FOSSIL RAVENS FROM THE PLEISTOCENE OF DRY CAVE, EDDY COUNTY, NEW MEXICO

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In the process of curating ravens from Pleistocene deposits in Dry Cave, Eddy County, New Mexico, we noted elements which seemed too small to be *Corvus corax* Linnaeus and too large for *Corvus cryptoleucus* Couch. This led us to study all the Dry Cave ravens, revealing a population of intermediate-sized individuals of *C. corax* and a new fossil species of *Corvus*.

Dry Cave is located some 23 km W Carlsbad in southeastern New Mexico (104° 28′ 55″ W long., 32° 22′ 25″ N lat.). It lies in rolling, limestone country about midway between the Pecos River (elev. ca. 900 m) to the east and the Guadalupe Mountains (elev. ca. 1830 m) to the west and southwest. The cave, at 1280 m, is in a sparsely vegetated ecotone between Upper and Lower Sonoran life-zones. The vegetation was described by Harris (1970).

At various times in the past, fissure systems broke through to the surface, allowing rocks, soil, plant debris, and both living and dead animals to enter the cave. All except the Entrance Fissure have clogged, stopping deposition. Radiocarbon dates (Buckley and Willis 1970, Buckley 1973) indicate that the Entrance Fissure and nearby Bison Sink (figs. 1, 2) opened about 15,000 years before present (BP) with deposition in Bison Sink ceasing some time after 10,700 BP. Faunal analyses indicate that pluvial conditions obtained during these times of Pleistocene deposition (Harris 1970, Holman 1970, Metcalf 1970, Harris et al. 1973). Harris (1970) concluded that the mammalian fauna most closely resembled that of present day central Wyoming, but that winters must have been warmer than they are now. There also was considerable evidence that the precipitation pattern was more like that of the Great Basin (more cool season than warm season precipitation) than that of southeastern New Mexico today, where more than half of the total precipitation occurs from July to September and is preceded and followed by periods of drought.

In the cave, some 300 m from the sites mentioned above, are earlier fossil deposits. These older faunas are similar in many ways, but differ sufficiently to imply lack of strict contemporaneity. Faunistically, the deposits seem to date to an interstadial time when summer temperatures may have been cooler than today, but winter temperatures probably were as mild or milder; effective precipitation may have been slightly greater (or deeper soils may have conserved moisture more efficiently). Non-pluvial marker taxa include cotton rats (*Sigmodon* sp.), land tortoises (*Gopherus agassizi* and *Geochelone* sp.), and armadillo (*Dasypus* sp.). The presence of prairie vole (*Microtus ochrogaster*) indicates more moisture than is available today; its present range reaches only as far southwest as Colfax County, in northeastern New Mexico (Rowlett 1972).

Attempts to date these sites from bone collagen failed due to insufficient collagen preservation; dates available are based on bone carbonates. The fossil localities related to the interstadial, older deposits are, with date when available, Laboratory for Environmental Biology (MALB) Locality 1 (29,290 ± 1060, TX–1774), Locality 5 (25,160 ± 1730, TX–1775), Locality 17, and Localities 26 and 27 (date from combined samples, 33,590 ± 1500, TX–1773).

METHODS

A series of modern specimens of *C. corax sinuatus*, *C. c. principalis*, and *C. cryptoleucus* served as a base against which the fossil specimens were assessed. From one to several measurements were taken from each major limb element of both sexes. The most useful were 1) carpometacarpus length from most proximal point to facet for articulation of digit II (CML), 2) greatest length of coracoid (CL), 3) length of femur from trochanter to external condyle (FL), 4) length of humerus from head to internal condyle (HL), 5) proximal width of humerus from bicipital crest to deltoid crest (HW), 6) length of tarsometatarsus from the intercotylar prominence to the trochlea for digit III (TML), 7) distal depth of trochlea of digit III of tarsometatarsus at deepest point (TMD), 8) distal width of tibiotarsus measured across anterior half of condyles (TD), and 9) proximal width of ulna from external cotyla to prominence for the anterior articular ligament (UW).

Fossils were designated as adult or immature. Bones were judged to be immature if they showed greater porosity than normal for modern adult

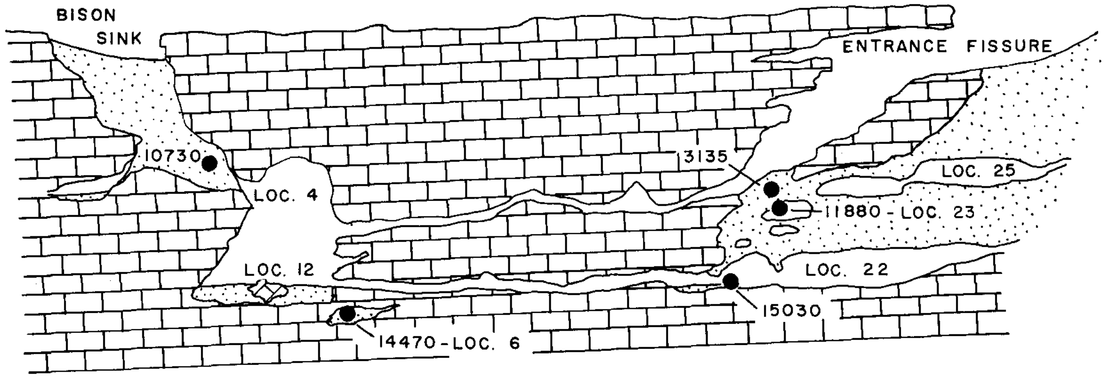

FIGURE 1. Schematic sketch showing vertical relationships between fossil localities associated with Entrance Fissure and Bison Sink Fissure; horizontal relationships are greatly distorted. Large dots show locations of C^{14}-dated material. Locality 31 (not shown) lies between Localities 22 and 23. Cave fill is indicated by stipple, passageways and chambers by non-patterned areas.

specimens or if the articular surfaces had not reached adult form and texture. Adult specimens were measured identically to the corresponding modern elements. All fossil elements are deposited in the Resource Collections (Paleobiology), Laboratory for Environmental Biology, The University of Texas at El Paso.

RESULTS AND DISCUSSION

We found no reliable qualitative characters of isolated skeletal elements of any of the raven material, fossil or modern, allowing us to identify such material to species. In considering the fossil material, we were hampered

TABLE 1. Selected measurements of raven skeletal elements.

Species	*Corvus corax principalis*	Pleistocene *C. corax*	*C. corax sinuatus*	*Corvus neomexicanus*	*Corvus cryptoleucus*
Character[a]					
CML: x̄ ± S.D.	63.94 ± 1.41	61.67 ± 2.10	59.63 ± 1.35	53.78 ± 1.13	49.53 ± 1.43
95% C.I.	62.22–65.57	60.06–63.28	58.77–60.48	51.99–55.57	48.66–50.40
Range (N)	62.0–65.8 (5)	57.8–65.1 (9)	57.2–61.2 (12)	52.4–55.0 (4)	46.0–50.9 (13)
CL: x̄ ± S.D.	61.58 ± 2.48	57.29 ± 1.98	55.12 ± 1.80	52.40 ± 0.87	45.33 ± 1.25
95% C.I.	58.50–64.66	55.46–59.12	54.08–56.16	50.24–54.56	44.53–46.12
Range (N)	58.3–65.1 (5)	55.0–60.6 (7)	52.3–58.9 (14)	51.9–53.4 (3)	43.7–47.5 (12)
FL: x̄ ± S.D.	70.00 ± 2.28	66.85 ± 5.74	64.52 ± 1.65	57.44 ± 1.85	53.22 ± 1.76
95% C.I.	67.17–72.83	62.05–71.65	63.57–65.48	55.14–59.74	52.10–54.34
Range (N)	68.0–73.2 (5)	63.5–69.6 (8)	61.5–67.4 (14)	55.5–60.3 (5)	51.0–56.0 (12)
HL: x̄ ± S.D.	96.28 ± 3.18	93.36 ± 2.07	88.36 ± 2.31	82.15 ± 2.68	71.76 ± 2.22
95% C.I.	92.33–100.23	91.45–95.27	86.81–89.92	77.89–86.41	70.35–73.17
Range (N)	93.1–101.4 (5)	88.9–95.0 (7)	86.6–91.6 (11)	78.3–84.5 (4)	68.0–74.7 (12)
HW: x̄ ± S.D.	26.56 ± 1.34	25.77 ± 1.67	23.55 ± 1.15	22.17 ± 0.41	19.37 ± 0.57
95% C.I.	24.89–28.23	24.48–27.06	22.89–24.21	21.74–22.60	19.01–19.73
Range (N)	24.3–27.6 (5)	23.3–28.3 (9)	21.2–25.1 (14)	21.7–22.9 (6)	18.7–20.5 (12)
TML: x̄ ± S.D.	65.46 ± 2.58	67.51 ± 2.29	66.83 ± 2.07	61.75 ± 0.92	59.72 ± 2.00
95% C.I.	62.25–68.67	65.59–69.43	65.51–68.14	53.49–70.01	58.45–60.99
Range (N)	62.4–68.6 (5)	63.4–70.8 (8)	62.6–69.5 (12)	61.1–62.4 (2)	56.1–62.6 (12)
TMD: x̄ ± S.D.	6.06 ± 0.28	5.76 ± 0.31	5.61 ± 0.30	4.97 ± 0.26	4.68 ± 0.22
95% C.I.	5.71–6.41	5.54–5.98	5.42–5.80	4.70–5.24	4.54–4.81
Range (N)	5.6–6.3 (5)	5.2–6.1 (10)	5.1–6.1 (12)	4.6–5.3 (6)	4.4–5.2 (12)
TD: x̄ ± S.D.	11.72 ± 0.62	10.97 ± 0.63	10.52 ± 0.60	9.55 ± 0.37	8.86 ± 0.20
95% C.I.	10.96–12.48	10.39–11.55	10.09–10.95	9.21–9.89	8.73–8.99
Range (N)	10.8–12.4 (5)	9.8–11.8 (7)	9.8–11.7 (10)	9.2–10.0 (7)	8.6–9.1 (11)
UW: x̄ ± S.D.	14.90 ± 0.37	13.44 ± 0.37	13.28 ± 0.65	12.07 ± 0.44	10.77 ± 0.25
95% C.I.	14.44–15.36	13.20–13.68	12.86–13.69	11.83–12.31	10.61–11.00
Range (N)	14.6–15.5 (5)	12.7–14.0 (12)	12.1–14.0 (12)	11.2–12.8 (15)	10.4–11.2 (12)

[a] CML carpometacarpus length, CL coracoid length, FL femur length, HL humerus length, HW proximal humerus width, TML tarsometatarsus length, TMD distal depth of tarsometatarsus, TD distal width of tibiotarsus, UW proximal width of ulna.

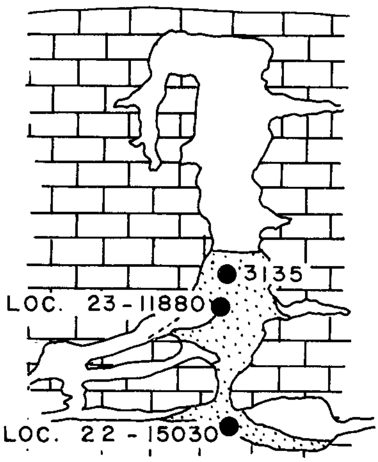

FIGURE 2. Schematic cross section through the Entrance Fissure deposits, approximately at the level of Locality 23, but with horizontal relationships distorted.

also by not knowing the sex of the specimens. Corvids generally show appreciable sexual dimorphism in skeletal characteristics (Baumel 1953, 1957); thus elements in a fossil sample including only females would have significantly smaller measurements than would those from an all-male sample. Different proportions of the sexes would present different mensural distributions. Nevertheless, statistical analysis does allow some meaningful interpretations.

One hundred specimens of Pleistocene *C. corax* were examined from the Entrance Fissure and Bison Sink deposits. Adult specimens fall well within the size range of modern *C. corax* (table 1, figs. 3, 4), but selected elements (humeral length, coracoid length) are significantly larger than those of *C. c. sinuatus* and smaller than those of *C. c. principalis* (t-test, $P < 0.001$), indicating individuals of intermediate size. Though the Pleistocene individuals averaged larger than modern *C. c. sinuatus*, they were otherwise similar. This similarity includes relatively long tarsometatarsi (table 1). Formal nomenclatural recognition of the Pleistocene population does not seem desirable.

If size is influenced by climatic conditions in *C. corax*, as is implied by the current distribution of the larger subspecies to the north, then the presence of individuals somewhat intermediate to *C. c. principalis* and *C. c. sinuatus* fits well with the hypothesized pluvial conditions. The population would have been subjected neither to the extremes of heat borne by *C. c. sinuatus* nor to the cold to which *C. c. principalis* is exposed. Lack of severe temperature extremes in the late Pleistocene has been noted for other areas by various authors (e. g., Hibbard 1960, Dalquest 1965). If climatic intensification is characteristic of the post-Pleistocene, modern subspecies of ravens may have formed during that time.

Most material from the older, interstadial deposits is intermediate in size between *C. cryptoleucus* and *C. corax sinuatus* (table 1, figs. 3, 4). As few *C. cryptoleucus* males are included in the table 1 data, the Dry Cave data and data from the large samples of male *C. cryptoleucus* published by Baumel (1953) were compared (two-sided t-test). Car-

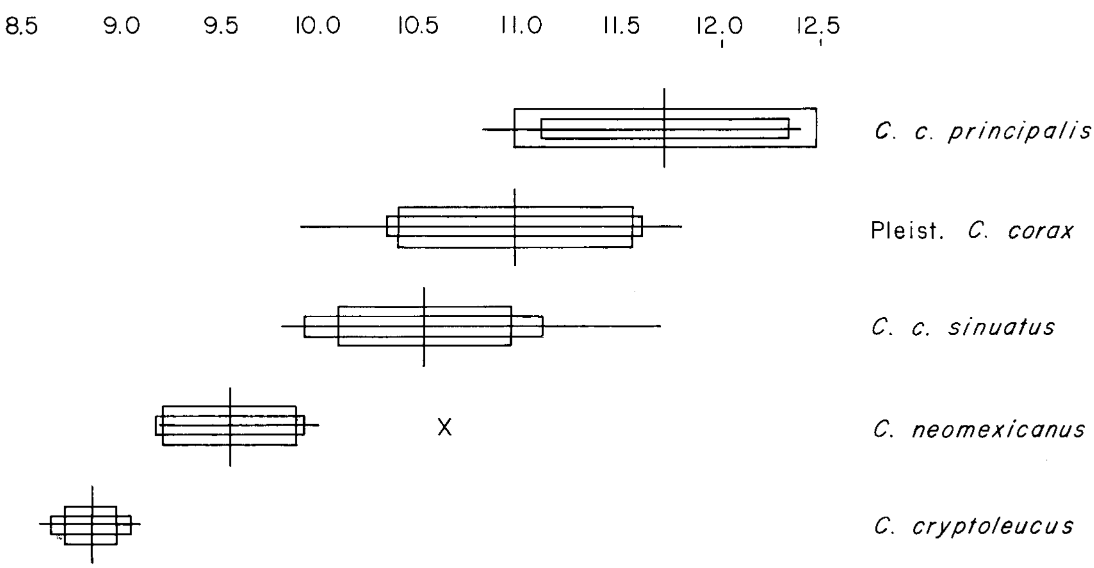

FIGURE 3. Comparison of anterior width of tibiotarsus of five populations of *Corvus*. Vertical line indicates mean; horizontal line, observed range; large rectangle, 95% confidence interval for the mean; small rectangle, plus and minus one standard deviation. "X" marks the position of MALB specimen 1–1033.

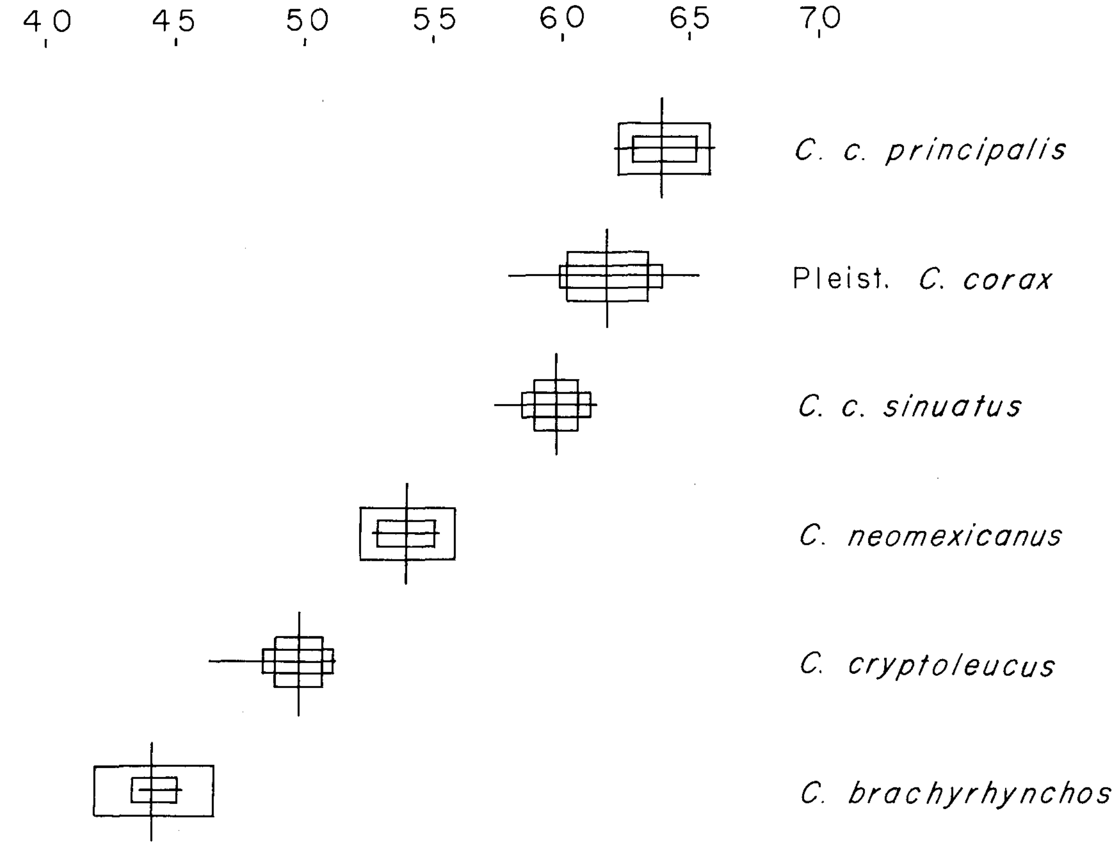

FIGURE 4. Carpometacarpal length. Symbols as in figure 3. N equals 3 for *Corvus brachyrhynchos*.

pometacarpal length, coracoid length, and humeral length differed significantly ($P < 0.001$), as did femoral length ($P < 0.01$); tarsometatarsal length did not ($P > 0.90$).

Aside from the intermediate-sized elements, seven considerably larger elements representing at least one individual (fig. 3) were present in Locality 1. Only one of these, tibiotarsus 1-1033, is complete enough to allow a standard measurement. A t-test indicates that tibiotarsi as large or larger than 1-1033 would be expected to be drawn from a population of the intermediate-sized elements less than 2% of the time. The tibiotarsus is more than 6% larger than the next largest, considerably more than expected if the difference were one of sexual dimorphism, assuming such dimorphism was of the magnitude observed in *C. cryptoleucus* (Baumel 1953). In addition, one immature ulna (MALB 26–233) is large enough to indicate a young *C. corax* from Locality 26. We conclude that *C. corax* likely is represented by the larger bones and a smaller species by the remaining elements.

At this point, we must decide if the intermediate-sized fossils represent an extinct species or a large *C. cryptoleucus*. We reject the latter as unlikely because, 1) no modern *C. cryptoleucus* are characterized by a body as large as is indicated for the fossil population. Known fossils of *C. corax* lie within the present size range of that species. 2) In contrast to the situation in the stadial deposits, hypothesized climatic conditions are not such as to indicate a climatically induced larger size. 3) Although *C. cryptoleucus* currently occurs in the Pecos Valley, it is unknown in the altitudinally higher Dry Cave area. With conditions presumably slightly less favorable during interstadial times, its presence would be even less likely. 4) Although possibly coincidence, the size of the Dry Cave individuals fills a gap in the series of morphologically similar taxa running from the small *Corvus brachyrhynchos* to the large *C. corax principalis* (figs. 3, 4). This may imply an ecological niche either currently unoccupied or no longer in existence. Therefore, we propose to recognize a new fossil species from Dry Cave. It may be known as:

Corvus neomexicanus new species

HOLOTYPE

Complete left femur, MALB 27-27.

PARATYPES

Eighty-seven specimens, including mandible, carpal, carpometacarpus, coracoid, femur, humerus, radius, scapula, tarsometatarsus, tibiotarsus, and ulna. Catalogue numbers available on request from the Laboratory for Environmental Biology.

DIAGNOSIS

Intermediate in size, but otherwise similar, to *C. corax* and *C. cryptoleucus* (table 1, figs. 3, 4).

GEOGRAPHIC AND GEOLOGIC RANGE

Known only from late Pleistocene interstadial deposits of Dry Cave, Eddy County, New Mexico, elevation 1280 m. Possibly represented in the contemporary Fossil Lake, Oregon, Pleistocene avifauna.

REMARKS

Corvus neomexicanus apparently nested on ledges of the vertical entrance fissures or in trees growing about the entrances. Both adult and immature individuals are well represented. The relative scarcity of *C. corax* remains in the same deposits may indicate that it was found primarily in the higher country to the west.

NOMENCLATURAL NOTES

A small raven has been named from beds of equivalent age at Fossil Lake, Oregon (Allison 1966); because the *C. cryptoleucus* nearest that locality are about 1300 km distant, this specimen would seem to be referable either to the Dry Cave taxon or to *C. corax*. The Fossil Lake specimen (a tarsometatarsus) is the holotype and sole specimen of *Corvus annectens* (Shufeldt 1892); this name was preoccupied and the taxon was renamed *Corvus shufeldti* by Sharpe (1909). Howard (1946), finding examples of *C. corax* tarsometatarsi as small and smaller than the holotype, synonymized *C. shufeldti* with *C. corax*. Unfortunately, the tarsometatarsus is one of the least useful elements for discrimination among ravens, and the holotype overlaps in size not only Howard's sample of *C. corax* but also the present sample of *C. cryptoleucus* and that of the Dry Cave taxon. As *C. shufeldti* is not separable morphologically from *C. corax*, *C. cryptoleucus*, and the Dry Cave taxon, it is a *nomen dubium*.

Pleistocene fossil material assigned to species of *Corvus* larger than crows is relatively rare, judging from published records. We find little indication that much of this material has received other than cursory examination. Careful investigation may well reveal other examples of *C. neomexicanus* and also elucidate intraspecific variation in *C. corax* during the late Pleistocene.

MODERN SPECIMENS EXAMINED

Corvus corax principalis (2 males, 1 female, 2 no sex given). CANADA. Manitoba, 1. UNITED STATES. Alaska, 3. New York: Herkimer Co., 1.

Corvus corax sinuatus (7 males, 6 females, 3 no sex given). UNITED STATES. Arizona: Santa Cruz Co., 1. Mohave Co., 1. Pima Co., 1. California: Marin Co., 1. Inyo Co., 1. San Bernardino Co., 1. Mendocino Co., 1. Nevada: Churchill Co., 1. Elko Co., 1. New Mexico: Otero Co., 1. McKinley Co., 1. Utah: Kane Co., 1. MEXICO. Sonora, 1. Baja California, 1. Clarion Island, 1. No Data, 1.

Corvus cryptoleucus (3 males, 9 females, 1 no sex given). UNITED STATES. Arizona: Cochise Co., 1. Gila Co., 1. Pima Co., 1. Cochise or Pima Co., 1. New Mexico: Sierra Co., 1. Dona Ana Co., 1. Texas: Taylor Co., 4. El Paso Co., 1. Dickens Co., 2.

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