

THE
AMERICAN JOURNAL OF SCIENCE

[FOURTH SERIES.]

ART. XXVI.—*The Mammals and Horned Dinosaurs of the Lance Formation of Niobrara County, Wyoming*; by RICHARD SWANN LULL.

[Contributions from the James Dwight Dana Memorial Fund, Yale University.]

Introduction
The problem
Historical résumé
Descriptions by Professor Marsh
Summary of the Lance fauna
 Comparison with the Belly River fauna
 Comparison with the Paskapoo fauna
 Comparison with the Fort Union fauna
 Summary
Reconnaissance of 1914
Stratigraphy of the Lance formation
 Beecher's section, 1889
 Hatcher's section, 1893
 Stanton and Knowlton's sections (*a, b*), 1897 and 1909
 Stanton's section (*c*), 1909
 Doneghy's section, 1914
Ceratopsian localities
 Geologic sequence
 Evolutionary sequence
Mammalian localities
Summary
Bibliography

Introduction

EVER since the completion of the Ceratopsia monograph in 1905, the writer has desired to visit the famous region which produced so many of the remarkable creatures which form the subject-matter of that volume. Last summer, through the kind coöperation of my colleague, Professor Schuchert, an expedition to Nebraska was made possible, and when a visit to the "Ceratops beds" of Wyoming was also planned, Mr. Schuchert immediately suggested that a reconnaissance be made with the particular purpose of determining, if possible,

the stratigraphic sequence of the mammal-bearing beds. To this end the Faculty of the Geological Department of Yale voted a sum of money from the research fund which the family of Professor James Dwight Dana have dedicated to his memory. The brief visit, while not in itself productive of many facts, nevertheless rendered possible a visualizing and better appreciation of the work already done on the area and stimulated the following compilation and summary of our knowledge of the Cretaceous mammals.

The sources of information are the large collections made principally by J. B. Hatcher, aided by Professor C. E. Beecher, Mr. O. A. Peterson, and others, together with the field notes and correspondence of the two first mentioned. There were also available the writings of Professor Marsh descriptive of the mammals themselves, and the subsequent work of Messrs. Hatcher, Stanton and other authorities mentioned in the bibliography.

I am indebted to Mr. O. A. Peterson of the Carnegie Museum in Pittsburgh for aid in the compilation of localities, as well as to Messrs. Gidley and Gilmore of the United States National Museum; and especially to Mr. J. T. Donoghly, Jr., graduate student in paleontology at Yale, who shared the field trip and prepared the geologic section of the Niobrara County beds. Professor Schuchert's kindly criticism and generous aid add to the already large sum of my debt of gratitude to him.

The Problem

The late Cretaceous beds of Wyoming, which have received from the United States Geological Survey the official designation of Lance formation, have borne at various times the names of Laramie formation, Converse County beds, and Ceratops beds, all of which are open to criticism on one ground or another. The strata are notable for having produced a large number of most characteristic fossils, the skulls of horned dinosaurs, in addition to other reptilian remains, but also for having proved in certain localities a veritable mine of treasure by the production of thousands of teeth and bones of the tiny contemporaneous mammals.

Whether such contemporaneity was exact, or whether the mammals differed from the associated dinosaurs in level, facies and implied habitat, and whether they occurred at more than one level were aspects of my problem. If the latter proved true, it would be interesting to learn whether or no a faunal sequence exists in the mammals comparable to that which the ceratopsian skulls seem to show, and what is the relationship of the mammals to older and newer mammalian faunas. It was hoped that more perfect, possibly associated skeletal

material might be found, but success in this regard is still short of fulfillment.

Historical Résumé

To John Bell Hatcher belongs the honor of discovering, not only the rich mammalian locality under discussion, but, with the exception of a premolar tooth, an imperfect molar and the distal end of a humerus found by Dr. J. S. Wortmann in Dakota and described by Cope in 1882 as *Meniscoëssus conquistus*, the Cretaceous mammals themselves. In 1888, Mr. Hatcher, then an aid to Professor Marsh, searched for mammals in the so-called Laramie formation in Montana and South Dakota, but without success. The following year, however, he went into what was then Converse County, Wyoming, in pursuit of horned dinosaurs, the discovery of which had been made known to him the year previous, and the results of the next few years (1889–1892) not only brought to light the remarkable series of more than thirty skulls and skeletons of these and other dinosaurs, but several thousand isolated teeth, jaws, and bones of mammals. To Hatcher, therefore, belongs the major credit for the discovery of this material, but he was ably seconded by Messrs. Peterson, Utterback, and Sullins. Peterson's work was especially valuable if one may judge from the field and museum records, for "Peterson's Quarry" is one of the most productive localities of all.

Although Hatcher does not mention it, Professor Charles E. Beecher of Yale was a member of Hatcher's party during the summer of 1889 and the following spring (1890) and did a large part of the actual work on the mammals.

Hatcher (1896, p. 119) thus describes the method of field research:

"The small mammals are pretty generally distributed but are never abundant, and on account of their small size are seen with difficulty. They will be most frequently found in what are locally known as 'blow outs' and are almost always associated with garpike scales and teeth, and teeth and bones of other fish, crocodiles, lizards and small dinosaurs. These remains are frequently so abundant in 'blow outs' as to easily attract attention, and when such a place is found careful search will almost always be rewarded by the discovery of a few jaws and teeth of mammals. In such places the ant hills, which in this region are quite numerous, should be carefully inspected as they will almost always yield a goodly number of mammal teeth. It is well to . . . sift the sand contained in these ant hills, thus freeing it of the finer materials and subjecting the coarser material remaining in the sieve to a thorough inspection for mammals. By this method the writer has frequently secured from 200 to 300 teeth and jaws from one ant hill. In localities where these ants have not yet

established themselves, but where mammals are found to be fairly abundant, it is well to bring a few shovels full of sand with ants from other ant hills which are sure to be found in the vicinity, and plant them on the mammal locality. They will at once establish new colonies, and, if visited in succeeding years, will be found to have done efficient service in collecting mammal teeth and other small fossils, together with small gravels, all used in the construction of their future homes."

Thus it was that the bulk of the Yale collection was secured. At first the collecting seems to have been done somewhat at random, or at any rate no record of exact locality is noted with the various specimens. Later, however, each specimen bore a quarry number, so that not only can its exact geographical origin be determined, but the stratigraphic level may also be learned with a considerable degree of accuracy.

This material speedily began to find its way to New Haven, especially while Beecher was in the party, as Professor Marsh's comments show, and with his characteristic energy when once his interest was aroused, the latter at once began the publication of the descriptions and figures of these remarkable forms.

Descriptions by Professor Marsh

The first of these descriptive papers appeared in this Journal for July, 1889, in which he described seventeen species representing no fewer than twelve distinct genera. August of the same year saw the publication of the second part of the paper, and the third appeared in March, 1892, bringing the total number of species up to thirty-two, while of genera there were eighteen in all. These publications also include a discussion of relationships and family definitions and were but the projected beginning of an extensive monograph upon the group, the completion of which was prevented by the distinguished author's untimely death. Aside from a quarto publication by Professor Osborn, reprinted in part in his "Evolution of mammalian molar teeth," little has been done on the Lance mammals by other writers, and practically every genus and species known is contained in the original series described by Professor Marsh and based upon types preserved in the Yale collection.

Summary of the Lance fauna

The Lance formation has produced an extensive vertebrate fauna of which the dinosaurian element is by far the most conspicuous, consisting as it does of the terminal representatives of all the phyla except the long extinct Sauropoda. There were also turtles and crocodiles, lacertilians and champsosaurs, and a number of genera and species of tiny mammals.

The mammalian forms are included under at least two of

the Mesozoic orders, Multituberculata and Trituberculata, the first of which is to be included under the infraclass Didelphia or marsupials, while of the Trituberculata Matthew says some are demonstrably marsupial, others of uncertain relationship, none demonstrably placental (1914, p. 386).

The list of genera and species thus far described from the Lance follows (Hay 1902, pp. 564 *ff.*):

ORDER MARSUPIALIA

SUBORDER POLYPROTODONTIA

(TRITUBERCULATA)

Family Stagodontidæ Marsh

- Stagodon nitor* Marsh
- “ *tumidus* Marsh
- “ *validus* Marsh
- Thlæodon padanicus* Cope
- Platacodon nanus* Marsh

Family Cimolestidæ Marsh

- Pedionmys elegans* Marsh
- Batodon tenuis* Marsh
- Didelphodon comptus* Marsh
- “ *ferox* Marsh
- “ *vorax* Marsh
- Cimolestes curtus* Marsh
- “ *incisus* Marsh
- Telacodon lævis* Marsh
- “ *præstans* Marsh

Family Dryolestidæ Marsh

- Dryolestes tenax* Marsh

SUBORDER ALLOTHERIA (MULTITUBERCULATA)

Family Bolodontidæ Osborn

- Allacodon fortis* Marsh
- “ *lentus* Marsh
- “ *pumilis* Marsh
- “ *rarus* Marsh

Family Plagiaulacidæ Gill

- Cimolomys agilis* (Marsh)
- “ *bellus* Marsh
- “ *digona* Marsh
- “ (*Halodon*) *formosus* (Marsh)*
- “ *gracilis* Marsh
- “ (*Nanomysops*) *minutus* (Marsh)*

* Referred to *Ptilodus* by Gidley, 1909, pp. 622-623.

- Cimolomys nitidus* (Marsh)
 “ *parvus* (Marsh)
 “ (*Halodon*) *serratus* (Marsh)
Meniscoëssus (*Selanacodon*) *brevis* (Marsh)
 “ (*Tripriodon*) *caperatus* (Marsh)
 “ “ *cœlatus* (Marsh)
 “ *conquistus* Cope
 “ (*Selanacodon*) *fragilis* (Marsh)
 “ (*Dipriodon*) *lunatus* (Marsh)
 “ “ *robustus* (Marsh)
 “ (*Halodon*) *sculptus* (Marsh)
Oracodon anceps Marsh
 “ *conulus* Marsh
Camptomus amplus Marsh

On comparison with older faunæ, no genera in common between the Lance and the Triassic, Jurassic or Comanchian (Morrison) are found, with the doubtful exception of *Dryolestes*, of which there are several species in the latter beds and but one in the former; as the Lance species, however, is based upon an imperfect jaw without teeth, its inclusion in the genus is open to question.

Comparison with the Belly River fauna.—Of the few forms reported from the Belly River, one is referred to the genus *Ptilodus* (*P. primævus* Lambe). Of this species Hatcher says it is related to but somewhat more primitive than *Meniscoëssus conquistus* Cope from the Laramie of South Dakota. The only other species which I find recorded is *Boreodon matutinus* Lambe, related, according to Hatcher, to *Stagodon*.

Comparison with the Paskapoo fauna.—Barnum Brown (1914A, p. 361) thus speaks of the mammals from the Paskapoo formation of Alberta:

“Near Erickson’s Landing, about 20 miles below the town of Red Deer, there is an enormous slide, the largest seen along the [Red Deer] river, where a full section of the canyon wall 100 yards in length has slipped down to the river level. In this fallen material there are many blocks of sandstone carrying on the lower side clay pebbles, *Unios*, and a few jaws, teeth, and bones of mammals, identified as follows:

“MULTITUBERCULATA:	TRITUBERCULATA:	
<i>Meniscoëssus</i> sp. indesc.	<i>Didelphops</i> sp.	} ? Marsupiala
<i>Ptilodus</i> sp.	? <i>Batodon</i> sp.	
<i>Cimolodon</i> sp.	? <i>Thlæodon</i> sp.	
	? Gen. indesc.	} ? Insectivora
	? Gen. indesc.	
	Pantolestidæ gen. indet.	
	? Creodonta	
	? Taligra	

Of these Brown says the multituberculates and trituberculates "are unmistakably those of the Lance, but the placental mammals have not been found in the Lance and appear to belong to the Palæocene groups of mammals, although they do not compare closely with Puerco or Torrejon genera. This layer was located in the bluff at a point 150 feet above the river. Apparently it was a local deposit, an old river channel of the Paskapoo period which crossed the present river at right angles. Twenty-five feet above the mammal stratum there is a bed of shells 8 inches thick, from which Doctor T. W. Stanton has identified *Unio* sp., *Sphærium* sp., *Goniobasis tenuicarinata*, *Planorbis* sp., *Viviparus* sp., *Campeloma* sp., which he says are suggestive of Fort Union rather than earlier forms."

Matthew (1914, p. 388) has checked up Brown's identification of the mammals and agrees with his findings and conclusions. He says in addition, in speaking of the apparently Palæocene element in the fauna:

"I suspect that it will be found to compare more nearly with the Fort Union fauna. It is evident at all events that there was a considerable element of placental mammals in the fauna. But the Multituberculates are those of the Lance and some of the Trituberculates appear to be identical. There is no indication of the presence of any of the Eocene orders of placentals."

Comparison with the Fort Union fauna.—A comparison of the Lance with the Fort Union brings to light a number of similarities and still more marked discrepancies. The Fort Union mammals are known from several localities, all of which, with one exception, are in the neighborhood of Fish Creek in Sweet Grass County, south central Montana, a region the importance of which was enhanced by Douglass' discovery of these interesting types.

Silberling (Stanton 1909, p. 261) separated the Fort Union into three members, of which number 1, the lowermost, and number 2, the intermediate, together constitute the softer, darker-colored shales and sandstones with a combined thickness of about 1300 feet, while the upper member, or number 3, consists of massive sandstones interbedded with shales, and is more than 4000 feet thick. The last member is identical with the whole of the Fort Union of Stone and Weed.

The middle member, Fort Union number 2, is the one wherein the most important mammal collections were made, and from a quarry 65 feet below the top of the formation on the east side of Bear Butte, Mr. Gidley has recognized the following (classification after Matthew):

<p>MULTITUBERCULATA</p> <p><i>Ptilodus montanus</i> Douglass</p> <p>“ <i>gracilis</i> Gidley</p> <p>“ <i>serratus</i>? (Marsh) [= <i>Cimolomys</i>]</p> <p>“ <i>formosus</i>? (Marsh) [“]</p> <p>INSECTIVORA</p> <p><i>Pentacodon</i>? sp.</p> <p><i>Myxodectes</i>? sp.</p> <p>CARNIVORA</p> <p>Creodonta</p> <p><i>Chriacus</i> sp.</p> <p><i>Oxyclænus</i> sp.</p> <p><i>Tricentes</i>? sp.</p> <p><i>Deltatherium</i>? sp.</p> <p><i>Didymictis</i> sp. nov.</p>	<p>TÆNIODONTA</p> <p><i>Psittacotherium</i> sp.</p> <p>CONDYLARTHRA</p> <p><i>Mioclænus</i> sp. nov.</p> <p><i>Euprotogonia</i> sp. nov.</p> <p>TALIGRADA</p> <p><i>Ectoconus</i>? sp. nov.</p> <p><i>Pantolambda</i> sp.</p>
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Matthew (1914, p. 389) adds to this list:

<p>? MARSUPIALIA</p> <p>? <i>Batodon</i> sp.</p> <p>? <i>Cimolestes</i> sp.</p> <p>? <i>Peratherium</i> sp.</p> <p><i>Picrodus silberlingi</i> Douglass</p> <p>INSECTIVORA</p> <p><i>Coriphagus montanus</i> Douglass</p> <p><i>Megopterna minuta</i> Douglass</p>	<p>CARNIVORA</p> <p>Creodonta</p> <p><i>Protochriacus</i> sp.</p> <p>TALIGRADA</p> <p><i>Anisonchus</i> sp.</p>
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The two doubtfully determined species of *Ptilodus* described by Marsh as *Cimolomys* occur in the Lance of Niobrara County, Wyoming. All the other species in Gidley's list show affinities with the Torrejon fauna of New Mexico.

Clænodon ferox (Cope) and *Pantolambda cavirictus*? Cope were obtained in Fort Union number 3, with an abundant Fort Union flora. Both *Clænodon* and *Pantolambda* are typical Torrejon genera. Comparing the mammals of the upper Fort Union with those of the Torrejon, Matthew says (1914, p. 392) that they appear “to be of the same age, as indicated by the identity of a part of the fauna. But it [Upper Fort Union] apparently represents a somewhat different facies, with certain points of analogy to the Lance.”

The Lance mammals, wherever they are found, generally lie in more or less close association with ceratopsian skulls, and I have no doubt that such highly specialized members of the dinosaurian phylum represent very limited environmental con-

ditions, whatever their nature may have been. The inference is therefore natural that the known mammals do also, and hence may not represent very completely the full aspect of mammalian life at that time. Exception has been taken to this statement, as the mammals are associated with an abundance of fresh-water fish scales, and as all are comminuted it means that the bones are drifted from a long way. Therefore one may have all sorts of mammals here. The ceratopsian skulls, from the extensive cavities which they contain and which must have filled with the gases incident to decay and thus become highly buoyant, were doubtless also extensively drifted, a point which the almost invariable lack of teeth in the upper jaws corroborates. Hence it would seem as though the fossil contents of these beds may have been the accumulation of the moribund flotsam of a considerable area, but still possibly of comparatively uniform environmental aspect. The wonderful preservation of the tiny cusps of many of the mammalian teeth does not indicate extensive rolling or disturbance after they were shed from the drifting carcass, but on the other hand, many of the sliver-like bone fragments found point to the dry disintegration of the bones before burial. Were the full Lance fauna known, it is probable that more of the precursors of the basal Eocene mammals would be found therein.

Summary.—To summarize: the Lance mammals are far removed in time from those of the Morrison, but because of the persistence of certain static Mesozoic types and the absence of known Tertiary forms in the former, there is a nearer resemblance in general character than between the Lance and basal Eocene. Comparison between the Belly River and the Lance is less satisfactory because of the dearth of mammalian fossils from the former and older formation, but, as Matthew says (1914, p. 391), the fauna of the Belly River is of the same facies (faunal aspect) as the Lance, despite the gap represented in the progressive evolution of the Ceratopsia and other dinosaurs. The Belly River mammals are doubtfully more primitive in stage and there is no good evidence of any change of fauna or of the appearance of any new immigrant groups. This last apparent fact may be due, however, to the dearth of our knowledge of Belly River types.

The Paskapoo and the Lance correspond closely in certain aspects of their faunæ, in that they have several types in common. These are, however, persistent Mesozoic forms, while the distinguishing animals of the Paskapoo are of decided Palæocene aspect. The Lance and the Fort Union show certain types in common, but they are again the static Mesozoic phyla which have persisted through long ages with so little change. The general faunal aspect has changed as materially as with the Lance and Puerco and Torrejon, though, as Mat-

thew says of the latter, it is not very clear whether the faunal difference is due to diverse local environments, or to a great movement of faunal migration, but a combination of both seems to fit the data more exactly. This would indicate that the apparent absence from the Lance of the more primitive and archaic groups of the Puerco-Torrejón fauna may be a matter of environment; but that the absence of the larger, more progressive and abundant Palæocene placentals from the Lance is to be ascribed to a migration movement after its close. The evidence on this point is, however, too scanty to be of any considerable weight.

Reconnaissance of 1914

The writer's visit to the Lance beds last summer was far too brief to be of material value, but it stimulated the gathering of data as a basis for future work. The difficulty of securing exact information regarding the old collections has proved well-nigh insuperable, for the field records are very meager, and of those who collected the mammals in the Yale Museum, but one, Mr. Peterson, then at the beginning of his valued career as a practical paleontologist, is available for further information. Such as he has I have been able to utilize in full.

Our party entered Wyoming from Sioux County, Nebraska, following the course of Indian Creek nearly to its source, then over the divide to Sage Creek, missing the Hat Creek post-office and Hatcher's old trail by turning north on the mail road to Warren instead. Hence we entered the Ceratopsia region from the east, making our camp on the Johnson Brothers' ranch at the point where their original dugout cabin lay, in a small tributary canyon which entered that of Buck Creek from the east and a mile or more from the confluence. Mr. Doneghy, who accompanied me, took up the task of running a section from Buck Creek west toward Lance, while I spent the time in exploration, trying by means of Hatcher's map to locate both geographically and stratigraphically the more important ceratopsian and mammalian localities. The map proved to be very sketchy, and the exact identification of localities worked twenty or more years before in a complex of topographic features was a matter of extreme difficulty.

Several of the larger counties of Wyoming have lately been divided into two or more portions, including the old county of Converse. Here the division runs north and south, a little east of the mid-line. The name Converse is still retained for the somewhat larger western part, while the Niobrara River which rises in the eastern portion has given its name to the remainder. It so happens that the entire area of the "Converse County beds," which were embraced by the old political

division, lies in the present Niobrara County, hence the inappropriateness of the older formation name.

Niobrara County is crossed from east to west by an important watershed, Pine Ridge, which continues eastward into Sioux County, Nebraska. South of this ridge, the land, with an average elevation of about 5000 feet, is drained by the Niobrara, although two small tributaries of the Platte rise in the southwestern portion. North of Pine Ridge the land falls abruptly for about a thousand feet, and is drained by the Cheyenne or its tributaries. Of the latter, Lance and Lightning creeks, together with Buck and Sage creeks, are the most important, the first mentioned giving its name to the formation. The map presented herewith (figs. 1 and 2) has been compiled largely from the General Land Office map of the state of Wyoming bearing the date of 1892, with such additions as Hatcher's field maps, thrice published (1896, 1907) seem to imply. This map has been submitted to Mr. Peterson for revision as to localities, but is only tentative and merely serves as a means of recording such otherwise perishable information as we now possess. It will show quite clearly the general relation of the Lance beds to the drainage, but the indicated boundaries of the formation, although based upon Hatcher's map, are only approximate, as the line of demarcation between the Fox Hills and Lance on the one hand and the Lance and Fort Union on the other is not clearly defined. As one approaches the locality from the east from Sage Creek, he climbs a gentle declivity for a distance of about 2 miles until near the summit of the divide separating the valley of Sage Creek from that of the parallel-flowing Buck Creek. Here the first escarpments are seen, of yellow sandstone, capped by hard brown concretionary masses and containing marine Cretaceous shells. From this divide several smaller canyons run with a general western trend to the bed of Buck Creek itself. These canyons are divided by pine-clad hills, with cottonwoods here and there along the water courses. In one such canyon near a strongly alkaline spring we pitched our camp.

From Buck Creek the land rises rapidly toward the west and north until the summit of the divide separating the watershed from that of Lance Creek is reached, when the land again descends to the latter stream. This area is grassed over, cottonwood trees following the main courses so that the latter are thus clearly indicated. Here and there are fairly deep tributary canyons where the ever-varying stratigraphy may be traced. The beds are alternating shales and sandstones with occasional bands of lignite. The sandstones in the canyons were mostly fairly hard, yellowish to whitish, often much cross-bedded and capped with a much harder brown sandstone, which often had the appearance of concretions. Some of the "concretions"

FIG. 1.

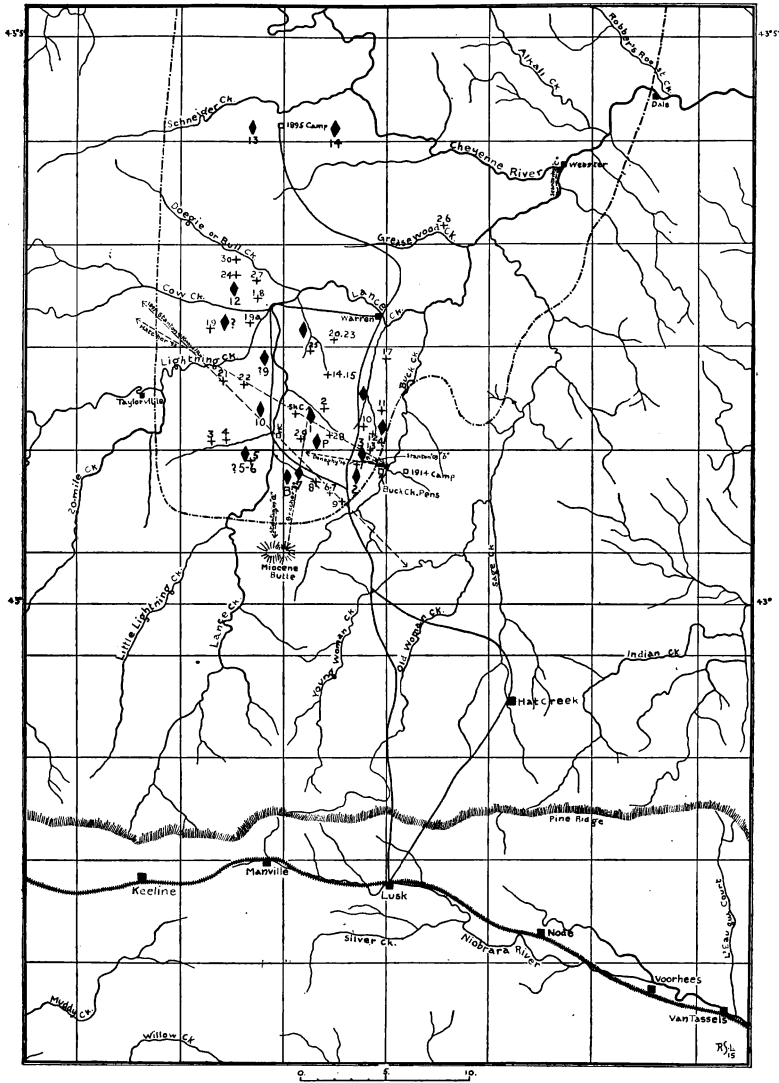


FIG. 1. Map of Niobrara Co., Wyo. Diamonds indicate mammal localities; crosses, ceratopsian skulls; broken and dotted line, limits of Lance formation.

FIG. 2.

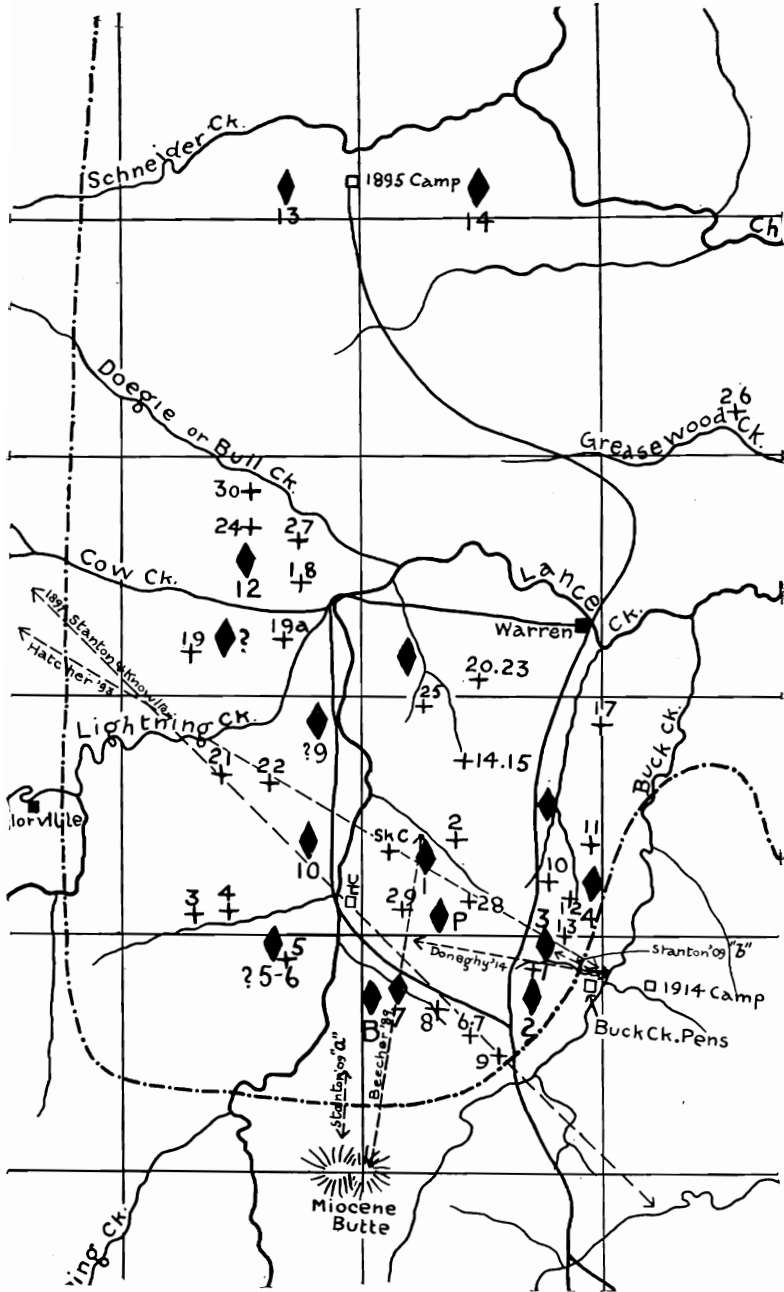


FIG. 2. Detail from the preceding map, showing the principal area of the Ceratops beds on a large scale.

were longitudinally fluted and many feet in length. There were bands of softer clays often at the same level as the sandstone, but local in extent. This rapid change in the character of the deposition, which has been noted by previous observers, greatly complicates the task of unravelling the stratigraphy, as no two sections taken at different places in the region agree.

East of Buck Creek the sediments are marine and of Pierre age. Overlying the Pierre is the Fox Hills, again marine, and Stanton had no difficulty in finding the line of demarcation clearly indicated. We were not so fortunate. West of Buck Creek the sediments are still of Fox Hills age and, so far as one can see from the physical evidence, they pass without a break in the deposition into those of the Lance formation. Nor can one tell, except for the contained fossils, to which series the sediments belong, and as there are some 400 feet devoid of fossils, which have at different times been referred to each, the precise limitation of the Fox Hills and Lance has been subject to dispute.

Knowlton (1909, p. 205) thus describes the area:

The "Ceratops beds" are very limited in extent, extending about 15 miles from east to west, by 30 from north to south. The beds "are best exposed along the eastern and southern borders of a synclinal basin, and according to Hatcher are 3000 feet in thickness, though Dr. T. W. Stanton and myself, when we visited the area in 1896, concluded that they could hardly exceed 2000 feet, but as a large portion of the beds are exposed at a low broad angle in a broad flat grassy plain, it is impossible to measure the beds with a great degree of accuracy. The entire section of the region, which begins with several hundred feet of soft, bluish shales of the Pierre, up to and including the acknowledged Fort Union, was supposed by Marsh and Hatcher to be one of continuous deposition; that is to say, no actual unconformity had been detected. The Fox Hills, with an estimated thickness of 500 feet, consists of an alternating series of sandstones and shales. The massive sandstones at the top contain numerous large concretions and a rich marine fauna of characteristic Fox Hills species. The line between the Fox Hills and the overlying beds is a difficult one to draw, Hatcher, at first, placing it arbitrarily at a six-inch band of hard sandstones which separates the fossil-bearing Fox Hills sandstone below from the very similar but non-fossiliferous sandstones above.

"Later, however, Hatcher appears to have changed his mind regarding the lower limits of the 'Ceratops beds,' for he says:

'At no place in the Converse [Niobrara] County region do the true Ceratops beds, with the remains of horned dinosaurs, rest upon true marine Fox Hills sediments; nor are the Ceratops beds in this region overlain by strata which could be referred without doubt to the Laramie.' This point was apparently well taken, for Stanton and I found four species of brackish-water in-

vertebrates in clays above a forty-foot bed of massive sandstone over 400 feet above the highest fossiliferous Fox Hills horizon in that particular section. The fact remains, however, that the fossiliferous portion of the 'Ceratops beds' is mainly the upper portion, the highest point at which dinosaurs were found, being only 100 to 150 feet below the Fort Union."

On the east side of the deposits, according to Hatcher, near Buck Creek the dip of the strata is about 16° N.W., whereas at the southwestern corner of the area between Twentymile and Little Lightning creeks it increases to 29° N.W. Our own observations, taken not far from the first mentioned place, gave a dip of about 10° . As one mounts the divide toward the west he crosses the entire section, for the slope beyond the summit practically coincides with the dip, so that no further exposures are seen except in the canyons. Bearing this in mind, if the localities of the ceratopsian skulls are at all accurately placed upon the map, they would seem to range through nearly the entire Lance formation, provided the lower 400 feet of non-fossiliferous sandstones belong to the Fox Hills (*vide supra*, p. 332).

Stratigraphy of the Lance Formation

The sections which have been recorded from the Niobrara County area are six in number, and may be described as follows:

1. *Beecher's section, 1889.*—This, a sketch section by Professor Beecher, runs approximately north and south, was taken east of Lance Creek, and covers a distance of about 8 miles. It was not published but I find it in a letter addressed to Professor Marsh and bearing the date of July 28, 1889. This section, together with a smaller one at Mammal Quarry No. 7 (map, \blacklozenge 7), is here shown (figs. 3, 4). It shows two distinct levels where mammals have been found, one near the middle of the section, the locality of the so called Quarry No. 7, and the other at the top of the section at Quarry No. 1 (map, fig. 2, p. 331, \blacklozenge 1). In each instance the mammal-bearing horizon will be seen immediately to overlie a bed of lignitic shales. Quarry No. 7 is also shown in the smaller section and lies in a canyon 30 feet in depth, tributary to Lance Creek on the eastward side. Beecher says of it (letter of July 28, 1889):

"We have also found another locality where the mammals are in place and it gives promise of furnishing more bones and jaws than have yet been seen. The sandstone is so soft and friable, however, and the bones so brittle and checked that it will be very difficult to save the specimens. The horizon is much lower than either Quarry No. 1 or Peterson's quarry. The following section shows its position. It lies at the base of a stratum of

FIGS. 3 AND 4.

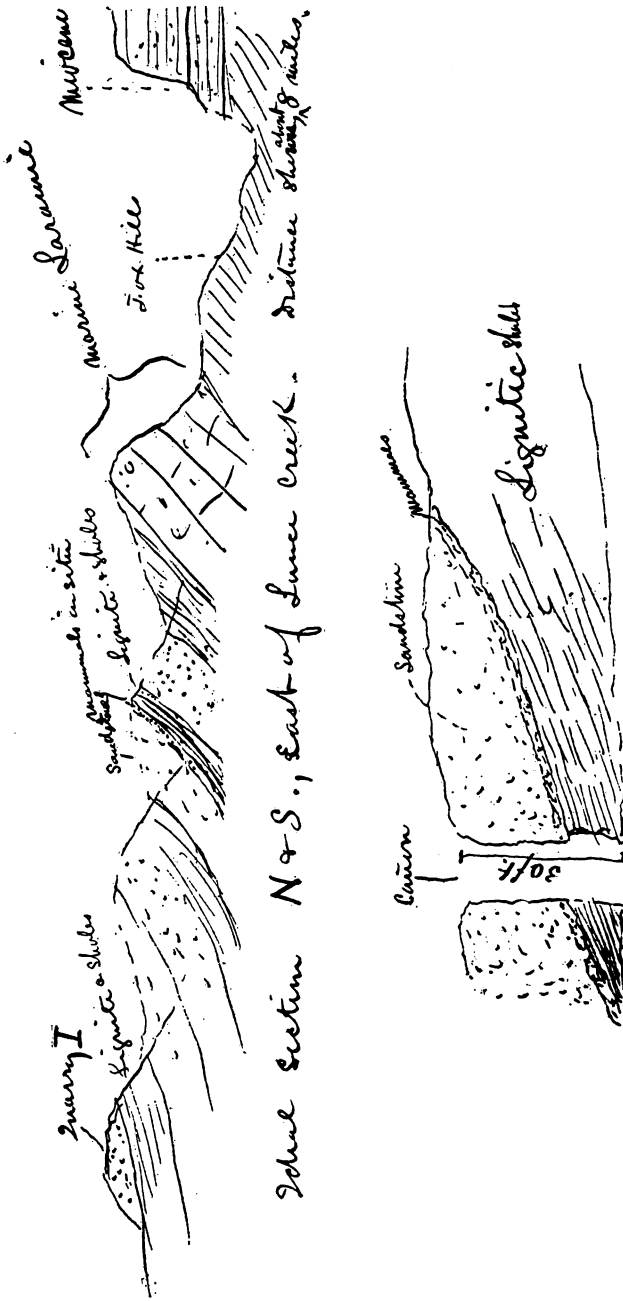


FIG. 3. Beecher's section of 1889 in the Ceratops beds. FIG. 4. Section at Quarry No. 7. From photographs of the original drawings.

sandstone and is from 1 to 3 feet thick. The bones and teeth are mingled with sand, nodules of clay and several varieties of fossil nuts.”

2. *Hatcher's section, 1893.*—Hatcher (1893, p. 137) thus describes the area :

“The Ceratops beds are made up of alternating sandstones, shales, and lignites, with occasional local deposits of limestones and marls. The different strata of the series are not always continuous, a stratum of sandstone giving place to one of shales and *vice versa*. This is especially true of the upper two-thirds of the beds. The lack of continuity in the different strata has rendered it well nigh impossible to establish any definite horizons in the upper members of the series. All the deposits of the Ceratops beds of this region bear evidence of having been laid down in fresh waters. . . . There is no evidence that marine or brackish-waters have ever had access to this region since the recession of the former at the close of the Fox Hills period.

“The sandstones largely predominate in the lower members of the beds. They are always fine-grained, massive to well-stratified, and nearly white to yellowish brown in color. They are occasionally compact and hard, but for the most part quite soft and friable. They are composed of sharp, angular grains of quartz with some clay and mica, the whole being loosely cemented together with carbonate of lime. Almost everywhere in the sandstones are numerous concretions of varying size and shape. Some are almost perfect spheres and vary from the size of a marble to 18 to 20 feet in diameter. Others are from a few inches to several feet in transverse diameter and sometimes several hundred feet in length, a cross section forming a nearly perfect circle. Others still are very irregular in form. These concretions usually show no concentric structure, and while they sometimes enclose foreign objects, as a *Triceratops* skull or a single bone as a nucleus, they are for the most part simply centers of solidification and not true concretions. This is frequently shown by the cross-bedding in them, so often seen in the sandstones themselves.

“The shales are almost entirely wanting in the lower 400 feet of the Ceratops beds, but they are well represented in the succeeding series. They are quite soft and loosely compacted, composed mostly of clay with more or less sand in places. The prevailing color is dark brown, but they are sometimes red or bluish. They are well stratified and finely laminated, and contain occasional limestone concretions enclosing numerous invertebrates.

“The lignites occur in thin seams, never more than a few inches thick, of only limited extent, and with many impurities. At no place in the Ceratops beds of this region have workable coal beds been found. These do occur, however, in the Ceratops beds of Montana

“Intercalated with the sandstones, shales, and lignites, are quite local deposits of limestones, clays, and marls. The latter

are composed almost entirely of fresh-water shells, fragments of bone, teeth, etc.

“Along their southern and eastern border, the Ceratops beds dip to the northwest, at an angle of about 16° between Buck Creek and Lance Creek. One half mile east of Lance Creek, the dip is 29° to the northwest. This angle of inclination rapidly diminishes toward the interior, and is scarcely noticeable in the vicinity of Lightning, Cow, and Doegie creeks. The fold is quite abrupt as is further shown by cracks which were made in the strata at the time of disturbance at right angles to their dip and parallel with their strike. These fissures have been filled by infiltration with materials now harder than those forming their walls, and now appear in many places as projecting veins, from a fraction of an inch to a foot or more in width, and from a few yards to several hundred in length.”

The section was that shown by the exposure made by a small tributary emptying into Buck Creek, four miles east of Lance Creek and a half mile northwest of the Buck Creek pens used by the cattle men for round-up purposes. This watercourse has cut its way in a southeasterly direction at right angles to the strike, down through the lower half of the Ceratops beds, through the underlying Fox Hills sandstones, and into the Ft. Pierre shales. All the strata of this entire section dip to the northwest at an angle of 16° .

The section (p. 139) is as follows :

	FEET
Alternating sandstones, shales, and lignites, fossiliferous . . .	2600
Almost white, fine-grained, massive sandstones with numerous concretions, no fossils, about	250
Yellowish brown, well stratified sandstones, apparently non-fossiliferous, about	150
Hard sandstone layer. Arbitrary Fox Hills-Ceratops beds line	$\frac{1}{2}$
Sandstones and shales. Shales predominant in lower portion, toward middle the sandstones in excess, upper 50 feet entirely sandstones. Sandstones yellowish brown, very fine-grained, firm, well stratified below but softer and quite massive at top, where they contain concretions and a Fox Hills fauna	500
Pierre shale	

Stanton and Knowlton's sections.—Two sections, which have been described by Stanton and Knowlton (Stanton 1910, p. 185), lie at the south end of the area, about 30 miles southwest of the mouth of Lance Creek. Of the first one of them (a) Stanton says :

One of these lies about 2 miles east of Lance Creek nearly opposite the mouth of Little Lightning Creek, and shows excellent exposures of Pierre, Fox Hills, and the lower part of the

Lance formation, all dipping northward 14° to 19°. No attempt was made to obtain a detailed section of the Lance formation, but a measurement across the strike as far as the strata have steep dips shows a thickness of about 1700 feet above the upper white sandstone, which was later determined to be the top of the Fox Hills. To this should be added perhaps 400 or 500 feet for the thickness of the nearly horizontal upper strata of the Lance formation. The lowest point at which dinosaur bones were seen is about 300 feet above the top of the Fox Hills.”

The section follows:

	FEET
Gray sandstone	10
Shale	25
Sandstone and shale	20
Shale and coal	15
Shale with brackish-water fauna	20

TOP OF FOX HILLS.

Massive white sandstone with brown concretions	40
Shaly sandstone	5
Coal and carbonaceous shale	15
Massive white sandstone	60
Shale	8
Sandstone	10
Shale	5
Massive white sandstone	100
Brownish gray sandstone in alternations of massive and more thinly bedded	130
Gray sandstone	30
Brown sandstone	20
Yellowish sandstone with Fox Hills fauna	30
Pierre shale	

Of the other section (b) in the southern end Stanton (1910, p. 186) speaks thus:

“The last section examined and perhaps the best exposed and most instructive of all is on Johnson Brothers’ ranch, near Buck Creek, about 8 miles east of the section just described.”

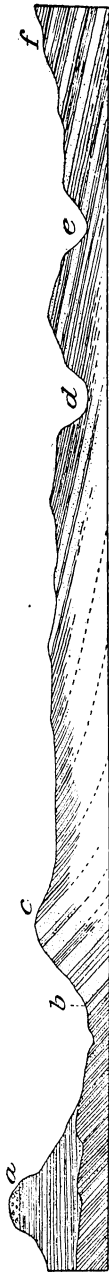
This section follows:

	FEET
Sandy shale with thin beds of coal	25

TOP OF FOX HILLS.

Massive white sandstone with <i>Halymenites major</i>	60
Yellowish massive sandstone with brown concretions	20
More thinly bedded brown sandstone with <i>Halymenites</i> ..	25
Massive white sandstone	75
Soft somewhat sandy shales with thin sandstone bands containing marine Fox Hills shells	30
Brown shaly sandstone	5
Massive white sandstone	60

FIG. 5.



Section across the Converse County area of Ceratops beds. (a) Fresh-water Miocene resting unconformably on Fort Pierre; (b) Fox Hills; (c) Base of Ceratops beds and horizon of brackish-water Laramie fossils; (d) Lance creek; (e) Lightning creek; (f) Horizon of Fort Union plants. From Stanton and Knowlton, 1897.

Thin-bedded brown and gray sandstone	130
Yellowish massive sandstone with concretions containing Fox Hills fauna	100
Pierre shale	

Stanton and Knowlton's sketch section of 1897 (p. 131) is reproduced in Figure 5.

Stanton's section (c), 1909.—In 1910 (p. 184) Doctor Stanton gives an additional section in this area, taken on the south side of the Cheyenne River at the mouth of Lance Creek, and extending up the creek a mile and a half or two miles. It is as follows:

	FEET
White cross-bedded sandstone with irregular brown indurated bands, masses, and concretions	50
Soft sandy shale with bands of lignitic shale. Fragments of dinosaur bones were found on the surface here	50
Sandy shale full of <i>Corbicula cytheriformis?</i> and <i>Corbicula subelliptica</i> var. <i>moreauensis</i>	½ to 1
More or less carbonaceous shale	15
Soft massive gray sandstone with many brown concretions	25
Gray sandstone and sandy shale with bands of sandstone containing Fox Hills fossils, about	150
Cross-bedded, ripple marked, reddish brown sandstone with irregular base	8 to 10
Massive soft buff sandstone with many large concretions and indurated masses and an abundant Fox Hills fauna	100
Pierre shale with only the top exposed	

Stanton says further of this section:

“When studying the section it was believed that the upper four members belong to the Lance formation, but afterward when comparison was made with sections at the south end of the field it seemed more probable that all the beds

examined here belong to the Fox Hills. The higher unquestioned Lance formation was not studied at this place."

Knowlton (1911, p. 372), however, says of the section under consideration :

"The section made on the south side of the Cheyenne River at the mouth of Lance Creek shows a thickness of 405 feet of Fox Hills above the Pierre, but the highest point in the section at which marine Fox Hills invertebrates were found is over 100 feet below the top. It further appears from this section that the upper four members, aggregating 115 feet in thickness, contain carbonaceous and lignitic shales as well as fragments of dinosaur bone and brackish-water invertebrates, certain of which are the same as those found in, and there said to indicate the Laramie age of, the 400 feet of beds already mentioned as reported by Stanton and Knowlton above the typical marine Fox Hills. To the writer [Knowlton] it seems altogether more probable that the four upper members of this section belong to the Lance formation and not to the Fox Hills. . . . If this portion of the section is placed in the Lance formation, where it certainly appears to belong, the thickness of the Fox Hills in the section is reduced to 285 feet, or but little more than half of the maximum thickness assigned to beds of this age in the Converse County region. While this evidence may not be considered conclusive, it must at least be admitted that it strongly suggests the possibility that even here, as in the areas already discussed in the Dakotas and Montana, the Fox Hills is of variable thickness, due to the erosion of the upper portions before the deposition of the Lance formation."

Doneghy's section, 1914.—Mr. Doneghy's section, prepared in the summer of 1914, begins in very nearly the same place where Stanton's section (b) and that of Hatcher in 1893 were taken, that is, in the canyon of Buck Creek near the mouth of the draw mentioned by Hatcher and a short distance north of the Buck Creek pens. While it was occasionally necessary to depart to the right or left of a straight line in order to follow the exposures, the general trend of the section was N. 80° W. It was continued up the slope across the successive outcrops until the summit of the divide between Lance and Buck creeks was reached. Thence west to Lance Creek the general slope of the land surface, which is about 10°, approximately coincides with the dip, so that practically nothing further can be learned. Mr. Doneghy did not go west of Lance Creek. This section is more detailed than any of the others and hence is hard to compare with them. Our supposition was that the lignite beds were necessarily Lance, so that the horizon "*" about 200 feet above the bottom of the section was taken as the possible line of demarcation between the Fox Hills and the Ceratops

beds. Productive ant hills and the remains of dinosaurs were found at a level some 300 feet higher, which is in agreement with the statement by Stanton (*vide supra*, p. 337).

Doneghy's section follows :

	FEET	
Gray sandstone, poor or no outcrops, surface slope approximating that of beds $\pm 10^\circ$ W....	125 to 150	600
Massive hard gray sandstone, often capped by huge concretions, productive ant hills, probable level of Quarry No. 2 (Skull No. 1).....	9 to 10	
Lignite, dinosaur bones at top.....	18	
Buff concretionary sandstone, ? possible limit of Fox Hills.....	1	
White concretionary sandstone.....	8 to 9	500
White sandstone with interbedded lenses of shale and lignite, massive in appearance but weathering brings out extremely irregular cross-bedding, concretions scarce, poor outcrops, ant hills barren.....	75 to 100	
Hard red sandstone, cross-bedded, jointed, slightly flexed.....	3	400
Massive gray sandstone, bedding like above....	12	
Talus of soft sandstone, shale and lignite, no outcrop.....	45 to 50	
Hard sandstone, much cross bedded but regularly bedded.....	3	
Soft sandstone, poor outcrop.....	7	
Hard red bed, massive in appearance, but seems to weather into thin dirty brown slabs. Unweathered layers show no sign of bedding, about.....	2	
Red beds, irregular bedding.....	2	
Hard buff massive sandstone.....	10	
Thin-bedded, even-bedded, hard sandstone....	4	
Sandstone.....	12	300
Alternating soft shale and lignite.....	20 to 25	
Massive buff sandstone.....	20	
Hard buff concretionary sandstone.....	10	
Alternating soft buff sandstone and red shale, with plant and bone remains, beds average 1 foot in thickness, about.....	16	
Lignite bed, about.....	4	
Resistant pink concretionary sandstone.....	0½	
*White to gray massive sandstone.....	15 to 20	200
Hard red sandstone.....	1	
Sandstone in alternating beds, 6 inches to 10 feet, occasional hard and concretionary layers....	75 to 79	
Red sandstone, about.....	2	
Thick-bedded sandstone.....	15 to 18	
Soft alternating shales and sandstones in beds 1 to 5 inches thick, varicolored.....	10	100

Soil and talus		8	
Resistant white concretionary sandstone, a ledge maker	1 to	2	
Hard white massive sandstone, regularly bedded.		15	
Alternating white to brown sandstone, in beds 1 inch to 1 foot thick, regularly bedded.....		10	
Very hard brown sandstone, concretionary, shark tooth, about		1½	
Resistant white sandstone		1½	50
Soil and talus		17	
Massive white sandstone	6 to	8	
Soil cover		17	
Massive irregularly bedded buff sandstone.....		8	

Ceratopsian Localities

Geologic sequence.—As a result of the labors of Mr. Hatcher and his aids, no fewer than thirty-two ceratopsian skulls in varying degrees of preservation were brought to light, in addition to several partial skeletons. This material was studied in part by Professor Marsh and later, in preparation for the *Ceratopsia* monograph, by Hatcher and Lull. The collection, therefore, includes every Lance ceratopsian type and nearly all of the figured material, so that its importance can not be overestimated. The material is now about equally divided between the United States National Museum and that of Yale. The collection of the former institution is entirely prepared, while upon the Yale material there is still much to be done. The skulls were given a series of numbers, 1–19, and 19A–31, making thirty-two all told, while the skeletons were indicated by letter, skeleton C and skull 26 constituting the composite mounted *Triceratops* at the National Museum. Professor Marsh and Mr. Hatcher naturally chose the best specimens for description, with the exception of the type of *Triceratops horridus*, which is Skull No. 1, and one or two others. Circumstances were such that the skulls of the upper levels were the best preserved, so that with the exception of skulls Nos. 1 and 9 (*Triceratops obtusus*), which are the lowest in the series, most of the types come from the upper portion and are all quite near one another stratigraphically, while between No. 1 and the next higher known form there are a number of unidentified and indeterminable specimens, which may or may not have their representatives in the higher levels.

I have arranged the skulls in their stratigraphic sequence, based upon all the data available at present, but taken very largely from a study of the map, and the tables will show not alone the ceratopsian sequence but that of each adjacent mammal quarry as well. I place rather less value upon an evolutionary sequence of ceratopsian species within the Lance

than I did some years ago (1912, p. 774) as there seem to be more lines of descent than were recognized at that time.

Evolutionary sequence.—Lambe (1915)* recognizes three main phyla of Belly River Ceratopsia, two of which lead into the two main groups of Lance forms, the third extending perhaps into the Edmonton but not as yet recognized in the Lance. He dismissed for the present the old Judith River genera *Monoclonius* and *Ceratops* as being insufficiently characterized. Brown (1914B, p. 550), however, considers Lambe's genus *Centrosaurus* to be the equivalent of the former. According to Lambe, the separation of these three phyla based upon the main characteristics of the horn-cores and neck frill, appears to be as follows:

***Eoceratops* to †*Triceratops* [also †*Diceratops*]

Large brow-horn increasing in size.

Nasal horn persistently small.

Squamosal broadly triangular.

Parietal fontanelle disappearing (closing).

***Centrosaurus* [= *Monoclonius*?], ***Styracosaurus*, and ***Brachyceratops*. †

Brow-horn persistently small.

Nasal horn persistently large.

Squamosal continuing small.

Parietal fontanelle diminishing.

***Chasmosaurus* to †*Torosaurus*

Brow-horn increasing.

Nasal horn decreasing.

Squamosal lengthening.

Parietal fontanelle diminishing.

In the Lance, therefore, there are two distinct series (Lull 1912, p. 774), the *Triceratops-Diceratops* race and that of *Torosaurus*. The latter is extremely rare and contains but two species, which may prove identical, as they are very similar and from nearly the same locality, though separated by a stratigraphic interval of about 200 feet.

Diceratops, with the obsolete nasal horn, represents an aberrant race of the *Triceratops* series, while of the genus *Triceratops* itself I can recognize two well-defined phyla and some additional species difficult to place. Of these the first phylum is represented by *Triceratops prorsus*, characterized by a well-developed nasal horn pointing forward, and moderate brow-horns. The race includes *T. prorsus*, the closely allied

* Geol. Surv. Canada, Mus. Bull. 12, p. 15.

† Lance.

‡ Two genera described by Brown from the Edmonton seem to belong to this group: *Anchiceratops*, showing affinities with *Styracosaurus*; and *Leptoceratops*, with *Brachyceratops*.

** Belly River.

TABLE 1.

U. S. N. M. skulls, other than types, identified by Gilmore. Yale skulls, other than types, identified by Lull.						Phyla					
						Torosaurus	Diceratops	Triceratops prorsus	Triceratops elatus	Miscellaneous	Nearest (stratig.) mammal quarry
Level	Sk. No.	Mus.	Cat. No.	Type	Genus and species						
High											
1	19	Y.M.	1830	Holo.	<i>Torosaurus latus</i>	x					?
2	31	Y.M.	1838		<i>Triceratops</i> sp. indet.						
3	19A	Y.M.	1831	Holo.	<i>Torosaurus gladius</i>	x					
4	24	Y.M.	1828		<i>Triceratops</i> "ingens" MS.				x		12
5	30	Y.M.	1837		<i>Triceratops</i> sp. indet.						
6	18	Y.M.	1829		<i>Triceratops ?elatus</i>				x		
7	27	N.M.	5740		<i>Triceratops</i> sp. indet.						
8	21	Y.M.	1832	Ples.	<i>Triceratops ?brevicornus</i>			x			
9*	22	Y.M.	1834	Holo.	<i>Triceratops brevicornus</i>			x*			10 19
10	2	Y.M.	1821	Holo.	<i>Triceratops flabellatus</i>				x		
11	25	N.M.	2412	Holo.	<i>Diceratops hatcheri</i>		x				
12	16	N.M.	1201	Holo.	<i>Triceratops elatus</i>				x		27 18
13	20 23	Y.M.	1833		<i>Triceratops</i> (suggests <i>Diceratops</i>)		?x				
14		Y.M.	1836		<i>Triceratops?</i> sp. indet.						
15	26	N.M.	2100	Ples.	<i>Triceratops ?prorsus</i> or <i>elatus</i>				?x		
16	5	N.M.	4276	Holo.	<i>Triceratops sulcatus</i>					x	5
17	29	N.M.	4928	Holo.	<i>Triceratops calicornis</i>				x		P** 1
18	4	Y.M.	1823	Holo.	<i>Triceratops serratus</i>			x			
19	3	Y.M.	1822	Holo.	<i>Triceratops prorsus</i>			x			
20	14 15	N.M.	7239		<i>Triceratops</i> sp. indet.						?6
21		N.M.	1208		<i>Triceratops sulcatus</i>					x	
22	28	N.M.	6679		<i>Triceratops</i> sp. indet.						
23	10	N.M.	5741		<i>Triceratops elatus</i>				x		
24	17	N.M.	1205		<i>Triceratops prorsus</i>			x			
25	11	N.M.	4708		<i>Triceratops elatus</i>				x		
26	12	N.M.	4286		<i>Triceratops sulcatus</i>					x	
27	13	N.M.	2124		<i>Triceratops</i> sp. indet.						
28	8	N.M.	5738		<i>Triceratops</i> sp. indet.						B** 7
29	6 7	N.M.	2416		<i>Triceratops serratus</i>			x			
30		N.M.			Cannot find						
31	1	Y.M.	1820	Holo.	<i>Triceratops horridus</i>			x			3 2
32 Low	9	N.M.	4720	Holo.	<i>Triceratops obtusus</i>		?x			x	4

* Stanton says not much higher than skulls Nos. 3, 4, 5.

** P, Peterson's mammal quarry; B, Beecher's; the rest were numbered.

if not identical *T. brevicornus*, probably *T. serratus* and *T. horridus*. All are of moderate size with the exception of the last and their range in the stratigraphic column is low, especially as Skull 22 and possibly 21 in the table may be placed entirely too high.

Of the second *Triceratops* phylum *T. elatus* is typical. In this race the nasal horn is very small and set well back from the terminus of the beak; the brow-horns, on the contrary, are very large. To this group belong *T. calicornis*, closely related to if not identical with *T. elatus*; probably also the immature though large *T. flabellatus*, and the gigantic "Skull 24" to which Marsh gave the manuscript name of *Triceratops ingens*.

The members of this second phylum are all large and range through the middle and upper portion of the Lance. To derive them from the first phylum would necessitate the retrogression of the nasal horn to which certain critics (Gidley in Peale, 1912, p. 751) object, although the principle is certainly well established in evolution. I am willing, however, to accept Mr. Gidley's main contention of the improbability of the reduction of a highly developed nasal horn while the brow-horns were being developed to be the principal ones.

Mammalian Localities

The table of ceratopsian distribution also shows the nearest mammal localities stratigraphically to each skull, and has enabled me to arrange them in an approximate sequence which, however, is open to the same chance for error as that of the skulls in that it is derived largely from the study of the map and the sections. It should, therefore, be verified by further accurate field work.

One thing at least is certain, that instead of being confined to any one level, mammalian remains are found throughout nearly the entire Ceratopsia-bearing beds.

From Peterson's quarry, Beecher's quarry, and Quarries Nos. 1-10 we have a recorded mammalian fauna. From Quarries 11-27 there is no recorded material at Yale or at Washington, so that at present I am unable to give a list of genera and species from them. This is unfortunate, as the four quarries highest in the list are included within the number and a record of their mammalian contents would be of great interest.

There are also a number of species of which the types bear no quarry number but which are in part duplicated by unnamed material the source of which is indicated.

The following table gives Marsh's original genera and species and in the adjacent columns their distribution in the several quarries is indicated. I have also identified in so far as possible all the additional material from these quarries, with

TABLE 2.

	Mammal-bearing quarries										Not recorded	No. 8, loc. not known	
	High ← Strat. sequence → Low												
	No. 10	No. 79	No. 5	No. 1	Peterson's	No. 76	Beecher's	No. 7	No. 3	No. 2			No. 4
T=holotype													
P=figured specimen													
Suborder Trituberculata													
<i>Stagodon nitor</i>					T							P	
<i>tumidus</i>												T	
<i>validus</i>				P								P	
sp. indet.				X	X							X	
<i>Platacodon nanus</i>					T								P
sp. indet.			X										
<i>Pedionomys elegans</i>				TP	P			X					
sp. indet.				X									
<i>Batodon tenuis</i>				P				P					P
<i>Didelphodon comptus</i>		X	X	TP								?P	?X
<i>ferox</i>		X		TP									
<i>vorax</i>				TP									P
sp. indet.				X	X							X	X
<i>Cimolestes curtus</i>	X			T									
<i>incisus</i>		X	P	TP				X				P	X
sp. indet.				X					X			X	
<i>Telacodon laevis</i>				T									P
<i>praestans</i>													T
<i>Dryolestes tenax</i>													T
Genus novum	X	X											
Suborder Allotheria (Multituberculata)													
<i>Allacodon fortis</i>													T
<i>lentus</i>		X	TP	X	P			X					
<i>pumilis</i>			?X	T									
<i>rarus</i>													T
sp.			X										
<i>Cimolomys agilis</i>													T
<i>bellus</i>			?X									TP	
<i>digona</i>	X	X	T		P								
(<i>Halodon</i>) <i>formosus</i> *	X				TP	X		X					X
<i>gracilis</i>				TP									
(<i>Nanomysops</i>) <i>minutus</i>				T				P	X				
sp.								X	X		X		
<i>nitidus</i>			P	T		P	P	P					
<i>parvus</i>				T			P						
(<i>Halodon</i>) <i>serratus</i> *				T			?X	X		P			
sp.		X		X				X				X	
<i>Meniscoëssus</i> (<i>Selenacodon</i>) <i>brevis</i>		?X		T				X				P	P
(<i>Triprionod</i>) <i>caperatus</i>				T							P		X
<i>cælatus</i>				TP									
(<i>Selenacodon</i>) <i>fragilis</i>		X		T									
(<i>Dipriodon</i>) <i>lunatus</i>		X		TP				X				P	
<i>robustus</i>		X	X	P	P			X		T		X	
(<i>Halodon</i>) <i>sculptus</i>			P	TP		P	P	X			P		
sp.												X	
<i>Oracodon anceps</i>	X	X						P				T	?X
<i>conulus</i>												T	
<i>Camptomus amplus</i>				TP									

* Referred to *Ptilodus* by Gidley, 1909, pp. 622-623.

the exception of Quarry No. 1 and Peterson's quarry. The former particularly was an immensely prolific locality and there are yet at least eighty-five vials containing unnamed specimens at Yale and more at Washington from these localities. These additions have served very largely to amplify the table, especially from Quarries Nos. 10, 9, 5, 7, and 3.

Comparing this table with that showing the distribution of ceratopsian species, it will be seen that no mammals are recorded above the level of *Triceratops brevicornus* type, so that those which were associated with the huge *T. "ingens"* and with *Torosaurus*, if there were any such, are unknown. Turning again to the table, the great number of species from Quarry 1 must be due in part to a happy accident of preservation; nevertheless some species range from the level of Quarry No. 1 upward, others downward, while some of the commoner species like *Meniscoëssus robustus* and *M. sculptus* continue throughout nearly the entire series. One rather remarkable feature is brought out, however, in that the Trituberculates are rarely found below the level of Peterson's quarry; Quarry No. 7, which is very productive, and a lone specimen in Quarry 3 constituting the record. The Multituberculates, on the other hand, are as plentiful below the level of Quarry No. 1 as above. This may be significant, though the greater resistance to destruction offered by the more massive multituberculate molars may in part explain it.

The material the quarry of which is unrecorded probably came very largely from either Peterson's quarry or Quarry No. 1, if one may judge from the date of shipment as compared with similar dates in Hatcher's field diary, in which the work done is meagerly recorded. Quarry No. 8 I can not locate, but it may be one of two unnumbered mammal localities, one of which would bring it not far from the level of Beecher's quarry, the other between Quarries No. 5 and No. 10. The last would be more in keeping with the "trituberculate" distribution.

Summary

It will be seen that the results of the above study are inconclusive in some important details, which only serves to emphasize the need of exact field work covering the entire area. This should include a carefully prepared topographic map whereupon the sections and fossil localities could be plotted with great accuracy, while the paleontological task should be to search minutely the whole region from south to north, keeping a careful record of the exact occurrence of any mammal deposits stratigraphically. There is reason to believe that such exhaustive search would be rewarded by

much more perfect material than any yet preserved. Possibly more complete jaws or even skulls and associated skeletal remains may be found, which alone will serve to put our knowledge of Lance mammals upon a more exact basis.

The main conclusions reached in the present paper are as follows :

1. That the mammals, instead of being confined to any one horizon, are pretty uniformly distributed throughout the entire Ceratopsia-bearing beds.

2. That the mammals are apt to be not far removed from lignitic deposits and are found in association with often worn scales and teeth of fresh-water fishes, generally in a bone conglomerate at the base of invading sands. This would seem to imply some transportation from the actual living habitat. The associated plant remains, both with the mammals and the Ceratopsia skulls, imply an abundance of vegetation, possibly forested conditions, in their respective homes, whether they differed or not.

3. That the more conservative and older Multituberculates range throughout the entire Lance, while the Trituberculates thus far found are absent from the lowermost quarries. This seems to be significant, for Multituberculates are known from the Jurassic and become extinct in the Palæocene, while descendants of the Trituberculates may still exist.

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