Evolutionary patterns in Pleistocene to Recent California condors

#132562

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ABSTRACT

Pleistocene fossils related to the living California condor (*Gymnogyps californianus*) have been found in several locations in western North America; different authors have either assigned these to the separate species *G. amplus* or considered them a chronological subspecies of *G. californianus*. We examined the morphology of the genus *Gymnogyps* from the Late Pleistocene to the present, using specimens from the asphalt deposits of Rancho La Brea (RLB) and modern skeletons, a total of about 80 specimens. The limb bones (using seven variables on each element) and skulls (using 13 variables) were quantitatively compared using bivariate and multivariate techniques. No significant size or shape change through time was apparent in RLB samples ranging from the Late Pleistocene (35 000 radiocarbon years b.p.) to the early Holocene (9 000 radiocarbon years b.p.), suggesting evolutionary stasis in the face of the climatic changes of the last glacial-interglacial cycle. However, proximal limb elements and skulls showed patterns of variation consistent with a species distinction between the RLB specimens and modern *G. californianus*. To explore this possibility, we measured the type specimen for *G. amplus* (a Pleistocene tarsometatarsus from near Shasta Lake) and found it outside the morphological ranges for both *G. californianus* and the RLB specimens. Based on these results, we support the validity of a species distinction between the larger *G. amplus* and the smaller *G. californianus*, but question the assignment of the RLB condors to either of these. Interestingly, a set of specimens from an Indian midden in Oregon as well as the presence of *Gymnogyps* in Pit 10 at RLB suggest that the modern and ancient *Gymnogyps* may have coexisted with each other as well as with humans.

INTRODUCTION

The Rancho La Brea (RLB) fossil asphalt pits of Los Angeles, California have been radiocarbon dated from 35,000 to 9,000 years b.p., from the late Pleistocene to the early Holocene (Marcus and Berger, 1984). Thus fossils from these deposits provide a fairly complete longitudinal picture of the fauna during this period, spanning the end of the Tioga glacial maximum in California and the beginning of the Holocene interglacial period. A recent survey of both modern and RLB fossil golden eagles, *Aquila chrysaëtos*, indicates no overall trends in body size over the period from 35 ka to the present (S. Molina, pers. commun.). In this study, we measured a set of modern and RLB bones from the California condor, genus *Gymnogyps*, in order to look for morphological trends over time related to the environmental changes of the glacial-interglacial cycle.

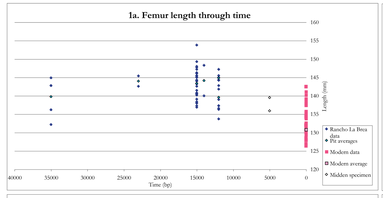
An additional question is raised in the literature regarding the validity of the species distinction between *Gymnogyps californianus*, the modern California condor, and *G. amplus*, a Pleistocene species. The type specimen for the latter is a single incomplete tarsometatarsus from the Pleistocene of Samwel Cave near Shasta Lake. Such a specimen is of limited diagnostic use, so taxonomic opinion is divided on the identity of the RLB specimens. Although the paper describing and naming *G. amplus* identifies the RLB condor remains as belonging to the modern species (Miller, 1911), more recent authors seem to assume the opposite (Fisher, 1944; Emslie, 1988). We attempted to resolve this disagreement by applying statistical techniques to our morphological data set.

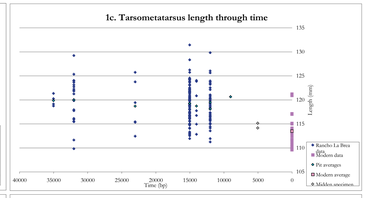
METHODS

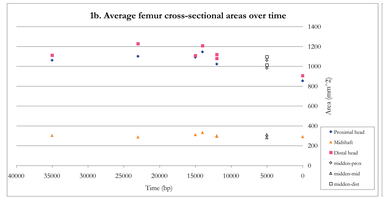
Our sample sizes are summarized in the table below; measured dimensions are marked on the figures at right. Seven dimensions were measured on limb bones, 11 on crania, and two on maxilla. Representative specimens of several elements are shown below with measured dimensions marked.

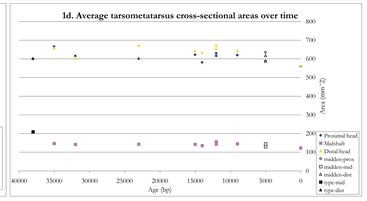
RLB specimens ranged from 35 000 years old to 9 000 years old (Marcus and Berger, 1984); however, only one specimen, a tarsometatarsus, was available from the 9 000 year old pit, so conclusions are generalizable only to the span from 35 000 to 12 000 years, as pits of these ages yielded abundant samples of *Gymnogyps* and provided data sets of usable size.

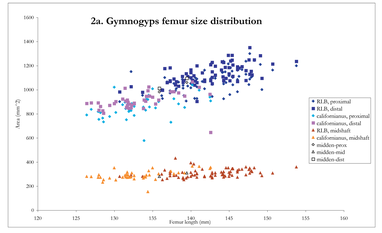
Element	RLB	Modern	Dalles archaeological midden specimens	Other
Crania	53	16	1	
Maxillae	49	13	1	
Humeri	42	29	3	
Radii	2	24	1	
Ulnae	25	25		
Carpometacarpi	95	21	2	
Femora	75	62	2	
Tibiotarsi	64	20	2	
Tarsometatarsi	238	20	2	1 (holotype)

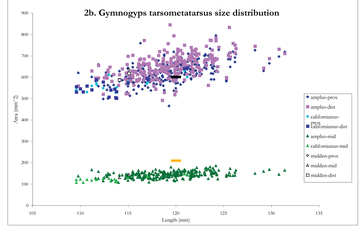


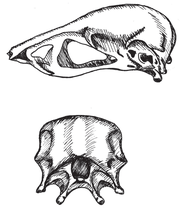












DISCUSSION

Morphological trends through time

In the RLB specimens we measured, no significant size or shape change through time was apparent in any element for samples ranging from 35 000 radiocarbon ybp to 12 000 ybp, suggesting evolutionary stasis in the face of the climatic changes of the last glacial-interglacial cycle. (Fig. 1abcd) This is consistent with the recent survey showing a similar lack of change in golden eagles from the RLB asphalts.

Species diagnoses and distinctions

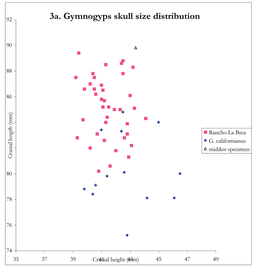
Proximal limb elements and skulls, however, showed patterns of variation consistent with a species distinction between the RLB specimens and modern *G. californianus*. In fig. 2a, all cross-sectional areas of the femur display noticeable segregation between the RLB and modern specimens. This is marked even more strongly in several skull dimensions (fig. 3abc), specifically the ratio of skull length to height of the cranial vault, ratio of the width between the occipital protrusions versus that between the opisthotic protrusions, and the relative length of the occipital protrusions, this last having been marked by Fisher (1944) as one of the distinctions between the RLB specimens (*G. amplus*, fide Fisher) and *G. californianus*.

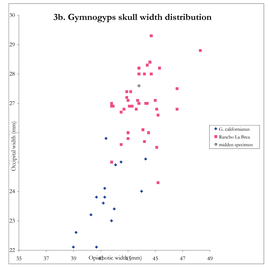
Species distinctions

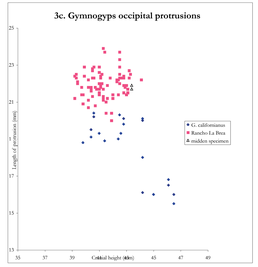
The lack of overall size change in *Gymnogyps* specimens observed during the 23 000 years of the RLB time span, as compared to the discrete jump in the above dimensions between 12 000 ybp and modern, leads us to support the validity of the species distinction drawn between the modern and Late Pleistocene condors. However, the standard for validating the difference between the names *G. amplus* and *G. californianus* required a comparison to the type specimen.

The type specimen for *G. amplus* is a broken tarsometatarsus (TMT) from the Pleistocene of Samwel Cave near Shasta Lake, which has never been radiocarbon dated. Fig. 2b demonstrates that although the TMT is notably not diagnostic for the distinction between the RLB and modern specimens, the midshaft area of the type specimen put it outside the morphological ranges for both *G. californianus* and the RLB specimens.

Based on these results, we support the validity of a species distinction between the larger *G. amplus* and the smaller *G. californianus*, but question the assignment of the RLB condors to either of these. Instead, we propose a third category be devised for the Late Pleistocene *Gymnogyps* of Rancho La Brea.







Potential temporal overlap with humans

There is a particular specimen tagged as *Gymnogyps californianus*, #13377 in the University of California Museum of Vertebrate Zoology at UC Berkeley, which bears a written note indicating that it was not a museum-prepared skeleton like all the others in the collection, but instead was found in a midden at an archaeological dig at The Dalles, Oregon, associated with ancient Native Americans. As there are three humeri present, this box clearly holds the remains of more than one animal. For the purposes of the present study, however, the interesting aspect of the specimen lies in its measurements. As visible in fig. 3abc, the skull of #13377 falls well outside the range of sizes observed for *Gymnogyps californianus*, and indeed at the large end of the spectrum of RLB specimens.

There is no reason to assume this is a single skeleton, and indeed it certainly contains at least one element from a second condor, if not more. However, since the bird to whom skull #13377 belonged presumably lived (and died) at the same time as the people depositing the midden, this unique specimen indicates likely coexistence of the Late Pleistocene California condor with humans.

This conclusion is supported by the solitary specimen of *Gymnogyps "amplus"* found in Pit 10 at Rancho La Brea. Pit 10 was the location where "La Brea Woman", the only human fossil found in the RLB deposits, was unearthed; it is also the youngest of the RLB excavations so far, with a radiocarbon age of 9 000 ya.

FURTHER WORK

The Pleistocene condor is known to have had a range much wider than that of the modern *Gymnogyps californianus*, north up the Pacific coast and east across the deserts of western North America. Specimens are known from a variety of locations as far as Florida and Utah, as well as from several other rich fossil localities in California such as the Carpenteria deposits near Santa Barbara. If the methodology of this study were extended to specimens from locations other than Rancho La Brea, the results could further confirm or deny our conclusion.

In addition, the two most noteworthy single specimens in our collection -- the *G. amplus* type specimen and the remains from the Native American midden -- have not been radiocarbon dated. Obtaining isotopic ages for these two bones would significantly improve our understanding of our current results, as this would enable us to place them either within the Rancho La Brea timespan or outside it.