THE FOSSIL BISON OF NORTH AMERICA.

By FREDERIC A. LUCAS,
Curator, Division of Comparative Anatomy.

The aim of this paper is to assign definite characters to the various species of bison occurring in a fossil condition in North America and to disentangle the complicated synonymy in which they have been involved. With the exception of *Bison crassicornis* and *Bos arizonica* the types of the various alleged species have all been examined, and to aid in defining the species and to unravel the synonymic snarl either the types or characteristic examples of all species are herein figured.

I wish to express my thanks to Profs. J. C. Branner and C. W. Greene, Dr. Josua Lindahl, Mr. S. N. Rhoads, and Prof. S. W. Williston for photographs and information concerning various specimens, and to Prof. O. C. Marsh, the Academy of Natural Sciences, Philadelphia, and to the University of Pennsylvania for the loan of specimens.

While remains of fossil bison are not uncommon in North America, they occur as a rule in such a scattered and fragmentary condition and the various parts so disassociated that at present it is impossible to correlate the teeth with the other portions of the skeleton and to diagnose the species in a thoroughly satisfactory manner. The best that can be done is to use such material as we have and endeavor to distinguish the species by their horn cores, and after going over the subject carefully I am convinced that in spite of an admitted amount of individual variation the horn cores afford very good specific characters. They do not differ among themselves any more than do other portions of the skeleton, and in the present case they are infinitely preferable to scattered teeth. Moreover the differences between the skulls of such species as *B. bison* and *B. occidentalis* indicate that the various species could be well differentiated did we possess sufficient material.

Little or no attempt has been made in this paper to name or describe individual teeth, since, so far as known, these so closely resemble the corresponding teeth of the existing bison that really the best that can be done is to make a guess at the species from the locality in which they were found.

So far as can be judged by the appearance of the specimens or the

conditions under which they have been found all species might have been coeval, although this is naturally highly improbable. *Bison bison* has been found in a mineralized condition beneath 25 feet of gravel, *B. crassicornis* has been found in a fairly fresh state on the tundra of Alaska, while *B. latifrons* has been found semifossilized at Big Bone Lick, Kentucky, and well mineralized at Peace Creek, Florida.

In regard to geographical distribution, it may be said that *Bison crassicornis* has not been found outside of Alaska; *B. antiquus* is not definitely known to occur farther east than Big Bone Lick, Kentucky; and that no species save *B. latifrons* is certainly known from Florida and other Southern localities, while it has not been found on the Pacific coast, horn cores ascribed to this species being really those of *B. antiquus*. *B. occidentalis* is so far known from Kansas and Alaska.

The changes of nomenclature proposed in this article are as follows:

Bison occidentalis is proposed for a species occurring in Alaska and Kansas.

Bison alaskensis Rhoads, is considered a synonym of *B. crassicornis* Richardson.

Bison californicus Rhoads, is considered a synonym of *B. antiquus* Leidy.

Bos scaphoceras Cope, is considered to be an *Ovis*.

Bos crampianus Cope, is considered a synonym of *B. alleni* Marsh.

Bos arizonica Blake, is considered as a synonym of *B. latifrons* (Harlan).

Bison appalachicolus Rhoads, needs no consideration, being confessedly based on a horn core of *Ovibos*,[1] nor does *Bison alticornis* Marsh, it having been founded on the horn cores of a dinosaur, *Triceratops*.[2]

As for *Bos scaphoceras* Cope,[3] the conviction has been forced upon me after careful consideration that this is not a *Bison*, but an *Ovis*, a conclusion concurred in by Dr. F. W. True. Dr. J. A. Allen, and Mr. G. S. Miller, jr. The type of this from northern Nicaragua and now in the Museum of the University of Pennsylvania may be described as follows:

Horn cores short and robust, circumference at base greatly exceeding length on concave face; subtriangular in section, flattened on concave face, transverse diameter greater than vertical; strongly recurved with tips directed slightly backwards.

The texture, structure, curvature, and subtriangular shape are like one of the big-horned sheep, such as *Ovis ammon*, the horn core being more triangular in section than that of our *Ovis montana*. The species will stand, but the genus must be changed. This extension of the range of the genus *Ovis* southwards is in accordance with the range of existing species.

[1] Proc Acad. Nat. Sci., Phila., 1897, p. 492.

[2] Am. Journ. Sci., XXXVIII, 1889, p. 174.

[3] *Bos* species Leidy, Proc. Acad. Nat. Sci.. Phila., 1886, p. 275. *Bos scaphoceras* Cope, Journ. Acad. Nat Sci., Phila., IX, 1894, p. 457, pl. XXII, figs. 5–9.

The horn core, considered to be that of the female, differs considerably from that of the male, being straighter and not flattened above It is keeled on convex face, the edge near the tip being quite sharp, and there is a bare possibility that it may belong to a young female of some species of *Bison*, although this is doubtful.

Measurements of horn cores given in this paper do not include the frontal pedicel, but are taken from the raised edge of the portion covered by horn. Transverse diameter means greatest diameter in a line parallel with the longitudinal axis of the skull; vertical diameter is the greatest diameter at right angles to this.

The dorsal views of the crania are taken perpendicularly to the plane of the forehead, the posterior views at right angles to the back of the skull. It is highly important that all views of crania for comparative purposes should be taken in the same manner, since a slight change in the angle of sight, looking down upon the skull, makes a considerable apparent change in the direction of the horn cores.

Seven species of *Bison* are herein recognized: *Bison alleni*, *antiquus*, *bison*, *crassicornis*, *ferox*, *latifrons*, and *occidentalis*. Descriptions of these are given below together with the location of the type, the principal synonymy and measurements of the more important specimens.

BISON BISON (Linnæus).

Bos bison LINNÆUS, Syst. Nat., 1758, I, p. 72.
Bos bison var. *β*, LINNÆUS, Syst. Nat., 1766, I, p. 99.
Bos americanus GMELIN, Syst. Nat., 1788, I, p. 204.
Bison americanus SMITH, Griffith's Cuv., V, 1827, p. 374.

Horn cores short, circumference at base usually much greater than length along upper curve; subcircular in section, vertical diameter slightly exceeding transverse, generally abruptly recurved; directed backwards at the tip.

Remains of this species occur abundantly in a semifossil condition at Big Bone Lick, Kentucky, and completely mineralized specimens have been obtained in Kansas. The upper portion of the skull, with perfect horn cores, No. 1718, U.S.N.M., was obtained by Dr. A. G. Chase, at Millwood, Kansas, 25 feet below the surface. Another good specimen, the fairly complete skull of a large bull, No. 4158, U.S.N.M., was collected by Dr. T. T. Minor, in the loess of Missouri, at a locality in the Winnebago Reservation. It is remarkable for the spread of the horns (655 mm.) and for the size of the teeth, which equal any yet discovered.

Measurements of horn cores of Bison bison.

	Vertical diameter.	Transverse diameter.	Circumference at base.	Length along upper curve.	Length along lower curve.	Distance between tips.
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
No. 4158, U.S.N.M., from loess of Missouri	81	77	247	220	270	655
No. 2050, Museum Comparative Zoology	.....	.....	300	260	.....	650
No. 12456, U.S.N.M	88	84	280	226	280	615

BISON OCCIDENTALIS Lucas.

(Plates LXV, LXVI.)

Bison antiquus STEWART, Kan. Univ. Quar., VI, July, 1897, p. 127, pl. XVII.
Bison occidentalis LUCAS, Science, November 11, 1898, p. 678.
Bison occidentalis LUCAS, Kansas Univ. Quar., VIII, January, 1899, pp. 17, 18.

Type.—No. 4157, U.S.N.M., from Fort Yukon, Alaska; collected by Sir John Richardson. Quaternary of Kansas and Alaska.

Horn cores moderate; circumference at base equal to or slightly greater than length along upper curve; subcircular in section, regularly curved upward and backward.

This species is readily distinguished from *B. antiquus* by its more slender and proportionally longer horn cores and the fact that they are directed upward and backward, as is well shown in the plates and the diagram.

An excellent figure of this species is given by Dr. J. A. Allen in his Monograph of North American Bison, on Plate IV, where it is called *B. antiquus*.

A practically complete skeleton of *Bison occidentalis* was discovered in the valley of the Smoky Hill River, in Gove County, Kansas, in the same deposit as remains of *Elephas* and *Platygonus* and in connection with small flint arrowheads. A detailed description of this specimen, which is preserved in the Museum of the State University in Lawrence, Kansas, has recently been published by Mr. Alban Stewart,[1] but, like other writers, he unfortunately confuses the species with *B. crassicornis* and *B. latifrons*, which are very distinct and from which it may readily be distinguished by the form and curvature of the horn cores. (See diagram on p. 762.) As shown by the Kansas specimen, the skull is larger than in *B. bison* and anteriorly more tapering, while the nasals and premaxillaries are much longer. The orbits look more directly forward than in *B. bison*, and the distance between orbits and horn cores is greater, the result being that the jugals are long and slender.

Specimens have been obtained from St. Michael, Fort Yukon, and the Tatlo River, Alaska, and Gove County, Kansas.

It is the species most nearly resembling the existing bison, with which it was probably for a time contemporaneous.

Measurements of horn cores of Bison occidentalis.

	Vertical diameter.	Transverse diameter.	Circumference at base.	Length along upper curve.	Length along lower curve.	Distance between tips.
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
Type No. 4157, U.S.N.M.	96	98	298	298	365	710
University of Kansas	108	108	343	318	372	875
Specimen from St. Michael, figured by Dr. J. A. Allen	.....	.....	300	260	.....	680

[1] Kansas University Quarterly, July, 1897, Ser. A, pp. 127–135.

BISON ANTIQUUS Leidy.

(Plates LXVII–LXX.)

Bison antiquus LEIDY, Proc. Acad. Nat. Sci., Phila., 1852, p. 117; Mem. Ext. Spec. Amer. Ox., 1852, p. 11, pl. II, fig. 1 (Smithsonian Contributions, III).

Bison latifrons LEIDY, Extinct Mam. of N. A., 1869, p. 371 (in part); Extinct Vert. Fauna, 1873, p. 253, pl. XXVIII, figs. 1–7 (Report U. S. Geol. Surv., I).

Bison antiquus ALLEN, Am. Bisons, Living and Extinct, 1876, p. 21 (in part).

Bison californicus RHOADS, Proc. Acad. Nat. Sci., Phila., 1897, p. 501.

Bos priscus LYDEKKER, Wild Oxen, Sheep and Goats of All Lands, London, 1898, p. 61.

Type.—In the Academy of Natural Sciences, Philadelphia; from Big Bone Lick, Kentucky. Horn cores comparatively short, stout, and abruptly tapering; circumference at base much exceeding length along upper curve; subcircular or slightly triangular in section, transverse diameter very little greater than vertical; slightly recurved at tips, which barely rise above the plane of the forehead.[1] Axis of horn cores nearly at right angles to longitudinal axis of skull. This last character distinguishes *Bison antiquus* from all other American species.

A large specimen from Ilford, Sussex (Plate LXXII), labeled *B. bonasus*, has the horn cores at right angles to the axis of the skull, but they are much larger and very much more up-curved than in *B. antiquus*.

The horn cores of *B. antiquus* have a rather sharp ridge along the inferior face toward the tip, and they are deeply grooved on the posterior face.

The horn cores of *Bison antiquus* are so different in size, proportions, and curvatures from those of *B. crassicornis* and *B. latifrons* that it is difficult to see why the species should have been confused. Putting aside all differences in appearance due to mere size, the horns of *B. antiquus*, it may be well to repeat, differ from all other American species in standing at right angles to the skull. Imperfect specimens of *B. antiquus* may be distinguished from similar specimens of *B. latifrons*, even should they be of approximately the same size, by the very different shape of the transverse section of the horn cores, this being broadly elliptical in *latifrons* and roundly subtriangular in *antiquus*.

Mr. Rhoads, who has named the Californian bison *B. californicus*, correctly says[2] that I concurred in his opinion that the California bison was distinct from *B. antiquus*, but at the time I had not seen the type of *B. antiquus* and labored under the impression that it was similar to the specimens from Alaska and Kansas which are herein described as *B. occidentalis*. From these the California specimen certainly is distinct, although it is the one specimen that has been correctly referred to *B. antiquus*. I regret that I should have thus inadvertently added

[1] The difference between *B. antiquus* and *B. occidentalis* in this respect is well shown in the plate (XVII) accompanying Mr. Stewart's paper in the Kansas University Quarterly for July, 1897, the upper figure being *antiquus*, the lower *occidentalis*, although described as *antiquus*.

[2] Proc. Acad. Nat. Sci., Phila., 1897, p. 501.

to the confusion existing in the nomenclature of our fossil bison, and I also regret that I find myself compelled to differ from Mr. Rhoads, to whom I am under many obligations. The fact remains, however, that the type of *B. antiquus*, imperfect as it is, agrees in every particular with the horn cores of the California specimen, and there can be no question as to their specific identity.

Remains of *Bison antiquus* have been found at the following localities: Big Bone Lick, Kentucky; Alameda County, California, in post-pliocene gravel, associated with bones of *Elephas*, *Mastodon*, *Equus*, and *Procamelus;* Pilarcitos Valley, California, in blue clay, 21 feet below the surface.

The teeth found at Darien, Georgia, are not definitely ascribable to *B. antiquus*, and are considerably smaller than the specimens noted from California. It is probable that they appertain to *B. latifrons*.

An imperfect ramus, probably of this species, from Alameda County, California, is characterized by its size, being very much larger in every way than any example of *B. bison*, although perhaps best shown by the length of the tooth series, which is 0.197 mm. in *B. antiquus* and but 0.164 mm. in *B. bison*.

The type of *antiquus* is unfortunately very imperfect and much water-worn, the upper and lower surfaces having lost much the most. The restoration of this is largely guesswork, but as well as may be estimated the vertical diameter is 120 mm., the transverse 128 mm., the circumference 390 mm., the length along upper curve 340 mm.

Measurements of horn cores of Bison antiquus.

	Vertical diameter.	Transverse diameter.	Circumference at base.	Length along upper curve.	Length along lower curve.	Distance between tips.
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
Type Acad. Nat. Sci., Phila.	102	122	364	213	252	.....
The same approximately restored	120	128	390	270	340	.....
California specimen *B. californicus* Rhoads	120	125	360	285	370	912

BISON CRASSICORNIS Richardson.

(Plates LXXIII–LXXVI.)

Bos urus Buckland, Beechey's Voy. to the Pacific, 1831, II, p. 539, pl. III, figs. 1-7.

Bison priscus ? Richardson, Zool. Voy. of *Herald*, 1852–54, pp. 33, 139, pls. VI, figs. 5, 6; VII; X, figs. 1–6; XIII, fig. 3.

Bison crassicornis Richardson, Zool. Voy. of *Herald*, 1852–54, pp. 40, 139, pls. IX, XI, fig. 6; XII, figs. 1–4; XIII, figs. 1, 2; XV, figs. 1–4.

Bison crassicornis Leidy, Proc. Acad. Nat. Sci., Phila., 1854, p. 210.

Bison priscus Leidy, Proc. Acad. Nat. Sci., Phila., 1854, p. 210; Ext. Mam. N. A., 1869, p. 371. (Journ. Acad. Nat. Sci., Phila., new ser., VII.)

Bison latifrons Leidy, Ext. Mam. N. A., 1869, p. 371 (Journ. Acad. Nat. Sci., Phila., new ser., VII), in part.

Bison antiquus Allen, The Am. Bisons, Living and Extinct, Cambridge, 1876 (Memoirs Geol. Surv., Kentucky, I, Pt. 2), in part, pp. 21–26.

Bison bonasus var. *priscus* LYDEKKER, Cat. Foss. Mam. Brit. Mus., Pt. II, Contng. the Order Ungulata, Suborder Artiodactyla, 1885, pp. 25, 26, London, in part.
Bison alaskensis RHOADS, Proc. Acad. Nat. Sci., Phila., 1897, p. 490.
Bos priscus LYDEKKER, Wild Oxen, Sheep, and Goats of All Lands, London, 1898, p. 61.

Type.—In the British Museum, from Eschscholtz Bay, Alaska. Horns long; length of horn core along upper curve very much greater than circumference at base; horn cores slightly flattened on superior face; transverse diameter much greater than vertical; curve of horn regular, the tip not abruptly reflected nor pointing decidedly backward; horn cores raking decidedly backward.

This species, which has fared so well in the matter of synonyms, is, so far as American species go, perfectly distinct, and its affinities with Europeo-Asiatic forms remain to be decided, though from the relations between the existing faunas of northeastern Asia and northwestern America it would be quite natural to find fossil bison in eastern Siberia that were indistinguishable from *B. crassicornis*.

Dr. J. A. Allen, in his Monograph of American Bisons, treats *B. crassicornis* as a synonym of *B. antiquus* Leidy, while still more recently Mr. Rhoads[1] has divided Richardson's specimens into two species, one of which, including the type, he considers as *B. antiquus*, while the other he calls *B. alaskensis*. The validity of Richardson's *Bison crassicornis* hinges on the question of the identity of his type I, A, with Leidy's *B. antiquus*. Both species are founded on more or less imperfect specimens, but after going over descriptions, figures, and specimens the conclusions reached are as follows: Richardson's I, A, Plate IX, fig. 1, is specifically identical with his No. 24589, Plate VII, fig. 1, and this in turn with the specimens in the U. S. National Museum and University of Pennsylvania, which do not in any way resemble *B. antiquus* and do resemble one another.

The disparity in size between the specimens under discussion amounts to nearly 30 per cent, but the form and proportions of the crania and horn cores are similar, while the specimen shown on Plate VII, fig. 1, is shown by the cast to be young, being what would be termed a spike horn. Owing to this youthfulness the horn cores do not have the proximal downward curve found in adults, but the slender nature of the horn cores and their backward inclination distinguish this from *B. antiquus* at a glance.

The type of *B. crassicornis* is Richardson's I, A, figured on Plate IX and described on pages 40–43 of the Voyage of the *Herald*,[2] and while the horn cores are broken off a short distance from the base, enough

[1] Proc. Acad. Nat. Sci., Phila., 1897, p. 490.

[2] A very good idea of the type may be obtained from Plate LXXV, taken from No. 13753 of the Museum of Archæology and Palæontology, University of Pennsylvania. This specimen Mr. Rhoads considers to be identical with *B. antiquus*, but from the backward rake of its horn cores this is out of the question.

remains to show that they had a very decided backward inclination, as noted by Richardson, who states that the horn cores—

Are more depressed at the base or flattened on the concave side than those referred above to *Bison priscus* ?,[1] and they are directed horizontally with a slight basilar inclination and more iniad, much in the way that the horns of the mushtush (*Bison bison*) would curve were that animal horned on a much larger scale. Their backward position is such that a spot on their posterior edge 2 inches from their base is even with the sides of the occipital arch when the skull is seen in profile. Though the cores are much wasted by decay, they are still considerably larger than those of an adult mushtush or aurochs bull.

This backward flare is very characteristic of *crassicornis*, as may be seen by reference to Plates LXXIII, LXXVI and the figures below, where the great differences between the horn cores of *B. antiquus*, *crassicornis*, and *occidentalis* are well shown.

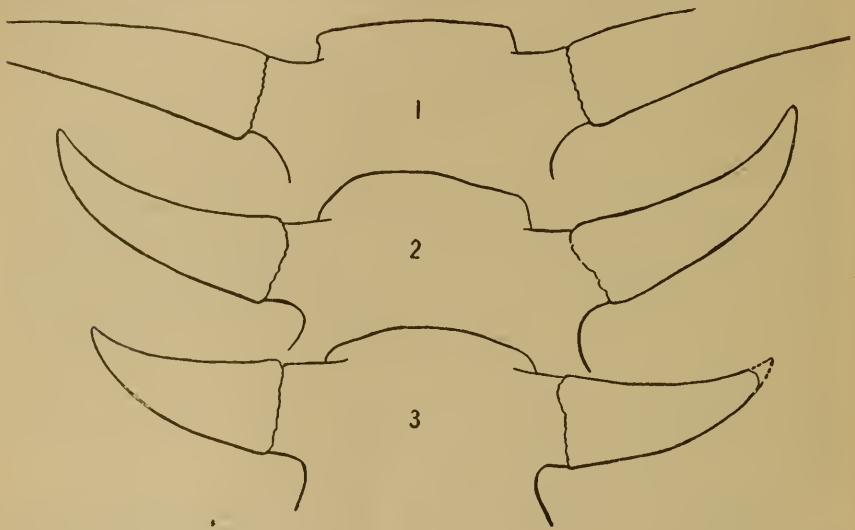


FIG. 1.—DIFFERENCES IN CURVATURE OF HORN CORES OF (1) BISON CRASSICORNIS, (2) B. OCCIDENTALIS, (3) B. ANTIQUUS.

No. 1 of these figures is from the small, complete specimen shown by Richardson,[2] No. 2 is *Bison occidentalis* in the University of Kansas, and No. 3 is *Bison antiquus* from the specimen in the Academy of Natural Sciences, Philadelphia, named by Rhoads *B. californicus*. The identity of this species is discussed under *Bison antiquus*.

The type of *Bison antiquus* is an imperfect, waterworn, right-horn core, which, however, shows the horn cores to be but moderately long, with the transverse diameter but little greater than the vertical, although this character is much exaggerated owing to the wearing away of the upper surface as shown in the plate. The horn cores of *B. antiquus*, as noted in the diagnosis of that species, stand out almost at

[1] This is the "spikehorn" figured on Plate LXXVI of this paper.

[2] Zoology of the Voyage of the *Herald*, pl. VII, fig. 1.

right angles to the longitudinal axis of the skull, so that a line drawn across the back of the cranium misses them completely, their tips being 3 inches within (anterior to) the line.

In this respect all specimens of *B. antiquus* differ very decidedly from any that have been referred to *B. crassicornis*, even such imperfect specimens as Richardson's type or the similar specimen figured herein on

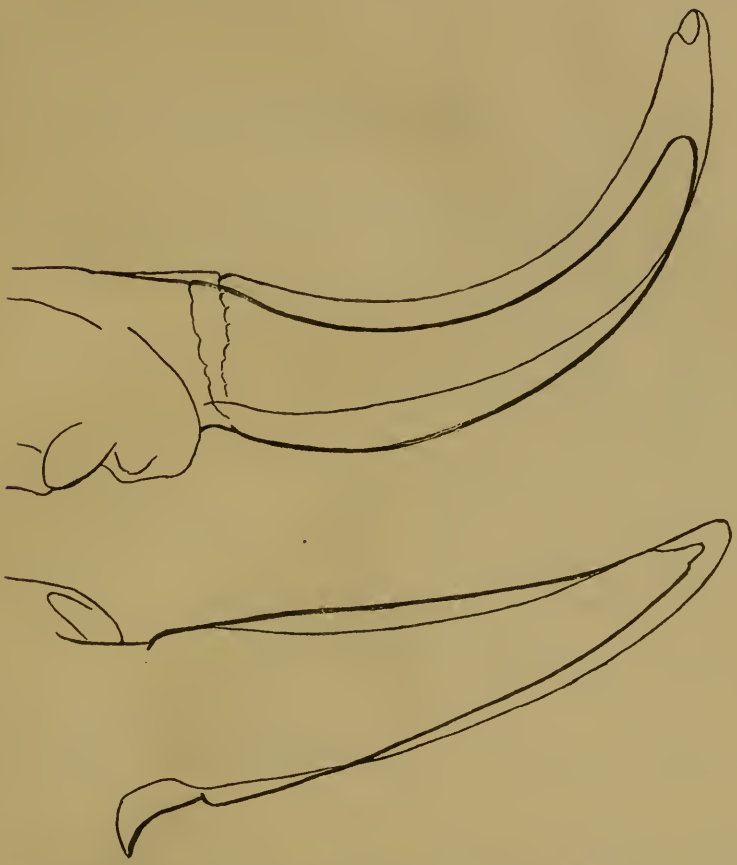


FIG. 2.—DIFFERENCES IN CURVATURE BETWEEN THE HORN CORES OF BISON CRASSICORNIS AND BISON ALLENI.

The light line distinguishes *Bison alleni*, the heavy line *Bison crassicornis*

Plate LXXV. This being the case, none of the Alaskan specimens can by any possibility be referred to *Bison antiquus*, and, as previously stated, the type stands.

Bison crassicornis may be distinguished from *B. alleni*, the species which it most nearly resembles, by the lesser curvature of the horn cores, which are also stouter, more flattened on the superior face, and more elliptical in section than are those of *B. alleni*. These differences are evident enough in the specimens, but not in small figures.

Dr. Lydekker[1] considers *B. crassicornis* as identical with *B. priscus*, "since the fossil crania agree precisely with European specimens, and those from Kotzebue Sound were obtained in company with remains of *Elephas primigenius* and *Oribos moschatus*." *Bison priscus* and *B. bonasus* are united[2] on the ground that while in the typical forms of *priscus* "the horns are larger and less curved than in the living aurochs, the specimens in the British Museum seem to indicate a complete transition in this respect, and some of them can not be distinguished from the living race."

That there is a great variety in the horns of fossil European bison is true, but it seems not at all improbable that two or more species have been confounded, that *Bison priscus* is a valid species, and that others remain to be described.

The cast of a bison cranium received from the Brussels Museum and labeled *Bison europæus* bears some resemblance to *B. crassicornis*, but differs in the curvature of its horns, the tips being more reflexed.

In another bison cranium from Ilford, Sussex, the horn cores stand nearly at right angles to the long axis of the skull and curve very regularly upward. (See Plate LXXI.) There can be little doubt but what these represent two distinct species.

Some bison bones were obtained by Capt. C. L. Hooper at Elephant Point, Kotzebue Sound, at the mouth of the Buckland River. They were associated with remains of the mammoth, *Elephas primigenius*, and a horse, probably *Equus fraternus*. These bones are of two sizes and may either indicate two sexes or two species, probably the latter. The smaller bones are the size of a large male *Bison bison*. The large bones are larger than the measurements given by Mr. Stewart[3] of bones of *B. antiquus* (= *B. occidentalis*), although, from the imperfect condition of the ends, the exact measurements can not be given.

A metacarpal from Alaska in the U.S. National Museum has been ascribed to, and very likely belongs to, *B. crassicornis*, although it is of course possible that it pertains to *B. occidentalis*, since the two overlap in Alaska.

It is a trifle larger and more robust than any example of *B. bison* examined, either by Dr. Allen or myself, although we have each had opportunities for examining large series. Otherwise there is no difference between the metacarpals of the two species.

---

[1] Catalogue of the Fossil Mammalia in the British Museum, II, p. 24.

[2] Idem., p. 24.

[3] Kansas University Quarterly, VI, July, 1897, pp. 134, 135

Appended are the measurements of these compared with good examples of *B. bison* and *B. bonasus:*

Measurements of metacarpals.

Species.	Locality.	Length.	Proximal breadth.	Distal breadth.	Least diameter.	Circumference.
		mm.	*mm.*	*mm.*	*mm.*	*mm.*
Bison latifrons?	Florida	254	91	92	55	150
Bison crassicornis?	Alaska	220	81	83	55	148
Bison occidentalis	Kansas	221	85	88	.....	.....
Bison bonasus	.....	218	88	76	52	134
Bison bison	.....	207	83	84	52	145

The term Ice Cliffs of Eschscholtz Bay, often given as the locality for the fossil remains from Kotzebue Sound, is a little misleading, since the bones either occur in the stratum of more or less frozen soil above the ice or in the talus at the foot of the bluffs. Capt. C. L. Hooper, who obtained numerous specimens for the U. S. National Museum, blasted off considerable portions of the ice without finding any bones therein.[1]

Measurements of horn cores of Bison crassicornis.

	Vertical diameter.	Transverse diameter.	Circumference at base.	Length along upper curve.	Length along lower curve.	Distance between tips.
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
Type 1, A, of Richardson	92	106	318	.....	.....	.....
No. 91, of Richardson	106	132	383	.....	.....	.....
No. 24589, *B. priscus?*, of Richardson	[1]76	93	280	300	330	830
No. 105, *B. priscus*, of Richardson	64	69	215	268	313	.....
No. 1584, U.S.N.M	103	133	390	460	500	1,110
Acad. Nat. Sci., San Francisco	90	114	343	358	442	1,030

[1] Part of lower side of horn core lacking.

BISON ALLENI Marsh.

(Plates LXXVII–LXXX.)

Bison alleni Marsh, Am. Journ. Sci., XIV, 1877, p. 252.

Bos crampianus Cope, Journ. Acad. Nat. Sci., Phila., IX, p. 456, pl. xxii, figs. 1–4.

Type.—No. 911, Museum of Yale College. Pleistocene of Idaho and Kansas.[2]

Horn cores long, slender, much curved, slightly flattened above at base; transverse diameter considerably greater than vertical; length along upper curve much greater than circumference at base. *Bison alleni* is distinguished from *B. crassicornis* by the much greater curvature of the horn cores, these being also more flattened and more elliptical in section in *crassicornis*. Like *crassicornis* this species is distin-

[1] For a description of these cliffs and a discussion of their origin see Richardson, Voyage of the *Herald*, pp. 1–8; Dall, Bulletin U. S. Geol. Surv., 84; Correlation Papers, Neocene, pp. 260–268.

[2] This species was assigned to the Lower Pliocene by Professor Marsh, but the specimen found in the gravel by Professor Greene shows it to have been beyond doubt Pleistocene.

guished from most specimens of equal size ascribed to *B. bonasus*[1] by the more regular taper and curve of the horn cores and by the fact that they are directed much more backward.

So far as is known, however, this species is separated geographically from any Asiatic species by the interposition of *B. crassicornis* and *B. occidentalis*. The horn cores are much longer and less conical than in *B. occidentalis*, while they are shorter and more curved than in the great *Bison latifrons*.

This species was founded by Professor Marsh[2] on a horn core found in the Blue River near Manhattan, Kansas. A much more complete specimen, deposited in Stanford University, California, was obtained by Prof. C. W. Greene from the banks of the Snake River, Idaho, about 9 miles above American Falls, in the gravel overlying the lava beds, which are considered by Dr. Lindgren to be late Miocene or early Pleistocene.

Two molars found by Mr. W. H. Hackney in the auriferous gravel on the south bank of the Snake River, 10 miles from Glenns Ferry, Idaho, are very possibly from this species. They are the largest teeth of bison in the collection of the U. S. National Museum.

Professor Cope's *Bos crampianus* from the Pleistocene sands of southern Kansas is assigned to *B. alleni*, because on examination, I find that the horn core of *B. crampianus* is less triangular in section than one would be led to suppose from the figure, and because this triangular section seems to a certain extent to be the result of crushing to which the specimens had been subjected. In size and curvature the two agree.

Measurements of horn cores of Bison alleni.

	Vertical diameter.	Transverse diameter.	Circumference at base.	Length along upper curve.	Length along lower curve.	Distance between tips of horns.
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
Type, No. 911, Museum of Yale College.	115	140	415	628	760	.....
Specimen in Stanford University	145	160	480	635	710	1,338
Bos crampianus Cope.....	130	150	[1]322	.....	[2]623	.....

[1] Imperfect at base. [2] Actual length, estimated length of complete horn core 720.

BISON FEROX Marsh.

(Plate LXXXI.)

Bison ferox MARSH, Am. Journ. Sci., XIV, 1877, p. 252.

Type.—No. 910, Museum of Yale College. Pleistocene (?) of Nebraska.[3] Horn cores long, length along upper curve much greater than circum-

[1] These very likely should be known as *Bison priscus* or *B. europæus*.

[2] Am. Journ. Sci., XIV, 1877, p. 252.

[3] I have ventured to call the horizon Pleistocene instead of Pliocene, as given by Professor Marsh, since the specimen was not associated with other species that would aid in determining its age, while, on the other hand, no other species of *Bison* is known from so low a horizon.

ference at base, slightly flattened above; transverse diameter slightly exceeding vertical; curve of horn core regular, but slight.

This species is based on an imperfect horn core, which indicates a species more nearly like *B. latifrons* in the shape of the horn cores than any other species, although little can be said save that the fragment indicates a robust horn core with comparatively little curve. The specimen is but little furrowed; less so than any other specimen examined.

It differs from *B. crassicornis* in having rounder and more massive horn cores, besides, as was said in the introduction, *B. crassicornis* has not as yet been found outside of Alaska.

Measurements of horn core of Bison ferox.

	Vertical diameter.	Transverse diameter.	Circumference at base.	Length along upper curve.	Length along lower curve.
	mm.	*mm.*	*mm.*	*mm.*	*mm.*
Type No. 911, Museum of Yale College.....	118	123	[1]360	[1]560	[1]650

[1] Estimated, the specimen being imperfect.

BISON LATIFRONS (Harlan).

(Plate LXXXII.)

Aurochs CUVIER, Ann. du Mus., 1808, p. 382, pl. XXXIV, fig. 2.

Aurochs CUVIER, Oss. Foss., IV, 1812, p. 50, pl. III, fig. 2.

Bos latifrons HARLAN, Fauna Americana, 1825, p. 273.

Bison latifrons LEIDY, Proc. Acad. Nat. Sci., Phila., 1852, p. 117.

Bison latifrons LEIDY, Mem. Ext. Sp. Am. Ox., 1852, p. 8, pls. I. II (Smithsonian Contributions).

Bos arizonica BLAKE, Am. Geologist, August, 1898, p. 65.

Bos latifrons LYDEKKER, Wild Oxen, Sheep and Goats of all Lands, London, 1898, p. 92.

Type.—In the Academy of Natural Sciences, Philadelphia, from Big Bone Lick, Kentucky. Horn cores very long, the distance along the upper curve very greatly exceeding the circumference at the base, regularly and slightly curved, subcircular in section, the transverse but slightly exceeding the vertical diameter; tips not abruptly recurved nor directed backward.

This is the largest species of American bison, the horn cores attaining a spread of 6 feet from tip to tip and the height at the shoulder, as indicated by a metacarpal, being upward of 6 feet, or from 6 to 9 inches greater than in the largest examples of *B. bison*.

The horn cores are directed somewhat backward, as in *B. crassicornis*, but they do not have the very decided downward dip which characterizes adults of that species.

The U. S. National Museum possesses an imperfect skull of this species from the Withlacoochee River, Florida, and a metacarpal and three teeth from the Peace Creek phosphate deposits are also ascribable to *B. latifrons*. The metacarpal is distinguished by its size, and particu-

larly by its length, which is 0.340 mm., or about one-seventh longer than that of the metacarpal ascribed to *B. crassicornis*. Posteriorly it is more convex and rugose near the proximal extremity than the metacarpal of any other bison examined, but this may be an individual peculiarity.

Two of the teeth are third upper molars, one from the left and one from the right side, and one is a second upper premolar from the right side. The premolar and one molar are large and massive, corresponding in character with teeth previously assigned to *B. latifrons*, though not exceeding in these respects the largest teeth of *B. bison*. The other molar is smaller and probably came from a female.

Four teeth contained in fragments of the lower jaw, obtained by Mr. R. T. Hill on Onion Creek, Travis County, Texas, are provisionally referred to *B. latifrons*. The jaw when entire was longer than that of *B. bison* and much more massive, the portion containing the last molar being very thick and heavy. On the other hand, the jaw is lighter and the teeth smaller than in *B. antiquus* from California.

Any statements, however, regarding teeth of fossil bison must be made and accepted with caution, as so far teeth and horn cores have not been found associated except in the case of *B. bison*. The longitudinal diameters of the teeth slightly exceed those of the corresponding teeth of *B. bison*, but the transverse diameters are much greater, the general appearance of the teeth being stout and massive, a character brought out much better by a direct comparison of specimens than by a comparison of their respective measurements.

In regard to the jaw from Texas, Mr. R. T. Hill writes:

> It was found in the banks of a little lateral flowing northward into Onion Creek, about 2 miles west of Pilot Knob, Travis County, Texas. It comes from an extensive formation which I am calling the Onion Creek formation, having wide development over the State of Texas. As an ancient marly alluvium of the older drainage, and for other reasons than this bone, I consider it to be the equivalent of the Equus beds, or early Pleistocene.

Mr. W. P. Blake's *Bos arizonica*[1] is referable to this species, as may be seen by his description and measurements. That the horns curved downward and forward is an inference probably due to the condition of the specimen on which *Bos arizonica* is based. The measurements of the horn cores are given in the table, and it will be seen that they harmonize perfectly with the measurements of other specimens of the species. That it should be found in Arizona agrees perfectly with the little that is known of its geographical distribution. The specimen was found at Greaterville, in the Pima Mountains, and is now in the Museum of the University of Arizona.

Remains ascribed to *Bison latifrons* have been found as follows:

. Peace Creek, Florida. Teeth.

[1] Remains of a species of *Bos* in the Quaternary of Arizona, Am. Geologist, XXII, August, 1898, pp. 65–71.

Withlacoochee River, Florida. Part of cranium.
Brunswick, Darien County, Georgia. Teeth.
Natchez, Mississippi. Teeth.
Ashley River, South Carolina. Teeth.
Big Bone Lick, Kentucky. Cranium.
Brush Creek, Brown County, Ohio. Horn cores.
San Felipe, Texas. Cranium.

By far the finest example of this species is that preserved in the collection of the Cincinnati Society of Natural History and noted above as having been found at Brush Creek. I am indebted to Dr. Lindahl for the photographs from which Plate LXXXII was made.

B. latifrons G. Fischer[1] is based on a fairly complete cranium from la Daourie, Siberia, but it is impossible to gather much idea of the specimen, either from the description or plate, the more that the latter shows only the proximal portion of the horns. From the description one infers that they stand out at right angles to the skull, as Fischer says (p. 82):

Les cornes commencent par une ligne droite, qui, sensiblement alongée dans cette espece, se dirige un peu en arriere. La courbure n'est sensible qu'à la pointe.

The following measurements are given in French feet and inches:

	Feet.	Inches.
From occipital crest to base of nasals	1	$1^{9}/_{12}$
Width between roots of horns		$11\,^{6}/_{12}$
Width between outer part of orbits	1	$1^{0}/_{12}$

Of a specimen from Volgada, Fischer says, "Penvergure a, en y conservant le peu de courbure, 3′ 2″ de France."

From this description, as well as from the measurements given, this Siberian species would seem to resemble *Bison antiquus* more nearly than any other.

Measurements of horn cores of Bison latifrons.

	Vertical diameter.	Transverse diameter.	Circumference at base.	Length along upper curve.	Length along lower curve.	Distance between tips.
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
Type, Acad. Nat. Sci., Phila.[1]	150	175	532	.....	.....	.....
Cincinnati Soc. Nat. Hist.	140	166	520	784	840	1,775
Bos arizonica Blake	140	152	442	[2]650	.....	[2]1,500
No. 1171, U.S.N.M.[1]	121	130	415	.....	.....	.....
No. 20700, British Museum	.....	.....	432	.....	.....	.....

[1] Incomplete; basal portion of horn core alone present. [2] Estimated.

It may be said, in conclusion, that owing to various circumstances the writing of this paper has extended over two years, and that it was not published until six months after completion, so that it can not be claimed to have been prepared with undue haste. The question of individual

[1] Bulletin de la Société Impériale des Naturalistes de Moscou, Seconde Année, 1830, pp. 81–84, pl. II.

variation has been carefully considered in the light of extensive series of crania of *Bison bison*, and while the material on which the paper is based is confessedly scanty, yet the species herein enumerated are believed to be valid.

EXPLANATION OF PLATES.

NOTE.—The smaller divisons on the scale shown in some of the plates are centimeters, the larger are decimeters.

PLATE LXV.

Bison occidentalis Lucas.

Posterior view of the type, No. 4157, U.S.N.M., from Fort Yukon, Alaska.

PLATE LXVI.

Bison occidentalis Lucas.

Superior view of cranium from Gove County, Kansas, in the museum of the University of Kansas.

PLATE LXVII.

Bison antiquus Leidy.

Superior view of the type, a right-horn core, in the collection of the Academy of Natural Sciences, Philadelphia.

PLATE LXVIII.

Bison antiquus Leidy.

Posterior view of the type, a right-horn core, in the collection of the Academy of Natural Sciences, Philadelphia.

PLATE LXIX.

Bison antiquus Leidy.

Posterior view of a cranium from California, in the Academy of Natural Sciences, Philadelphia. Described by Rhoads as *Bison californicus*.

PLATE LXX.

Bison antiquus Leidy.

Superior view of the specimen shown on Plate LXIX.

PLATE LXXI.

Bison species.

Posterior view of a specimen of bison from Ilford, Sussex, England. Recorded in the catalogue of the British Museum as *Bison bonasus*, No. 45392.

PLATE LXXII.

Bison.

Superior view of specimen shown on Plate LXXI.

PLATE LXXIII.

Bison crassicornis Richardson.

Superior view of a specimen from Alaska; No. 1584, U.S.N.M.

PLATE LXXIV.

Bison crassicornis Richardson.

Posterior view of specimen shown on Plate LXXIII.

PLATE LXXV.

Bison crassicornis Richardson.

Superior view of a specimen from the tundra back of Point Barrow, Alaska; No. 13753, Museum of Archæology and Paleontology, University of Pennsylvania. This specimen is figured because it so nearly resembles the type of Richardson's *Bison crassicornis*.

PLATE LXXVI.

Bison crassicornis Richardson.

Superior view of cranium from Eschscholtz Bay, Alaska, figured by Richardson on Plate VII, fig. 3, Zoology of the Voyage of the *Herald*. No. 24589, Catalogue of the British Museum.

PLATE LXXVII.

Bison alleni Marsh.

Anterior view of left-horn core from the type No. 911, museum of Yale University.

PLATE LXXVIII.

Bison alleni Marsh.

Superior view of specimen shown on Plate LXXVII.

PLATE LXXIX.

Bison alleni Marsh.

Posterior view of specimen deposited by C. W. Greene in the museum of Stanford University.

PLATE LXXX.

Bison alleni Marsh.

Superior view of specimen shown on Plate LXXIX.

PLATE LXXXI.

Bison ferox Marsh.

Superior and posterior (?) views of the type specimen No. 910, museum of Yale University.

PLATE LXXXII.

Bison latifrons (Harlan).

Anterior and superior view of the horn cores in the collection of the Cincinnati Society of Natural History.

These have been carefully adjusted by Dr. Lindahl, as shown in this picture, with the result that they have more of an upward curve than in other published views. This has naturally slightly lessened the distance between the tips.

PLATE LXXXIII.

Left hand, smaller figure, a right metacarpal from Alaska, ascribed to *Bison crassicornis*, although possibly belonging to *B. occidentalis;* No. 1719, U.S.N.M. Right hand, larger figure, a right metacarpal from Peace Creek, Florida, ascribed to *Bison latifrons;* No. 1989, U.S.N.M.

PLATE LXXXIV.

Ovis scaphoceras (Cope).

Horn core from Nicaragua named *Bos scaphoceras* by Cope. From the specimen belonging to the School of Biology, University of Pennsylvania.

BISON OCCIDENTALIS LUCAS. *Type.*

FOR EXPLANATION OF PLATE SEE PAGE 770.

BISON OCCIDENTALIS LUCAS.

FOR EXPLANATION OF PLATE SEE PAGE 770.

BISON ANTIQUUS LEIDY. Type.

FOR EXPLANATION OF PLATE SEE PAGE 770.

BISON ANTIQUUS LEIDY. Type.

FOR EXPLANATION OF PLATE SEE PAGE 770.

BISON ANTIQUUS LEIDY.

FOR EXPLANATION OF PLATE SEE PAGE 770.

BISON ANTIQUUS LEIDY.

FOR EXPLANATION OF PLATE SEE PAGE 770.

BISON.

Ilford, Sussex, England.

FOR EXPLANATION OF PLATE SEE PAGE 770.

BISON.

Ilford, Sussex, England.

FOR EXPLANATION OF PLATE SEE PAGE 770.

BISON CRASSICORNIS RICHARDSON.

FOR EXPLANATION OF PLATE SEE PAGE 770.

BISON CRASSICORNIS RICHARDSON.

FOR EXPLANATION OF PLATE SEE PAGE 770.

BISON CRASSICORNIS RICHARDSON.

FOR EXPLANATION OF PLATE SEE PAGE 771.

BISON CRASSICORNIS RICHARDSON.

FOR EXPLANATION OF PLATE SEE PAGE 771.

BISON ALLENI MARSH. *Type.*

FOR EXPLANATION OF PLATE SEE PAGE 771.

BISON ALLENI MARSH. Type.

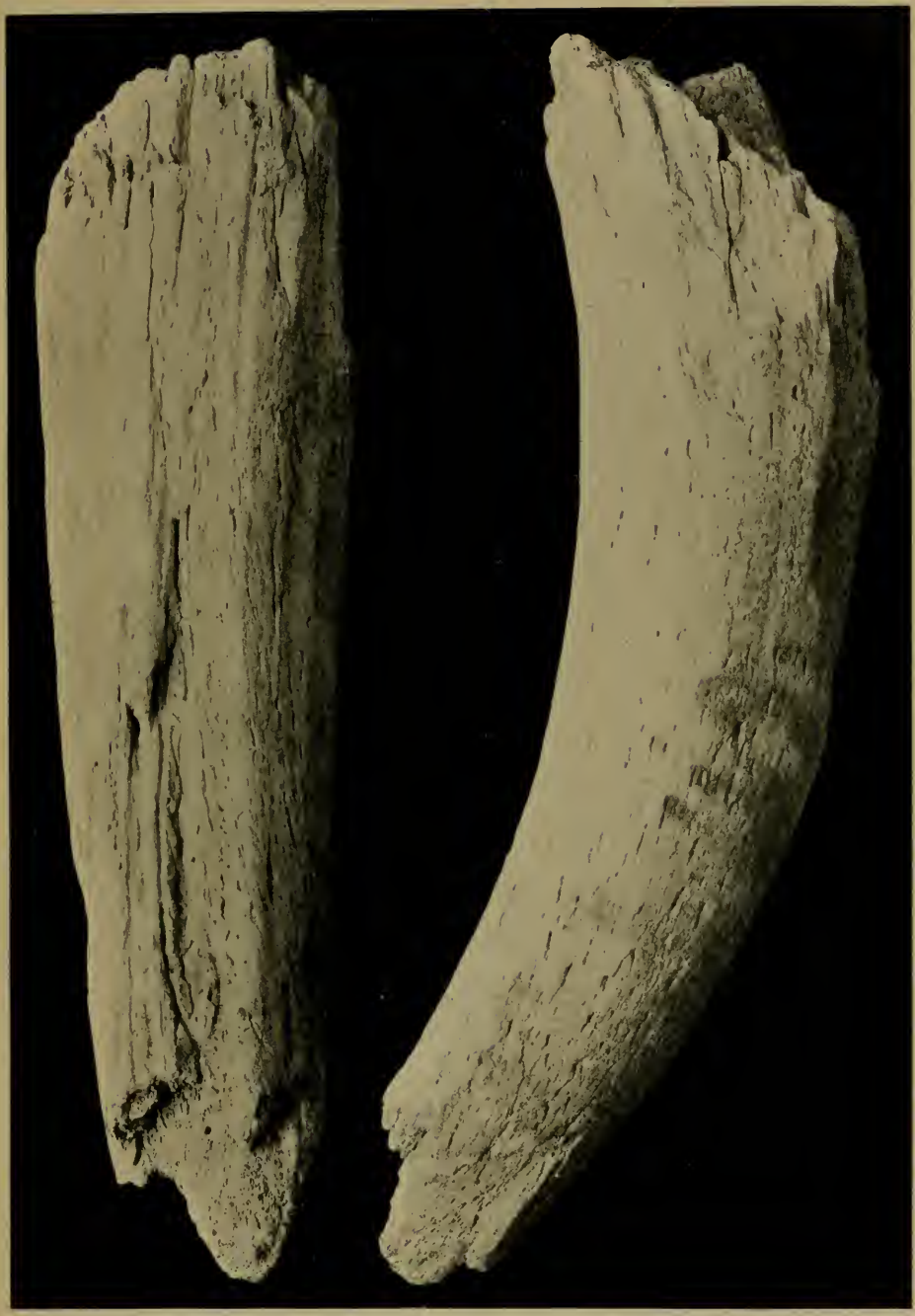
FOR EXPLANATION OF PLATE SEE PAGE 771.

BISON ALLENI MARSH.

FOR EXPLANATION OF PLATE SEE PAGE 771.

BISON ALLENI MARSH.

FOR EXPLANATION OF PLATE SEE PAGE 771.



BISON FEROX MARSH. Type.

FOR EXPLANATION OF PLATE SEE PAGE 771.

BISON LATIFRONS (HARLAN).

FOR EXPLANATION OF PLATE SEE PAGE 771.

BISON CRASSICORNIS RICHARDSON.
BISON LATIFRONS (HARLAN).

FOR EXPLANATION OF PLATE SEE PAGE 771.

OVIS SCAPHOCERAS (COPE).

FOR EXPLANATION OF PLATE SEE PAGE 771.