

Los Angeles Museum

Publication No. 1

Rancho La Brea

A Record of Pleistocene Life
in California

By
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Contribution No. 42



Science Series No. 1

Paleontology No. 1

PP. 1-84, 27 Figs. in Text

Los Angeles, California

April 15, 1930

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Los Angeles Museum
History, Science and Art

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Announcement

Although the Los Angeles Museum during the decade that has elapsed since its cornerstone was laid, has co-operated in a number of important scientific, artistic and historical activities, it has not heretofore attempted to publish the results growing out of such interests. In presenting "Rancho La Brea, a Record of Pleistocene Life in California" by Dr. Chester Stock, we take pleasure in designating the paper as Los Angeles Museum publication number one. Dr. Stock, who for many years has been engaged in scientific research in connection with the very large collection of Pleistocene fossils in this institution is eminently fitted for the presentation of an article of highly authoritative character. It is confidently felt that his paper is also well suited to serve as a foundation and cornerstone for the series of anticipated future publications emanating from the various departments of the museum.

Reference to the extensive bibliography cited by Dr. Stock will indicate the activities of the museum in its endeavor to co-operate with various authorities and institutions interested in paleontological research that have studied material excavated by the museum from the now famous tar pits of Rancho La Brea located on Wilshire Boulevard, Los Angeles, and now known as Hancock Park. Similarly, in the department of history, and the department of art, the museum has made valuable, though unpublished, contributions that have been utilized by students and experts. However, the publications heretofore issued by the museum under its own impress have been largely in the nature of catalogues, lists and reports of such a varied and occasional nature that in inaugurating a series of formal publications at this time, it seems best in the interests of uniformity, to disregard them as official publications of the institution. This paper then in addition to being a scientific document is also to serve as a guide to the museum's collection from the Rancho La Brea. It will supplant the popular pamphlet "Notes on the Pleistocene Fossils, etc." compiled by the late Mr. L. E. Wyman as an explanatory visitors' guide to the La Brea collections. The present booklet is therefore to be designated as the first official paper of what is hoped to be a series of publications emanating from the museum from time to time, growing out of the activities of the institution and recording the progress and achievements of its various departments.

For the foregoing reasons it seems desirable at this time to state that it is proposed that in the future all publications issued by the institution, regarded as of permanent value, will be issued as separate pamphlets under the general heading of Los Angeles Museum publications. Each publication will have its own title page, bearing its publication number in sequence. When desirable each pamphlet, irrespective of the number of pages, will be made up of a table of contents, list of illustrations, text, bibliography index and plates. Four series of publications will ultimately be recognized, namely: First: History series. Second: Science series. Third: Art series. Fourth: Miscellaneous series. All publications will also bear a series number. These series will be further subdivided and designated as emanating from various departments of the institution and will be numbered consecutively as the publications of that particular department. Reference to any publication or citations from any pamphlet issued by the museum should always be made by reference to the *page and publication numbers only*. Thus, reference to the present publication would read,—L.A.M.P. No. 1, p. —, fig. —. This arrangement admits of the binding of contributions as complete publications of the Los Angeles Museum, as series publications (History, Science, Art, Miscellaneous), as papers from a single department as paleontological papers, or as individual papers as may be desired.

WM. ALANSON BRYAN,
Director, Los Angeles Museum.

March, 1930.

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Rancho La Brea

A Record of Pleistocene Life in California

By CHESTER STOCK

Introduction



THE extremely unique collection of fossils secured from the asphalt deposits of Rancho La Brea finds no parallel among the great records of the past life of the earth brought to light by the paleontologist and geologist. Dating from a period not far remote in earth history, yet possessing presumably considerable antiquity as measured in terms of years, this collection furnishes a basis for reconstruction of a remarkably clear picture of life as it existed in the Los Angeles region of Southern California in late geologic time.

Among the many outstanding features of the Rancho La Brea collection are to be noted at once the wealth of material represented principally by skulls, teeth, and skeletal elements. The specimens displayed in the exhibit hall of the Los Angeles Museum are but a part of the collection secured from the asphalt deposits. In not a few types, individual skulls and parts of skeletons are duplicated many times by specimens not on exhibition. This abundance of skull and skeletal material has permitted an opportunity to prepare mounted skeletons of many of the characteristic forms, particularly of the larger mammals.

Moreover, the fine state of preservation of the material is sufficiently striking to be readily noted by the most casual observer. Lastly, a survey of the entire collection reveals an unusual variety of types, a fullness of life, that is encountered but rarely in the fossil record of a land-laid deposit at a single locality. More than one hundred different kinds of animals and plants have been described from Rancho La Brea. To this list doubtless other forms will be added as the study of the entire assemblage progresses.

It is not surprising therefore that the occurrence and collection have aroused considerable interest on the part of the scientific specialist and of the layman. Much intensive research during the past twenty years or more has resulted in the accumulation of a fund of information relating to these deposits and their exhumed

organic remains. This knowledge has been shared with the intelligent observer to whom fossils no longer make an appeal merely as objects of curiosity or as "medals of Creation." To further this interest and to serve the needs of the daily visitor to the exhibit hall of the Los Angeles Museum and the site of Rancho La Brea are the motivating desires prompting the present review of our knowledge of these deposits and their record of life.

A final statement can not be presented until the studies of many groups of organisms occurring in the asphalt are completed.

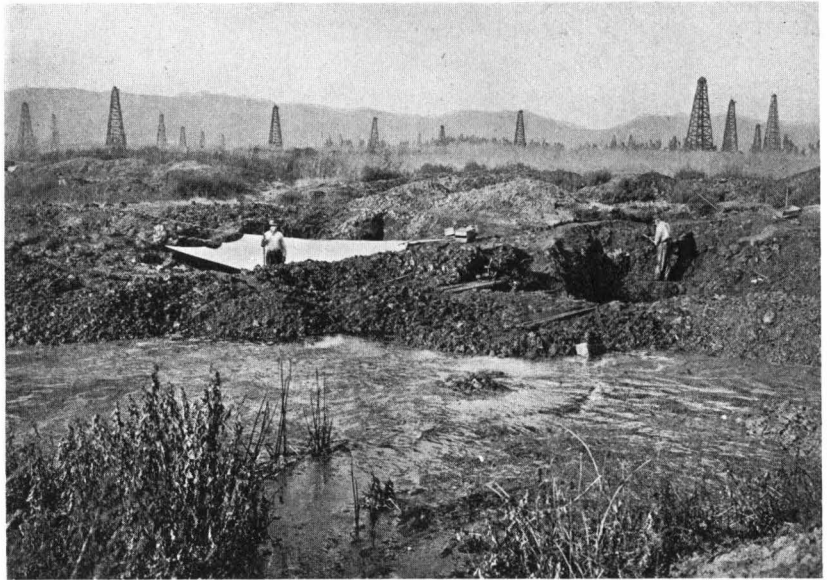


FIG. 1. View looking north showing Rancho La Brea and a portion of the Salt Lake Oil Field with Santa Monica Mountains in background. Museum pits 61 and 67 shown beyond pond. Photograph taken November, 1914.

A number of problems still await critical investigation and their satisfactory solution is perhaps attendant upon a more comprehensive knowledge of the American life of the Pleistocene. Of special importance are questions which relate to the occurrence and to the position of Rancho La Brea in late geological time.

Acknowledgments

The writer has drawn freely on the results obtained by a large group of students who have concerned themselves with Rancho La

Brea and its fauna and flora. The appended bibliography citing many papers relating specifically to Rancho La Brea furnishes at a glance the long list of contributors to this field of investigation. To Dr. John C. Merriam are we indebted particularly for valuable contributions to the many aspects of the Rancho La Brea occurrence and for his special studies of the Pleistocene mammals. The studies of Dr. Loye Miller have established likewise a very substantial body of facts concerning the birds of the asphalt.

History of Discovery and Development

Tar seeps or "springs of pitch" in the Los Angeles region were apparently first recorded by Gaspar de Portola in his diary of the Portola California Expedition of 1769-1770. Approximately seventy years later a second early report of the occurrence of bituminous springs near Los Angeles was made by the French explorer Duflot De Mofras. In his account appears the following statement:

"Two leagues to the southeast of Los Angeles there are four great sources of asphaltum, situated on a level with the earth in a vast prairie. These springs open in the middle of little pools of cold water, while the bitumen possesses a higher temperature. This water has a mineral taste, which, however, does not prevent animals from drinking it. At sunrise the orifices of these springs are covered by enormous bubbles of asphaltum, often being more than a yard high, and looking like soap bubbles."¹

On the map accompanying this report De Mofras indicates the source of the bitumen in the plains west of Los Angeles. Apparently the first cartographic record of the position of bituminous springs, which may be identified with those of Rancho La Brea,² is that made by E. O. C. Ord³ in 1849. On a topographical sketch map of the Los Angeles plains and vicinity, issued with Lieutenant Ord's report, the location of pitch springs is shown at a point several miles west of Los Angeles and south of the gap in the mountains now known as Cahuenga Pass.

In 1853 the region was again examined as part of the program of exploration for the Pacific Railroad survey. In the report of this

1. Mofras, Duflot De., *Exploration du Territoire de l'Oregon, des Californies et de la Mer Vermeille, executee pendant les annees 1840, 1841 et 1842.* 2 vols. with atlas in folio, pp. 357-358, Paris, 1844. Translation quoted from A. W. Vogdes, *Calif. State Min. Bur. Bull. No. 10*, p. 98, 1896.

2. The name Rancho La Brea refers to an old Mexican land grant in the vicinity of Los Angeles. As now generally understood the name applies more specifically to the plot of ground on which the fossil-bearing asphalt beds are located.

3. Report of the Secretary of War, communicating information in relation to the geology and topography of California. Report of Lieutenant Ord to General Riley, dated October 31, 1849. Senate Ex. Doc. 47, 31st Congress, 1st sess., pp. 119-127, 1 map, 1850.

expedition the geologist William P. Blake describes the occurrence of bituminous deposits, possibly those of Rancho La Brea. Not until 1875, however, was a published statement made of the occurrence of skeletal remains of extinct animals in the asphalt deposits of Rancho La Brea. In that year William Denton gives an account of his visit to the brea ranch of Major Henry Hancock, describes the asphalt accumulations which were then being excavated for their tar content, and states furthermore that Major Hancock presented him with a tooth which was later determined to be a canine tooth of a sabre-tooth cat. Denton at the time of his visit also secured bones and teeth of a fossil horse as well as other mammalian and bird remains.

The account given by Denton appears to have escaped further notice and apparently no interest in the occurrence of fossil materials

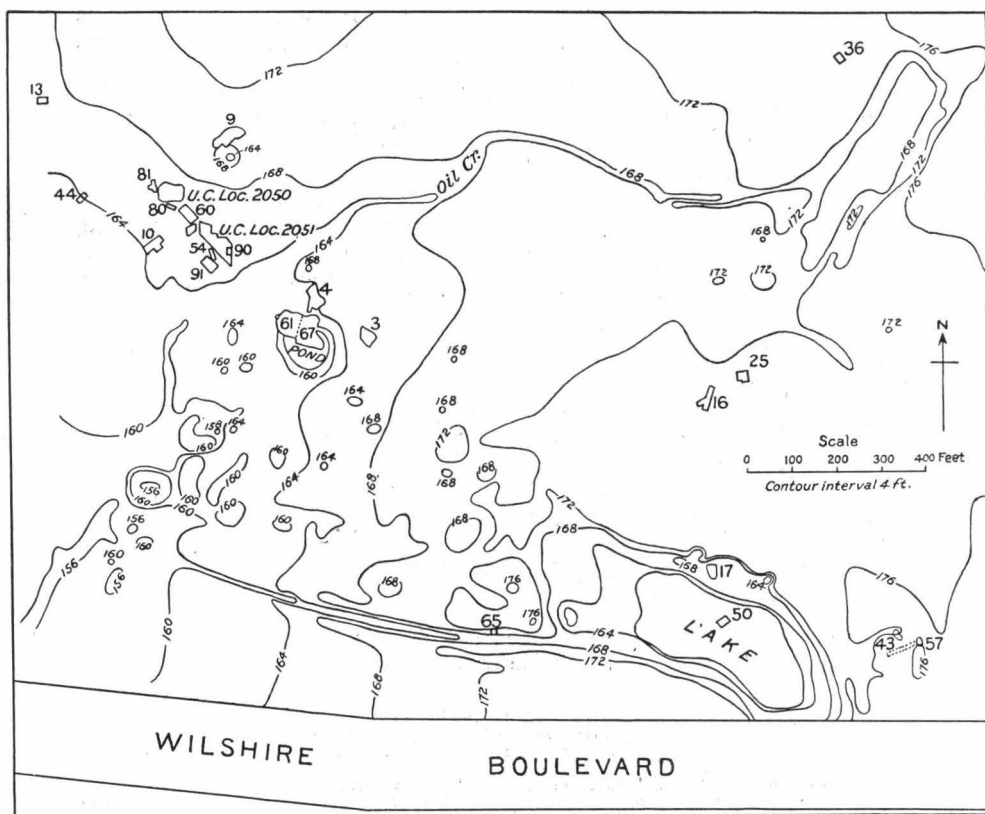


FIG. 2. Topographic map of Rancho La Brea showing location of principal excavations of the Los Angeles Museum and University of California.

at this locality was manifested by scientists until 1905. In these later years the scientific importance of the presence of fossil forms in the deposits was first recognized by Mr. W. W. Orcutt of Los Angeles. Late in 1905 the locality was visited by Mr. Frank M. Anderson and Mr. Orcutt and a number of fragmentary specimens were collected including a portion of a sabre-tooth cat skull, jaws of a large wolf and several dermal bones of a large ground sloth. The materials were placed at the disposal of Dr. John C. Merriam of the University of California. Dr. Merriam appreciated the importance of this discovery and on a visit to the locality was convinced that further excavating would yield larger collections.

Permission to excavate was kindly granted the University of California by Madam Hancock Ross and the subsequent explorations were carried on at intervals from 1906 to 1913. During this period other institutions were also active in the field, the Southern California Academy of Sciences, Occidental College, and the Los Angeles High School securing collections at that time.

In 1913 Mr. G. Allan Hancock granted Los Angeles County the exclusive privilege to excavate at Rancho La Brea for a period of two years. The excavations were conducted by the Los Angeles Museum and the materials obtained at that time are now preserved in this institution as the Hancock Collection, a memorial to Major Henry Hancock and Madam Ida Hancock Ross.

In recent years Mr. Hancock has generously given the tract of land on which the famous fossil beds occur, approximately 32 acres, to Los Angeles County with a request that the scientific features of the site be adequately exhibited and preserved. A public park of unique character and of exceptional interest, to be known as Hancock Park, will be maintained. Here can be seen exposures of the fossil-bearing asphalt with the bones, skulls, and teeth of the creatures that once were moving about over this region. Here also can be seen in progress at the present time an exudation of the tar and an occasional entrapment of organisms. While the activity which has brought about the surface outpours has diminished considerably since the period of formation of the large asphalt deposits, the accumulations forming to-day assist in an impressive way in the full appreciation of the conditions as they prevailed during an earlier time. Within the corporate mass of a metropolitan community there still remains at Rancho La Brea an indubitable link with the reality of a magnificent life of the geologic past.

Position in Geologic Time

Any attempt to reach a satisfactory determination of the position of Rancho La Brea and its life record in the geologic past must of necessity take into account the stratigraphic relationships of the deposits containing the fossil remains. The asphalt beds are essentially part of an alluvial formation consisting of sands, clays, gravels, and angular rubble whose present thickness may be several hundred feet as determined in the well borings of the old Salt Lake oil field lying immediately to the north of the fossil beds. Beneath this alluvial accumulation are older formations of marine shales and sandstones containing the oil sands from which the petroleum has been derived. The attitude and relationships of these earlier beds clearly indicate that they were folded and to some extent eroded prior to the accumulation of the more or less flat-lying alluvial deposits, for the latter rest upon their truncated edges.

Obviously the earliest age which may be assigned to the alluvium is limited by the age of the latest marine beds affected by the folding and of the period of deformation and subsequent erosion. In the present instance no attempt is made to evaluate in terms of years the length of time involved in these various events, for an evaluation of this kind in our present state of knowledge would yield at most but crude approximations. The sequence and relative position of the events in the geological time scale can however be determined with a considerable degree of accuracy. Granting the late Tertiary age of the underlying marine strata on the basis of geological and paleontological evidence, the superjacent series of loosely consolidated materials containing the asphalt deposits must be at least Pleistocene in age. If, as some geologists believe, early Pleistocene formations have also been involved in the folding which affected the strata of the Los Angeles basin prior to the accumulation of the formation containing the Rancho La Brea beds, it follows that the latter are elevated still farther in the geological column.

Determination of the latest age of the period of accumulation of the alluvial formation takes into account the sequence of geologic events which have transpired since its deposition. If the deposits were once somewhat thicker than at present, as has been assumed to be the case, then sufficient time must have elapsed to permit the forces of erosion to remove a portion of this material. The topographic relief of the region about the asphalt beds gives evidence of a terracing of

the alluvial formation. The absence of any considerable series of sediments in the vicinity of Rancho La Brea overlying the horizon of the asphalt beds would appear to indicate that the conditions for accumulation since the period of terracing have remained about as we find them to-day at this locality.

Viewing the problem of age in the light of the geologic facts, there can be no question that the deposits and the entombed life record are not older than the latest geological period antedating the Recent, namely the Pleistocene. Strong substantiating evidence is derived independently from the fossil assemblage. Many of the characteristic mammals occurring at Rancho La Brea are structurally similar to or identical with types described elsewhere from

PERIOD	EPOCH	Characteristic Formations in Southern California
Quaternary	Recent	<i>Alluvium (Land-laid)</i>
	Pleistocene	<i>Rancho La Brea (Land-laid)</i>
Tertiary	Pliocene	<i>Fernando (Marine deposits)</i>
	Miocene	<i>Modelo (Marine and brackish-water deposits)</i>
	Oligocene	<i>Sespe (Land-laid)</i>
	Eocene	<i>Domengine (Marine deposits)</i>
	Paleocene	<i>Martinez (Marine deposits)</i>

FIG. 3. Geologic divisions of the Cenozoic or Age of Mammals.

Pleistocene horizons. The position of Rancho La Brea in the geological time scale removes in large measure the surprise which may be manifested in the presence of a number of animals and plants regarded as identical with living species. Moreover, the changes which have occurred in the geographic distribution of many of these forms since the time of their entombment in the asphalt are in themselves an indication of the relative antiquity of the assemblage.

The Pleistocene, or as it is frequently called, the Glacial Period, records an exceedingly eventful chapter in the later history of the earth. Considering the length of time which elapsed during this period in North America, a more specific statement regarding the position of Rancho La Brea in the Pleistocene succession is highly desirable.

We are here confronted however with a difficult problem, whose solution has been diligently sought but not as yet obtained.

It becomes apparent from a study of the geologic features of the deposits and from a consideration of the fossil assemblage that the whole of Pleistocene time is certainly not recorded at Rancho La Brea. While the accumulation of the fossiliferous asphalt and the entrapment of organic forms doubtless represent a long period of time, these events are assumed to have furnished a cross-section of Pleistocene life for a particular stage in this period. Nor has it been definitely shown that in the deposits, as they are now known to us, there is evidence of a continuous entombment extending into Recent time from a time stage somewhere within the Pleistocene. The fauna secured from the various pits excavated by the Los Angeles Museum appears to be essentially an homogeneous assemblage. To be sure certain types of mammals and perhaps other forms are better represented in some pits than in others, but the possibility of a catastrophe overtaking an entire troop of elephants or a family of ground sloths in one pool cannot be wholly disregarded. Critical examination of the faunal composition of the various Pleistocene pits will probably throw additional light upon this matter.⁴

Significant in determining the position of Rancho La Brea in the Pleistocene is the relation of the fossiliferous asphalt to the surface developed on the alluvial formation of which it forms a part. A removal in the course of erosion of considerable material including perhaps still later accumulations of fossiliferous asphalt, would tend to accentuate the age of the Pleistocene deposits and life record. If, on the other hand, the formation in the course of aggradation had not reached a thickness much in excess of its present thickness or if the asphalt had entrapped organisms during the early stages of degradation, a somewhat later age would necessarily be conceded to the fossil assemblage. These are questions which can be answered perhaps only with the help of more detailed geological information. In either case, however, the geological features do not point to a very great antiquity for the fossiliferous beds.

4. Recent outpours of tar in which the life of the Recent period is registered, have been encountered in the excavations conducted at Rancho La Brea, but the deposits are not to be confused with the typical Pleistocene accumulations. The former are not to be compared in magnitude with the latter and contain, moreover, a life record in which the many characteristic elements of the Pleistocene population are conspicuously absent. (See pp. 28-30). The presence of pockets, pipes, and chimneys filled with tar or asphalt containing the bones of Recent mammals and birds is not unexpected in view of the constant movement of gas and oil to the surface from the oil sands below.

Unfortunately our knowledge of the life of the North American Pleistocene has not advanced to a stage where the life range in geologic time for many species of mammals can be accurately defined, nor can we state definitely the time of appearance or of disappearance of these forms. Much valuable information has been secured, particularly in the middle west where an attempt has been made to establish the position of various Pleistocene types in the succession of glacial and interglacial deposits belonging to this period. Similar information is almost wholly lacking for the California province and we may be

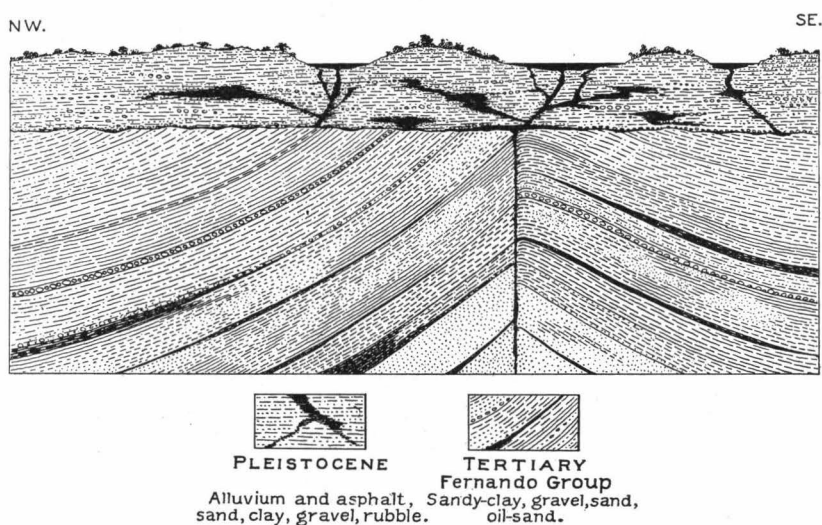


FIG. 4. Cross-section showing geologic structure and relationships of formations at Rancho La Brea during period of mingling of Pleistocene animals and plants. Character and structure of the sediments containing the oil sands taken from section in Salt Lake Oil field, after Arnold (U. S. Geol. Surv. Bull. 309, p. 189, 1907).

forced of necessity to seek other methods in determining our chronological sequence. Furthermore, there is no reason for assuming that the appearance or disappearance of mammalian groups in one region of North America implies the appearance or disappearance of these types at exactly or even approximately the same time in other regions of the continent. It seems desirable to point out some of the difficulties encountered in a study of the problem, for they emphasize the need of much additional investigation before a satisfactory chronological sequence can be established.

The presence in the deposits of still living species of plants and animals associated with characteristic types of the Pleistocene suggests that the assemblage approximates to this extent the Recent. In the past few years several occurrences have been noted in North America of rather well preserved remains of types, generally assumed to have disappeared with the Pleistocene, in deposits whose age may fall somewhere in the period of transition from Pleistocene to Recent or within the latter period of time. To cite a single example, A. S. Romer⁵ has recently described from a cave deposit near Fillmore, Utah, a remarkably preserved skull of a camel, belonging undoubtedly to the species represented at Rancho La Brea. The preservation of the specimen and the facts concerning its occurrence have led Romer to conclude that camels of this species were living at no very remote date on the North American continent. Additional evidence of this character may tend also to give a more youthful aspect to the Rancho La Brea assemblage.

Attention has been directed to the fact that since the period of accumulation of the asphalt the geographic distribution of several of the modern species represented by fossils at this locality has undergone change. This evidence and that derived from the entire Pleistocene assemblage point unmistakably to climatic conditions somewhat different from those which prevail today in the region of southern California. Presumably the change was slow and gradual. The absence of a number of typical cold climate forms appears to indicate that conditions were not rigorous. Some information would seem to suggest a cooler climate with perhaps a slightly greater rainfall than at the present time.

Origin and Physical Features of the Asphalt Deposits

It appears quite clear that the processes responsible for the accumulation of the tar beds are to be seen to-day in operation at this locality, although the forces and materials which have led to the special conditions of entrapment are insignificant in contrast to their former magnitude. The source rocks from which the petroleum is derived are the oil sands inter-stratified with the older shales and sandstones that underlie the Pleistocene beds in the region of Rancho La Brea. As determined by the geologic structure (see figure 4) in the Salt Lake oil field, these older marine strata are deformed or folded. Immediately to the north of Rancho La Brea a local upward flexure of the older

5. Romer, A. S., *Science*, N. S., vol. 68, pp. 19-20, 1925.

rocks, whose crest has been broken, is known to extend in a NE-SW direction and without much question facilitates the upward movement of gas and oil in the vicinity of the asphalt beds.

Presumably the exudation of the petroleum and penetration of the sedimentary strata, forming the tar pools and asphaltic material, occurred concomitantly with deposition of the Pleistocene alluvial accumulation, for asphalt deposits have been encountered at various levels from the base to the top of the formation. At the present time oil



FIG. 5. Example of a "tar volcano" in the Summerland Oil field, Santa Barbara County, California. Photograph by Ralph Arnold; courtesy of U. S. Geological Survey.

and gas reach the surface through small fissures, pipes or chimneys, the oil forming small and generally shallow pools about the vents. This activity can still be seen at Rancho La Brea. Bubbles of gas rise constantly to the surface of the artificial lake and the outpours of oil spread over and through the soil of the adjacent ground. It is interesting to note that occasionally a downward movement of the oil or tar can be discerned at the vents. A temporary release of gas pressure below permits the heavy oil to recede again into the pipe or chimney whence it has exuded. The downward flow may carry remains of organisms or hardened lumps of asphalt and other detrital materials

from the surface mass into the pipes. This action is of significance in suggesting perhaps a factor responsible for the movement of submerged animal remains in the larger Pleistocene outpours. When the oil reaches the surface its more volatile constituents escape leaving a denser residue which becomes crusted. This hardening of the surface may occur rapidly along the edges of the pool and may extend gradually inward towards the middle. The surface may remain exposed for some time or may be gradually covered by soil or dust. During certain seasons of the year or during the heat of the day the asphaltic crust becomes quite soft.

During the Pleistocene the exudation of the petroleum was doubtless much more extensive than at the present time. The pools of oil which were formed, occupied the natural depressions of an irregular land surface and were on occasion many square feet in area. The depth and borders of these pools were probably variable features. Excavations conducted at Rancho La Brea have shown that the fossiliferous asphalt was frequently of irregular outline and varied from relatively shallow accumulations to thick deposits having a maximum depth of 30-35 feet. On the average, however, productive pits reached a depth of approximately 15-25 feet.

That the outpouring of oil and tar contributed to the building up of the land surface is suggested by interesting evidence secured in Pit 3 of the Los Angeles Museum excavations. Here, at a depth of approximately 4 feet was first encountered, what later proved to be, an upright trunk of a conifer. The top of the tree had either burned or rotted away. At a depth of $7\frac{1}{2}$ to $8\frac{1}{2}$ feet a large limb projected from the trunk and at a level of 12 feet the tree was found to be definitely rooted in a stiff clay. The material surrounding the trunk was clay, sand and asphalt. Packed also about the limb and portions of the trunk were dense masses of bones and skulls representing many of the typical mammals and birds of the Rancho La Brea Pleistocene assemblage. There can be little question that the tree occurred *in situ*, growing perhaps originally along the border of a depression in which detrital materials and asphalt were accumulating. Continued exudation of oil may have caused ultimately an encroachment of the asphaltic mass upon the tree with consequent juxtaposition of the entombed animal remains.

It appears possible that not all the pools were formed in natural depressions occurring at the Rancho La Brea locality during the Pleistocene. Sudden expulsions of large quantities of gas and oil accom-

panied by sufficient force may have formed in the past crater-like vents many feet in diameter. Presumably the excavations thus created were partially or totally filled by an inflow of viscous material. Moreover the rim of a vent of this type was perhaps elevated somewhat above the general level of the adjacent surface, forming a buttress against which clays, sands and rubble may have been deposited. Small crater-like structures are occasionally seen at the present time in the oil fields of California. Arnold,⁶ for example, has figured (see figure 5) a small "tar volcano" in the Summerland field. Additional infor-



FIG. 6. Ground squirrel (*Citellus*) mired in Recent tar seep at Rancho La Brea.

mation pointing toward this method of formation of a fossiliferous asphalt bed is seemingly to be found in some of the productive fossil pits excavated by the Museum. Contour records apparently indicate in some instances a more or less funnel-shaped mass of asphalt in which fossil remains occur.

Mode of Accumulation of the Fossil Material

The small pools of oil or tar now forming at Rancho La Brea are known to catch and hold in their midst the unfortunate creatures

6. Arnold, Ralph, U. S. Geological Survey Bull. 321, Pl. III, B, 1907.

who unwarily have come in contact with the sticky substance. Thus the pools present a unique and most efficient type of trap operating almost unceasingly and capable of catching many of the birds, mammals and insects now inhabiting the region. Similarly the more extensive Pleistocene outpours, situated in a region richly stocked with vertebrate life, also entrapped animals, but the larger size and greater depth of these pools permitted even greater tragedies to occur. It is not difficult to visualize some of these Pleistocene catastrophes. A single animal, large or small, becoming mired in the tar would as a result of its struggles and cries lure others to the trap. The carnivorous birds and mammals seeking to reach this bait would frequently fall victims to the tenacious grip of the viscous material and thus in turn would serve to attract still others to the pool.

It is conceivable that a single pool might gather into its mass in an incredibly short time a great many victims, whose remains now form the remarkable accumulations of bones, skulls, and teeth found at Rancho La Brea. That the carnivorous types were ever ready to yield to temptation in a desire to reach the baited prey and were therefore particularly susceptible to entrapment and subsequent entombment is clearly attested by their preponderant representation. Attention has been directed to the occurrence of many remains of young, aged, and maimed individuals. Doubtless the age of the animal, its keenness in sensing danger, and its ability to secure food in and away from the traps are but a few of the causes contributing to the uniqueness of this type of accumulation.

Nature and Preservation of the Fossil Remains

The peculiar character of the embedding material, a heavy oil or soft tar in some instances, or frequently a granular asphalt, has without much question contributed largely to the excellent preservation of the animal and plant remains. Seldom indeed are conditions found so favorable for the reconstruction of a life record of the past. To be sure the softer animal tissues have disappeared and we are therefore dependent upon the structure of the harder parts, as for example skulls, teeth and bones, for an identification of the various forms.

The abundance of the latter material has been commented upon many times. Specimens of mammals and birds are particularly well represented, the various skeletal elements and skulls of these types forming not infrequently thickly matted accumulations as shown in

figure 7. The distribution of these deposits is usually irregular, the masses of bones occurring as pocket-like concentrations in the asphalt. Merriam states that in a mass comprising less than four cubic yards, a careful count indicated the presence of more than 50 heads of the dire wolf, at least 30 skulls of the sabre-tooth cat, and numerous remains of bison, horse, sloth, coyote, birds, and other forms. Reptiles and amphibia are but sparsely represented. Insect remains occur but



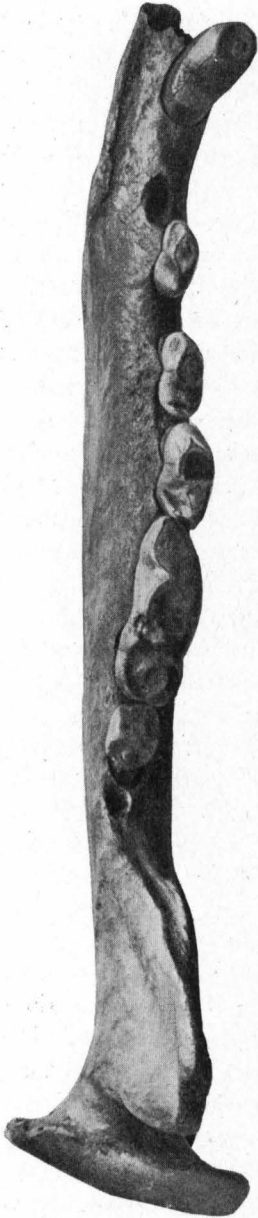
FIG. 7. Excavation in Los Angeles Museum Pit 4, Rancho La Brea, showing exposure of skulls and bones of Pleistocene animals. Note wolf skull at top, camel skull with teeth exposed at middle, and bison skull at bottom.

are not exceptionally abundant. The record of plants is rather limited as to species and the material consists principally of wood with an occasional cone. In addition leaves and seeds have been found.

Skulls, teeth, and skeletal elements found at Rancho La Brea have come down through time practically unchanged from their original state. During the period of entombment the investing substances have found their way through the hard layers of the bones and teeth. Save for a thorough penetration by the oil and a prevailing black or brown color imparted to the bone, little difference in state of preservation is noted between this material and that of modern forms. Oil or tar may accumulate in quantity in the remote sinuses of skulls or in the marrow cavities of the long bones. The brain and nasal cavities of skulls are filled with asphalt which frequently has carried into these chambers the osseous remains of small mammals and birds. The soft matrix has likewise held intact the largest as well as some of the smallest bones. It is interesting to mention that from some mammalian skulls have been recovered the tiny bones of the inner ear. Teeth are generally well preserved and often retain the evidences of wear to which they were subjected in life. Limb elements exhibit not only the form and manner of articulation with adjacent bones but also many surface markings showing the courses of nerves and blood-vessels and the place of attachment of important tendons and ligaments.

Injured and diseased bones and teeth occur in the collections. Fractured bones that have healed in life are found among the mammalian and avian remains. Bone lesions due to pathological disturbances other than those arising from fractures are not uncommon. Materials displaying the characters of wear and disease emphasize the reality of the organic remains from the asphalt and point unmistakably to the fact that they were parts of once living creatures.

Curious as it may seem, the epidermal structures of vertebrates are not preserved. Thus, no preservation has been noted of hair or feathers, of the strong, horny nails and claws in mammals, or of the horny beaks and talons in birds. On the other hand, parts of the chitinous bodies of insects are present in the asphalt. Wood found at Rancho La Brea has a remarkably fresh appearance and, as may be expected, burns readily. Cones of pine and cypress have been thoroughly impregnated by the oil and exhibit their structures in considerable detail. Occasionally leaves occur, but more often only the impressions remain, in which however the details of the nervation can still be discerned.



Frequently parts of an individual skeleton are associated in the asphalt, although movement in the mass has tended to shift the bones laterally and vertically. It appears not improbable that in some instances a fairly complete skeleton occurred within a radius of relatively few feet. Moreover, with the exposure of bodies at the surface of a tar trap it appears logical to assume that parts were occasionally destroyed or devoured before submergence preserved the remains. Movement of the osseous material is apparently indicated also by what has been termed "pit wear." The larger bones may exhibit grooves or cuts which apparently cannot be ascribed to the work of predatory beasts. The abrasions may be deep and in some specimens have nearly sheared an individual bone in two. Specimens are known in which the outer surfaces are almost entirely destroyed by such wear.

In contrast to these specimens, skeletal elements in the collections exhibit surface effects clearly due to attrition by organic forms, presumably carnivores and rodents. Relatively large abrasions have been noted in which chips of bone an inch or more in length have been flaked off or broken away. Apparently in some cases the bite has been strong enough to expose the marrow cavity. Small abrasions also occur, usually in the form of grooves approximately one-sixteenth of an inch in width, and sometimes parallel. An individual groove may show on closer inspection minute transverse ridges representing stages in the production of the groove by the chisel-like edge of the incisor teeth of rodents.

FIG. 8. Superior view of lower jaw of the large dire wolf (*Enocyon dirus* (Leidy)). Specimen belonged to an old animal in which the teeth were considerably worn during the life of the individual. Los Angeles Museum collection; Rancho La Brea Pleistocene.

Occasionally the two types of markings are superimposed. It is apparent also that the mammals intent upon breaking or gnawing a particular bone found a convenient grasp along the more pronounced borders, for the latter are often scarred. Skeletal remains exhibiting these features may have furnished a source of food coveted particularly by the strong-jawed carnivores and by the smaller gnawing forms.

The exposure of mammalian materials for any length of time at the surface of a tar pool, or in its immediate vicinity, is indicated not only by the markings left by other mammals but also by the type of preservation of the compact bony tissue of the skull and skeletal elements. The osseous remains usually retain their smooth external surfaces except where these have been modified for ligament or tendon attachment. In some instances, however, the material exhibits quite strikingly the effects of weathering, the specimens although thoroughly penetrated and stained by the oil possess a surface appearance so closely similar to that of weathered skeletal remains found lying on the plains at the present time as to fully justify the recognition of similar causes.

Occurrence of Human Remains

Since the deposits in which human remains and associated vertebrate material were found at Rancho La Brea are apparently not of the period of antiquity of the Pleistocene fossiliferous asphalt, as demonstrated by the preliminary investigations of Dr. John C. Merriam, Man must be excluded from a consideration of the older fauna. In view, however, of a constantly increasing knowledge of the history of early Man in America and of certain associational features of the occurrence at Rancho La Brea, it appears desirable in passing to relate some of the more important features of this discovery.

Portions of a human skull and associated skeletal remains were encountered by the Los Angeles Museum in the course of excavations in Pit 10 at a depth extending from approximately 6 to 9 feet. The remains occurred in one of two pipes or chimneys arising from an asphaltic reservoir below and connecting with a surface flow above. The material filling the pipe consisted of a viscous mass containing sand and the hardened lumps of weathered asphalt. Presumably the material was in part derived from below and in part from above. With the human remains and within the mass filling the pipe occurred also the remains of many birds and mammals. The striking features of the bird and mammal assemblage were the close resemblance which



FIG. 9. Lateral views of upper arm bone of dire wolf (*Enocyon dirus* (Leidy)). Figure on left, specimen showing a healed oblique fracture with an abnormal bone growth; figure on right, a normal specimen of the same bone. Both to same scale. Los Angeles Museum collection; Rancho La Brea Pleistocene.

it bore to the fauna of Recent time and the absence of the characteristic mammals of the Pleistocene asphalt deposits. The only extinct type definitely recognized as occurring in this assemblage was the large *Teratornis*, a condor-like vulture described from the Pleistocene asphalt of Rancho La Brea. Bones of this bird were found in the fill of the chimney well above some of the human remains.

The human remains belonged to one individual and were clearly those of a modern type. Judging from the structural features of the skull this individual apparently possessed racial characteristics not unlike those of the aboriginal peoples known to have lived on the Channel Islands and in the coastal province of southern California prior to the advent of the white man.

The possible contemporaneity of Man and the extinct bird *Teratornis* may indicate some antiquity for the human type or a relatively late extinction of certain birds and perhaps mammals once prevalent in this region. A presumed late disappearance of *Teratornis* is, however, particularly interesting in view of an expected, relatively early extinction of the larger types of animals occurring at Rancho La Brea. In summarizing the available information relating to the occurrence of human remains at Rancho La Brea, Dr. Merriam in a preliminary report states in part: "The evidence as a whole indicates that the human skeleton from Pit 10 is of a period much later than that of the typical Rancho La Brea fauna, the time being either within the Recent period or not earlier than the very latest portion of Pleistocene time."

The Mammalian Assemblage

The most striking feature of the Rancho La Brea mammalian assemblage is the preponderant representation of the predatory forms. In this single character the fauna differs noticeably from living and extinct assemblages dwelling under the environmental conditions of the plains or open country where the balance between carnivores and herbivores has not been materially disturbed. This peculiarity is without much question the direct result of a most effective lure presented by the victims in the tar traps, which has tended particularly to bring to the pools members of the flesh-eating mammals.

A census taken of the Pleistocene mammals recorded in the collection of the Los Angeles Museum, reveals a total number of at least 4264 individuals.⁷ Of this number 3894 or 91 percent are carnivores,

7. One type, namely the tapir, not represented by materials in the Los Angeles Museum collections but occurring in the University of California collection from the asphalt, has been added to complete as nearly as possible the list of mammals from the Pleistocene locality.



FIG. 10. Two views of shin bone of large lion (*Felis atrox* Leidy) showing tooth marks left by carnivores and rodents. Los Angeles Museum collection; Rancho La Brea Pleistocene.

while the remainder or 9 percent are herbivores or predominantly plant-feeders. Figure 11 illustrates graphically the relative size of the various orders of Rancho La Brea mammals. Among the Carnivora the largest number of individuals is included under the canid or dog family, with the cats forming the next largest group. The dogs constitute 57 percent of the carnivore population, the cats 40 percent. Each of these groups greatly exceed in numbers the bears and mustelids. The raccoons are conspicuously absent. Among the plant-feeders the largest family is that of the bison (Bovidae). Then follow in turn the horses (Equidae), the mylodont ground sloths (Mylodontidae), the camels (Camelidae), the antelopes (Antilocapridae), the megalonychid ground sloths (Megatheriidae), the elephants (Elephantidae), the mastodons (Mastodontidae), and the deer (Cervidae). Lastly come the peccaries (Tayassuidae) and the tapirs (Tapiridae).

Within families in which extinct mammals are associated with types which range from Pleistocene to Recent, the former are always represented by a greater number of individuals. In other words, the typical Pleistocene forms in the Rancho La Brea fauna are relatively more important elements in this assemblage than those types which are characteristic of the Recent period but whose range extends also into the Pleistocene. Thus within the dog family the number of dire wolves is far in excess of that of the coyotes and gray wolves. The modern gray fox is known by only 15 individuals. Among the cats the sabre-tooth, a form now entirely extinct, is much better represented in the fauna than the great lion. The latter while specifically different is still closely related to the large living cats of the Old World. Both the sabre-tooth and the lion greatly exceed in numbers the puma and the lynx. Among the bears the tremarctotheres, or short-faced bears, are twice as abundant as individuals of the black bear-grizzly bear group. Among the hoofed mammals where comparison can be made the same relationship is evident. Within the antelope family, an extinct type (*Capromeryx*) forms a decidedly more important group than the modern prong-horn.

Factors Influencing Group Representation Among the Mammals

The relative size of the groups of Pleistocene mammals, whose range does not extend into the Recent period, is in a measure an index of the antiquity of the assemblage. In other words, the position of the Rancho La Brea fauna in geologic time is undoubtedly reflected

by the many typical Pleistocene mammals in the assemblage, and the element of time becomes therefore an important factor responsible for the representation of types. Were Rancho La Brea a stage occurring in the Recent rather than in the Pleistocene period, its position would probably be indicated by a noticeable decrease in the number

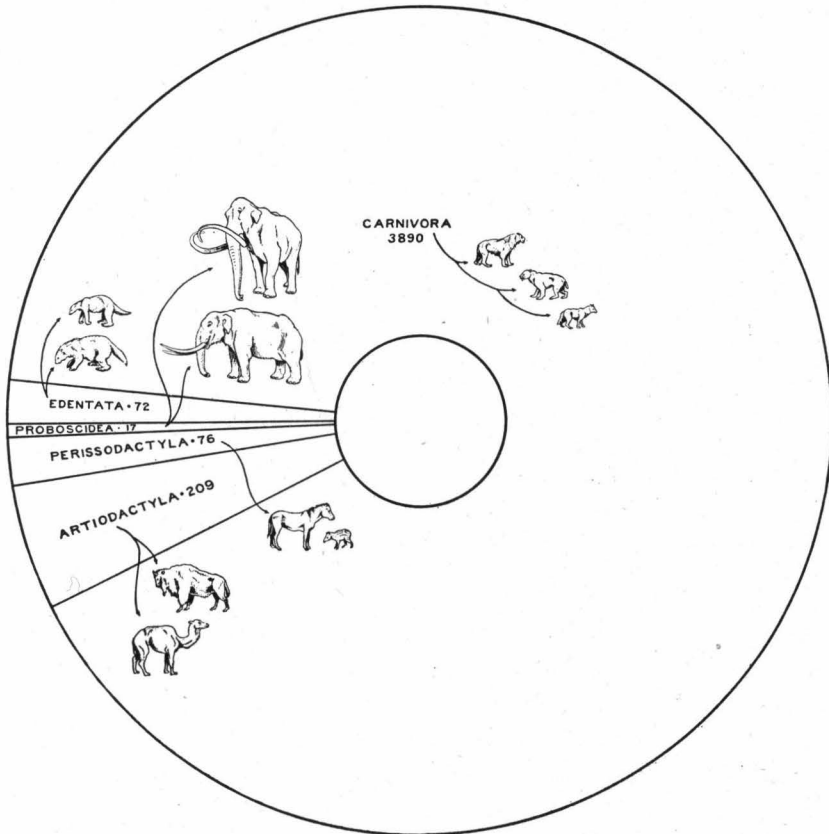


FIG. 11. Diagram illustrating relative sizes of orders of Pleistocene mammals (exclusive of rodents, insectivores, and bats) occurring in the asphalt of Rancho La Brea. Note preponderance of predatory forms.

of typical Pleistocene mammals and by an increase of those forms characteristic of the Recent.⁸

In addition to the factor of time, the determining elements exerting an influence on the occurrence of the various groups of mammals

8. The Recent fauna is a natural outgrowth of that of the Pleistocene. The lack of considerable diversity of type at the present time is largely, but not entirely due to the extinction of many of the older forms. Accurate knowledge of the time of disappearance of these earlier types is of great importance in determining the exact position of Rancho La Brea in the chronological succession, but we are here not especially concerned with this problem (see page 19).

appear to be found in the environmental conditions which prevailed and in the habits of the animals themselves.

THE ENVIRONMENT IN AND NEAR THE TAR TRAPS.—Undoubtedly the remarkable representation of the dire wolves and the sabre-tooth cats reflects in large measure the conditions prevailing in the immediate vicinity of the asphalt accumulations and the availability of a food supply. While the dire wolves undoubtedly preyed upon the large, cumbersome, and slow-moving mammals with which they were associated, it appears also probable that the group in a broad way occupied a position in the Pleistocene fauna like that occupied by the hyenas in the living assemblage of South Africa. The tar traps, with their living hosts and partly devoured, dismembered carcasses, may be regarded as offering especially favorable feeding grounds for these types.

The sabre-tooth in contrast to the great lion seems quite certainly not to have been a predatory form depending upon its fleetfootedness in securing its prey. It exhibits rather an organization admirably adjusted to grappling and fighting at close quarters. Truculent to the extreme, this creature found its victims particularly among the slow-moving mammals and the stationary live bait of the tar traps. The unfair advantage which the sabre-tooth cat possessed around the borders of the asphalt accumulation was apparently compensated only by its own high mortality.

THE ENVIRONMENT OF THE REGION ABOUT RANCHO LA BREA.—That the country surrounding the asphalt deposits presented topographic features essentially similar to those characterizing the Los Angeles area to-day is suggested by the mammalian assemblage as a whole and apparently also by the geologic history of the region. The climate may have been as equable as it is to-day with, however, a somewhat greater precipitation. A plains, or open rolling country supporting a richer vegetation than that of the present, in which grass-covered surfaces were interspersed with copses of trees and brush, appears to have been favorable for the development of a diverse population of hoofed mammals. In this environment would be normally found such types as the bison, horse, mylodont ground sloths, elephants, camels, and antelopes. Associated with these herbivores would occur typical cursorial carnivores like the lion and the coyote. As important members of the community should be listed the dire wolves and the sabre-tooth cats. One might regard this assemblage as the resident population.

In contrast to this group the sparse representation at Rancho La Brea of such types as the megalonychid ground sloths with browsing habits, the tapirs, peccaries, deer, mastodons, and doubtless other forms, may be interpreted as indicating mammals that were not habitually to be found in this region but which only occasionally penetrated it from adjacent areas. The region seems, however, to have been sufficiently wooded or covered with brush to afford shelter to a number of diminutive antelope (*Capromeryx*). The latter, possessing possibly nocturnal habits, may have occupied a niche in the environment some-

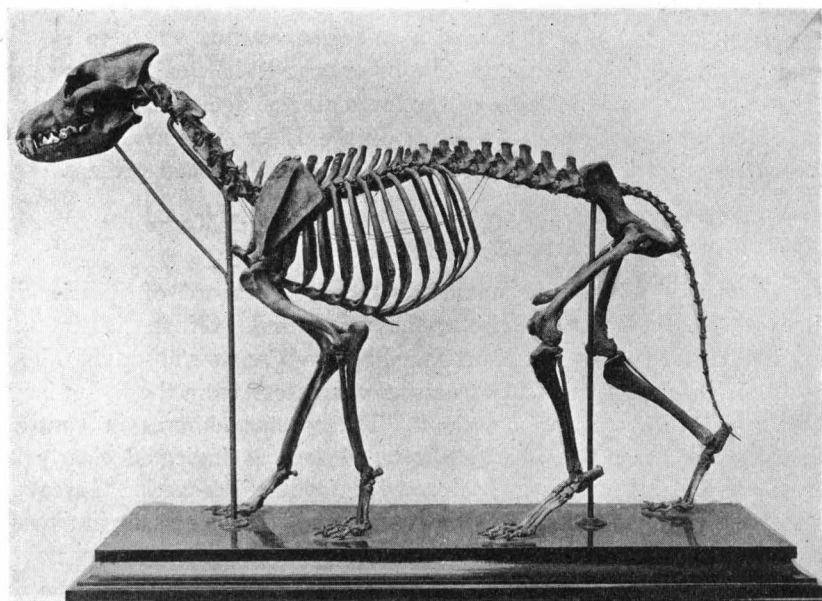


FIG. 12. Skeleton of large dire wolf (*Aenocyon dirus* (Leidy)). Los Angeles Museum collection; Rancho La Brea Pleistocene.

what like that in which the dik-dik and duiker antelopes of South Africa are found to-day.

It is curious to note the total absence in the record of members of the raccoon family. That these forms were absent in the Los Angeles region during the period of entombment at Rancho La Brea seems rather unlikely. The raccoon has been recorded in the Pleistocene of California and its range at the present time extends into this southern area. Possibly the extreme wariness of this mammal may account for

its absence in the asphalt. The absence of the kit-fox may be due to the presence of the less arid conditions than prevail at present.

Contrary to opinion sometimes expressed, there appears to be no special reason for assuming that the mammals found at Rancho La Brea were attracted to this particular locality by the presence of water. A comparison of the environment at Rancho La Brea and that about a water hole on the African veldt does not appear to be entirely warranted. While springs, ponds, and some flowing water may well have been present in the immediate vicinity of the asphalt beds, it seems also probable that at no great distance were streams, as for example the predecessor of the present Los Angeles River, which even during the driest seasons may have had a sufficient flow of water to sustain the animal life of the region. In other words it would appear unnecessary to assume, because of the large assemblage recorded, that the surrounding area during this stage of the Pleistocene was as devoid of water as are the drier portions of the African veldt at present.

Consideration of Individual Groups of Mammals Ursidae (Bears)

Among the bears discovered in the fossil record of Rancho La Brea three distinct types are to be recognized. Of special interest are the tremarctotheres or short-faced bears (*Tremarctotherium*). This form differs in a number of structural characters from the living bears of the North American continent. The tremarctotheres in contrast to the black bears possessed a shortened face as indicated clearly by the skull and by the somewhat crowded front cheek-teeth. Moreover, while the number of teeth in the upper and lower jaws is similar to that in existing bears of North America, the carnassial or principal cutting teeth (upper premolar 4 and lower molar 1) are somewhat more like those in typical carnivores like the dogs than the corresponding teeth in bears of the grizzly or black bear type. Doubtless the tremarctotheres were more carnivorous in their habits than were the true bears. These forms are characterized also by very large size, in which respect they resemble the great brown and kadiak bears of the coastal region of Alaska. They were undoubtedly the largest flesh-eating mammals occurring at Rancho La Brea.

The tremarctotheres enjoyed an extensive distribution over the North American continent in Pleistocene time, for remains of these creatures have been found in the Yukon, in Pennsylvania, Kentucky and Texas, and at a number of localities in California. This group

of bears while now entirely extinct, is seemingly more closely related to the spectacle bear of the South American Andes than to any living North American type.

The true bears are represented in the Rancho La Brea fauna by a black bear and by the grizzly. These forms are closely related to types now living in the California region, or existing here during the historic past. The fossil black bear possessed relatively large grinding teeth, in which character it differs specifically from its living relatives.

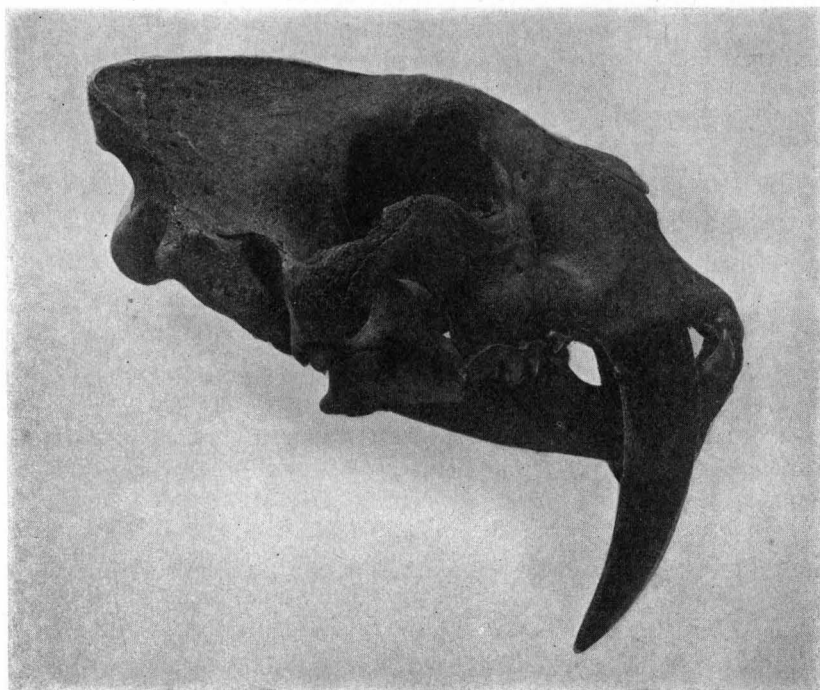


FIG. 13. Lateral view of skull of sabre tooth cat (*Smilodon californicus* Bovard). Los Angeles Museum collection; Rancho La Brea Pleistocene.

Within the bear family it is interesting to note that those forms most closely related to types now living in California were distinctly outnumbered by bears of a kind now entirely extinct. With the disappearance of the tremarctotheres, however, the black and grizzly bears established themselves as the prevailing representatives of the family in California. The grizzlies have since become extinct in this region.

Mustelidae (Skunks, Weasels, Badgers)

Like the rodents the smaller Pleistocene carnivorous mammals, particularly those of the mustelid family, from Rancho La Brea, are closely related structurally to living representatives of the group. It is probably not surprising to find recorded in the asphalt the striped skunk (*Mephitis*), spotted skunk (*Spilogale*), weasel (*Mustela*), and badger (*Taxidea*), in view of the habits of these animals at the present time.

The predaceous skunks and weasels feed on small mammals and birds. The prevalence of the latter forms in and about the asphalt traps undoubtedly accounts for the presence of their natural enemies. The badgers with food habits somewhat like those of the skunks and weasels are fossorial. It appears not improbable that in some instances these mammals were trapped in their burrows during the exudation or outpouring of the tar. On the other hand, badgers are known to move about considerably over the surface of the ground and may have floundered on occasion in the petroliferous material.

Canidae (Wolves, Coyotes, Foxes)

Individuals of the canid or dog family are the most commonly occurring mammals in the Rancho La Brea assemblage. No other group of carnivores is represented by so great a number of individuals, although the cats make a close approach in this respect. The dogs from the asphalt deposits were described in detail by Merriam (1912).

An unusual feature of this group is the large representation of the dire or grim wolves (*Ænocyon*). These forms were presumably very wide-spread over the North American continent during Pleistocene time, for their remains have been encountered fossil at a number of localities. Originally described from Pleistocene deposits in the Mississippi Valley, the dire wolves have since been recognized as far east as Florida and as far south as the Valley of Mexico. In addition to the occurrence at Rancho La Brea records of their presence in California have been found in Pleistocene deposits of Livermore Valley, in beds of similar age along the border of the San Joaquin Valley, and at several other localities.

Ænocyon dirus (Leidy), shown in figure 12, is a large species of wolf approximating in form and proportions the timber wolf. This type is characterized by a relatively heavy head, relatively small brain, massive dentition, and possessed, as judged from the structure of the

skull, a strong masticatory musculature for biting and for breaking large bones. The feet while not noticeably different from those of typical dogs, appear to be relatively shorter than in the timber wolf type.

The comparatively light limbs, short feet, and heavy head suggest a creature less fleet-footed than the coyote or timber wolf. The massive dentition suggests a propensity to bone-crushing or splitting, and it appears not improbable that these wolves fed also on carrion. Mer-



FIG. 14. A series of four anterior lumbar vertebrae of the sabre tooth cat (*Smilodon californicus* Bovard). Upper figure, fused vertebrae with ossification of the lateral muscle mass; lower figure, a series of corresponding vertebrae in a normal individual. Los Angeles Museum collection; Rancho La Brea Pleistocene.

riam has remarked concerning the habits of these creatures as follows: "The form of the skull suggests that the head was normally held low and was often used in hard pulling and hauling of heavy bodies. The great number of individuals of *C. dirus* found at Rancho La Brea

suggests that the wolves of this species sometimes associated themselves in packs, and that groups of considerable size may have assembled to kill isolated ungulates and edentates. Particularly the young, aged and injured, when they could be separated from their associates, would be the natural prey of the great wolf, but adults in normal strength may also have succumbed to the combined attack of several of these powerful animals."

Associated with the dire wolf although occurring much less frequently was another member of the *Ænocyon* group. This form, described as *Ænocyon milleri* (Merriam) and as yet recognized only on the basis of skull material, differs in certain structural characters of the skull and dentition from the typical dire wolf.

Still another dog, occurring again more rarely than the dire wolf, is *Canis furlongi* (Merriam), a type related rather closely to the modern gray wolves.

In the canid family the coyote group ranks next to the dire wolves in number of individuals found in the asphalt. These animals occur, however, approximately one-tenth times as frequently as *Ænocyon*. The coyotes are known principally by one species (*Canis ochropus orcutti* Merriam), very closely similar in structure of skull, dentition and skeleton to the coyote (*Canis ochropus* Eschscholtz) living today in the Los Angeles region. Another type, known by a single skull in the University of California collection, differs from the existing coyote in possessing a relatively short and broad muzzle. This coyote-like wolf has been described as *Canis andersoni* Merriam.

The presence of many coyotes at Rancho La Brea is presumably due in large measure to the prevalence of their natural prey, namely, small mammals and birds held captive in the tar or hovering about the tar pools. In contrast to the dire wolves the decidedly smaller representation of the coyotes may be accounted for by assuming a less frequent occurrence of these carnivores in the vicinity of Rancho La Brea during the period of accumulation of the asphalt beds, or a distinctly greater intelligence on the part of these creatures in avoiding the dangers of the petroleum traps. With the passing of the Pleistocene and the extinction of the dire wolves, the coyotes have established themselves as an important group of carnivores in the region.

A gray fox identical with the modern species (*Urocyon californicus* Mearns) is also recorded. The desert kit fox (*Vulpes*) is however absent, indicating perhaps less arid conditions during the period of accumulation than at the present time.

Felidae (Cats)

The cat family as recorded in the asphalt includes representatives of both the sabre-tooth and true cat groups. Perhaps the most unusual type in point of specialization is the sabre-tooth (*Smilodon*). This form ranks next to the dire wolf in number of individuals found in the tar pools and greatly outnumbers all other types of cats.

The sabre-tooth approximated in size the African lion, although the body and limbs were somewhat differently proportioned. In *Smilodon* the hind limbs are relatively light while the front limbs are developed as relatively strong and powerful extremities. It becomes apparent from an analysis of the structural features that these creatures were not fleet-footed carnivores like the lion or tiger. On the con-

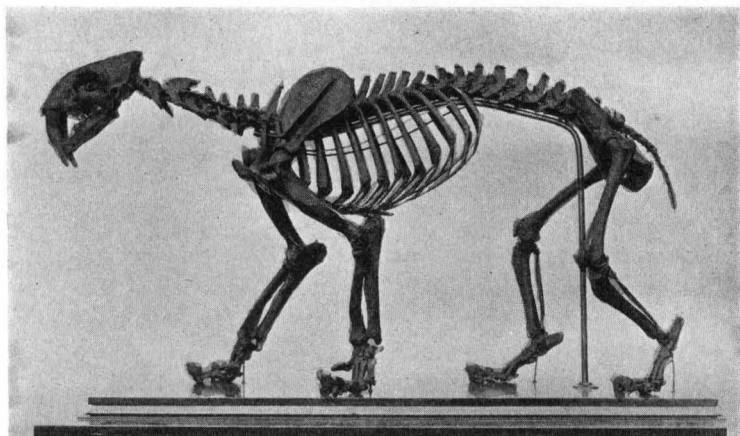


FIG. 15. Skeleton of the sabre tooth cat (*Smilodon californicus* Bovard). Los Angeles Museum collection; Rancho La Brea Pleistocene.

trary they probably preyed on the larger and more slow-moving mammals with which they were associated during Pleistocene time. A curious feature is the reduced tail, in which respect *Smilodon* exhibits a superficial resemblance to the lynx or bob-cat.

Fundamental differences between the sabre-tooth and the lion or puma are perhaps most strikingly shown in the skull and dentition. *Smilodon* possessed a relatively small brain and was doubtless a more savage or truculent beast of prey than either the lion or the puma. The skull is curiously modified in adjustment to the great development of the dagger-like canine teeth in the upper jaw. Some of these modifications may be mentioned.

The external nasal opening has receded somewhat from its normal position seen in typical cat skulls. The hard palate develops rather prominent bony ridges which run the length of this surface. In the ear region the sabre-tooth skull exhibits a remarkable character in the growth of the mastoid, furnishing thereby a greater area for attachment of muscles exerting a strong downward pull on the head. The lower jaw in contrast to that in the true cats is weakly constructed. Judging from the development of structures to which important muscles were attached the lower jaw swung through a wide angle when the mouth was opened in attack and the biting strength of this element was correspondingly weakened.

The dental battery of the sabre-tooth presents some extremely unusual features. In this type the dentition of an adult individual usually consists of 26 teeth, while in the lion or puma 30 teeth are present. In other words the sabre-tooth has lost a front premolar tooth on each side of the upper and lower jaw. The upper canines are great dagger-like teeth, considerably elongated in their long curvature and flattened transversely. The front and back edges of the crown of the canine are minutely serrated. *Smilodon* literally means sabre tooth, a name well applied to this cat. The lower canine teeth are reduced in size and resemble in this character and in shape the lower incisors. In the cheek-tooth region the principal cutting teeth have their blades compressed transversely and lengthened in fore and aft line in adjustment to a cutting or slashing action.

In attacking a large mammal like an elephant, mastodon, or ground-sloth the sabre-tooth cat would perhaps seek a vulnerable spot on the body or neck of its prey, grip the victim with its powerful front limbs and claws and repeatedly stab with the upper canines, thus inflicting a jagged wound. In this attack the lower jaw was capable of swinging downward giving a considerable gape to the mouth, the powerful head and neck muscles furnishing at the same time a strong thrust which accompanied the stabbing action of the teeth. The backward position of the nasal opening presumably permitted the animal to breathe with head plunged deeply into the side of its victim, and the presence of a strongly corrugate gum covering the ridges of the hard palate may have rendered service in blood-sucking.

A curious feature noted in an examination of the great collection of skeletal remains of the sabre-tooth cat is the relatively high frequency of lesions in particular elements. While pathological disturbances of the normal structure are occasionally noted in the skull and

dentition they are particularly evident in the limb bones and in the lumbar region of the vertebral column. Moreover, while fractures which have healed during the life of the individual are to be found in a number of bones of mammals and birds from the asphalt, abnormalities in bone growth were apparently rather prevalent among the sabre-tooth cats. According to Dr. R. L. Moodie who has given considerable attention to the study of the diseases affecting Rancho La Brea mammals and birds most of the pathological conditions are

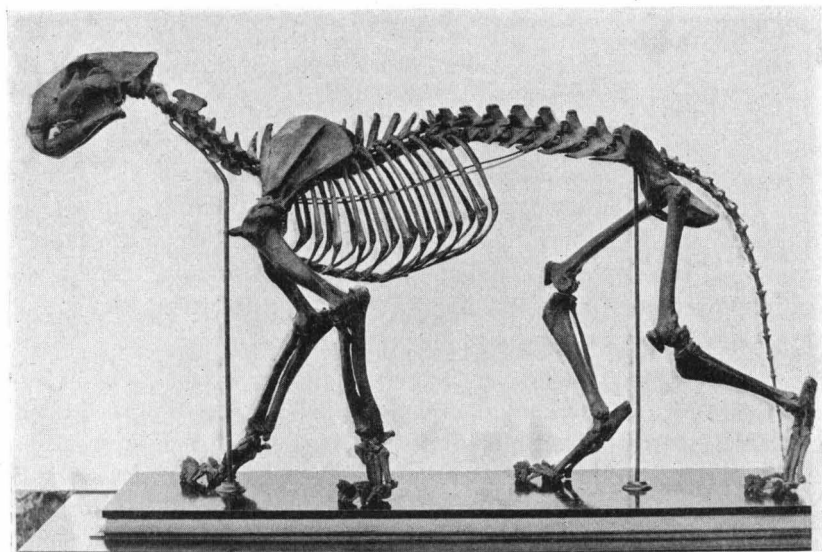


FIG. 16. Skeleton of the great lion (*Felis atrox* Leidy). Los Angeles Museum collection; Rancho La Brea Pleistocene.

to be attributed to injury with subsequent infection. Furthermore, cases of luxation and arthritis have been recognized. It is perhaps not surprising to find disturbances of the normal bone development in creatures as savage as the sabre-tooth cat and dire wolf.

Less evident are the causes which have contributed to the occurrence of abnormalities in the lumbar vertebrae of *Smilodon*. In this region two vertebrae or as many as four may fuse to form a more or less solid tube due to the development of excess bony tissue particularly along the sides and bottom of the vertebral series. This malady resembles a pathological state occurring in Man in which a progressive ossification or formation of bone takes place in the muscle

tissue lying adjacent to the lumbar vertebrae. Whether or not the peculiar habits of these creatures were in a measure responsible for this unusual fusion has not been determined, but the condition remains as one strikingly characteristic of this group of predatory beasts.

Occasionally skulls of the sabre-tooth are encountered in the asphalt in which one or both of the sabre-like teeth have become broken in life, an injury resulting apparently from combats engaged in by these forms. In such specimens the broken edge of the sabre exhibits a worn and smooth surface, clearly denoting the fact that the cat subjected the tooth to use after injury occurred. Quite obviously such forms were at a decided disadvantage in their struggles for existence.

The sabre-tooth cats have had a long and eventful history in the course of geologic time, the first record of their occurrence being found at an early stage of the Age of Mammals. The last members of the group occur in the Pleistocene. Sabre-tooth cats closely related to the Rancho La Brea species have been recorded in Florida, Nebraska and Texas and similar forms are known from the Pleistocene of South America and western Europe.

For the group of true cats, represented today by the African lion, Indian and Asiatic tiger and all other types of cats, the asphalt deposits have revealed a noteworthy record. Undoubtedly the most remarkable member of this group is the great lion (*Felis atrox* Leidy), male individuals of which were nearly one-fourth larger than any of the large living cats of Eurasia. While differing in size from the great felines of the Old World these creatures are no less unusual because of their close structural similarity to modern species. Without much question the great lion was the most formidable predaceous mammal present in the Rancho La Brea assemblage, rivaled only by the short-faced bears in size.

These powerful cats are by no means as well represented in the asphalt as their cousins, the sabre-tooth cats, although they overshadow in numbers types like the puma and lynx. Agile and strong of body and limb, fleet-footed, doubtless possessing to a superlative degree the grace of line, surety of step, and stealth of approach, so characteristic of the feline tribe, it is not difficult to conceive of *Felis atrox* as the greatest hunter of the time. Stalking prey in the open, depending upon its great biting strength and speed in its attack on the larger herbivores, this magnificent creature was as characteristic of the North American

continent during the Pleistocene as the lion is of the African veldt at the present time.

A type specifically identical with the Rancho La Brea lion was described many years ago from the Pleistocene of Natchez, Mississippi and this species has been recognized as far south as the Valley of Mexico. During the glacial period large cats closely related to the North American form were widespread over the Eurasiatic area. While the sabre-tooth cats have become totally extinct the group to which the great lion belongs still maintains its position in the living assemblage of the Old World.

In contrast to the sabre-tooth cat and the lion, the puma and lynx occurring at Rancho La Brea are closely allied to types still living in western North America. The puma (*Felis daggetti* Merriam) is structurally similar, although slightly larger, than our western mountain lion, while the lynx or bob-cat (*Lynx*, near *rufus* (Schreber)) is possibly identical with the living species found in California.

A very small type of cat, comparable in size to the domestic cat, may also be present in the asphalt deposits, but its remains are too incompletely known to permit definite identification.

Rodentia (Gnawers)

Although remains of rodents are but sparsely represented in the Los Angeles Museum collection these forms are known by a number of skulls and many parts of skeletons in the collection of the University of California. We are chiefly indebted to the studies of Louise Kellogg (1912) and of Dice (1925) for information concerning this group.

The surface activities of rodents during the Pleistocene were probably instrumental in bringing about a record of the group at Rancho La Brea. The relatively small outpours of tar at this locality during the present period not infrequently catch these small mammals (see figure 6). Furthermore the occurrence of particular types of rodents doubtless accounts also for the presence of certain species of birds and small carnivorous mammals known to feed at present on living representatives of these forms.

The entire rodent assemblage including not less than nine forms bears a close similarity to rodent types living in the Los Angeles region at the present time. From the asphalt are recorded several distinct genera of mice, namely, the grasshopper-mouse (*Onychomys*),

pocket-mouse (*Perognathus*), harvest-mouse (*Reithrodontomys*), white-footed mouse (*Peromyscus*), and meadow-mouse (*Microtus*). Here also are found the kangaroo rat (*Dipodomys*), wood-rat (*Neotoma*), gopher (*Thomomys*), and ground-squirrel (*Citellus*).

It is interesting to note that many of the rodents have been referred to living species and even to existing subspecies. In other words, while profound changes have occurred in the mammalian life of the Los Angeles area since the time of accumulation of the asphalt deposits as is evidenced by the disappearance of many of the larger types, the rodents apparently have remained remarkably stable, not only with reference to the constituent members of the group as a whole but also with regard to the structural characters of particular forms.

Lagomorpha (Rabbits, Hares)

According to Dice (1925) at least three distinct types of lagomorphs are known from Rancho La Brea. These have been identified as the black-tailed jack-rabbit (*Lepus californicus*), the brush-rabbit (*Sylvilagus bachmani*), and the cottontail (*Sylvilagus auduboni*). Here again close similarity has been recognized between the fossil forms and types now existing in the Los Angeles region, although the jack-rabbit and cottontail from the asphalt are regarded as subspecifically distinct from their living representatives.

Tayassuidae (Peccaries)

The infrequent record of peccaries in the Pleistocene mammalian assemblage of California leaves much to be desired in our present knowledge of the extinct types. The most complete material thus far known from the state has been secured at Rancho La Brea and represents a fragmentary skull and several limb elements. These specimens indicate a form (*Platygonus*) known to have ranged widely over the region of the United States and probably Mexico in Pleistocene time. Species closely related to the Rancho La Brea type have been described for example from fissure deposits in the lead region of Illinois, alluvial accumulations in northern Kansas, and from a number of additional localities in the east and middle west. In California the genus *Platygonus* has been recorded from the asphalt deposits of McKittrick in Kern County and doubtfully from the Pleistocene of Potter Creek Cave, Shasta County.

Peccaries are hog-like creatures representing the New World division of the pig-peccary group. Existing members of the family range from the region of northern Texas to Patagonia. The characters of the skull and teeth are in general like those in swine, although differing from the latter in a number of important details. The skull specimen from Rancho La Brea exhibits the typical features found in

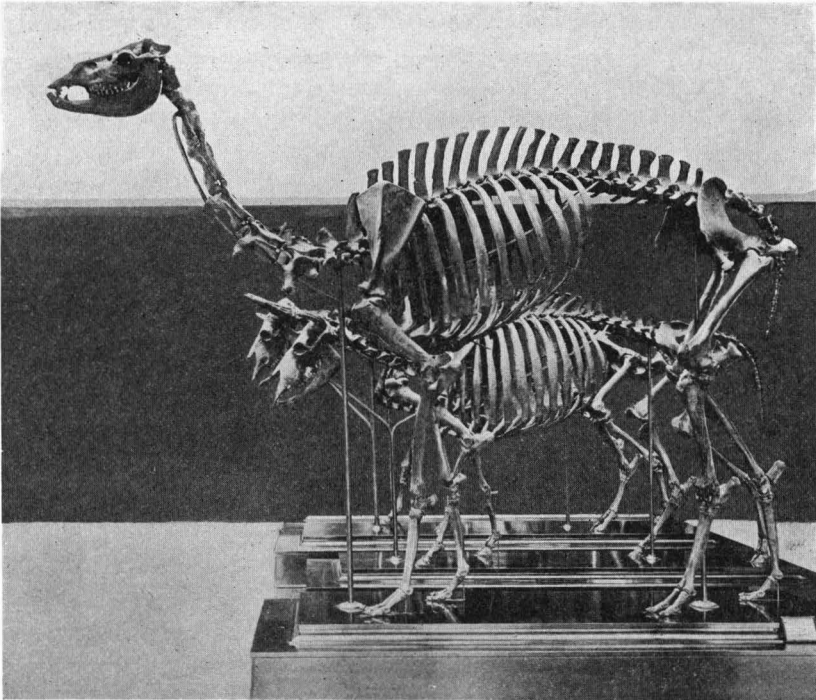


FIG. 17. Skeleton of camel (*Camelops hesternus* (Leidy)). Skeletons in background are of the bison from the asphalt. Los Angeles Museum collection; Rancho La Brea Pleistocene.

Platygonus. Two incisor teeth are present on each side of the upper jaw, followed behind by a short, triangular-shaped canine tooth. The cheek-teeth have relatively low crowns on which a series of tubercles or cusps are developed. In the molars these cusps pair off to form two transverse crests which are however not so high as in modern peccaries.

Judging from the sparse record of the Pleistocene types in California and particularly at Rancho La Brea, one may conclude perhaps

that peccaries favored more wooded regions and were not represented by large numbers in the environment which prevailed in the vicinity of the asphalt traps.

Camelidae (Camels)

Strikingly foreign as the camels appear to the North American mammalian life of to-day, this group of animals during the Age of Mammals was well represented over the northern continental area of the New World. Apparently only in late geological time have they disappeared entirely from this region, the group as a whole being now represented by the bactrian camel of Asia, the dromedary of northern Africa, and llama of South America.

Several distinct types of camels are known from the Pleistocene of North America and some of these were presumably broadly distributed, ranging northward beyond the arctic circle. Elsewhere, remains of these creatures have been found at a number of localities in the United States from Washington to Florida.

The camels of Rancho La Brea all belong to a single species (*Camelops hesternus* (Leidy)). These were undoubtedly striking animals as they appeared in the region about the tar pools. The fossil materials furnish practically all the important structures of the skull and skeleton, the species being more completely known than any other camel type described from the Pleistocene. Two fine skeletons have been prepared and mounted from specimens collected by the Los Angeles Museum (see figure 17).

The mounted specimens of *Camelops hesternus* exhibit the unusual characteristics of these fossil forms. The skeleton has a height of more than 7 feet as measured from the highest point of the back or of more than 8 feet measured from the top of the skull. While the size of the body was somewhat like that in the bactrian camel, the fossil species has much longer legs. Whether or not the Rancho La Brea species possessed a hump or humps as in the Old World representatives of the camel family can not be satisfactorily determined for these structures leave no impress on the spines of the vertebrae. The llamas are without humps. While the camels native to the desert region of the Old World are adjusted structurally to a rigorous climate, the more favorable environment of the Rancho La Brea hinterland during the Pleistocene probably did not necessitate those special adaptations suited to an existence under arid conditions.

While the skull of *Camelops hesternus* agrees more in size with that of the bactrian camel than with that of the South American llama, it resembles more closely the latter in certain structural characters. However, there remain other features in which the Pleistocene type differs from both the Old World and New World living representatives of the camel group.

Camel remains are by no means of infrequent occurrence in Pleistocene deposits of California, materials having been found in at least 15 counties of the state. Probably several distinct types are represented.

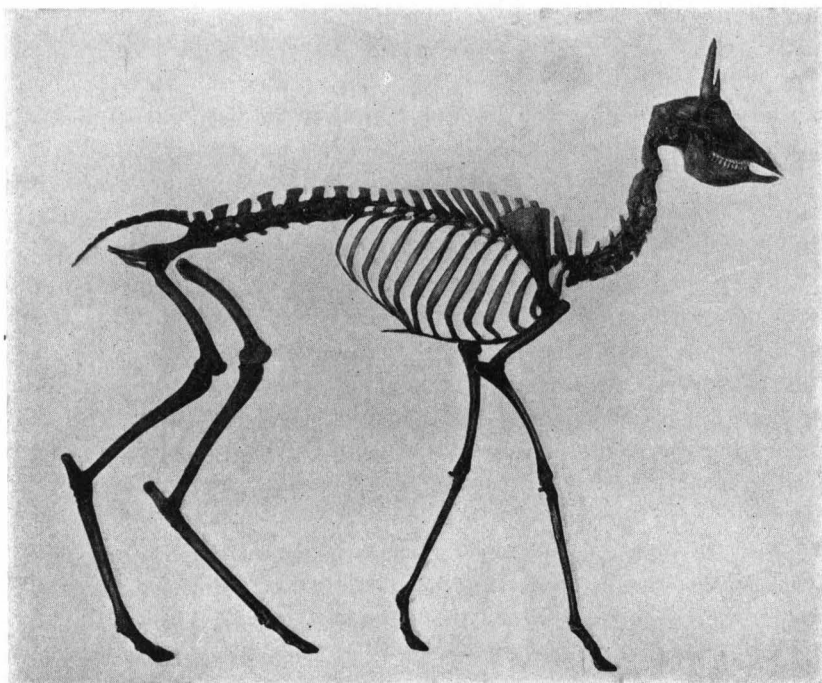


FIG. 18. Skeleton of the small antelope (*Capromeryx minor* Taylor). Los Angeles Museum collection; Rancho La Brea Pleistocene.

The species *Camelops hesternus* was first described in 1873 from beds in Livermore Valley, Alameda County. Skull remains of a camel identical with the Rancho La Brea form have been described recently by Romer from a cave near Fillmore, Utah. This specimen is remarkable because of its comparatively fresh state of preservation, for some of the dried muscle tissue is still attached to the skull. Discovery of this most interesting material has led to a supposition held by some

investigators that *Camelops hesternus* may have continued to live in North America during very late geological time and perhaps into the Recent.

Cervidae (Deer)

While the deer of to-day represent the most prevalent type of the larger game mammals of California, this group curiously enough occurs but sparsely in the Rancho La Brea Pleistocene assemblage. Judging from the rather scanty material available the Pleistocene deer are apparently related to the California mule deer (*Odocoileus hemionus*), although establishment of definite relationships of these forms must await a more critical examination of the fossil specimens.

The rarity of deer in the asphalt record may indicate among other reasons an infrequent occurrence of the group during this stage of the Pleistocene or the presence of environmental conditions which were not particularly favorable to these types. Remains of deer have been recorded from a number of Pleistocene localities in California.

Antilocapridae (Antelopes)

The North American family of antelopes is represented today by a single form, the pronghorn (*Antilocapra americana* (Ord)), now largely limited in its range to certain areas in the western portion of the United States and northern Mexico. Prior to the advent of the white man its distribution extended over a much larger area. Occurring also in California during the Recent period its range in this region has likewise become more restricted and has approached the vanishing point. Fossil remains of species identical with or closely related to the pronghorn have been found in Pleistocene deposits at several localities in California, but the presence of *Antilocapra* at Rancho La Brea is doubtfully recorded.

In the asphalt occurs, however, a diminutive antelope (*Capromeryx minor* Taylor) which clearly belongs to the antilocaprid family, although exhibiting some interesting differences from the American antelope of today. This animal, figure 18, was less than 2-feet tall at the shoulders or approximately 27-inches as measured to the top of the head. The Pleistocene type possessed long-crowned grinding teeth, suggestive of grazing habits similar to those of the pronghorn. While no complete skull has been found at Rancho La Brea, sufficient material is available to permit determination of the character of the bony horncore. This interesting structure, growing

on each side from the top of the skull above the rim of the eye-socket, consists of two distinct prongs arising from a common base. The hinder of the two prongs is the longer and has a round cross-section, while the front prong is decidedly shorter and has a triangular cross-section. While the sword-like horncore of the modern pronghorn antelope shows no separation into two parts the contour and shape of this structure are rather strongly indicative of a kinship between the modern type and *Capromeryx*. Moreover, in the fossil form the cleft separating the two prongs suggests the presence of a forked sheath

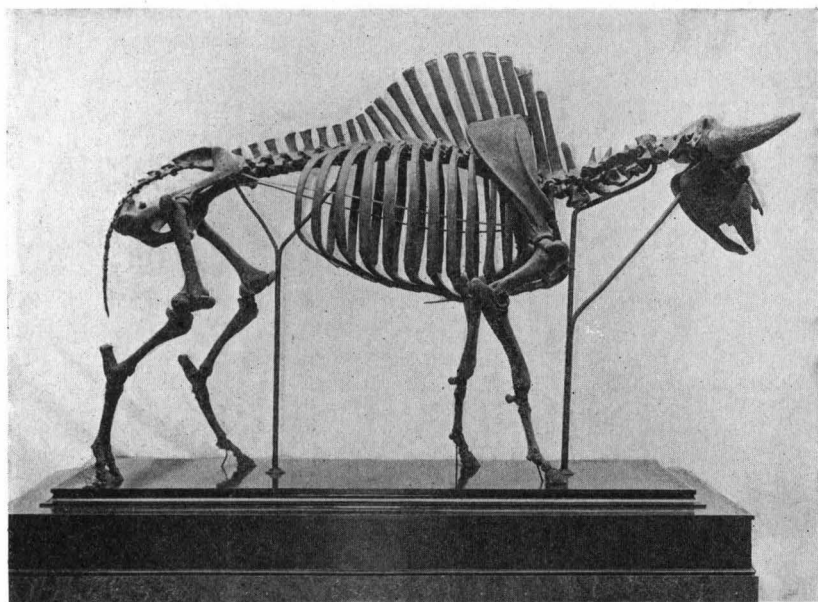


FIG. 19. Skeleton of the ancient bison (*Bison antiquus* Leidy). Los Angeles Museum collection; Rancho La Brea Pleistocene.

covering the horncore. In the existing pronghorn the sheath is forked, and this is the only known case among living mammals where a simple horncore carries a forked sheath.

A number of resemblances are to be noted in a comparison of the skeletons of *Capromeryx* and *Antilocapra*. Like the latter the fossil form possessed long, light limbs, in which respect it can be separated from most of the true antelopes of the Old World. The long-crowned teeth serve to distinguish it from the light-limbed African gazelles.

A member of a distinctively American family of hoofed animals, *Capromeryx* has been recognized, in spite of the rather fragile nature of its remains, in Pleistocene deposits of Nebraska and of the Valley of Mexico. Additional records of the presence of this animal in the Californian region have been secured in the Pleistocene beach accumulations at San Pedro, in asphalt deposits at McKittrick, Kern County, and doubtfully in the Bautista Creek badlands of Riverside County.

Bovidae (Bison)

Judging from their record in the asphalt the bison or buffalo were even more numerous than the horses in the vicinity of Rancho La Brea during the Pleistocene, although it should be clearly borne in mind that factors other than abundance of individuals may have been instrumental in bringing about a greater representation of the bovid group in the tar. The total number of these mammals exceeds that of all other even-toed hoofed animals (camels, antelopes, peccaries, and deer) found at this locality.

The similarity of the fossil forms to living buffalo in fundamental characters offers little difficulty in visualizing these creatures in the flesh as they roamed over the plains and rolling country of the Los Angeles area during the Pleistocene. These ancient bison (*Bison antiquus* Leidy), figure 19, were larger types than the living North American buffalo (*Bison bison* Linnaeus), the skeleton as mounted having a height of more than 6 feet, measured from the highest point of the back. Some individuals were probably distinctly taller. That the fossil bison, like their living relatives, possessed a hump is indicated by the great development of the spines of the vertebrae in the forward region of the back. Specimens of vertebrae are available in the collection having a length of spine measuring from 26 to 27 inches.

Structurally *Bison antiquus* resembles *Bison bison*, but differs from the latter in certain specific details in addition to size. In the skull, for example, the horn cores arise at right angles to the median fore and aft axis of the head, whereas in the living species they are directed somewhat backward in their outward course. The largest skull in the Museum collection has a span of 32 inches as measured between the tips of the horn cores. It is not improbable that some individuals possessed a width across the skull of more than a yard as measured from the outer sides of the horny sheaths which covered the horn cores. Skulls of males and females are apparently to be distinguished by the size of the individual horn core.

Remains of fossil bison of the species *Bison antiquus* were recorded many years ago from deposits in Livermore Valley, Alameda County, California. This type appears to be represented also in the asphalt deposits of McKittrick, Kern County. During its existence on the North American continent this species was widely distributed for *Bison antiquus* was first described from the Pleistocene of Kentucky. A rather frequent record of bison has been found in the Pleistocene of California, and remains of these types, when not too fragmentary, seemingly indicate the presence of several species in this region.

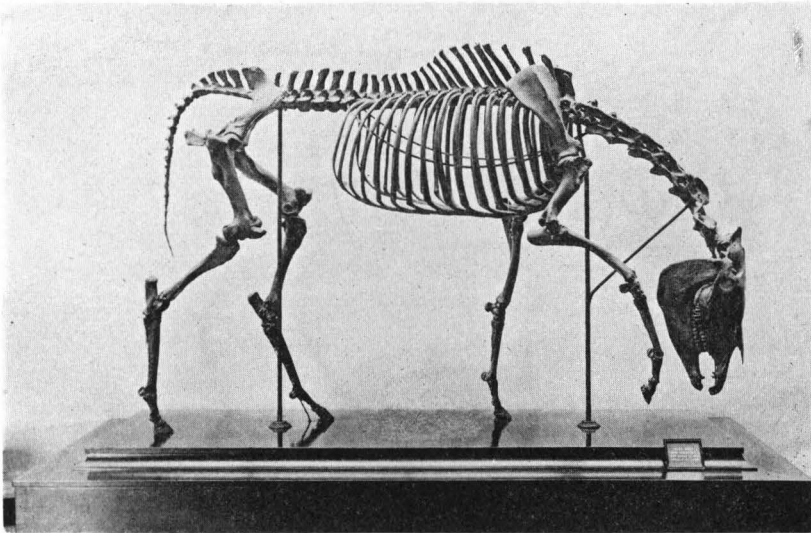


FIG. 20. Skeleton of the western horse (*Equus occidentalis* Leidy). Los Angeles Museum collection; Rancho La Brea Pleistocene.

Equidae (Horses)

The presence of bands of horses in the vicinity of the asphalt deposits during the period of accumulation is clearly testified by the numerous remains of these mammals found at Rancho La Brea. While many individuals are recorded in the collections, all of them belong to a single species (*Equus occidentalis* Leidy). In stage of evolution and in general body structure this type resembles the modern horse, although differing from the latter in a number of specific details. Standing approximately 15 hands (5 feet) at the withers this animal compared favorably in height with an average sized modern horse.

In the fossil form the skull is somewhat domed in the region of the forehead and the sutures separating the individual bones of the skull in this area give a slightly different pattern from that seen in living species. In these two characters the Rancho La Brea species exhibits some resemblance to the asses. Another noticeable difference between *Equus occidentalis* and *Equus caballus*, as the modern species is called, is presented in the front end of the lower jaw between the cheek-teeth and the cropping teeth. In this region the jaw is deeper in the fossil form. The dentition of the Rancho La Brea type is not fundamentally different from that in modern species, but individual grinding teeth have a simpler enamel pattern. As a matter of fact, among the species of fossil horses described from the Pleistocene of North America *Equus occidentalis* presents one of the least complicated patterns developed by the enamel on the wearing surface of the tooth crown.

These horses like their living relatives were one-toed animals. Limb and body are supported wholly by the enlarged third toe while slender splint-like bones represent the elements which during an earlier history of the horse group were more fully developed and carried the second and fourth toes. The hoofs in the Rancho La Brea species are distinctly smaller and more slender than in the larger types of existing horse.

Equus occidentalis or the western horse has been known heretofore by isolated teeth and fragmentary skull material secured in Pleistocene deposits in Tuolumne County and in the Buena Vista Lake region of Kern County. Following identification of this form on the basis of very complete remains at Rancho La Brea, *Equus occidentalis* has been recorded from several additional Pleistocene localities in California.

Horses were among the more common types of hoofed mammals on the North American continent during Pleistocene time and a number of distinct species have been described from fossil remains. The abundance and widespread distribution of horses in North America make the apparent disappearance of the group in this region prior to the advent of the white man an added and an unusual feature of their long and eventful career.

Tapiridae (Tapirs)

Although tapir remains have not been recognized in the Los Angeles Museum collection from Rancho La Brea, evidence indicating the presence of these interesting forms in the asphalt is seemingly furnished by at least two phalanges in the collection of the University of California. Slight as this evidence may seem to be the elements in question

resemble the corresponding bones of the living tapir more closely than they do those of any Pleistocene mammal known to occur at this locality.

The extremely rare occurrence of tapirs in the asphalt record doubtless results from the fact that the environment in and immediately about the tar traps was not particularly favorable to the group. Their sparse representation may indicate moreover that they were nowhere very abundant. Tapir remains are, as a matter of fact, of infrequent occurrence in California. Late Tertiary or Pleistocene records of these forms have been found in the auriferous gravels of the Sierra Nevada, in Santa Barbara County, and in the Bautista badlands of Riverside County.

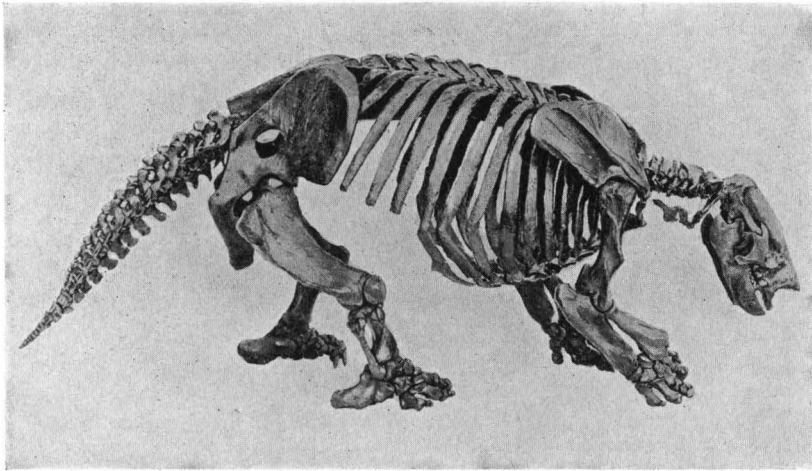


FIG. 21. Skeleton of the mylodont ground sloth (*Mylodon harlani* Owen). Los Angeles Museum collection; Rancho La Brea Pleistocene.

Xenarthra (Ground Sloths)

The ground sloths are among the most unique types of herbivores occurring in the asphalt. Belonging to an important and rather primitive group of mammals, the edentates, these forms are known to have emigrated to North America from the South American continent during the Pleistocene, although forerunners and close relatives of some of the Rancho La Brea types had already reached the northern continent during the Pliocene, the period immediately preceding the Ice Age. Living representatives of the Xenarthra, found in South and

Central America, are the armadillos, anteaters, and tree sloths. Armadillos are to-day found also in North America, but their geographic range is largely restricted to the state of Texas and adjacent regions.

Among existing edentates the nearest relative of the extinct ground sloth is the tree sloth. This form, as its name implies, is a tree-dweller and is characterized by sluggish movements. It lives in the dense forests of Central and northern South America. In contrast to other arboreal mammals the tree sloth possesses the peculiar habit of moving about with its body suspended from the branches of the trees, using for support the large claws that are carried by the fingers and toes of the hands and feet. Of relatively small size, it feeds on the foliage of the trees and when forced to the ground moves about with difficulty. The tree sloth possesses a shaggy coat of hair and in some forms this has a protective color, due to the presence of a green alga which lives normally in the flutings or grooves of the individual hair.

The extinct edentates of the western hemisphere include not only the ground sloths, but types characterized by a heavy bony armor which protects the head and encases the body and tail. The glyptodonts, as the latter are called, are like the armadillos in possessing this protective covering made of dermal plates of bone or scutes.

Some of the edentates, notably the anteaters, have lost their teeth. When, however, the dentition is present, the teeth lack the hard outer substance, namely the enamel, which is an important constituent of the tooth crown in higher mammals. The ground sloths possessed teeth of this type in which the principal substance forming the crown was dentine of varying hardness. As the teeth were worn away they continued to grow from within the sockets, very much like the gnawing teeth of rodents.

Three distinct species of ground sloths are known from the Rancho La Brea deposits. Of these forms *Myiodon harlani* was the commonest type. This creature, represented in the collections of the Los Angeles Museum by very complete skull and skeletal materials, figure 21, was much smaller than the mastodon, but like the latter, possessed considerable bulk and weight. Somewhat blunt-nosed and with lobate grinding teeth *Myiodon* was probably a grazing mammal frequenting the open stretches of flat or rolling country in the vicinity of the asphalt beds. Presumably its natural enemies were the sabre-tooth cat, the great lion and the packs of dire wolves. The skeleton of this ground sloth is massively constructed and the strongly built chest

and powerful front limbs suggest great crushing strength. These characters and the stout claws of the hand were undoubtedly of great service to *Myiodon* in combating the attacks of predatory mammals.

An additional protection, particularly against neck and body attacks, was obtained by the presence of nodules of bone or dermal ossicles as they are called, embedded in the deeper layers of the skin. These bony elements have the same origin as the scutes in armadillos and glyptodonts. While the skin or hide of *Myiodon* is not preserved in the tar the occurrence of these nodules is definitely indicated by the fact that they were found frequently in great abundance lying in the asphalt immediately adjacent to the skeletal remains of these animals.

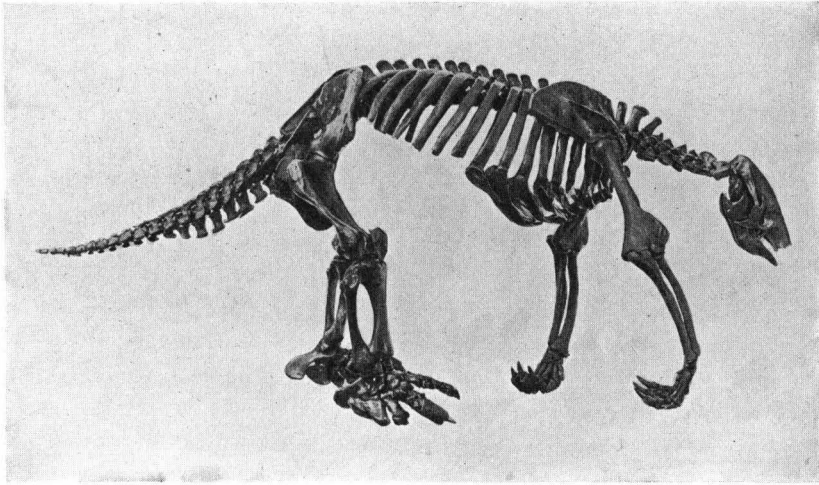


FIG. 22. Skeleton of the megalonychid ground sloth (*Nothrotherium shastense* Sinclair). Los Angeles Museum collection; Rancho La Brea Pleistocene.

Moreover, our knowledge of the structure of the skin in the mylodont ground sloths has been enriched by a discovery made many years ago of remains of creatures closely related to the Rancho La Brea forms in a cave deposit in southern Patagonia. Here occurred not only the skull and skeletal remains but patches of the hide, showing the presence of dermal ossicles in the deeper portions of the skin and the coarse shaggy hair on the outside. This discovery has had an important bearing on the interpretation of the characters of the Rancho La Brea mylodonts and on the restoration of the forms.

The mylodont ground sloths enjoyed an extensive distribution over the American continent during the Pleistocene, their remains having been recorded, usually in association with those of plains-dwelling mammals, from the northern United States to Patagonia. In California *Mylodon* is known to have ranged from the Klamath River region southward to the Los Angeles basin and at least 10 localities within the state are now known where skull or skeletal materials have been found.

Next in abundance were the nothrotheres (*Nothrotherium shastense*) also ground sloths but of smaller size and of somewhat different appearance and habits than *Mylodon*. These creatures are characterized by a fewer number of teeth than in *Mylodon* and the individual tooth was not lobate as in the latter type but of a rectangular outline. The chisel-like edges on the teeth indicate a cutting rather than a grinding action and suggest a browsing habit. The skull was somewhat tubular in front and the lower jaw has a spout-like forward end. Fundamentally the skeleton is like that in *Mylodon*, although differing in a number of details. Rudimentary bony nodules were apparently absent in the skin. Perhaps the most remarkable feature is presented in the hind foot which has undergone profound modification. Whereas in some mammals the sole of the foot rests on the ground, such forms being known as plantigrade or sole-walking types, in *Nothrotherium* the foot has been rotated from this position and the weight of the body rests on the outer side of the foot. As a result of this curious change the outer toes particularly have suffered considerable reduction. A similar modification occurs also in the hind foot of *Mylodon*, but the change is in some respects not so striking as in the nothrotheres. Claws are present on both the feet and hands as in the mylodonts. It is difficult to conceive of these mammals as types moving with any degree of rapidity over the surface of the ground. Rather is one inclined to conclude from their ungainly appearance and from what one may be tempted to designate malformation in some parts of skeletal structure that they were characterized by a slow and labored gait. Yet these characters were apparently in no wise a handicap in their distribution for the nothrotheres are found not only in Pleistocene strata of North America but in Brazilian cave deposits as well. These forms were first described in California in cave accumulations in Shasta County. They have since been recognized at Hawver Cave in El Dorado County, and elsewhere in Texas, New Mexico, and in Mexico. The nothrotheres were apparently forest-dwellers, a habit suggested by some of their structural characteristics and by their occur-

rence and association at other localities. They do not appear to have been habitually present in the vicinity of Rancho La Brea, but seemingly penetrated this region on occasion from adjacent areas.

A third type of ground sloth (*Megalonyx jeffersoni*) is more sparingly represented in the asphalt than *Nothrotherium*. This type is more closely related to the nothrotheres than to *Mylodon*, but approximated more closely the latter in size. *Megalonyx* possesses considerable historic interest for large claws and other bones of this creature were first described in 1794 from a limestone cavern deposit in western Virginia by Thomas Jefferson. Since that time *Megalonyx* has been

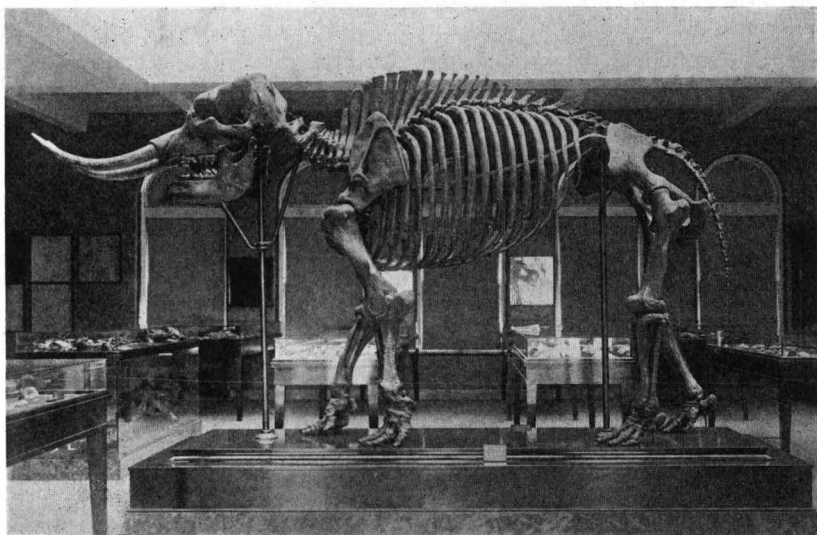


FIG. 23. Skeleton of the American mastodon (*Mammuth americanum* (Kerr)). Los Angeles Museum collection; Rancho La Brea Pleistocene.

recognized in Pleistocene beds at a number of localities in the region of the United States, often in association with forest-dwelling mammals. In California this ground sloth is known also from Pleistocene cave accumulations in Shasta County and in the Sierran region. No complete skeleton of *Megalonyx* has been obtained at Rancho La Brea, although a number of scattered elements and a lower jaw have been recovered.

Megalonyx is quite similar in structure to the nothrotheres. The teeth are shaped somewhat as in the latter, but *Megalonyx* possessed a caniniform tooth at the front end of each tooth row in the upper and lower jaws which is absent in *Nothrotherium*. The skull appears to

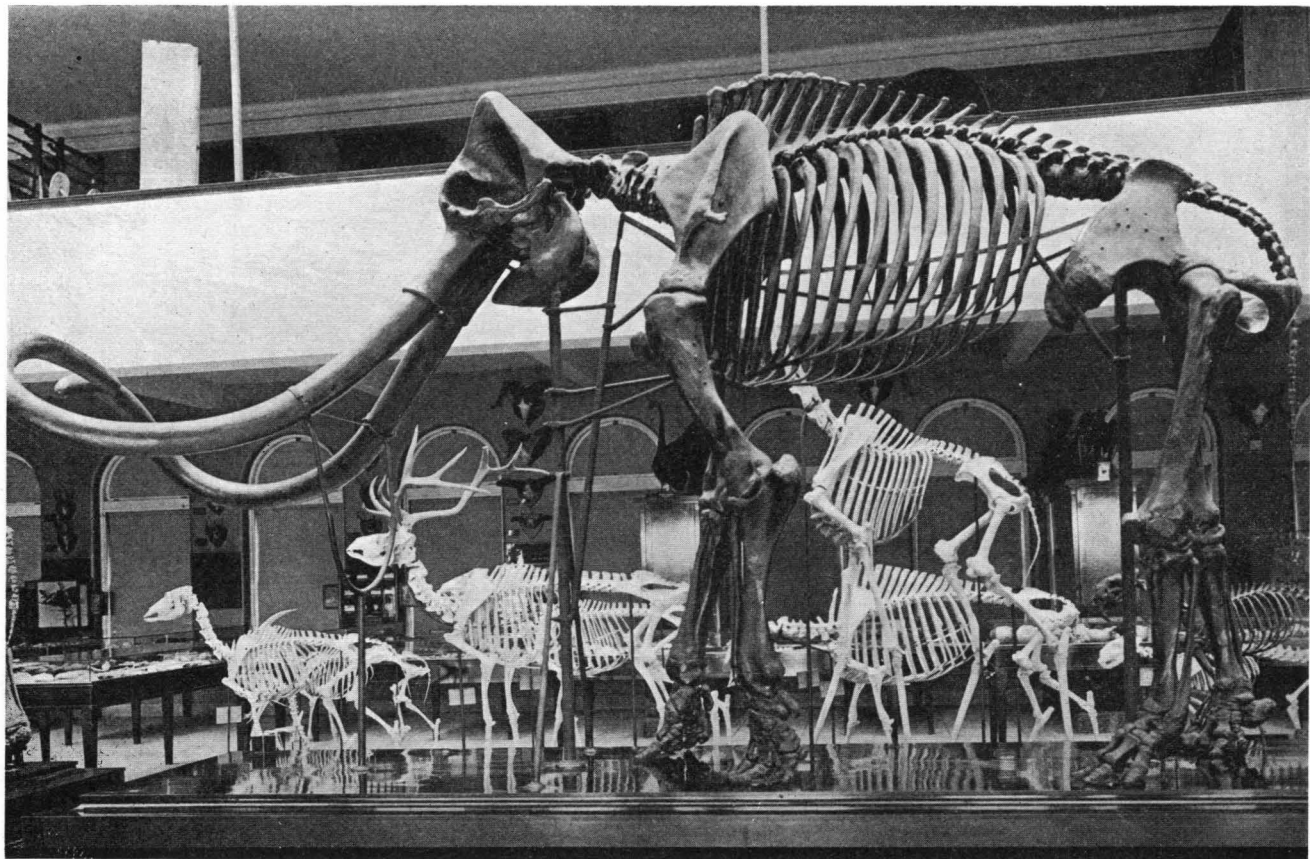
terminate somewhat more bluntly in front. The remains available of the skeleton indicate a form heavier and more massively constructed than *Nothrotherium*, with however many of the peculiarities noted in the latter ground sloth. *Megalonyx* apparently also lacked the bony nodules in the skin, but was probably covered by a heavy coat of coarse hair.

Proboscidea (Mastodons, Elephants)

Elephant and mastodon remains are by no means of frequent occurrence in the Rancho La Brea collections. In reaching a full understanding of these types an added difficulty is experienced in the comparatively imperfect preservation of a number of the larger skeletal parts. This is particularly true for the elephants whose remains were largely secured by the Los Angeles Museum in a single excavation (Pit 9.) Here the presence of clay and sand saturated with water hastened somewhat the disintegration of the skulls and of the long bones of the limbs. On the other hand, materials of the mastodon are usually in a better state of preservation.

The contemporaneity of the mastodon and elephant is clearly indicated for the Rancho La Brea occurrence. The former type determined as the American mastodon (*Mammot americanum* (Kerr)) was of smaller size than the elephant and possessed a number of primitive features, but exhibited nevertheless many of the outward characteristics of the elephant tribe. A mounted specimen of this type from the asphalt is shown in figure 23. The tusks of the mastodon, made of dentine or ivory, were of smaller size than those of the Pleistocene elephants and their curvature was not so marked as in the latter. A greater number of grinding teeth are present in the jaws and the individual tooth differs noticeably in its structure from that of the elephant. These teeth are comparatively low-crowned, each crown forming a series of crests and V-shaped valleys which extend transversely. No cement occurs on the wearing surface of the grinders in the American mastodon.

The elephants or mammoths of the asphalt were distinctly larger than the mastodon, and exceeded in size their living relatives. Some of these animals had a height of more than 13 feet as measured at the shoulders. Apparently both the imperial mammoth (*Archidiskodon imperator* (Leidy)) and the Columbian mammoth (*A. columbi* (Falconer)) occur at this locality. The tusks were huge structures and were present only in the upper jaw. The grinding battery in adult individuals consists of a single large tooth situated on each side of the



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FIG. 24. Skeleton of the imperial mammoth (*Archidiskodon imperator* (Leidy)).
Los Angeles Museum collection; Rancho La Brea Pleistocene.

upper and lower jaw. As in modern elephants the crown of each tooth is made up of a series of compressed enamel plates enclosing dentine and virtually embedded in a heavy deposit of cement. The long-crowned teeth exhibit great wearing properties and undoubtedly contributed to the longevity of these forms. The large skull furnished an expanse of external surface for attachment of muscles and tendons necessary in the manipulation of the trunk and in the support of the tusks. The heavy body was supported by the pillar-like limbs.

The American mastodon during Pleistocene time is known to have ranged from Alaska to Florida and from New England to southern California. The imperial and Columbian mammoths, on the other hand, were more limited in their range to the southern and southwestern portions of the United States, but their distribution extended into the Valley of Mexico. Remains of Pleistocene mastodons and elephants, for the most part fragmentary, have been found at a number of localities in California. It becomes apparent that several species of mammoths were present in this region during the Glacial Period.

The Bird Assemblage

The rarity of birds in the geologic record is an acknowledged fact and is due in large measure to the fragile nature of their remains and to the special conditions of rapid entombment that are frequently necessary for their preservation. There appears to be no particular reason for assuming that birds of flight were less numerous during later geologic time than at present. On occasion very complete remains are encountered as fossils in sedimentary deposits. The occurrence of fragmentary specimens in formations representing several periods of the Age of Mammals gives clear evidence of the presence of flying types either closely related to living species or differing from them in a number of important characters. Our knowledge of fossil birds, however, has not reached a stage where similar forms have been identified at a number of localities for given periods of geologic time. In other words, the geographic distribution of extinct species of birds is not so well defined as that of extinct mammals.

In the light of the known paleontological record of birds the Pleistocene occurrence at Rancho La Brea grows considerably in significance. The birds of this deposit form a more varied and certainly no less interesting assemblage than the mammals. Approximately 75 different types have been recognized and to this list probably others will be added as the study of the avian group progresses. To be sure the

bird assemblage includes a number of types that are essentially like those of to-day. Within the group, however, occur forms now entirely extinct and known principally from this locality. Still others representing both living and extinct species find their nearest relatives living today in regions distantly removed from southern California.

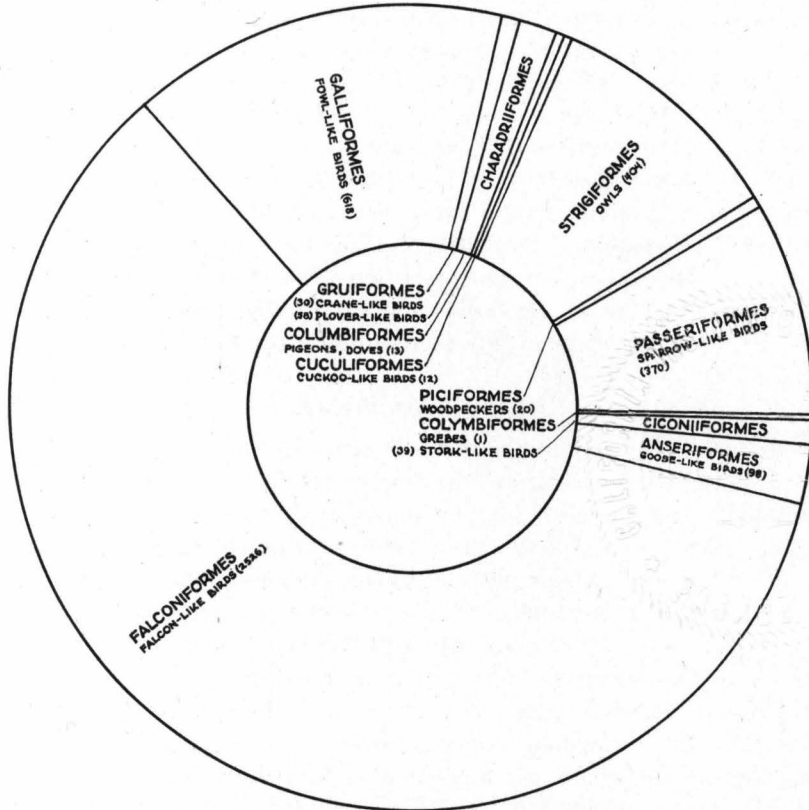


FIG. 25. Diagram illustrating relative sizes of orders of Pleistocene birds occurring in the asphalt of Rancho La Brea. After Hildegarde Howard.

The unusual conditions responsible for the remarkably complete record of the mammalian life of the region were no less favorable in bringing about a full representation of the birds. It is not surprising to find a relatively high mortality among these types, considering the effectiveness of the lure which attracted many of them to the asphalt traps. The ensuing dangers of floundering and miring in the tar on chance contact of wing or body feathers or of the limbs with the sticky

material were extremely great. Even the more powerful birds of flight obviously suffered a decided disadvantage once their principal means of escape were rendered useless. Further struggles merely ensured a firmer grasp on the mired forms.

Varied doubtless were the causes responsible for the representation of birds. The record of specific kinds of birds in the fossil assemblage is often an expression of the relative frequency of occurrence of such forms in the region about Rancho La Brea. The presence of live bait furnished by mammals and other creatures trapped in the tar and of carcasses not yet wholly submerged undoubtedly served to attract from some distance away the predatory and scavenger types of birds to the asphalt locality. The soaring and circling of the great birds of prey above the tar pools probably furnished a common sight in the sky during the active period of the traps. Remains of raptors and of certain species of owls, crows, ravens and of magpies are frequently found in great numbers. Not only feeding habits but environmental conditions as well were presumably of considerable importance in bringing about a highly diversified avian population.

Colymbiformes (Grebes)

Determination of the presence of the grebe (*Colymbus?*) is based upon a single specimen in the Los Angeles Museum collection. While grebes are known to occur elsewhere in Pleistocene deposits of western North America, notably at Fossil Lake in southern Oregon, their infrequent occurrence in the asphalt suggests an environment in which permanent lakes or ponds were absent. No doubt temporary bodies of water of varying size occupied the natural depressions at the Rancho La Brea locality, particularly during the wet seasons and these might well have served to attract aquatic birds.

Ciconiiformes (Stork-like Birds)

Although there is considerable range of type within this group as it occurs in the Pleistocene asphalt, most of the forms are represented by relatively few individuals. Only the storks and jabirus are fairly abundant. The rarer species include the night heron (*Nycticorax nycticorax* (Linnaeus)), a second type of heron related perhaps to the Little Blue heron (*Florida caerulea* (Linnaeus)), the wood ibis (*Mycateria americana* Linnaeus?), glossy ibis (*Plegadis gaurauna* (Linnaeus)), and the roseate spoonbill (*Ajaia ajaja* (Linnaeus)?), each represented by not more than one individual. Slightly more frequent

in occurrence are the Great Blue heron (*Ardea herodias* Linnaeus) and the bittern (*Botaurus lentiginosus* (Montagu)). All these birds and the jabiru (*Jabiru* near *mycteria* (Lichtenstein)) are apparently closely related to or identical with their living representatives.

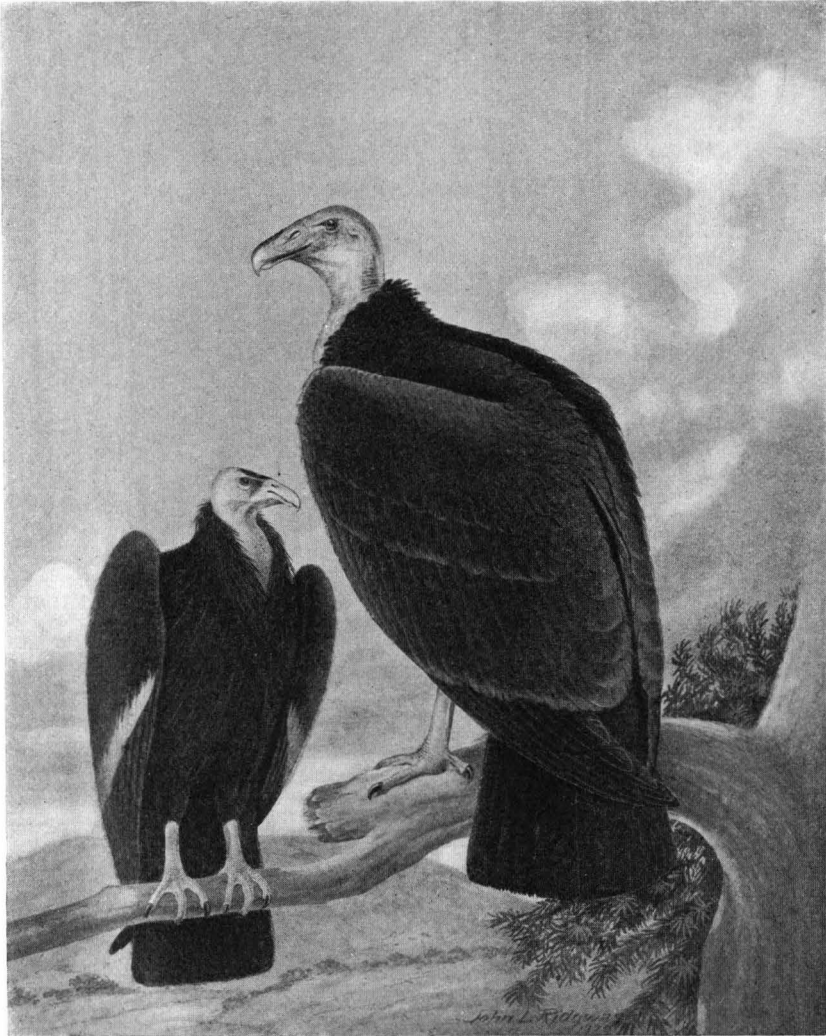


FIG. 26. Restoration of the extinct condor-like vulture (*Teratornis merriami* Miller). Restoration by John L. Ridgway. The smaller bird is the California condor (*Gymnogyps californianus* (Shaw)). Both types drawn to same scale. Rancho La Brea Pleistocene.

The stork (*Ciconia maltha* Miller) from the asphalt differs from all modern species and appears to be most closely related to a type living in Argentina. Regarding the fossil occurrence of the form Dr. Miller remarks:

"The fairly abundant remains of this stork in the Asphalt deposits must not be interpreted as indication of a greater humidity in the region than is at present encountered there. Various writers upon the habits of storks in both Old and New Worlds speak of the plains-dwelling habit of the birds, especially during insect outbreaks, such as the locust storms of Palestine and of Argentina. *Ciconia maltha* probably had much the same appetites and perhaps presented much the same appearance as does *Euxenura maguari* of the Argentine pampas today."

Anseriformes (Goose-like Birds)

The presence of water, forming surface pools at Rancho La Brea, is indicated also by the occurrence of ducks and geese. While these birds are recorded in greater number than the grebes, their total representation is still rather limited. In so far as determination can be made from the fossil material the types are either identical with or closely related to living species. The assemblage includes the mallard duck (*Anas platyrhynchos* Linnaeus?), a second type possibly the shoveller duck (*Spatula clypeata* (Linnaeus)?), the green-winged teal (*Nettion carolinense* (Gmelin)?), and the Canada goose (*Branta canadensis* (Linnaeus)).

Falconiformes (Falcon-like Birds)

Within this group of raptors perhaps the most striking type is an extinct condor-like vulture (*Teratornis merriami* Miller). This great bird was first described from Rancho La Brea, although it has since been recognized in the Pleistocene asphalt assemblages of Carpinteria in Santa Barbara County and at McKittrick in Kern County. Standing no less than 2½ feet high, *Teratornis* possessed a wing-spread of at least 9 feet and ranks among the largest known birds of flight. Its skull and skeleton exhibit a curious combination of eagle- and vulture-like characters. Thus the top of the cranium is flattened and the beak is noticeably compressed transversely giving the head an accipitrine appearance. In the structure of the skeleton, however, resemblances are seen pointing unmistakably to a kinship with the vultures. The feet are quite condor-like.

Several additional unique features may be mentioned with regard to the skull. The hooked beak in life was probably covered by a stout

horny sheath possessing considerable strength in biting and in the tearing of flesh. The articulation of the lower jaw permitted apparently a considerable gape to the mouth. The external nasal openings through

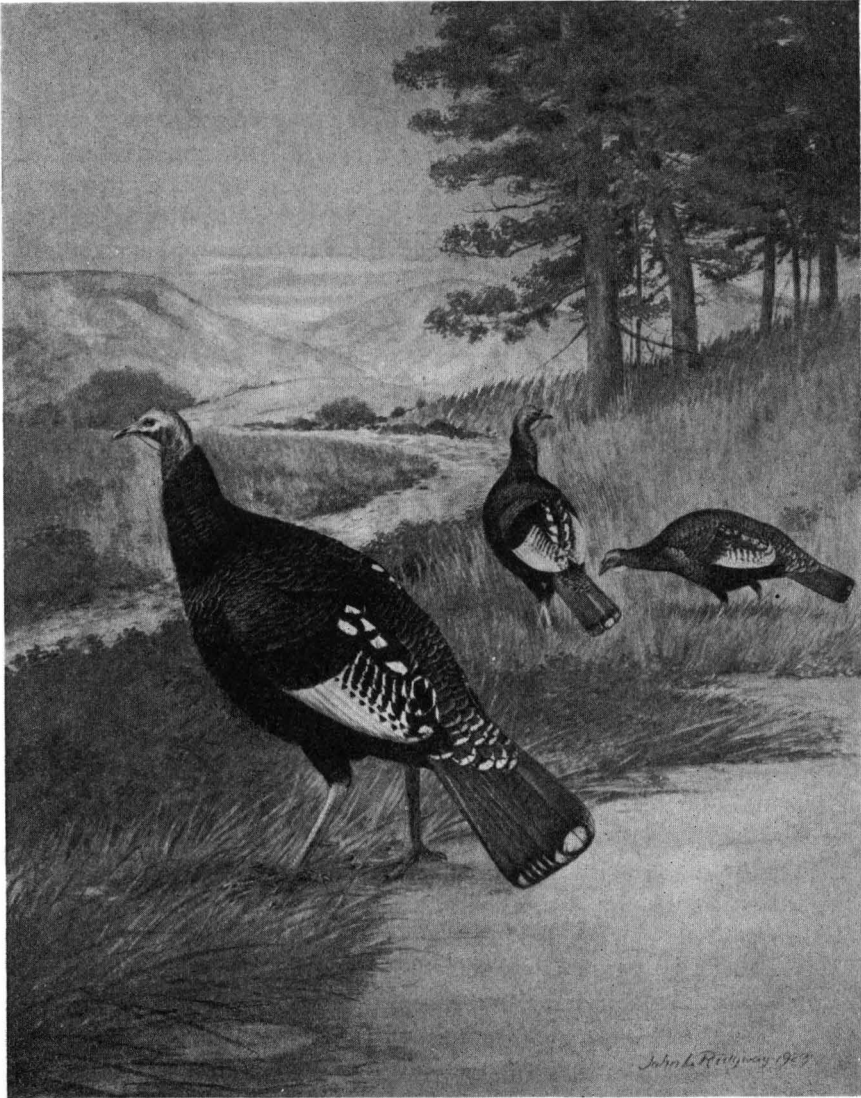


FIG. 27. Restoration of the extinct turkey (*Parapavo californicus* (Miller)) by John L. Ridgway. Note large spurs on the legs of male bird in foreground. Rancho La Brea Pleistocene.

the beak are of enormous size and are indicative perhaps of an especially acute sense of smell on the part of this bird. Lastly the brain-case is relatively small suggestive of a size of brain in keeping with the presumed rapacious habits of *Teratornis*.

A species of vulture identical in structure of skull and skeletal elements with the existing California condor (*Gymnogyps californianus* (Shaw)) is represented by many individuals in the asphalt. Judging from the habits of this powerful bird of prey its presence in large numbers at Rancho La Brea might well be expected. A further record of the California condor in the Pleistocene is to be noted at Carpinteria, while a larger species has been found in the cave deposits of Shasta County. Within the Recent period this bird is known to have ranged from the Columbia River southward to Lower California. Due in part to the persistence with which it has been persecuted by Man, the species is becoming more limited in its geographic distribution.

A second species (*Sarcorhamphus clarki* Miller), related to the condors of South America, is represented by a few individuals in the asphalt. Still another vulture, again occurring but rarely, is *Cathartornis*. Somewhat larger than the California condor this bird differs from both the North and South American species.

At least four additional types of vulturine birds are known from Rancho La Brea. Within the group it is interesting to note that two (*Neophrontops americanus* Miller and *Neogyys errans* Miller) are related to the Old World vultures, whose representatives are not now living in America, and the third, a black vulture (*Coragyps occidentalis* (Miller)), is most closely allied to a South American group. Only the turkey vulture (*Cathartes aura* Linnaeus) of the Rancho La Brea Pleistocene is still found living in the California region. Curiously enough this species is represented in the asphalt by relatively few individuals.

Of the smaller birds of prey many distinct types are found. Kites are known by a single species identical with the Recent bird (*Elanus leucurus* (Vieillot)). Among the hawks are numbered several distinct kinds including the marsh hawk (*Circus hudsonius* (Linnaeus)), sharp-shinned hawk (*Accipiter velox* (Wilson)), Cooper hawk (*Accipiter cooperii* (Bonaparte)) and red-tailed hawk (*Buteo borealis* (Gmelin)). All of the fossil remains of these birds have been referred to Recent species.

The eagle population exhibits also considerable diversity. Here again do we note forms whose nearest relatives are to be found to-day

in South America, the eagles resembling somewhat the vultures in this respect. The golden eagle (*Aquila chrysaetos* (Linnaeus)) represents a type which has persisted from Pleistocene time into the Recent. This species occurs more abundantly at Rancho La Brea than any other bird, a census indicating the remains of more than 800 individuals in the Los Angeles Museum collection. Less numerous are the remains of the bald eagle (*Haliaeetus leucocephalus* (Linnaeus)), whose characters are more variable than those of the modern races of this bird.

In contrast to these forms, the morphnine eagles, with one species (*Morphnus woodwardi* Miller) in the Pleistocene avifauna, are now confined to Central and South America. Likewise the crested eagles of the southern hemisphere have a related form (*Spizaetus*⁹ *grinnelli* (Miller)) at Rancho La Brea. Yet another type from the asphalt is the slender-limbed *Geranoaetus fragilis* Miller. Perhaps the most interesting of all is a long-legged bird (*Wetmoregyps daggetti* (Miller)). Resembling superficially the living secretary bird of South Africa and the Central and South American *Urubitinga* in certain structural adaptations, *Wetmoregyps* possessed relatively very long legs suggesting ground habits considerably different from those of typical members of the eagle tribe.

Galliformes (Fowl-like Birds)

The gallinaceous birds of the Rancho La Brea avifauna form a most interesting assemblage in which the lack of considerable specific diversity is compensated by an extremely abundant representation of one member of this group. Only two types are known of which the quail (*Lophortyx californica* (Shaw)?) is apparently similar to the species now inhabiting the region.

The extinct ground fowl (*Parapavo californicus* (Miller)) is unusually well represented, more than 500 individuals being recorded in the Los Angeles Museum collection. The bird was regarded originally as related to the peacocks of the Old World, but further investigation has shown that it is much more closely allied in structural characters to the wild turkeys of America. *Parapavo* approached the North American wild turkey in size, and the skeleton was similarly proportioned. The astonishing number of individuals found at Rancho La Brea clearly indicates that these forms were the prevailing game birds of the region. Their value as a potential food supply for many types of carnivorous animals of the Pleistocene was probably very great. The

9. From Ms. entitled: The Fossil Eagles of Rancho La Brea, by Hildegard Howard.

ground habits of the extinct turkeys may have made them particularly susceptible to entrapment in the tar pools.

Gruiformes (Crane-like Birds)

Representation of this group is limited to the crane family. The types recorded are apparently identical with living species. The brown cranes (*Grus canadensis* (Linnaeus)) including probably the little brown and sandhill cranes occur more commonly than the whooping crane (*Grus americana* (Linnaeus)).

Charadriiformes (Plover-like Birds)

These water-loving birds are also sparingly represented in the asphalt, but presumably include several distinct kinds. Remains of killdeer (*Oxyechus vociferus* (Linnaeus)) and of the dowitcher (*Limnodromus griseus* (Gmelin)) have been found in the Rancho La Brea deposits. These and doubtless other members of the group were probably attracted to the region by the temporary bodies of water or perhaps by the surface films of water that occasionally covered the tar pools.

Columbiformes (Pigeons, Doves)

Both the band-tailed pigeon (*Columba fasciata* Say) and the mourning dove (*Zenaidura macroura* (Linnaeus)) occur in the Pleistocene asphalt. The fossil forms are regarded as not differing specifically from the living types. Pigeons presumably did not frequent the region of Rancho La Brea in great numbers for only one specimen has been definitely determined as belonging to this group of birds.

Cuculiformes (Cuckoo-like Birds)

The sole representative of this group of birds known from the asphalt is a roadrunner (*Geococcyx californianus* (Lesson)), slightly larger than although still referable to the species of living roadrunner of California.

Strigiformes (Owls)

All of the types of owls occurring at Rancho La Brea are apparently of species still existing. The fossil assemblage includes the barn owl (*Aluco pratincola* (Bonaparte)), screech owl (*Otus asio* (Linnaeus)), horned owl (*Bubo virginianus* (Gmelin)), long and short-eared owls (*Asio wilsonianus* (Lesson)) and *A. flammeus* (Pontopidan)), burrowing owl (*Speotyto cunicularia* (Molina)), and the pigmy owl (*Glaucidium gnoma* Wagler).

Miller has summarized the following salient facts regarding the occurrence of these nocturnal hunters in the Pleistocene avifauna of Rancho La Brea:

“1. As compared with diurnal raptors, owl remains are rare both in point of numbers and of species.

2. This discrepancy is out of harmony with the balance of fauna as between nocturnal and diurnal raptors to-day.

3. Owls were possibly less attracted to the Asphalt trap than were hawks, although in Recent outpours owls are among the most commonly entrapped forms.

4. More copious outpour during the Pleistocene may have resulted in rapid entombment of small forms, leaving only the larger victims exposed to view.

5. Results of this more rapid entombment would be that the small hawks and the owls would find bait less constantly before them.

6. Cooling of the Asphalt surface at night may have rendered the trap less dangerous to owls than to birds hunting by day.”

Piciformes (Woodpeckers)

Of this group the flicker and the Lewis woodpecker are recorded from the Pleistocene of Rancho La Brea. The former species (*Colaptes cafer* (Gmelin)) and the latter (*Asyndesmus lewisi* Riley) are regarded as identical with modern forms. Remains of flickers are not entirely unexpected in the asphalt in view of the ground feeding habits of their modern representatives. With reference to the occurrence of the Lewis woodpecker it is of interest to note that the coast live oak, a type of tree which it now inhabits, is relatively abundant in the Pleistocene deposits.

Passeriformes (Sparrow-like Birds)

No less than 17 different types of passerine birds have been recognized in the fossil assemblage as a result of recent studies by Alden H. Miller. Of this number eight, representing the horned lark (*Otocoris alpestris* (Linnaeus)), yellow-billed magpie (*Pica nuttalli* (Audubon)), raven (*Corvus corax* Linnaeus), western crow (*Corvus brachyrhynchos hesperis* Ridgway), northwest crow (*Corvus brachyrhynchos caurinus* Baird), cedar waxwing (*Bombycilla cedrorum* Vieillot), loggerhead shrike (*Lanius ludovicianus* Linnaeus), and western meadowlark (*Sturnella neglecta* Audubon), are identical with living species. A thrasher, possibly the California thrasher (*Toxostoma cf. redivivum* (Gambel)), is also present. Among these it is significant

to recognize the relatively high percentage of individuals representing birds accustomed now to feeding on both animal and plant life. The type of food available during the active periods of the traps frequently attracted to this locality the raven, the crow and the magpie. The latter is the commonest passerine recorded in the collections.

Additional forms which have been recognized include the kingbird (*Tyrannus*), jay (*Aphelocoma*), chickadee (*Penthestes*), bluebird (*Sialia*), red-winged blackbird (*Agelaius*), oriole (*Icterus*), and possibly the yellow-headed blackbird (*Xanthocephalus?*). Finches are present but their identity still remains obscure for want of more complete material. Lastly, an extinct blackbird (*Euphagus maguirostris* Miller) is described from this locality.

In the light of the known habits and distribution of many of the passerines found fossil at Rancho La Brea it may be presumed that the opportunities for shelter and sustenance in the country about the tar pools were not unlike those suggested by a study of the mammalian assemblage. Moreover, the passerine group as represented in the deposits suggests a region with climate more humid, if not slightly cooler, than that of the present.

Reptiles and Amphibia

Remains of reptiles include scattered snake vertebrae and the fragments of carapace and plastron of turtles. The latter materials apparently belong to a type resembling the western pond or mud turtle (*Clemmys*). The record suggests the presence of occasional ponds or small water courses.

Skull and skeletal materials of toads also have been found in the asphalt. These represent a species (*Bufo boreas halophilus* Baird and Girard) still living, whose present distribution extends along the Pacific Coast from southeastern Alaska to southern California. An extinct species (*Bufo nestor* Camp) differing from the modern type in several structural characters of the skull is also recorded. Toads were apparently as abundant at Rancho La Brea during the Pleistocene as they are at that locality at the present time. It is of interest to record in this connection that beetles similar to those now used as food by toads occur in numbers in the asphalt.

Invertebrate Fossils

A few fragments of mollusks have been encountered in the asphalt. Aside from this material the principal invertebrate fossils represent myriopods and insects of which the latter are relatively abundant.

Remains of these types are usually fragmentary, consisting of stray body segments and the chitinous wing covers.

A single millipede (*Spiroboldus australis* Grinnell) has been recognized in the collections. Among the insects are recorded several carabids or predaceous ground beetles (*Platynus*, *Amara*, *Pterostichus*, *Calosoma*). A water beetle (*Dytiscus marginicollis* Le Conte), known to frequent to-day the vicinity of ponds and streams, also occurs in the Pleistocene asphalt. The darkling beetles (*Coniontis*) and the stink bugs (*Eleodes*) are known by several species.

Viewing the insect assemblage as a whole one is impressed by its resemblance to the insect fauna now living in the region. A larger representation of types may however tend to accentuate the difference between the Pleistocene insect life and that of the Recent.

The Record of the Plants

Because plants are as a rule excellent indicators of life zones and reflect in their present distribution the varying climatic conditions over geographic provinces, their presence at Rancho La Brea may be expected to yield interesting information on the matter of climate during the period of accumulation of the Pleistocene asphalt. Many structural characters of plants are known to change but slowly in the course of geological time, and it is therefore not surprising to find in so late a stage as that of Rancho La Brea species of plants identical with those living to-day in California. Interest largely centers in the association of plant types and in the comparison which can be made between their past and present distribution.

It is to be regretted that the Pleistocene plant life of this region is not more completely known. Relatively few types are recorded by the available fossil materials. Wood is the more common material and has been identified by a microscopic examination of its cellular structure. Occasional cones, seeds, and leaves assist also in reaching a determination of the various plants.

The pine family is represented in the asphalt by the Bishop pine (*Pinus muricata* Don.). Regarding the distribution of this species to-day, Mason makes the following statement:

"*Pinus muricata* is at present a relict with a scattered distribution. It ranges from Fort Bragg, Mendocino County, California, to north of San Quentin and on Cedrus Island, Lower California. It rarely reaches much more than a few miles inland from the sea—reaching to a distance of 10 miles inland on the summit of La Purissima Hills near Lompoc, Santa Barbara County, California."

Associated with the Bishop pine at Rancho La Brea is the Monterey cypress (*Cupressus macrocarpa* Hartweg), whose present range is limited to the Monterey peninsular at the northern end of the Santa Lucia mountains. The occurrence of the latter type is particularly interesting in view of its present restricted distribution. The California Coast Range juniper (*Juniperus californica* Carr) is abundantly represented in the Museum collection by sections of trunks and branches. Seeds and apparently fragmentary leaf parts have been recovered also from the asphalt. The coast live oak (*Quercus agrifolia* Nee) has been recognized by the remains of its wood, leaves and seed. Manzanita (*Arctostaphylos*) has been reported. In addition to these forms the cockle bur (*Xanthium calvum* M. & S.), the blue elderberry (*Sambucus glauca* Nutt.), and the western hackberry (*Celtis mississippiensis* Bosc. var. *reticulata* Sarg.) have been identified in the collections.

With the exception of the western hackberry the flora would seem to indicate a climate for the Los Angeles basin region slightly cooler than that of to-day with seasonal changes perhaps less marked than at present. The annual rainfall may have approximated 15 inches, accompanied by fog during the summer, or the average annual precipitation may have been greater in the absence of fog.

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