

GSA Data Repository Item 2006138**APPENDIX A. EXPANDED MATERIALS AND METHODS****Carbon and nitrogen stable isotopes and ¹⁴C: sample preparation and analysis**

Bone samples that were tar-impregnated (La Brea and McKittrick tar pits) were prepared differently than bones from the southwest and Florida sites. Both methods are modified from Brown et al. (1988), Tuross et al. (1988) and Stafford et al. (1991).

We collected ~150 milligram (mg) bone pieces from museum specimens using a handheld microdrill. For tar-impregnated samples, 120 mg of coarse bone powder was sealed in synthetic filter bags. For hydrocarbon removal the filter bags were soxhlet extracted in petroleum ether and acetone (24 hours each). Samples were decalcified in 0.5M HCl at 4°C for 2-3 days. The remaining collagenous residue was then gelatinized in 0.01M HCl at 57°C for 12-15 hours. The gelatin solution was passed across a 1.5 µm glass-fiber filter. For non-tar-impregnated samples, 120 mg of small bone shards were decalcified in a 0.5M EDTA solution (pH 8.0). The collagenous residue was gelatinized and filtered as above. The filtrate was then ultrafiltered, with retention of the >30 kilodalton fraction. Extensive experimentation on artificial mixtures of La Brea tar with modern bone demonstrated that our methods were sufficient to remove tar contaminants.

Carbon and nitrogen stable isotope ratios were measured using elemental analyzers coupled with mass spectrometers at the Stanford Light Stable Isotope Laboratory (Finnegan Delta Plus XL) and the UC Davis Stable Isotope Facility (Europa Hydra 20/20). Collagen preservation was assessed from C/N atomic ratios, with values <3.6 viewed as acceptable (Ambrose, 1990). For the tar-impregnated bones, hydrocarbon contamination can be detected by high C/N ratios due to excess carbon. Likewise, poor collagen preservation in the southwest and Florida due to groundwater leaching and surface weathering results in loss of nitrogen, and high C/N ratios. The standard deviations for replicates of a gelatin standard were <0.2‰ for both

carbon and nitrogen. Radiocarbon analysis was performed at the Center for Accelerator Mass Spectrometry, Lawrence Livermore National Laboratory.

Hydrogen stable isotopes: sample preparation and analysis

The approximate non-exchangeable hydrogen isotope ratios of bone collagen samples were determined using the comparative equilibration method introduced by Wassenaar and Hobson (2002). Sub-samples (150 μg) of the extracted collagen (see above) were weighed into silver capsules and allowed to equilibrate with water vapor in the laboratory atmosphere alongside standards for which non-exchangeable $\delta^2\text{H}$ values were known. Following an equilibration period of 7 days, the samples and equilibrated standards were dried under vacuum for at least 7 days. Hydrogen isotope ratios for the samples were determined following pyrolysis at 1400° C and chromatographic separation of the resulting H_2 gas using a thermochemical elemental analyzer coupled to an isotope ratio mass spectrometer (ThermoFinnegan).

Because collagen standards were not available for this work, the standards used were horse hair standards characterized by Bowen et al. (2005). Although the structural protein α -keratin, which comprises the majority of hair is broadly similar to bone collagen, some imprecision in the corrections for hydrogen exchange is likely given that the standard material and samples were not perfectly matched in terms of their physical state or chemical composition. Use of bone collagen hydrogen isotope ratios in ecological and paleo-ecological studies is a technique in its infancy; further work will be required to resolve this issue, particularly since the hydrogen exchange properties of collagen have only been characterized at high temperatures that may not be relevant to equilibration conducted under ambient laboratory conditions.

References Cited

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APPENDIX B. PLEISTOCENE AND MODERN BIRDS SPECIMEN LIST AND STABLE ISOTOPE VALUES (‰)

Taxon	Specimen #	Locality	$\delta^{13}\text{C}$	$\delta^{15}\text{N}$	$\delta^3\text{H}$
<u>Pleistocene La Brea and McKittrick Raptors and Vultures</u>					
<i>Gymnogyps californianus</i>	UCMP 148875	La Brea, CA (Pit 3874)	-19.2	11.7	-31.1
<i>Gymnogyps californianus</i>	UCMP 148876	La Brea, CA (Pit 3874)	-15.9	16.3	-11.4
<i>Gymnogyps californianus</i>	UCMP 148877	La Brea, CA (Pit 3874)	-15.1	14.2	-15.6
<i>Gymnogyps californianus</i>	UCMP 148878	La Brea, CA (Pit 3874)	-13.5	13.5	0.2
<i>Gymnogyps californianus</i>	UCMP 148879	La Brea, CA (Pit 3874)	-19.8	11.6	-73.0
<i>Gymnogyps californianus</i>	UCMP 148880	La Brea, CA (Pit 3874)	-18.7	12.0	-46.2
<i>Gymnogyps californianus</i>	UCMP 148881	La Brea, CA (Pit 3874)	-17.7	14.2	-5.8
<i>Gymnogyps californianus</i>	UCMP 148884	La Brea, CA (Pit 3874)	-13.4	13.3	-2.1
<i>Gymnogyps californianus</i>	UCMP 148885	La Brea, CA (Pit 3874)	-18.4	12.6	-27.1
Mean			-16.9	13.3	-23.6
SD			2.5	1.5	23.9
<i>Teratornis merriami</i>	UCMP 148855	La Brea, CA (Pit 3874)	-18.6	9.9	-21.9
<i>Teratornis merriami</i>	UCMP 148856	La Brea, CA (Pit 3874)	-17.6	11.4	-30.1
<i>Teratornis merriami</i>	UCMP 148859	La Brea, CA (Pit 3874)	-19.1	8.9	-21.2
<i>Teratornis merriami</i>	UCMP 148860	La Brea, CA (Pit 3874)	-19.4	12.3	na
<i>Teratornis merriami</i>	UCMP 148873	La Brea, CA (Pit 3874)	-19.6	11.6	-15.0
<i>Teratornis merriami</i>	UCMP 148874	La Brea, CA (Pit 3874)	-19.2	11.1	-22.9
<i>Teratornis merriami</i>	UCMP 149255	McKittrick, CA (Pit 1370)	-19.3	10.3	na
<i>Teratornis merriami</i>	UCMP 149256	McKittrick, CA (Pit 1370)	-18.8	10.2	-31.7
<i>Teratornis merriami</i>	UCMP 149257	McKittrick, CA (Pit 1370)	-19.5	9.6	-43.4
<i>Teratornis merriami</i>	UCMP 149258	McKittrick, CA (Pit 7139)	-17.6	12.2	-49.4
Mean			-18.9	10.8	-29.5
SD			0.7	1.2	11.8
<i>Coragyps occidentalis</i>	UCMP 148861	La Brea, CA (Pit 3874)	-19.5	12.2	-34.3
<i>Coragyps occidentalis</i>	UCMP 148862	La Brea, CA (Pit 3874)	-19.7	12.2	-38.8
<i>Coragyps occidentalis</i>	UCMP 148863	La Brea, CA (Pit 3874)	-20.4	12.0	na
<i>Coragyps occidentalis</i>	UCMP 148864	La Brea, CA (Pit 3874)	-20.2	11.9	-47.8
<i>Coragyps occidentalis</i>	UCMP 148865	La Brea, CA (Pit 3874)	-19.5	12.3	-31.9
<i>Coragyps occidentalis</i>	UCMP 148868	La Brea, CA (Pit 3874)	-20.8	12.3	-46.8
<i>Coragyps occidentalis</i>	UCMP 148869	La Brea, CA (Pit 3874)	-19.8	11.4	-31.4
<i>Coragyps occidentalis</i>	UCMP 148870	La Brea, CA (Pit 3874)	-20.1	11.5	-54.2
Mean			-20.0	12.0	-40.7
SD			0.4	0.4	8.9
<i>Haliaeetus leucocephalus</i>	UCMP 148790	La Brea, CA (Pit 3874)	-15.5	16.0	na
<i>Haliaeetus leucocephalus</i>	UCMP 148791	La Brea, CA (Pit 3874)	-19.7	11.3	-26.3
<i>Haliaeetus leucocephalus</i>	UCMP 148792	La Brea, CA (Pit 3874)	-15.1	14.5	na
<i>Haliaeetus leucocephalus</i>	UCMP 148793	La Brea, CA (Pit 3874)	-18.8	7.2	na
<i>Haliaeetus leucocephalus</i>	UCMP 148794	La Brea, CA (Pit 3874)	-14.3	15.4	na
<i>Haliaeetus leucocephalus</i>	UCMP 148815	La Brea, CA (Pit 2051)	-16.3	14.6	na
<i>Haliaeetus leucocephalus</i>	UCMP 148816	La Brea, CA (Pit 2051)	-15.0	14.0	na
<i>Haliaeetus leucocephalus</i>	UCMP 148817	La Brea, CA (Pit 2051)	-14.9	16.2	na
Mean			-16.2	13.6	-26.3
SD			2.0	3.0	
<i>Aguila chryseatos</i>	UCMP 148813	La Brea, CA (Pit 2051)	-20.8	7.2	-47.6
<i>Aguila chryseatos</i>	UCMP 148814	La Brea, CA (Pit 2051)	-19.5	10.2	na
Mean			-20.1	8.7	-47.6
SD			0.9	2.1	

Pleistocene Southwest and Florida Vultures

<i>Gymnogyps californianus</i>	GCNP	Shrine Cave, AZ	-14.7	11.2	-65.8
<i>Gymnogyps californianus</i>	GCNP	Sandblast Cave, AZ	-19.0	11.2	-75.0
<i>Gymnogyps californianus</i>	TMM 41228-1625	Dark Canyon Cave, NM	-15.2	11.6	na
<i>Gymnogyps californianus</i>	TMM 41228-4825	Dark Canyon Cave, NM	-14.7	11.6	na
<i>Gymnogyps californianus</i>	TMM 41228-1774.2	Dark Canyon Cave, NM	-12.6	13.8	na
<i>Gymnogyps californianus</i>	TMM 41228-4827	Dark Canyon Cave, NM	-14.6	13.6	-53.5
<i>Gymnogyps californianus</i>	USNM 320806	Mule's Ear Peak Cave, TX	-13.7	11.8	-49.8
<i>Gymnogyps californianus</i>	UF(PB) 807	Ichetucknee River, FL	-12.0	9.9	na
<i>Gymnogyps californianus</i>	UF 15709	Ichetucknee River, FL	-13.4	7.7	-16.1
<i>Gymnogyps californianus</i>	UF 145279	Page Ladson, FL	-18.4	9.6	-44.2
<i>Coragyps occidentalis</i>	TMM 41229-3535	Hall's Cave, TX	-11.4	14.2	na
<i>Coragyps occidentalis</i>	TMM 41229-3536	Hall's Cave, TX	-11.6	15.4	-70.1
Cathartidae	TMM 908-261	Kincaid Shelter, TX	-20.9	12.7	20.3
Cathartidae	TMM 908-908	Kincaid Shelter, TX	-18.6	8.4	-68.3
Cathartidae	TMM 908-3508	Kincaid Shelter, TX	-20.0	5.9	na

Modern Coastal California Seabirds

<i>Phalacrocorax penicillatus</i>	UCSC BC-1	Monterey Bay, CA	-13.6	15.7	27.6
<i>Phalacrocorax penicillatus</i>	UCSC BC-2	Monterey Bay, CA	-13.0	15.8	14.9
<i>Pelecanus occidentalis</i>	UCSC BP-1	Monterey Bay, CA	-13.6	17.6	5.0
<i>Pelecanus occidentalis</i>	UCSC BP-2	Monterey Bay, CA	-14.2	18.1	-14.0

SD - standard deviation (1σ)

na - not analyzed

Gymnogyps californianus - California condor; *Teratornis merriami* - teratorn; *Coragyps occidentalis* - black vulture;

Haliaeetus leucocephalus - bald eagle; *Aquila chryseatos* - golden eagle; Cathartidae - vulture species;

Phalacrocorax penicillatus - Brandt's cormorant; *Pelecanus occidentalis* - brown pelican;

GCNP – Grand Canyon National Park, TMM – Texas Memorial Museum, UCSC - University of California Santa Cruz,

UCMP - University of California Museum of Paleontology, UF (PB) – Florida Museum of Natural History (Pierce

Brodkorb collection), USNM – U.S. National Museum.
