THE AVIFAUNA OF THE BARSTOW MIOCENE OF CALIFORNIA

By LOYE MILLER

For more than forty years the Upper Miocene beds known as the Barstow Syncline have been under the scrutiny of vertebrate paleontologists representing widely separated institutions and having greatly divergent backgrounds. An extended account of this area in the Mohave Desert of California was published by Merriam (1919). Here he discussed the general geology and paleontology and correlated the faunas as far as known up to that time. Very little had been recovered except mammal remains. One reptile was described (*Testudo mohavense*) and three fragments of bird bone were recorded as buteonid hawks. In succeeding years there has been a good deal of work done on the mammal fauna but very little has been added to the record of birds (L. Miller, 1950).

During the past three years, some painstaking and enthusiastic surface collecting has been done in the Barstow Syncline by Messrs. Richard Tedford and Robert Shultz with the result that an interesting, though small, collection of bird remains has been assembled. Some of this material is located at the Los Angeles Museum (L. A. Mus.) and some at the University of California at Los Angeles (UCLA). All of it has been made available for this study along with field notes and personal comment by Tedford and Shultz.

The material is so highly fragmentary that specific identity has in most instances not been determined. However, the familial relationships displayed are of great significance in reconstructing the ecologic picture of the area during Upper Miocene time. Specimens are beautifully mineralized and have suffered very little corrosion or distortion from pressure. Fragmentation seems to be due to breaking up of the matrix by Recent surface erosion. Excavation below the weathered zone is not practicable because of the rarity and the widely separated locations of bird remains. It is a pleasure to acknowledge the services of Messrs. Tedford and Shultz in bringing this bird material to light.

RECORD OF SPECIMENS

CICONIIFORMES

Megapaloelodus connectens A. H. Miller

Four specimens: UCLA no. 2303.—Distal condyles of left tibiotarsus in excellent condition; this is the second example of the species and the first from the Upper Miocene. UCLA no. 2303A.—Distal end of right ulna in less perfect condition than the preceding. UCLA no. 2303B.—The distal end of a toe bone that probably came from the same individual as did the tibia and ulna. UCLA no. 2346.—Coracoid nearly complete.

The tibial condyles and the distal portion of the ulna of this species were described in a previous paper (L. Miller, 1950). The coracoid (UCLA no. 2346) was collected two years later from the same station where the others were taken. The characters of the bone and its size are so distinctly in harmony with other remains that I feel little doubt that all the specimens came originally from the same individual bird.

The coracoid resembles nothing else so much as it does the flamingos but still it is quite distinct from *Phoenicopterus*. Likewise it differs from *Paloelodus* of the Oligocene of France in its greater size and in the relatively longer shaft. Unfortunately both extremities of the sternal base are lost, which fact makes it difficult to express these differences in mathematical ratios. Reference to figure 1 is more enlightening. Measurements of the coracoid of *Megapaloelodus* follow:

Length, head to axial end of base	62.5 mm.	Depth, narrowest part of shaft	10.0 mm.
Length, head to center of scapular cup	27.0	Humeral facet	19.0 x 10.0
Width, narrowest part of shaft	10.5	Scapular cup	9.0 x 7.7

Comparison is here made with the corresponding bone from *Phoenicopterus antiquorum,* a specimen from captivity, unfortunately, but one that shows no pathologic abnormality. The coracoid of the fossil differs from that of the Recent bird in the following respects: (1) The head, distal to the glenoid facet, is narrower and more elongate. (2) The furcular facet is differently proportioned and its proximal border (brachial

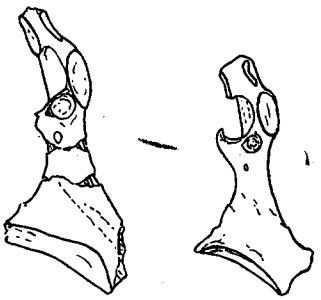

Fig. 1. Left, *Megapaloelodus connectens,* coracoid; UCLA no. 2346; Upper Miocene, Barstow Formation. Right, *Phoenicopterus antiquorum*; Recent, aviary specimen. Both ×½.

tuberosity) overhangs a deep pit which is lacking in *Phoenicopterus.* (3) The coracohumeral surface is longer and describes a much more open curve. (4) The scapular facet is a deeper and more sharply defined pit (this distinction is possibly accentuated by the fact that the Recent skeleton came from a captive bird). (5) The coracoidal foramen is larger and more elliptical in outline. (6) The shaft of the bone is more elongate; hence it appears to widen out less abruptly toward the sternal articulation. (7) The sternocoracoidal impression is marked by two practically continuous intermuscular ridges that are scarcely indicated in the flamingo.

This flamingo-like bird was assigned to a distinct genus and species by its describer (A. H. Miller, 1944) because of its divergence from *Paloelodus* of France which was considered to be its closest relative. The Old World specimens were collected from Oligocene strata which yielded fairly abundant material representing several species (Milne-Edwards, 1867-71). They were set off from true *Phoenicopterus* by a variety of characters which include a much less specialized beak. The Barstow specimen of *Megapaloelodus,* on the other hand, has a more specialized intratarsal articulation than either *Paloelodus* or *Phoenicopterus.* Assuming that the general characters of the North American bird are rightly interpreted, it seems to me that subfamilial distinction is strongly indicated. A. H. Miller suggests the same distinction after his study of the metatarsal trochleae. The following quotation from his original description is offered: "The characters of the metatarsus alone might lead one to erect a separate subfamily for *Paloelodus* and *Megapaloelodus* although other parts of the skeleton apparently do not support the action." This statement was based on the study of the trochleae alone. The tibial condyles of *Megapaloelodus* (L. Miller, 1950) show a degree of specialization of the intratarsal articulation that I have seen in no other group of birds. The European *Paloelodus* shows but the faintest indication of this specialization. Was it the incipient stage of a specialization that progressed through Oligocene and Lower Miocene to a

climax in the Upper Miocene of Barstow? Unfortunately the geologic record of intermediate stages has not been uncovered. The genera *Paloelodus* and *Phoenicopterus* were both found in the same Oligocene strata of France, but up to the present *Phoenicopterus* has not been reported from American formations older than Pliocene (L. Miller, 1944).

ANSERIFORMES

There are seven fragments in the assembled collections from Barstow that are recognizable as duck remains. Specimens are so fragmentary and the duck family is such a large and widely diversified group that it is not felt wise to assign these fossils to genus and species. Basic principles concerning distribution, both in time and in space, would be involved if names were suggested, and, once a statement gets into the literature, it may prove a stumbling block rather than a stepping stone. I prefer therefore to discuss the fragmentary material in broader taxonomic terms and to emphasize its ecologic significance only.

The following specimens are definitely assigned to the Anatidae:

L. A. Mus. no. V493.—Distal condyles of a left femur, quite badly fragmented but recognizable as a duck about the size of the Mallard (*Anas platyrhynchos*).

L. A. Mus. no. V493.—Head of right coracoid from a duck about the size of a female Green-winged Teal (*Anas carolinensis*).

L. A. Mus. no. V471.—Tibial condyles approximately the same as those of the Mallard (female).

L. A. Mus. no. V492.—Left coracoid almost complete from a duck about the size of a female Baldpate (*Mareca americana*) but with relatively shorter head and longer shaft. I have seen no Recent species with the same proportions.

L. A. Mus. no. V492.—Head of right coracoid about equal to that of the Ruddy Duck (*Oxyura jamaicensis*).

L. A. Mus. no. V498.—Distal condyles of the left humerus of a small duck.

L. A. Mus. no. V498.—Head of coracoid similar to that of the Ruddy Duck.

FALCONIFORMES

Three fragments of tibiae and tarsi representing buteonine hawks of two species were reported by Merriam (1919). I examined them at Merriam's request in 1915 and they were again examined by Dr. Hildegarde Howard thirty years later without change of classification. The specimens were not available for the present study. Presumably they were taken from the tufaceous matrix that comprises the main mass of the Barstow accumulation. There is an ungual phalanx (L. A. Mus. no. V498) which appears to be from a small species of *Buteo*.

GALLIFORMES

Cyrtonyx tedfordi new species

Type.—no. 42,223 Univ. Calif. Mus. Paleo., right carpometacarpus.

Diagnosis.—Very similar to the male of *Cyrtonyx montezumae mearnsi*, but much stouter and with intermetacarpal tubercle much less developed.

The first portion of this tiny bone was picked up in April of 1951. After a rain storm the site was revisited in the following July, when Tedford found the second fragment. In the laboratory the two surfaces of the fracture were found to intermesh perfectly. The result is a carpometacarpus almost exactly the size of the corresponding bone from a male Mearns or Massena Quail (*Cyrtonyx montezumae mearnsi*) from Arizona but it is heavier throughout and has the intermetacarpal tubercle represented by a very slightly developed though sharp-edged ridge instead of by a papilla. *Cyrtonyx* has this papilla much less strongly developed than does *Lophorytx*. In fact, this character as developed in *Cyrtonyx* shows a stage almost exactly intermediate between *Lophortyx* and the Barstow fossil.

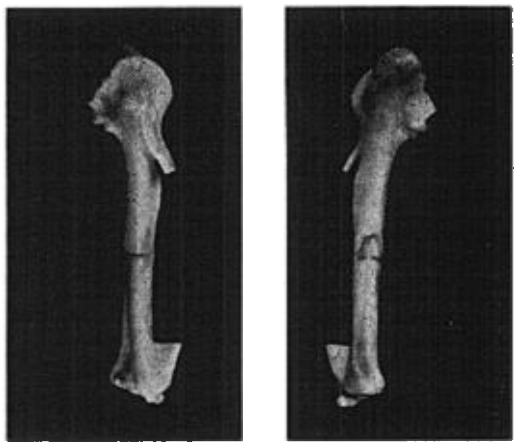

Fig. 2. *Cyrtonyx tedfordi,* carpometacarpus, anconal and palmar aspects, × 2; no. 42223 Univ. Calif. Mus. Paleo. Photo by Robert I. Bowman.

Colinus, Callipepla, Oreortyx, Dendrortyx, Rollulus, and *Arborophila* all have the tubercle strongly developed. *Crax* and *Penelope* have it represented only by a scar while other osteologic characters show these cracids to be far removed from the quails.

The Barstow specimen is much smaller than *Ortalis pollicaris* A. H. Miller, a chachalaca from the Lower Miocene of South Dakota, and it shows osteologic differences that separate it from that genus. The familial relations of the Barstow bird, except for the intermetacarpal tubercle, appear to lie with the American quails, but assignment to the genus *Cyrtonyx* is tentative.

The specific name is chosen in honor of the astute young paleontologist Richard Tedford.

CHARADRIIFORMES

The tibial condyles (UCLA no. 2346C) of a gull-like bird constitute the total material definitely assigned to this great order. The specimen corresponds in size fairly closely with the California Gull, *Larus californicus.* The present day California Gull frequents the inland lakes of the West. Was this an antecedent relative with comparable habit?

A single tiny ungual phalanx (UCLA no. D) is assigned with great reserve to the gull tribe. Along with the preceding tibial fragment, it came from the lacustrine lens that yielded the flamingo remains.

COLLECTING LOCALITIES

The avian remains here recorded were retrieved from a number of field localities that are fairly well distributed over the area known as the Barstow Syncline and they come also from several different levels in the vertical section. Tedford's notes give us the following information:

Specimens labeled V471 came from "Locality in south limb of the syncline entirely within a bed of pure white tuff some fifteen feet in thickness and of local extent. This locality is the '*Hemicyon* Stratum' of the Frick parties—extensive quarrying operations had been carried on here. The locality is approximately in the SE ¼, SW ¼, Sec. 14, T11N, R2w, MDB&M. Searles Lake Quadrangle of U.S.G.S." The tibial condyles of a Mallard-sized duck were taken here.

V492. Lake Bed Horizon (Also UCLA 2303 & 2346). "Tuffaceous clays varying between 1 and 3 ft. in thickness; calcareous lenses in its lower ⅔; resting on 3 ft. of compact white sandstone which is in turn underlain by fossiliferous brown tuffs of the usual character and the whole is overlain by fossiliferous brown tuffs of similar composition. Mollusks found along the extent of the beds which is lens-like in appearance. South limb of syncline approximately ½ mile west of V471; approximately

300 ft. below V471 in the middle of SE ¼, NW ¼, Sec. 15, T11N, R2w." This locality has yielded the majority of the bird remains known from the Barstow. They include a flamingo, several ducks, a hawk, and a quail. The physical evidence of lake bed type of deposition is here most definitely recognizable.

V493. "Thick and abundantly fossiliferous bed of brown tuff and fine sandstones approximately ⅛ mile east of V492 and extending along about ⅛ mile of exposure. South limb of syncline approximately 20 ft. below V492 in SW ¼, NE ¼, Sec. 15, T11N, R2w." The very fragmentary material from this locality represents two species of ducks, one about the size of the Recent Mallard and the other one comparable to the Green-winged Teal. A premolar of a three-toed horse, *Merychippus,* a rabbit tooth, and the toe bone of a cat-like animal were associated.

V498. "Beds of fine orange brown tuff exposed in the upper reaches of the first large wash from the south opening to the west. South limb of the syncline approximately ¾ mile southeast of V493 and stratigraphically about 100 ft. above it. Approximately in N ½, SW ¼, Sec. 14, T11N, R2w." Two small duck bones and the claw of a buteonid hawk were taken here.

Tedford also comments on the much more abundant mammal fauna as follows: "We could not find any difference in the total aspect of the fauna from top to bottom of the fossiliferous tuff—the fauna viewed as a whole is homogeneous, the slight differences present being differences in facies." There is furthermore no reason to feel that other than Upper Miocene is represented.

DISCUSSION

Merriam's study of the mammal faunas (1919) pictured in his mind "an open country . . . affording fairly abundant grass and herbage, and evidently better watered than the Mohave Desert of the present day. The abundant remains of grazing horses of the *Merychippus* type, the presence of mastodonts, oreodonts, and merycodonts, a considerable variety of camels and a peccary all indicate that nutritious vegetation must have been more abundant than at present." He mentions *Planorbis*, *Limnaea* and *Anodonta* in his tabulation of faunas but does not designate the exact locality from which they came. His only comment is that "the section in the Barstow Syncline consists in large part of volcanic materials with beds of clay and shale at some horizons. The deposits are evidently partly of terrestrial and partly of lacustrine origin. At rare horizons, remains of fresh water mollusca . . . are abundant. In other beds, scattered and weathered bones representing a large tortoise and numerous mammals belonging to the open plains type probably indicate accumulation on dry land." Tedford and Shultz evidently worked one of these lenses when they uncovered the aberrant flamingo. In recording this bird from California (L. Miller, 1950) it was stated that the area apparently consisted of "a small shallow and ephemeral body of water in which sedimentation took place, for the lens is thin and it diminishes gradually to its margins. It is overlain by the same type of rock as that upon which it rests. Whether or not its waters were entirely fresh is not known but careful search revealed no significant deposits of gypsum, borax, or soluble salts. The presence of calcareous layers interbedded with clays would, however, suggest cycles of time greater than annual cycles, during which the lake waters were highly concentrated . . . . It is possible, therefore, that the Miocene lake may have contained salts not preserved to us in Recent time. On the other hand, Merriam postulates a more abundant rainfall than is normal in Barstow today. In the Lower Pliocene beds (Ricardo) to the westward there occur the petrified stems of palms and broad-leaved trees (*Robinia*). Furthermore, imprints of palm leaves were found in the Barstow by Tedford and Shultz. Quite certainly the present mountain barrier which cuts off the moisture laden sea winds from the south coastal area, was either much lower or even nonexistent . . . . Still there is no assurance that there did not occur at times the bitter lake environment that seems to attract the modern flamingos."

A survey of the avifauna as a whole gives a definite impression of lacustrine influence not only in localities where lakes were of sufficient permanence to develop an aquatic

molluscan fauna but in some which showed no such evidence either in molluscan species or in lithologic characters.

Rainwater ponds of short duration in the southwest country at the present day prove attractive to migrating or winter-drifting gulls, ducks, and wading birds. Such ponds seem to have been quite widely scattered both in space and in time during the accumulation of the Barstow beds. The suggestion is of rainwater ponds of a mesa land rather than true lakelets of a drainage system. In those cases where they were sufficiently lasting to accumulate aquatic molluscs and a measure of lacustrine sediments, they may have been parts of local drainage systems but the suggestion to the present writer is of a mild topography without pronounced stream action though with fairly abundant rainfall at certain seasons. It supported an open-country vegetation with ephemeral pools that offered loafing grounds to a shifting population of aquatic birds. Only occasionally were the ponds of sufficient duration to harbor mollusks and attract flamingo-like birds. The surprising fact is that so few land birds have left any record of their presence in these beds that are so rich in mammal remains and that have been so extensively explored.

SUMMARY AND DEDUCTIONS

A collection of nineteen specimens of fossil birds from the Upper Miocene of Barstow, California, was studied. So far as known, there is no other bird material from these beds on deposit in American institutions. The material is well petrified but highly fragmentary; therefore generic and specific classification is attempted in but few instances.

A minimum of nine species is represented. A maximum of three of these fall in the general class of "land birds." Ducks make up the majority both of species and specimens. Two hawks, one flamingo, and one quail are represented.

Collecting stations yielding birds are widely distributed both in the horizontal and in the vertical sections of the formation. Mammal remains are abundant and indicate that only the Upper Miocene is represented.

Seasonal rainfall definitely greater than that of today is indicated. In a few instances lake waters persisted for a period sufficient to harbor aquatic mollusks and accumulate lacustrine sediments. These sediments were never of great thickness and were in turn covered by landlaid accumulations. Highly temporary rain water pools may have served as loafing grounds for drifting populations of water birds. Mild topography without marked drainage systems is postulated.

More pronounced desert conditions followed the uplift of the Sierra Madre Mountain barrier after the close of Miocene time and particularly during the Pleistocene. This barrier cut off the area from moisture-laden sea winds and at the same time caused a retreat of the coastline to approximately its present location.

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