Loye Holmes
UNIVERSITY OF CALIFORNIA PUBLICATIONS

BULLETIN OF THE DEPARTMENT OF

GEOLOGY

Vol. 7, No. 5, pp. 61-115

Issued October 12, 1912

CONTRIBUTIONS TO AVIAN PALAEON-
TOLOGY FROM THE PACIFIC COAST
OF NORTH AMERICA

BY

LOYE HOLMES MILLER

UNIVERSITY OF CALIFORNIA PRESS

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LOYE HOLMES MILLER

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INTRODUCTION

When the vertebrate palaeontologist turns his attention to the group Aves as represented in North America, especially if he be confronted with the problems represented by a considerable mass of unassorted material, he cannot but feel that he pushes out into almost uncharted waters, a wide sea where the few islands recorded by previous explorers— islands too often shrouded in mist—may perhaps never appear upon his horizon. The scarcity of previous record, the wide separation in place of the bird-bearing deposits, coupled with the inadequacy of descriptions and the poverty of museums in collections of Recent avian osteology—all these are factors which conspire to give the student entering upon such an undertaking the feeling that he stands or falls unto himself. In full cognizance of these conditions the present paper is undertaken. Its dual purpose is the recording of certain facts but recently made known in this interesting field, and the correlating, insofar as this is possible, of the results thus far attained.

ACKNOWLEDGMENTS

Study of the University of California collections was taken up at the invitation of Professor John C. Merriam, head of the Department of Palaeontology of that institution, and to his unstinted aid, encouragement, and advice much of what value this study may possess is here freely ascribed. Grateful acknowledgement is also made to Messrs. Joseph Grinnell and H. S. Swarth of the California Museum of Vertebrate Zoology for information cheerfully furnished on many Recent species and for the loan of osteological material. Specimens of great interest and value were loaned or donated by Dr. F. A. Lucas, Dr. A. Smith-Woodward, Dr. F. C. Clark, Dr. C. O. Esterly, Mr. E. J. Fischer, and Mr. J. Z. Gilbert. The very generous attitude taken by Madam Ida Hancock-Ross and the associated owners of Rancho La Brea in issuing permits to excavate the asphalt deposits made possible the assembling of much valuable material essential to the work. Through the personal efforts of Dr. J. C. Hawver, of Auburn, California, as well as by the very cordial

assistance extended by him to the author, our knowledge of the Hawver Cave deposits has been greatly advanced. To each of these persons the author's sincere thanks are extended.

SIGNIFICANCE OF OSTEOLOGICAL CHARACTERS IN ORNITHOLOGY

In a zoological group of such narrow delineation and of such great homogeneity as the class Aves, where separation into the various systematic divisions is based upon relatively small variations and where these variations affect structures not preserved for study, a considerable degree of care must be exercised when interpreting discoveries of the palaeontologist in terms of modern systematic zoology. The difference noticeable to a worker in the former field should in many cases be multiplied by a very large factor upon their transposal to the latter. Degrees of divergence which to the palaeontologist seem of no more than specific rank might, by the worker in systematic ornithology, having also various intricate details of color-pattern or feather structure at his disposal, be found correlated with differences of more than generic importance. The distinction upon osteological characters of many well-defined species of Recent birds is a matter requiring complete skeletons of individuals of known sex; even then conclusions are often in question. It is here conceded as possible under these conditions, and considering the fact that most of the fossil specimens are not capable of articulation, that many of the fossil specimens ascribed to living species might, if all characters were determinable, be separated as distinct forms. It must be remembered also that within certain groups the osteological differences between species is greater than in others. The feather of the bird is an epidermal structure which reflects with sensitiveness the activities of the animal and is plastic as a specific character under the influences of environmental changes. It is a proper basis of specific distinction, yet it is almost never preserved in the fossil state. The tooth of the mammal, likewise an epidermal structure and highly representative of the animal's activities, is a character used in common by the palaeontologist and the modern systematist. Zoology and palaeontology are then much more nearly upon the same

basis in the determination of mammals than is the case with birds. Recognizing this principle, the author of this paper has proceeded with perhaps more than necessary caution in the announcement of new species, preferring to err on the part of conservatism rather than to confuse the literature of the subject by making assertions which must later be modified; and there are in the collections studied many specimens regarding which further knowledge is considered necessary before problems upon which they may throw light can be attacked in more than a speculative way.

REVIEW OF THE LITERATURE

Since the epoch-making discoveries by Marsh which added so materially to our conception of the ancestry of birds, contributions to knowledge in the field of avian palaeontology have been few as compared with the rapid enlargement of our understanding of the other vertebrate groups. Bird remains on the Pacific Coast are mainly from Pleistocene strata; thus there is eliminated the probability of shedding much new light upon the ancestry of certain groups in which our interest is so acutely focused, for example the Stereornithes. Discoveries recently made have contributed to science chiefly in two ways, first in giving us an appreciation of the relative antiquity of the main groups into which birds are divided; and, second, in adding to our knowledge of the geographical distribution of these groups. The consideration of geographical distribution is but begun when we record the range of the Recent species. Determination of the factors which have led to such distribution, if we aspire to something better than mere speculation, must look to the record of previous conditions as brought to light through palaeontological inquiry.

The fossil-bearing rocks of the Pacific Coast of North America, while rich in the remains of mammals and reptiles, have until recently yielded but little information concerning the avian group.

In 1878, Cope¹ described three new species of birds from the Equus Beds of Oregon. All three species belong to genera

¹ Cope, E. D., Bull. U. S. G. S., Terr., iv, No. 2, May 3, 1878.

still inhabiting the region; thus their importance is limited to the evidence they furnish of the division of a genus into several coördinate species.

In 1892, Shufeldt² published the results of an extended study of the Cope and the Condon collections of birds from this same region. In this very thorough discussion there are fifty species enumerated, fourteen of which are described as new. The entire number, with the exception of the gallinaceous *Paleotetrix gilli*, are assigned to existing genera. *Phoenicopterus* is the only existing genus recorded which is foreign to the region at present.

In 1894, Cope³ described a single species, *Cyphornis magnus*, from a formation in Vancouver, British Columbia, which he placed with some reservation in the Eocene, but which was later considered by others to be Oligocene. The species is considered as pelecanid in its affinities but generically distinct from any form now living.

Lucas, in 1901,⁴ described a new genus and species of diver, *Mancalla californiensis*, from a formation at Los Angeles, California. From the associated invertebrate fauna, this species is considered by Dall to be of upper Miocene or lower Pliocene age.

As a result of the preliminary study put upon the University of California collections by the present writer, there have appeared a series of short papers dealing with a number of species from Fossil Lake, Oregon, and from the caverns and the asphalt beds of California. While these papers record one unique form, *Teratornis*, of unusual interest, the main value of the contributions, like that of Shufeldt's, lies in the light shed upon the former distribution of families of birds still living.⁵

² Shufeldt, R. W., Journ. Acad. Nat. Sci. Phila., Ser. 2, No. 9, p. 389, 1892.

³ Cope, E. D., Journ. Acad. Nat. Sci. Phila., Ser. 2, No. 9, p. 449, 1894.

⁴ Lucas, F. A., Proc., U. S. Nat. Mus., vol. 24, p. 133, 1901.

⁵ Miller, L. H., Univ. Calif. Publ., Bull. Dept. Geol., vols. 5-6 *passim*, 1909-11.

MATERIAL AVAILABLE

The material upon which studies of the west coast fossil birds have been based has been collected from nine different horizons, summarized as follows:

OLIGOCENE

Vancouver, B.C. One species (a single specimen).

MIOCENE

Virgin Valley Beds, Virgin Valley, Nevada. One species.

Los Angeles, California. One species (a single specimen).

PLEISTOCENE

Potter Creek Cave, California. Sixteen species.

Samwel Cave, California. Nineteen species.

Hawver Cave, California. Twelve species.

Rodeo Pleistocene, California. One species (a single specimen).

Rancho La Brea, California. Forty-nine species.

Fossil Lake, Oregon. Fifty-three species.

The avian collections assembled at the University of California represent seven of these localities. One of the seven is identical with that studied by Cope and Shufeldt, namely, the Fossil Lake region of Oregon. The remaining six collections, so far as known to the writer, have not been studied previous to the assumption of the task here in part recorded. Three or four hundred specimens represent the bird remains from the caves, and three or four thousand have been taken from the asphalt at Rancho La Brea.

So far as can be learned, the Oligocene horizon yielding *Cyphornis* to Cope, and the Miocene, from which Lucas described *Mancalla*, have yielded no other avian fossils.

OLIGOCENE FAUNA

Cyphornis magnus Cope is the only species known to the coast from strata of possibly so great age. The form was described by Cope⁶ from a single specimen, the proximal end of a tarsometatarsus, the property of the Geological Survey of Canada. The osteological characters displayed by the specimen are such as to have led Cope to assign the species with some reserve to the family Pelecanidae. Interest centers to some extent in a combination of the two characters,

⁶ Cope, E. D., Journ. Acad. Nat. Sci., Phila., Ser. 2, No. 9, p. 449, 1894.

large size and high degree of pneumaticity. The latter character was considered by the author of the species as indicating the bird's ability to fly. If such conclusion be true, the species, since the tarsometatarsus equaled in size that of the rhea, must be considered as the largest known flying bird.

It may not be out of place here to consider the propriety of Cope's position regarding the relation of pneumaticity to the power of flight. Let it be conceded that *Cyphornis* belonged to the Pelecanidae, birds of large size which are possessed of a high degree of pneumaticity. We may then ask if the character pneumaticity necessarily became vestigial or disappeared with the loss of ability to fly resulting from increased size. The development of such a character as gigantism might be a matter of comparatively short time, while the persistence of the character pneumaticity might be very tenacious. An instructive case in point is that of *Geococcyx*, a cuckoo of terrestrial habit whose powers of flight have been almost entirely sacrificed. The pectoral arch in this bird is an absurdly weak structure, while there is an accompanying accentuated development of the posterior limb region. Despite this inversion of the appendicular parts, the skeleton remains highly pneumatic. It seems well within the range of possibility that *Cyphornis* should have gained its large size by a rapid specialization—a tendency run riot under certain conditions not adverse to it—and yet this specialization cost the bird its power of flight without blotting out the character of pneumaticity.

MIocene FAUNA

Mancalla californiensis Lucas, from the upper Miocene of Los Angeles, California, is described by Lucas⁷ as being much like the Recent species of murre (*Uria troille*) of that region, but more highly specialized in that it was probably without the power of flight. The single specimen known consists of the major part of the left humerus of a bird about the size of the recently extinct great auk (*Plaurus impennis*). Interest in this discovery lies largely in the strong similarity of the bird to Recent

⁷ Lucas, F. A., Proc. U. S. Nat. Mus., vol. 24, p. 133, 1901.

forms, in its flightless character suggesting to the author of the species an insular breeding-ground free from enemies, and finally in the fact that the accompanying molluscan fauna indicates a climate cooler than that which characterizes the region at present. It is regrettable that a larger number of species was not discovered in the same horizon.

PLEISTOCENE FAUNA

Potter Creek Cave.—Potter Creek Cave^s takes its name from its location on Potter Creek, about one mile east of Baird, a station of the U. S. Bureau of Fisheries on the McCloud River in Shasta County, California. The locality lies at present in the lower Transition zone at an elevation of 1500 feet above the sea. The surrounding country is well timbered with conifers, oaks, and maples in the main, and with lower scrub forming thickets in less favorable exposure. Topographically the region is rendered rather rough by numerous small tributaries of the McCloud River cutting through the Baird Shales, and the McCloud Limestones, to form cañons with abrupt slopes and much dissected ridges. The cave occupies at present a position 800 feet above the McCloud River, only slightly over a mile away.

According to the observations of Sinclair, the river flowed during the formation of the cavern deposits at approximately the level of the cave floor. The lowering of the river bed and the backward cutting of tributary streams brought about more rapid drainage of the country to either side of the cave, less water entered the fissure, and cave-cutting ceased. Openings were formed later in the roof of the cave by surface erosion, thus permitting the entrance of clay, rock fragments, broken bones and possibly of live animals. Subsequent uplift increased the cutting by streams in the region, and Potter Creek cut down through one of the galleries, thus forming the present cave entrance.

There were two or three of these periods of uplift as determined by Sinclair which changed the character of the country from one of moderate relief to one of mountainous aspect dis-

^s See Sinclair, W. J., Univ. Calif. Publ. Am. Arch. Ethn., vol. 2, pp. 1-27, 1904.

sected by river cañons. The indications are that the actual elevation at present is considerably greater than that during the deposition of the bone-bearing material. Certainly the relation of the cave to the river level has changed in the neighborhood of eight hundred feet. There is no evidence of a later subsidence noted, so we may assume that the conditions during the period of deposition were more like those at Rancho La Brea than they are at present, i.e., less abrupt elevation and a smoother topography. The presence of *Dendragapus* in the cave deposits is an indication, however, that conditions were not identical in the two localities.

A very interesting description of the various chambers and galleries of the cavern is given in Sinclair's paper. The fossil-bearing matrix represents the accumulation on the floors of the chambers and pockets in the form of fans of detritus, admitted doubtless through old chimney-like chutes now entirely blocked by limestone accretions and washed debris. These fans of accumulated material were encrusted, and in some instances cemented, by stalagmitic deposits so that blasting had to be resorted to in places.

The remains are in most cases entirely dissociated. Sinclair notes the finding of a few skeletons in their proper anatomical relations, such as those of a squirrel, a woodrat, a snake, and a bat. These are all animals which would go into caves of their own accord and after death fall upon the floors of the caverns. No case of bird skeletons in any degree associated is to be found. The bones have entirely lost their organic matter and appear almost as though calcined. Perfect bones of the smaller vertebrates are rare. In most cases fracture has occurred and in many the articular surfaces have been injured, either on account of the delicacy of the cancellated bone in that region, or because the presence of articular cartilages tempted the appetites of gnawing forms. Weathering and cracking due to exposure on the surface is the only reasonable explanation of the imperfections of some specimens.

Sinclair suggests three methods of possible introduction of animal remains into the cave. Washing by rills which carried bones from the surface down by way of the nearly vertical chim-

neys seems a very probable method. These open chimneys may have acted as pitfalls into which animals blundered in passing over the surface. Again, predatory forms may have carried their prey into the mouths of the caverns whence the accumulated bones were washed, or carried by woodrats, into the more remote recesses. This last method seems to the present author the most probable means of introduction of such forms as the anserines among birds. *Falco peregrinus*, whose remains also occur in the deposits, is a large and powerful hawk which habitually resorted to such places to nest. About the entrances to their nesting crevices today one commonly finds the accumulated bones of a great variety of vertebrates brought as prey. Their predilection for the anserines has given these birds their common name of duck hawk.

Sinclair records the following list of vertebrates from the Potter Creek Cave deposits, marking extinct species with an asterisk:

SINCLAIR'S LIST OF SPECIES FROM POTTER CREEK CAVE

* <i>Arctotherium simum</i> Cope.	<i>Callospermophilus chrysodeirus</i>
* <i>Ursus</i> , n. sp.	Merriam, C. H.
* <i>Felis</i> , n. sp.	<i>Lepus californicus</i> Gray.
<i>Felis</i> , near <i>hippolestes</i> Merriam,	<i>Lepus klamathensis</i> Merriam, C.
C. H.	H.
<i>Lynx fasciatus</i> Rafinesque.	<i>Lepus</i> , near <i>auduboni</i> Baird.
<i>Lynx fasciatus</i> , n. subsp. (?)	<i>Lepus</i> , sp.
<i>Urocyon townsendi</i> Merriam, C. H.	* <i>Teonoma</i> , n. sp.
<i>Vulpes cascadiensis</i> Merriam, C. H.	<i>Neotoma fuscipes</i> Baird.
* <i>Canis indianensis</i> Leidy.	<i>Microtus californicus</i> Peale.
* <i>Taxidea</i> , n. sp.	* <i>Thomomys</i> , n. sp.
<i>Bassariscus raptor</i> Baird.	<i>Thomomys leucodon</i> Merriam, C.
<i>Mephitis occidentalis</i> Baird.	H.
* <i>Spilogale</i> , n. sp.	<i>Thomomys monticola</i> Allen
<i>Putorius arizonensis</i> Mearns.	* <i>Aplodontia major</i> , n. subsp.
<i>Arctomys</i> , sp.	<i>Scapanus californicus</i> (?) Ayres.
<i>Sciurus hudsonicus albolimbatus</i>	<i>Antrozous pallidus</i> Merriam, C. H.
Allen.	* <i>Platygonus</i> (?) sp.
<i>Sciuropterus klamathensis</i> Mer-	<i>Odocoileus</i> , sp. a.
riam, C. H.	<i>Odocoileus</i> , sp. b.
<i>Spermophilus douglasi</i> Richard-	<i>Haplocerus montanus</i> Ord.
son.	* <i>Eucatherium collinum</i> Sinclair
<i>Eutamias senex</i> (?) Allen.	and Furlong.

* Species marked with the asterisk (*) are either extinct or are no longer represented in the region.

*Bison, sp.	*Equus occidentalis Leidy.
*Camelid.	*Equus pacificus Leidy.
*Megalonyx wheatleyi (?) Cope.	Crotalus, sp.
*Megalonyx jeffersonii (?) Harlan.	Mylopharadon conocephalus Baird and Gerard.
*Megalonyx, n. sp.	Ptychocheilus (?) grandis (?) (Ayres).
*Megalonyx, sp.	Acipenser medirostris (?) Ayres.
*Mastodon americanus Kerr.	
*Elephas primigenius Blumb.	

To this list of species published by Sinclair, the studies of the present author⁹ would add the following birds:

SPECIES OF BIRDS FROM POTTER CREEK CAVE

Branta canadensis (Linnaeus).	*Catharista shastensis Miller.
Oreortyx picta (Douglas).	Buteo borealis (Gmelin).
Dendragapus obscurus (Say).	Falco peregrinus Tunstall.
*Bonasa umbellus (Linnaeus).	Falco sparverius Linnaeus
Indeterminate odontophorid.	Otus asio (Linnaeus).
*Meleagris, sp.	*Bubo sinclairi Miller.
*Gymnogyps amplus Miller.	Colaptes cafer (Gmelin).
Cathartes aura (Linnaeus).	Corvus brachyrhynchos Brehm.

Species marked with the asterisk () are either extinct or are no longer represented in the region.

Samuel Cave.—Samuel Cave was explored by E. L. Furlong, then of the University of California, who published an account of his work two years after the appearance of Sinclair's paper on the Potter Creek Cave. Furlong's account¹⁰ pictures a cavern not essentially different from that described by Sinclair. The conditions of interment seem to have been somewhat different, however, since there occurred a number of entire skeletons of large and small carnivores and one form of ungulate, *Preptoceras*, which were preserved without fracture of the bones and in the proper anatomical relation. Furlong reaches the conclusion that the cavern was used as a lair by such forms as the bear and the cougar. To this lair the bodies of larger ungulates like *Eucatherium* and *Preptoceras* were dragged as prey. Some of the carcasses were left almost entire while others were torn to pieces and the bones more or less broken by the

⁹ Miller, L. H., Univ. Calif. Publ., Bull. Dept. Geol., vol. 6, p. 385, 1911.

¹⁰ Furlong, E. L., Am. Journ. Sci., vol. 22, pp. 235-247, Sept., 1906.

teeth of the captor. The suggestion is also made that the cavern may have been used as a den for hibernation by various ursines, even as other caverns in the region are known to be used by bears of today.

No specimen of bird skeleton was found with bones in proper place, so the probability is that the remains representing this class were introduced largely as in the case of the Potter Creek Cave specimens. Some essential difference must have existed, however, since the relation in numbers of the different species is so different in the two localities. The Cathartiformes appear in Potter Creek Cave represented by forty-five specimens distributed over three species. In Samwel Cave there appear but six specimens possibly assignable to the group. *Falco peregrinus*, represented in the former cave by four specimens, is wanting in the latter. The owls are represented by five specimens in the former and eleven in the latter, the grouse by thirty-four in the former as against one hundred and twenty-four in the latter.

This difference of faunal proportions is perhaps most readily explained by the probable difference between the original openings of the caves. Let it be conceded that, as suggested by the respective authors, Potter Creek Cave opened by a relatively small chimney or two on the surface of the Pleistocene hillside and that Samwel Cave opened by a large chamber, the first part of which ran more nearly horizontally. Vultures, ravens, and the peregrine falcon nest in small cavities in rocky cliffs out of the way of small predatory mammals like the raccoons and the weasels. Their bones and those of their prey would accumulate in these pockets and eventually find their way into deeper recesses through fissures or chutes as described by Sinclair. The owls, however, resort to large open-mouthed caves to roost during much of the year, which fact would account for their greater abundance in Samwel Cave. Raccoons were found in abundance by Furlong as entire skeletons on the floor of Samwel Cave, thus suggesting that these animals frequented the place as a lair. The ground-dwelling birds, their natural prey, thus come to form a large proportion of the avian remains in these deposits. Procyonid forms are not listed by Sinclair from Potter Creek

Cave. They were either absent from the region or did not frequent the vicinity of the cave mouth. It seems not improbable that these small carnivores had a distinct relation to the number of gallinaceous bird remains to become entombed in the various cave deposits.

The following list of mammals is recorded by Furlong from the Samwel Cave:

FURLONG'S LIST OF SPECIES FROM SAMWEL CAVE

<i>Ursus americanus</i> Pallas.	<i>Lepus</i> , sp.
<i>Ursus</i> , n. sp.	<i>Thomomys monticola</i> Allen.
<i>Ursus</i> , sp.	<i>Thomomys</i> , sp.
<i>Vulpes</i> , sp.	<i>Microtus</i> , sp.
<i>Urocyon townsendi</i> Merriam, C. H.	<i>Neotoma fuscipes</i> , Baird.
<i>Procyon</i> , near <i>lotor</i> Linn.	<i>Neotoma</i> , sp.
<i>Putorius arizonensis</i> Mearns.	<i>Citellus douglasi</i> Richardson.
<i>Mephitis occidentalis</i> Baird.	<i>Sciurus</i> , sp.
<i>Mustela</i> , sp.	<i>Eucatherium collinum</i> Sinclair and Furlong.
<i>Felis</i> , near <i>hippolestes</i> Merriam, C. H.	<i>Preptoceras sinclairi</i> Furlong.
<i>Aplodontia</i> , near <i>major</i> Merriam, C. H.	<i>Haplocerus</i> , sp.
<i>Aplodontia rufa</i> Rafinesque.	<i>Odocoileus</i> , sp. <i>a</i> .
<i>Erethizon epixanthus</i> Brandt.	<i>Odocoileus</i> , sp. <i>b</i> .
<i>Arctomys</i> , sp.	<i>Equus occidentalis</i> Leidy.
<i>Lepus auduboni</i> Baird.	<i>Elephas</i> , sp.
	<i>Megalonyx</i> , sp.

SPECIES OF BIRDS FROM SAMWEL CAVE.

Indeterminate anserine a.	<i>Falco sparverius</i> Linnaeus.
Indeterminate anserine b.	<i>Asio wilsonianus</i> (Lesson).
Indeterminate anserine c.	<i>Bubo virginianus</i> (Gmelin).
<i>Oreortyx picta</i> (Douglas).	* <i>Bubo sinclairi</i> Miller.
Indeterminate odontophorid.	<i>Glaucidium gnoma</i> Wagler.
* <i>Gymnogyps amplus</i> Miller.	* <i>Micropallas whitneyi</i> (J. G. Cooper).
<i>Cathartes aura</i> (Linnaeus).	<i>Colaptes cafer</i> (Gmelin).
* <i>Catharista shastensis</i> Miller.	<i>Cyanocitta stelleri</i> (Gmelin).
<i>Accipiter velox</i> (Wilson).	
<i>Buteo swainsoni</i> Bonaparte?	

* Species of birds marked with the asterisk (*) are extinct or else foreign to the locality.

Hawver Cave.—Hawver Cave is now located in the same faunal zone as the caves previously discussed and at about the same elevation, though some two degrees to the southward. The

formation of the cave is essentially the same except that the work of solution is still probably going on to some extent. The method of entombment of the organic remains appeared to Furlong to be the same as that acting in the case of Potter Creek Cave, i.e., the washing in of surface material by the action of streamlets.

The presence of *Megalonyx* and *Equus* indicate the Pleistocene age of the bone-bearing deposits in the fissure. There appear no remains of the large ungulates *Euceratherium* and *Preptoceras* to correspond with the deposits of the Shasta caves, but this condition may be more apparent than real, since but a limited amount of work was done in the cave before the level of the water in some of the passages rose to a point so high that access to the main bone-bearing chambers was prevented.

But twelve species of birds are represented in the collections from this cave. Four of these are no longer represented in the region. The fact that the cave is still open and that changes due to the action of water are still going on lends a feeling of uncertainty as to the exact age of any specimen. The association in loose material of remains which are unquestionably Pleistocene in origin with others representing still existing species is no guaranty of the age of the latter. There is continually going on a measure of differential motion in some of the debris accumulated, which would possibly mingle fragments deposited at quite different times. Solution, shifting and re-cementing may have recurred several times although the excellent state of preservation of most of the bones would militate against the idea that a great deal of such movement had taken place.

The few mammals thus far identified from Hawver Cave are listed as follows:

Equus occidentalis (?) Leidy.
Aplodontia, sp.

Megalonyx, sp.
Felis hippolestes Merriam, C. H.

LIST OF BIRDS FROM HAWVER CAVE.

* <i>Nettion carolinense</i> (Gmelin).	* <i>Geranoaëtus melanoleucus</i> Auct.?
* <i>Oreortyx picta</i> (Douglas).	* <i>Colaptes cafer</i> (Gmelin).
* <i>Lophortyx californica</i> (Shaw).	* <i>Cyanocitta stelleri</i> (Gmelin).
* <i>Meleagris</i> , sp.	* <i>Corvus corax</i> Linnaeus.
* <i>Cathartes aura</i> (Linnaeus).	* <i>Euphagus cyanocephalus</i> (Wag- ler).
* <i>Catharista shastensis</i> Miller.	
* <i>Archibuteo ferrugineus</i> (Lichten- stein).	

* An asterisk indicates that the species is extinct or no longer found in this region.

Rancho La Brea.—The Rancho La Brea beds constitute one of the most unique and at the same time one of the richest of Pleistocene deposits in the west; unique because in the entombment of remains the factor of chance has been reduced to a minimum by the presence of an attractively baited and automatic trap; rich because the trap was insatiable in its demands, because the material was promptly immersed and preserved in semi-fluid asphalt, and because of the fact that the trap was almost continually operative, it would seem, for a considerable period of time.

According to Merriam,¹¹ who bases his conclusions on personal observation and upon the opinions of Arnold, Oreutt, and other geologists, crude asphaltic oil from the underlying Fernando shales, here gently upfolded, has been forced to the surface through cracks or chimneys in these folded strata to accumulate upon the surface as more or less extensive oil pools. This heavy oil, under the influence of sun and wind, underwent a process of natural distillation, becoming more and more viscid until in the larger accumulations it was sufficiently tenacious to entrap and hold the largest mammals of the region, *Elephas*, *Mastodon*, and *Paramylodon*. As pointed out by the same author, additions to these lenses of asphalt took place at the center as fresh oil rose through the chimneys from below; at the same time dust and sand drifted over and obscured the firmer asphalt of the margins. These two factors combined to bring about a most deceptive condition in the mass by leaving the periphery fairly firm and yet permitting a gradually increas-

¹¹ Merriam, J. C., Mem. Univ. Calif., vol. 1, No. 2, pp. 199-213, 1911.

ing degree of plasticity toward the center without a positive demarcation of the danger zone. Upon this treacherous surface a mammal would be unaware of danger until the dust-covered surface yielded under his weight. His sudden start or his leap for safety would make all the more complete his entanglement.

While these exposed traps must have been in many cases passive, concealed in an open or perhaps but slightly wooded locality where animals would blunder into them, they must often also have been actively attractive to animals through the two important factors of water and food. During a considerable period of time spent in working these fascinating deposits, the author has had frequent recourse to the water accumulated in depressions of the asphalt. This water has proven quite acceptable for drinking and for bathing. As algae accumulate, frogs, toads, dragonflies, mosquitoes, and other insect forms invade it; rushes and marsh-grass border the pools, their roots actually in contact with asphalt of the highest degree of tenacity. In a number of cases the asphalt accumulations represent depressions in the general surface of the country where not only the direct rainfall would be temporarily held empounded but more lasting pools representing surface drainage or even seepage would accumulate. The presence of bedded leaf-masses and of water-worn fragments of wood intermingled with the animal remains would support the view that there were at times ponds of a more or less permanent nature. The animals of poorly watered regions in the southwest are perforce far from fastidious in the matter of drinking water; hence the herbivorous mammal must certainly have found the vicinity of these water pools one offering very positive attraction as to water and perhaps grass as well.

The entanglement of one ungulate would suffice to attract a multitude of carnivores. The creature probably acted not infrequently as live bait for a considerable time, so that its struggles and outcries served to whet the appetites and overcome the instincts of caution in the hungry carnivore. It appears from Merriam's studies that young animals or else old or diseased individuals have very frequently been thus tempted, though there appear animals of all ages.

The prevailing conditions also led to a greatly distorted relation between predaceous and non-predaceous species in point of numbers. While removing a single femur of *Paramylodon* there were found touching it three complete skulls of *Canis indianensis*, and even this proportion of three to one is much too small to represent the facts truthfully. In a collection of bird remains made by the writer the number of specimens of *Aquila* exceeds the number representing all the non-raptorial species combined, while fifty-six per cent of the species recorded are predatory.

The cessation of struggling on the part of the entrapped animal did not end its services as trap bait. Some forms which normally seek an active prey, e.g., *Canis* and *Aquila*, may on occasion resort to carrion. A decrepit wolf or a hungry eagle may not infrequently thus supply the demands of necessity. The odors emanating from these pits where freshly excavated are, to human nostrils, strongly suggestive of carrion. Gases exhaled by animal bodies submerged in the plastic mass would accentuate this olfactory effect to such a degree as probably to attract carrion feeders. Was this influence also felt by birds? Darwin's well-known experiments on Andean condors kept in captivity have long been accepted as proving that the vultures do not employ the olfactory sense in the perception of food. However, the experiences of later naturalists with *Cathartes*, which is often caught in wolf-traps with concealed bait, leads us to emphasize the fact that Darwin was experimenting with birds in captivity which had been fed perhaps from early youth in more or less regular fashion. We must at least concede it possible that the abundant vulture remains in the asphalt are the result in part of this factor of odor in attracting them to the locality.

PARTIAL LIST OF MAMMALS FROM RANCHO LA BREA.

* <i>Canis indianensis</i> Leidy.	<i>Putorius</i> , sp.
* <i>Canis oreutti</i> Merriam, J. C.	* <i>Arctotherium californicum</i> Merriam, J. C.
* <i>Canis andersoni</i> Merriam, J. C.	* <i>Elephas</i> , sp.
* <i>Canis occidentalis furlongi</i> Merriam, J. C.	* <i>Mastodon</i> , sp.
* <i>Lynx occidentalis fischeri</i> Merriam, J. C.	* <i>Equus</i> , sp.
* <i>Felis atrox bebbi</i> Merriam, J. C.	* <i>Bison antiquus</i> Leidy.
* <i>Smilodon californicus</i> Bovard.	* <i>Capromeryx minor</i> Taylor.
<i>Mephitis</i> , sp.	* <i>Camelops</i> (?), sp.
	* <i>Paramylodon</i> , sp.

SPECIES OF BIRDS KNOWN FROM RANCHO LA BREA.

<i>Chaulelasmus streperus</i> (Linnaeus).	<i>Haliaeetus leucocephalus</i> (Linnaeus).
<i>Anser albifrons</i> (Scopoli) ?	* <i>Morphnus woodwardi</i> Miller.
<i>Branta canadensis</i> (Linnaeus).	* <i>Geranoaëtus grinnelli</i> Miller.
* <i>Ciconia maltha</i> Miller.	* <i>Geranoaëtus fragilis</i> Miller.
<i>Jabiru mycteria</i> (Lichtenstein).	<i>Falco peregrinus</i> Tunstall.
<i>Mycteria americana</i> Linnaeus.	<i>Falco</i> , sp.
<i>Ardea herodias</i> Linnaeus.	<i>Falco sparverius</i> Linnaeus.
* <i>Grus minor</i> Miller.	* <i>Polyborus tharus</i> Auct.
<i>Grus canadensis</i> (Linnaeus).	<i>Aluco pratineola</i> (Bonaparte).
<i>Lophortyx</i> sp.	<i>Asio flammeus</i> (Pontoppidan).
* <i>Meleagris</i> ?	<i>Otus asio</i> (Linnaeus).
* <i>Pavo californicus</i> Miller.	<i>Bubo virginianus</i> (Gmelin).
<i>Gymnogyps californianus</i> (Shaw).	<i>Speotyto cunicularia hypogaea</i> (Bonaparte).
* <i>Sarcorhamphus clarki</i> Miller.	* <i>Neomorpha</i> , ? sp.
* <i>Pleistogyps rex</i> Miller.	<i>Colaptes cafer</i> (Gmelin).
* <i>Cathartornis gracilis</i> Miller.	<i>Otocoris alpestris</i> (Linnaeus).
<i>Cathartes aura</i> (Linnaeus).	<i>Corvus corax</i> Linnaeus.
* <i>Catharista occidentalis</i> Miller.	<i>Corvus brachyrhynchos</i> Brehm.
* <i>Teratornis merriami</i> Miller.	* <i>Corvus</i> , sp.
<i>Elanus leucurus</i> (Vieillot).	<i>Xanthocephalus xanthocephalus</i> (Bonaparte).
<i>Circus hudsonius</i> (Linnaeus).	<i>Agelaius gubernator</i> (Wagler).
* <i>Circus</i> , sp.	<i>Sturnella neglecta</i> Audubon.
<i>Buteo</i> , sp.	<i>Pipilo</i> , sp.
<i>Buteo borealis</i> (Gmelin).	<i>Lanius ludovicianus</i> Linnaeus.
<i>Aquila chrysaetos</i> (Linnaeus).	

* Species marked with an asterisk (*) are extinct or foreign to the locality.

Fossil Lake.—The horizon designated by Cope as Silver Lake and classed collectively with several other horizons as the Equus Beds, was thought for many years to be of Pliocene age and as such was considered by Cope and by Shufeldt in their studies

of the birds from that region. Our knowledge of the various western horizons has, however, been extended by later investigators in stratigraphy and in the correlation of faunas, with the result that these beds are now proven unquestionably to be of Pleistocene age. Such change of interpretation alters materially the significance of discoveries announced by Cope and by Shufeldt in that it reduces appreciably the extent to which several existing genera are known to run back in time.

The various descriptions of this region are summarized in a concise and very lucid paragraph or two by Osborn¹² from which the following may well be quoted:

"One hundred and fifty miles northwest of the old Lahontan shore lines in the heart of the Oregon Desert of the great basin, and twenty miles northeast of Silver Lake, there is a slight depression in the desert perhaps twenty acres in extent marked Christmas Lake on the maps, to which Cope gave the name 'Fossil Lake.' This 'Silver,' 'Christmas,' or 'Fossil' lake region was successively explored by Condon, Cope, Sternberg (who made the chief collections), and Russel (1882). . . . Though actually twenty miles distant from Silver Lake, the rich fauna of mammals and birds found has been described by Cope¹³ and Shufeldt, and referred to by Gilbert, as the fauna of the Silver Lake *Equus* beds. . . .

"Proof that the country was partly fluviatile and partly wooded is afforded by the presence of the muskrat (*Fiber*), the otter (*Lutra*), the beaver (*Castor fiber*), and the giant beaver (*Castoroides*).

" . . . The bird life was very abundant and not very dissimilar from what we might observe at any of the alkaline lakes of the West, resorted to at the present day by wild fowl during their migrations. Great flocks of swans (*Cygnus paloregonus*), geese (*Anser condoni*), and ducks were there; a cormorant (*Phalacrocorax*) was among the rarities; among the species of grebe (*Podiceps occidentalis*) is one still inhabiting this region. There were also coots (*Fulica minor*) and herons (*Ardea paloccidentalis*). Other forms of birds include two species of grouse, crows, and eagles. The strangest figure upon the scenes among the birds was a true flamingo (*Phoenicopterus copei*). The northernmost distribution of flamingoes at the present is southern Florida and the Bahama Islands (lat. 27° N). Shufeldt concludes that the climate might well be compared with that of Florida or the lower part of Louisiana, that the vegetation was fully as luxuriant as it now is in those parts, and that the palms were abundantly represented. This conclusion as to a Floridan climate and the existence of palms is, however, very questionable. Brown¹⁴ observes that the South American flamingoes (*Phoenicopterus chilensis*) migrate as far south as

¹² Osborn, H. F., The Age of Mammals, p. 458.

¹³ Cope, E. D., The Silver Lake of Oregon and its Region, Am. Nat., vol. 23, pp. 970-982, 1889.

¹⁴ Mr. Barnum Brown in a note to the author [Osborn].

the lakes in central eastern Tierra del Fuego, lat. 53° S, where they are said to breed, and certainly spend a part of the season. This region corresponds in temperature to the climate of central Alberta, Canada, 400 miles north of Silver Lake. Thus it appears that the presence of *Phoenicopterus copei* at Silver Lake has very little weight in the determination of climate. It is more probable that the northern lakes of that period contained mollusks on which the flamingoes fed.”

Aside from an extinct genus of grouse, *Phoenicopterus* is the only genus recorded fossil that might not reasonably be expected to occur in the region at the present time.

Shufeldt's original paper¹⁵ gives a detailed description of most of the species of birds found in the Fossil Lake beds and a synoptical list of the known species was published in a paper by the writer¹⁶ as follows:

Aechmophorus occidentalis (Lawrence).

Pygopodes:	<i>Aechmophorus occidentalis</i> (Lawrence).
<i>Colymbus holboelli</i> (Reinhardt).
<i>Colymbus auritus</i> Linneus.
<i>Colymbus nigricollis californicus</i> (Heermann).
<i>Podilymbus podiceps</i> (Linneus).
Longipennes:	<i>Larus argentatus</i> Pontoppidan.
<i>Larus robustus</i> Shufeldt.
<i>Larus californicus</i> Lawrence.
<i>Larus oregonus</i> Shufeldt.
<i>Larus philadelphia</i> (Ord).
<i>Xema sabini</i> (J. Sabine).
<i>Sterna elegans</i> Gambel.
<i>Sterna forsteri</i> Nuttall.
<i>Hydrochelidon nigra surinamensis</i> (Gmelin).
Steganopodes:	<i>Phalacrocorax macropus</i> (Cope).
<i>Pelecanus erythrorhynchos</i> Gmelin.
Anseres:	<i>Lophodytes cucullatus</i> (Linnaeus).
<i>Anas platyrhynchos</i> Linnaeus.
<i>Mareca americana</i> (Gmelin).
<i>Nettion carolinense</i> (Gmelin).
<i>Querquedula discors</i> (Linnaeus).
<i>Querquedula cyanoptera</i> (Vieillot).
<i>Spatula clypeata</i> (Linnaeus).
<i>Dafila acuta</i> (Linnaeus).
<i>Aix sponsa</i> (Linnaeus).

¹⁵ Shufeldt, R. W., Journ. Acad. Nat. Sci. Phila., ser. 2, no. 9, pp. 389-45, 1892.

¹⁶ Miller, L. H., Univ. Calif. Publ., Bull. Dept. Geol., vol. 6, pp. 79-87, 1911.

	<i>Marila valisineria</i> (Wilson).
	<i>Clangula islandica</i> (Gmelin).
	<i>Harelda hyemalis</i> (Linnaeus).
	<i>Anser condoni</i> Shufeldt.
	<i>Anser albifrons gambeli</i> Hartlaub.
	<i>Branta hypsibata</i> Cope.
	<i>Branta canadensis</i> (Linnaeus).
	<i>Branta propinqua</i> Shufeldt.
	<i>Chen hyperboreus</i> (Pallas).
	<i>Olor palaregonus</i> (Cope).
Odontoglossae:	<i>Phoenicopterus copei</i> Shufeldt.
Herodiones:	<i>Ardea palaeccidentalis</i> Shufeldt.
Paludicolae:	<i>Fulica americana</i> Gmelin.
	<i>Fulica minor</i> Shufeldt.
Limicolae:	<i>Lobipes lobatus</i> (Linnaeus).
Gallinae:	<i>Tympanuchus pallidicinctus</i> (Ridgway).
	<i>Pediocetes phasianellus columbianus</i> (Ord).
	<i>Pediocetes lucasi</i> Shufeldt.
	<i>Pediocetes nanus</i> Shufeldt.
	<i>Palaeotetrix gilli</i> Shufeldt.
Accipitres:	<i>Aquila pliogryps</i> Shufeldt.
	<i>Aquila sodalis</i> Shufeldt.
Striges:	<i>Bubo virginianus</i> (Gmelin).
Passeres:	<i>Euphagus affinis</i> Shufeldt.
	<i>Corvus annectens</i> Shufeldt.

ADDITIONAL SPECIES OF BIRDS IN THE CALIFORNIA COLLECTIONS

Pygopodes:	<i>Aechmophorus lucasi</i> Miller.
Anseres:	<i>Erismatura jamaicensis</i> (Gmelin).
Accipitres:	<i>Circus hudsonius</i> (Linnaeus).

PARTIAL LIST OF MAMMALS FROM FOSSIL LAKE.¹⁷

<i>Ursus</i> , sp.	<i>Lepus</i> , sp.
<i>Felis</i> , sp.	<i>Myiodon sodalis</i> Cope.
<i>Canis latrans</i> Say.	<i>Equus pacificus</i> Leidy.
<i>Canis</i> , cf. <i>occidentalis</i> Richardson.	<i>Equus</i> , n. sp.
<i>Vulpes</i> , cf. <i>pennsylvanicus</i> Bodd.	<i>Elephas</i> , sp.
<i>Lutra canadensis</i> Schreber.	<i>Platygonus</i> , cf. <i>vetus</i> Leidy.
<i>Fiber zibethicus</i> Linnaeus.	<i>Platygonus</i> , sp.
<i>Arvicola</i> , sp.	<i>Eschatus conidens</i> Cope.
<i>Thomomys</i> , sp.	<i>Camelops kansanus</i> Leidy.
<i>Geomys</i> , sp.	<i>Camelops vitakerianus</i> Cope.
<i>Castor</i> , sp.	<i>Camelops</i> , sp.
<i>Castoroides</i> , sp.	<i>Antilocapra</i> , sp.

¹⁷ Sinclair, W. J., Univ. Calif. Publ. Am. Arch. Ethn., vol. 2, p. 1, 1904.

Rodeo Pleistocene.—Almost nothing has been recorded concerning this formation. The region has been repeatedly visited by parties from the University of California and the Pleistocene age of the beds definitely established.

The single specimen of bird remains from the locality was picked up at the base of the exposure by Professor J. C. Merriam with parts of the matrix of the Pleistocene beds still adhering to it. The bone is a perfect tarsometatarsus of average size.

SINGLE SPECIES FROM RODEO PLEISTOCENE.

Æchmophorus occidentalis (Lawrence).

PRESENT PHYSIOGRAPHIC AND GEOGRAPHIC RELATIONS OF THE
WEST AMERICAN REGIONS IN WHICH FOSSIL AVIAN
REMAINS ARE KNOWN

The nine localities referred to above have yielded several thousand specimens in all. Only five of these specimens, representing three species, are from deposits older than the Pleistocene; hence we may consider our knowledge as practically limited to that age. Since also the systematic groups larger than the species display in the case of birds such remarkable longevity, time relations between the several Pleistocene horizons become of minor importance except as we learn of variations in climate during that period.

There is on the other hand an advantage to be derived from the approximate contemporaneity of the deposits. The entombment of many specimens at about the same time under a variety of conditions and in a number of different localities gives us an unusually accurate conception of the avifauna of that time. The Fossil Lake deposits yield mainly those species to be found about open, shallow lakes; the caverns are so located as to have entombed those species which inhabit lower mountainous country; the Rodeo Pleistocene consists of seashore accumulation; the Rancho La Brea beds are the result of a peculiarly diverse combination of circumstances which led to the trapping of open-plains birds with a preponderance of raptorial species.

The asphalt beds lie in latitude 34° N, on the coastal side of the Santa Monica Mountains within a few miles of the sea and

less than two hundred feet above its level. The locality is today a typical open valley country, protected on the north by the east-and-west Santa Monica Range, yet tempered by the cool and moisture-laden breeze from the sea. Faunally, the locality lies in the Upper Sonoran zone of the San Diego region.

The Shasta caves occupy a position further inland and seven degrees to the northward of Rancho La Brea. Their elevations vary between 1300 and 1500 feet above sea-level. The isothermic zone represented is slightly above that of Rancho La Brea, it being Upper Sonoran and lower Transition. The isohumic area is that of the Sacramento-San Joaquin, which is an area of slightly greater precipitation than is the San Diegan.

The two localities are at present distinguishable in their avifauna by the presence or the absence of several species which are of interest in the light of palaeontological records. The entire group of grouse, represented in the Shasta region by *Dendragapus*, is wanting at Rancho La Brea. *Orcortyx* and *Cyanocitta*, present in the cave region, are wanting in the immediate vicinity of the asphalt beds. *Geococcyx*, present in the latter locality, is wanting in the former.

These, however, are birds of slight volant power. The species of less restricted activity, such as the Raptores and the water-birds, are common to the two localities at present.

The Fossil Lake region of Oregon lies in latitude 43° N, full nine degrees north of Rancho La Brea, and is on the eastern side of the Cascade Range. This separation from the coastal slope would influence the smaller species of birds more than the larger. Winter temperatures would be more severe, with summer temperatures fully equal to those of southern California. The rainfall at the present time is such as to give the region the name of "Oregon Desert."

There appears, then, as distinguishing the five more important localities today, a difference of nine degrees of latitude, a range of elevation from 100 to 1500 feet above the sea, and a faunal difference limited to the Upper Sonoran and lower Transition zones. There is no evidence of marked change in elevation since Pleistocene times; hence it seems probable that a somewhat similar relationship between the localities prevailed

during the Pleistocene period and that the specimens obtained from the various horizons represent in the aggregate, with a considerable degree of accuracy, the avifauna of the Pacific coast at that time.

RELATION OF PLEISTOCENE FAUNAS TO THOSE OF THE PRESENT DAY

A partial list of the Recent birds of the Transition zone in the Shasta region is given in the report of a biological survey of the region by C. H. Merriam.¹⁸ The list is appended here and the more striking differences displayed by the other localities are noted. This comparison may prove of interest in considering the fossil avifauna.

RECENT AVIFAUNA OF THE SHASTA REGION

(Partial list from Upper Sonoran and Transition zones)

<i>Oreortyx picta</i> (Douglas).	<i>Speotyto cunicularia</i> (Molina).
<i>Lophortyx californica</i> (Shaw).	<i>Glaucidium gnoma</i> Wagler.
<i>Dendragapus obscurus</i> (Say).	<i>Colaptes cafer</i> (Gmelin).
<i>Zenaidura macroura</i> (Linnaeus).	<i>Aphelocoma californica</i> (Vigors).
<i>Cathartes aura</i> (Linnaeus).	<i>Cyanocitta stelleri</i> (Gmelin).
<i>Circus hudsonius</i> (Linnaeus).	<i>Sturnella neglecta</i> Audubon.
<i>Buteo borealis</i> (Gmelin).	<i>Euphagus cyanocephalus</i> (Wagler).
<i>Aquila chrysaëtos</i> (Linnaeus).	<i>Lanius ludovicianus</i> Linnaeus.
<i>Falco mexicanus</i> Schlegel.	<i>Planesticus migratorius</i> (Linnaeus).
<i>Falco sparverius</i> Linnaeus.	
<i>Bubo virginianus</i> (Gmelin).	

To this list may be added the following species which possibly occur in the locality, though not recorded by the collectors of the survey party:

<i>Accipiter velox</i> (Wilson).	<i>Falco peregrinus</i> Tunstall.
<i>Accipiter cooperi</i> (Bonaparte).	<i>Aluco pratineola</i> (Bonaparte).
<i>Astur atricapillus</i> (Wilson).	<i>Asio wilsonianus</i> (Lesson).
<i>Buteo swainsoni</i> Bonaparte.	<i>Otus asio</i> (Linnaeus).
<i>Archibuteo ferrugineus</i> (Lichtenstein).	<i>Geococcyx californianus</i> (Lesson).
<i>Haliaeetus leucocephalus</i> (Linnaeus).	<i>Corvus corax</i> Linnaeus.
<i>Gymnogyps californianus</i> (Shaw).	<i>Corvus brachyrhynchos</i> Brehm.
	Cosmopolitan water birds

¹⁸ Merriam, C. H., Results of a Biological Survey of Mt. Shasta, California, N. Am. Fauna, No. 16, 1899.

SOME RECENT BIRDS NOTED IN THE SILVER LAKE REGION.¹⁹

Geese, Swans, Pelicans, Cormorants	<i>Oreoscoptes montanus</i> (Townsend,
<i>Æchmophorus occidentalis</i> (Lawrence).	J. K.)
<i>Myadestes townsendi</i> (Audubon).	<i>Asyndesmus lewisi</i> Riley.
<i>Ixoreus naevius</i> (Gmelin).	<i>Recurvirostra americana</i> Gmelin.
	<i>Himantopus mexicanus</i> (Müller).

If, as is suggested by the configuration of the country, the former elevation of the caves was slightly less than at present and the country less broken, conditions were then more favorable than at present for such species as *Geococcyx californianus* and *Archibuteo ferrugineus*. The probability that slow-moving streams and small lakelets served to attract waders, anserines, and *Haliaeetus* would be greater in such a condition of the country.

In the vicinity of Fossil Lake, Oregon, the present avifauna would show probably several points of divergence from the cave region and from Rancho La Brea. *Oreortyx*, *Cyanocitta*, *Aphelocoma*, and *Geococcyx* would probably be lacking, while one would doubtless meet with *Pediocetes*, *Centrocercus* and *Cyanocephalus*.

At Rancho La Brea, *Elanus* and *Geococcyx* would prove more abundant, *Agelaius*, *Xanthocephalus*, and *Otocoris* would be plentiful, while *Dendragapus*, *Oreortyx*, and *Cyanocitta* would not be likely to occur. *Elanus* and *Geococcyx* at Rancho La Brea, *Dendragapus* in the Shasta region and *Centrocercus* and *Pediocetes* in the Fossil Lake region are the chief differences dependent upon latitude to be noticed among the three faunas. The other discrepancies are such as would be due to slight difference in altitude, the proximity of water or the topography of the region.

The long list of smaller passerines, piciforms and macrocheirs is here purposely omitted, since they, though very important in the determination of faunal zones, seem not to have been preserved in the fossil state to any great extent.

Distribution of the Cathartidae.—One of the groups of chief interest in discussing the subject of distribution in the light

¹⁹ Cope, E. D., The Silver Lake of Oregon and its Region, Am. Nat., vol. 23, p. 970, 1889.

of palaeontological study is the raptorial subdivision embracing the New World vultures. The exclusive possession by the Americas of so marked a group of large and strong-flying birds as the Cathartidae and the total absence there of any form of the true Vulturidae, which occupy the same bionomic position in the Old World, is one of the striking phenomena in animal distribution. Aside from the fact that the group is so well defined, there being no Recent forms showing transition between it and the other raptorial subdivisions, we find it not poor in species and it is widely distributed in the western hemisphere.

There are endemic to the New World no less than five distinct cathartine genera—a goodly number for a group, the smallest member of which approaches in size the largest eagles. All are birds capable of long-sustained flights and they are unsurpassed in their ability to meet the emergencies of changed elevation and shifting air currents that would prove disturbing to less perfect fliers. This very factor may, by insuring them against being driven astray by storms, bring about a distribution more in accord with their own needs or inclinations.

As an instructive comparison in the matter of distribution one might consider the short-eared owl (*Asio flammeus*). This bird is almost cosmopolitan, occurring unmodified over both hemispheres and even in such isolated islands as the Hawaiian group, though no more maritime and no more capable a flier than the cathartid vultures. It might be suggested as a distinction between these two cases that the vultures are non-migratory and are confined to the tropics, and would, therefore, have no tendency to wander, would not be exposed to the danger of scattering by storms and would always be separated from the other continents by the widest parts of the ocean basins. An examination of the ranges and the habits of the existing species will, however, prove the fallacy of such views. *Cathartes aura* is migratory or not as occasion demands. It is resident to 40° N latitude and thence northward it becomes migratory, being starved out in winter. Its habitual range extends from 55° N latitude to Tierra del Fuego and the Falkland Islands on the south.²⁰

²⁰ Coates, E., Key to N. Am. Birds (ed. 5; 1903), vol. 2.

Other members of the group range as follows: The Andean condor (*Sarcorhamphus*) occurs along the Cordillera from equatorial Peru to the extremity of Patagonia and from sea-level to the highest summits of the Andes; *Catharista urubu* inhabits the whole of tropical America, southward to Argentina and northward as a straggler to the Canadian border; the two remaining genera, *Gyparchus* and *Gymnogyps*, occupy successively more circumscribed areas. Not, however, till the latter was so nearly exterminated by human agency, was either form of restricted range. *Gymnogyps* is confined entirely to the Nearctic realm, *Sarcorhamphus* is entirely Neogaic, but the three remaining forms are distributed without regard to realm and all are independent of the generally recognized life-zones. That a group thus distributed, many of whose members are so independent of climatic and of minor geographic barriers, should be limited to the western hemisphere seems indeed strange.

The influence of a virile and aggressive species is not infrequently effective as a barrier to the distribution of a less active one and it may be urged that the slightly more rapacious vulturines of the Old World have served as a check upon any tendency of the cathartids to diffuse into Eurasia. Such a view is controverted by the fact that the latter birds prove themselves perfectly able to maintain their existence in competition with the polyborine scavengers which, in a way; represent the Old World vultures in their habits.

With the geographical limitations of the group before us, the question of ancestry and the geological record assume a very important aspect.

Concerning the antiquity of the group there is unfortunately but little known. Previous to the opening up of the Rancho La Brea deposits in California, fossil cathartids of unquestionable identity were unknown to North America. Cope's *Palacoborus umbrus*²¹ from the Pliocene of New Mexico, which he originally placed in the genus *Cathartes*, he later transfers to the genus *Vultur*. The new genus *Palacoborus* was established by Coues for its reception since " . . . the description and figures

²¹ Cope, E. D., U. S. G. Surv. W. of 100th Merid., vol. 4, pt. 2, p. 287, 1876.

clearly indicate a bird generically distinct from *Cathartes* and the improbability of the occurrence of a true *Vultur* in North America is extreme.²² With the former point at least there can be no possible disagreement after a consideration of Cope's figures of *Palaeoborus*. Whether the form may be considered cathartine at all is open to very serious question. Lucas²³ considers it as more probably of polyborine affinities.

In South America fossil cathartids are less rare. *Cathartes* and *Gyparchus* are reported from the Pleistocene caves of Brazil.²⁴ Moreno and Mercerat²⁵ describe two species from the Pampean Pleistocene and three from the Pliocene of the Santa Cruz. The Pleistocene species, *Cathartes fossilis* and *Sarcorhamphus fossilis*, represent genera still existing in that region. The three species from the Santa Cruz, *Psilopterus communis*, *P. australis* and *P. intermedius*, belong to an extinct genus which is placed by the authors adjacent to *Cathartes* and is considered by them to be intermediate or transitional between that genus and *Sarcorhamphus*. The three species of *Psilopterus* are based on the most fragmentary material. The figures are such as to indicate specimens in rather poor state of preservation as to surface markings. Trochleae are corroded away and intermuscular lines are entirely wanting. *P. intermedius* is based on a single specimen consisting of two tarsal trochleae. The other two species are based upon fragmentary tarsi poorly preserved. While there may be no question in the minds of these authors as to the relationships of the genus *Psilopterus*, there appears nothing in the lithographed figures or in the very meager descriptions that is at all convincing.

Beyond the above instances, the only record of fossil cathartids previous to the excavations at Rancho La Brea is the remarkable specimen made known by Gaillard²⁶ from the phosphorites of Quercy, an Oligocene horizon in France. This species,

²² Coues, E., Key to N. Am. Birds (ed. 2; 2884), p. 822.

²³ Lucas, F. A., in Zittel's Text-Book of Palaeontology, Eng. trans., vol. 2, p. 277, 1902.

²⁴ Winge, O., Fugle fra Knoglehuler i Brazilien, Museo Lundii, 1887.

²⁵ Palae. Argentina, An. Mus. La Plata, pt. 1, p. 67, 1891.

²⁶ Gaillard, C., Ann. de l'Univ. de Lyon, n. ser. 1, Sc. & Med., fasc. 23, 1908.

Plesiocathartes europs Gaillard, thus becomes at once the most ancient cathartid, and the only instance known to the author of the occurrence, fossil or Recent, of the family outside the American continents. The species, as far as can be learned, is represented by a single bone, a fragmentary tarsometatarsus preserved in the Museum of Lyons. The specimen is, however, sufficient to establish beyond question the cathartine relationships of the species. Its author considers the case to be one of an individual's having straggled from its normal range. In view of the extensive examination of most of the European horizons which has failed thus far to furnish evidence of its further occurrence there, the conclusions reached by Dr. Gaillard may be considered as probably correct.

With the progress of work at the University of California our knowledge of the group under discussion is considerably advanced. In the collections from Fossil Lake the abundant avian remains are almost entirely of aquatic forms, although there appear in the University collections, as well as in the much larger Cope and the Condon collections, a number of raptorial species. There are, however, no specimens referable to the Cathartidae, a rather conspicuous absence.

There appears no reason deducible from the habits of the turkey vulture of today why, if vultures were present during the formation of these beds, their remains should not have been preserved there. In fact, there is every reason for considering the vulture a more favorable subject for preservation in such deposits than are the other raptors. The turkey vulture is one of the commonest of beach-combers along the shores of both fresh and salt-water bodies and it comes habitually in great flocks to spend the warmer parts of the day wading in the shallower waters or sitting about the sand bars of quiet streams. The negative evidence very strongly suggests the absence of cathartids from the region during the deposition of the Fossil Lake beds.

Potter Creek and Samwel caves both furnish remains of these vultures, while the Rancho La Brea asphalt is especially rich in raptorial species, about equally divided between the cathartids and the falconids.

At Rancho La Brea there occur six truly cathartine species as follows: *Gymnogyps californianus*, *Sarcorhamphus clarki*, *Cathartornis gracilis*, *Pleistogyps rex*, *Cathartes aura*, and *Catharista occidentalis*. Besides these forms, the aberrant *Teratornis* is nearer to the Cathartidae than to any other family at present recognized. In the cave deposits there appear the two forms, *Catharista shastensis* and *Gymnogyps amplus*, belonging to existing genera.

The condors and *Teratornis* represent the extreme of specialization in point of size, the greatest degree of diversity, and possibly also the least specific longevity. *Gymnogyps californianus* alone of the six larger forms has persisted unchanged from the time of formation of the asphalt beds, where it is the most abundant of the condors, until the present time, when it seems on the verge of extinction. Probably its associates of that time had passed the prime of their specific existence while the present form, less specialized toward gigantism, constituted a younger development reaching its maximum of virility later than its congeners but becoming decadent by the present time.

As a result of the excavations at Rancho La Brea the genus *Catharista* became known to the Pleistocene of North America, its first discovery in the fossil state. Its range was at the same time extended from its previous limits—the tropical and lower Austral zones of both continents—to include the Pacific Coast region of California, an area at present occupied by an Upper Sonoran fauna. The fossil species *C. occidentalis* is found in great abundance in the asphalt. Its relative abundance as compared with the other vultures there is shown by a census of an unsorted collection of the bird remains, which gave the following results:

<i>Gymnogyps californianus</i>	11 individuals
<i>Cathartes aura</i>	20 individuals
<i>Catharista occidentalis</i>	21 individuals

As indicated in the note descriptive of *Catharista occidentalis*, the difference between the fossil and the Recent forms lies in the greater body size of the fossil form accompanied by a difference in proportion of the segments of the posterior limb. The tarsus *Polyborus* there appear the following fossil forms whose nearest

shows a greater degree of robustness, both absolute and relative. The humerus is slightly longer and stouter, but whether the wing expanse is increased to a degree commensurate with the increased body weight is questionable. We seem, then, to be dealing with a vulture that was of a heavier body and shorter limb than the persistent *Catharista urubu*. The difference becomes more significant when it is noted that the character separating the extinct from the persistent species of *Catharista* is identical with one of those separating the more restricted *Catharista urubu* from the wider ranging *Cathartes aura*. It should also be noted that the extinct form *Catharista shastensis* from the caves is separable from the Rancho La Brea species, *C. occidentalis*, by a greater robustness of the tarsometatarsus and by a greater body size as indicated by its stouter coracoid. The cave form, the asphalt form, and the Recent form of *Catharista* thus fall with the Recent *Cathartes* into a series of progressively lighter-bodied and possibly more strongly flying vultures, which display, in the cases of the last three at least, a progressively greater ability to cope with their environment.

That the cavern and the asphalt deposits are not of the same age is evidenced by the occurrence therein of distinct but closely related species of cathartids belonging to two genera, i.e. *Gymnogyps* and *Catharista*. The localities are separated by approximately seven degrees of latitude and a difference in elevation of fourteen hundred feet. Both lie at present in approximately the same faunal zone. Species possessed of the excellent volant powers shown by the large vultures when present in the considerable numbers indicated by their remains in the two deposits would scarcely feel the restrictions of such slight barriers as could have existed at that time.

The existing species of *Gymnogyps*, before its numbers were depleted by the influence of man, ranged from Lower California to British Columbia and from sea-level to the summits of the Coast Range, while the existing *Cathartes* is almost ubiquitous. Furthermore our knowledge of the Recent vultures as a group would lead us to discard as incongruous the conception of a vulture so strictly boreal as to come southward in considerable numbers as far as the Shasta region and not reach the more

favorable environment of Southern California. We must, then, almost of necessity conclude that the separation of the two faunas is due to difference in time rather than to any other factor.

The two horizons have in common with the Recent North American fauna three cathartine genera, viz., *Cathartes*, *Catharista*, and *Gymnogyps*. *Catharista*, at present foreign to the immediate vicinity, is represented in the two deposits by distinct species. *Gymnogyps californianus* is abundant in the asphalt beds and in the Recent fauna of a region including and extending far beyond both localities, yet the genus is represented in the cave deposits only by a distinct species, *G. amplus*. It is hard to explain how the cavern deposits could have been interpolated between the Rancho La Brea horizon and the Recent and still possess two distinctive cathartine forms and only one, *Cathartes aura*, in common with either of them.

Distribution of Falconidae.—Palaeontology has added materially to our knowledge of this group in at least two respects, namely in our concepts of the former distribution of its members and of the degree of adaptive radiation that has taken place within its limits. The three genera *Geranoaëtus*, *Morphnus*, and *Polyborus*, limited in Recent time to tropical or to south temperate America, are now known to have ranged in the previous period well up into California. *Geranoaëtus* went as far north as Hawver Cave and the other two as far as Los Angeles. The larger phase of *Haliaëtus*, which is limited at present to the northern parts of North America, had not at the time of deposition of the asphalt beds withdrawn to the northward as a distinct geographical race. The remains of *Haliaëtus leucocephalus* from these beds embrace in their range of variation extremes of size surpassing at either end of the scale the two existing races, *H. l. alascanus* and *H. l. leucocephalus* now geographically distinct.

As illustrative of the number of adaptive radiations of the eagle group we may point to the six fossil eagles of Marsh, Shufeldt, and Miller. These are as follows: *Aquila sodalis*, *A. pliogryps*, *A. dananus*, *Morphnus woodwardi*, *Geranoaëtus grinnelli*, and *G. fragilis*. Besides these extinct forms there were found fossil the three persisting species *Aquila chrysaetos*,

Haliaëtus leucocephalus, and *Geranoaëtus melanoleucus*. *Aquila pliogryps* Shufeldt is described from a single bone, the basal phalanx of the right hallux. The species is considered to be slightly larger but more slender-limbed than *Aquila chrysaëtos*. The material representing the species is so limited that no clear impression of its closer relationships can be formed. *Morphnus woodwardi* from Rancho La Brea may well have been such a bird, though there is no way of obtaining more than the suggestion of similarity from the fact that they were both eagles of slender build. The statement made by Shufeldt is that *Aquila pliogryps* was slender of foot, as indicated by the slightly longer digits. *Morphnus* is a genus of long-shanked eagles with relatively weak feet, as indicated by the size of the trochleae. The digits certainly must have been much smaller in *Morphnus woodwardi* than in *Aquila chrysaëtos* or in *A. pliogryps*.

Shufeldt's species, *A. sodalis*, is founded on the proximal part of a tarsometatarsus. The specimen is figured from the anterior aspect drawn to natural scale. Compared with the Rancho La Brea eagles, *A. sodalis* corresponds quite closely in size with *Geranoaëtus fragilis*, the smallest of the group there represented. *A. sodalis* seems, however, to be of an entirely different nature if the position of the papilla of the tibialis anticus may be taken as indicative. In a discussion of the splendid series of eagle tarsi from the asphalt, it has been pointed out by the author²⁷ that the position of this tubercle seemed to bear a very definite relation to the slenderness of the tarsus, i.e., the long-shanked forms have the tubercle placed high up on the shaft of the bone. Applying this principle to Shufeldt's figure of *A. sodalis*, it would seem that the Fossil Lake species was not of the same group of eagles as the more southern genera *Morphnus* and *Geranoaëtus* assembled by Ridgway under the caption Morphni. In *A. sodalis* the papilla of the tibialis anticus is placed farther down the shaft and the proximal foramina are separated by a much wider space. Unfortunately the character of the hypotarsus is not shown in Shufeldt's figure of *Aquila sodalis* nor is an accurate impression of the region obtainable from the description. It seems proper to consider the two species

²⁷ Miller, L. H., Univ. Calif. Publ., Bull. Dept. Geol., vol. 6, p. 305, 1911.

described by Shufeldt as distinct from any of the Rancho La Brea forms.

Aquila dananus Marsh²⁸ is described as being slightly smaller than the existing *A. chrysaëtos*. A single specimen of the species was taken in the Loup Fork of Nebraska. It consists of the distal part of the tibia only and is not figured by Marsh in the original description. The assignment of the specimen to the genus *Aquila* is proper in the absence of any feature to distinguish it from that genus. The suggestion of the possible identity of one of the Fossil Lake forms, *A. sodalis*, with Marsh's *A. dananus* is made in Shufeldt's paper but that author considers the case improbable on the score of smaller dimensions in the former species. *Geranoaëtus gracilis* Miller from the asphalt is the smallest of the fossil eagles from California and, as indicated above, this species is about the same size as *A. sodalis* Shufeldt. Marsh himself considered the Loup Fork specimen to be "nearly as large as the Golden Eagle," in which case *A. dananus* may be considered as probably intermediate in size between *Aquila chrysaëtos* (Linnaeus) and *Morphnus woodwardi* Miller.

The only other fossil falconids from American localities outside of California are Cope's *Palaeoborus umbrosus*,²⁹ which Lucas³⁰ very properly ascribes to the Polyborinae, and two species from South America recorded by the Argentine palaeontologists, Moreno and Mercerat.³¹ *Lagopterus minutus* Mor. and Mer. is the smaller of these two South American species. It is represented by an almost perfect humerus which, according to the authors describing it, is intermediate between *Buteo* and *Polyborus*, with the preponderance of characters relating it with *Polyborus*. The other species, *Foetopterus ambiguus*, Mor. and Mer., is considered to be intermediate between *Buteo* and *Cathartes*, but is assigned by the authors to the Falconidae. The

²⁸ Marsh, O. C., Am. Journ. Sci., vol. 2, p. 125, Aug. 1871.

²⁹ Cope, E. D., U. S. Geol. Surv. W. of 100th Merid., vol. 4, pt. 2, p. 287, 1876.

³⁰ Zittel, Textbook of Palaeontology, trans. by Eastman, vol. 2, p. 277, 1902.

³¹ Moreno and Mercerat, Palae. Argentina, An. Mus. La Plata, vol. 1, 1891.

more intimate relationships of the forms are not discussed by the authors.

LIST OF SPECIES ASSIGNED TO THE SUBORDER FALCONES THAT ARE KNOWN TO OCCUR AS FOSSILS IN NORTH AMERICA

Species marked with the asterisk are extinct or are no longer represented in the region. Species marked with the double asterisk are considered to show their closest relationship to forms at present more southern in their distribution.

- Elanus leucurus (Vieillot), Rancho La Brea.
- Circus hudsonius (Linnaeus), Rancho La Brea, Fossil Lake.
- **Circus sp. (smaller than hudsonius), Rancho La Brea.
- Aquila chrysaëtos (Linnaeus), Rancho La Brea.
- *Aquila sodalis Shufeldt, Fossil Lake.
- *Aquila pliogryps Shufeldt, Fossil Lake.
- *Aquila dananus Marsh, Loup Fork.
- Haliaëtus leucocephalus (Linnaeus), Rancho La Brea.
- **Morphnus woodwardi Miller, Rancho La Brea.
- **Geranoaëtus grinnelli Miller, Rancho La Brea.
- *Geranoaëtus melanoleucus Auct. (?), Hawver Cave.
- **Geranoaëtus fragilis Miller, Rancho La Brea.
- Buteo borealis (Gmelin), Rancho La Brea, Potter Creek Cave.
- Buteo swainsoni (?) Bonaparte, Samwel Cave.
- *Buteo, sp. (larger than Archibuteo), Rancho La Brea.
- Archibuteo ferrugineus (Lichtenstein), Hawver Cave.
- Falco peregrinus Tunstall, Rancho La Brea, Potter Creek Cave.
- *Falco, sp. (smaller than peregrinus), Rancho La Brea.
- Falco sparverius Linnaeus, Rancho La Brea, Samwel Cave and Potter Creek Cave.
- **Polyborus tharus Auct., Rancho La Brea.
- *Palaeoborus umbrosus (Cope), Loup Fork of New Mexico.
- Accipiter velox (Wilson), Samwel Cave.

The species of *Circus* remaining undetermined is a form smaller than the North American *C. hudsonius*. It is not named in this paper since no opportunity has been presented to compare it with the South American species *Circus cinereus* and *C. maculosa*. The last two species, it seems, are smaller than *C. hudsonius* and possibly the asphalt specimens referred to the indeterminate species are of a form identical with the one or the other.

The material from Rancho La Brea representing *Polyborus* is abundant and embraces most parts of the appendicular skeleton and the beak, including the characteristic nareal region. All this material was compared very carefully with the Recent

phase of *Polyborus tharus* as represented by a single specimen from Argentina. As no appreciable difference could be noted, the fossil form is referred to the existing species, *P. tharus*.

Anomalies in Distribution.—According to Ridgway³² the present distribution of *Polyborus tharus* is from Amazoniã southward through South America. The bird thus reaches in the Argentine and the Patagonian climates a set of conditions as rigorous as any that it would be liable to experience in the northern hemisphere in the latitude of Los Angeles. The extremes of climate due to the presence of the ice sheet is thought by Allen to have given rise to the periodical movements of birds which finally merged into the present seasonal migration.³³ Would not a plausible explanation be that the polyborine under discussion was driven southward by the cold of the glacial epoch but failed to respond to the later amelioration of climate because of a nature less susceptible to the development of a migratory instinct and therefore remained in the lower latitudes or below the tropics? No record of the true Polyborinae is yet found in the deposits of the southern hemisphere to correspond with the Pliocene form, *Palaeoborus umbrosus* (Cope), from New Mexico or to extend the occurrence of the group even back to the Pleistocene, as the Rancho La Brea material does so abundantly for the northern hemisphere. If, on this slender thread of negative evidence, we assume that the group arose in the North Temperate zone, the explanation suggested above seems a plausible one.

Geranoaëtus and *Circus* present cases similar to that of *Polyborus*, while *Morphnus* differs in that the genus is at present limited to the tropics and probably never reaches a southward distribution which would correspond climatically with the region of Hawver Cave or of Los Angeles.

These two cases of *Polyborus* and *Morphnus* mentioned above are typical of as many classes of change in distribution since the formation of the various Pleistocene deposits. Parallel with *Polyborus* there appear the following fossil forms whose nearest

³² Ridgway, R., U. S. Geol. & Geog. Surv. Terr., vol. 1, No. 6, p. 451, 1876.

³³ Allen, J. A., The geography and distribution of birds, Auk, vol. 10, No. 2, April, 1893.

relatives occur in the southern hemisphere at a latitude corresponding with the region of deposit in the northern hemisphere.

Fossil Species	Nearest Living Relative
Phoenicopterus copei Shufeldt.....	Phoenicopterus ruber ? Linnaeus
Ciconia maltha Miller.....	Euxenura maguari (Temm.)
Mycteria americana Linnaeus	Mycteria americana Linnaeus
Jabiru mycteria (Lichtenstein).....	Jabiru mycteria author
Catharista occidentalis Miller.....	Catharista urubu (Vioillot)
Sarcorhamphus clarki Miller.....	Sarcorhamphus gryphus Auct.
Circus, sp.	Circus cinereus or C. maculosus
Geranoaëtus melanoleucus Auct.....	Geranoaëtus melanoleucus Auct.
Geranoaëtus fragilis Miller	
Polyborus tharus Auct.....	Polyborus tharus Auct.

Cases parallel with *Morphnus* in having their nearest related Recent phase limited to more tropical zones are as follows:

Fossil Species	Nearest Living Relative
Pavo californicus Miller.....	Pavo cristatus or Meleagris ocellatus
Morphnus woodwardi Miller.....	Morphnus guianensis Auct.
Geranoaëtus grinnelli Miller.....	Morphnus guianensis Auct.
Micropallas whitneyi (Cooper).....	Micropallas whitneyi (Cooper)
Geococcyx (?), sp.	Neomorpha geoffroyi (Temm.)

One of the striking features in the study of so representative a series of deposits, all of so nearly the same age as are the bird-bearing deposits of the Pacific Coast, is the total absence of certain forms which one would expect to find therein. While it is conceded that negative evidence in palaontology is a frail peg upon which to hang an opinion, yet the negation may be so pronounced and so uniformly persistent that, in some cases at least, the only conclusion possible is that species did not occur in the region during the time of deposition.

The particularly favorable conditions offered at Rancho La Brea for the trapping of vultures and eagles has been commented upon in a previous paper on the condors. There was exposed at that place during an indefinite period a more or less constantly baited trap which was unusually attractive to both vulture and eagle. It was automatic in its operation, effective in its hold upon the victim, and almost ideal in the preservation of its catch, the remains of which were sealed from the air in liquid asphalt while still in the flesh. The entire collection of raptorial remains includes, however, no specimen of the royal vulture (*Gyparchus papa*) or of the harpy eagle (*Thrasaëtus harpyja*).

both of which occur at present along the Mexican border within fifteen degrees of the latitude of Los Angeles.

The collection of wading birds from the coast, while not rich in point of numbers, embraces a goodly variety. *Jabiru*, *Mycteria*, *Ciconia*, *Grus*, *Ardea*, and *Phoenicopterus* are represented; yet there is no record of the spoonbill (*Ajaia*) or of the ibis (*Guara*), both of which have been taken in the flesh well to the northward of Rancho La Brea.

Grouse, quail, and meleagrines have been taken in various of the deposits under discussion; yet we find there none of the cracid birds such as *Ortalis* which occurs at present along the Rio Grande valley of Texas.

The absence of the above-mentioned species, particularly the Raptores, from all the bird-bearing deposits thus far known to North America becomes very striking in view of the large number of instances recorded of the southward retraction of species and genera since the Pleistocene period. It is possible that the forms mentioned above were more sensitive to the cold and were driven southward before the deposition of the Pleistocene strata thus far explored, or that they were, on the other hand, more tropical species that have only in Recent time diffused northward to their present range. *Gyparchus* is reported from the Pleistocene caves of Brazil by Winge (*op. cit.*) which fact would support the latter hypothesis. *Polyborus cheriway* would fall in the same category with *Gyparchus*, being represented in the asphalt by its close relative *Polyborus tharus*. The same is perhaps true of the Recent species of *Geococcyx* found in the Sonoran zone of California at the present time but represented in the asphalt only by a longer-shanked form which can scarcely be considered as the direct ancestor of the living *Geococcyx californianus*. The species from the asphalt may be identical with one of the species of *Neomorpha* from South America, comparison between them having been thus far impossible.

Approximately eighty species of true columbine birds inhabit the Americas today and many of the species are forms which feed on the ground and which congregate about water holes to drink; yet there is no specimen in all the material examined which is referable to this group. The commonest species in the

coast region today is the turtle-dove (*Zenaidura macroura*), a bird of wide distribution over the Austral region and even to the tropics. Its habits and its abundance are such that one can scarcely concede as possible that it could have been present during the deposition of the Pleistocene beds of Rancho La Brea and yet not be preserved as a fossil.

Palamedea and *Cariama* have in their present home in South America a distribution and habits not unlike those of the stork, *Euxenura*. Both groups are, however, absent from the fossil collections. The peculiarly isolated positions which these birds occupy in the scheme of classification, as well as the measure of uncertainty as to their proper location systematically, makes any light that palaeontology might throw upon the subject especially desirable. Most careful search was made therefore to see if any part of the skeleton of these birds had been preserved, but nothing was found that resembled either species in the smallest degree.

The parrot order, abundant a few degrees to the southward, is unrepresented in the deposits. This may be due to the fact that the only forest fauna which we have preserved to us (cavern deposits) is of Upper Sonoran and lower Transition zones, and thus local conditions may have been unfavorable for these birds. On the other hand, as suggested in the case of *Ortalis*, they may have been driven southward before the deposition of any of the beds thus far explored.

All trace of true struthious birds is lacking in the collections also. The northward diffusion of such forms as the edentates and *Hydrochoerus* among the mammals, the presence since early Pleistocene time of rheas in South America, the occurrence of tridactyl struthionids in the Pliocene of northern India, and of *Struthiolithus* in the superficial deposits of northern China, increase the probability that some day the discovery of true struthious birds in North America will be announced. The most potent factors that would bring about such distribution are first, the possible northward diffusion of rheids along with edentate mammals and, second, the passage of *Struthiolithus* or its relatives along the line of proboscidean invasion from Asia by way of the land bridge to Alaska.

The earliest occurrence of rheids in South America is in strata now referred to the Pleistocene (the Pampean of Monte Hermosa). If the group had reached that continent by way of the Antarctic at an earlier time, their bones would probably be found with the primitive mammals supposed to have been derived from Australia and known to us from the Santa Cruz beds. The rheas with their true struthious characters could hardly have originated *de novo* in South America; hence the conclusion that they entered from the north, as did the true cats, deer, elephants and other mammals of northern or Old World origin.

Cope's discovery of *Diatryma*³⁴ in the Wahsatch Eocene of New Mexico was at first considered as fixing a very early date for the group of Struthionies in the New World. Lucas,³⁵ however, places this unique specimen in the group of Stereornithes with the great *Phororhacos* of South America (Miocene of Santa Cruz). A wide gulf exists between the ostriches and these South American phororhacids. The latter are more probably a local development brought out in response to the peculiar conditions prevailing there in Tertiary time. There existed in South America no large carnivores among mammals until the northern incursion of machaerodonts and the true felines in relatively late geological time. Edentates were left free to develop to the tremendous extent noticeable in the South American Tertiary and Quaternary. In this region of low pressure among mammals there developed unrestrained the predatory bird *Phororhacos*, to occupy a bionomic place like that of the mammalian carnivore. The reference by Lucas of the North American *Diatryma* to the Stereornithes is tentative. He states the case in these words in part: "Still there are sufficient resemblances between the two to warrant the suggestion that if material comes to light it will be found that the affinities of *Diatryma* are with the Stereornithes and not with the Dromaeognathae."

In view of the indeterminate character of the single specimen of *Diatryma* where its relationship between two such distinct

³⁴ Cope, E. D., U. S. Geol. Surv. Terr. W. of 100th Merid., vol. 4, pt. 2, p. 69, 1876.

³⁵ Lucas, F. A., Proc. U. S. Nat. Mus., vol. 24, p. 545, 1903.

groups as the Struthionies and the Stercorornithes are in question, it would seem that the chief value of Cope's discovery is to show us that a group of gigantic terrestrial birds can inhabit a region and leave almost no trace of their occupation of that part of the globe. The same fact is pointed out by Eastman³⁶ in his discussion of *Struthiolithus* and the distribution of the Dromaeognathae. Before the discovery of this species in the superficial deposits in the mountainous regions of northern China no one would have surmised that this great area to the north of India was ever inhabited by struthious birds. Why not expect, then, with perfect propriety, that some day the path of immigration of *Rhea* into South America may be traced in yet undiscovered deposits of North America?

The other principle which encouraged the search for rheids in the asphalt, that of a northward migration of southern forms in the Pleistocene, is applicable whether *Rhea* be considered a product of the southern continent or not. Among mammals we have the northward diffusion of the various edentates and *Hydrochoerus*, which may be considered products of southern soil, and we have also a re-entrance from the south of certain forms which are Neogaëic by adoption. For example, we may look upon *Didelphys* as having performed such migration. The objection might be raised that the tropical belt would act as a barrier preventing the plains-dwelling *Rhea* from retracing its steps, but such an objection is reduced to questionable validity by the presence of true rheids in the cavern deposits of Brazil.

The following is a list of lipotypes which are considered by the author as of particular interest:

LIST OF LIPOYPES

<i>Gavia</i> , sp.	Palamedeidae—all species
<i>Gyparehus papa</i> Auct.	Cariamidae—all forms
<i>Thrasaëtus harpya</i> Auct.	Phororhacidae—all species
<i>Polyborus cheriway</i> (Jaquin)	<i>Gaura</i> , sp.
Cracidae—all species	<i>Plegadis</i> , sp.
Columbae—all species	<i>Ajaia</i> , sp.
Psittaci—all species	<i>Geococcyx californianus</i> (Lesson)

³⁶ Eastman, C. R., Bull. Mus. Comp. Zool. Harvard Coll., vol. 32, p. 127-144, 1898.

Possible Influences Conditioning Present Distribution of Certain Groups.—In considering the relation of past to present distribution of American birds, at least two principles present themselves in explanation of the apparent southward retraction of certain forms since Pleistocene time. The first is typified by the case of *Polyborus tharus*. May this species not have been driven southward across the equator after the time of formation of the asphalt deposits by the advance of a cold period such as sent the mammals of the Ovibos zone as far south as Big Bone Lick and Conard Fissure?

Extremes of climate due to the presence of the ice sheet are thought by Allen³⁷ to have given rise to the periodical movements of birds which finally merged into the present seasonal migration. The polyborine under discussion may thus have been driven southward, but lacked the incipient migratory instinct and furthermore failed to return northward upon the amelioration of the climate. This failure may have been due to the presence of more virile species blocking the return path, or it may have been due to the limiting tendency of the torrid zone which it would have had to recross in a return to the north. No record of the true Polyborinae has yet been found in the deposits of the southern hemisphere to correspond with the Pliocene *Palaeoborus* of New Mexico or to extend the occurrence of the group even back to the Pleistocene, as the Rancho La Brea material does so abundantly for the northern hemisphere. If, on this slender thread of negative evidence, we assume that the group arose in the North Temperate Zone, the explanation suggested above seems a plausible one. The distribution of *Circus*, *Geranoaëtus*, *Sarcorhamphus*, and *Euxenura* would further uphold this view of the question. These birds are typically of the southern hemisphere in latitudes to the south of the tropics or at high elevations and the Tierra Caliente would act as a more or less effective barrier to their northward dissemination.

The second hypothesis offered is that the returning annual isotherm has never yet reached the point at which it stood during the deposition of the fossil remains. Sinclair (*Op. cit.*, p. 19) links the Potter Creek Cave deposits pretty closely with the

³⁷ Allen, J. A., *The Auk*, vol. X, No. 2, Apr. 1893.

Upper San Pedro series of marine deposits and the San Pablo Bay oyster beds at Rodeo. These shell deposits are considered by western palaeontologists to represent a time of higher average annual temperatures than prevail in the region at present. The cases of *Morphnus*, *Micropallas*, *Geococcyx* (?) and *Pavo* make a strong aggregate in favor of this theory. To harmonize the cases of *Circus*, *Polyborus*, *Sarcorhamphus*, *Geranoaëtus* and *Ciconia* with those of the more tropical species, it would be necessary to assume nothing further than that these forms, since the partial amelioration of the climate, had developed powers of resistance to cold and had extended their ranges to the southward instead of remaining intertropical species. The extension of range took place from the tropics southward instead of to the northward again because of overcrowded conditions in the north. The advance of arctic cold toward the equator would drive northern animals into narrower and narrower quarters, while the forms of the southern hemisphere, under like encroachment of the antarctic, would experience the opposite effect. The convergence of all the Boreal species into the Austral on the continent of North America would be in effect like crowding the basal contents of a cone into its apex. The result would be an enormous intensification of the natural attrition of species upon species with a resultant stimulus to the surviving form. In the southern hemisphere conditions would be reversed and the advance of polar cold, whether synchronous with or alternating with the northern fluctuations, would have much less serious effect. Assuming the various faunal zones to be fully populated, the driving of the Patagonian fauna into the wide expanse of Argentina and southern Brazil would serve to dilute greatly the Boreal fauna without materially disturbing the Austral. A form that had been obliged to flee the rigorous conditions resulting from an advance of the cold in North America might find, upon the return of milder conditions, that the path of least resistance to expanding range from the tropics led toward the south.

Bird Remains as Indicators of Climatic Conditions.—Certain appearances in the deposits at Rancho La Brea might be interpreted as evidence that the climate during deposition of the beds was warmer and more moist than it is at present in the region.

The fauna is certainly a rich one and embraces a considerable variety of ungulates of large size which were dependent on a goodly supply of grass and browse. Purely local conditions of drainage may, however, have brought about such a condition. In the fickle streams of the southwest such change of bed may occur in a single season and a deposit laid down under conditions of abundant moisture amounting almost to a peat formation may be left high and dry after a severe freshet to suffer a reversion to almost desert condition. Relatively few of the anserines are found in the collections from the asphalt. Geese of the Recent species become almost upland forms during the rainy season when grass is abundant. *Euxenura* is, according to Hudson's account in *Naturalist in La Plata*, a plains-dwelling form of the open pampa at some times of the year. The sand-hill crane, *Grus canadensis*, is notably a plains feeder in the winter and spring, while the great blue heron, *Ardea herodias*, has been seen by the author on the dry hillsides in midsummer seemingly in pursuit of grasshoppers. The presence of these birds in the asphalt in the limited numbers found is not then a positive indication of open water or of even marshy ground. The water-worn fragments of wood and the leaves in bedded deposit are such as occur in small streams of the region today when the streams may be more or less intermittent. A rich and varied mammalian fauna is taken by some writers as an indication of mild climatic conditions. Such conclusion seems scarcely warranted, however, in view of the present conditions in the desert parts of the world. The writer found deer abundant on the open and thorny desert of Lower California in the region of Cape San Lucas. On the mainland of Mexico, in the desert of Sonora, deer, peccary, and mountain sheep are abundant. The accounts by Roosevelt of game distribution in Africa indicate an abundance and a great variety of game in almost desert regions of that continent. On the Mohave, the Colorado, and the great Nevada deserts, the most ephemeral pools of water, even when highly impregnated with alkaline salts, are the resort of multitudes of waterfowl, while Cope and Shufeldt describe abundant life in the region near Fossil Lake on the Oregon Desert.

There is some very credible evidence that the mammals entrapped in the asphalt pools were in part attracted to the locality by water. Over the top of the asphalt layer there may accumulate after a shower a stratum of fairly pure rain water, so little does the viscid asphalt mix with the water. Such an accumulation remains in the impervious basins until evaporated by the heat of the sun, without loss by seepage through the oil-impregnated earth. Pools of water suitable for the use of cattle and horses thus remain impounded in natural reservoirs after adjacent streams have vanished. Natural reservoirs are of such importance in the southwestern deserts as to have received the local Spanish name of "tinajas," and wild mammals of the desert come from long distances to drink at them. Such conditions would tend to concentrate the remains of mammals of a poorly watered region and furnish the asphalt trap with scores of victims which otherwise would have escaped.³⁸

Summing up the evidence of a warm, moist climate during the Pleistocene, we have the following points, all of which are inconclusive:

1. The presence of species whose nearest relatives are at present more tropical in distribution.
2. The presence of an abundant fauna which is suggestive of favorable conditions of climate.
3. The presence of aquatic species and of waterworn chips laid down in places now dry but showing no great changes in topography.
4. The suggestion that the mammals of Rancho La Brea were in some measure led to the region by the presence of water.

Time Relations as Suggested by a Study of Bird Remains.—Osborn divides the Pleistocene period into three great time subdivisions, namely, Pre-Glacial, Glacial and Post-Glacial.³⁹ The Glacial again shows evidence of division into five periods of fluctuation, during which the ice cap oscillated northward and southward with the changing isotherms. The period also represents a time of high elevation of the land surface in general

³⁸ See Darwin, C., *Journal of Voyage of H.M.S. Beagle*, 1845 (New ed. 1909), pp. 128-130.

³⁹ Osborn, H. F., *The Age of Mammals*. New York, 1910.

as compared with the Pre-Glacial. The Post-glacial epoch was characterized by an ameliorated climate and a depression of the land surface. Great river floods and large lakes were the result of this amelioration, and extensive fluviatile and lacustrine deposits appear, while the previously restricted species of vertebrates spread out over parts of the country that were formerly covered by the ice cap.

The faunas of the time are divided by Osborn into three life-zones which are distributed through the Pleistocene, but do not coincide with the three time divisions as given above. They do not necessarily represent consecutive faunas, but rather faunas from different topographic divisions which, in some respects, overlap each other, though in the main consecutive. Characteristic mammals have given the names to these zones as follows: *Equus* Zone, a plains fauna partly earlier than and partly synchronous with the second, the *Megalonyx* Zone, which was a forest and meadow fauna mainly of mid-Pleistocene time. The third, or *Ovibos* Zone, is an impoverished fauna, perhaps corresponding with the Arctic and Tundra period of Europe and synchronous with the last great glacial advance, the period of maximum glaciation, which is recorded in the great terminal moraine.

RELATIONS OF SEVERAL PLEISTOCENE MAMMALIAN HORIZONS; ADAPTED
FROM OSBORN

<i>Equus</i> Zone	<i>Megalonyx</i> Zone
6—Kansas Pleistocene, several localities.	9—Big Bone Lick, Ken.
5—Lake Lahontan, Nev.	8—Samwel Cave, Calif.
4—Fossil Lake, Ore.	7—Potter Creek Cave, Calif.
3—Rock Creek, Texas.	6—Washtuena Lake, Wash.
2—Hay Springs, Neb.	5—Rancho La Brea, Calif.
1—Peace Creek, Fla., Late Pliocene or Early Pleistocene.	4—Ashley River, S. Carolina.
	3—Frankstown Cave, Penn.
	2—Port Kennedy Cave, Penn.
	1—Afton Junction, Iowa.—1st interglacial stage.
<i>Ovibos</i> Zone	
4—Alaska Ground Ice.	
3—Conard Fissure, Ark.	
2—Scattered middle west.	
1—Big Bone Lick, Ken.	

The exact time-relations between the several faunas is not determinable, and the overlap of one column upon another is purposely indefinite. The *Equus* fauna is considered in part older than the *Megalonyx* fauna and this in turn than the *Ovibos*.

It must be stated also that the study of mammalian remains from Rancho La Brea, from the caves of California, and from Fossil Lake, Oregon, is still being actively pursued and the list of species revised. Any statement of time-relations must be considered as purely tentative. Few investigators have had so wide and so comprehensive an acquaintance with the mammalian palaeontology of North America as has Professor Osborn; hence it is considered in this connection that his chronological arrangement of the various mammal-bearing horizons represent the truth as nearly as we have yet arrived at it.

It will be noted that the Fossil Lake horizon is placed by him midway in the tabulation of the *Equus* Zone fauna while Rancho La Brea and the caves occupy the middle and upper parts of the *Megalonyx* Zone. Thus Fossil Lake is to be considered as the earliest Pleistocene horizon on the coast productive of avian remains.

If we apply the criterion of percentage of extinct forms, the evidence furnished by the avian remains would indicate a different time-relation than that suggested by Professor Osborn. The various horizons here discussed show the following sequence when arranged according to the percentage of Recent species of birds recorded fossil:

Rancho La Brea.....	60%	still living
Fossil Lake	66%	still living
Potter Creek Cave	68%	still living
Samwel Cave	72%	still living
Hawver Cave	79%	still living

The application of this principle in the case of fossil birds seems, however, less accurate than in the case of mammals when we consider the migratory nature of many bird species. The Fossil Lake fauna according to this basis of estimate would appear to be younger than that of Rancho La Brea. A glance at the list of species from Fossil Lake shows, however, the large

percentage of migratory forms such as the anserines and the pygopodes. These birds by their migratory habits are rendered largely immune to the effects of climatic change that might have brought about extinction in such forms as the raptors and the scratchers. Ten of the fifteen extinct species recorded from Fossil Lake belong to genera which are at present non-migratory in the region.

Whether or not these genera were migratory during Pleistocene time is, of course, a matter of pure conjecture. Allen⁴⁰ suggests that it was during the Glacial Epoch that the migratory instinct was indelibly impressed upon birds by the pronounced seasonal contrast prevailing at that time. Whether the instinct was at that time incipient or real, it seems proper to conclude that those genera which now display it are the ones which would have profited by its initial operation and have escaped extinction.

There presents itself, then, the very potent suggestion that the relatively small proportion of extinct forms represented in the Fossil Lake horizon is due to the fact that many of the genera there represented possessed or else developed the migratory instinct and were preserved except as influenced by other factors.

The remaining four horizons may more properly be compared as to age upon the basis of percentage of surviving species, and such comparison bears out the conclusions reached by Osborn in his study of the mammals.

Causes of Extinction of Birds.—After a consideration of the varied and in many respects remarkable avifauna of Pleistocene times, it is natural that the causes of extinction of these forms should hold an important place in our attention. Why should we now have but two eagles in southern California where five once flourished? Why does but one condor remain of the five species found fossil? The large phase of the variable Pleistocene *Haliaeetus* has withdrawn toward the north into British Columbia and Alaska, while *Phoenicopterus*, the ciconids, *Polyborus* and the morphnine eagles have withdrawn to the southward.

The gigantic *Teratornis* disappeared, leaving no near relative

⁴⁰ Allen, J. A., The geography and distribution of birds, *Auk*, vol. 10, No. 2, Apr. 1893.

to represent the family among the Cathartiformes. How late did this great bird persist, and did that important factor, man, have anything to do with his disappearance? According to Dr. C. Hart Merriam,⁴¹ the Me-wah Indians of California have a legend concerning a gigantic vulture, Yel-lo-kin, so large that he was able to capture the condor and carry him up through a hole in the sky. The bird myths of these Indians indicate a close acquaintance with the California species. It may be that *Teratornis* persisted until the arrival of man upon the scene, and thus gave rise to the Mew-wah Indian myth of Yel-lo-kin.

Granting the possible truth of such an assumption as the contemporaneity of man and *Teratornis*, the primitive human animal could have had but little cause to direct his efforts against the large raptorial birds. His meagre offensive armament would probably have availed him but little in any event. Thus the only influence he would have been likely to exert would be but the indirect effect through the extermination of large mammals. The possibility of man's having exerted any such influence on the lives of avian species seems remote, in view of the negative evidence afforded by the absence thus far of human remains from western horizons of undoubted Pleistocene age.

Direct extermination, or the sharpening of competition, by incursions of Old World forms, is a theory without the support of any tangible evidence in the case of birds. The procyonids and *Didelphys* are of long standing in America. Felines would greatly influence the larger birds by direct attack either upon the bird or its nest. It seems highly improbable, then, that birds could have been directly influenced by man or the other mammals, but that the chief relation of mammals to the large birds was in the dependence of the latter upon the former for food-supply.

As has been pointed out in an earlier paper,⁴² the large raptorial birds depended in a dual respect upon the large mammals. First, these birds fed upon the bodies of either carnivores or herbivores dying of whatever cause; second, the vulture fed upon the rejected portion of the carnivore's kill. Thus, any factor

⁴¹ Merriam, C. H., *The Dawn of the World*, p. 163, 1910.

⁴² Miller, L. H., *Univ. Calif. Publ., Bull. Dept. Geol.*, vol. 6, p. 2, 1910.

which tended to reduce the numbers of either group of mammals must have reacted also upon the large birds of prey.

It is not at all improbable that the things which brought about the extinction of Pleistocene mammals were also directly operative in bringing about the extinction of many species of birds. Non-raptorial birds, except where migratory, would respond to climatic changes very much as did mammals. Osborn makes suggestions regarding the mammals as follows:

“the Glacial period in North America originated certain new conditions of life which directly or indirectly resulted in extinction.

“These conditions include diminished herds, enforced migrations, the possible overcrowding of certain southerly areas, changed conditions of feeding, disturbance in the period of mating and reproduction, new relations with various enemies, aridity, deforestation; in short, a host of indirect causes.”⁴³

Disease, in all probability a factor in the extinction of some mammals, may likewise have been the determining influence in the case of certain birds. During the winter of 1908-9 in southern California, the bodies of thousands of sea-birds were cast up on the beach within a comparatively short time. Many of these specimens were examined by Dr. F. C. Clark of Los Angeles and by the author. The intestines were found filled with tape-worms. Mildness of the weather coupled with the profound emaciation of the birds indicated that death was not due to violence or sudden cause. While the presence of parasites may not have been the only influence leading to death, it was, in all probability, an important and possibly the determining factor.

If, as is so variously suggested, the rainfall is now much less than it was during the Pleistocene, the influence upon bird life may have been effective over wide areas through the several factors of food, shelter and nesting sites. *Pavo* and *Meleagris*, although not always confined to wooded country, are both forms which might have been strongly influenced by deforestation. The morphine eagles, with the possible exception of *Geranoaëtus*, are forest-dwelling birds. The local extinction of these birds in California may have resulted from a thinning-out of the forests.

⁴³ Osborn, H. F., *The Age of Mammals* (New York, Macmillan, 1910).

Development of gigantic size in the cathartids is in effect a case of over-specialization in that it works frequently to the detriment of the species. The condors of today are of such unwieldy size that, after a full meal, they experience much difficulty in taking wing from low ground. This fact is reported to have caused the destruction of many individuals which had been led to alight in places from which they could not rise again into the air. *Teratornis* must have attained a bulk almost thrice that of the condor if we may judge from coracoid and furecula. The suggestion conveyed by the sternum is that the pectoral muscles were not so heavy in proportion, yet the weight of the bird must have been far greater than that of the condors. The nature of its food was such that it must have come to the ground to feed. The effort to rise again, gorged with food, must have been a severe tax upon its strength, and slowness in taking wing may have subjected it to frequent danger. The high, compressed beak of *Teratornis* resembling the eagle's in form, though structurally cathartine, indicated the extreme of specialization. The large body size, likewise a phase of specialization, may have militated in the end against the life of the species.

The principle of specific decay or senility of species as a cause of extinction may have suffered somewhat through the too frequent application of it by the palaeontologist, yet there often appear cases in which no other factor seems adequate to explain the loss of a species. Certainly the intersterility of species would lead to inbreeding with its attendant ill effects. Incipient strains of intersterility within a species might, where geographically restricted, lead to the more rapid deterioration of the stock; generation upon generation of individuals, like the succeeding generations of somatic cells, become less and less virile until the species would decline in a manner comparable to the senile decay of the individual. The rapid decline of certain of the less conspicuous species of Hawaiian birds, such as *Palmeria* and *Chactoptila*, seems almost of necessity the result of such depleting influence. How effective this factor was in robbing us of many Pleistocene birds it is of course impossible to estimate; it would seem proper, however, to look upon it as possibly a contributing cause.

TABULAR ARRANGEMENT OF WEST-AMERICAN PLEISTOCENE
AVIFAUNAS

	Fossil Lake	Rancho La Brea	Potter Creek Cave	Sanwel Cave	Hawver Cave	Rodeo
<i>Æchmophorus lucasi</i> Miller	*					
<i>Æchmophorus occidentalis</i> (Lawrence)						
<i>Colymbus holbœlli</i> (Reinhardt)	*					
<i>Colymbus auritus</i> Linnaeus	*					
<i>Colybus nigricollis californicus</i> (Heermann)	*					
<i>Podilymbus podiceps</i> (Linnaeus)	*					
<i>Larus argentatus</i> Pontoppidan	*					
<i>Larus robustus</i> Shufeldt	*					
<i>Larus californicus</i> Lawrence	*					
<i>Larus oregonus</i> Shufeldt	*					
<i>Larus philadelphia</i> (Ord)	*					
<i>Xema sabini</i> (J. Sabine)	*					
<i>Sterna elegans</i> Gambel	*					
<i>Sterna forsteri</i> Nuttall	*					
<i>Hydrochelidon nigra surinamensis</i> (Gmelin)	*					
<i>Phalacrocorax macropus</i> (Cope)	*					
<i>Pelecanus erythrorhynchos</i> Gmelin	*					
<i>Lophodytes cucullatus</i> (Linnaeus)	*					
<i>Anas platyrhynchos</i> Linnaeus	*					
<i>Chaulelasmus streperus</i> (Linnaeus)	*					
<i>Mareca americana</i> (Gmelin)	*					
<i>Nettion carolinense</i> (Gmelin)	*				*	
<i>Querquedula discors</i> (Linnaeus)	*					
<i>Querquedula cyanoptera</i> (Vieillot)	*					
<i>Spatula clypeata</i> (Linnaeus)	*					
<i>Dafila acuta</i> (Linnaeus)	*					
<i>Aix sponsa</i> (Linnaeus)	*					
<i>Marila valisineria</i> (Wilson)	*					
<i>Clangula islandica</i> (Gmelin)	*					
<i>Harelda hyemalis</i> (Linnaeus)	*					
<i>Erismatura jamaicensis</i> (Gmelin)	*					
<i>Anser condoni</i> Shufeldt	*					
<i>Anser albifrons gambeli</i> Hartlaub	*	?				
<i>Branta hypsibata</i> (Cope)	*					
<i>Branta canadensis</i> (Linnaeus)	*	*	*			
<i>Branta propinqua</i> Shufeldt	*					
<i>Chen hyperboreus</i> (Pallas)	*					
<i>Olor paloregonus</i> (Cope)	*					
Indeterminate anserine				*		
Indeterminate anserine				*		

	Fossil Lake	Rancho La Brea	Potter Creek Cave	* Samuel Cave	Hawver Cave	Rodeo
Indeterminate anserine						
Phoenicopterus copei Shufeldt	*					
Ciconia maltha Miller		*				
Jabiru myetaria (Liechtenstein) ..		*				
Myetaria americana Linnaeus		*				
Ardea herodias Linnaeus		*				
Ardea paloccidentalis Shufeldt	*					
Grus minor Miller		*				
Grus canadensis (Linnaeus)		*				
Fulica americana Gmelin	*					
Fulica minor Shufeldt	*					
Lobipes lobatus (Linnaeus) ..	*					
Oreortyx picta (Douglas)						
Lophortyx californica (Shaw)						
Lophortyx, sp.		*				
Dendragapus obscurus (Say)						
Bonasa umbellus (Linnaeus)						
Tympanuchus pallidicinctus (Ridgway) ..	*					
Pedioecetes phasianellus columbianus (Ord) ..	*					
Pedioecetes lucasi Shufeldt	*					
Pedioecetes nanus Shufeldt ..	*					
Palaeotetrix gilli Shufeldt	*					
Indeterminate odontophorid				*		
Meleagris, sp.		*		*		
Pavo californicus Miller ..				*		
Gymnogyps californianus (Shaw) ..				*		
Gymnogyps amplus Miller				*		
Sarcorhamphus clarki Miller ..		*		*		
Cathartornis gracilis Miller ..		*		*		
Pleistogyps rex Miller		*		*		
Cathartes aura (Linnaeus)		*		*		
Catharista occidentalis Miller ..		*		*		
Catharista shastensis Miller ..		*		*		
Teratornis merriami Miller ..		*		*		
Elanus leucurus (Vieillot) ..		*		*		
Circus hudsonius (Linnaeus) ..		*		*		
Circus, sp.		*		*		
Accipiter velox (Wilson)				*		
Buteo borealis (Gmelin)				*		
Buteo swainsoni Bonaparte (?) ..				*		
Buteo, sp.				*		
Archibuteo ferrugineus (Liechtenstein) ..				*		
Aquila chrysaetos (Linnaeus)				*		

	Fossil Lake	Rancho La Brea	Potter Creek Cave	Samuel Cave	Hawver Cave	Rodeo
<i>Aquila pliogryps</i> Shufeldt	*					
<i>Aquila sodalis</i> Shufeldt	*					
<i>Haliaëtus leucocephalus</i> (Linnaeus)		*				
<i>Morphnus woodwardi</i> Miller		*				
<i>Geranoaëtus melanoleucus</i> Auct. (?)						
<i>Geranoaëtus grinnelli</i> Miller		*				
<i>Geranoaëtus fragilis</i> Miller		*				
<i>Falco peregrinus</i> Tunstall ..						
<i>Falco</i> , sp.		+				
<i>Falco sparverius</i> Linnaeus						
<i>Polyborus tharus</i> Auct.		*				
<i>Aluco pratincola</i> (Bonaparte)		*				
<i>Asio wilsonianus</i> (Lesson)						
<i>Asio flammeus</i> (Pontoppidan)		*				
<i>Otus asio</i> (Linnaeus)						
<i>Bubo virginianus</i> (Gmelin)						
<i>Bubo sinclairei</i> Miller				*	*	
<i>Speotyto cunicularia hypogaea</i> (Bonaparte)		*				
<i>Glaucidium gnoma</i> Wagler						
<i>Micropallas whitneyi</i> (J. G. Cooper)						
<i>Neomorpha</i> ?, sp.		*				
<i>Colaptes cafer</i> (Gmelin) ..						
<i>Otocoris alpestris</i> (Linnaeus)		*				
<i>Cyanocitta stelleri</i> (Gmelin)						
<i>Corvus corax</i> Linnaeus ..						
<i>Corvus brachyrhynchos</i> Brehm						
<i>Corvus annectens</i> Shufeldt	*					
<i>Corvus</i> , sp.		*				
<i>Xanthocephalus xanthocephalus</i> (Bonaparte)		*				
<i>Agelaius gubernator</i> (Wagler)		*				
<i>Sturnella neglecta</i> Audubon		*				
<i>Euphagus cyanocephalus</i> (Wagler)						
<i>Euphagus affinis</i> Shufeldt	*					
<i>Pipilo</i> , sp.		*				
<i>Lanius ludovicianus</i> Linnaeus		*				

BIBLIOGRAPHY OF PACIFIC COAST FOSSIL AVIFAUNAS

1878. Cope, E. D., Bull. U. S. Geol. Surv. Terr. iv no. 2, May 3, 1878. Describes three species of birds from Fossil Lake, Ore.
1892. Shufeldt, R. W., A Study of the Fossil Avifauna of the Equus Beds of the Oregon Desert, Journ. Acad. Nat. Sci. Phila. no. 9, p. 389.
1894. Cope, E. D., On Cyphornis, an Extinct Genus of Birds, Journ. Acad. Nat. Sci. Phila. no. 9, p. 449.
1901. Lucas, F. A., A Flightless Auk, *Manicallia californiensis*, from the Miocene of California, Proc. U. S. Nat. Mus., vol. 24, p. 133.
1909. Miller, L. H., *Pavo californicus*, a Fossil Peacock from the Quaternary Asphalt Beds of Rancho La Brea, Univ. Calif. Publ., Bull. Dept. Geol., vol. 5, p. 285.
1909. Miller, L. H., *Teratornis*, a New Avian Genus from Rancho La Brea, Univ. Calif. Publ. Bull. Dept. Geol., vol. 5, p. 305.
1910. Miller, L. H., Wading Birds from the Quaternary Asphalt of Rancho La Brea, Univ. Calif. Publ. Bull. Dept. Geol., vol. 5, p. 437.
1910. Miller, L. H., The Condor-like Vultures of Rancho La Brea, Univ. Calif. Publ. Bull. Dept. Geol., vol. 6, p. 1.
1911. Miller, L. H., Additions to the Avifauna of the Pleistocene Deposits at Fossil Lake, Oregon, Univ. Calif. Publ. Bull. Dept. Geol., vol. 6, p. 79.
1911. Miller, L. H., A Series of Eagle Tarsi from the Pleistocene of Rancho La Brea, Univ. Calif. Publ. Bull. Dept. Geol., vol. 6, p. 305.
1911. Miller, L. H., Avifauna of the Pleistocene Cave Deposits of California, Univ. Calif. Publ., Bull. Dept. Geol., vol. 6, p. 385.

NOTE.—Since the text of this paper went to press, bird remains have been found in the Upper San Pedro Pleistocene at San Pedro, Cal., by Dr. F. C. Clark of Los Angeles. These remains were very generously presented to the present writer by Dr. Clark, and by permission of the latter, were deposited in the Vertebrate Palaeontology Collections at the University of California. Three of the specimens are almost perfect, the several others are too fragmentary for determination. One specimen represents an undescribed species of grebe of the genus *Echmophorus* but in view of the fact that the active exploration of these beds now going on will possibly bring to light other remains of like nature, a description of the species is thought unwise at present.

Remains of *Bison*, *Equus*, a camelid, rodents, seals, small turtles, and sting rays have also been taken from these beds by Dr. Clark and the writer.

LIST OF SPECIES FROM UPPER SAN PEDRO

Mammals	Birds
<i>Equus</i>	<i>Echmophorus</i> , n. sp.
<i>Bison</i>	<i>Nettion carolinense</i> (Gmelin)
<i>Camelid</i>	<i>Sturnella neglecta</i> Audubon

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