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Systematic Status of Wild *Canis* in North-Central Texas

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Abstract - Skulls of wild *Canis* collected 2003–2004 in north-central Texas are morphometrically similar to a series taken there and in nearby areas in 1964–1971, which was considered to represent a population of Coyotes (*C. latrans*) modified through introgression from Red Wolves (*C. rufus*). A few of the new specimens closely resemble small examples of Red Wolves. Such affinity is supported by authoritative examination of living and videotaped animals. The persistence of influence of Red Wolves, long after presumed extirpation through hybridization and human persecution, may be relevant to wolf conservation.

Introduction

Three species of *Canis* historically inhabited Texas (Hall 1981; Nowak 1979, 2002). The natural range of *Canis latrans* Say (Coyote) covered approximately the western half of the state and also the area south of San Antonio. Available specimens show that *Canis lupus* L. (Gray Wolf) was found as far east as Jack and Kimble counties in, respectively, north-central and central Texas. Bailey (1905) reported Gray Wolves still common over most of the plains and mountain country, mainly west of 100°W. The subspecies of Gray Wolf in most parts of Texas was designated *C. lupus monstrabilis* by Goldman (1937) and placed in the synonymy of *C. lupus nubilus* by Nowak (1995). The subspecies *C. lupus baileyi* (Mexican Gray Wolf) once occurred in extreme western Texas. Native populations of Gray Wolf were extirpated from Texas by the early 1940s, though individuals of *baileyi* apparently crossed back from Mexico as recently as 1970 (Scudday 1972).

The systematic status of the third species, *Canis rufus* Audubon and Bachman (Red Wolf), has been challenged by molecular assessment, with Reich et al. (1999) claiming it developed through modern hybridization of Coyotes and Gray Wolves, and Wilson et al. (2000) arguing it has an ancient origin and is conspecific with *Canis lycaon* (Eastern Wolf). For purposes of this paper, we will avoid the controversy and follow the IUCN (2009) in regarding the Red Wolf as a valid and critically endangered species. Its historical range is not well known, but specimens indicate presence throughout the eastern half of Texas, as far west as Edwards County in the central part of the state, and along most of the Gulf Coast. By about 1900, Red Wolves and Coyotes had begun to hybridize in central Texas (McCarley 1962). That

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process spread eastward and developed elsewhere and, together with human persecution, led to the disappearance of pure Red Wolves from Texas and the other remaining parts of their range. A largely unmodified population apparently survived into the 1970s in extreme southeast Texas and southern Louisiana. Animals from there have been used for captive breeding and reintroduction in North Carolina (Nowak 1979, 2002).

The Coyote, to some extent modified through hybridization with the Red Wolf, went on to occupy all of Texas and nearly all the southeastern United States (McCarley 1959, 1962; Nowak 2003; Schmidly 1983). However, the genetic influence of the Red Wolf, as expressed in the morphology of some components of the Coyote/hybrid population, remained strong, at least through the 1960s and early 1970s. Many, if not most, skulls collected at that time within about 150 km of the Texas Gulf Coast were statistically intermediate to the larger Red Wolf and the smaller Coyote or fell within the size range of the former. Even many specimens taken well inland at that time, in eastern Texas, southern Arkansas, and Louisiana, morphometrically approach the original Red Wolf, and a few are within its range of variation (Nowak 1979).

Since the 1970s, little effort has been made to determine whether and to what extent Red Wolf influence persists in the population of wild *Canis* of Texas, though Kelly et al. (1999) recommended such an assessment. We studied the morphology of a population of *Canis* in north-central Texas to determine the degree of influence by the different species of the genus.

Methods

Specimens were contributed by Coyote hunters, who had taken them within an area of approximately 3200 km^2 in Cooke County, TX (34°N, 97°W; Fig. 1). It is a relatively open area with grazing and remnant forests (especially along the Red River). The hunters shot any *Canis* they saw; thus, our sample was not selective for large animals. Of 36 specimens submitted, 28 were complete skulls of full-grown individuals. Sex of the animals was not known.

The following 10 measurements (numbered as in Table 1) were taken: (1) greatest length of skull, (2) zygomatic width, (3) alveolar length from P1 to M2, (4) maximum width of rostrum across outer sides of P4, (5) palatal width between alveoli of P1, (6) width of frontal shield, (7) height from alveolus of M1 to most ventral point of orbit, (8) depth of jugal, (9) crown length of P4, and (10) greatest crown width of M2 (see Nowak 1995 for further description and illustrations of the measurements).

Mean, range, and standard deviation were determined for each measurement and compared to those of three series used by Nowak (1979): 57 Coyotes collected 1891–1918 in southern Texas; 119 wild *Canis* taken 1964–1971 in inland eastern Texas, and 115 Red Wolves collected 1919–29 in the south-central United States (Fig. 1). Each of those series was divided by sex, whereas our 2003–2004 sample could not be so divided. The measurements

of the 2003–2004 sample thus show a generally greater standard deviation than do those of the other series, but the means of those measurements are closely comparable to appropriate male and female samples of the other series (see below).

Results

The 28 newly collected specimens from Cooke County were statistically very close (Table 1) to the skulls taken 1964–1971 in a proximal but larger area (Fig. 1), corresponding to that part of Texas east of 98°W longitude and more than 300 km inland (Nowak 1979). The means of 9 of the 10 measurements of the newly collected specimens fell between the means of the measurements of the male and female specimens of the 1964–1971 series. None of the older specimens was from Cooke County, but some were from neighboring Denton and Grayson counties. Although the older

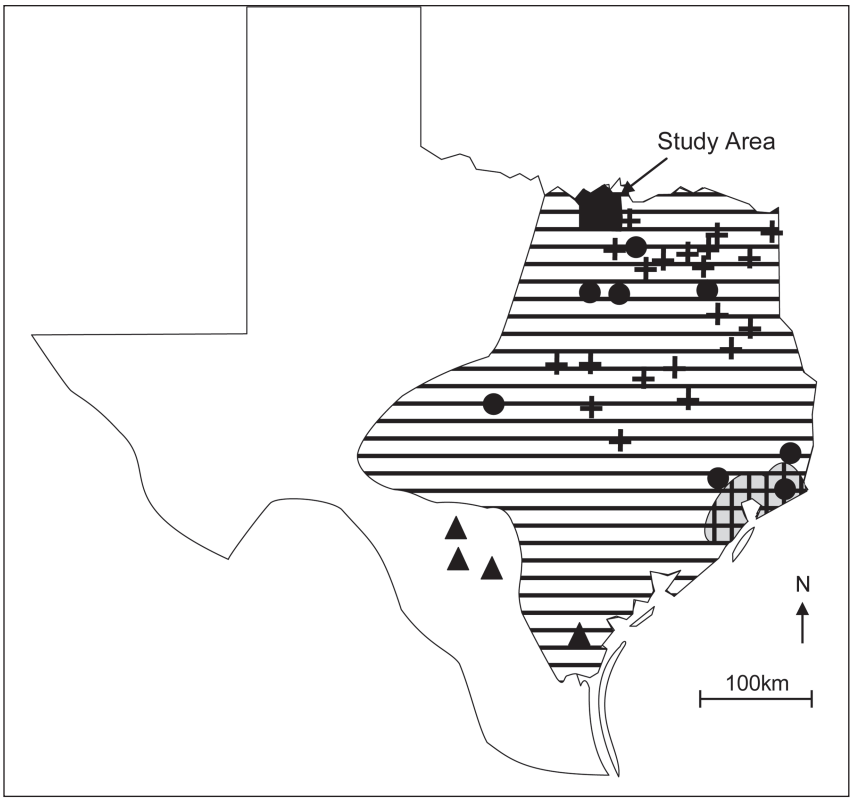

Figure 1. Distribution of Texas *Canis* referred to in the study. Horizontally lined area indicates the original range of the Red Wolf. Vertically lined area indicates the range of Red Wolves in early 1970s; dots mark localities of recent sightings and photos of Red Wolf-like animals; triangles mark counties where the 1891–1918 series of Coyotes used in this study was collected; crosses mark counties where the 1964–1971 series of wild *Canis* used in this study was collected.

Table 1. Comparison of cranial measurements (in mm) of 4 populations of *Canis*: Coyotes collected 1891–1918 in southern Texas; specimens collected in 2003–04 in Cooke County, TX; specimens collected in 1964–71 in inland eastern Texas; Red Wolves collected 1919–29 in Arkansas, Louisiana, Missouri, and Oklahoma. Sexes are shown separately, except for the 2003–04 series, for which sex is unknown. The column headed by the letter "*n*" shows sample size. The numbers heading other columns indicate the 10 measurements so numbered and described in the text. The first number in each data entry is the mean, the numbers in parentheses are the range, and the final number is the standard deviation. Aside from those on the 2003–04 series, all data were taken from Nowak (1979), except for those on Coyotes, which were taken from Nowak (1973).

	n	1	2	3	4	5
Coyote ♀	26	187.3 (172.0–199.0) 6.71	93.54 (88.0–103.0) 3.28	65.78 (60.5–72.3) 2.42	53.10 (49.9–56.7) 1.81	19.54 (16.5–21.9) 1.18
Coyote ♂	31	197.9 (187.0–209.0) 6.00	98.60 (90.0–105.0) 3.37	68.55 (60.1–73.0) 2.91	55.16 (51.1–58.4) 1.74	20.53 (18.1–23.0) 1.21
2003–04	28	201.8 (191.0–220.0) 8.48	101.75 (91.8–115.7) 5.14	71.05 (65.9–77.0) 3.13	57.87 (52.5–65.3) 3.16	20.66 (18.0–24.0) 1.51
1964–71 ♀	42	198.0 (180.0–214.0) 7.51	99.52 (91.0–109.0) 3.78	69.81 (64.7–75.5) 2.77	57.39 (53.6–63.8) 1.94	20.59 (18.6–23.1) 1.08
1964–71 ♂	77	206.8 (192.0–221.0) 5.62	104.2 (96.0–112.0) 3.45	71.90 (65.5–76.8) 2.14	59.22 (53.3–64.8) 1.91	21.56 (18.8–24.6) 1.25
Red Wolf ♀	52	220.9 (210.0–245.0) 5.58	115.4 (108.0–130.0) 4.40	75.15 (68.5–80.5) 2.58	66.78 (61.6–74.7) 2.85	25.32 (21.2–29.7) 1.98
Red Wolf ♂	63	232.6 (218.0–261.0) 8.76	121.2 (110.0–138.0) 5.93	78.98 (72.6–86.8) 2.79	69.37 (63.6–75.3) 2.73	26.21 (22.3–32.0) 1.95

	n	6	7	8	9	10
Coyote ♀	26	45.20 (39.3–51.2) 3.36	24.21 (19.8–28.5) 1.77	11.49 (10.0–13.5) 0.97	18.82 (17.3–20.4) 0.83	11.58 (10.5–12.5) 0.61
Coyote ♂	31	46.91 (42.3–51.9) 2.63	25.57 (21.4–28.8) 1.67	11.71 (10.2–14.0) 1.02	19.75 (18.2–21.2) 0.69	11.85 (11.0–13.0) 0.54
2003–04	28	48.58 (41.2–60.8) 4.42	26.64 (22.5–31.6) 1.99	12.38 (9.8–14.0) 1.10	20.76 (18.8–23.4) 1.16	12.39 (11.4–13.6) 0.67
1964–71 ♀	42	47.36 (42.1–56.0) 3.23	26.60 (22.3–30.8) 1.77	12.41 (10.7–15.5) 1.01	20.43 (18.5–23.0) 0.96	12.31 (10.5–13.6) 0.70
1964–71 ♂	77	49.55 (43.5–61.5) 3.59	27.91 (24.3–30.5) 1.44	13.15 (10.8–15.1) 0.97	21.04 (19.2–23.0) 0.85	12.29 (10.3–13.6) 0.64
Red Wolf ♀	52	52.93 (42.7–63.0) 4.20	31.66 (27.3–36.1) 1.72	14.84 (12.0–17.3) 1.02	22.31 (20.0–24.4) 1.08	13.29 (11.7–14.7) 0.72
Red Wolf ♂	63	55.52 (47.2–62.1) 3.73	33.64 (29.1–38.0) 2.24	15.78 (13.3–18.5) 1.26	23.66 (21.4–26.0) 1.00	13.68 (10.6–16.0) 0.82

specimens were mostly close to Coyotes, two fell within the statistical limits of the skulls of Red Wolves collected 1919–1929 in the south-central United States.

One of the new Cooke County skulls also falls well within the statistical limits of that series of Red Wolves; each of its measurements is larger than the minimum found in the latter series. It also resembles the Red Wolf in the non-measurable features discussed by Nowak (1979). Seven of the other new specimens are larger than the minimum of Red Wolves in at least 7 of the 10 measurements. None of the 28 new Cooke County skulls shows any characters suggesting hybridization with *Canis familiaris* (Domestic Dog).

Discussion

The series of inland Texas specimens from 1964–1971, along with chronologically and morphologically similar series from adjacent parts of southern Arkansas and Louisiana, apparently represent a single population of wild *Canis*, predominantly Coyotes but modified through hybridization with Red Wolves (Nowak 1979). The measurements of our new Cooke County specimens correspond closely to those of the older series and suggest continuity with the population represented.

Wolves reportedly still occurred along the Texas side of the Red River in 1940, and two specimens of Red Wolves were taken on the Oklahoma side in 1936 (McCarley 1962, Nowak 1979). A remnant Red Wolf pocket there may have genetically influenced the Coyote population that expanded into north-central and northeast Texas, perhaps in the same manner that the more substantial concentration of Red Wolves surviving in southeast and coastal Texas modified the populations of *Canis* there. In any case, it is remarkable that such influence persists and that some individuals, well inland, retain characters of the Red Wolf.

The above assessment is based on cranial morphology but is supported by supplementary observation of external appearance and body mass, in keeping with criteria previously used to characterize Red Wolves (Adams et al. 2003, Carley 1975, Riley and McBride 1975). Our collection area was centered on a small ranch, whose residents had notified us of the presence there of large, wolf-like *Canis*. Coyotes are common in the area, but were distinguished from the larger *Canis* by our informants.

On 17–20 January 2005, the senior author live-trapped 6 *Canis*, in a 2-km^2 area around the ranch. The animals were taken in modified-steel-foothold traps, held for 1–3 days in pens, anesthetized with Telazol and weighed, measured, photographed, blood-sampled, and released. This research complied where applicable with guidelines of the American Society of Mammalogists (Animal Care and Use Committee 1998). The senior author also examined 1 road-kill from near the ranch, and examined videotape of 3 *Canis* in the field on 2 February 2004 (http:// tinyurl.com/y8elko2).

In the opinion of the senior author and 3 local Coyote hunters, the live-trapped and videotaped *Canis* appear Red Wolf-like, especially in being

larger and darker colored and in having a broader nose than most Coyotes. The Red Wolf had a locally common melanistic phase, and dark coloration in Coyotes has been used in the past as a measure of Red Wolf influence (Nowak 1979). We weighed 11 individuals, including the 6 live-trapped and 5 that were part of the 28 full-grown specimens of which skulls were measured. The mean weight was 14.82 kg (range = 10–22 kg); the largest animal was within the size criteria used to define Red Wolves (Riley and McBride 1975). Young and Jackson (1951) reported mean weight of 84 south Texas Coyotes as 11.64 kg (range = 8–19 kg).

We showed the videotape, without providing date or location, to 3 biologists who work or had worked with the US Fish and Wildlife Service Red Wolf Recovery Program and who were familiar with Coyotes, Red Wolves, Coyote x Red Wolf hybrids, and Gray Wolves. It also was shown to 3 other such individuals who knew where and when the video had been taken. Five of the 6 biologists identified the animals as Red Wolves or Red Wolf x Coyote hybrids. One even suspected that the animals were from the Red Wolf Recovery Program. We also have unsolicited reports, and in some cases photos, of large, wolf-like animals in Orange County in 1986, in Harris County in 1995 and 2002, and in Jefferson, Dallas, Tarrant, Collin, Wood and San Saba counties in subsequent years (Fig. 1). In addition, unpublished genetics findings from our specimens showed that of 42 Cooke County specimens, 2 had mtDNA that was only 2 base pairs different from that of the official Red Wolf matriline (R.K. Wayne and J.P. Pollinger, Department of Ecology and Evolutionary Biology, University of California, Los Angeles, CA, pers. comm.) of Adams et al. (2003); 1 Orange County carcass showed 30% Red Wolf ancestry based on nuclear DNA (L.P. Waits and J.R. Adams, Department of Fish and Wildlife, University of Idaho, College of Natural Resources, Moscow, ID, unpubl. data).

While it is unlikely that distinct wolf populations have maintained reproductive isolation from the Coyote-like canids that have spread across eastern Texas and adjacent states, zones of genetic influence of Red Wolves and Gray Wolves may persist in the region. An investigation of where such pockets exist, and of the mechanisms that have enabled their survival, could be of value in developing measures to conserve groups of remnant and reintroduced Red Wolves proximal to expanding Coyote and hybrid populations. Control of the latter populations, landscape augmentation, and manipulation to reinforce natural behavioral and ecological factors could help to maintain exclusivity of Red Wolf groups. Even large mammalian species, capable of long-distance dispersal and apparently distributed continuously without obvious physical barriers, may be divided into genetically distinctive populations in relatively limited geographical areas, through territorial behavior, local physical obstacles, and differences in habitat and diet (Aspi et al. 2009, Pilot et al. 2006). Measures to aid the Red Wolf may also be applicable to the Gray Wolf and/or Eastern Wolf, which now may be threatened by hybridization with one another and/or with Coyotes in the Great Lakes region (Kyle et al. 2006, Nowak 2009).

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