males of *Ovibos* are also highly specialized through their great basal breadth and peculiar curvature, but there is an approach to this in the horns of old males in *Buffelus* (formerly *Bubalus*), as long ago noted by Owen (*cf. antea*, p. 164). The muskox has practically no tail, its vestigial tail being wholly hidden by the long hair of the rump,— an adaptive feature correlated with the tremendously elongated fleece. So far as this character goes, *Ovibos* is less divergent from *Bison* than it is from *Connochætes*. The long hair of the head, throat and shoulders, and the thick layer of woolly under-fur in *Bison* is simply greatly exaggerated in *Ovibos*, in accordance with its Arctic environment. The restricted naked area of the muffle in *Ovibos*, as compared to that of most other Bovinæ, can easily be regarded as an environmental modification in correlation with the general enormous increase of the protective hairy covering, and not a morphological modification toward the hairy muffle of the sheep. In regard to the teeth, the accessory columns of the inner angles of the molars are present as in *Bison*, *Bos*, *Buffelus*, *Scaphos*, and other bovine genera, though rather less developed, and not absent as in *Ovis*, *Budorcas*, *Connochætes*, and in the goats and antelopes. While the nearest living relative of *Ovibos* is the genus *Bison*, it is still more nearly related to *Scaphos* (=*Scaphoceros*), as has been clearly shown by Osgood.[1]

Prior to the appearance of Knotterus-Meyer's new scheme for classifying the Ruminants, *Connochætes* had been placed with the antelopes in the subfamily Bubalinæ of the family Bovidæ, the Bubalinæ including the three genera *Connochætes*, *Bubalis*, and *Damaliscus*. So far as cranial characters go there is a striking resemblance between *Connochætes* and *Bubalis*, and their general structure fully bears out this resemblance. The divergence of *Connochætes* from *Ovibos* is not only almost antithetical in skull structure and dentition, but in external form there could not well be greater diversity. A more arbitrary and heterogenous association of the three genera *Connochætes*, *Ovibos*, and *Budorcas* in one family could not well be devised. Between *Budorcas* and *Ovibos* there is a superficial resemblance in the enlarged base of the horns, but in dentition and in the general form and proportions of the skull — the narrow facial portion and spatulate rostrum, short and weak toothrow and absence of the accessory cusp on the inner side of the molars in *Budorcas*, contrasted with just the opposite conditions in *Ovibos* — there is almost the widest possible dissimilarity. These are also differences of profound significance in comparison with the varying modifications of the lacrymal in even closely allied forms, and the wide individual differentiation of its form in the same subspecies, already shown to obtain (*antea*, p. 147) in *Ovibos moschatus wardi*. There is thus in Knotterus-Meyer's classification of these three genera a

[1] Osgood, Wilfred H. *Scaphoceros tyrrelli*, an extinct Ruminant from the Klondike Gravels. Smithson. Misc. Coll., quart. issue, Vol. XLVIII, pp. 173–185, pl. xxxvii–xlii, July 1, 1905.

strange estimate of the weight or value of characters. Indeed, it is surprising that at this late day a system of classification should be offered on the basis of a single character, which is also one of rather small value in comparison with the many of far greater weight that are practically ignored in this new arrangement. It may be noted that we also have here a new valuation of groups, which may be illustrated by reference to the genera commonly of late years placed in the family Bovidæ. Flower and Lydekker, in 1891,[1] were perhaps ultra-conservative in failing to recognize subfamilies among the Bovidæ. They state: "There is scarcely any natural and well-defined group in the whole class [of mammals] which presents greater difficulties of subdivision than this [the Bovidæ];. . . . For the present the genera provisionally adopted may be arranged under a number of sections or groups which some writers regard as subfamilies." But Trouessart's classification, published in 1905,[2] may be regarded as fairly reflecting the current usage of practically the date (1907) of the Knotterus-Meyer system. Trouessart[3] divided the family Bovidæ into 10 subfamilies while Knotterus-Meyer makes of the same group 23 families and 40 subfamilies. Trouessart's subfamily Bovinæ is raised to the rank of a family and divided into the three subfamilies Buffelinæ, Bisontinæ, Bovinæ. On this scale of subdivision *Ovibos* might be added as the sole living member of a fourth subfamily Ovibovinæ; but I fail to see that this scale of subdivision is either necessary or desirable.

Furthermore, his diagnoses of groups are not always correct, as where, in the case of *Ovibos*, he asserts, contrary to previous investigators, that *Ovibos* has no lacrymal pit. This error has already been pointed out by Kowarzik,[4] who also objects emphatically to the inclusion of *Connochætes* and *Burdorcas* and *Ovibos* in the family Ovibovidæ, which he would retain as a full family or subfamily exclusively for *Ovibos*. He thus agrees with Lönnberg in ascribing to *Ovibos* a high taxonomic value, a proceeding that appears to me wholly uncalled for, unless we are to ascribe family rank to every well differentiated genus. It is my conviction that the proper classification of *Ovibos* is as a genus of the subfamily Bovinæ, with the genus *Bison* as its nearest affine among existing mammals, and *Buffelus* not far removed.

Kowarzik (*l. c.*, p. 107), however, through a most singular oversight in respect to the presence or absence of a tear pit (Tränengrube) in the different subspecies of *Ovibos moschatus*, divides the muskoxen into two sharply separated groups, an eastern and a western, the latter consisting of the form inhabiting only the barren-grounds east of the Mackenzie River. These groups he says[5] stand as far apart in certain ways as *Bos* and *Ovis*! In a later paper he proposes to recognize these two groups as full genera.[6] He restricts the name *Ovibos* to the western group, represented by *O. mackenzianus* Kowarzik, and places the other four species he recognizes (including *Ovibos moschatus* Kowarzik, emend.) in a new genus *Bosovis*. The main basis for this radical division is the alleged absence of a lacrymal pit (Tränengrube) and the presence of only two teats in *Ovibos* and the presence of a lacrymal pit and four teats in *Bosovis*. In the skulls of *Ovibos* examined by me in the present investigation are a number from the type region of *Ovis mackenzianus* (vicinity of Great Bear Lake), and I find the 'Tränengrube' just as well developed

[1] Flower, W. H., and R. Lydekker. Introduction to the Study of Mammals, living and extinct, 1891, p. 334.

[2] Osborn, in 1910, recognized 11 subfamilies, he giving the genus *Ovibos* the rank of a subfamily.— Osborn, Henry Fairfield. The Age of Mammals in Europe, Asia and North America, 1910, pp. 553–555.

[3] Trouessart, E.-L. Catalogus Mammalium tam viventium quam fossilium, quinq. suppl., 1904–05, pp. vi, 713–747.

[4] Kowarzik, Rudolf. Das Tränenbein von *Ovibos moschatus* Blainv. Zool. Anzeiger, Bd. XXXVII, pp 106, 107, Feb. 14, 1911.

[5] Kowarzik, Rudolf. Der Moschusochs und seine Rassen. Zool. Anzeiger, XXXIII, pp. 616–618, Nov. 10, 1908. An advance abstract of his larger memoir under the same title published in Dr. F. Römer's Fauna Arctica, Bd., V., 1ste Lief., 1910, pp. 85–126, pl. i, text figs. 1–16.

[6] Zool. Anzeiger, 1911, p. 107.

in these as in my large series of *O. moschatus wardi* from Grant Land; *and both of his two groups have four teats.* These two forms (*mackenzianus* and *wardi*) present only minor differences barely sufficient to warrant their separation as subspecies.[1]

The nearest relative of *Ovibos* appears to be, as first pointed out by Osgood, the extinct genus *Symbos* (*Bootherium*, in part, of Leidy). *Symbos* may have been its immediate progenitor, or both may have originated from a still earlier type, in common with *Bootherium* (sens. stric.) and *Bison*. It is not probable, however, that the ancestor of the *Symbos-Ovibos-Liops* group is to be looked for in either the recently described genus *Uceratherium* Sinclair and Furlong,[2] or in the genus *Preptoceras* Furlong,[3] from the Quarternary caves of California, neither of which is nearly related to either *Symbos* or *Ovibos*.

As no probable immediate Eurasian ancestor of *Ovibos* has been discovered, it seems reasonable to assume that *Ovibos* originated in America and spread thence to northern Asia and Europe.

Comparison of Ovibos with Symbos.

A nearly complete male skull of *Symbos* (*Bootherium*, part Leidy), from Hebron, Indiana, recently received by the Department of Vertebrate Palæontology (No. 14365), furnishes the means of direct comparison of this extinct type with an abundant series of skulls of *Ovibos*. The *Symbos* skull (*S. cavifrons*) is one of the most nearly complete of any of the skulls of this genus thus far discovered, it lacking only the lower jaw, the tip of the right maxillary, the anterior two thirds of the nasals, the premaxillaries, and the teeth except m^2 of the right side. The portion preserved is not at any point abraded or weathered, but everywhere presents as natural a surface as a recent skull. It is dark brown and heavily mineralized and has the appearance of having been preserved in a peat-bog, without subjection to wear by transportation before it became buried.

Its close relationship to *Ovibos* is apparent at a glance, and a detailed comparison of the two types confirms this impression. There are, however, many cranial differences between *Symbos* and *Ovibos*, as in the relative length, breadth, and depth of the skull, and the much less specialization of the orbits in *Symbos*. The single tooth preserved (m^2) differs mainly in size from the corresponding tooth in *Ovibos*. The sutures of the skull are obliterated in about the same degree and in the same regions as in old skulls of *Ovibos*.

A striking feature of the *Symbos* skull, as shown in the accompanying illustrations (Plates XVI–XVIII), is its great depth in proportion to its breadth, and also its great length, as compared with *Ovibos*, as represented by a large old male *Ovibos* skull from Grant Land (No. 28009). The length in *Symbos* from the occipital tubercle to the tip of the maxillary is 40 mm. greater than the total length of the skull in *Ovibos*, and 87 mm. greater than the corresponding measurement in *Ovibos*. The maxillary toothrow is 26 mm. longer than in *Ovibos* (178 and 152 mm. respectively). On the other hand, the mastoid breadth is 3 mm. more than in *Ovibos*, while the postorbital

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[1] Further comment on Kowarzik's papers will be made later in treating of the subspecies of *Ovibos moschatus*.

[2] Sinclair, William J., and E. L. Furlong. *Euceratherium*, a new Ungulate from the Quarternary Caves of California. Bull. Depart. Geol., Univ. California, Vol. III, pp. 411–418, pll. l, li, June, 1904.

Sinclair, William J. New Mammalia from the Quarternary Caves of California. Bull. Depart. Geol., Univ. California, Vol. IV, pp. 145–161, pll. xix–xxiii, July, 1905.

[3] Furlong, Eustace L. *Preptoceras*, a new Ungulate from the Samuel Cave, California. Bull. Depart. Geol., Univ. California, Vol. IV, pp. 163–169, pll. xxiv, xxv, July, 1905.

breadth is 17 mm. less, the orbital breadth 25 mm. less, and the breadth of the occipital condyles 15 mm. less.

A notable feature in *Symbos* is the narrowness of the occipital portion of the skull in comparison with the great breadth of the facial region. As just shown, the occipital region is narrower than in *Ovibos*, notwithstanding the much greater size of the skull. In *Symbos* the breadth at p^2 is 129 mm. as against 90 in *Ovibos* — a difference of 29 mm. In *Symbos* the width of the palate at m^1 is 93 mm., in *Ovibos* 82 mm.

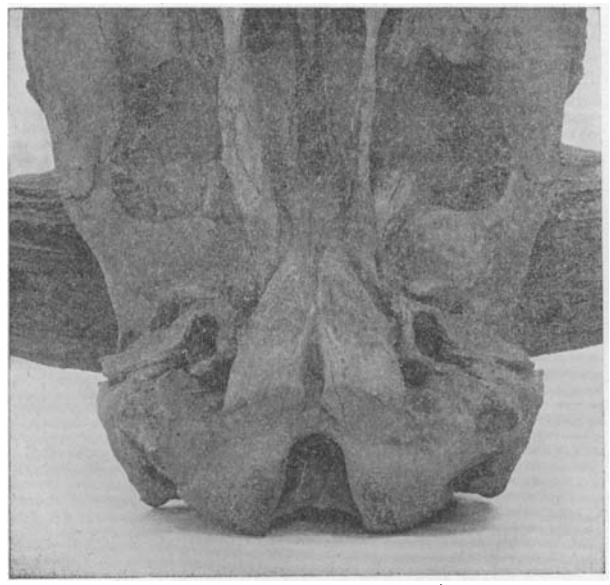

Fig. 25. *Symbos cavifrons* (Leidy), old ♂. No. 14365, Depart. Vert. Palæontology, Hebron, Indiana. Basi-occipital region, for comparison with *Ovibos*, $\frac{3}{5}$.

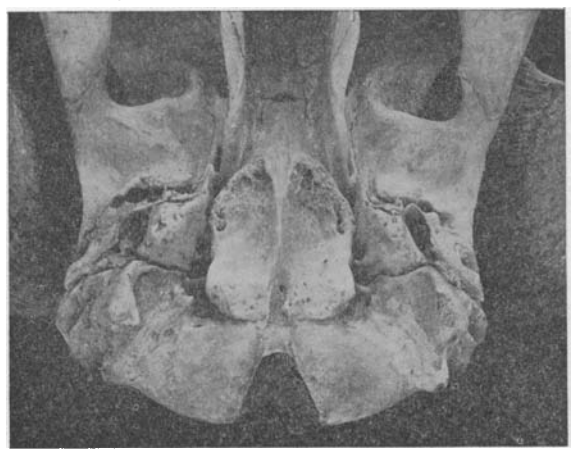

Fig. 26. *Ovibos moschatus niphœcus*. No. 19490, ♂, about 8 years old, Wager Inlet, Hudson Bay. Basioccipital region, for comparison with *Symbos*. $\frac{1}{3}$.

Another notable feature, as mentioned above, is the great depth of the skull in *Symbos* in comparison with *Ovibos*. In *Symbos* the skull is deep and narrow, in *Ovibos* broad and shallow, the occiput having a depth of 180 mm. in the former as against 130 mm. in *Ovibos*, and the frontal region at m^2 has a depth respectively of 148 and 132 mm.

The horncores are also markedly different in the two forms, being relatively much longer in *Symbos* than in *Ovibos*, with the curvature uniformly downward and outward instead of abruptly downward as in *Ovibos*. In the former the horncores have a length, following the curvature and measured from the dorso-median line of the skull to the tip, of 401 mm. as compared with 305 for the same measurement in *Ovibos*. The horncores differ much in form at base, or where they join the skull, in the two types, they being much less flattened dorso-ventrally in *Symbos*. In *Ovibos* they expand abruptly anteroposteriorly just before their junction with the skull, over the top of which they extend as a broad exostosis nearly, but not quite, to the median line. In *Symbos* the area broadened by exostosis at the base of the skull does not extend laterally much beyond the border of the skull, but much further both anteriorly and posteriorly, and also medially, so that the exostoses of the two horncores meet and coalesce throughout their basal extent, and the supra-parietal deposition of bone is thicker and more massive than in *Ovibos*. In the latter the exostoses at the base of the two horncores never quite meet, and hence do not coalesce.

The orbits also show much differentiation in the two forms, they being much more specialized in *Ovibos*. In *Symbos* they are not much more protrusive than in *Bison*, while they are greatly developed in *Ovibos*. The breadth at the outer border, both anteroposteriorly and vertically, is greater in *Symbos* than in *Ovibos*, but this difference is correlative with the size of the skull in the two genera.

There are also important differences at the base of the skull, the basioccipital being relatively much narrower in *Symbos*, which also lacks entirely the prominent lateral process seen in *Ovibos* between (and adjoining) the condyles and the paroccipital processes. As clearly shown in Figs. 25 and 26, the basioccipital differs widely in the two forms, being divided by a median furrow, deepening and broadening posteriorly in *Symbos*. This furrow is replaced in *Ovibos* by a heavy median ridge, which often becomes high and sharp in old males.

Comparative Measurements of the Skull in Symbos and Ovibos in Males of corresponding age.

	Symbos.	Ovibos. No. 28009.
Occipital tubercle to front border of maxillary	557	470
Length of maxillary toothrow	178	152
Depth at occiput (supra-occipital to condyle)	180	130
" " " (top of exostosis to condyle)	235	154
" " proximal end of nasals	195	133
Mastoid breadth	200	197
Orbital breadth	252	277
Postorbital breadth	124	141
Breadth of rostrum at p^2	129	90
" " occipital condyles	120	115
" " palate at m^1	93	82
$Molar^2$, breadth of posterior border at alveolus	32	23
" length of crown on outside	38	29
Length of exostosis on median line	270	200
Length of horncore [1] to midline of skull	401	305
" " " " margin " "	315	220
Distance between tips of horncores	510	250
Width of horncores at margin of skull	115	143
Lachrymal, anteroposterior extent	142	68
" vertical extent	104	55
Basioccipital, length on outer side	115	94
" breadth posteriorly	83	64
" " anteriorly	24	20

Ovibos *Blainville.*

Bos ZIMMERMANN, Geogr. Gesch., II, 1780, p. 76, part (and of most subsequent authors for the next fifty years).

Ovibos BLAINVILLE, Bull. Soc. Philomat. Paris, May, 1816, p. 76. Type, *Bos moschatus* Zimmermann. Erroneously said to have only 2 mammæ and no muffle; regarded as having a greater resemblance to sheep than to oxen.— DAWKINS, Proc. Roy. Soc. London, XV, 1867, p. 516 (relationships); Palæontogr. Soc., XXV, 1872, pt. 5, p. 29 (closely allied to the sheep; number of its teats said to be two, etc.).— RÜTIMEYER, Verhandl. naturf. Gesel. Basel, IV, 1867, p. 328; Versuch einer naturl. Gesch. des Rindes, etc., zweite Abth., 1867, pp. 6–20, figs. 1, 2; Abhandl. der schweizer. paläont. Gesel., V, 1878; pp. 103, 104 (*Ovibos* considered to be a sheep).— MATSCHIE, Sitzungsb. Gesel. naturf. Freunde Berlin, Jahrg. 1898, pp. 30, 31 (segregated, with *Budorcas*, to form a subfamily Ovibovinæ of Bovidæ).— LÖNNBERG, Proc. Zool. Soc. London, 1900, p. 167 (regarded as an isolated type, not closely related to either sheep or oxen).— OSGOOD, Smithson. Misc. Coll., quart. issue, XLVIII, 1905, pp. 177, 178 (compared with *Scaphoceros* Osgood = *Symbos* Osgood).— KNOTTERUS-MEYER, Arch. f. Naturgsch., Jahrg. 73, Bd. 1, 1907, p. 142 (raised to the rank of a subfamily of his Obovidæ).— KOWARZIK, Zool. Anz., XXXVII, No. 5, p. 107, Feb. 14, 1911 (divides *Ovibos* into two genera, *Ovibos* and *Bosovis*).

Bubalus OWEN, Quart. Journ. Geol. Soc. London, XII, 1856, p. 124, part (*Ovibos* considered a synonym of *Bubalus* (*Buffelus*).

Præovibos STAUDINGER, Centralblatt f. Min., Geol. und Palæont., Jahrg. 1908, p. 483. Type *Præovibos priscus* sp. nov.

Bosovis KOWARZIK, Zool. Anz., XXXVII, No. 5, p. 107, Feb. 14, 1911 (no type designated, but includes all forms of recent muskoxen except *Ovibos mackenzianus* Kowarzik, 1910).

Horns extremely specialized having in the old males a very broad base covering the greater part of the postorbital region of the skull; abruptly decurved in both sexes and apically recurved; roughened basally, smooth apically. Legs

[1] Slightly broken at tip. The measurements of the horncores for *Ovibos* are from another skull, No. 28072.

short, tail vestigial and concealed by the long hair of the rump; general form bison-like; pelage very full, with a heavy covering of long, rather coarse overhair, nearly reaching the ground, and a basal layer of long, thick, woolly underfur. Orbits greatly specialized, protruding from the skull. Muffle narrow, lunate, situated below and connecting with the nostrils. Mammæ 4, as in other Bovinæ.

Ovibos finds its nearest ally among living mammals in the genus *Bison* (*cf. antea*, p. 168). With a general close resemblance to this genus in dentition and cranial characters, it differs from it in having the teeth less hypsodont and in the reduction of the accessory column on the inner side of the molars to a vestigial condition, varying through individualization from total absence to fairly full development, but usually disappearing, when present, through the wearing down of the crowns in adult life. There are strongly pronounced minor differences in skull structure, as in the proportions of width to depth, and in the wide separation of the paroccipital processes from the condyles in *Bison* and the absence of this separation in *Ovibos*.

The nearest known affine of *Ovibos* is the extinct genus *Symbos* Osgood (= *Bootherium*, part, Leidy), with which it has already been compared in detail (*cf. antea*, p. 169).

As already shown (*antea*, p. 159), the genus *Ovibos* was founded by Blainville in 1816, under the impression that the muskox was closely related to the sheep. It is almost certain that at this date he had never seen a skull, or even a figure of one,[1] and that he knew autoptically only the stuffed skin of a male in Bullock's Museum, of which he gave a description. This is doubtless the explanation of his misstatements and misapprehension of the real relationship of the muskox. His dictum, as implied in the name *Ovibos*, was first formerly questioned by Richard Owen (*cf. antea*, p. 164) in 1856, although Wagner, Gray, and most other previous systematists had declined to place it among the sheep. Dawkins, however, in 1867 and later, through misinformation as to its characters, was emphatic in his declaration that *Ovibos* was a sheep. This erroneous conclusion seems to have been accepted more or less tentatively by many later authors till the appearance, in 1900, of Lönnberg's admirable contribution to the soft anatomy and osteology of *Ovibos*, which showed conclusively that it has no close relationship to the sheep, and, overlooking the genus *Bison* in his comparisons, he assumed that it was almost as distantly related to the oxen.

Although the genus *Bootherium* of Leidy, founded in 1852 for extinct forms supposed by him to be closely related to *Ovibos*, was formerly erroneously referred to this genus by Dawkins and Rütimeyer, no real synonym of *Ovibos* appeared till Staudinger, in 1908, proposed the genus *Præovibos* for a Pleistocene form of *Ovibos* found in a gravel pit near Frankenhausen, Germany. The author's description and figures of the type, an imperfect skull, lacking the preorbital portion, seems to show no feature inconsistent with its identification as a female of the large Pleistocene muskox named *Ovibos pallantis* by Hamilton-Smith in 1827.

A still later synonym is *Bosovis* of Kowarzik, proposed in 1911, as already noted, for the barren-ground form of *Ovibos moschatus*. Aside from the fact that *Bosovis* has no valid characters, it is in any case a synonym of *Ovibos*, since the type and only species of *Bosovis* is the *Bos moschatus* Zimmermann, the monotypic type of *Ovibos*. The alleged characters of *Bosovis* are the absence of a lacrymal pit and the possession of only two instead of four mammæ, both assumptions being without basis.

[1] The skull of the existing muskox was first figured by Cuvier in 1823 (Rech. Ossem. foss., nouv. ed., IV, 1823, pl. x, figs. 15, 16, 17, three views), from "un crâne dans le cabinet de Camper." He had also just received from "M. Brookes, savant chirurgien et anatomiste, à Londres, une portion de crâne avec les cornes, venue de l'île Melville; en sorte que du capitaine Parry,....en ont aussi tue un individu mâle, a l'île Melville, et en ont donné une bonne figure, p. 227; de sorte qu'on peut considérer l'espece comme suffisamment connue et determinée" (*l. c.*, p. 134). Apropos of this complacent comment, *cf.* the quotation from his first edition of the 'Rech.' given *antea*, p. 160, footnote 4.

Species and Subspecies of Ovibos.

Kowarzik's 'Der Moschusochs und seine Rassen.'

Notwithstanding the great number of authors who have written of the muskox of the Canadian Barren Grounds, it had no technical synonym till 1908, when Kowarzik published a preliminary summary [1] of his later extended memoir,[2] in which he divided the muskoxen into two groups, an eastern group and a western group, the latter inhabiting the Barren Grounds west of the divide separating the drainage which flows into the Atlantic Ocean from that which reaches the Arctic Ocean; in other words, the Canadian Barren Grounds west of about the 105th meridian and north from the vicinity of Great Slave Lake to the Arctic Coast. This western group consisted of the single form he here named *Ovibos moschatus mackenzianus*, while the eastern group comprised the muskoxen of all other regions at present inhabited by the genus *Ovibos:* (1) *O. moschatus* Blainville, (2) *O. m. wardi* Lydekker, (3) *O. m. niphœcus* Elliot, (4) *O. m. melvillensis* subsp. nov. In a still later paper [3] he proposed the following classification:

"Familie Ovidæ: Tränengrube vorhanden.
Familie Ovibovidæ: 1. Genus *Ovibos*. Tränengrube vorhanden.
2. Genus *Bosovis*. Tränengrube fehlt.
Familie ———* (Überbleibsel der Ovibovidæ nach Knottnerus-Meyer). Tränengrube fehlt.
Familie Bovidæ: Tränengrube fehlt.

* Die Benennung dieser Familie überlasse ich denen, die sich eingehend mit der Untersuchung ihrer anatomischen Merkmale beschäftigt haben."

Here, as will be noticed, the muskoxen are divided into two genera, *Ovibos* being restricted to the so-called western group, while a new generic name, *Bosovis*, is provided for the eastern group. In the same connection all of his previously proposed forms are raised to full species.

In his preliminary paper (1908, p. 617) he cites as distinguishing the two groups the following characters:

Western group.	*Eastern group.*
"Tränenbein mit deutlicher Tränengrube.	Keine deutliche Grube.
Weibchen 2 Zitzen.	4 Zitzen.
Hornbasen lang und niedrig.	Kurz und hoch.
Hörner ganz an die Seiten des Schädels angepresst.	Viel weniger angepresst, ja sogar stark abstehend.
Farbe derselben dunkel.	Licht.
Basioccipitale ganz oder nahezu quatratisch im Umrisse.	Viel weniger quadratisch, nach vorn zu verschmälert.
Backenzahnreihe ganz schwach gekrümmt.	Stark gekrümmt.
Fossa sphænomaxillaris weit hinter dem Ende der Backenzahnreihe.	In derselben Linie mit dem Ende des letzten Backenzahnes.
Vorkommen: westlich von der Wasserscheide zwischen dem atlantischen Ozean und dem nördlichen Eismeer.	Östlich von dieser Wasserscheide umfassend alle übrigen vom Moschusochsen bewohnte Gebiete."

He further states (1908, pp. 617, 618):

"Aber damit ist die Unterscheidungsmöglichkeit nicht abgeschlossen. Wohl gehören zur westlichen Gruppe Tiere, die voneinander nur unbedeutend abweichen, und die ich als *O. moschatus mackenzianus* bezeichtnet habe. Die östliche zerfällt dagegen in 4 Rassen, deren Berechtigung nicht nur in Färbungsunterschieden, sondern auch auf

[1] Kowarzik, Rudolf. Der Moschusochs und seine Rassen. Zoolog. Anzeiger, Bd. XXXIII, No. 17–18, pp. 616–618, Nov. 10, 1908.
[2] Der Moschusochs und seine Rassen. Fauna Arctica, Bd. V, 1ste Lief., pp. 84–126, pl. i, 16 Fig. im Texte, Mai, 1910.
[3] Das Tränenbein von *Ovibos moschatus* Blainv. Zoolog. Anzeiger, Bd. XXXVII, No. 5, pp. 106, 107, Feb. 14, 1911.

Skeleteigentümlichkeiten beruht. Diese Rassen sind in chronologischer Reihe ihrer Begründung folgende: *Ovibos moschatus* Blainville, *O. m. wardi* Lydd., *O. m. niphoecus* Elliot, *O. m. melvillensis* Kowarzik.

"Eine Unterscheidung der 4 Typen ist zunächst schon durch die Länge der Hornbasen gegeben, die bei *O. m. melvillensis* und *O. m.* länger sind als bei den zwei andern. Auch in der Krümmung der Hörner stehen die Typen weit voneinander ab. *O. moschatus* hat nur halbmondförmig gekrümmte, *O. m. niphoecus* mehr halbkreisförmig, *O. m. wardi* noch stärker, und *O. m. melvillensis* besitzt Krümmungen, die fast $\frac{3}{4}$ eines Kreises erreichen. Auch der Abstand und die Lage der Hornspitzen ist von Bedeutung.

"Aber auch in der Färbung werden die Tiere deutlich unterscheidbar. *O. m. niphoecus* und *melvillensis* sind dunkel, der erstere heisst nicht umsonst 'schwarzer Moschusochs,' dunkler als *O. moschatus* [und] *O. m. wardi*. Die genauen Unterschiedsangaben muss ich natürlich der Hauptarbeit überlassen, da es mich hier zu weit führen möchte.

"Die Eigentümlichkeiten des westlichen Typus, die zugleich Gruppenmerkmale sind, habe ich schon bei der Trennung der letzteren erwähnt.

"Eine Fülle neuer Fragen wird durch diese Arbeit hervorgerufen. Zunächst sind selbstverständlich alle Verwandtschaftssysteme der Cavicornier, bei denen die Schafnatur des Moschusochsen angenommen wird, in diesem Punkte ebenso hinfällig, wie diejenigen, bei denen er als *Bos* angenommen wird. Weiter ist es klar, dass ein Tier, das sozusagen Gattungsmerkmale in seinen Species zeigt, gewiss berufen ist, eine grosse Rolle in der Erkenntnis der Stammesgeschichte zu spielen. Wenn heute noch *O. moschatus* als gleich im Range mit *Bos* und *Ovis* angenommen wird, dann muss in Zukunft berücksichtigt werden, dass er die Eigenschaften beider und auch noch solche einer dritten Tiergruppe — der Antilopen — vereinigt und ihm deshalb zweifellos ein viel höheres Alter zukommt, als man es eben bisher angenommen hat. Auch in geographischer Beziehung gibt es so manches interessante Ergebnis meiner Untersuchungen. In erster Linie is die auffällige Ercheinung zu nennen, dass *O. moschatus mackenzianus* und *O. m.*, die doch so nahe beieinander wohnen, doch anatomisch viel weiter voneinander entfernt sind, als die Typen der östlichen Gruppe. Durch Prof. Matschies Gesetz der Begrenzung der Tierspecies durch die Wasserscheiden lässt sich jedoch diese Erscheinung sehr leicht erklären und liefert wiederum einen Beweis für die Richtigkeit dieses Gesetzes."

In his later memoir (1911), the characteristics of the two groups and of the several subspecies, or 'types,' are elaborated at length. Here is also presented a list of the material which, with the literature of the subject, constituted the basis of his work, together with tables of cranial measurements and ratios. The text illustrations include views of the skulls of three of the forms, and of the animals, the latter in part from photographs of mounted specimens and in part from illustrations from previous authors; also diagrams (geometrical projections) to show the ratio of orbital breadth to the basal length of the skull, and the relative position of the horn tips in the several races. A plate gives four views (dorsal, occipital, basal, and lacrymal region) each of a type skull of his two groups, namely: "I. Typus: *Ovibos moschatus* Blainville"; "V. Typus: *Ovibos moschatus mackenzianus* Kowarzik"; the former from "westlich von der Hudson-Bay," the other from "Grosser Bärensee."

His *moschatus* type is represented by two male skulls and the mounted skin of one of them, and a female skull with its mounted skeleton, all from "westlich von der Hudson-Bay," but none of them with definite localities, nor any assurance that they were really from the type region of his restricted *moschatus*. His new 'Typus IV' (*Ovibos moschatus mackenzianus*) is based on a male skull and a mounted skin from Great Slave Lake, and a skull and its skeleton from Great Bear Lake. My material includes three mounted specimens, three unmounted skins, and eight skulls. His new 'Typus V' (*Ovibos moschatus melvillensis*) is based on a skull with its skeleton from Melville Island. My material includes a living three-year-old female and three adult skulls all, from Melville Island. His 'Typus III' (*Ovibos moschatus niphœcus* Elliot) is based wholly on Elliot's description and figures. My material consists of the type skull and 15 topotype skulls and nearly as many skins. Of his 'Typus II' (*Ovibos moschatus wardi*) he had a series of specimens from East Greenland, comprising four skulls of males and six skulls of females, these being further represented by two skeletons (male and female) and several mounted skins belonging to the above mentioned skulls. My series consists of about 140 skulls with their skins, representing both sexes and all ages.

Underlying his method of procedure are two fundamental errors: (1) that one of his two primary groups (later recognized as genera) has only two teats while the other has four; (2) that one of the groups has no lacrymal depression ("Tränengrube"), while the other has such a depression. Furthermore, great stress is laid upon features of notorious inconstancy, as the curvature of the horns and their breadth at base; also upon the form of the basioccipital and the condyles, which not only vary with age in the same animal, but have a wide range of individuality in animals of the same age and sex from the same locality.

As a general criticism of his work, it may be said that outside of his series of *O. m. wardi*, his material was woefully insufficient for the ambitious task he attempted. Besides this is his obvious unpreparedness through lack of study of large series of specimens of single species from one and the same locality, and consequent insufficient knowledge of the wide range of individual variation normal to all mammals, and his resultant overestimation of the value of slight differences that fall far within the norm of individuality. Again, he seems to have been too much influenced in the present case by the theory of watershed barriers to distribution, which, generally speaking, is to be given weight, but only in connection with the degree to which such barriers may be restrictive. In the present instance the region of the watershed supposed to separate the ranges of his two genera of muskoxen, *Ovibos* and *Bosovis*, is a country of comparatively low elevation, with low hills and dotted with small lakes and marshes, presenting no physical barriers of faunal significance. Muskoxen still inhabit not only the divide between Clinton Golden Lake and the upper tributaries of the Dubaunt River, but extend thence continuously both to the eastward and westward. Hence in a country where muskoxen can roam freely without the slightest check by physical barriers, and where they present also no difference in external appearance that is recognizable as distinctive even of race, the assumption that those living on either side of a purely hypothetical boundary should differ generically is a rather startling proposition, to which Kowarzik's scanty material lends no support. The muskoxen living to the westward of the boundary that should separate the ranges of his two genera are known from the examination of specimens to have *four* teats [1] and not *two*, as he states, and a lacrymal depression no more marked than in the eastern group.

It is quite true that the muskoxen of the Barren Grounds of the Great Slave Lake region differ markedly from those of Greenland and the northeastern insular areas of North America, not only in coloration but in the form of the horns and in certain features of the skull, as shown by me in 1901, in a paper [2] which Kowarzik appears never to have seen, where, on page 76, *wardi* and the Barren Ground form (*mackenzianus* of Kowarzik) are compared and where the skulls of both forms are figured (*l. c.*, pp. 74, 75; they are here reproduced in Figs. 27–31). It is there stated: "The geographical relations of the two are not clear, but it seems probable that *O. wardi*

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[1] I am indebted to Mr. Roy C. Andrews, Assistant Curator of Mammals in this Museum, and to Mr. Wilfred H. Osgood, Curator of Mammals in the Field Museum of Natural History in Chicago, for kindly examining, in my behalf, female skins of muskoxen from the Barren Grounds north of Great Slave Lake, now in the Field Museum, with reference to the number of teats, which Mr. Andrews reports to me to be four, as in *wardi* and in *niphœcus*. The females living in the New York Zoölogical Park — two from Ellesmere Land and one from Melville Island — are found to have, of course, each four teats. Lönnberg has stated (*l. c.*, 1900, p. 163) that he found four teats in specimens of *wardi* from East Greenland. This should forever establish the fact that muskoxen have four teats like other Bovines.

Since writing the preceding part of this note I have met with the following statement by Colonel J. C. Jones respecting the number of teats found by him in the muskoxen captured by him near the divide east of Great Slave Lake. He says: "The cows are of about the size of a thorough-bred Jersey, but not so tall.... They have four teats like a cow, but they are short; they have a round, compact udder."— Buffalo Jones' Forty Years of Adventure,....compiled by Colonel Henry Inmam, 1899, p. 383.

[2] The Muskoxen of Arctic America and Greenland. Bull. Amer. Mus. Nat. Hist., XIV, pp. 69–86, pll. xiii–xvi, text figures 1–7, March 27, 1901.

is the form inhabiting the numerous islands, more or less joined by ice in winter, situated north and east of Belcher Channel and Jones Sound, while *O. moschatus* is confined mainly to the [continental] Barren Grounds, with formerly, probably, continuous distribution westward across Alaska. The eastern limit of *O. moschatus* cannot at present be accurately defined" (*l. c.*, p. 76). In 1905 a geographically and zoölogically intermediate form, *O. m. niphœcus*, was described by Elliot from the northwest coast region of Hudson Bay.[1] This form is almost exactly intermediate between *wardi* and true *moschatus*, as would be expected on geographical grounds, and as I have found by an examination of a good series of topotypes and some of the original type material. In early times it doubtless extended south along the west side of Hudson Bay till it merged with the muskoxen then inhabiting the Churchill River region, the type locality of true *moschatus*. Indeed, it may be considered an open question whether the Churchill River muskoxen were not more like the *niphœcus* type than like the muskoxen of the Great Slave Lake region — a question now unfortunately impossible to answer conclusively owing to the extinction of muskoxen in the southeast part of their former range and the absence of material from this region in museums. It is interesting to note that Kowarzik takes his external characters of *moschatus* from Jérémie, even to the "halfmondförmige Krummung der Hörner." He figures a skull showing horns with rather thick tips, such as occur from the blunting of the extremities by wear, exactly as occurs now and then in *wardi*, *niphœcus*, and *moschatus*. Three of his four cited illustrations are not based on Hudson Bay specimens,[2] and the locality of his own figured skull is not definite. Now that *niphœcus* is known to range for a long distance "westlich von [northern] Hudson Bay," it is questionable whether his specimens of his restricted '*moschatus*' are not referable to *niphœcus*.

Kowarzik's carefully prepared tables of ratios are a valuable contribution to the subject, but he appears to have overlooked their real significance and to have made little practical application of them. His manner of presenting these tables, however, has rendered them vexatiously difficult to utilize, since he employs only the catalogue numbers of the specimens for their designation in the tables and arranges the ratios in the order of numerical sequence, from highest to lowest. The tables do not indicate either the subspecies or the localities of the specimens they include, nor do they carry any captions, rendering an examination of the context necessary to determine to what they relate. In consequence of adopting the numerical sequence of the ratios as the order of arrangement, specimens from the same locality and representing the same subspecies are arbitrarily separated instead of being grouped together, although the author professes to have followed, under the advice of his friend Dr. Matschie, the 'geographical method.' By writing in the names of the subspecies as a prefix to the catalogue numbers, and rearranging the ratios in accordance therewith, their real significance is immediately apparent. Rarely, under this rearrangement is the sequence of the 'typus,' or subspecies, the same as in Kowarzik's arrangement. In thirteen tables thus rearranged the '*mackenzianus*' and '*moschatus*' specimens,

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[1] The locality where the type series of *niphœcus* was taken was not known at the time the subspecies was described and was erroneously given as "600 miles north of Hudson Bay," whereas it is now known (see *infra*, p. 191) to have been near the head of Wager Inlet, west of northern Hudson Bay.

[2] Kowarzik cites (*l. c.*, p. 99) figures by Gray, Hermann, Cuvier, and Elliot as illustrating his restricted *O. moschatus*. The figure cited from Gray is of a skull received from Melville Island, and hence represents Kowarzik's '*melvillensis*.' Hermann's figure is a distorted reproduction of Buffon's head of the muskox and is worthless for any scientific use. Cuvier's figure is of a skull in Camper's collection, probably from the Hudson Bay region. The skull figured by Elliot came from Wager Inlet, and forms part of the material on which he later based his *O. m. niphœcus*, as he has himself informed me.

and the *wardi* and *melvillensis* specimens, respectively, fall together (*niphœcus* is unrepresented), confirming my own conclusions, based on other and much more material, regarding their relationships.[1] I found no reason for recognizing two forms of muskoxen from the continental Barren Grounds, and I had already assigned the Melville Island 'species' (*melvillensis* Kowarzik) to *wardi*.

Furthermore, Kowarzik's tables of ratios accord with my results regarding individual variation in cranial characters, based on a series of *wardi* specimens comprising 31 adult males and 26 adult females, or more than ten times the amount of material available to Kowarzik.[2] His ratios for '*moschatus*' indicate, so far as his actual specimens go, that they must have come, as already said, from the range of *niphœcus*, as the range of this form is now known. His skulls of '*mackenzianus*' agree of course with specimens of *moschatus* from the Barren Grounds of the Great Slave Lake region, with which there is probably no material from the Churchill River region (type locality of *moschatus*) extant for comparison. His *melvillensis*, based on a single specimen (skull and skeleton), and on Parry's figure, belongs with the *wardi* group; so far as a living specimen from Melville Island shows, *melvillensis* is not distinguishable from *wardi* in coloration, nor in cranial characters, judging not only from Kowarzik's measurements and ratios, but from three additional skulls from Melville Island. Parry's figure,[3] though regarded formerly as praiseworthy, is really very defective, the nose being modelled apparently on that of an ox as regards general shape, while it shows no naked black muffle beneath and along the inner margin of the nostrils, the whole muzzle being uniform white except the nasal openings; that it is also defective in color values is shown by the feet being represented as wholly black like the body instead of white, which leads one to suppose that any white there may have been on the face has also been suppressed, since it is now known that the Melville Island form is white-faced.

Kowarzik dwells especially upon the importance of the lacrymal bone as a character distinctive of different types of muskoxen, he claiming, among other features, that it shows no concavity or depression in any of the members of his eastern group, whereas I find such a depression fully as well developed and as constant in both *wardi* and *niphœcus* as in his '*mackenzianus*,' where alone, according to him, it should be found.[4] Still further, he considered that the size and form of this bone are so important as distinctive features that he has constructed tables to show the ratio of its length to the skull length, the ratio of its length to its least breadth, and the ratio of length to breadth. In Part I of this paper, under the section devoted to 'Individual Differentiation,' the variability of the lacrymal (*antea*, p. 147) is especially considered, and further comment in the present connection is unnecessary. The nasal bones have been treated with similar detail, and as of especial importance for diagnostic use, whereas, for reasons already given in Part I (*antea*, p. 147), they are too variable through individuality and changes due to age to have any great importance as features distinctive of race in the muskox group.

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[1] It may be here stated that Part I of the present paper was completed before I took up Kowarzik's memoir for serious consideration. Also that the measurements given in my tables were made by another hand, by one and the same standardized method, leaving no chance for personal bias to enter into the work.

[2] In the greater part of his ratio tables the ratio variation in 3 to 5 male skulls of *wardi* covers the ratios given for the other three forms!

[3] Parry's First Voyage, plate facing p. 356.

[4] Occasionally in female skulls and sometimes in young male skulls, the lacrymal, in both *wardi* and *moschatus*, presents no depression, its surface contour being uniform with that of the surrounding bones; in others the depression is very slight and might be disregarded as having any significance; but in the majority of skulls it is well-marked, ranging in depth, measured from a transverse line tangent to the inner and outer edges of the lacrymal bone, from 8 mm. to 15 mm. It increases in depth with the age of the animal, and in very old males is exaggerated through the building up of the edges of the bone through exostosis.

The amount and direction of curvature in the horns is also given a greatly exaggerated value, the author having taken the trouble to construct a 'geometrical projection' of the position of the horn-tips with reference to the mid-line of the skull-length for his series of muskox skulls! In viewing a tenfold larger series than he had the privilege of studying, one is at once impressed with the variability of the horns in both length and curvature, even in specimens of the same age, sex, and locality. In occasional specimens the difference in the curvature of the right and left horns of the same animal is widely different, the variation between them being greater than that shown by a number of other individuals taken collectively. That no feature of the skull is more unstable than the length and curvature of the horns, or even their size, is evidenced by the extensive tables of measurements already given in Part I (pp. 144, 145), and the comment thereon.

Another highly overvalued feature is the ratio of the width of the hornbase to the length of the skull; while this has value within certain limits, it varies so greatly with age that it is necessary to make comparisons between strictly comparable individuals, and furthermore to bear in mind the enormous range of variation one is liable to encounter in specimens of the same age and sex from the same locality, as shown in my Grant Land series of *wardi*. That Kowarzik believes this to be a feature of high importance is shown not only by his taking the trouble to construct a 'hornbase index' for his specimens, but by his use of the hornbase breadth as a basis for grouping the fossil forms of *Ovibos*,[1] where he says:

"In erster Linie muss man sein Augenmerk auf die Gestaltung und Ausdehnung der Hornbasen lenken, da meine Studien am rezenten Tiere diesem Teile des Schädels eine grosse Wichtigkeit beim Vergleiche zugesprochen haben. Und so braucht man nur die Länge der Hornbasen sämtlicher zur Verfügung stehender rezenter und fossiler Exemplare in absteigenden oder aufsteigenden Werten untereinander zu schreiben — wobei man allerdings auch immer Alter und Geschlecht berücksichtigen muss — um in tadelloser Weise die Beziehungen der einzelnen Schädel zu einander zu ergründen. Um diese Tatsache deutlicher zu machen, gebe ich im nachfolgenden eine Zusammenstellung sämtlicher von mir untersuchter Schädel mit Rücksicht auf die Länge der Hornbasis" (*l. c.*, p. 53).

Following this is a table of measurements compiled from authors, giving the length of the hornbase in 28 "male" fossil skulls of *Ovibos*, arranged in numerical sequence from the largest to the smallest, the largest having a hornbase length of 230 mm., the smallest a hornbase length of 72 mm. He heads the table with the hornbase length in two male skulls of his *O. moschatus mackenzianus*, in which it is, respectively, 232 mm. and 235 mm. He then goes on to say:

"Es war nun natürlich nicht schwer herauszubringen, dass diejenigen diluvialen Schädel, die längere Hornbasen als 200 mm. besitzen, zu dem von mir aufgestellten V. Typus des rezenten Moschusochsen gehören. Ich habe denselben charakterisiert als eine Rasse mit sehr langen Hornbasen, deutlichen Tränengruben, fast quadratischem Basioccipitale und nur ganz schwach gebogenem Nackenkamm. Und eine Untersuchung der fossilen Schädel nach diesen 3 letztgenannten Gesichtspunkten ergab den deutlichen Beweis, dass die Zugehörigkeit der mit einer Hornbasislänge von mehr als 200 ausgestatteten Exemplare zu der genannten lebenden Rasse ausser Zweifel steht. Dieses Ergebnis war sehr wichtig, weil wir dadurch schon den Weg kennen lernten, den der V. Typus *O. moschatus mackenzianus* Kowarzik zurücklegte, bevor er seinen gegenwärtigen Standpunkt erreichte.

"Doch nun blieb eine ganze Reihe von Schädeln mit einer Hornbasislänge von 200 oder weniger übrig. Eine kurze Ueberlegung klärte mir jedoch den scheinbaren Sprung zwischen der erstwähnten und den jetzt genannten Schädeln auf. Die letzteren stellen ein früheres Entwicklungsstadium des V. Typus des lebenden Tieres vor und sind deshalb auch geologisch gesprochen älter als die ersteren, und man hat keinen Grund, ihnen die Berechtigung der Bezeichnung *O. moschatus mackenzianus* Kowarzik streitig zu machen" (*l. c.*, pp. 53, 54).

He then calls attention to where, lower down in the table, the hornbase length drops from 157 mm. to 127 mm., with a further decline of 72 mm. for the smallest. This latter series he

[1] Kowarzik, Rudolf. Der Moschusochs im Diluvium von Europa und Asien. Verhandl. des naturf. in Brünn, Bd. XLVII, 1908 (1909), pp. 44–49.

refers to another species, although several of the specimens here given as males had been previously identified by good authorities as females. The designation of the sex in fossil forms is of course more or less hypothetical, but in many instances, as in the case of fossil muskox skulls, the determination can generally be made with considerable and often with entire certainty. For example, the "Forrest Bed" skull, with a hornbase length of 127 mm., was described and figured by Dawkins as the skull of a female, and such it obviously is, although Kowarzik has listed it as a male. But the above quotations from Kowarzik's paper seemingly need no comment, so evident is its unscientific character to any one familiar with the subject to which it relates. In the first place it is based on the descriptions and figures of previous authors and not on the actual specimens; secondly, it is a sequel to his memoir on the living species and is based on the false conceptions and conclusions there formulated. It is indeed to be regretted that scientific literature should be burdened with such puerile productions.[1] He seems to have heard of no later authority than Rütimeyer, 1867, on the status of *Bootherium bombifrons* and *B. cavifrons*, and so refers them to the genus *Ovibos*, without reference to Osgood's genus *Symbos*, described in 1905. All of the large (the male) fossil skulls of Eurasiatic muskoxen he refers to his *Ovibos mackenzianus*, and the smaller ones to "*Ovibos fossilis* (non Rütimeyer) spec. emendata Kowarzik," although the name *Ovibos moschatus β fossilis* was first used, and in the same sense, by Fischer in 1829, at which date it is still antedated by *Ovibos pallantis* Hamilton-Smith, 1827.

Geographic Variation in Ovibos.

The muskoxen of North America, as indicated by the material now available, present well-marked geographic variations in size, in coloration, in the size and form of the horns, and in certain cranial characters, notably in the length of the toothrow and relative size of the teeth.

Specimens from the continental barren-grounds are larger, with shorter but more massive and less spreading horns, smaller teeth and shorter toothrows, absolutely as well as relatively, and darker coloration, including the color of the horns, than those from the insular parts of the continent northeast of the continental barren grounds.

The large series now known from near the head of Wager Inlet (*Ovibos niphœcus* Elliot), are smaller than those of the barren grounds east of the Mackenzie River, and in coloration are intermediate between the Barren Ground and Bache Peninsula (Ellesmere Land) forms. On the other hand, they have the short toothrow of the Barren Ground form.

The Bache Peninsula specimens (3 adult males and 5 adult females) are appreciably smaller than those from northern Grant Land, but they do not appear to differ from the latter in coloration nor in cranial features, as will be shown more fully later in considering the races of *Ovibos*.[2]

The Greenland form does not appear to differ essentially in any feature from that inhabiting northern Grant Land,[3] nor is there any geographical barrier separating their ranges. *Ovibos*

[1] Thus, R. F. Scharf, in his 'Distribution and Origin of Life in America,' 1912, p. 59, commenting on Kowarzik's paper on 'Der Moschusochs und seine Rassen,' says: "After a very careful and extended examination of a number of skins and skulls of musk oxen from this region [Canadian barren-grounds], he was able to show that they differed from those now living elsewhere by the possession of a deep lachrymal pit and two mammary glands. The Greenland musk ox, which belongs to the eastern group, has no lachrymal pit and four mammary glands. There are other minor differences clearly proving that Dr. Kowarzik's *Ovibos moschatus mackenzianus* is much more than a mere race."

[2] It is possible that the smaller size of the Bache Peninsula specimens may be more apparent than real, and that a larger series would eliminate the difference in size as a differential feature, though this does not seem probable.

[3] Kowarzik's measurements of a dozen skulls from East Greenland agree closely with my own measurements of a much larger series of skulls from Grant Land, and there appears to be no average difference in the amount of white on the head, judging from the numerous published illustrations of East Greenland muskoxen.

moschatus wardi appears to have, in fact, a continuous range from Greenland westward throughout the Arctic Archipelago. If there is a distinguishable western form (*Ovibos moschatus melvillensis* Kowarzik), its satisfactory substantiation must await the examination of further material. Just where and how the white-faced muskoxen of Melville Island merged with the continental Barren Ground type can probably never be determined, owing to the almost complete extinction of the muskoxen which formerly inhabited Victoria Land. The material at present available, however, seems to indicate complete intergradation between the present known forms in geographical sequence.

Synopsis of Species and Subspecies.

As already shown (*antea*, p. 179) there are three well-marked types of muskoxen inhabiting North America and Greenland. Probably if an abundance of material could be brought together for comparison from widely separated localities, as is so readily done in the case of small mammals, other more slightly marked forms could be distinguished, as seems indicated by the smaller size, for example, of the present small series from Ellesmere Land, and might prove to be the case with Melville Island specimens if adequate material were available. From descriptions of the muskox by early writers, it is evident that the Churchill River type did not differ materially from the muskoxen found to the eastward and northward of Great Slave Lake. Hence it seems advisable to consider for the present, or until adequate material shows otherwise, that all of the muskoxen of the continental barren-grounds are referable to the type form, *Ovibos moschatus moschatus*, including those that appear to have occupied the barren-grounds of northern Alaska down to probably about the middle of the last century.

The bibliographic references given below, under the several subspecies here recognized, have been arranged in accordance with this view, all the references to the muskoxen of the insular areas having been grouped under *Ovibos moschatus wardi*.

The extinct forms are too little known to be dealt with critically in the present connection. Doubtless a direct comparison of all the extant material in the museums of Europe from the Pleistocene of Siberia and northern Europe would show the propriety of recognizing more than a single form, since these fragmentary remains represent not only an immense geographic area but a long interval of time. Like most of the other known Pleistocene representatives of modern mammal species, the fossil remains of *Ovibos* indicate that in general the immediate ancestors of the existing forms of muskoxen attained a larger size than their modern representatives, and in all probability differed in other correlated features. For convenience the references to fossil muskoxen are here brought together under two headings, those relating to North America being placed under *Ovibos yukonensis* Gidley, and those relating to Siberia and Europe under *Ovibos pallantis* Hamilton-Smith.

Living Forms.

No coronal nor facial white areas in adults; horns dark brown, very broad at base in proportion to their length; toothrow relatively short (maxil. toothrow 132 mm.), basal length of skull in old males, 466 mm. . . . *O. m. moschatus.*

Usually no coronal nor facial white areas in adult males, but traces of them (often well developed) in young males and females; horns more slender and longer in proportion to their basal breadth, and generally light-colored; toothrow relatively longer (max. series, ♂, 130); basal length of skull in old males, 442 mm. . . . . *O. m. niphœcus.*

Conspicuous areas of white between and behind the horns, and face and sides of the head sometimes suffused with white to a greater or less extent in old males, in which much of the original white area is obliterated by the development of the horn bases; horns long and slender in proportion to their basal breadth, very light creamy white; toothrow relatively longer than in *moschatus* (max. series in males 140 mm.); basal length of skull in old males, 442 mm. . . *O. m. wardi.*

Table III.—Measurement of skulls of Muskoxen from Wager Inlet (Hudson Bay) and the Barren Grounds.

	Wager Inlet.						Barren Grounds.																					
																						From Kowarzik.[3]					
	♂ 19490	♂ 19346	♂ 19488	♂ 19489	♂ 19487	♂ 1267 Field Mus.[1]	Minimum.	Maximum.	Average.	♀ 19345	♀ 1261[2]	♂ 16604 Barren Grounds.	♂ 11743[2]	♂ 11744[2]	♂ 29042 Aylmer Lake.	A. Parry Peninsula.	B. Parry Peninsula.	Minimum.	Maximum.	Average.	♀ 11746[2]	♂ 11707	♂ 2822	♂ 2261	♂ 385	♀ 320
Total length	485	485	486	465	489	436	465	489	482	457	456	479	470	461	513	500	515	461	515	489	447	—	—	—	—	—
Basal length	445	441	442	436	446	413	436	446	442	438	426	450	426	415	473	437	455	415	473	443	415	450	445	435	—	440
Mastoid breadth	167	171	171	164	176	152	164	176	170	158	157	183	163	161	185	162	182	161	185	173	152	—	—	—	—	—
Orbital breadth	254	252	255	243	268	239	243	268	254	226	224	260	237	236	271	265	—	236	271	254	214	265	245	264	237	227
Postorbital breadth	133	133	138	117	140	131	117	140	132	125	118	134	132	133	148	—	—	132	148	138	125	135	132	140	—	122
Nasals, length	154	153	146	148	151	126	146	154	150	158	158	148	148	137	155	—	—	137	155	147	146	141	145	161	136	137
" greatest breadth	69	68	73	61	74	64	61	74	69	53	56	80	56	67	80	—	—	56	80	71	63	75	73	75	69	52
Maxillary toothrow, length	136	129	131	120	138	135	120	138	131	131	119	128	133	136	136	138	132	128	138	134	137	131	133	145	—	—
Palatal breadth at m^2	73	74	75	70	80	71	70	80	74.4	73	75	81	73	76	81	79	77	73	81	78	75	—	—	—	—	—
Lower jaw, length	384	382	382	380	387	366	380	387	383	—	373	385	—	—	405	370	—	370	405	386	—	—	—	—	—	—
" " angle to condyle	141	127	132	148	140	140	127	148	137.6	—	127	150	—	—	154	—	—	150	154	152	—	—	—	—	—	—
" " " " condylar process	183	170	166	188	180	180	166	188	177.4	—	161	194	—	—	200	—	—	194	200	197	—	—	—	—	—	—
" " toothrow, length	145	139	138	128	140	142	128	145	138	—	123	140	—	—	138	145	—	138	145	141	—	—	—	—	—	—
Horns, spread at tips	665	391	532	426	691	—	391	691	541	516	—	564	—	—	508	620	675	508	675	574	—	660	635	638	660	—
" breadth at base	241	192	205	206	237	—	192	241	216	87	—	250	—	—	201	235	230	201	250	229	—	—	—	—	—	—
" length on outer curvature	595	563	562	543	649	—	543	649	582	485	—	551	—	—	553	650	565	551	650	579	—	—	—	—	—	—
" distance between bases of sheaths	11	12	14	11	12	—	11	14	12	15	—	7	—	—	11	—	—	7	11	9	—	—	—	—	—	—
Weight of skull	17	$17\frac{3}{8}$	$17\frac{7}{8}$	$14\frac{1}{4}$	$20\frac{1}{2}$	—	$14\frac{1}{4}$	$20\frac{1}{2}$	$17\frac{3}{8}$	7	—	$16\frac{5}{8}$	—	—	$23\frac{3}{8}$	—	—	$16\frac{5}{8}$	$23\frac{3}{8}$	20	—	—	—	—	—	—
" " lower jaw	$1\frac{3}{4}$	2	2	$1\frac{7}{8}$	22	—	$1\frac{3}{4}$	2	$1\frac{7}{8}$	—		$1\frac{7}{8}$		—	$2\frac{1}{4}$	—	—	$1\frac{7}{8}$	$2\frac{1}{4}$	2	—	—	—	—	—	—
Total weight of skull	$18\frac{3}{4}$	$19\frac{3}{8}$	$19\frac{7}{8}$	$16\frac{1}{8}$	$22\frac{1}{2}$	—	$16\frac{1}{8}$	$22\frac{1}{2}$	$19\frac{3}{8}$	—		$18\frac{1}{2}$		—	$25\frac{5}{8}$	—	—	$18\frac{1}{2}$	$25\frac{5}{8}$	22	—	—	—	—	—	—

[1] Type of *Ovibos moschatus niphœcus* Elliot. Field Mus. Nat. Hist., Chicago. This proves to be a dwarf, and is omitted in the columns of minimum and average.
[2] From 150 miles north of Fort Resolution, Great Slave Lake. Field Mus. Nat. Hist., Chicago.
[3] From Kowarzik, Fauna Arctica, V, 1910, pp. 122, 123. Nos. 11707 and 2821, his *O. makenzianus;* Nos. 2261, 385, 320, his *O. moschatus.*

Extinct.

Similar to the *moschatus* forms but larger and probably otherwise more or less different. Pleistocene of Eurasia.
O. pallantis.

Similar to the *moschatus* forms but larger and probably otherwise different. Pleistocene of northern North America.
O. yukonensis.

Table IV.—Measurements of 3 male and 5 female skulls of Muskoxen from Bache Peninsula and Melville Island.

	♂ 15599	♂ 15596	♂ 15593	♂ Average.	♀ 15680	♀ 15590	♀ 15681	♀ 15592	♀ 15683	♀ Minimum.	♀ Maximum.	♀ Average.	♂ 1428[1]	♂ 1427[1]	♂ 1300[2]	♀ 1431[1]
Total length	449	465	465	459.6	422	421	432	435	434	421	435	426.9	497	490	—	409
Basal length	419	440	437	432	397	398	410	412	412	397	412	405.4	455	447	435	382
Mastoid breadth	165	173	176	171.3	155	150	157	158	160	150	160	156	—	186	—	147
Orbital breadth	241	249	246	245.3	205	205	221	211	—	205	211	210.5	265	265	255	207
Postorbital breadth	132	125	130	129	117	110	115	116	118	110	118	115.2	156	150	131	112
Nasals, length	139	146	153	146	138	137	146	144	143	137	146	141.6	148	154	143	134
" greatest breadth	63	60	71	646	55	60	59	63	56	55	63	58.6	82	78	68	60
Maxillary toothrow, length	140	140	142	140.6	140	135	138	140	136	135	140	137.8	140	137	138	129
Palatal breadth at m^2	74	77	80	77	68	70	70	71	71	68	71	70	80	78	—	67
Lower jaw, length	364	385	382	377	345	357	357	350	353	345	357	352	—	401	—	-
" " angle to condyle	127	142	130	133	123	122	127	122	—	122	127	123.5	—	151	—	—
" " " to condylar process	167	—	166	166.5	160	161	164	162	—	160	164	161.7	—	190	—	—
" " toothrow, length	149	146	147	144.3	143	144	136	141	136	136	144	140	—	140	—	—
Horns, distance between tips	551	525	618	564.6	335	—	361	360	370	335	370	356.5	510	611	—	301
" breadth at base	194	212	164	190	68	66	88	77	78	66	88	75.4	222	240	—	70
" length on outer curvature	554	535	583	557.3	365	383	475	420	430	365	475	414.6	750	746	—	464
" distance between bases of sheaths	23	12	12	15.7	66	—	25	44	57	25	66	48	14	12	—	46
Weight of skull	$12\frac{3}{4}$	$11\frac{1}{2}$	12	$12\frac{1}{8}$	5	$5\frac{3}{8}$	$6\frac{1}{8}$	6	$5\frac{1}{2}$	5	$6\frac{1}{8}$	$5\frac{4}{5}$	—	—	—	—
" " lower jaw	$1\frac{7}{8}$	2	$1\frac{7}{8}$	$1\frac{14}{16}$	$1\frac{5}{8}$	$1\frac{5}{8}$	$1\frac{1}{2}$	$1\frac{1}{2}$	—	$1\frac{1}{2}$	$1\frac{5}{8}$	$1\frac{9}{16}$	—	—	—	—
Total weight of skull	$14\frac{1}{4}$	$13\frac{1}{2}$	$19\frac{3}{8}$	16	$6\frac{5}{8}$	7	$7\frac{3}{8}$	$7\frac{1}{2}$	—	$6\frac{5}{8}$	$7\frac{5}{8}$	$7\frac{1}{2}$	—	—	—	—

Table V.—Average Measurements of adult Muskox skulls from Grant Land, Bache Peninsula, Wager Inlet, the Barren Grounds, and Melville Island.

	31 Adult Males. Grant Land.	26 Adult Females. Grant Land.	3 Adult Males. Bache Peninsula.	5 Adult Females. Bache Peninsula.	5 Adult Males. Wager Inlet.	2 Adult Females. Wager Inlet.	6 Adult Males. Barren Grounds.	2 Adult Males. Melville Island.	1 Adult Female. Melville Island.
Total length	477	437	459.6	429	482	456.5	489	493.5	409
Basal length	442.2	410	432	406	442	432	443	451	382
Mastoid breadth	180	155	171.3	156	170	157.5	173	186	147
Orbital breadth	253.4	215.2	245.3	210.5	254	225	254	265	207
Postorbital breadth	136.5	117	129	115.2	132	121.5	138	153	112
Palatal breadth	77	70	77	70	74.4	74	78	79	67
Maxillary toothrow	140.5	136	139	138	131	125	134	138.5	129
Mandibular toothrow	144.4	139.2	144.3	140	138	123	141	140	—
Nasals, length	150.6	144	146.	141.6	150	158	147	151	134
" breadth	67.5	55.3	64.6	58.6	69	54.5	71	80	60
Lower jaw, length	378	355	377	352.4	383	373	386	401	—
" " angle to condyle	132.7	123.5	133	123.5	137.6	127	152	151	—
" " " to top of condylar process	175.4	161	166.5	161.7	177.4	161	197	190	—
Horns, spread at tips	616.7	468	564.6	356.5	541	516	574	560	301
" length on outer curvature	607.5	—	557.3	414.6	582	485	579	748	464
" breadth at base	190	86.4	190	75.4	216	87	229	231	70

[1] Nos. 1428, 1427, 1431, Melville Island, collected by Captain G. E. Bernier on the Voyage of the 'Arctic'. Loaned for examination by the Victoria Memorial Museum, Ottawa, Canada, through Mr. Paul A. Taverner.

[2] No. 1300, Melville Island. From Kowarzik's table, *l. c.*

Ovibos moschatus moschatus (*Zimmermann*).

Barren Ground Muskox.

Bœuf musqué, Jérémie, Relation du Détroit et de la Baye de Hudson, in Bernard's Recueil de Voyages au Nord, VI, 1720, pp. 9, 10; nouv. éd., III, 1732, pp. 314, 315. (First published account of the muskox, on which was exclusively based all subsequent accounts of this animal for the next half century, and one of the two principal original sources of all references to it for a century.)

Bœuf musqué, Charlevoix, Journal d'un Voyage dans l'Amérique sept., III, 1744, pp. 132, 133. (Quoted from Jérémie; this is the source from which Jérémie's account has usually been taken).— Blainville, Bull. Soc. Philomatique, 1816, pp. 81, 82 (description of a male in Bullock's collection).

Musk-Ox, Dobbs, Account of the Countries adjoining Hudson's Bay, 1744, pp. 18, 19, 29. (A paraphrase of Jérémie's account, very much abridged, 9 lines on pp. 18 and 19, and 2 lines on p. 29; not an original source, as citations of Dobbs would lead one to suppose, but obviously based on Jérémie, though Jérémie is not mentioned. On comparison of his text with that of Jérémie, there is nothing in Dobb's account that would lead one to infer that he ever saw a muskox.)

Musk ox, Ellis, Voyage to Hudson's Bay, 1748, p. 232. (The only reference to the muskox is the statement that the Eskimos of the Hudson Bay region wear "a cap made of the skin of a Buffalo's Tail; which, tho' it has a horrid Appearance, yet it is very useful in keeping off the Musketoes, which in this country are excessively troublesome." Cited by later authors as referring to the muskox. Stated by Hearne, in correction of Ellis, that the cap is made of the long hair from the throat.)

Musk Buffalo, Pennant, Hist. Quad., I, 1781, p. 27, pl. ii, fig. 2. (Based wholly on Jérémie, as above, as far as it relates to the muskox, with a composite figure representing the body of a bison with apparently the head of a muskox. This is the first formal introduction of the species into natural history literature); Arctic Zool., I, 1784, pp. 8–11, pl. vii. (Still based on Jérémie so far as the male is concerned, but the description and plate are from a skin collected and sent to England by Hearne. The figure of the female is the first illustration based on a specimen — a fair representation, often copied by subsequent authors during the next quarter of a century.)

Bison musqué, Buffon, Hist. Nat., Suppl., VI, 1782, pp. 46, 47, pl. iii, "la tête du Bison musqué." (Erroneously states that the horns are united at the base. The figure was received from "M. Magwan, un Savant de l'Université d'Edimbourg.")

Bisamochsen, Hermann, Naturforcher, 1783, pp. 91–95, pl. v. (Based on previous authors; pl. v, head, altered from Buffon.)

Musk ox, Hearne, A Journey from Prince of Wales's Fort in Hudson's Bay to the Northern Ocean, in the years 1768–1772 (1795), pp. 4, 31, 135–139. (The first full and intelligent account of the muskox from personal observation; still important as an original source of information; freely quoted by subsequent writers).— Parry, Second Voyage for the Discovery of the North-west Passage, 1824, p. 497 (muskox hair and teeth found in possession of the Eskimos of Winter Island, off Melville Peninsula, probably brought from west of Hudson Bay); 503 (also cups or bowls made from muskox horns); p. 512 ("the muskox is very rarely found to extend his migrations to the eastward of a line passing through Repulse Bay, or about the meridian of 86° West. . . .In Greenland this animal is known only by vague and exaggerated report; on the western coast of Baffin Bay it has certainly been seen, though very rarely by the present inhabitants; and the eldest person belonging to the Winter Island tribe had never seen one to the eastward of *Einwillik*, where, as well as at *Akkōōleĕ* they are said to be numerous on the banks of fresh-water lakes and streams." — J. Ross, Ross's Second Voyage, App., 1835, pp. xviii, xix (important notes on distribution).— Rae, Journ. Roy. Geogr. Soc. London, 1852, p. 73. (A large muskox bull killed near the mouth of the Coppermine River and its skeleton saved, June 9, 1851, presumably the one figured and described by Richardson in the 'Zoology of the Herald.' — Kennedy, Second Voy. of the 'Prince Albert' in Search of Sir John Franklin, 1853, p. 128 (Cresswell Bay); p. 133 (Belloit Strait).— Anderson, Journ. Roy. Geogr. Soc. XXVII, 1857, p. 321. (Eskimo lodges seen at Lake Franklin made of muskox skins).— Schwatka, Nimrod in the North, 1885, 87–111, 3 illustrations (relates to observations made en route from Wager Inlet to King William Land).— Inman, Buffalo Jones's Forty Years of Adventure, 1899, p. 369 (range south to the north end of Artillery Lake); p. 372 (description); p. 383–386 (lassooing musk-ox calves); p. 389 (females have four teats like a domestic cow).— Pike, Barren Ground of Northern Canada, 1892, p. 64 (a muskox killed near Lac de Gras); pp. 103–109 (muskox hunting; growth of the horns, etc.); pp. 166–169 (muskoxen near Lake Aylmer).— Hornaday, N. Y. Zoöl. Soc. Bull., No. 7, Sept. 1902, pp. 33–35, with 1 text fig. (account of the living specimen in the Park, taken in March, 1901, north of Great Bear Lake, 30 miles from the Arctic coast); *ibid.*, No. 45, May, 1911, pp. 754, 755 (probable recent occurrence near Point Barrow, Alaska).— Hanbury, Sport and Travel in the Northland of Canada, 1904, pp. 11–13, 40, and *passim* (habits, measurements, weight, distribution, etc.; colored plate of muskox as frontispiece).

Bos moschatus Zimmermann, Geogr. Gesch., II, 1780, p. 76 (based primarily on Pennant).— Gmelin, Syst. Nat., I, 1788, p. 205 (based on Pennant, Jérémie, as quoted by Charlevoix, and Dobbs).— Shaw, Gen. Zool., II, pt. ii, 1801, pp. 407–410, pl. ccxii (based on Pennant; the plate, with two figures, is copied from Pennant, and is titled "Musk Ox. Male

and Female." The "male" is from Pennant's Plate II, fig. ii, of 1771 and 1781, a composite picture representing the body of a bison with the head of a muskox; the female is a copy of Pennant's "Musk Cow" of 1784).— CUVIER, Régn. Anim., IV, 1817, p. 271; Ossem. foss., nouv. éd., IV, 1823, pp. 133–137, pl. x, fig. 15–17, skull (from a skull in Camper's cabinet).— DESMOULINS, Dict. class. d'Hist. nat., II, 1822, p. 369.— WAGNER, Schreber's Säuget., V, ii, 1838, pp. 1706–1716, pl. cccii A, animal (from Pennant), pl. cccii B, head of male (from Buffon. Extended summary of its history, habits, external characters, and distribution as then known); Schreber's Säuget., Suppl., IV, 1844, p. 512; V, 1855, p. 471 (regarded as not separable from the genus *Bos*).

Ovibos moschatus BLAINVILLE, Nouv. Bull. Soc. Philomat. Paris, 1816 (basis of his genus *Ovibos*).— DESMAREST, Mamm., II, 1822, p. 492.— RICHARDSON, Parry's Second Voyage, App., 1825, pp. 331, 332 (distribution and habits); Faun. Bor.-Amer., I, 1829, pp. 275–278 (general account and external characters); Zool. Voy. Herald, Mamm., 1854, pp. 66–87, 119–122 (osteology), pl. ii (skeleton), pll. iii and iv (skulls), pl. v (atlas and axis).— GODMAN, Amer. Nat. Hist., III, 1827, pp. 29–36, pl. (general account; illustration of male, copied from Parry's 'First Voyage').— HAMILTON-SMITH, Griffith's Anim. Kingd., IV, 1827, p. 373 (general account).— FISCHER, Syn. Mamm., 1829, p. 494.— GRAY, Cat. Mamm. Br. Mus., pt. 3, 1852, pp. 42–44, pl. v, figs. 1, 2, skull of male, pl. v*, figs. 1–4, skulls of female and young male, sex marks, ♂ and ♀, transposed; records a "male stuffed, N. America. Presented by the Lords of the Admiralty, from Capt. Parry's first voyage. Specimen figured, Parry's *First Voyage*, t. 189."— AUDUBON & BACHMAN, Quadr. N. Amer., III, 1854, pp. 46–52, pl. cxi (plate drawn from the Parry specimen in the British Museum, "which is the only one hitherto sent to Europe").— BAIRD, P. R. R. Exped., VIII, 1857, pp. 680, 681, fig. 33, muzzle (the only specimen then in the United States said to be in the museum of the Academy of Natural Sciences of Philadelphia, presented by Dr. Kane).— DAWKINS, Proc. Roy. Soc., London, XV, 1867, pp. 516, 517 (systematic position and geographical distribution, recent and extinct); Ann. and Mag. Nat. Hist., (3) XX, Aug., 1867, pp. 139, 140 (same as the last); Palæontol. Soc., XXV, pt. 5, 1872, pp. 1–20, pll. i–v, part (osteology, classification, external characters, habits, distribution).— LEIDY, Journ. Acad. Nat. Sci. Philadelphia, N. S., VII, 1869, p. 373 (four skulls obtained by Dr. I. I. Hayes at Port Foulke, Greenland).— M'CORMICK, Voy. of Discov., II, 1884, pp. 113, 132 (a weathered skull and fresh tracks found on the west shore of North Devon).— MURDOCH, Rep. Internat. Polar Exped. to Point Barrow, 1885, p. 98 (skull, from near Point Barrow, believed to be recent).— "PIKE, Badminton Library: Big Game Shooting, I, 1894, pp. 424–435" (distribution and habits).— WHITNEY, On Snowshoes to the Barren Grounds, 1896, pp. 216–235 (Barren Grounds, north of Great Bear Lake; general account of habits and external appearance at different ages; illustrations: muskox at bay, frontispiece; old bull, from photograph of a mounted specimen, p. 225; hoofs, pp. 228, 229; head of two-year old bull, p. 230).— TYRRELL, Geol. Surv. Canada, 1897, pp. 165 F–167 F (distribution).— LYDEKKER, Wild Oxen, Sheep, and Goats of all Lands, 1898, p. 146 (general account; believed to have "never been brought alive to Europe," at this date.— RUSSELL, Explor. in the Far North, 1898, pp. 232–236 (Barren Grounds, near Bathurst Inlet, where five were killed; habits, external characters, with measurements; also 'The Muskox Hunt', pp. 108–124).— TROUESSART, Cat. Mamm., fasc. V, 1899, p. 984; fasc. vi, 1899, p. 1356; Suppl., 1905, p. 742.— KIDD, Proc. Zool. Soc. London, 1900, p. 680 (in hair slope agrees with *Buffelus*, *Bison*, and *Poëphagus*).— A. J. STONE, Bull. Amer. Mus. Nat. Hist., XIII, 1900, p. 42 (signs of their recent presence southeast of Cape Lyon; no evidence obtained of their former presence west of Anderson River); Vol. XIV, pp. 84–86, 1901 (on their supposed former occurrence in Alaska and between the Mackenzie and Anderson Rivers).— ELLIOT, Synop. Mamm. N. Amer., 1901, p. 48, pl. xxii, part; Check List Mamm. N. Amer., 1905, p. 55.— PREBLE, N. Amer. Fauna, No. 22, pp. 43, 44, Oct. 31, 1902 (distribution in the Hudson Bay region. A pair seen during the summer of 1897 on the 'Barrens' about half way between York Factory and Fort Churchill and the male killed and brought to Fort Churchill by Indians. This is "probably the most southern authentic record of this animal").— HORNADAY, Amer. Nat. Hist., 1904, pp. 103–107, and 3 text figs. part (general account of the muskoxen, *O. moschatus* and *O. wardi*, with illustrations: (1) of a female in the New York Zoölogical Park, from a photograph of the living animal; (2) range of the muskox, with map; (3) a muskox herd at Franz Joseph Fiord, East Greenland. Full list of living specimens taken to Europe and the United States, 1899–1903, and of those still living in zoölogical parks in December, 1903).— MACFARLANE, Proc. U. S. Nat. Mus., XXVIII, 1905, pp. 686–689 (habits and distribution, in large part from original observation).— PREBLE, North Amer. Fauna, No. 27, pp. 150–155, with map, Oct. 26, 1908 (distribution in North America, with map and detailed summary, including citations, of previous records; invaluable for references to original sources of information).— GILMORE, Smithson. Misc. Coll., LI, No. 1807, 1908, pp. 35, 36 (Pleistocene remains, provisionally referred to *O. moschatus*).— QUACKENBUSH, Bull. Amer. Mus. Nat. Hist., XXVI, pp. 93–127, *passim*, March 24, 1909 (Pleistocene, Alaska; includes *O. yukonensis* Gidley; p. 93 (Keewalik River); p. 95 (Eschscholtz Bay); p. 105 (Goose Bay); p. 106 (north side of Eschscholtz Bay); p. 120 (Buckland River); p. 127 (in a list of Alaska Pleistocene mammals).— ALLEN, Bull. Amer. Mus. Nat. Hist., XXVIII, p. 8, Jan. 5, 1910 (Aylmer Lake; measurements of an old bull, collected and measured in the flesh by E. Thompson Seton).— KOWARZIK, Fauna Arctica, V, 1910, pp. 97–101, fig. 2, animal, fig. 3 skull.— ALLEN, Science, N. S., XXXVI, pp. 720–722, Nov. 22, 1912 (probable recent extinction in Alaska.

Ovibos moschatus mackenzianus KOWARZIK, Fauna Arctica, V, Lief. 1, 1910, pp. 97, 116–122, fig. 15, skull.— MILLER, List N. Amer. Mamm., Bull. 79, U. S. Nat. Mus., 1912, p. 394.

Ovibos mackenzianus KOWARZIK, Zool. Anz., XXXVII, Feb., 1911, p. 107.

Fig. 27. Map showing present and recent Distribution of Muskoxen in North America and Greenland.

(1) Present range; (2) probable range at the beginning of the Nineteenth Century; (3) localities where fossil remains have been found. (See explanation of symbols in lower right hand corner of map.)

Ovibos moschatus moschatus is very dark, nearly black on the head, neck, sides, and underparts, with the feet and nose white; the back is lighter (browner black), with a still lighter 'saddle' behind the shoulders. There is no white area on the head in adult males, although individual white hairs may often be found on the face; in young animals and females there is sometimes quite a trace of white on the front of the head.

Few measurements of the animal in the flesh are available. An old male (No. 29042) killed and measured by Mr. E. T. Seton at Aylmer Lake gave the following: Total length, 2338 mm. (96 in.); tail vertebræ, 102 mm.; hind foot, 508 mm.; height, 914 mm.

Distribution.

The muskox of the Canadian Barren Grounds (*O. moschatus moschatus*), as shown in the above table of bibliographic references, has a voluminous literature, the gist of which is summarized in the above annotated references and in the 'Historical Summary' already presented (*antea*, pp. 157). Its habits have long been well known and scarcely need recapitulation in the present connection. The account given by Hearne, already quoted (*antea*, p. 163) based on extended observations made in 1769–1772, is a concise summary that has well stood the test of time. An excellent account of its geographical distribution was given by Preble [1] in 1908, with citation of all the important sources of original information that had appeared prior to that date, and little has since been published.

It is common knowledge that the range of the Barren Ground Muskox is becoming year by year more restricted and its numbers fewer, especially where its range is accessible to the Eskimos, who, as explorers of muskox country have repeatedly stated, always exterminate any herd of these animals, large or small, with which they come in contact. Likewise roving bands of Indians from the Hudson Bay Company's posts on Great Slave Lake and near Great Bear Lake are reported as making occasional raids upon them, and as almost always destroying the entire herd attacked. A decade ago many were killed by whalers along the Arctic coast near Cape Bathurst for their meat and robes, where also the first living specimen brought to the New York Zoölogical Park was captured by Captain H. H. Bodfish, of the whaling steamer 'Beluga,' in March, 1901. While many were killed by whalers, or by Eskimos for them, on Parry Peninsula and as far west as Anderson River (about the 127th meridian) during the closing decade of the last century, they are now rarely found west of the 120th meridian. For the following statement respecting their range in the Coppermine River district, in Victoria Land, Wollaston Land, and Banks Island, I am indebted to Mr. V. Stefansson and Dr. R. M. Anderson, who have recently returned from an exploration of this region in the interest of the American Museum. The following notes by Dr. Anderson on the present distribution and recent great decline in numbers along the Arctic coast and eastward to Coronation Gulf, kindly prepared in response to my solicitation for use in the present connection, are an important authoritative contribution to present knowledge of the subject. From their statement it is evident that very few muskoxen remain north of a line connecting Great Bear Lake and the western end of Coronation Gulf, nor along the southern shore of Coronation Gulf west of about the 113th meridian. They also appear to have been practically exterminated on Victoria Island except near the northern border.

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[1] Preble, Edward A. North American Fauna, No. 27, Oct., 1908, pp. 150–155, with map.

Notes on Muskoxen.

By Dr. R. M. Anderson.

Herschel Island. In August, 1908, Mr. Stefansson and myself found an old muskox skull on the southwest sandspit of Herschel Island, Yukon Territory, Canada. It seems hardly probable that this skull was brought from the Franklin Bay region by whaling ships, both on account of its weathered appearance and the fact that the harbor for ships is at the other end of the island.

Arctic Coast of Alaska. June 24, 1909. Found part of an old muskox skull (frontal bones, base of skulls, and part of each horn core), water-logged and green with moss, half-buried in the mud of a beach, about three feet from the bank, near the mouth of a little creek about two miles west of the western mouth of Colville River, Alaska.

June 2, 1909. Musk-ox remains were found in Colville River valley.

Panniyulak, one of the older and most prominent men in the Colville region (Alaska), told us that there is a muskox skull in a good state of preservation on the west side of Kupuk Island, Colville delta, about five miles below the mouth of the Stkillik River (the largest eastern affluent of the Colville, near its mouth). This skull was also known to other natives in this village. None of the men here, the oldest probably sixty years of age, have ever seen a living muskox, although all had seen skulls and bones at various places on the level country (coastal plain) but none in the mountains.

Liverpool Bay. April 14, 1910. While camping in the southwest part of Liverpool Bay, Memoranna ("Jimmy"), one of the most trustworthy Eskimos of this region, about 35 or 40 years old, told me that formerly muskoxen were often killed on the west side of Liverpool Bay, and that he had seen two here when he was a boy. Since that time (probably twenty-five years ago), none had been heard of west of Cape Bathurst.

Extinction in region around Franklin Bay. I have information from numbers of whalers, as well as from natives of the region, that muskoxen were frequent around Langton Bay and in the highlands on the west side of Franklin Bay as far north as the mouth of Horton River, as late as 1897. During 1897–1898, four ships wintered at Langton Bay, and over eighty muskoxen were killed, mainly by Alaskan Eskimos hunting for the ships. Some of the meat was hauled to the ships, but the bulk of the animals were killed too far away for the meat to be hauled in, and most of the robes were left out too long in the spring thaws, so that very little use was made of anything. Since that time no traces of living muskoxen have been seen in the region, either by natives who occasionally hunt there, or by our party during over two years. Muskox heads, horns and bones are occasionally found on the ground.

The same winter that the ships were at Langton Bay, Akpellik (an Alaskan Eskimo) killed a herd of about twenty muskoxen near the coast about the middle of the east side of Darnley Bay, near the base of a small range of conspicuous rocky hills.

Last record of Muskoxen seen by western Eskimo. Somewhere between the years 1898 and 1905, four Alaskan Eskimo hunters made a long expedition after muskoxen. Ascending a fairly large river which enters the east side of Darnley Bay, they travelled inland (southeast) for nine days before seeing muskoxen and finally killed twenty-seven, in two bands. These skins with some heads were sold to whalers at Baillee Island. Coming out, they travelled north six days before they struck the Arctic coast, four and one half days east of Cape Lyon. From the circumstances of their account it is practically certain that these hunters went as far east as the lake which is the source of Rae River. The Rae River Eskimos, at the western end of Coronation Gulf, from Mr. Stefansson's account, know little about the range of the muskox, and many had never seen the animal. It is probable that a few muskoxen may still be found in the high, rocky uplands at about the center of the triangle bounded by Darnley Bay, Coronation Gulf, and Great Bear Lake.

In our winter traverse from Langton Bay to Great Bear Lake, on January 5, 1911, we saw old tracks and dung on the snow which were declared by the Slavey Indians in our party to be those of muskoxen. This was on barrens 40–50 miles northwest of Dease Bay, Great Bear Lake.

Muskox at Great Bear Lake. David T. Hanbury (Sport and Travel in the Northland of Canada. New York: The MacMillan Company. London: Edward Arnold, 1904, pp. 225, 234), describes the killing of two bulls in August, 1902, in the sparsely timbered country between Dismal Lake and Dease River.

We spent the greater part of the winter of 1910–1911 on the east branch of Dease River and eastern end of Great Bear Lake, and saw no recent signs of muskoxen. Two or three years before the Bear Lake (Slavey) Indians had made a big hunt in this region and killed about eighty. During the winter we were there, the Indians had made an unsuccessful hunt to the northeast of Great Bear Lake, seeing no signs, but later in the winter (February or March, 1911) had seen three on "Caribou Point" (the great peninsula between Dease Bay and McTavish Bay, Great Bear Lake), and had killed all three.

Dease River, N. W. T. In the summer of 1910, Mr. Stefansson and his Eskimos found numerous muskox droppings of the previous winter around the Lake Immaernirk, the head of Dease River. None were seen the following winter however.

West End of Coronation Bay. Apparently muskoxen are seldom if ever found at the present time in the region around the mouths of Rae River, Richardson River, or the Coppermine River. Quite a number of groups of Eskimos hunt in this region and they say that muskoxen are all further to the East.

Coronation Gulf. Eskimos in a village about midway between Home Island and Epworth Point, Coronation Gulf, told us (April 15, 1911), that there are many muskoxen on the mainland around a river called Kogyuktuayuk (about at the Tree River of charts, some 75 miles east of the mouth of the Coppermine River). They said they often see muskoxen near the sea coast, but seldom hunt them, because they have only bows and arrows, and are afraid. These people had heard of people to the eastward (near Kent Peninsula), who have guns and kill many muskoxen.

Eskimos from the country west of Kent Peninsula came to the schooner 'Teddy Bear,' near the mouth of Coppermine River, in the spring of 1911, bringing about thirty muskox skins with them.

May 31, 1911, while hunting for traces of muskoxen in the above mentioned region, we found several Eskimos who had been camping a few miles inland for some time, and these told us that they had seen no muskoxen that spring. They say the muskoxen keep pretty far inland in spring and early summer, and come to the coast later in the season.

Victoria Island. From information which Mr. Stefansson received from numerous groups of Eskimos in Coronation Gulf, Dolphin and Union Straits, and Prince Albert Sound, it seems probable that no muskoxen at all are found in either the southern or central portions of Victoria Island (*i. e.*, Wollaston Land, Victoria Land, Prince Albert Land). Muskox horn implements among these people are said to come from eastern Coronation Gulf, or the mainland south and east of this region.

Some of the Eskimos of Prince Albert Sound remember of the former occurrence of the muskox around Minto Inlet and Walker Bay, but say that there are now none in that region. These natives say that up to fifteen or twenty years ago they occasionally made hunting trips across to the north side of Victoria Island (Collinson Inlet) and found muskox there. It is their belief that muskox are still found near the north coast of the island.

Banks Land. I have talked with a reliable Eskimo (Kotzebue Sound, Alaska), who was with us four years, concerning muskoxen in Banks Land. He had gone ashore one day several years before near Cape Kellett (west side of Banks Land) to try to kill caribou for a whaling ship, and saw numbers of muskox skulls on the land. Eskimos who winter on the ice between Cape Collinson and De Salic Bay, say that the muskox sometimes come down to the coast in winter.

The Stefansson-Anderson collection contains an imperfect skull (lacking most of the facial portion anterior to the base of the nasal bones) of an old male muskox found inland on the tundra 40 or 50 miles southeast of Point Barrow, on the Mead River. It is more or less discolored, apparently by green algæ, and strongly shows the effect of weathering, but it is not mineralized and apparently has always had surface exposure. It does not differ much in size or in any other features from an old male skull of *moschatus* of large size from Lake Aylmer, with which it has been carefully compared. The length of the horncore base is slightly greater than in the Lake Aylmer specimen, but the mastoid breadth and the postorbital breadth are slightly less. The outer third of both orbits has been smoothly and symmetrically cut away with some sharp implement, evidently the work of Eskimos. The collection also contains the horn sheath of a large old male muskox, comprising the apical half complete; the upper half of the remainder is lacking, but the lower side runs out to a narrow point nearly to the base of the sheath. The missing part was removed by fracture and not by a cutting implement. In other respects the sheath is in good condition, having suffered little from weathering. It was obtained at the site of a former village about six miles southwest of Point Barrow.

There are also a number of fragments of muskox skin with the matted hair. The skin has nearly disappeared by decomposition, and the hair and wool remaining are brittle and much frayed. These fragments are from a village site about 15 to 20 miles southwest of Point Barrow. Several muskox teeth were also obtained at this same village site, which have the appearance of recent origin. With them are several horse teeth, but the latter are heavily mineralized and probably came originally from nearby Pleistocene deposits. Mr. Stefansson suggests that they may have been used as toys by Eskimo children.

It has long seemed probable that the muskox inhabited, at a not very remote time, the barren-grounds of northern Alaska, this having been the conviction of a number of explorers who have visited this region within the last thirty years, their belief being founded in part on the occurrence of weathered muskox skulls on the surface of the tundra, and in part on the reports of the natives

of the region, whose traditions attest their presence in the Colville River region and the vicinity of Point Barrow nearly as late as the middle of the last century. A summary of the evidence was recently published in 'Science,'[1] and is here reprinted.

Probable Recent Extinction in Alaska.

The question of the probable recent extinction of the muskox (*Ovibos moschatus*) in northern Alaska, which has often been mooted, acquires new interest through information kindly furnished me by Mr. Vilhjálmur Stefánsson, who has just returned from four years of exploration in Arctic America in the interest of the American Museum of Natural History. Under date of New York, November 2, 1912, he writes:

"*Dear Dr. Allen:* At your request I summarize briefly my information in regard to muskoxen in Alaska secured on the museum's arctic expedition during the years 1908–12; a full statement will in due course be prepared by Mr. R. M. Anderson, who was in charge of the zoological work of the expedition.

"(*a*) Information secured from natives and white residents in Alaska: During the winter 1899–1900 there died at Cape Smythe (or near there) the Eskimo man called Mangi by the whalers (probably Mangilanna). He was the last to die of Cape Smythe (Point Barrow) natives who had seen live muskoxen in that vicinity. He was probably born between 1845 and 1850, as he was able to remember Maguire's visit to Point Barrow. A few years after Maguire's time — perhaps therefore about 1858 — there was scarcity of food in winter at Cape Smythe. Mangi's father then went inland looking for caribou, and some distance up the Kunk River, which flows into Wainwright Inlet, they fell in with a band of thirteen muskoxen and killed them all. Since then no one near Point Barrow is known to have killed muskoxen or seen them.

"There are many places inland from Point Barrow where muskox skulls and bones are abundant. As these are heavy and there is no market for them locally, few are brought to the coast. Our party secured one skull only.

(*b*) Information based on specimens: While digging in an old house ruin about 15 miles southwest along the coast from Cape Smythe an Eskimo last summer (1912) found a muskox skin and brought it to me for sale; it is in the Point Barrow collection which has just arrived at the Museum but has not yet been unpacked. Another Eskimo found a smaller piece of skin in another house which I believe to be of a muskox, though its badly decayed condition makes it difficult to say positively that it is not the skin of the barren-ground bear.

"I have myself seen muskox skulls both in the delta of the Colville (imbedded in the earth) and on Herschel Island (on top of the ground).

Respectfully,

V. STEFÁNSSON."

In this connection it may be recalled that Richardson in 1829[2] stated: "From Indian information we learn that to the westward of the Rocky Mountains, which skirt the Mackenzie, there is an extensive tract of barren country, which is also inhabited by the muskox and reindeer."

But no muskoxen were found when this section of country was subsequently visited by white men. Muskox skulls, however, have been found upon the surface of the tundra inland from Point Barrow in a condition indicating a recent and not a Pleistocene origin. Thus Mr. John Murdock, of the International Polar Expedition to Point Barrow,[3] reported that just before leaving Point Barrow in 1884 a muskox skull was brought in by one of the trading parties which had been as far eastward as the Colville River, and he presumed that the skull had been brought from there, and adds: "The natives knew the animal well, and called it by nearly the same name as the eastern Eskimos, but none had ever seen it alive. The skull obtained appeared very old and much weathered."

Some years later the McIlhenny Expedition to Point Barrow obtained "one weather-beaten [muskox] skull picked up on the tundra."[4]

Mr. L. M. Turner, in referring to the muskox,[5] says: "There is no positive evidence of the actual occurrence of this mammal within the region here included [the Yukon District and the Aleutian Islands]; but, as the northern Innuit and Indians are so well acquainted with it, there can be no doubt that it has but recently disappeared, if scattered individuals do not yet inhabit the region north of the Rumianzof Mountains near the Arctic coast."

In 1898, Mr. Frank Russell[6] made the following statement: "The muskox was formerly common between the Mackenzie and Behring Straits, as evidenced by the remains which are scattered over the tundra. The oldest natives at Point Barrow say that their fathers killed muskox, which were then abundant.

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[1] Allen, J. A. The probable recent occurrence of the Muskox in Northern Alaska. Science, N. S., Vol. XXXVI, No. 934, pp. 720-722, Nov. 22, 1912.

[2] Faun. Bor.-Amer., I, p. 276.

[3] Rep., 1885, p. 98.

[4] Witmer Stone, Proc. Acad. Nat. Sci. Phila., 1900, p. 35.

[5] Contr. to Nat. Hist. Alaska, 1886, p. 203.

[6] Expl. in the Far North, 1898, pp. 235, 236.

Recently Dr. W. T. Hornaday has published [1] additional information furnished him by Mr. Charles D. Brower, who has lived at or near Point Barrow since 1884, much of which is in substance the same as that given above by Mr. Stefánsson. The latter, however, not only confirms the main details of Mr. Brower's account, but gives additional facts of considerable importance.

The information presented above, except that recently published by Dr. Hornaday, was gathered and published by me in 1901 [2] apropos of the alleged then recent occurrence of muskoxen along the Arctic coast of Alaska east of Point Barrow, based on three fresh skins with their skulls shipped from Camden Bay to San Francisco and thence to New York, where, through the kindness of Mr. E. Bowsky, of New York City, I had opportunity of compare them with skins and skulls from the Barren Grounds east of the Mackenzie. A communication from Mr. A. J. Stone was published in the same connection to the effect that these muskox skins must have originally been obtained by whalers around the head of Franklin Bay or on Parry Peninsula and by them taken to Camden Bay, as he had found no evidence of the recent existence of muskoxen in northeastern Alaska. This, however, does not in any way controvert the testimony afforded by skulls found on the surface of the tundra near the coast of this portion of Alaska, nor the facts now furnished by Mr. Stefánsson in confirmation of the previous evidence of the existence of living muskoxen there as recently as fifty to sixty years ago.

J. A. ALLEN.

As stated above, a letter from Mr. Charles D. Brower was published by Dr. Hornaday in April, 1911, evidently based on the sources of information cited above by Mr. Stefansson. Dr. Hornaday has since received from Mr. Brower a horn of a muskox which he says in his accompanying letter, dated Banoa, Alaska, Sept. 6, 1912, was "taken from the ground [two days before], about five feet below the surface, in what looks as though it had been [the site] of an ice house." This horn, recently shown to me by Dr. Hornaday, is that of an old bull, from which the broad basal portion has been removed, and more or less of one side cut away with a knife or other cutting instrument, or, as stated by Brower in his accompanying letter, the horn "has been worked on by the Eskimos." He also refers to "a part of the skin of a muskox which was unearthed at one of the oldest Eskimo villages in this part of Alaska" which he is sending to Dr. Hornaday through Mr. Stefansson, and adds that this new evidence "goes to prove in my [his] estimation that muskoxen must have been at one time fairly plentiful here."

As said above in my 'Science' article, it seems reasonable to believe that the muskox existed on the tundras of northern Alaska till nearly the middle of the nineteenth century.

The probable range of *Ovibos moschatus* and its subspecies is indicated on the map facing p. 185 (Fig. 27), the shaded area indicating approximately its present occurrence and its probable range at the beginning of historic records.

Ovibos moschatus niphœcus *Elliot.*

HUDSON BAY MUSKOX.

Ovibos moschatus niphœcus ELLIOT, Proc. Biol. Soc. Washington, XVIII, 1905, p. 135, April 18, 1905 (original description. Type locality, "600 miles north of Hudson Bay" = head of Wager Inlet); Check List Mamm. N. Amer., 1905, p. 56, — KOWARZIK, Zool. Anz., XXXIII, Nov., 1908, p. 617; Fauna Arctica, V, 1910, pp. 97, 110–113, fig. 8 (animal, after Elliot). MILLER, List N. Amer. Mamm., Bull. 79, U. S. Nat. Mus., 1912, p. 395.

Bosovis niphœcus KOWARZIK, Zool. Anz., XXXVII, Feb., 1911, p. 107.

The males are similar in coloration to males of *O. m. moschatus* except that they are rather more intensely black, while the horns are lighter colored; usually there is no or very little white on the head; females and young males have a variable amount of white on the head and face, in some specimens nearly as much as in average individuals of *O. m. wardi*.

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[1] New York Zool. Soc. Bull., No. 45, May, 1911, pp. 754, 755.

[2] Bull. Amer. Mus. Nat. Hist., XIV, 1901, pp. 81–83.

External measurements of specimens from the type locality are not available. Hanbury[1] gives the length of an average full-grown male, taken on the Arkilinik (or Thelon) River, west of Baker Lake, as 92½ inches (including the tail, length 2 inches); height at shoulder, 52 inches; girth, 69 inches; weight 579 pounds. He states that he has seen larger bulls, and gives the height at shoulder of one as 55 inches. Measurements of 8 skulls are given in Table III (*antea*, p. 181).

The type of *Ovibos moschatus niphœcus* proves, on comparison with the rest of the series from Wager Inlet, to be a dwarf, and for this reason is excluded from the averages given in Table V of measurements. In basal length it falls 29 mm. below the average of 5 other males, 15 mm. below in orbital breadth, and 24 mm. below in the length of the nasals. Yet the tooth-row is 4 mm. longer than the average. It is a young male in the sixth year, with all the sutures of the anterior portion of the skull still open as far as the postorbital region, but the dention has reached full development.

Distribution.[2]

The exact range of *O. m. niphœcus* cannot be given. The type locality, according to Captain George Comer, who collected not only the types in the Field Natural History Museum at Chicago, but also a series of topotypes for this Museum, is the country at the head of Wager Inlet, whence muskoxen extend west to Baker Lake, and thence along the Thelon River westward nearly to Great Slave Lake, but where *niphœcus* passes into *moschatus* (or Kowarzik's 'mackenzianus') is at present unknown. Muskoxen appear to have never been found east of Repulse Bay, and, according to Captain Comer, they do not at present occur south of Chesterfield Inlet. They probably range north from Chesterfield Inlet, Baker Lake, and Dubaunt River to the Arctic coast of the mainland, wherever the country is favorable to their existence.

Hanbury states (*l. c.*, p. 11): "After ascending the main Ark-i-linik River for about thirty-five miles, musk-ox tracks commenced to get numerous. The muddy shores in places were so ploughed up with them as to give the idea that a drove of cattle has passed along." He further states, writing of conditions in 1902 (*l. c.*, p. 13): "On the main Ark-i-linik River [Thelon River of most modern maps] there is a stretch of country about eighty miles in length into which no human being enters. The Eskimo do not hunt so far west, and Yellow Knives and Dog Ribs from Slave Lake do not go so far east. To penetrate this country in the dead of winter would be simply to court starvation. Then the deer have all departed, and to depend on finding muskoxen at the end of the journey would be risky indeed. Thus there still remains one spot in this Great Barren Northland which is sacred to the muskox. Here the animals remain in their primeval state, exhibiting no fear, only curiosity. I approached several herds within thirty yards, photographed them at my leisure, moving them round as I wished, and then retired, leaving them still stupidly staring at me as if in wonder."

Whether the same favorable conditions still continue is open to doubt; nor is it quite certain whether these observations relate to *niphœcus* or to *moschatus*; more probably to the latter.

For the following important information on the present distribution of muskoxen in the Hudson Bay region I am indebted to Captain George Comer, who has spent the greater part of the last twenty years in pursuit of the northern bowhead whale (*Balœna mysticetus*) in Hudson Bay,

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[1] Hanbury, David T. Sport and Travel in the Northland of Canada, 1904, pp. 12, 13.
[2] See map (Fig. 27) facing p. 185.

and has taken great interest in the archæology and natural history of the region, and incidentally has made important collections of the mammals and Eskimo products of the region for the American Museum of Natural History. The type locality of *O. m. niphœcus* was originally given as "600 miles north of Hudson Bay," on the basis of erroneous information received by the author. The type series of specimens, however, proves to have been taken by Captain Comer at the head of Wager Inlet, where he later obtained a series of topotypes for this Museum. His notes on the distribution of muskoxen in the Hudson Bay region, kindly prepared for use in the present connection, are based on his personal knowledge. His suggestions in relation to preventing the extermination of the muskoxen in the Hudson Bay region are prompted by his strong interest in the welfare of the Eskimos, as well as by a desire to prevent the annihilation of the muskox, on which the Eskimos depend for their means of existence.

Present Range in the country bordering Hudson Bay.

By Captain George Comer.

Regarding the region in which muskoxen are now found I can say from my own knowledge that they range along the coast of Hudson Bay from Chesterfield Inlet to Repulse Bay, but how far they extend to the west I am unable to say. They are not found, however, on Melville Peninsula nor in Baffin Land, and the natives of the present day have no remembrance of their ever having been there. I do not think they are found south of Chesterfield Inlet or Baker Lake. They are quite numerous west and northwest of Wager Inlet. Last winter (1911–1912) forty were taken by the Eskimos. I was unable to get their skins as they were held for the Hudson Bay Company. It is from this locality that I obtained the specimens for the Field Museum in 1896, and for the American Museum in 1902.

The natives claim that the muskoxen found in the country north of Baker Lake are much larger than those of Wager Inlet, and are known among them by the name of Oum-ming-mung-lüger.[1]

In former years the skins of these animals were not sought after, but of late years, with the decline of whaling and the increase in the value of furs, muskoxen have been more hunted. There is always much risk in hunting them unless the start is made with a good supply of provisions and of oil for the lamps. During the winter of 1891–92, thirty-seven lives were lost by the Iwilic tribe around Wager Inlet hunting muskoxen. The natives will undertake these trips, if left to themselves, only under the most favorable conditions. But the trader wants the skins and uses means to get them, fearing that if he does not get them some other party will. Rivalry in trade will have the double effect of first reducing the game and then the destruction of the natives. I speak from the standpoint of a trader and know that when we have traded as long as it is profitable the natives will be abandoned. Not only should the muskox be saved for the sake of the natives, but also all the other animals that serve them as food.

Ovibos moschatus wardi *Lydekker*.

White-faced Muskox.

Bos grunniens Fabricius (not of Linné), Faun. Groenl., 1780, p. 28. Skull found on an ice-floe off the coast of (West) Greenland, exact locality not stated; Kong. Danske Vidensk.-Selsk. Skrivter for 1809 og 1910, VI, pp. 61–63 (referred to *Bos moschatus* Zimm.; reference furnished by Mr. Witmer Stone).

Musk Ox, Parry, First Voyage for the Discovery of a North-west Passage, 1821, p. 68 (Melville Island, dung of muskoxen seen and "several heads of the musk-ox were picked up"; p. 79 (skulls of muskoxen found but no living animals met with); p. 202 (one muskox seen, June 13, 1820; notes on the appearance and habits of the species); p. 223 (seven muskoxen seen, July, 1820); p. 239 (a male muskox killed August 9); pl. facing p. 256, with the legend, "Musk Bull, Melville Island"; "from a sketch by Lieut. Beechey"; p. 257 (herd of muskoxen seen and a "fine bull" killed; "in this herd were two calves, much whiter than the rest, the older ones having only the white saddle; another bull killed, making three obtained on Melville Island during a period of nearly twelve months. See also below under Sabine, *Ovibos moschatus*. Noteworthy as the first record of the muskox from any of the insular areas north of the continental barren-grounds).

Musk-ox, Kane, Arct. Expl. in years 1853–1855 (1856), pp. 80, 456 (muskox skulls, etc., found near Renssalaer Bay, west coast of Greenland, in about latitude 78°, the first positive evidence of the existence of muskoxen in Greenland).—

[1] Probably the larger *Ovibos moschatus moschatus.*— J. A. A.

M'DOUGALL, Voyage of the 'Resolute' to the Arctic Regions, 1857, p. 103 (Lowther Island); pp. 288, 289, 296 (habits, Hardy Bay); p. 525 (albino seen); p. 525 (common at Melville Island); p. 529 (game list, includes 114 muskoxen).— HAYES, Open Polar Sea, 1867, p. 390 (recent muskox remains near Wolstenholme Sound; one killed there by Eskimos in 1859, showing "that the Muskox is not yet extinct in Greenland, as naturalists have supposed." — KOLDEWEY, German Arct. Exped. of 1869–70, English transl., 1874, pp. 322, 325–329, 427, 428, 455–477, 497, 498, 503, 544 (habits, distribution, and muskox hunting in East Greenland).— NARES, Narr. Voy. to the Polar Sea, I, II, 1878, *passim* (numerous references to muskoxen in Ellesmere Land, Grinnell Land, and Grant Land, all duly indexed on p. 373 of Vol. II).— BERNIER, Report on the....Arctic Islands and Hudson Strait, 1910, p. 16 (killing of muskoxen in Ellesmere Land by explorers); p. 32 (muskoxen on Byam Martin Island); pp. 54–61, 86 (hunting muskoxen on Melville Island); p. 98 (Melville Island muskoxen do not migrate); p. 139 (skinning a muskox on Melville Island); p. 314 (habits, Melville Island); p. 374 (habits, Melville Island, in report of J. G. McMillan, geologist); p. 511 (habits, Melville Island, in report of Frank Hennessey).

Myskoxen, NATHORST, Tidskr. Landtmän, 1900, pp. 829–833 (domestication); pl. (group from East Greenland in Stockholm museum).

Moschusochsen, MERVISS, Zool. Gart., Jahrg. 41, 1900, pp. 432–434 (acclimatisation).— NEHRING, Sitzungsb. Ges. nat. Freunde Berlin, 1901, pp. 151–153 (muskoxen recently brought alive to Europe — the Duke of Bedford specimens).— SCHIÖTT, Zool. Gart., Jahrg. 44, 1903, 305–317, 11 figg. (living muskoxen from East Greenland).— SCHWEDER, Korr. Bl. Nat. Ver. Riga, No. 52, 1909, pp. 192–195 (general account, and offering hypothetical suggestions on the basis of Kowarzik's classification of muskoxen.— BJÖRKMAN, Kosmos Stuttgard, Jahrg. 6, 1909, pp. 114, 115, fig. (living muskox calves from East Greenland).

Ovibos moschatus SABINE, Parry's First Voyage, Zool., App. X, 1824, p. clxxxix (range extended to the "North Georgian Islands"; specific name spelled "*moscatus*").— BROWN, Proc. Zool. Soc. London, 1868, p. 351 (distribution in Greenland; comment on Fabricius's "*Bos grunniens*").— FEILDEN, Zoologist, 3rd ser., I, Sept., 1877, pp. 353–358 (distribution and habits in Greenland. "There can be no question that the Musk-oxen found by the Germans on the east coast of Greenland are descendants of those that crossed Robeson Channel, rounded the north of the Greenland continent, and extended their range southward until they met with some physical obstruction that barred their further progress, as has also been the case on the western shore of Greenland"; Quart. Journ. Geol. Soc. London, XXXIV, 1878, p. 566 (fossil remains found in recent deposits in Greenland and Grinnell Land); Zoologist, 3rd ser., XIX, Feb., 1895, pp. 41–44 (distribution in Greenland); Nares's Voy. to the Polar Sea, II, 1878, pp. 198–202 (habits and distribution, with special reference to its migration from America to Greenland. In substance, and in large part verbally, the same as given by the same author in 'The Zoologist,' 3rd ser., I, Sept., 1877, pp. 355–358).— GREELY, Three Years of Arctic Service, I, 1886, p. 104 (muskoxen near Fort Conger, with plate of dead bull); pp. 362, 363 (9 killed near Fort Conger and 4 young calves taken alive, June 10, 1882, with cut of 2 "musk calves, four months old." — PEARY, Northward over the Great Ice, I, 1898, pp. 329–354, *passim,* with illustrations from photographs (northernmost Greenland); II, pp. 471–500, *passim,* with several illustrations from photographs taken near Independence Bay, northern coast of Greenland); Nearest the Pole, 1907, *passim,* with illustrations from photographs (pp. 35, 60, 142, 154, 181, 204, 300, 320, 333 (Bache Peninsula); pp. 57, 60, 62, 64, 80, 93, 98 (Lake Hazen and Markham Inlet regions); pp. 154–161 (Nares Land, with illustrations); pp. 179–182 (Cape Columbia, with two illustrations); p. 204 (tracks seen on Jesup Land = Heiberger Land); p. 300, 310 (northern Ellesmere Land); pp. 311, 312 (Fort Conger); p. 313 (Buchanan Bay); p. 320 (Fort Conger); pp. 333, 334 (Lake Hazen); pp. 339, 340 (Cape Hecla); The North Pole, 1910, pp. 151–161, and photographic illustrations (northern coast of Grant Land); p. 183 (how they obtain food in the winter).— SCLATER, Proc. Zool. Soc. London, 1899, pp. 985, 986, with fig. (illustration, from a photograph, of one of the young muskoxen captured on Clavering Island, East Greenland (lat. about 74°), August 16, 1899, and purchased by the Duke of Bedford; "believed to be the first examples of this remarkable mammal that had reached Europe alive").— LYDEKKER, Knowledge, XXIII, June 1, 1900, pp. 137–139, with figure of "young Bull Musk-Ox" from East Greenland, from a living animal in the Duke of Bedford's collection at Woburn Abbey; a semi-popular article entitled 'The first Musk-oxen in England since the Glacial Epoch,' containing remarks on the former and present range of the species).— KOBELT, Bericht d. Senkenbergerischen naturf. Gesel. in Frankfurt am Maine, 1900, pp. 61–66, pl. vii, 1 text fig. (records the acquisition of two specimens from East Greenland by the Frankfort Museum; the relationships of *Ovibos,* and its past and present distribution; pl. vii, view of two mounted specimens).— CONWENTZ, Verhandl. d. Gesel. f. Erdkunde zu Berlin, XXVII, No. 8, 1900, pp. 427–431, with map of distribution by A. G. Nathorst (distribution in Greenland, with historical comment; record of 5 calves taken alive to Sweden prior to 1900; of 2, male and female, taken to Norrland by Kolhoff; of 3, two females and a male, taken by Liljevalch to Jämtland; acclimatisation of the Musk-ox in northern Europe, especially in Lappland, believed practicable by Nathorst).— LÖNNBERG, Proc. Zool. Soc. London, 1900, pp. 142–167, figs. 1–14 (on the soft anatomy); *ibid.,* 1900, pp. 686–718, figs. 1–4: (development of the horns, pp. 687–694; character of the hoofs, pp. 694, 695; description of the skull, pp. 695–715; comparison of skulls of *Ovibos* and *Budorcas,* pp. 715–718).— NATHORST, Bull. Soc. de Géog., III, Jan., 1901, pp. 1–16, 4 text figs. (bœuf musqué, pp. 6–16, figs. 2–4; fig. 2 is a map showing its distribution; figs. 3 and 4 are illustrations from photographs showing wild muskoxen on the eastern coast of Greenland. The text deals with the distribution of its fossil remains in England, continental Europe, Siberia, Alaska, and the United States; extent of its former and present distribution in Greenland and northeastern North America; the possibility of its acclimatisation in northern Europe; reference to living specimens taken to Norway, Sweden,

and Denmark).— GIRTANNER, Ber. St. Gallischen Ges., 1899–1900 (1901), pp. 120–146, 1 pl. (from a mounted specimen; general account of muskoxen, living and extinct).

Ovibos moschatus wardi LYDEKKER, Nature, LXIII, Dec. 13, 1900, p. 157 (the original description, 7 lines, based on "a mounted adult male and female musk-ox from East Greenland, which differ from the ordinary form in having a large whitish patch on the face, as well as in certain other details of coloration. They may be made the types of a new race, under the name *Ovibos moschatus wardi*"); Nature, LXIV, May 16, 1901, p. 63, with fig. (the Woburn Abbey specimen, then "considerably more than two years old," from a photograph. "For our own part we see no reason to depart from the view that the Greenland and American musk-oxen are local races of one and the same species").—KOWARZIK, Zool. Anzeiger, XXXIII, Nov., 1908, pp. 615–618 (passim); Fauna Arctica, V, 1910, pp. 97, 102–110, fig. 4, animal, fig. 6, skull, fig. 7, lacrymals.

Ovibos wardi ALLEN, Bull. Amer. Mus. Nat. Hist., XIV, pp. 69–86, pl. xii–xvii (animal), text fig. 1–7 (skulls), March 27, 1901 (Bache Peninsula, Ellesmere Land; compared with *O. moschatus;* distribution of the American and Greenland Muskoxen).—MILLER, List N. Amer. Mamm., 1912, p. 395.

Bosovis wardi KOWARZIK, Zool. Anz., XXXVII, Feb., 1911, p. 107.

Ovibos moschatus melvillensis KOWARZIK, Fauna Arctica, V, 1910, pp. 113–116, fig. 9, animal, from Parry; figs. 10–12, skull, 3 views; fig. 13, right lacrymal; fig. 14, horn-sheath.—MILLER, List N. Amer. Mamm., 1912, p. 395.

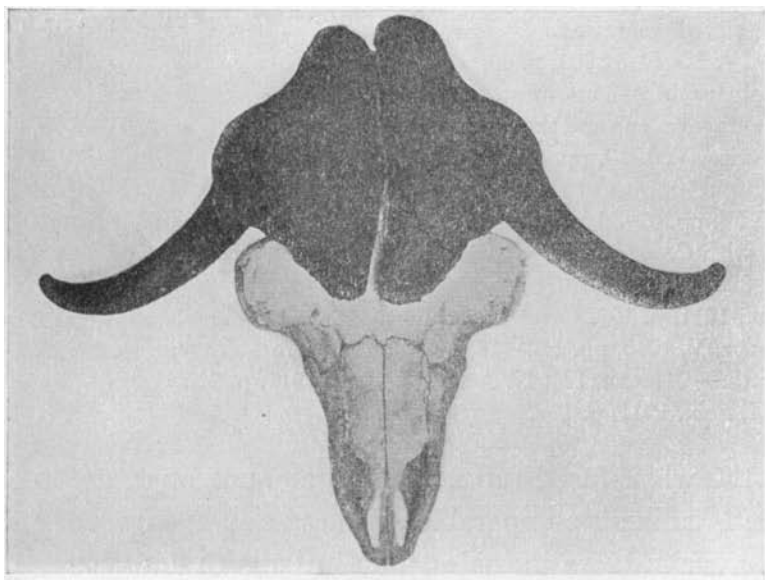
Bosovis melvillensis KOWARZIK, Zool. Anz., XXXVII, Feb., 1911, p. 107.

Ovibos moschatus wardi is emphatically the white-faced form, but the amount of white on the face and coronal region is widely variable in animals comparable as to sex and age from the same locality. The extent of the white area varies more in males than in females and young males, as the basal expansion of the horns in adult males encroaches upon the white coronal area usually so conspicuous in young animals, and if this area is restricted to the top of the head it thus becomes obliterated. In addition to the white space between the horns and on the face there is usually much white on the sides of the head and a white band behind the horns; a portion of the latter usually persists after the horns have become fully developed. In some males white on the head is not a conspicuous feature; in others the whole head is heavily grizzled with white. In general coloration *wardi* is not so dark as either *moschatus* or *niphœcus*; the saddle area and especially the horns, are much lighter in color. As a detailed account of the individual variation in coloration has already been given, as well as the changes in the character of the pelage with age, a further recapitulation is unnecessary. (See *antea*, pp. 140–143.) No external measurements of *wardi* are available, but it apparently attains about the same size as *niphœcus*. A large series of cranial measurements, comprising skulls of nearly sixty adults, has already been given in Tables I and II (pp. 144, 145).

Distribution.[1]

O. m. wardi was described from specimens obtained on Clavering Island, off the coast of East Greenland, and it has been found to occupy a narrow coast belt of Greenland from about latitude 70° on the east side north as far as land extends, and thence southward along the west coast to about 81°, and within historic times as far south as Westenholme Sound (latitude 78°), where its further progress south appears to have been checked by impassable glaciers. It formerly occupied practically the whole Arctic Archipelago from Grant Land and Ellesmere Land westward to Prince Patrick Island, and south to Lancaster Sound and Coronation Gulf. Thus it must have nearly met the range of *niphœcus* on the mainland west of the Gulf of Boothia, and the range of *moschatus* thence westward to Coronation Gulf and Dolphin and Union Strait. As already noted (p. 187), they have been exterminated from the greater part of Victoria Island (including Victoria Land, Wollaston Land, and part of Prince Albert Land. Hundreds have

[1] See map (Fig. 27) facing p. 185.



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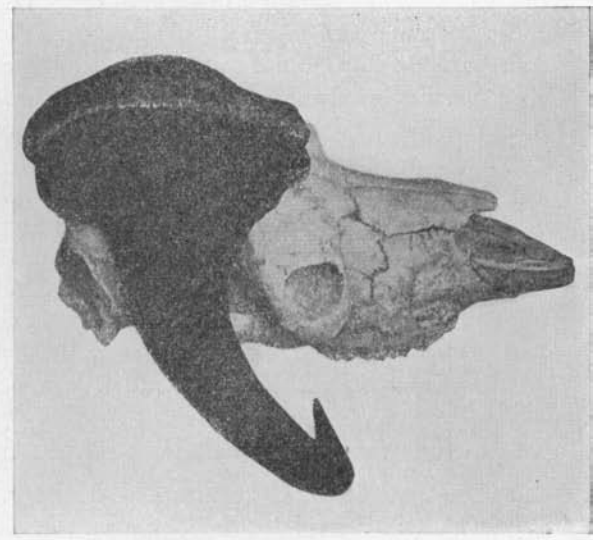

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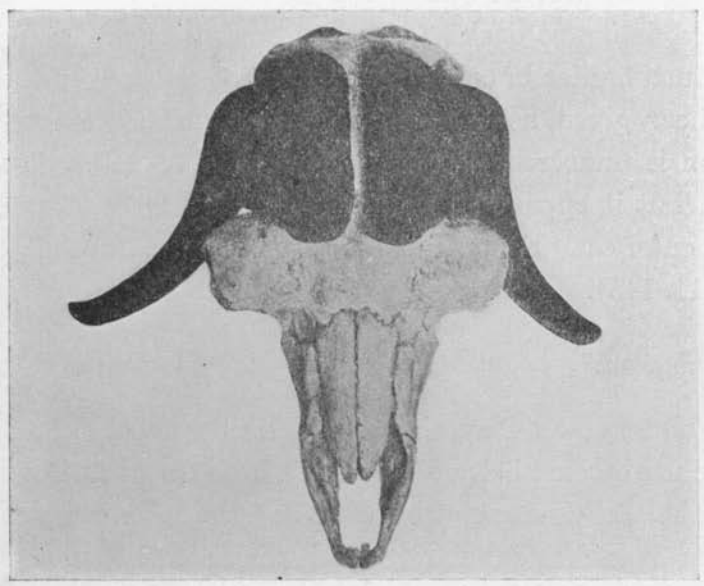

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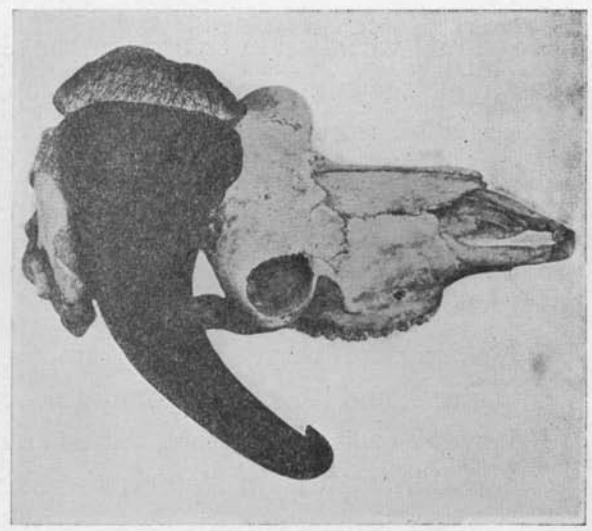

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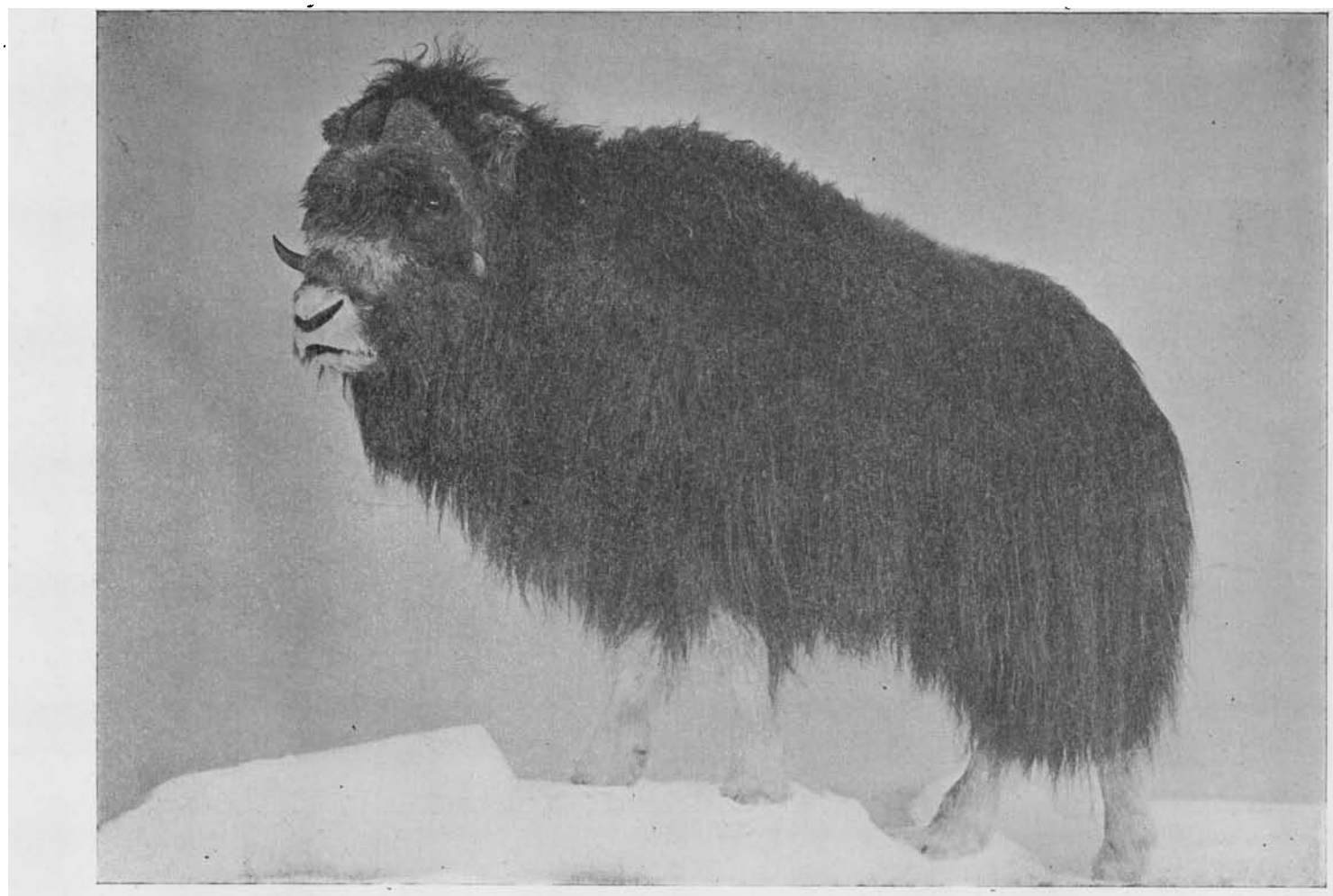
Fig. 28.[1] *Ovibos moschatus moschatus*, No. 16604, ♂ ad., Barren Grounds near Great Slave Lake.
Fig. 29. *Ovibos moschatus wardi*, No. 15594, ♂ ad., Bache Peninsula.
Fig. 30. *Ovibos moschatus moschatus*, same skull as shown in Fig. 28.
Fig. 31. *Ovibos moschatus wardi*, same skull as shown in Fig. 29.

The *Ovibos moschatus wardi* skull from Bache Peninsula is much below the average size of *wardi* from Grant Land and Melville Island, as shown by the large series of the former received since the original publication of Figs. 30 and 31.

[1] Figs. 28–45 are reprinted from the Bulletin of this Museum, Vol. XIV, 1901, pp. 74–75, text figures 1–4, and plates xii–xvi.



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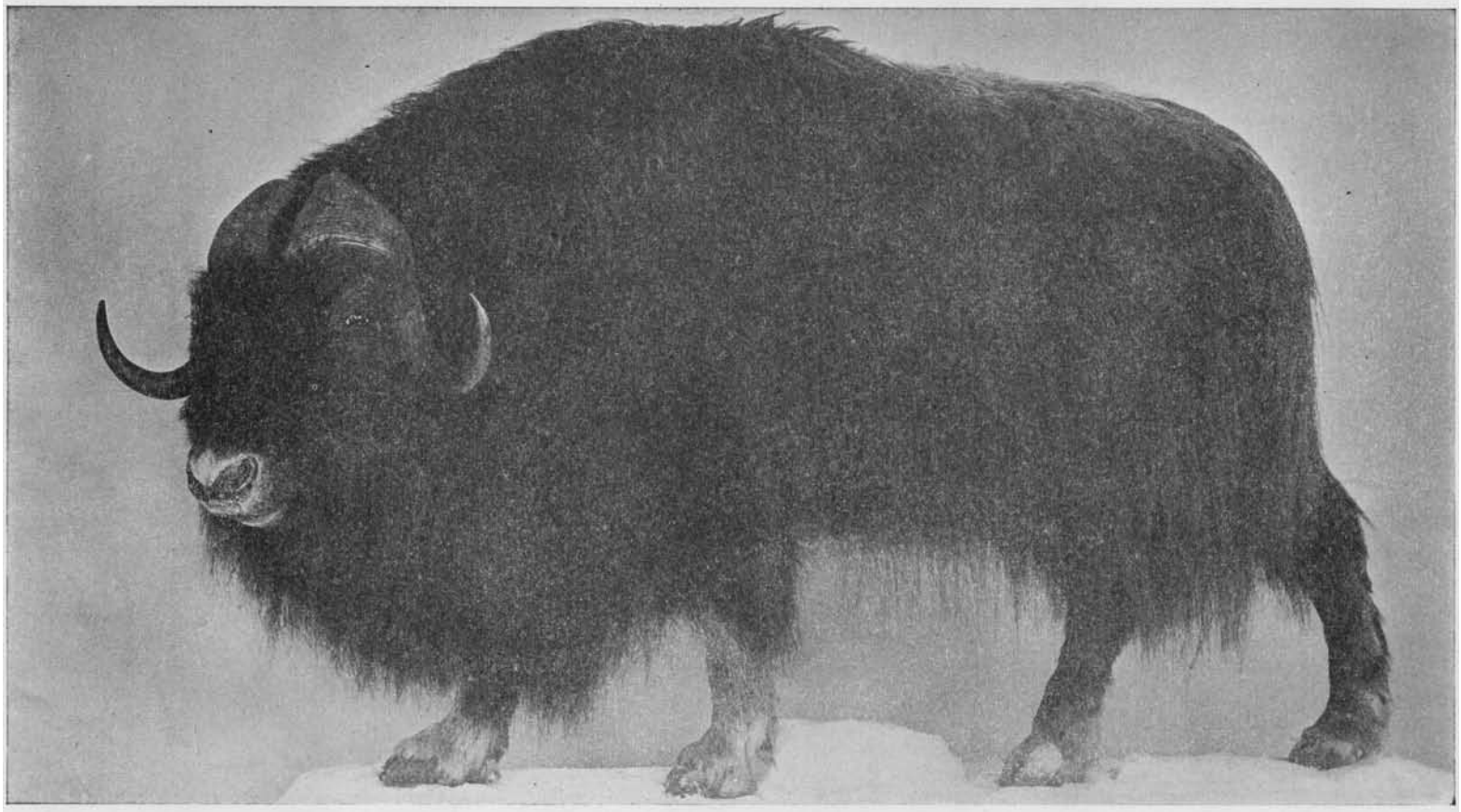

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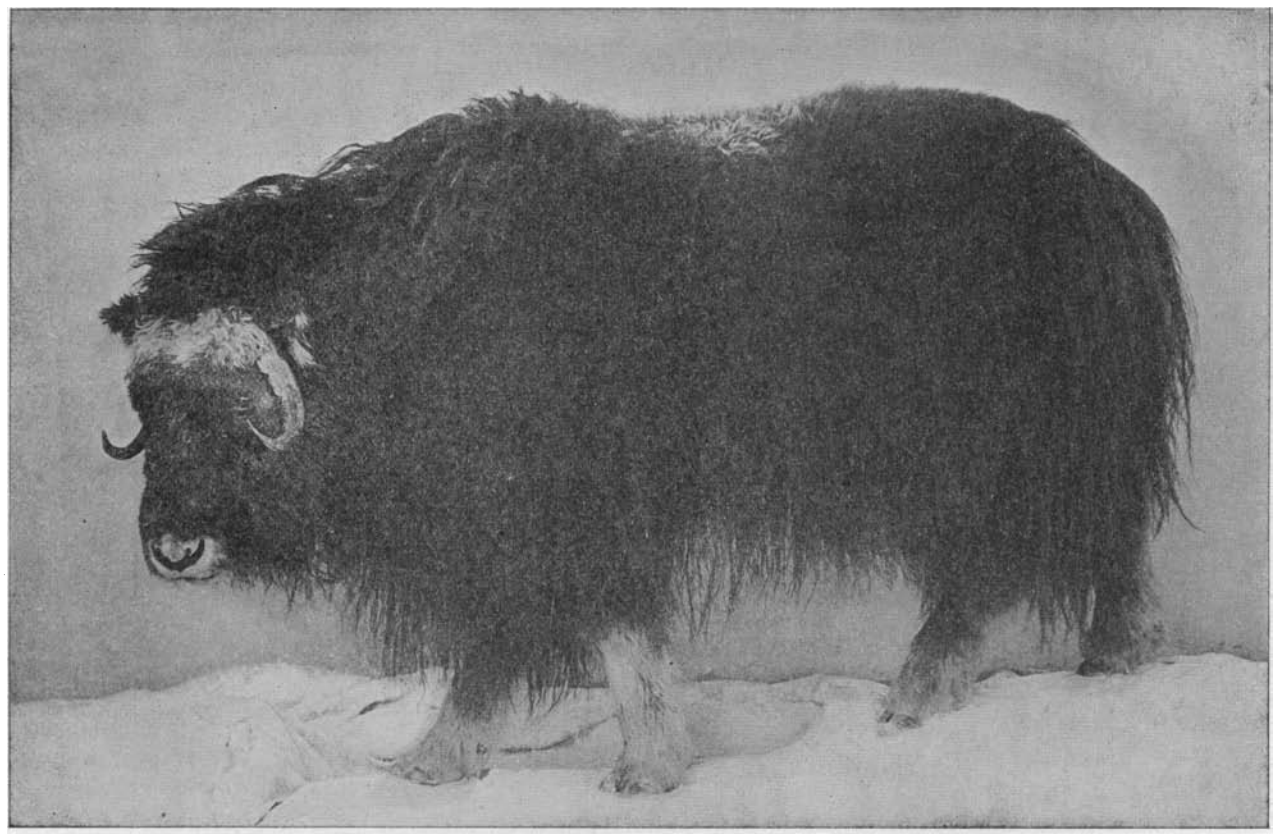
Fig. 32. *Ovibos moschatus moschatus*, No 17102, ♂ ad., Barren Grounds near Great Slave Lake. From a mounted specimen in the American Museum of Natural History.

Fig. 33. *Ovibos moschatus wardi*, No. 15594 ♂ ad., Bache Peninsula. Mounted specimen, from a group in the American Museum of Natural History.



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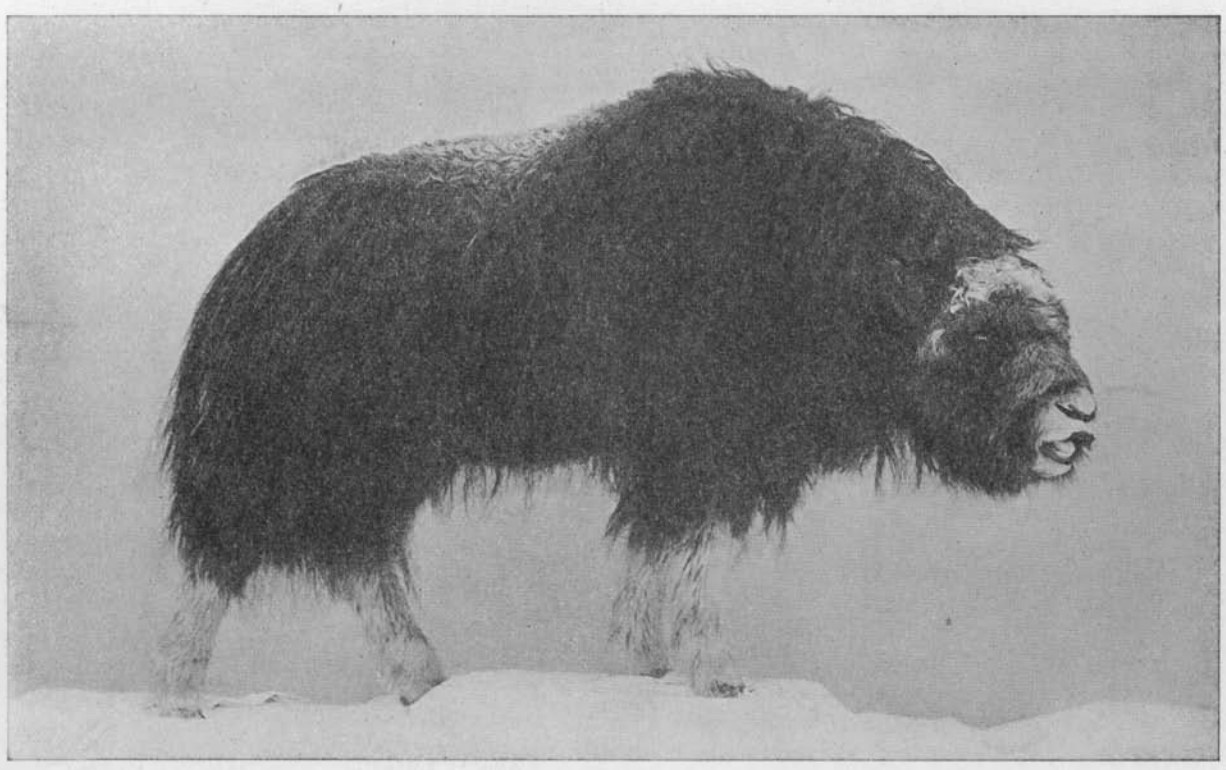

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Fig. 34. *Ovibos moschatus wardi*, No. 15591, adult female, Bache Peninsula. Mounted specimen, from a group in the American Museum of Natural History.

Fig. 35. *Ovibos moschatus wardi*, young male, Bache Peninsula. Mounted specimen, from a group in the American Museum of Natural History.

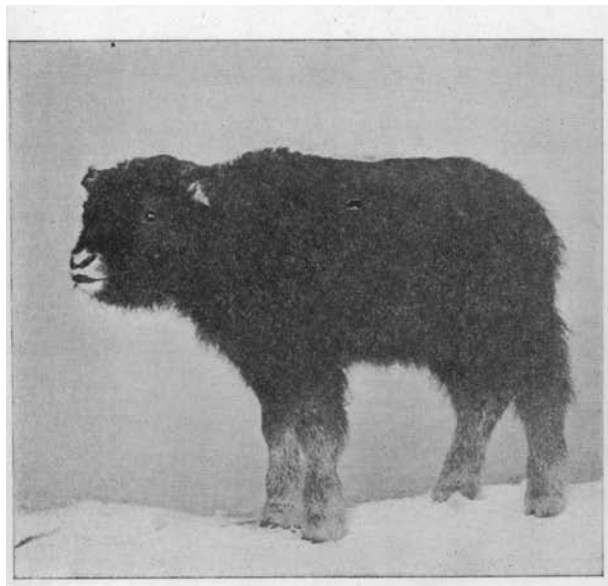

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Fig. 36. *Ovibos moschatus wardi*, No. 15597. Female calf, a few weeks old, killed at Fort Conger, Grant Land, May 18, 1899. Mounted specimen, from a group in the American Museum of Natural History.

Fig. 37. *Ovibos moschatus wardi*, adult male, killed at Independence Bay, North Greenland. From Peary's 'Northward over the Great Ice,' Vol. II, p. 477. To show the whiteness of the front and top of the head and the back.

Fig. 38. *Ovibos moschatus wardi*. Six-months-old calf, taken alive near Fort Conger, in the spring of 1902. Presented to the New York Zoölogical Society by the Peary Arctic Club. Photograph taken in October, 1902.

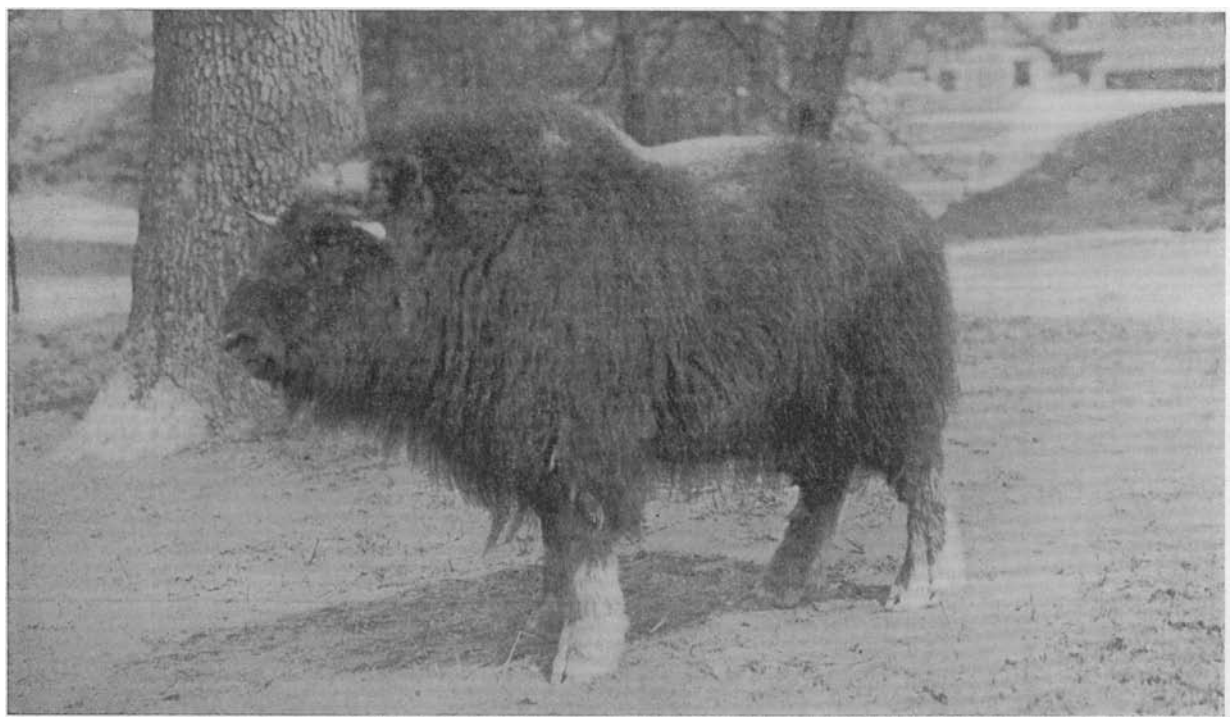

Fig. 39. *Ovibos moschatus moschatus*. From a two-year old female, taken alive near Cape Bathurst by Captain H. H. Bodfish. Presented to the New York Zoölogical Society by Hon. William C. Whitney in March, 1902. Photograph taken in April, 1902.

been killed on Melville Island, and thousands in northern Ellesmere Land, Grinnell Land, and Grant Land, mainly by explorers for the support of their dogs and men. They are found in winter as well as in summer on the most northern known land, being in no sense migratory.[1]

The range of *wardi* thus extends, with probably little interruption, from the eastern coast of Greenland, in about latitude 70°, northward to North Greenland and thence westward from Grant Land to Banks Land, or from longitude 20° W. to 125° W., and south to Boothia Peninsula and Victoria Land (formerly) in latitude 70°. It would be surprising to find any animal presenting a uniform character throughout such a vast expanse. As yet adequate material for the determination of the geographic forms that may occur among the muskoxen of this great area does not exist in museums. A small series of muskoxen was obtained at Cape Morris K. Jesup in North Greenland on Peary's last expedition, but they prove to be indistinguishable from those taken in northern Grant Land, only a few miles to the westward, nor would they be expected to differ in this short distance with no physical barrier separating them; nor do they appear to differ from those of East Greenland, judging from published descriptions, including measurements of many skulls, and numerous published photographic illustrations of both young and adult living animals.

A small series from Ellesmere Land appears to differ, as already noted, from Grant Land specimens in somewhat smaller size, but not appreciably in coloration. Should further specimens confirm this difference, the Ellesmere Land form might be considered as recognizable in nomenclature as a rather weakly differentiated local form.

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[1] They were reported by Parry's first Expedition to be migratory on Melville Island, arriving there in May and leaving again in September. This has since been found to be an error. Captain J. E. Bernier states that they do not migrate but are permanent residents on Melville Island. He says: "They seek ravines and sheltered places during winter and appear in the open in summer, feeding at night, as the day seems too warm for these heavy coated animals to move about." — Report on the Dominion of Canada Expedition to the Arctic Islands and Hudson Strait on board the D. G. S. 'Arctic,' [1908–09], 1910, p. 98. See also *infra*, p. 201.

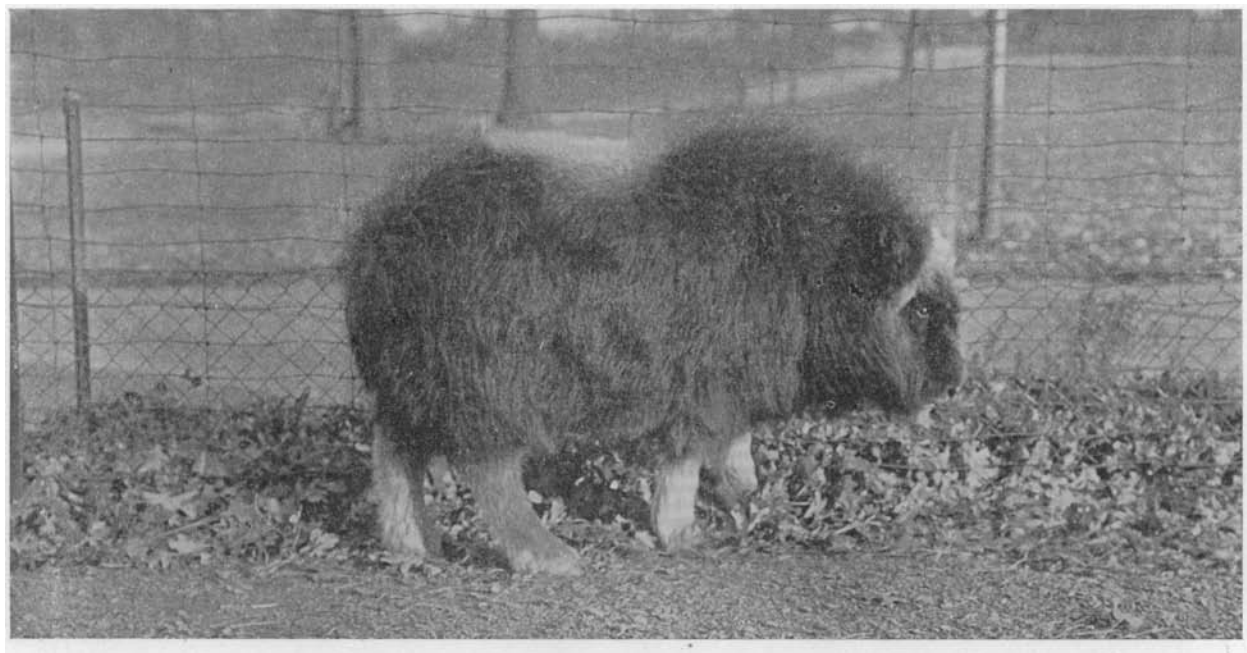

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Fig. 40. *Ovibos moschatus wardi.* A female calf taken alive on Melville Island in the early summer of 1909 by Captain Joseph E. Bernier, and received by the New York Zoölogical Society, Nov. 7, 1909. Photograph taken in November, 1909.

Fig. 41. *Ovibos moschatus wardi.* Same Melville Island specimen as shown in Fig. 40. Photograph taken in April, 1911.

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Fig. 42. *Ovibos moschatus wardi.* Five young specimens taken by Paul J. Rainey in Ellesmere Land, spring of 1910; received at the New York Zoölogical Park, Sept. 10, 1910. Photograph taken in September, 1910.

Fig. 43. *Ovibos moschatus wardi.* The same five Ellesmere Land specimens shown in Figs. 42 and 44, from a photograph taken April, 1911.

Fig. 44. *Ovibos moschatus wardi.* The same five Ellesmere Land specimens shown in Figs. 42 and 43, from a photograph taken in January, 1912, when they were about 17 months old.

As already noted, Kowarzik has proposed to recognize a Melville Island form as distinct, under the name *Bosovis melvillensis*, but his material consisted of only a single specimen (skull and skeleton without skin) and the erroneous figure of the animal published in Parry's 'First Voyage' (see *antea*, p. 177). That the Melville Island form is not without white face-markings and white feet, as supposed by Kowarzik, is now positively known. In fact, in coloration it does not differ appreciably from Ellesmere Land specimens (see Figs. 40–44, from photographs of living animals), nor is there any appreciable difference in cranial characters from the usual or average *wardi* type from Ellesmere Land, Grant Land, and North Greenland.

Through the kindness of Mr. Percy A. Taverner, Curator of Zoölogy in the Victoria Memorial Museum at Ottawa, I have been placed in communication with Mr. Frank Hennessey, who acted as topographical draughtsman for Captain J. E. Bernier of the Dominion Government Steamer 'Arctic,' which wintered at Melville Island in 1908–09, and he has kindly responded to my inquiries for information concerning the coloration and habits of the muskoxen of Melville Island as observed by him under exceptionally favorable conditions. I am further indebted to Mr. Taverner for the loan of three adult skulls for examination taken on Melville Island on Captain Bernier's expedition. The skulls are found to accord in size and in all other features with my large Grant Land series, as do also Kowarzik's measurements of the single Melville Island skull available for study in the preparation of his 'Der Moschusochs und seine Rassen.' The measurements of the four skulls are here given in Table IV (p. 182).

Mr. Hennessey's letter, bearing date Winona Lake, Ind., Dec. 14, 1912, in so far as it relates to muskoxen, is as follows:

"*Dear Sir:*

"Your esteemed favor of the 23rd Nov., I have just received and I assure you that I am indeed only too pleased to do my best to assist you in acquiring the information you desire.... I note you mention the muskox in the New York Zoölogical Park. I might mention that I helped to capture it. I caught a younger cow than this one but it died on our homeward voyage.... Among the some fifty-five skins I had occasion to handle, the whiteness on the head, of which you speak, was very evident. The white on the face and between the horns was more characteristic of the cow and young but the 'saddle' of the bull had scattered throughout an abundance of white. The white was due to the presence of white hairs among dark ones and not to a common hue. In the cows the saddle was more of a buffy color.

"Muskoxen were abundant on Melville Island. During the winter the animals always herd. It is likely that some outcasts go about singly but we saw not one of these. The smallest herd we saw during the winter was four and the largest forty. In the depths of winter they were practically never seen on the level land about Winter Harbour but when parties traveled to points where the country was rugged they were found in the valleys which parts they sought as protection from the blizzards.

"Towards the coming of summer the herds always break up and I noted the bulls wandering aimlessly about the sea coast. Between the time when the ice and snow had left the greater part of the land and the time of our departure, we saw at Winter Harbour only one cow, the rest being solitary bulls. This may have been an accidental occurrence but it is certainly interesting for it leads me to think that perhaps during the season of propagation the cows remain inland.

"They certainly do not migrate. I am sure of this not only because we found them there throughout the winter but also for this reason: If they did migrate it would be to the northern shore of the continent (which is just as inhospitable as where they live now), and Melville Sound is open sometimes for more than three-fourths of the year, and it is open during the worst months of the year, the blizzards keeping it open...."

Ovibos yukonensis *Gidley.*

Muskox, DALL, Proc. Boston Soc. Nat. Hist., XIII, 1869, p. 136 ("near the great bend of the river Yukon bones of the muskox, ... are frequently found upon the surface of the ground having still an animal odor about them....Yet the Indians and Esquimaux have neither knowledge nor tradition of any large animals save the reindeer and the moose."

? *Ovibos maximus* RICHARDSON, Zool. Voy. Herald, Mamm., 1854, pp. 25–28, 119, 120, pl. xi, figs. 2–4 (axis, more or less abraded; not identifiable; *cf.* LEIDY, Proc. Acad. Nat. Sci. Philadelphia, VII, 1854, pp. 209, 210).— LYDEKKER, Proc. Zool. Soc. London, 1900, p. 832 (*maximus* is suggested as available "for the fossil American" form of *Ovibos*).

Ovibos moschatus LEIDY, Proc. Acad. Nat. Sci. Philadelphia, VII, 1854, p. 210, part (recent and fossil).— LAMB, Ottawa Nat., XXI, 1907, pp. 15–18, pl. i (a tooth from Pleistocene gravels near Midway, B. C.).— QUACKENBUSH, Bull. Amer. Mus. Nat. Hist., XXVI, 1909, p. 127 (Alaska and Canada).

Ovibos yukonensis GIDLEY, Proc. U. S. Nat. Mus., XXXIV, p. 681, 1 text fig. and pll. lvii, lviii, Sept. 15, 1908 (Palisades, Yukon River).— GILMORE, Smithson. Miscel. Coll., LI, 1908, pp. 35, 38.— QUACKENBUSH, Bull. Amer. Mus. Nat. Hist., XXVI, 1909, pp. 92, 127.

This species was based on the greater portion of a skull of an old male found by C. W. Gilmore in the "Pleistocene silts along the Palisades of the Yukon River, about 35 miles below Tanana, Alaska." It is described by Gidley in considerable detail and well figured. It is closely related to the living forms of *Ovibos moschatus*, from which it differs mainly in size, but in this respect, according to Gidley's measurements, the orbital breadth falls much below the maximum for old males of either *moschatus*, *niphœcus* or *wardi*, while the maxillary toothrow is somewhat longer, and the mastoid breadth is considerably in excess of the same measurement in the recent forms. Gidley's detailed comparison with a single skull of *Ovibos*, by means of which he enumerates seven points of cranial difference, cannot be given much weight, since quite as great differences in most of the features mentioned are to be noted between different skulls of the same subspecies when a considerable series of skulls is available for comparison *inter se*.[1] Possibly additional material representing the fossil form might show average differences other than in size. It seems better, in view of the great probability of other differences existing in life, and for convenience of record, to treat the fossil form nomenclaturally as distinct. It seems also proper to ignore altogether in this connection Richardson's name *Ovibos maximus*, since it was based on an axis so much abraded that it cannot be identified with certainty.

Pleistocene remains of muskoxen have been found over a wide area in North America. In the collection of the Department of Vertebrate Palæontology of this Museum are several fragmentary skulls of *Ovibos*. One is a female (No. 13731) collected by L. S. Quackenbush from the beach at the foot of 'Historic Bluff,' Eschscholtz Bay, Alaska, on the American Museum Expedition of 1907. It is the postorbital portion of a skull with, however, the occipital wall of the braincase lacking, and the lower surface of the basioccipital and postpalatal region greatly abraded. So far as the parts available for comparison are concerned, this fragment agrees in size and in all other features with average recent female skulls of *Ovibos* from Grant Land.

Feilden and De Rance [2] have recorded the occurrence of muskox remains in recent beds in Grinnell Land and North Greenland, but no details are given.

Lamb [3] has described and figured a tooth of *Ovibos* (referred provisionally to *O. moschatus*) from Pleistocene gravels near Midway, B. C.

Ovibos sp. indet.

Bison appalachicolus RHOADS, Proc. Acad. Nat. Sci. Philadelphia, 1895, p. 248 (small fragment of base of horn-core).— LUCAS, Proc. U. S. Nat. Mus., XXI, 1899, p. 756 ("needs no consideration, being confessedly based on a horn-core of *Ovibos*").

Ovibos (*Bootherium?*) *appalachicolus* RHOADS, Proc. Acad. Nat. Sci. Philadelphia (1897), Jan. 18, 1898, p. 492 (same as the above, transferred to *Ovibos*).

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[1] *E. g.*, he says, "ascending process of the premaxillaries nearly or quite reaching the nasals." In Grant Land adult male specimens of *O. m. wardi* the space separating these bones varies from 18 mm. to 30 mm.

[2] Feilden, H. W., and C. E. De Rance. Geology of the Coasts of the Arctic Lands visited by the late British Expedition under Captain Sir George Nares, R. N., etc. Journ. Geol. Soc. London, Vol. XXXIV, 1878, pp. 556–566, pl. xxiv (map), muskoxen at p. 566.

[3] Lamb, Lawrence M. On a tooth of *Ovibos*, from Pleistocene gravels near Midway, B. C. Ottawa Nat., XXI, 1907, pp. 15–18, pl. i.

Ovibos sp. BROWN, Mem. Amer. Mus. Nat. Hist., IX, pt. iv, 1908, p. 203 (an abraded fragment of a skull from Ottumwa, Iowa).

Symbos sp. BROWN, Mem. Amer. Mus. Nat. Hist., IX, pt. iv, 1908, p. 203 (a greatly abraded postorbital portion of a skull from Wilson, Kansas).

The above records are based on material identifiable as referable to the genus *Ovibos* but too fragmentary for specific determination.

Ovibos appalachicolus Rhoads was based on the basal portion of a horncore with a small piece of frontal bone attached. It was at first referred to the genus *Bison*, but the author later decided it was more properly referable to *Ovibos*. It was found in "Durham Cave, near Riegelsville, Bucks Co., Pa."

There are three very imperfect skulls, consisting merely of the brain-case with nearly all the surfaces greatly abraded, in the collection of the Department of Vertebrate Palæontology of this Museum, two of which were recorded by Barnum Brown (*l. c.*) respectively as *Symbos* sp. and *Ovibos* sp., and there is another similar fragment as yet unrecorded.

The first, No. 12699, from near Wilson, Kansas, is identified by Brown as referable to *Symbos*. The second, No. 12700, is labelled as from "Ottumwa, Iowa, E. L. Lathrop," and has been recorded by Brown as *Ovibos*. The third, No. 13830, is from the banks of White River, near Walesboro, Bartholomew County, Indiana, and was presented by Dr. J. J. Edwards of Columbus, Ohio. Like the other two specimens, it is not determinable specifically beyond the fact that it is not *Ovibos moschatus*.

The three last mentioned skulls are all heavily mineralized and seem probably referable to the same species. They are all skulls of very old males; only the walls of the braincase are preserved, the outer surface of which is greatly abraded or largely broken away. The parts that remain indicate animals considerably exceeding the size of any of the existing forms of *Ovibos*, as is shown especially by the size of the occipital condyles and the basioccipitals, about the only parts preserved that are of any diagnostic value. These fragmentary skulls show that *Ovibos* had a wide range in the United States during Pleistocene times, extending along the northern border from Pennsylvania to Iowa, and south to Kansas and Indiana.

Ovibos pallantis *Ham. Smith.*

Tauri feri PALLAS, Nov. Comm. Acad. Sci. Imp. Petrop., XVII, 1773, pp. 604–609, pl. vii, figs. 1–3 (two skulls from vicinity of the Obi River, Siberia).

Bison musquê, OZERETSKOVSKY, Mém. de l'Acad. de Sci. de St. Pétersbourg, Tom. III, 1811, pp. 215–219, pl. vi (mouth of the Jana River, Siberia).

Buffle de Sibérie, CUVIER, Rech. Ossem. foss., IV, pt. 3, 1812, pp. 59–62, pl. iii, figs. 9, 10 (from Pallas, as above).

Bos moschatus CUVIER, Rech. Ossem. foss., nouv. éd., IV, 1823, pp. 155–159, pl. xi, fig. 6, 7, pl. xii, fig. 9, 10 (fossil skulls from Siberia, described and figured by Pallas and Ozeretzkovsky, their figures reproduced).

Ovibos moschatus LARTET, Comp. rend. Acad. Sci. Paris, LVIII, 1864, pp. 1198–1201 (remains from diluvium of Précy, Oise, France); Ann. des. Sci. nat., sér. 4, XV, 1864, p. 224 (tooth from Viry-Noureuil); Quart. Journ. Geol. Soc. London, XXI, 1865, pp. 474–476 (bones of the extremities from Gorg d'Enfer).— DAWKINS, Palæontolog. Soc. Mem., XXV, pt. 5, 1872, pp. 1–30, pl. i–v (fossil, from Lower Brickearths, Kent, England, with figures of a male skull); Quart. Journ. Geol. Soc. London, XXXIX, 1883, pp. 575–581, fig., p. 575 (female skull from the Forest-bed of Trimingham, Norfolk, England); *ibid.*, Vol. XLI, 1885, pp. 242–244 (skull from the sea bottom of the Doggerbank, near Ostend).— LYDEKKER, Cat. Foss. Mamm. Br. Mus., pt. 2, 1885, p. 38, part (Pleistocene, Berkshire and Kent, Engl.; Eschscholtz Bay, Alaska; Upper Porcupine River, Canada).— TSCHERSKI, Mém. Acad. Imp. des Sci. de St. Pétersbourg, sér. 7, XL, 1893, pp. 153–187, and four figs. in pll. iii and iv (three imperfect skulls, 2 from the Jana and 1 from Ljachow Island; also lower jaws, vertebræ, bones of the extremities, and numerous teeth, from Jana, mouth of the Lena River, Ljachow and new Siberian Islands. Measurements of 10 skulls of fossil muskoxen from northern Siberia; larger than skulls of recent muskoxen. Contrary to Tscherski's belief, his fossil skulls are not closely related to *Bootherium*, the characters of which he quite misunderstood).— BEYER,

Zur Verbreitung der Tierformen der arktische Region in Europe während der Diluvialzeit, 1894, pp. 28, 29 (localities where muskox remains have been found).— GRÉVE, Sitzungsb. naturf. Gesel. Universität Dorpat, XII, Heft 3, 1901, pp. 371–374, part (localities where fossil remains have been found in Europe and Asia; also present distribution in Greenland and North America).— ANDREWS, Proc. Zool. Soc. London, 1905, Vol. I, pp. 50–53, with fig. (remains from the Pleistocene beds of southern England).— STAUDINGER, Centralbl. f. Min., Geol. u. Palæont., Jahrg. 1908, pp. 498–502 (list of specimens known from the Pleistocene of Germany, the collections to which they belong, and the published references to them; 23 positive records and 3 doubtful ones).

Bubalus moschatus OWEN, Quart. Journ. Geol. Soc. London, 1856, XII, p. 124, figs. 1–6 (description of a fossil cranium of the Musk-Buffalo from the Lower-level Drift at Maidenhead, Berkshire, England).

Ovibos pallantis HAM. SMITH, Griffith's An. Kingdom, IV, 1827, p. 375 (refers wholly to remains found by Pallas on the Obi River, and by Ozeretskovsky on the Lena River.

Ovibos moschatus pallantis LYDEKKER, Proc. Zool. Soc. London, p. 832 (suggests that "*Ovibos moschatus pallantis* (De Kay)" may be used to designate "the fossil Asiatic and European Musk-ox").

Bos pallasii DE KAY, Ann. Lyc. Nat. Hist. New York, II, 1828, p. 291 (proposed for the fossil crania from Siberia described by Pallas and Ozeretskovsky, and "provisionally" for the specimen from New Madrid, Missouri, here described by De Kay); New York Fauna, part I, 1842, p. 110 (Kentucky and Missouri = *Bootherium* Leidy).— COOPER, Month. Amer. Journ. Geol. and Nat. Hist., I, Oct. and Nov. 1831, pp. 173, 206 (in part of De Kay, 1828, not of Baer, 1823).

Bos moschatus β fossilis FISCHER, Synop. Mamm., 1829, p. 494 (based on Pallas, Ozeretskovsky, and Cuvier).

Bos canaliculatus FISCHER DE WALDHEIM, Bull. Soc. Imp. des Nat. de. Moscou, II, 1830, pp. 85–87; Nouv. Mém. Soc. Imp. des Nat. de Moscou, III, 1831, p. 295 (measurements of two skulls; based on recently discovered specimens, which are said to be not so few as one might think, many having been received at the St. Petersburg Academy of Sciences).

Ovibos fossilis RÜTIMEYER, Verhandl. naturf. Gesel. Basel, IV, 1867, p. 328 (fossil muskoxen of Eurasia).

Præovibos priscus STAUDINGER, Centralb. f. Min., Geol. u. Palæont., Jahrg. 1908, 487 (postorbital part of a skull from "Kiesgrube bei Frankenhausen, Germany").— WÜST, Zeitschr. f. Naturw. zu Halle, Bd. 81, Juli 1909, pp. 176–178 (fossil remains in Thüringen).

Ovibos fossilis (non Rütimeyer) spec. emendata KOWARZIK, Verhandl. naturf. Vereines in Brünn, XLVIII, 1909, p. 55.

Ovibos moschatus mackenzianus KOWARZIK, Verhandl. naturf. Vereines in Brünn, XLVII, 1909, p. 54 (not of Kowarzik, 1908).— WANDERER, Abhandl. Naturw. Ges. Isis in Dresden, 1909 (1910), pp. 79–85 (muskox remains in Saxony).

As already stated (p. 160), fossil remains of muskoxen, consisting usually of imperfect skulls, have been found at many localities in Northern Europe and northern Asia, from England, France and Germany north to the Arctic Ocean, and in deposits identified as ranging in age from early Pleistocene to Recent. These remains, so far as they have been described and figured, closely resemble corresponding parts of the existing forms of *Ovibos*, and have generally been referred to *Ovibos moschatus*, though other names, as shown by the above synonymy and references, were proposed for them as early as the first half of the last century. Doubtless could these precious relics be all brought together and studied by a competent investigator, they would be found to present differences that would warrant their classification as specifically distinct from the living *O. moschatus*, and probably disclose the existence of several forms entitled to recognition in nomenclature. Kowarzik's lamentable attempt, in 1909, to arrange the group in a systematic way has already been mentioned (*antea*, p. 178). Staudinger,[1] in 1908, referred to a new genus and species (*Præovibos priscus*), a well preserved postorbital portion of a skull from a gravel pit near Frankenhausen, Germany, which greatly resembles a large female skull of *Ovibos*. The horncores, however, appear to be more divergent from the sides of the skull, less depressed, and larger than in females of existing forms of *Ovibos*. He compares it, however, with the skull described and figured by Dawkins from the Forest-bed of Trimingham, England, which he thinks is referable to his genus *Præovibos*, although Dawkins considered it to be "specifically identical" with *Ovibos moschatus*.

With only the published descriptions and figures of the Old World remains of muskoxen

[1] Staudinger, Wilhelm. *Præovibos priscus* nov. gen. et nov. sp., ein Vertreter einer Ovibos nahestehenden Gattung aus dem Pleistocän Thüringens. Centralb. f. Mineral, Geol., u Päleont., Jahrg. 1908, pp. 481–502, figs. 1–4.

available for study in the present connection, it seems best merely to cite the literature of the subject, so far as it has come to my notice, under the earliest tenable name applicable to any of these remains; namely, *Ovibos pallantis* Hamilton Smith (1827), based on Siberian specimens described by Pallas and Ozeretskovsky, respectively, in 1773 and 1811.

It seems quite clear, however, that none of the Eurasiatic muskox remains suggest near relationship with the genera of muskox-like extinct genera of North America, as *Symbos* and *Liops*, and hence that the muskox type did not originate in the Old World.[1]

Extermination.

As has many times been observed by those familiar with muskoxen in their arctic haunts, no animal is better adapted to its surroundings. Their only natural enemies, aside from the Eskimos and Indians who live near or within their range, are the wolves, against which they are admirably equipped for defense. The blizzards and low temperatures of an arctic winter seem not greatly to interfere with their comfort, so well are they protected by their heavy fleece of wool and long hair. Formerly the southern border of their range was formed approximately by the northern limit of tree-growth, into which they are said to have sometimes wandered a short distance in winter, or to browse on the willows that grow along the streams in broken, rocky districts. That they are perfectly at home along the northern coast of Grant Land has been noted by Peary and others. In reply to my inquiries Mr. Donald B. MacMillan, who accompanied Admiral Peary on his final expedition to these northern lands, informs me (*in litt.*, May 20, 1912) that when in camp at Cape Columbia, latitude 83° 07′, "fresh muskox tracks were abundant the middle of November, 1908, around the shore at the head of Parr Bay, the tracks leading back into the hills. The boys thought there were plenty of muskoxen here on our arrival November 12, and that they were frightened away by the howling of the dogs." This date was well into the arctic winter.

In April and May, 1909, Mr. MacMillan made a hunting trip for muskoxen to North Greenland. Of this trip he has kindly sent me the following memoranda:

"May 7, 1909, Cape Morris K. Jesup, Lat. 83° 40′. Most northern point of Greenland and most northern point of known land in the world.

"Upon our arrival here we saw tracks everywhere, so numerous, in fact, that it was impossible to follow any particular one as they crossed and recrossed over the hills and even down to the edge of the sea ice. As yet there had been no melting of the snow, so the hills as we found them were as they had been throughout the winter — barely covered, and in many cases swept clean. In the vicinity of large boulders there was much dung and hair, as if the animals had here taken shelter during drifting snow storms.

"On sighting our dogs the different herds would invariably run to the highest point of land and stand in a circle, heads out, brandishing their horns and acting as if they were anticipating the coming battle with pleasure. The calves took refuge beneath the long hair on the belly of the mothers. Our strongest and best dogs charged in, but were immediately repelled by fierce rushes of the bulls, uttering a peculiar snort. In general, our dogs were so active that they escaped injury, but now and then one would be tossed to a height of six or seven feet. I have never known a dog to be killed outright, but have seen them badly injured. I do not believe the muskox kills by crushing with his massive head, but with a quick side thrust rips and tears with its sharp pointed horns."

But with all its natural fitness to survive, the muskox is doomed wherever it can be utilized by man as a commercial asset. The history of its restriction in range and its decline in numbers over the western part of its former range during the last quarter of a century (see *antea*, p. 185

[1] As already noted, and as will be referred to again later, Osgood has shown that *Bootherium*, as now restricted, has no close relationship with either *Ovibos* or *Symbos*.

and map) indicates clearly its fate wherever it can be reached by the white man, either directly or through his Eskimo or Indian allies. Fortunately its extensive haunts in the great insular areas north of the mainland of the North American continent are beyond the reach of the commercial trader, and these inaccessible resorts will furnish it indefinitely with a place of secure refuge. But wherever its range is shared by the Eskimos, as many portions are, the muskox's fate is sealed, as shown by its extermination over the greater part of the large expanse of land known as Victoria Island. It will also rapidly decline over the more accessible parts of Ellesmere Land and Grinnell Land, through intrusions of ambitious sportsmen. It is doomed throughout the mainland of northern Canada unless the Canadian Government takes the utmost care in restricting the killing for commercial purposes and for trophies — a difficult task in a country so sparsely inhabited. The muskox seems in a fair way, despite all practical means for its protection, to soon share, in continental North America, the fate that has already overtaken the American Bison, interest in whose preservation as the noblest animal of the New World was awakened almost too late to save even a small remnant of the vast herds once regarded as beyond the power of man to extirpate.[1] The muskox is in many ways a more attractive, interesting, and picturesque animal than the bison, and should be saved in the interest of future generations of mankind. It is also the main dependence of the Eskimos in certain sections, who rely upon it in large degree for clothing, utensils and food, as did the Plains Indians upon the bison. The Eskimos have, however, proved incompatible neighbors for the muskoxen, and as history has shown, Eskimos and muskoxen can never live together, owing to the improvident ways of the Eskimos, who are unable to resist the temptation to destroy every animal of a muskox herd they chance to meet, regardless of the waste of life and resources thus incurred. In East Greenland the muskox was able to extend its range south through several degrees of latitude as soon as the Eskimos formerly inhabiting that stretch of coast became extinct (in the early part of the last century). The Eskimos of northern Alaska are doubtless responsible for the comparatively recent extermination of the muskox over the tundras bordering the Arctic coast; and it has been suggested that the final disappearance of the muskox over the tundras of northern Europe and Asia was due to their gradual invasion by man in pursuit of them. The manner of defense by muskoxen against wolves, that of huddling together with the old bulls facing outward, while effective against wolves, invites total destruction in case they are attacked by man, from whose weapons they seem never to have devised any means of escape. It is the unanimous testimony of hunters that the killing of muskoxen is as pure slaughter as would be an attack on a herd of domestic cattle, and not *sport*.

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[1] My observations on the western plains in 1871 and 1873, at the height of the slaughter of the American bisons for their hides, convinced me that only the most stringent legal measure, rigidly enforced, would save our so-called 'buffalo' from speedy extermination. After recounting the history of this slaughter in my 'The American Bisons, Living and Extinct,' published in 1876, I sounded the following note of warning, which also contains, so far as I am aware, the first suggestion of Government reservations for the preservation of our rapidly disappearing large game animals. The case is thus stated (*l. c.*, p. 180):

"These facts are sufficient to show that the present decrease of the buffalo is extremely rapid, and indicate most clearly that the period of his extinction will soon be reached, unless some strong arm is interposed in his behalf. As yet no adequate game-laws for the protection of the buffalo, either by the different States and Territories included within its range, or by the general government, have been enacted. In a country so sparsely populated as is that ranged over by the buffalo, it might be difficult to enforce a proper law, yet the parties who prosecute the business of buffalo-hunting professionally are so well known that it would not be difficult to intercept them and bring them to justice, if found unlawfully destroying the buffalo. It is evident that restrictions should be made, not only in respect to season, but the young and the bearing females should be protected at all seasons. The government might even set apart certain districts within which the buffalo should be constantly exempt from persecution."— The American Bisons, Living and Extinct. Memoirs of the [Shaler] Geological Survey of Kentucky, Vol. I, part ii, 1876, pp. i–ix, 1–246, pll. i–xii and map. Published also simultaneously as: Mem. Mus. Comp. Zoöl., IV, No. 10, 1876.

Much could be done to preserve a considerable remnant of these unsuspicious animals if the Danish, Canadian, and other governments would declare muskox peltries contraband and suppress all traffic in them, while the Canadian and Danish governments might set aside reservations within which neither Eskimos and Indians nor white hunters should be allowed to kill them. The Canadian Government has at present a close season and game-bag limit on the killing of muskoxen, but they are by no means adequately enforced.

Muskoxen in Zoölogical Gardens.

Lydekker, in 1898, wrote:[1] "The muskox has, I believe, never been brought alive to Europe, and indeed would probably be unable to withstand transportation from its icy home to more genial climes;...." This statement, true in 1898, became untrue in the spring of 1899, when two young calves, caught on Clavering Island, East Greenland, in about latitude 74°, were brought alive to Tromsö, Norway, and later were purchased by the Duke of Bedford and placed in his collection at Woburn Park, England. One soon died, the other lived till July, 1903. In the following year (1900) thirteen calves were brought alive to Europe by the Kalthoff-Amdrup Expedition, and distributed to various zoölogical gardens; some of them soon died, but others lived until 1906. Other living specimens were taken alive to Europe in subsequent years, so that by the end of 1908 no less than thirty young muskoxen had been taken alive to Europe, all captured in East Greenland, of which only five were living at the close of that year.[2]

The bringing alive of the first muskoxen to Europe excited great interest, and was heralded throughout the world; within a few months the Woburn Park specimens had been illustrated, from photographs, in a large number of scientific journals as well as in the public press.

In 1902, three years after the arrival of the Bedford Park specimens in Europe, the first living muskox reached the United States, having been captured on the Barren Grounds near Cape Bathurst. This was purchased for the New York Zoölogical Park, where, however, it soon died, but in a few weeks was replaced by a female calf, taken near Fort Conger, Grinnell Land. Seven years later the New York Zoölogical Society received another specimen, captured on Melville Island, which is still living and in excellent health. The following year (September 10, 1910), the Society received six others from Ellesmere Land, one of which soon died from injuries received during capture; the other five are still alive and in excellent condition, and, with the one from Melville Island, form a most attractive and interesting group.

The following detailed history of the muskoxen thus far received at the New York Zoölogical Park, has been kindly prepared by the Director of the Park, Dr. William T. Hornaday, for use in the present connection. No other living specimens appear to have thus far reached the United States. The illustrations (Figs. 38–44, pp. 197–200) kindly furnished by Dr. Hornaday, and the measurements and other information conveyed in the following account, constitute a valuable contribution to the history of an animal never exhibited alive before the beginning of the present century, or till nearly three hundred years after its first description by Jérémie in 1720.

The living specimens here mentioned have also been of great service in the preparation of the present memoir.

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[1] Lydekker, R. Wild Deer, Sheep, and Goats of All Lands, Living and Extinct, 1898, p. 146.

[2] *Cf.* Kowarzik, Rudolf. Der Moschusochs und seine Rassen. Fauna Arctica, V, 1910, pp. 124–126.

Musk-oxen in the New York Zoölogical Park.

First specimen.— On March 17, 1902, the Zoölogical Society received as a gift from Hon. William C. Whitney a female musk-ox from the Barren Grounds of Northern Canada. That animal was born in the spring of 1900, and was captured in March, 1901, by Captain H. H. Bodfish and a party from the whaling steamer 'Beluga,' which was then wintering near Cape Bathurst. The point of capture was about 30 miles from the shore of the Arctic Ocean, and at the time the animal arrived at the Zoölogical Park it was about 25 months old. Its measurements were as follows: — Height at the shoulders, 3′ 2″; length, 4′ 10″.

When this animal was first captured it was fed upon the Arctic willow and bunch grass, but as soon as the 'Beluga' reached Teller City, Port Clarence, where civilized hay was procurable, she promptly abandoned her diet of native grass and dry willow twigs. In captivity her food at the Zoölogical Park consisted of red clover and crushed oats. The accompanying illustration [Fig. 39, p. 198] shows this animal as she appeared in April, 1902. At two years of age her horns were 9″ long, widely separated at the base, and except that they curved downward more than is usual in young cattle, were quite bovine in their appearance. The space between the bases of the two horns was filled with a broad band of light gray hair,— quite like the leading specific character of *Ovibos wardi*. This animal, which for convenience was named 'Olive,' died on August 16, 1902, of pneumonia.

Second specimen.— On September 21, 1902, the Zoölogical Society received a female musk-ox calf as the gift of the Peary Arctic Club, through Mr. H. L. Bridgeman, Secretary. That animal was born in the spring of 1902, near Fort Conger. Its height was 25″; length 41″; tail 1½″; and weight 40 pounds. At the time of its death the horns were not yet visible through the hair. The front hoof was 3″ wide by 2½″ long, and the rear hoof 2½″ wide by 2″ long. This animal died on October 25. Its death was due to a fall on the steep rocks of the corral in which it was confined, which injured its spine and brain. [Fig. 38, p. 197.]

Third specimen.— On November 7, 1909, the Society received another female musk-ox, which was captured on Melville Island by Captain Joseph E. Bernier in the early summer of 1909. The animal was born in the spring of that year. On November 27, 1909, the weight of this animal was 190 pounds, and on February 5, 1910, its weight was 225 pounds. On September 1, 1912, the horns of this animal measured as follows: — Length on curve, 15½″; circumference at base, 7½″; widest outside spread, 20½. The shoulder height of this animal on September 1, 1912, was 46½″. The total length, measured in a straight line from the rear base of the horn to the base of the tail, was 5′ 4½″. [Figs. 40, 41, p. 199.]

In temper this animal is quite vicious toward all other musk-oxen; but she is docile to her keeper.

This specimen has been kept in perfect health ever since its arrival at the Park, and is in very vigorous condition. If her temper toward other musk-oxen were less vicious, we would expect that she would breed successfully here; but in view of her disposition, her breeding is at least doubtful.

Rainey specimens.— On September 10, 1910, the Society received as a gift from Paul J. Rainey, six musk-ox calves, which had been captured on Ellesmere Land in the spring of 1910 by Mr. Rainey and his companions. One of the female calves was seriously bitten during capture by the Eskimo dogs, and so severely wounded that she died on October 23, 1910. This leaves the Rainey gift consisting of a herd of five animals, of which four are males and one a female. These animals have all remained in the most perfect health ever since their arrival. On September 1, 1912, the largest female stood 3′ 6″ in height at the shoulder, and measured 5′ in length from the base of the horns to the root of the tail. The longest horn was 14″ in length on the curve, 8″ in circumference, and the widest outside spread of the horns was 23″. [Figs. 42–44, p. 200.]

Many visitors to the Zoölogical Park, and members of the Zoölogical Society, have expressed surprise at the healthy condition of our musk-ox herd, which consists of six animals. Judging by their appearance, their size and length of horn, it would seem that they have developed quite as rapidly and successfully as wild animals on their native soil would have done in the same time. It is no exaggeration to say that the public generally expected that these animals would suffer during the warm weather of midsummer; but all these expectations have been happily disappointed. The location chosen for the herd is one of the coolest and best-shaded situations in the Zoölogical Park, yet sheltered from sweeping winds. The animals have been carefully kept out of the rain. At the approach of every rain-storm, they have been driven into their barn and shut in. This is for the express purpose of avoiding pneumonia,— which probably would be induced by permitting the animals to become thoroughly rain-soaked, and being obliged afterward to remain inactive while in a wet condition. This anti-rain precaution has also been observed with our mountain goats, and I think is the foundation of our success with that species.

We have observed no suffering on the part of any of our musk-oxen during even the warmest weather of midsummer. On the afternoons of the hottest days, the animals breathe more rapidly than usual; but there is not the slightest evidence of anything approaching distress.

We see no reason why the musk-ox should not breed here in captivity, and we confidently look forward to results in that direction.

William T. Hornaday.

PART III.— BOOTHERIUM, SYMBOS, AND LIOPS.

As already said, no immediate ancestor of the muskox group has yet been found in the Old World. In North America two recently extinct types closely related to *Ovibos* are now known, besides a third type which seems to hold a midway position between *Ovibos* and *Bison*. This is the restricted genus *Bootherium* Leidy. The genus is at present known from a single species, represented by only the type skull. A second supposed species, *Bootherium sargenti* Gidley, proves to be referable to the genus *Symbos*.

Bootherium *Leidy*.

Bootherium LEIDY, Proc. Acad. Nat. Sci. Philadelphia, VI, No. 3, July, 1852, p. 71 (provisional name for *Bos bombifrons* Harlan, and *Bootherium cavifrons* sp. nov.); Smithson. Contr. to Knowl., V, art. iii, 1852, p. 12, pll. iii–v; Proc. Acad. Nat. Sci. Philadelphia, VII, 1854, pp. 209, 210 (reply to criticisms of Sir John Richardson in 'Zool. Voy. of the Herald,' pt. 1, p. 200; three months' priority claimed for his *Bootherium cavifrons* over Richardson's *Ovibos maximus*); Journ. Acad. Nat. Sci. Philadelphia, N. S., VII, 1869, p. 374 (here considered a synonym of *Ovibos*).— DAWKINS, Proc. Roy. Soc. London, XV, 1867, p. 516 (referred to *Ovibos*); Quart. Journ. Geol., XXXIX, 1883, p. 557 (in text; closely allied to *Ovibos moschatus; "O. cavifrons*, male, *O. bombifrons*, female, = *Bootherium* of Leidy).— LYDEKKER, Cat. Foss. Mamm. Brit. Mus., pt. 2, 1885, p. 39 (cast of Leidy's type of *Ovibos cavifrons* figured).— OSGOOD, Smithson. Misc. Coll., quart. issue, XLVIII, 1905, p. 173 (type fixed as *Bos bombifrons* Harlan).

Bootherium bombifrons (*Harlan*).

[An imperfect skull having "some resemblance to the genus *Bos*"], WISTAR, Trans. Amer. Phil. Soc., N. S., I, 1818, pp. 373–380, pll. x, xi (described at pp. 379, 380, pl. xi, figs. 10, 11. Later this skull became the basis of *Bos bombifrons* Harlan).

[*Imperfect skull from Big Bone Lick, Kentucky*], COOPER, Month. Amer. Journ. of Geol. and Nat. Hist., I, Oct. and Nov. 1831, pp. 173, 174 (first full description of the skull later described and figured by Leidy as *Bootherium bombifrons*).

Bos bombifrons HARLAN, Fauna Amer., 1825, p. 271 (based on an imperfect skull from Big Bone Lick, Kentucky, first described and poorly figured by Wistar in 1818, but "not heretofore introduced into the systems, nor even noticed by systematic writers.") — COOPER, Month. Amer. Journ. Geol. and Nat. Hist., I, 1831, pp. 173, 206. (Refers to the Wistar specimen, and alludes to a "second head of this species" collected by Benjamin Finnell.)

Bootherium bombifrons LEIDY, Proc. Acad. Nat. Sci. Philadelphia, VI, July, 1852, p. 71; *ibid.*, VII, 1854, p. 210; Smithson. Contr. to Knowledge, V, art. iii, 1853, pp. 17–19, pll. iv, fig. 2, pl. v, figs. 1, 2.

Ovibos cavifrons DAWKINS, Palæontograph. Soc., XXV, pt. v, p. 29, pl. v.

Ovibos bombifrons LEIDY, Journ. Acad. Nat. Sci. Philadelphia, VII, 1869, p. 374 (the genus *Bootherium* being here considered a synonym of *Ovibos*).

Ovibos bombifrons LYDEKKER, Cat. Foss. Mamm. in Br. Mus., pt. ii, 1885, p. 39 (cast of the type specimen); Wild Oxen, Sheep, and Goats, 1898, p. 148. (Includes both *Bos bombifrons* Harlan and *Bootherium cavifrons* Leidy, the former being regarded as the female of the latter.)

Ovibos priscus RÜTIMEYER, Verhandl. naturf. Gesel. Basel, IV, 1867, p. 328. (New name for "♂ *Bootherium cavifrons*" + "♀ *Bootherium bombifrons*." Refers both *Budorcas* and *Ovibos* to the sheep.)

Bootherium was tentatively proposed by Leidy, in 1852, for two extinct species of Bovine animals which, in the light of present knowledge, prove to be not only not congeneric, but not very closely allied. This interesting discovery is due to Osgood, whose paper [1] on the status and relationships of *Bootherium* is entitled to high praise.

Bootherium was originally proposed provisionally for "*Ovibos bombifrons* and *O. cavifrons*," in case, the author stated, *Ovibos moschatus* does not possess "large larmiers or lachrymal depressions, as in the deer." Two years later, in replying to Sir John Richardson's comment on

[1] Osgood, Wilfred H. *Scaphoceros tyrrelli*, an extinct Ruminant from the Klondike Gravels. Smithson. Miscel. Coll. (quart. issue), Vol. XLVIII, pp. 173–185, pll. xxxvii–xlii, July 1, 1905.

Bootherium, he stated that this genus differs from *Ovibos* in possessing "large lachrymal fossæ or larmiers situated in front of the orbits as in Cervidæ," which, he erroneously added, do not exist in *Ovibos*. In 1869, Leidy treated *Bootherium* as a synonym of *Ovibos*, remarking in explanation as follows: "At the time of preparing my memoir on the extinct species of American Ox [1852], I had neither seen a recent Musk Ox skull nor characteristic representations of one. Subsequently, in comparing the fossils referred to *Bootherium* with Richardson's plates of the Musk Ox skull, in the Zoölogy of the Voyage of the Herald, my opinion that they might belong to the genus *Ovibos* appeared to be confirmed, though of this I am not quite positive. In the fossils the lachrymal fossæ are of remarkable comparative depth; in the Musk Ox, as represented in Richardson's plates, they appear not to be more conspicuous than in the Sheep, nor does Richardson mention them in the description of the lachrymal bones. Rütimeyer says distinct lachrymal fossæ exist in *Ovibos*, and considers the fossils as belonging to this genus." [1]

It may be noted in passing that Leidy's type specimen of his *Bootherium cavifrons* was too imperfect to show whether or not it had lacrymal fossæ, and that while he speaks of "the fossils" as having "the lachrymal fossæ. . . . of remarkable comparative depth," only the skull of *Bootherium bombifrons* had the lacrymal region preserved, and this only on the right side, sufficiently to show whether a fossa was present; and here it is so well-marked as to form a deep, sharply defined cavity of truly "remarkable comparative depth." Later discovered, better preserved skulls of Leidy's *B. cavifrons* show that the lacrymal fossa is only of slight depth, as in *Ovibos*, and not sharply defined. The fact that all of Leidy's references to the lacrymal fossæ in *Bootherium* prove to have been necessarily based on *B. bombifrons* is another and a very important reason for selecting this species as the type of the genus additional to those assigned by Osgood.

The genus *Bootherium* is still known only from a single imperfect skull, first described and poorly figured by Wistar in 1818; Wistar's description and figures became in 1825 the basis of Harlan's *Bos bombifrons*, which Harlan states to have been "not heretofore introduced into the systems, nor even noticed by systematic writers." This historic type skull, now before me as I write, was first fully described by Cooper in 1831, and became the type of *Bootherium* by designation of Osgood in 1905. It was first well figured by Leidy in 1853, and later by Osgood in 1905. But none of these figures give a satisfactory side view, which is highly distinctive and is presented here in Fig. 45.

The characteristic features of *Bootherium* are (1) its *Bison*-like horns, (2) the abrupt downward slope of the dorsal outline of the skull posterior to the horncores; (3) the lower surface of the basisphenoid, which is not anteroposteriorly deflected but horizontal, and has a sharp median ridge. None of these features are well brought out in illustrations. (4) The presence of small but deep and sharply defined lacrymal fossæ;[2] (5) the small size of the animal, as indicated by the skull, which is that of a very old male, with all the sutures of the preserved part of the skull wholly obliterated by anchylosis. In all probability it represents the male sex.[3]

As stated by Osgood, the horncores stand out from the skull on a distinct pedicel, and "have a burr as in *Bison*." They are round and not flattened in any degree, and if detached from the skull might easily be mistaken for the horncores of a bison; as attached to the skull they are

[1] Journ. Acad. Nat. Sci. Philadelphia, N. S., VII, 1869, p. 375.

[2] The lacrymal fossa is a circular pit about 25 mm. in diameter and about 15 mm. deep.

[3] A more un-sheep-like creature than *Bootherium* can hardly be found among Ungulates, yet Scharff says: "The name *Bootherium* is now applied to an extinct large sheep-like creature, viz., *B[ootherium] bombifrons*. . . ."—Distribution and Evolution of Life in America, 1912, p. 154.

decurved and not recurved as in *Bison*; but they in no way, either in mode of attachment or form, nor in their outward trend, suggest the horncores of even the female sex of *Ovibos*. The form and mode of attachment of the horncores, however, are the only features of the type skull that suggest a comparison with *Bison*.

Description of the Skull.

The portion of the skull preserved consists of the region posterior to the base of the nasals, including both orbits and a small area in front of the left orbit sufficient to show the lacrymal fossa. The mid-ventral surface is fairly preserved from the foramen magnum to the anterior border of the basisphenoid; the right condyle is fairly intact but the left condyle and the whole palatal surface is broken away, including the ventral border of the maxillaries and the dentition.

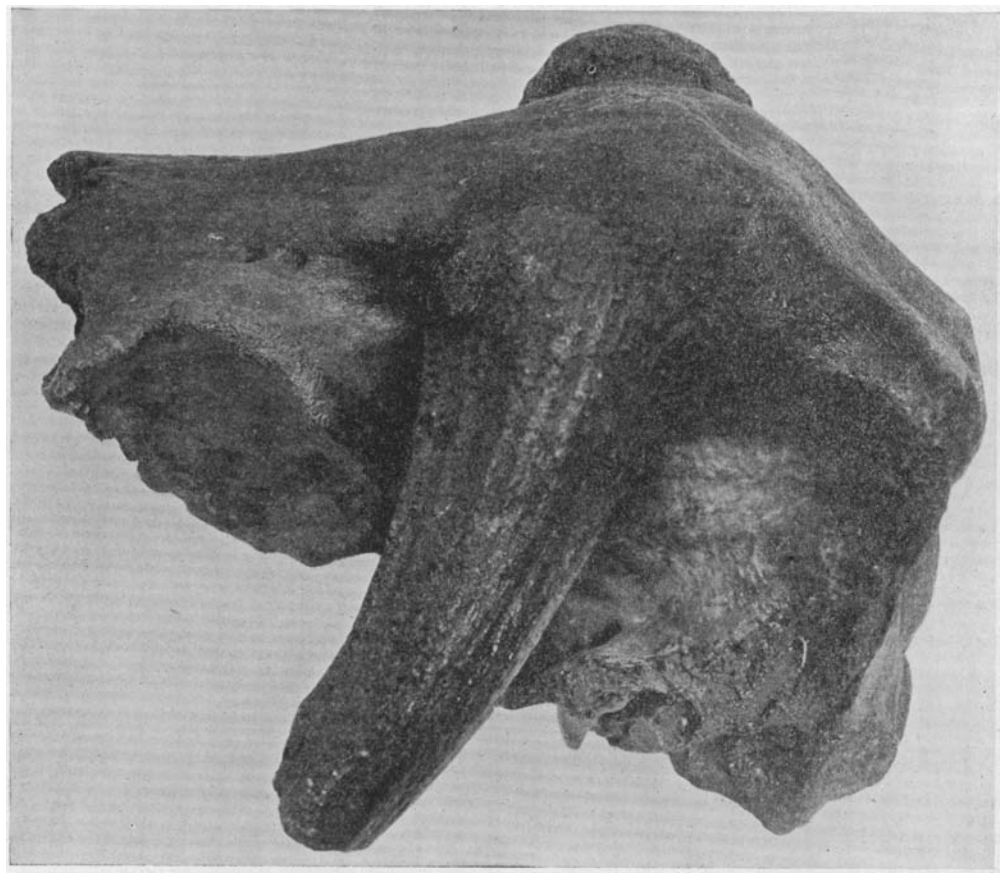

Fig. 45. *Bootherium bombifrons*. Side view to show dorsal contour of the skull. Type and only known specimen of the genus.

The right horncore is nearly complete, the tip only being abraded, rendering it possible to estimate the total length with certainty. The left horncore has lost about the apical fourth of its length. The skull is heavily mineralized.

A striking feature of the skull is its small size in comparison with either *Bison*, *Ovibos*, *Symbos*, or *Liops*. An equally striking feature, in comparison with the genera just named, is its dorsal outline, which forms a sharp angle at a transverse line connecting the bases of the horncores, the surface of the skull behind this line declining at an angle of 55° from the plane of the portion anterior to this point. At the same time the dorsal contour is markedly convex transversely. Another feature that sharply differentiates this skull from the above-named genera is that the

ventral surface of the basisphenoid, as noted by Osgood, is in the same plane as that of the basioccipital, not sharply depressed (in ventral view) as in all of the others. Besides this, the ventral surface of the basisphenoid rises into a sharp ridge along the median line to a height of from 2 mm. to about 6 mm., the sides sloping like the sides of a sharp-ridged house-roof, the height and width of the ridge increasing from behind anteriorly.

The bison-like horncores and the lacrymal fossa have already been described. The condyles and adjoining parts of the skull, as far as they are preserved, are similar to the same parts in *Symbos*, and consequently very different from what is seen in either *Bison* or *Ovibos*. The occipital plane also resembles that of *Symbos*. The proportions of the skull are as in *Symbos* and *Liops*, the skull being narrow and deep, not broad and shallow as in *Bison* and *Ovibos*. In the absence of the entire rostral portion of the skull, including the dentition, its nearest relationship to other forms cannot be predicated. The portion preserved, while combining features of *Symbos* and *Bison*, is sufficient to show that it is not closely related to either. *Preptoceras* Furlong, from the Pleistocene caves of California, seems allied in general features to *Bootherium*, but not to *Symbos*. *Bootherium* and *Preptoceras* are not closely related, but more nearly so than is either to any other known genus.

Measurements of the Skull.

	Mm.
Occipital breadth	120
" depth, superior border of occiput to upper edge of foramen magnum	91
" depth, superior border to lower edge of foramen magnum	131
" spine to front edge of orbit	225
Breadth at postorbital constriction	110
" " constriction behind horncores	100
Horncores, tip to tip in straight line (estimated, the tips being abraded)	435
" " " " over convexity (estimated)	610
Right horncore, length over convexity (tip broken)	210
" " " " " (tip estimated)	230
" " " of pedicel	120
" " circumference of pedicel	195
" " " " burr	223
Lacrymal fossa, diameter of pit	25
" " depth of pit	15

The only known skull [1] of *Bootherium*, as already said, is the fragmentary type skull from Big Bone Lick, Kentucky, collected nearly a century ago by General William Clark, the associate of General Meriwether Lewis, of the famous Lewis and Clark Exploring Expedition, and presented by President Thomas Jefferson to the American Philosophical Society of Philadelphia, and now the property of the Academy of Natural Sciences of that city.

The scientific history of this unique type is of unusual interest, as it 'points a moral' in the matter of too hasty generalization from insufficient basis. Leidy, in 1852, believed his *Bootherium bombifrons* (Harlan) and *B. cavifrons* were congeneric species, but he was in doubt as to whether they ought not to be referred to *Ovibos*, he at this date never having seen a skull of *Ovibos* nor a

[1] Quackenbush records (Bull. Amer. Mus. Nat. Hist., XXVI, 1909, p. 127) a specimen of *Bootherium bombifrons*, identified by him "from a very good photograph (in the possession of Professor Henry Fairfield Osborn); taken by Mr. T. Obalski at Gold Run Creek, Indian River, near Dawson, Canada, in July, 1903." A careful search, made in my behalf, of the photographic files of Professor Osborn and of the Museum has failed to disclose any such photograph. I am therefore unable to confirm the identification, and suspect there may have been some mistake in the determination. Nevertheless *Bootherium bombifrons* has been given in literature as "already known from the Yukon territory of Canada." — SCHARFF, R. F. Distribution and Evolution of in Life America, 1912, p. 80.

good illustration of one. Dawkins, in 1867,[1] announced his conclusion that *Bootherium* should be referred to *Ovibos;* Rütimeyer, in the same year,[2] on the basis of Leidy's descriptions and figures of these two species, not only referred them to *Ovibos,* but to the same species as respectively male and female, he assuming *B. cavifrons* to be the male and *B. bombifrons* the female, and renamed the combination as "*Ovibos priscus.*" Dawkins, again recurring to the subject seven years later, in republishing Leidy's plates of the two species,[3] reached the same conclusions, stating that the skull of *bombifrons* "bears exactly the same relation to that of *B. cavifrons,* as the male to the female of the Musk Sheep. It is therefore highly probable that *B. cavifrons* and *B. bombifrons* are the male and female of the same species," for which he adopted the name *Ovibos cavifrons,* regardless of the fact that the name *cavifrons* was published 27 years later than *bombifrons.*

Leidy,[4] two years later, remained unconvinced that *B. bombifrons* and *B. cavifrons* merely represented the two sexes of the same species, yet they were so regarded by Lydekker, not only in 1885 [5] but as late as 1898,[6] and the supposed species was referred to the genus *Ovibos.* They were thus considered by all authors, who had occasion to refer to them, till Osgood in 1905, set forth the real facts of the case, and thus commented on this singular lapsus: "Since *bombifrons* and *cavifrons* have been considered by several authors as being not only congeneric but conspecific, the establishment of a separate genus for each may appear surprising. While it may be possible, from an examination of figures only, to construct a hypothesis to the effect that *cavifrons* represents the male and *bombifrons* the female of one species, it is inconceivable that any modern taxonomist would reach such a conclusion after comparing the original types." [7] Upon carefully reading Osgood's paper I felt sure that he had correctly solved the problem, though previously, on the basis of the published figures, I had shared the current opinion, but wishing first-hand knowledge of the case, I sent to Mr. Witmer Stone, Curator of Mammals and Birds at the Philadelphia Academy of Natural Sciences, for the skull for examination, and on its receipt a glance was sufficient to show that *B. bombifrons* had very little in common with *B. cavifrons,* and very much to demonstrate that they had no near relationship. The history of this case shows the importance of first-hand examination of the material involved in questions of this character.

Symbos *Osgood.*

Bootherium LEIDY, Proc. Acad. Nat. Sci. Philadelphia, VI, 1852, p. 71 (part).

Ovibos DAWKINS, Proc. Roy. Soc. London, XV, 1867, p. 516 (part); Palæontograph. Soc., XXV, pt. v, 1872, p. 29 (part).— RÜTIMEYER, Verhandl. naturf. Gesel. Basel, IV, 1867, p. 328, pl. v, (part).

Scaphoceras OSGOOD, Smithson. Misc. Coll. (quart. issue), XLVIII, 1905, pp. 174–183, pl. xxxvii, fig. 2, pl. xxxviii, fig. 2, pl. xxxix, fig. 1, pl. xl, fig. 2: Type, *Scaphoceros tyrrelli* sp. nov.

Symbos OSGOOD, Proc. Biol. Soc. Washington, XVIII, p. 223, 1905 (nom. nov., to replace *Scaphoceras* Osgood, preoccupied).

A comparison of *Symbos* with *Ovibos* has already been made (*antea,* pp. 169–171). A comparison of *Symbos* with *Liops* is given under the latter. The following three species of *Symbos* have been described. *Symbos cavifrons* (Leidy) is known from many specimens, found chiefly in the Pleisto-

[1] Proc. Roy. Soc. London, XXV, 1867, p. 516.
[2] Verhandl. naturf. Gesel. Basel, Vol. IV, 1867, p. 382.
[3] Palæontograph. Soc., XXV, pt. v, p. 29, pl. v, figs. 2–4.
[4] Journ. Acad. Nat. Sci. Philadelphia, N. S., VII, 1869, p. 365.
[5] Cat. Foss. Mamm. Brit. Mus., pt. 2, 1885, p. 39.
[6] Wild Oxen, Sheep, and Goats, 1898, p. 148.
[7] Smithson. Miscel. Coll. (quart. issue), Vol. XLVIII, July 1, 1905, pp. 181, 182.

cene of the Mississippi Valley. *Symbos tyrrelli* Osgood is thus far known only from the type and another less complete skull from the Pleistocene gravels of the Klondike District, Yukon Territory. *S. australis* Brown is known only from a few teeth and other referred bones found in Conard Fissure, Arkansas, and from the nature of the material cannot be considered as resting on a very sure foundation. A fourth species described as *Bootherium sargenti* by Gidley is apparently the female of *Symbos cavifrons.*

Symbos cavifrons (*Leidy*).

Bootherium cavifrons LEIDY, Proc. Acad. Nat. Sci. Philadelphia, VI, No. 3, July, 1852, p. 71; Smithson. Contr. to Knowledge, V, 1853, pp. 12–17, pl. iii, figs. 1, 2, pl. iv, fig. 1; Proc. Acad. Nat. Sci. Philadelphia, VII, 1854, p. 210.

Ovibos cavifrons DAWKINS, Quart. Journ. Geol., XXXIX, 1883, p. 557 (in text). ("It [*Ovibos moschatus*] is represented by a closely allied form in the Pleistocene strata of the United States, the *Ovibos cavifrons* (male), *bombifrons* (female) (= *Bootherium*) of Leidy.").— LEIDY, Journ. Acad. Nat. Sci. Philadelphia, N. S., VII, 1869, p. 374.— LYDEKKER, Cat. Foss. Mamm. Brit. Mus., pt. ii, 1885, p. 39 (cast of Leidy's type specimen of the species).— MCGEE, Amer. Journ. Sci., ser. 3, XXIV, Sept., 1887, pp. 217–220. ("Larger part of the cranium with horn cores attached and some of the molars in place, about half of the lower jaw, the atlas, a femur, and a number of other bones in more or less fragmentary condition. The material has been placed in the cabinet of the State University [of Iowa] at Iowa City." "Found in the loess of the Missouri River at Council Bluffs, Iowa, at a point 12 feet below the surface and 130 feet above the river." Associated with remains of "elephant and mastodon").

Scaphoceros cavifrons OSGOOD, Smithson. Miscel. Coll., quart. issue, XLVIII, 1905, p. 181, pl. xl, fig. 1, pl. xli, fig. 1, pl. xlii, fig. 1, from photographs of Leidy's type.

Symbos cavifrons OSGOOD, Proc. Biol. Soc. Washington, XVIII, p. 223, Oct. 17, 1905 (= *Scaphoceros cavifrons* Osgood; *Scaphoceros* preoccupied).

Ovibos cavifrons HATCHER, Science, N. S., XVI, Oct. 31, 1902, pp. 707–709 (skull, found in West Virginia, near Steubenville, O.).

Symbos australis BROWN, Amer. Mus. Nat. Hist., IX, pt. v, Feb. 1908, p. 203, pl. xxii, teeth, and two phalanges, from Conard Fissure, Newton Co., Arkansas.

Bootherium sargenti GIDLEY, Proc. U. S. Nat. Mus., XXXIV, p. 683, pl. lix, Sept. 15, 1908 (an imperfect skull from Moorland Swamp, near Grand Rapids, Mich.; Pleistocene).

Symbos cavifrons, the *Bootherium cavifrons* Leidy, was founded on an imperfect skull, lacking the preorbital and palatal portions, found at Fort Gibson, Indian Territory (now Oklahoma). It was described and figured by Leidy in 1853, and his figures have been several times republished. In 1869, Leidy stated (*l. c.*, p. 374): "Remains of this species are comparatively abundant," apparently in comparison with other fossil Bovines, and he enumerated, in addition to Fort Gibson, New Madrid, Mo.; Benton County, Mo.; St. Louis, Mo.; Big Bone Lick, Ky.; Trumbull County, O. Additional remains have since been found at Council Bluffs, Iowa (McGee, *l. c.*, p. 203); West Virginia (near Steubenville, O.); Conard Fissure, Newton Co., Ark.; near Grand Rapids, Mich.; and the Indiana specimen is here described and figured (pp. 169–171, Fig. 25, Pll. XVII, XVIII).[1] The total number of authenticated localities of *S. cavifrons* is now at least 11. I have myself examined only the Hebron, Indiana, specimen. The present location of most of these specimens is unknown to me.

Prior to 1905, all of the known remains representing the genus *Symbos* were referred to *Ovibos cavifrons;* in that year a second species, *Symbos tyrrelli* Osgood, was made known from the Klondike district of Yukon Territory, as noted more fully below. In 1908, two supposed species, *Symbos australis* Brown and *Bootherium sargenti* Gidley, were described from remains found respectively in Conard Fissure, Newton County, northern Arkansas, and from a swamp near Grand Rapids, Michigan. The type material of *Symbos australis* consists of three molar teeth (No. 11828, Dept. Vert. Palæont., Am. Mus.), which were found associated; the referred material consists of three premolars, an atlas, and two ungual phalanges found together in a pocket near

[1] The skull recorded by Brown from near Wilson, Kan., proves to belong to *Ovibos* (*cf. antea*, p. 203).

the type molar teeth. This material has kindly been placed at my disposal for study. To me, I regret to say, it forms a very unsatisfactory basis for a species. The type molar teeth, while unmistakably referable to *Symbos*, differ from corresponding teeth of *S. cavifrons* only in size, and in this respect very slightly. These teeth are identified by Brown as "a right upper m^2 and left lower m_2 and m_3." The single tooth belonging to the Hebron, Indiana, skull, described and figured in the present paper, is a left upper molar, corresponding to the upper molar identified by Brown as m^2. The only difference between them is the slightly larger size of the Indiana specimen, which is that of an old male. Measurements of these teeth at exactly corresponding points are:

S. cavifrons, length, 37 mm., width, 30 mm.
S. australis, " 33 " " 27 "

This slight difference may be sexual, or merely individual. The premolars appear to be rightly referred to *Symbos;* the phalanges and atlas seem probably also referable to this genus.

As Conard Fissure is situated near several localities where skulls of *Symbos cavifrons* have been found, it seems hardly probable that a second species of *Symbos* is represented by the teeth from Conard Fissure, that differ so slightly from known teeth of *S. cavifrons*. Fort Gibson, Oklahoma, the type locality of *S. cavifrons*, is only 100 miles west of Conard Fissure; and there are three other *cavifrons* records from relatively near localities to the northward and eastward in Missouri. Under these circumstances it seems warrantable to refer *S. australis* to *S. cavifrons*, as probably representing the female of that species.

Bootherium sargenti was founded on an imperfect skull consisting of the postorbital upper portion, with complete horncores, found in a swamp near Grand Rapids, Michigan. In the description comparison is strangely made with *Bootherium bombifrons*, with which it shares no essential feature. The horncores are attached to the skull as in the female of *Ovibos*, with about the same relative area of exostosis extending from the base over the lateral third or more of the frontals and not, as in *Bootherium*, supported on a pedicel and terminating in a burr as in *Bison*. The relationship of *Bootherium sargenti* is entirely with *Symbos*, and well fulfills the conditions that would be expected in the female of *S. cavifrons*.

Symbos tyrrelli *Osgood.*

Scaphoceros tyrrelli OSGOOD, Smithson. Miscel. Contr. (quart. issue), XLVIII, 1905, pp. 173–185 (sp. nov., type of *Scaphoceros*, gen. nov., Lovett Gulch, Bonanza Creek, Klondike District, Yukon Territory, Canada).

Symbos tyrrelli OSGOOD, Proc. Biol. Soc. Washington, XVIII, Oct. 17, 1905 (to replace *Scaphoceros*, preoccupied).—QUACKENBUSH, Bull. Amer. Mus. Nat. Hist., XXVI, p. 127, March 24, 1909. (an incomplete skull found near Dawson, Canada).

The type of this species is a skull found in gravels, 70 feet below the surface, "in Lovett Gulch, Bonanza Creek, Klondike District, Yukon Territory, Canada," and is now in the United States National Museum. It was well described and figured by Osgood in the paper in which he cleared up the case of the genus *Bootherium*. Another less well preserved skull is mentioned, both discovered by J. B. Tyrrell, who generously presented them to Osgood for deposit in our National Museum at Washington. Quackenbush (*l. c.*) mentions a third incomplete skull seen by him in Dawson in 1907, which was found in Magnet Gulch, a tributary of Bonanza Creek, in the Klondike, near Dawson. These are the only specimens of which I have thus far seen definite mention.

Symbos tyrrelli appears to differ from *S. cavifrons* mainly in much smaller size, as stated by Osgood and as shown by his table of measurements (*l. c.*, p. 184).

Liops *Gidley.*

Liops GIDLEY, Proc. U. S. Nat. Mus., XXX, p. 165, April 4, 1906 (original description; type, *Liops zuniensis* sp. nov.).
Lissops GIDLEY, Proc. U. S. Nat Mus., XXXIV, p. 684, Sept. 15, 1908 (lapsus for *Liops*).

Liops zuniensis *Gidley.*

Liops zuniensis GIDLEY, Proc. U. S. Nat. Mus., XXX, pp. 166, 167, figs. 1–3, April 4, 1906 (near Zuñi, N. Mex.).

The genus *Liops* was based on the upper part of a skull found in excavating for the irrigating dam at Black Rocks, near Zuñi, New Mexico. The parts preserved consist of the upper surface from the base of the nasals posteriorly to and including the occipital region, and the ventral portion from the basisphenoid posteriorly to the foramen magnum; the palatal region, with the lower border of the maxillaries and the dentition, is lacking. The dense smooth natural surface of the bones is preserved over the greater part of the dorsal aspect of the skull, except laterally in the postorbital region; the surface elsewhere consists of the cancellous structure of abraded bone, the abrasions being in places quite superficial, as in the case of the horncores and upper surface of the skull, and elsewhere so deep as to greatly obscure or wholly obliterate important features, as the condyles, the characters of the mastoid and tympanic regions, and the occipital angles. The unabraded dorsal surface of the skull shows that it must have been that of an old animal, and probably that of a male, the sutures being entirely obliterated by anchylosis.

The nearest known relative of *Liops* is undoubtedly *Symbos*, as stated by the author. The horncores are similar in form and position, being very broad at the base, which everywhere presents a smooth surface, and at its junction occupies nearly the whole of the postorbital edge of the skull, as in the males of both *Symbos* and *Ovibos*. But the surface of the horncores is smooth, not thickened and roughened by exostosis as in *Symbos* and *Ovibos*. The width of the horncores at base is approximately 95 mm., but as they have suffered considerable abrasion at the edges, they probably had a basal breadth of at least 110 mm.; at about 75 mm. from the base the transverse breadth is reduced to about 60 mm., and was probably less than 80 mm. in life. The horncores are decurved about as in *Symbos* and have about the same relative size. A striking difference between *Liops* and both *Symbos* and *Ovibos* is the smoothness of the surface of the basal portion of the horncores and the entire absence of exostosis between the horn-bases over the top of the skull, which is here smooth, with the same dense surface as that of the interorbital and preorbital portions. The intra-horn area is transversely slightly concave.

The size of the skull is about one half that of *Symbos*, but the proportions appear to be similar. So far as the ventral surface is preserved, there is also similarity, as in the form of the basioccipital and basisphenoid, including the angle they make with each other. The condyles are entirely lacking, and the foramen magnum is much enlarged and its natural outline changed by abrasion of the superior border. The mastoid angles of the skull are also greatly abraded, and unequally so on the two sides. These seem to have been mistaken by the author for the condyles; and he failed also to recognize the unnatural condition of the foramen magnum with relation to its size and position. These and other errors appear in the generic diagnosis in consequence of his failure to recognize to how great an extent the occipital region of the skull had suffered by abrasion.

ILLUSTRATIONS.

PLATES

Plate XI.

Fig. 1. No. 28072, ♂, 5 years old. Oblique dorso-lateral view of skull, to show dorsal surface of right horncore (sheath removed). $\frac{5}{8}$.

Fig. 2. Lower (ventral) surface of apical third of the same horncore. $\frac{1}{1}$.

Plate XII.

Fig. 1. Vertical transverse section of horn at point of lateral junction with the skull (No. 28092, old male, northern Grant Land), proximal surface. $\frac{1}{1}$.

Fig. 2. Transverse section of same horn, 105 mm. on upper side and 12 mm. on lower side beyond the section shown in Fig. 1. $\frac{1}{1}$.

Fig. 3. Transverse section of same horn, 200 mm. on upper side and 70 mm. on lower side beyond the section shown in Fig. 2, and nearly at the tip of the core. $\frac{1}{1}$.

Fig. 4. Transverse section of another horn (old male, No. 28091, northern Grant Land), 85 mm. from the base, showing not only the sheath and horncore but the upper wall of the skull with its vacuities. (The dark vertical line near the left border of the figure is due to a false section made inadvertently by the preparator, the two parts being afterwards joined together with glue.)

Fig. 5. Base of the right horn of a four year old male (No. 28093, Grant Land), showing the growing surface of both the sheath and the exostosis, and a section of the skull. $\frac{1}{3}$.

Plate XIII.

Fig. 1. Longitudinal section of the left horn of a four years old male (No. 28093, northern Grant Land). $\frac{1}{2}$.

Fig. 2. Longitudinal section of the left horn of a very old male (No. 28091, Grant Land). $\frac{1}{2}$.

Plate XIV.

Fig. 1. Longitudinal section of the right horn of an old male (No. 28092, Grant Land). $\frac{1}{2}$.

Fig. 2. Base of the horn of an old male (No. 28091, Grant Land) with the sheath removed, showing the dorsal surface of the exostosis. The white basal layer (*a*) is the skull wall; the middle lighter section (*b*) is the lamella at the inner base of the exostosis; the darker upper half (*c*) is the surface of the exostosis, the sheath having been removed. $\frac{2}{3}$. (See Plate XII, Fig. 4, for another transverse section of this same horn.)

Fig. 3. View of the same section from the anterior end (the end toward the right in Fig. 2), showing in profile (at *a*) the vertical lamella at the posterior end of base of the exostosis. (In some specimens this is higher and thinner than in the specimen here figured.) $\frac{1}{1}$.

Fig. 4. View of the inner surface of the base of the sheath which covered the exostosis shown in Fig. 2. $\frac{2}{3}$.

Plate XV.

Left maxillary toothrow, crown and lateral views, illustrating ontogenesis in dentition. Figs. 2–10, males, Fig. 11, female.

Fig. 1. Fœtal (8th month). No. 16727, Canadian Barren Grounds. (See text fig. 1, *c*.)

Fig. 2. One week old. No. 29939, ♂, northern Grant Land. (See text fig. 2, *c*.)

Fig. 3. One year old. No. 28108, ♂, northern Grant Land. (See text fig. 4, *c*.)

Fig. 4. One and a half years old. No. 27995, ♂, northern Grant Land. (See text fig. 6*e*.)

Fig. 5. Three years old. No. 28011, ♂, northern Grant Land. (See text fig. 10, *d*.)

Fig. 6. Four years old. No. 19561, ♂, northern Grant Land. (See text fig. 12, *d*.)

Fig. 7. Five years old. No. 29948, ♂, northern Grant Land. (See text fig. 14, *d*.)

Fig. 8. Six years old. No. 28072, ♂, northern Grant Land. (See text fig. 15, *e*.)

Fig. 9. Seven years old. No. 19490, ♂, northern Grant Land. (See text fig. 16, *d*.)
Fig. 10. Ten years old. No. 28069, ♂, northern Grant Land.
Fig. 11. Twelve (or more) years old. No. 29964, ♀, northern Grant Land. (See text fig. 17, *d*.)

Plate XVI.

Left mandibular toothrow and incisors, crown and lateral views, illustrating ontogenesis in dentition.
Fig. 1. One week old, No. 29939, ♂, northern Grant Land. Crown view, both mandibles. ½.
Fig. 1*a*. Do., lateral view (outside), right mandible. ½.
Fig. 2. Six months old, No. 29914, ♀, northern Grant Land. Crown view, left mandible. ½.
Fig. 2*a*. Do., lateral view. ½.
Fig. 3. One year old, No. 28108, ♂, northern Grant Land. Crown view. ½.
Fig. 3*a*. Do., lateral view. ½.
Fig. 5. Two years old, No. 29936, ♂, northern Grant Land. Crown view. ½.
Fig. 5*a*. Do., lateral view. ½.
Fig. 6. Two and one half years old, No. 28017, ♀, northern Grant Land. Crown view. ½.
Fig. 6*a*. Do., lateral view. ½.
Fig. 7. Three years old, No. 29938, ♀, northern Grant Land. Crown view. ½.
Fig. 7*a*. Do., lateral view. ½.
Fig. 8. Four years old, No. 15588, ♀, Bache Peninsula, Ellesmere Land. Crown view. ½.
Fig. 8*a*. Do., lateral view. ½.
Fig. 9. Five years old, No. 28005, ♂, northern Grant Land. Crown view. ½.
Fig. 9*a*. Do., lateral view. ½.
Fig. 10. Six years old, No. 28072, ♀, northern Grant Land. Crown view. ½.
Fig. 10*a*. Do., lateral view. ½.
Fig. 11. Twelve (or more) years old, No. 28027, ♀, northern Grant Land.
Fig. 11*a*. Do., lateral view. ½.

Plate XVII.

Fig. 1. Skull of *Symbos cavifrons* (Leidy), No. 14365, ♂, Depart. Vert. Palæont., lateral view. ⅓.
Fig. 2. Occipital view of same skull. ⅓.

Plate XVIII.

Fig. 1. Skull of *Symbos cavifrons* (Leidy), No. 14365, ♂, Depart. Vert. Palæont., palatal view. ¼.
Fig. 2. Dorsal view of same skull. ⅓.

TEXT FIGURES.

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PLATE XI.

Fig. 1. No. 28072, ♂, 5 years old, northern Grant Land. Oblique dorso-lateral view of skull, to show dorsal surface of right horncore (sheath removed). $\frac{5}{8}$.

Fig. 2. Lower (ventral) surface of apical third of the same horncore. $\frac{1}{1}$.

1

2

OVIBOS MOSCHATUS WARDI.

PLATE XII.

Fig. 1. Vertical transverse section of horn at point of lateral junction with the skull (No. 28092, old male, northern Grant Land), proximal surface. $\frac{1}{1}$.

Fig. 2. Transverse section of same horn, 105 mm. on upper side and 12 mm. on lower side beyond the section shown in Fig. 1. $\frac{1}{1}$.

Fig. 3. Transverse section of same horn, 105 mm. on upper side and 70 mm. on lower side beyond the section shown in Fig. 2, and nearly at the tip of the core. $\frac{1}{1}$.

Fig. 4. Transverse section of another horn (old male, No. 28091, northern Grant Land), 85 mm. from the base, showing not only the sheath and horncore but the upper wall of the skull with its vacuities. (The dark vertical line near the left border of the figure is due to a false section made inadvertently by the preparator, the two parts being afterwards joined together with glue.)

Fig. 5. Base of the right horn of a four year old male (No. 28093, Grant Land), showing the growing surface of both the sheath and the exostosis, and a portion of the fronto-parietal surface of the skull. $\frac{4}{5}$.

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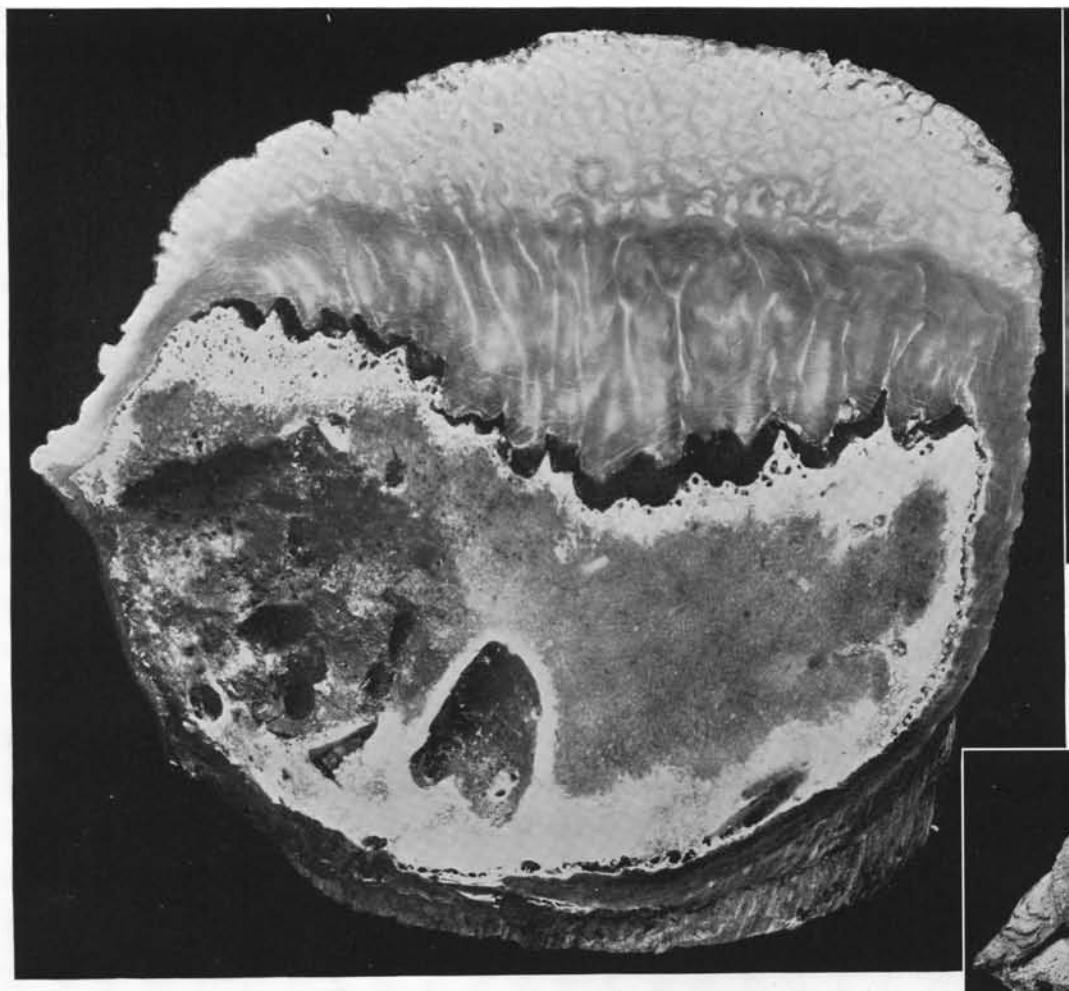

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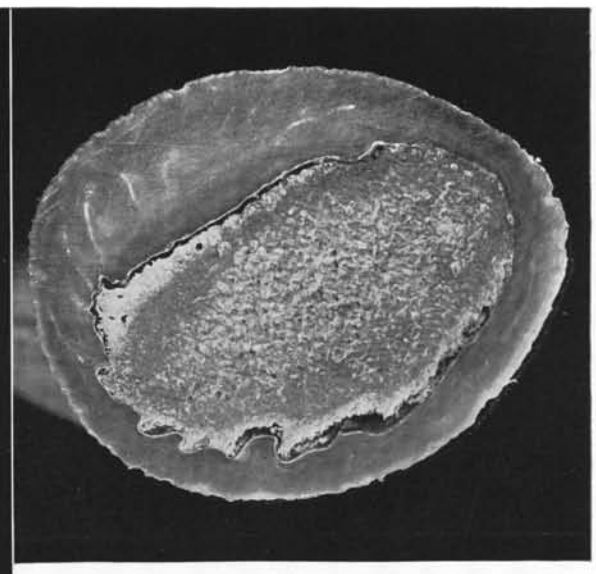

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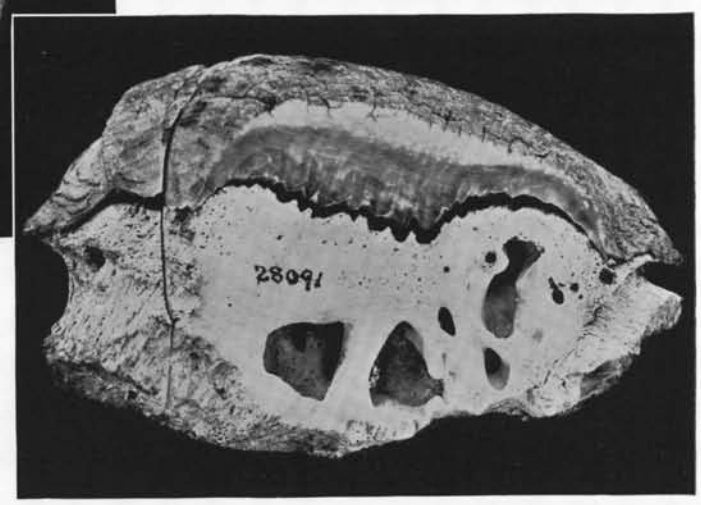

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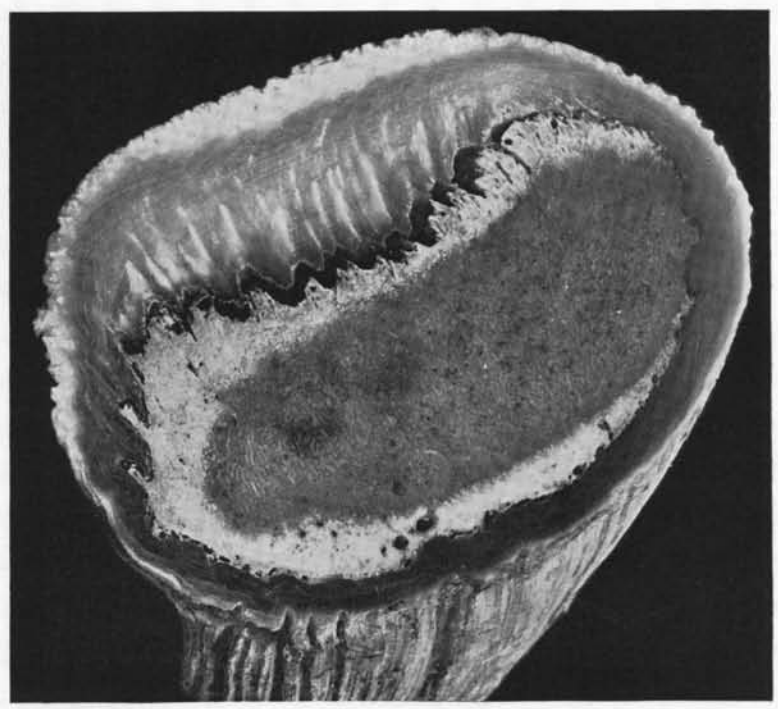
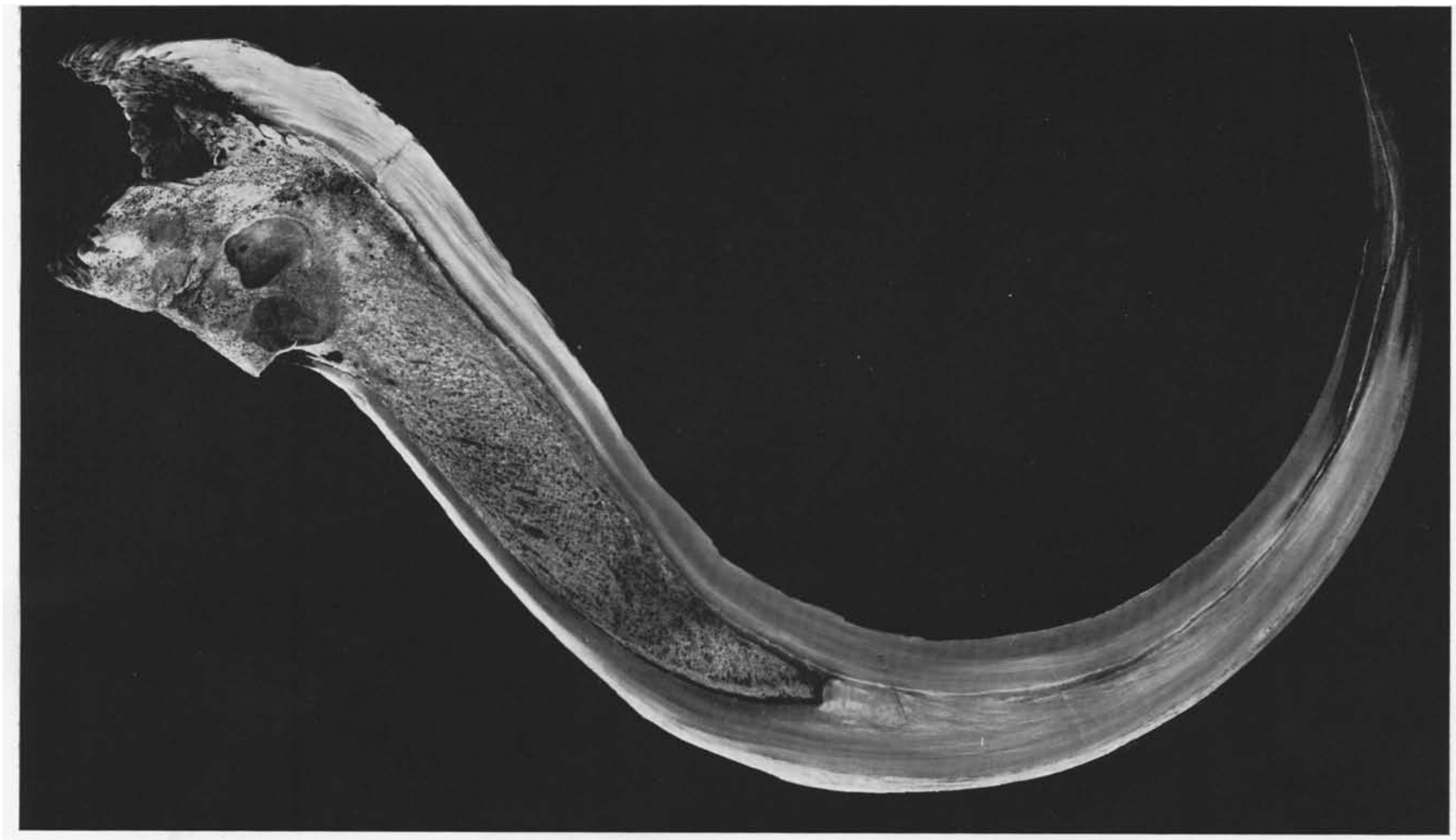


OVIBOS MOSCHATUS WARDI.

PLATE XIII.

Fig. 1. Longitudinal section of the left horn of a four years old male (No. 28093, northern Grant Land). $\frac{1}{2}$.

Fig. 2. Longitudinal section of the left horn of a very old male (No. 28091, Grand Land). $\frac{1}{2}$.



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OVIBOS MOSCHATUS WARDI.

PLATE XIV.

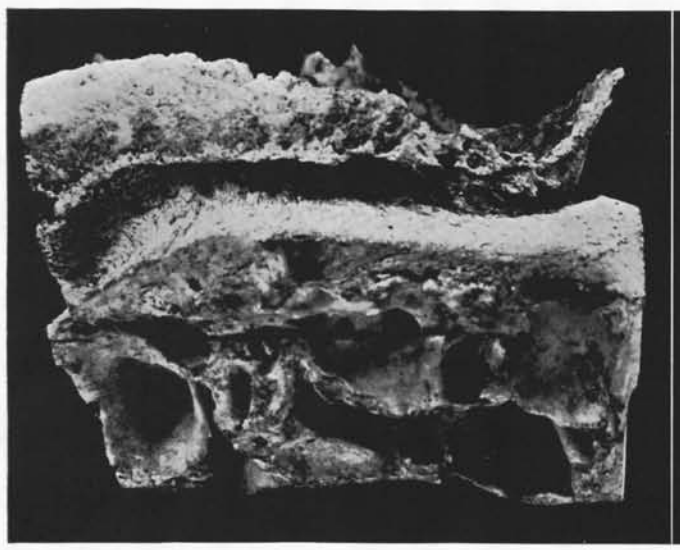
Fig. 1. Longitudinal section of the right horn of an old male (No. 28092, Grant Land). $\frac{1}{2}$.

Fig. 2. Base of the horn of an old male (No. 28091, Grant Land) with the sheath removed, showing the dorsal surface of the exostosis. The white basal layer (*a*) is the skull wall; the middle lighter section (*b*) is the lamella at the inner base of the exostosis; the darker upper half (*c*) is the surface of the exostosis, the sheath having been removed. $\frac{2}{3}$. (See Plate XII, Fig. 4, for another transverse section of this same horn.)

Fig. 3. View of the same section from the anterior end (the end toward the right in Fig. 2), showing in profile (at *a*) the vertical lamella at the posterior end of base of the exostosis. (In some specimens this is higher and thinner than in the specimen here figured.) $\frac{1}{1}$.

Fig. 4 View of the inner surface of the base of the sheath which covered the exostosis shown in Fig. 2. $\frac{2}{3}$.

4



a

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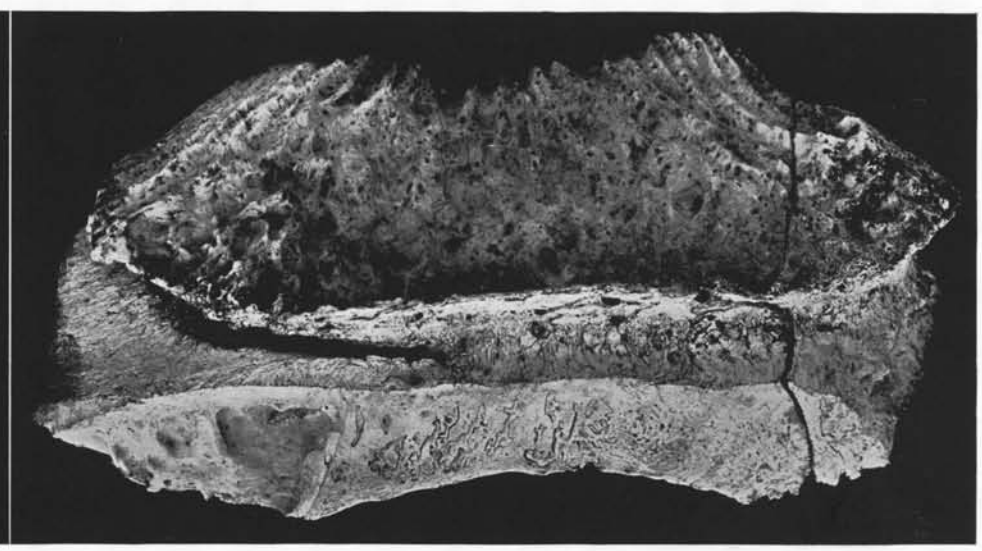

c

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b

a

1

OVIBOS MOSCHATUS WARDI.

PLATE XV.

Left maxillary toothrow, crown and lateral views, illustrating ontogenesis in dentition. Figs. 2–10, males, Fig. 11, female.

Fig. 1. Fœtal (8th month). No. 16727, Canadian Barren Grounds. (See text fig. 1, *c*.)
Fig. 2. One week old. No. 29939, ♂, northern Grant Land. (See text fig. 2, *c*.)
Fig. 3. One year old. No. 28108, ♂, northern Grant Land. (See text fig. 4, *c*.)
Fig. 4. One and a half years old. No. 27995, ♂, northern Grant Land. (See text fig. 6*e*.)
Fig. 5. Three years old. No. 28011, ♂, northern Grant Land. (See text fig. 10, *d*.)
Fig. 6. Four years old. No. 19561, ♂, northern Grant Land. (See text fig. 12, *d*.)
Fig. 7. Five years old. No. 29948, ♂, northern Grant Land. (See text fig. 14, *d*.)
Fig. 8. Six years old. No. 28072, ♂, northern Grant Land. (See text fig. 15, *e*.)
Fig. 9. Seven years old. No. 19490, ♂, northern Grant Land. (See text fig. 16, *d*.)
Fig. 10. Ten years old. No. 28069, ♂, northern Grant Land.
Fig. 11. Twelve (or more) years old. No. 29964, ♀, northern Grant Land. (See text fig. 17, *d*.)

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10

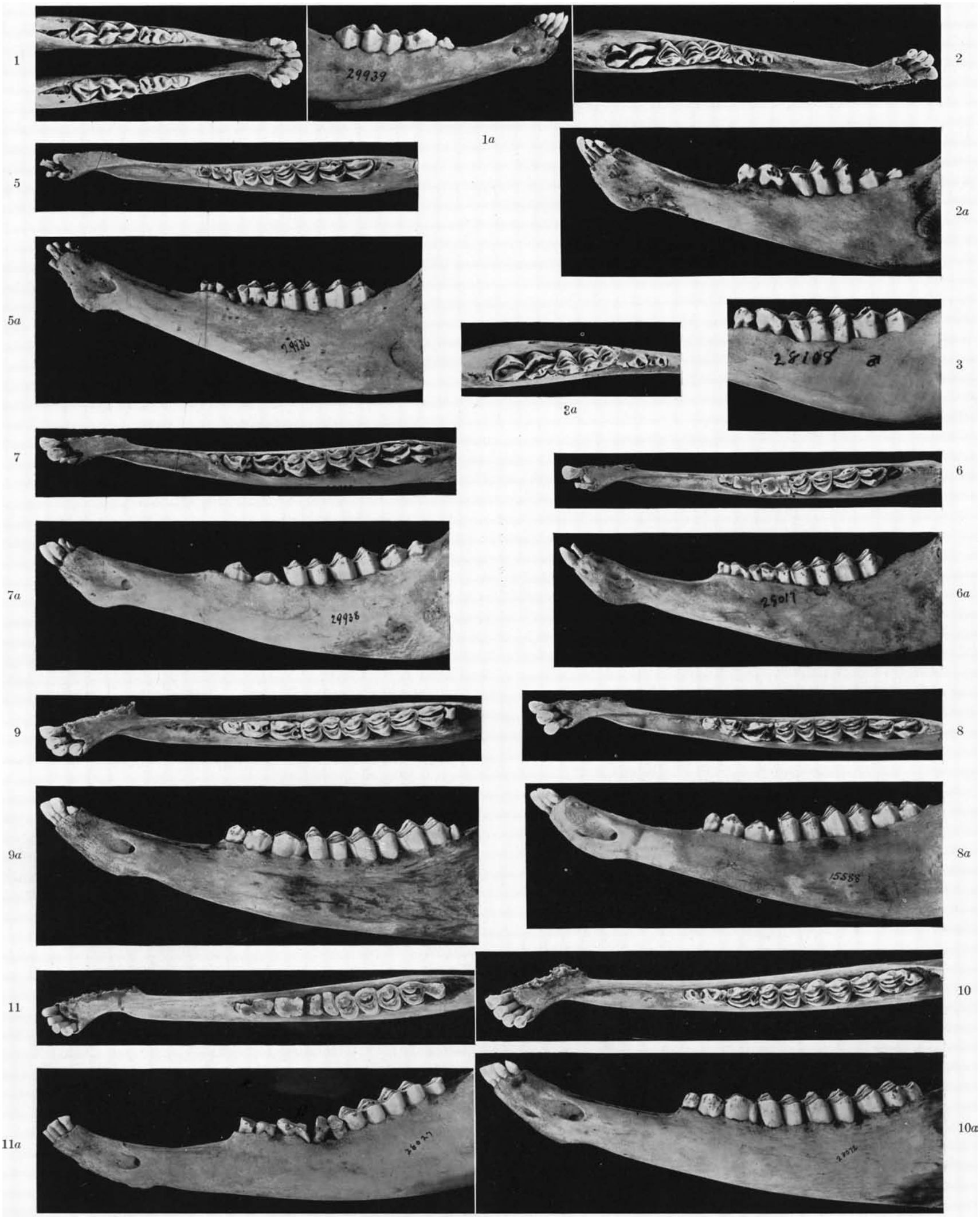
11

OVIBOS MOSCHATUS WARDI (except Fig. 1).

PLATE XVI.

Left mandibular toothrow and incisors, crown and lateral views, illustrating ontogenesis in dentition.

Fig. 1. One week old, No. 29939, ♂, northern Grant Land. Crown view, both mandibles. ½.
Fig. 1*a*. Do., lateral view (outside), right mandible. ½.
Fig. 2. Six months old, No. 29914, ♀, northern Grant Land. Crown view, left mandible. ½.
Fig. 2*a*. Do., lateral view. ½.
Fig. 3. One year old, No. 28108, ♂, northern Grant Land. Crown view. ½.
Fig. 3*a*. Do., lateral view. ½.
Fig. 5. Two years old, No. 29936, ♂, northern Grant Land. Crown view. ½.
Fig. 5*a*. Do., lateral view. ½.
Fig. 6. Two and one half years old, No. 28017, ♀, northern Grant Land. Crown view. ½.
Fig. 6*a*. Do., lateral view. ½.
Fig. 7. Three years old, No. 29938, ♀, northern Grant Land. Crown view. ½.
Fig. 7*a*. Do., lateral view. ½.
Fig. 8. Four years old, No. 15588, ♀, Bache Peninsula, Ellesmere Land. Crown view. ½.
Fig. 8*a*. Do., lateral view. ½.
Fig. 9. Five years old, No. 28005, ♂, northern Grant Land. Crown view. ½.
Fig. 9*a*. Do., lateral view. ½.
Fig. 10. Six years old, No. 28072, ♀, northern Grant Land. Crown view. ½.
Fig. 10*a*. Do., lateral view. ½.
Fig. 11. Twelve (or more) years old, No. 28027, ♀, northern Grant Land.
Fig. 11*a*. Do., lateral view. ½.

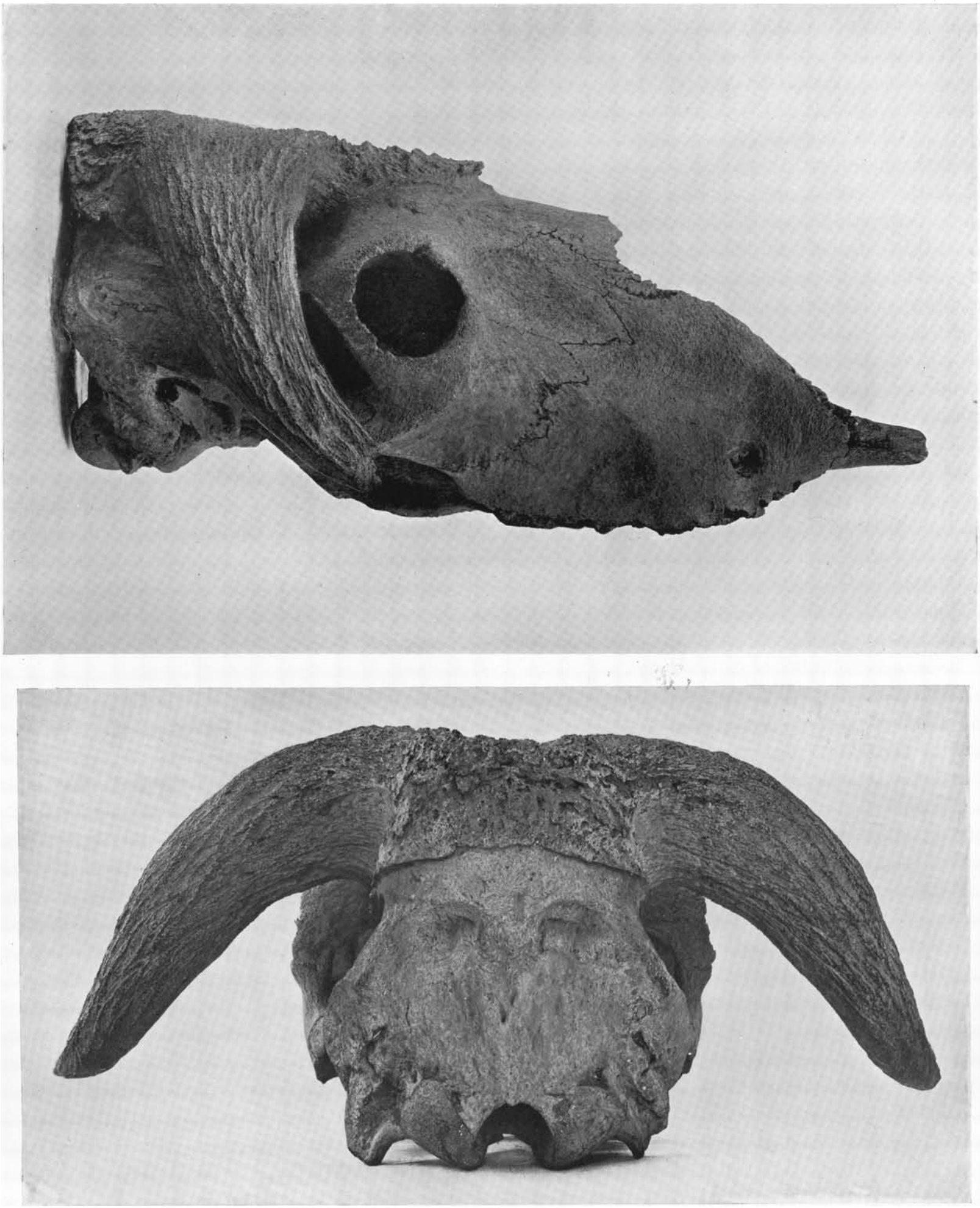


Ovibos moschatus wardi (except Fig. 1).

PLATE XVII.

Fig. 1. Skull of *Symbos cavifrons* (Leidy), No. 14365, ♂, Depart. Vert. Palæont., lateral view. Hebron, Indiana. $\frac{1}{3}$.

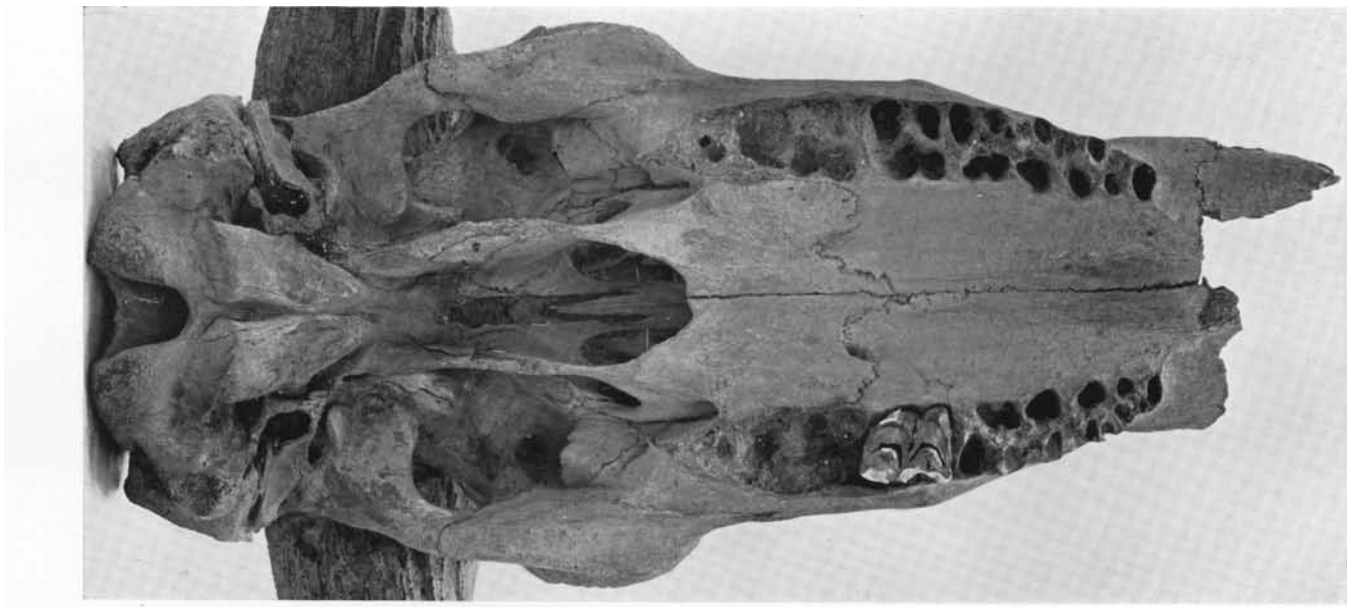
Fig. 2. Occipital view of same skull. $\frac{1}{3}$.



SYMBOS CAVIFRONS. $\frac{1}{3}$.

PLATE XVIII.

Fig. 1. Skull of *Symbos cavifrons* (Leidy), No. 14365, ♂, Depart. Vert. Palæont., palatal view. Hebron, Indiana. $\frac{1}{4}$.
Fig. 2. Dorsal view of same skull. $\frac{1}{3}$.



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