CHIHUAHUAN RAVEN (*CORVUS CRYPTOLEUCUS*) REPRODUCTIVE SUCCESS AND NEST SPACING IN THE SOUTHERN HIGH PLAINS OF TEXAS

J. PAUL BURTON* AND JAMES M. MUELLER

Department of Biology, Sul Ross State University, Alpine, TX 79832
Present address of JPB: 3414 A Nashville Avenue, Lubbock, TX 79413
Present address of JMM: Department of Animal Sciences, Box T-0070, Tarleton State University, Stephenville, TX 76402
**Correspondent: jpbburton@hotmail.com*

ABSTRACT—We measured reproductive success of 52 Chihuahuan raven (*Corvus cryptoleucus*) nests in the southern High Plains of Texas in 1999. Egg laying was initiated between 12 April and 21 June. We observed 5.2 ± 0.2 eggs (mean ± *SE*) per nest, 3.3 ± 0.3 hatched chicks per nest, and 2.6 ± 0.2 fledged chicks per nest. Incorporating ''days at risk,'' we estimated reproductive success was 36.5 ± 0.5%, and reproductive output was 1.9 fledged chicks per nesting female. Average distance from each nest to its nearest neighbor nest was 851 ± 168 m (minimum = 233 m, maximum = 8,465 m). Nest success was unrelated to nearest neighbor distance or nest height, but was correlated with clutch initiation date. The likelihood of nest failure increased by 0.9% with each passing day.

RESUMEN—Medimos el éxito reproductivo de 52 nidos de cuervos chihuahuenses (*Corvus cryptoleucus*) en las planicies altas sureñas de Texas en 1999. La nidificación se inició entre el 12 de abril y el 21 de junio. Observamos 5.2 huevos ± 0.2 (promedio ± *ES*) por nido, 3.3 ± 0.3 polluelos eclosionados por nido, y 2.6 ± 0.2 polluelos plumados por nido. Incorporando ''días en riesgo,'' estimamos que el éxito reproductivo fue de 36.5 ± 0.5% y el rendimiento reproductivo fue de 1.9 polluelos plumados por hembra empollando. La distancia promedio de cada nido a su más cercano vecino fue de 851 ± 168 m (mínimo = 233 m, máximo = 8,465 m). El éxito de un nido no tuvo relación con la distancia de su vecino o con la altura del nido, pero estuvo correlacionado con la fecha del inicio de la puesta. La probabilidad del fracaso del nido aumentó un 0.9% por cada día que pasaba.

A recent review of the Chihuahuan raven (*Corvus cryptoleucus*) lamented the dearth of research on this conspicuous corvid, which is the subject of few studies (Bednarz and Raitt, 2002). The species breeds throughout most of the arid and semiarid regions of the southwestern United States and northern Mexico (Bednarz and Raitt, 2002). It is more social than the common raven (*C. corax*; Terres, 1991). Flock size increases as nesting wanes, and winter groups can include up to 500 individuals (Bednarz and Raitt, 2002).

Chihuahuan ravens build conspicuous nests in trees and human-made structures (Bent, 1946; Mishaga, 1974). Colonial nesting can occur, perhaps due to a scarcity of suitable nesting sites (Goodwin, 1976). Nesting usually occurs from April to June, and clutch size ranges from 1 to 8 eggs (Bednarz and Raitt, 2002). Hatching is asynchronous (Mishaga, 1974; Haydock and Ligon, 1986). We report on reproductive success and nest spacing of Chihuahuan ravens in an area of western Texas in which they are common.

METHODS—The study was conducted on 24,300 ha of land used for grazing and petroleum production in Andrews County, Texas, 24 km east of Andrews (32°N, 102°W; 914 to 1,036 m elevation). Mean annual precipitation for the study area was 39 cm (National Oceanic and Atmospheric Administration, 1998, 1999*d*). Habitat consisted predominantly of honey mesquite (*Prosopis glandulosa*)-grassland and honey mesquite-sand shinnery oak (*Quercus havardii*) vegetation types (Conner et al., 1974).

We searched for nests from late February through mid August 1999 by driving roads throughout the

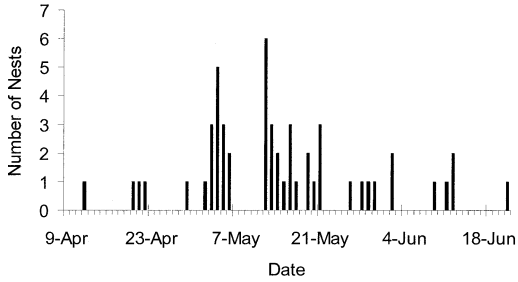

FIG. 1—Clutch initiation dates of 52 Chihuahuan raven (*Corvus cryptoleucus*) nests in Andrews County, Texas, 1999.

study area. We located 62 active nests, of which 52 were monitored until fledging of chicks, failure, or abandonment. Each nest was checked approximately once each week until completion of nesting. Stage of development was noted and numbers of eggs and chicks were recorded. Nest contents were viewed using a mirror mounted on a pole (Parker, 1972). As chicks matured, they were observed and counted from a greater distance through either binoculars or a spotting scope, so that fledglings would not attempt to leave the nest in response to disturbance.

After nesting was completed, all nest sites were revisited for additional data collection. Nest height was measured from the ground to the bottom of each nest to within 1 cm with a wooden pole. Nest sites were georeferenced with a differential GPS unit (GeoExplorer, Trimble Navigation, Sunnyvale, California). Location data were corrected to approximately 1-m accuracy using Pathfinder Office software (version 2.11, Trimble Navigation, Sunnyvale, California). Data were imported into ArcView (version 3.1, Environmental Systems Research Institute, Redlands, California) for calculation of distance from each nest to its nearest neighbor nest.

Nest success, defined as the proportion of nests hatching or fledging at least one chick, was estimated for the incubation and nestling periods using the Mayfield (1961, 1975) exposure-day method. Hatching success (the proportion of eggs that hatched) and fledging success (the proportion of chicks that fledged) within successful nests were estimated by this same method. Reproductive success (the proportion of eggs that resulted in fledglings) was calculated as the product of nest success and combined hatching and fledging success. Standard errors were calculated following Johnson (1979).

Logistic regression was used to test for a linear relationship between the logit of nest success and clutch initiation date, nest height, and nearest neighbor distance (PROC LOGISTIC; SPSS Advanced Statistics, 1994). Significance was assessed using a full-reduced model likelihood ratio chi-square test. A successful nest was defined as fledging at least one chick. Clutch initiation dates were estimated by backdating of chicks based on a 21-d incubation period (Terres, 1991) and a 40-d nestling period (Haydock and Ligon, 1986).

TABLE 1—Reproductive success of Chihuahuan ravens (*Corvus cryptoleucus*) in western Texas, 1999, using the Mayfield (1961, 1975) exposure-day method (n = number of nests for nest success, number of eggs for hatching success, and number of chicks for fledging success).

	n	Mean (%)	*SE*
Nest success	52		
Incubation		76.7	0.4
Nestling		90.3	0.1
Incubation + nestling		69.3	0.5
Hatching success	213	64.6	0.3
Fledging success	164	81.6	0.1
Reproductive success		36.5	0.5

RESULTS—Egg laying was initiated at individual nests between 12 April and 21 June 1999, with 77% of clutches (n = 52) initiated in May (Fig. 1). We observed 5.2 ± 0.2 eggs (mean ± *SE*) per nest, 3.3 ± 0.3 hatched chicks per nest, and 2.6 ± 0.2 fledged chicks per nest. Eight nests failed during incubation, and 4 nests failed during the nestling period. Daily survival rates of nests were 0.987 during the incubation period and 0.997 during the nestling period. Overall nest success was 69.3 ± 0.5% (Table 1). Forty-nine of 213 eggs laid in the 40 successful nests did not hatch. Twenty-nine of 164 nestlings disappeared from successful nests during the nestling period due to unknown causes. Combined hatching and fledging success within successful nests was 52.7 ± 0.3%. Finally, reproductive success was 36.5 ± 0.5%. Assuming one clutch per female and calculating reproductive output as the product of fecundity and reproductive success, we estimated a reproductive output of 1.9 fledged chicks per nesting female.

Mean distance from each nest to its nearest neighbor nest was 851 ± 168 m (minimum = 233 m, maximum = 8,465 m; Fig. 2). Mean nest height was 2.45 ± 0.73 m, and 85% of nests were in honey mesquite, with the remaining 15% in other woody species. The few nests observed in human-made structures were not monitored due to the probability of human de-

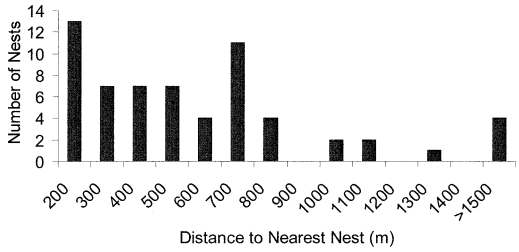

FIG. 2—Frequency of Chihuahuan raven (*Corvus cryptoleucus*) nests (n = 62) having a nearest neighbor nest located within each 100-m grouping, Andrews County, Texas, 1999.

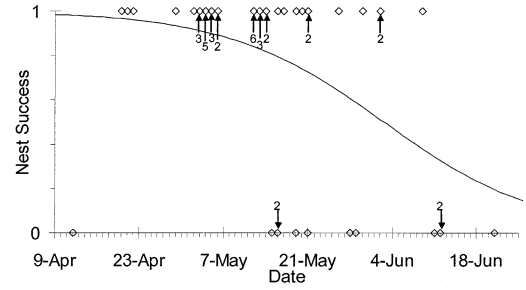

FIG. 3—Relation between Chihuahuan raven (*Corvus cryptoleucus*) nest success (n = 52) and date of initiation in Andrews County, Texas, 1999. The probability of nest success, represented by the line, decreased over the course of the nesting season (P = 0.002). The equation depicted by the line is $y = e^{(11.842 - 0.077x)}/(1 + e^{(11.842 - 0.077x)})$. Diamonds denote individual nest initiation dates. Arrows and associated numbers denote the number of overlapping values at points.

struction by ranch and oilfield personnel. Nest success was unrelated to nearest neighbor distance or nest height, but was correlated with clutch initiation date (χ^2_1 = 9.5, P = 0.002). The likelihood of nest failure increased by 0.9% with each passing day (Fig. 3).

Ants, probably *Forelius foetidus,* were observed and photographed attacking a recently hatched Chihuahuan raven on 18 June 1999. None of the other 5 eggs in this nest had hatched. When revisited 1 week later, the nest was found abandoned and empty of young and eggs. Following the bait-cup technique of Mueller et al. (1999), 486 *F. foetidus* were collected in 30 min in the nest 2 mo later. The general morphology of this species matched the ants in the photograph, but key taxonomic characters could not be seen.

DISCUSSION—Our estimates of reproductive parameters were similar to those summarized by Bednarz and Raitt (2002:13), with the exception that nest success reported by Bednarz et al. (1990) ranged from 31 to 48%, versus 69% in our study. The difference between our observed reproductive output of 2.6 fledged chicks per nest and our estimate of 1.9 fledged chicks per female is the estimated bias that results if exposure days are not included in the analysis (Mayfield, 1961). Neither value incorporated an estimate of renesting attempts; in fact, we were unable to determine if renesting was attempted after nest failure because the ravens were not marked. While we suspect that some renesting occurred, any subsequent nests probably contributed little to overall reproduction in this population because of the combination of high nest success (69%) and the lower success of late nests.

Hot summer temperatures probably influenced the increased rate of nest failure over time (Fig. 3). The average maximum temperature during this study was 31.1°C in May, 33.1°C in June, and 35.0°C in July (National Oceanic and Atmospheric Administration, 1999*a,* 1999*b,* 1999*c*). Ten of the 12 nest failures occurred in June or July. The lack of shade in Chihuahuan raven nests and the high summer temperatures might limit the success of late nests due to hyperthermia.

Only 53% of eggs in successful nests resulted in fledged chicks. This brood reduction might have been due to egg infertility or destruction, starvation of smaller, later hatched nestlings, or consumption or removal by parents of weak or defective hatchlings (Goodwin, 1976). Because chicks in smaller broods might have an increased likelihood of survival (Mishaga, 1974; Haydock and Ligon, 1986), brood reduction might be a factor contributing to the relatively high rate of nest survival during the nestling period.

The nearest Chihuahuan raven nests were >200 m apart (Fig. 2). However, the distribution of nests was clustered, with vast areas of the study site devoid of nests. Optimal nest spacing in this species might be the result of tradeoffs between intraspecific behaviors that are beneficial and others that are detrimental. First, clustering of nests might result from a scarcity or patchiness of nest-site availability

and might enable greater use of limited, clustered nest sites (Goodwin, 1976). Second, close nest spacing facilitates communal mobbing of predators, a common practice among corvids (Kilham, 1989). As many as 7 Chihuahuan ravens would circle and call overhead when a nest was being examined in this study. Finally, territoriality might limit the closeness of nests. All corvids that have been studied defend at least a small nest territory (Goodwin, 1976). Ensuring brood parentage might be one reason for guarding such a territory (Goodwin, 1976).

Future work should explore the effect of habitat patterns on *C. cryptoleucus* nest spacing, the extent and nature of predation on *C. cryptoleucus* nests, and potential causes for the observed correlation between clutch initiation date and nest success.

We thank the following individuals for assistance and support: M. Powell, K. Sternes, A. Knight, J. Richerson, K. Urbanczyk, A. Pachlhofer, D. Wood, J. Trager (identification of ant specimens), K. Craig, J. Karges, L. Loomis, L. Harveson, P. Harveson, W. Conway, M. Robinson, E. Wilson, P. Spooner, E. Kelchlin, K. Mcintyre, J. Evans, M. Barnett, M. Christenson, D. Christenson, J. Burton family, and J. Baxter and family. J. Tafoya provided the Spanish translation of the abstract, and 2 anonymous reviewers provided helpful comments.

Literature Cited

Bednarz, J. C., T. Hayden, and T. Fischer. 1990. The raptor and raven community of the Los Medaños area in southeastern New Mexico: a unique and significant resource. In: R. S. Mitchell, C. J. Sheviak, and D. J. Leopold, editors. Ecosystem management: rare species and significant habitats. New York State Museum Bulletin 471. Pages 92–101.

Bednarz, J. C., and R. J. Raitt. 2002. Chihuahuan raven (*Corvus cryptoleucus*). In: A. Poole and F. Gill, editors. The birds of North America, number 606. Birds of North America, Inc., Philadelphia, Pennsylvania.

Bent, A. C. 1946. Life histories of North American jays, crows, and titmice. United States National Museum Bulletin 191.

Conner, N. R., H. W. Hyde, and H. R. Stoner. 1974. Soil survey of Andrews County, Texas. United States Department of Agriculture, Soil Conservation Service, Washington, D.C.

Goodwin, D. 1976. Crows of the world. Cornell University Press, Ithaca, New York.

Haydock, J., and J. D. Ligon. 1986. Brood reduction in the Chihuahuan raven: an experimental study. Ecology 67:1194–1205.

Johnson, D. H. 1979. Estimating nest success: the Mayfield method and an alternative. Auk 96:651–661.

Kilham, L. 1989. The American crow and the common raven. Texas A&M University Press, College Station.

Mayfield, H. 1961. Nesting success calculated from exposure. Wilson Bulletin 73:255–261.

Mayfield, H. 1975. Suggestions for calculating nest success. Wilson Bulletin 87:456–466.

Mishaga, R. 1974. Notes on asynchronous hatching and nestling mortality in white-necked ravens. Wilson Bulletin 86:174–177.

Mueller, J. M., C. B. Dabbert, S. Demarais, and A. R. Forbes. 1999. Northern bobwhite mortality caused by red imported fire ants. Journal of Wildlife Management 63:1291–1298.

National Oceanic and Atmospheric Administration. 1998. Climatological data annual summary: Texas. National Climatic Data Center, Asheville, North Carolina.

National Oceanic and Atmospheric Administration. 1999*a*. Climatological data: Texas: May 1999. National Climatic Data Center, Asheville, North Carolina.

National Oceanic and Atmospheric Administration. 1999*b*. Climatological data: Texas: June 1999. National Climatic Data Center, Asheville, North Carolina.

National Oceanic and Atmospheric Administration. 1999*c*. Climatological data: Texas: July 1999. National Climatic Data Center, Asheville, North Carolina.

National Oceanic and Atmospheric Administration. 1999*d*. Climatological data annual summary: Texas. National Climatic Data Center, Asheville, North Carolina.

Parker, J. W. 1972. A mirror pole device for examining high nests. Bird-Banding 43:216–218.

SPSS Advanced Statistics. 1994. Version 6.1. SPSS, Inc., Chicago, Illinois.

Terres, J. 1991. The Audubon Society encyclopedia of North American birds. Wings Books, Avenel, New Jersey.

Submitted 23 July 2004. Accepted 31 May 2005.
Associate Editor was Timothy Brush.