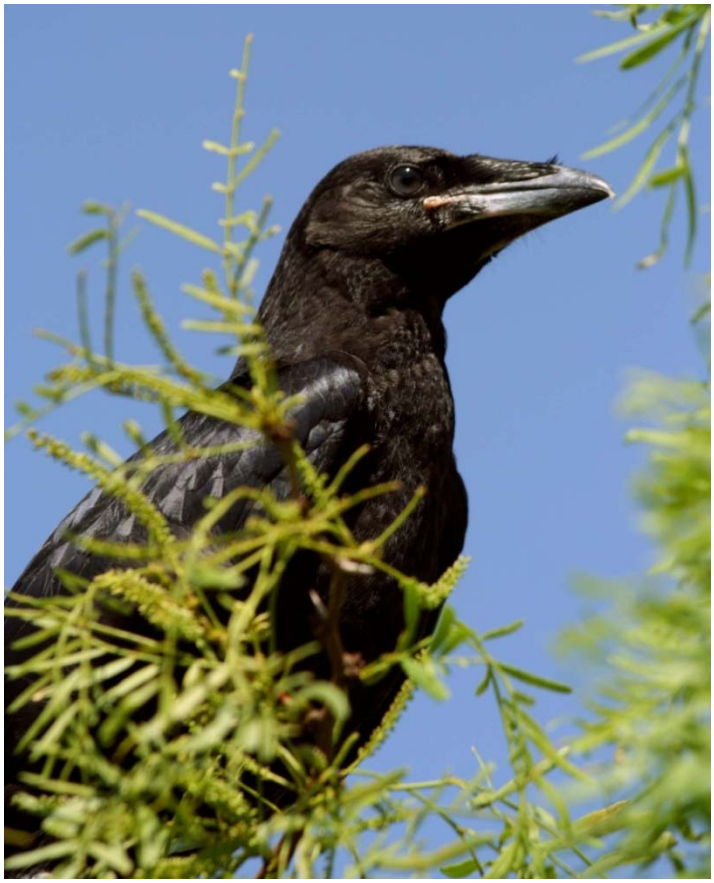
BIOMONITORING OF CHIHUAHUAN RAVENS: PREVALENCE OF ENVIRONMENTAL CONTAMINANTS, AVIAN INFLUENZA VIRUS, AND WEST NILE VIRUS



Submitted by
Marco Restani, Ph.D.
Department of Biological Sciences
St. Cloud State University
St. Cloud, MN 56301

4 March 2008

Submitted to
Center of Excellence for Hazardous Materials Management
505 North Main Street
Carlsbad, NM 88220

BACKGROUND

Birds are valuable indicators of environmental contamination (Beyer et al. 1996). Upper trophic level species, such as raptors and colonial waterbirds, bioaccumulate contaminants contained within terrestrial and aquatic prey and thus provide early warning of harmful environmental levels of heavy metals, organochlorines, polychlorinated biphenyls (PCBs), and organophosphates. These contaminants exhibit both sublethal and lethal effects, ranging from behavioral aberrations to widespread wildlife population declines. These compounds also pose a threat to human health.

The Center of Excellence for Hazardous Materials Management (CEHMM) in Carlsbad, New Mexico established a Biomonitoring Project in the border region of New Mexico, Texas, and Mexico in 2007. CEHMM proposed the Chihuahuan raven (*Corvus cryptoleucus*), a predatory/scavenger species that bioaccumulates toxins and pathogens, as the model organism to monitor environmental contaminants. In addition to environmental contaminants, CEHMM proposed ravens to assess prevalence of West Nile Virus and Avian Influenza. Ravens were an appropriate choice as the model organism because they 1) are a top-of-the-food-chain omnivore, thus their foraging samples a large ecological range of environmentally sensitive prey, from insects to small mammals to birds; 2) are abundant throughout different habitat types within the region; and 3) are largely non-migratory, which reduces the confounding effects of point exposure outside the U.S. and subsequent data interpretation (Bednarz and Raitt 2002).

The CEHMM Biomonitoring Project is intended to collect baseline information for a period of three years, beginning in 2007. Extending the study over multiple years is necessary to establish mean, and associated variation, levels of contaminants and pathogens, and to obtain the statistical power to detect trends and distributions over the large study region. The project includes several important collaborators and cooperators: the Los Alamos National Laboratory, the New Mexico Department of Agriculture's Veterinary Diagnostic Services, and the California Animal Health and Food Safety Laboratory (University of California-Davis). The New Mexico Game and Fish Department, Texas Parks and Wildlife, and the U.S.G.S. Bird Banding Laboratory (Patuxent Wildlife Research Center) permitted field activities and sample collections. The project is being conducted through the Department of Biological Sciences, St. Cloud State University (SCSU).

The goal of this study, based on CEHMM Request For Proposals (RFP) # 002-2007 (as amended), was to collect baseline data on prevalence of environmental contaminants, West Nile Virus, and Avian Influenza. Specific contaminants surveyed were heavy metals (lead, mercury, and selenium), organophosphates (indicated by cholinesterase activity), and organochlorines (PCBs). Specific RFP requirements/objectives included:

- locate and sample raven nestlings from not less than 15 nests
- sample ravens for contaminants and viruses
- band ravens and submit banding reports
- prepare scientific publications.

STUDY AREA and METHODS

The study area extended from Hobbs, New Mexico through the greater Carlsbad area (Los Medanos), south to Dell City, Texas, and west to El Paso, Texas (Fig. 1). My assistants and I searched suitable raven habitat for stick nests beginning in April (Fuller and Mosher 1987). Nests were located from a distance with a spotting scope and locations (UTM, NAD 27) were plotted with a handheld Global Positioning System. We did not search for nests at midday, when temperatures commonly exceeded 35°C, or during inclement weather, so as to reduce egg and nestling exposure (Grier and Fyfe 1987). Nest chronology was established by use of a mirror pole. We returned to nests once after eggs hatched and young were 3-5 weeks old to collect samples (blood, oral-pharyngeal and cloacal swabs – see below) for analyses and to band young. Young ravens were returned to nests following sampling, which averaged 30 minutes and typically took place from late June to early July.

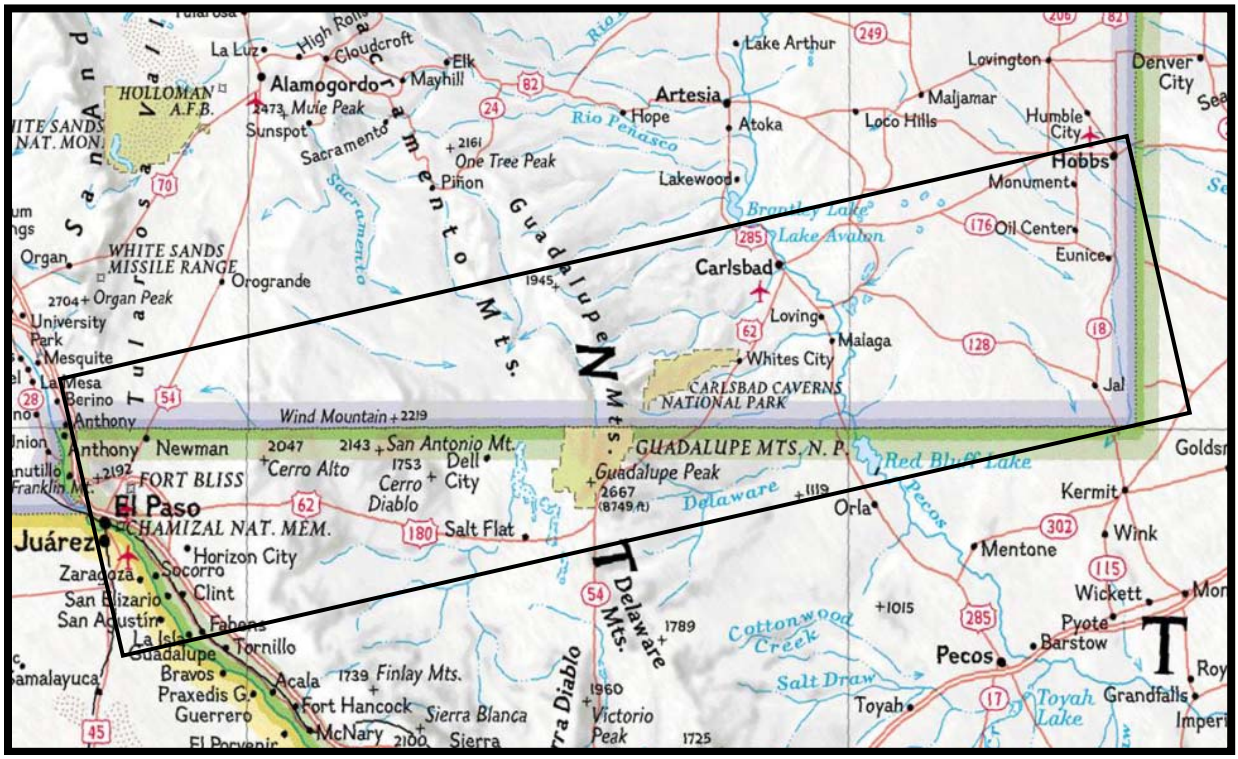


Figure 1. Approximate location of the study area in southern New Mexico and western Texas, 2007.

We used a remotely-triggered net launcher (Coda Enterprises, Inc., Fig. 2) to capture free-flying ravens attracted to garbage bait at municipal landfills (Caffrey 2001). We collected samples (blood, oral-pharyngeal and cloacal swabs) and banded captured ravens, which were released at the site of capture within one hour. We captured ravens in November and December.

Figure 2. The capture of 15 Chihuahuan ravens at the Eunice, New Mexico landfill, 2007. Arrow indicates the location of the net launcher.

We used a heparinized 25-gauge needle and 6 cc syringe to collect approximately 3 cc of blood from the brachial vein of nestling and free-flying ravens following standard sterile field procedures (Fig. 3; See Harmata and Restani 1996, Miller et al. 1998). Oral-pharyngeal (Avian Influenza) and cloacal (West Nile Virus) swabs were also collected following procedures established by the U.S.G.S. National Wildlife Health Laboratory (*http://www.nwhc.usgs.gov/ disease _ information/avian_influenza/2007%20NWHC%20Protocol%20Combined%20OP%20 &% 20CL%20Swabs%20v5-29-07.pdf*). To ensure the well-being of field biologists, we followed recommendations for human health safety practices established by the U.S.G.S. Bird Banding Laboratory in conjunction with the Centers for Disease Control and Prevention (*http://www.doi.gov/issues/appendixOHSguidanceforAvian%20Influenza12-18.pdf* and *http://www.nwhc.usgs.gov/publications/wildlife_health_bulletins/WHB_05_03.jsp*).

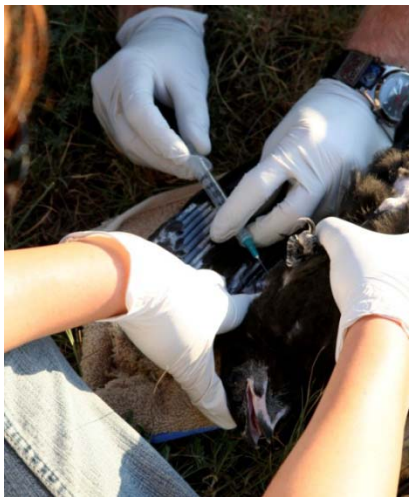


Figure 3. Collecting blood from Chihuahuan ravens in southeastern New Mexico, 2007.

Laboratory analyses of environmental contaminants (heavy metals and PCBs) and cholinesterase activity (to assess organophosphate and carbamate exposure) were conducted in the California Animal Health and Food Safety Laboratory by Dr. Robert Poppenga (University of California-Davis). Metals in blood samples were analyzed after the samples were prepared by Nitric Acid digestion in open vessel heating blocks. After digestion, samples were diluted into another dilute acid solution and analyzed by Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES).

PCBs in blood samples were analyzed via Arcolor analyses. Arcolors were common commercial mixtures of PCB congeners, and were an appropriate metric for this study, which was in the preliminary stages of risk assessment (Bernhard and Petron 2001). PCBs were first extracted into an ethanol:ethyl acetate solvent mixture, and sample extracts were then run through a Florisil column. PCBs were identified according to Aroclor mixture. Identification was made by comparing chromatograms of sample extracts with the chromatograms produced by standards. Analyses were performed utilizing Gas Chromatography coupled with a Mass Selective Detector.

Cholinesterase in blood serum was analyzed by the classic Ellman method, which is an enzyme kinetic, spectrophotometric method. Cholinesterase enzyme present in the sample hydrolyzed acetylthiocholine to thiocholine. Thiocholine reacted with 5,5′-dithiobis-2-nitrobenzoic acid (DTNB) to produce a yellow color. The rate of color production was measured at 405 nm using a Microplate Reader. Activity of the cholinesterase was expressed in micromoles of acetylthiocholine hydrolyzed per mL (blood) of sample per minute.

Oral-pharyngeal swab samples were collected to monitor Avian Influenza (H5 and H7 subtypes) in collaboration with Dr. Flint Taylor of the New Mexico Department of Agriculture's Veterinary Diagnostic Services (Albuquerque). Because of the very low probability of detecting Avian Influenza, samples were pooled into groups of five for analyses. A PCR assay was run to detect either H5 or H7 subtypes within pooled samples.

Cloacal swabs (PCR test) and blood samples (for ELISA antibody tests) were sent to Dr. Jeanne Fair, Los Alamos National Laboratories, for West Nile Virus analyses. Positive samples were verified with a crow (*C. brachyrhynchos*) from a West Nile Virus infection study at Colorado State University.

RESULTS and DISCUSSION

In 2007, locating and monitoring nesting Chihuahuan ravens occurred during three field visits: nest surveys from 3-8 April and 21-31 May, and nestling banding and sampling from 24 June - 9 July. Nesting chronology in southeastern New Mexico was similar to that reported by D'Auria (2002) in western New Mexico. We located 75 nests within the study area and, of these, 47 nests were known to produce young. We sampled and banded 81 young from 23 nests (Appendix, Table 1). Distribution of nesting ravens was clumped in the study area (Fig. 4), with nesting density highest in the eastern portion from Halfway, New Mexico east to the Texas line. An unusually high nesting density was found northeast of Maljamar along Highway 249 near the western edge of the llano Estacado. The area surrounding Carlsbad, New Mexico also supported nesting ravens. Very few ravens were found in the higher elevation areas, from Whites City, New Mexico southwest to west of the Guadalupe Mountains. A few nests were located along Highway 62/180 near Cornudas, Texas but availability of public land in this area limited nest survey opportunities.

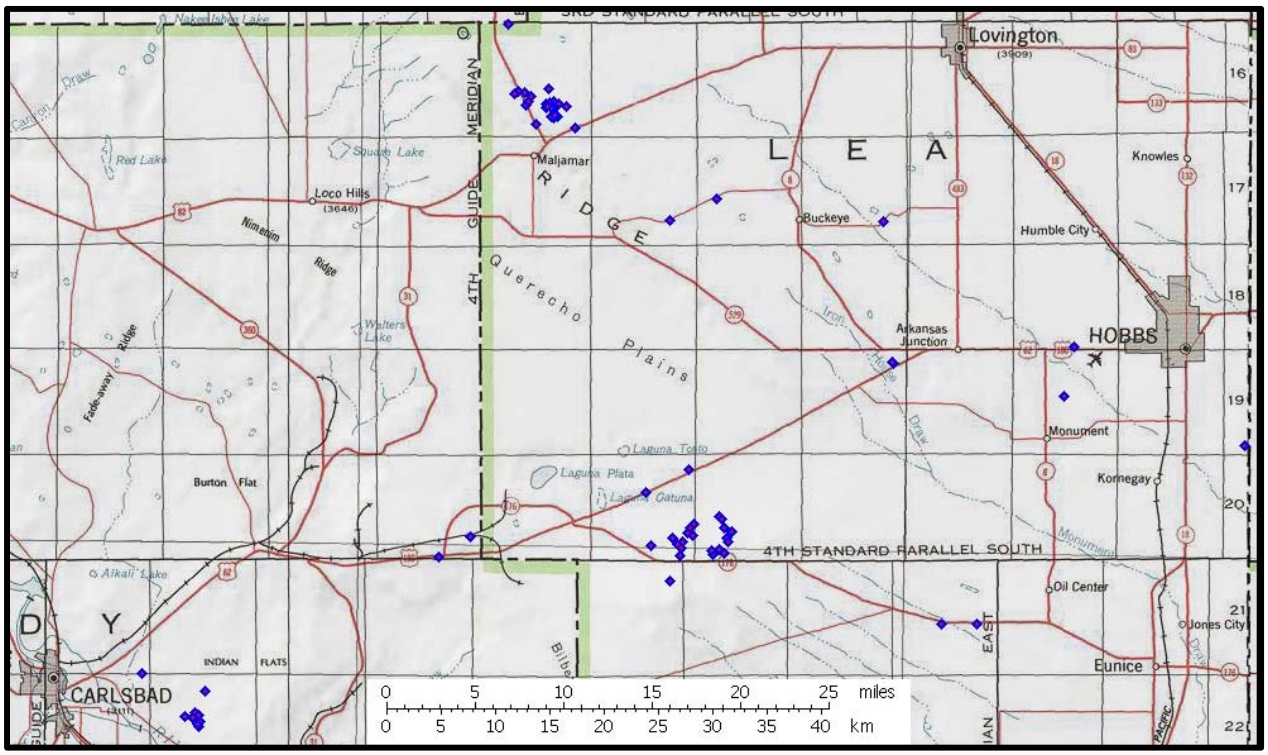


Figure 4. Clumped distribution of Chihuahuan raven nests in southern New Mexico, 2007.

In 2007, we captured and banded free-flying ravens at the Eunice, New Mexico landfill from 7-11 November and 26-30 December. Of the 25 free-flying ravens captured, we sampled 21 for environmental contaminants and West Nile Virus (Fig. 5). We also investigated the Dell City, Texas landfill for trapping opportunities in November, however a local sanitation worker we met at the site reported that ravens did not congregate at the landfill during the non-breeding season. Few ravens used the Carlsbad, New Mexico landfill in November and December.

Figure 5. Banding and sampling a Chihuahuan raven at the Eunice, NM landfill, 2007.

All ravens sampled for heavy metals had detectable levels of selenium (Appendix, Table 2). Nestling ravens (n = 13) had arithmetic mean ± SE ppm levels representative of background exposure (0.31± 02). Adult ravens (n = 15) had significantly (t = 8.14, df = 26, $p < 0.001$) higher mean levels (0.67 ± 0.04), but which were nonetheless relatively low and probably not of concern. Source of selenium found in raven blood remained unknown but probably included the metal dissolving naturally from local soils. Other common sources of selenium in the U.S. that were not observed on the study area were sewage sludge, fly ash, and emissions from smelters. Egg and liver tissue concentrations of selenium were the best predictors of harm to birds (Heinz 1996), but given the low levels currently observed in Chihuahuan ravens, destructive sampling of ravens to analyze eggs or livers is unwarranted.

Three adult ravens had lead levels ≥ 0.20 ppm, which may have indicated recent exposure to lead. However, these levels also were still quite low given toxic levels reported in the literature (Franson 1996). Sources of lead on the study area remained unknown. Recent scientific investigations have focused on the role of lead fragments from bullets and shot in environmental contamination (Fisher et al. 2006). The possibility existed that ravens may have ingested lead by scavenging small game wounded or killed during sport hunting but which went unrecovered in the field. All levels of mercury were low. In general, levels of the three heavy metals analyzed in this study from ravens sampled during 2007 were low or went undetected.

PCBs within Arcolor mixtures were not detected in either nestling or adult ravens (Appendix, Table 3). It will be difficult to ascertain the exact relevance of cholinesterase levels in Chihuahuan ravens in southeastern New Mexico because standards for the species and area have not been established. A laboratory study run in conjunction with this field study would provide interpretative power, but given that cholinesterase activity was generally low (Appendix, Table 4) compared to published values for other species, exposure to organophosphates and carbamates on the study area is low and not of immediate concern.

Neither H5 and H7 subtypes of Avian Influenza (Appendix, Table 5) nor West Nile Virus (Appendix, Table 6) were detected in nestling or adult ravens. The latter result was encouraging because 20 humans, three horses, and numerous mosquitoes tested positive for West Nile Virus Eddy, Chaves, and Dona counties in 2007 as part of New Mexico's surveillance program (http://www.health.state.nm.us/epi/wnv.html).

Field activities for 2008 will include 1) sampling of nestling and free-flying ravens in extreme western Texas and 2) repeated sampling in some areas of New Mexico. Depending on the timing of budget approval, field activities will commence in late March. Now that some baseline information is available (e.g., detectable levels of selenium in all ravens tested), it may be prudent to consider expanding the study to record detailed ecological data on raven habitat use.

ACKNOWLEDGMENTS

D. Lynn at CEHMM provided the impetus to develop this study, and without his foresight and effort none of this work would have been possible. M. Davies, G. Doney, J. Frye, E. Lynn, and J. O'Connell provided dedicated field assistance. T. Allen and S. Bird supported our work and offered useful background and land access information for New Mexico. F. Armstrong and R. Rakes helped us in Texas. K. Etheridgehill, J. Fair, G. Jillson, R. Poppenga, and F. Taylor facilitated laboratory analyses and provided helpful data interpretation. K. Mower supported our Avian Influenza sampling in New Mexico. G. Brown (CEHMM), L. Donnay (SCSU), and M. McKenzie (SCSU) kindly administered the contract. The SCSU Institutional Animal Care and Use Committee approved field procedures through permits to M. Restani (Federal: # 22513, New Mexico: #3358 Texas: #SPR-0707-1397).

LITERATURE CITED

Bednarz, J. C., and R. J. Raitt. 2002. Chihuahuan raven (*Corvus cryptoleucus*). *In* Birds of North America, No. 606 (A. Poole and F. Gill, Eds.). The Birds of North America, Inc., Philadelphia, PA>

Bernhard, T., and S. Petron. 2001. Analysis of PCB congeners vs. Arcolors in ecological risk assessment. Issue paper.

Beyer, W. N., G. H. Heinz, and A. W. Redmon-Norwood. 1996. Environmental contaminants in wildlife: interpreting tissue concentrations. Society of Environmental Toxicology and Chemistry, Clemson University, Clemson, South Carolina.

Caffrey, C. 2001. Catching crows. North American Bird Bander 26: 137-145.

D'Auria, D. E. 2002. The breeding biology and social system of the Chihuahuan raven, *Corvus cryptoleucus*. M.S. Thesis, New Mexico State University, Las Cruces.

Fisher, I. J., D. J. Pain, and V. G. Thomas. 2006. A review of lead poisoning from ammunition sources in terrestrial birds. Biological Conservation 131:421-432.

Franson, J. C. 1996. Interpretation of tissue lead residues in birds other than waterfowl. Pages 265-279 *in* Beyer, W. N., G. H. Heinz, and A. W. Redmon-Norwood (Eds.), Environmental contaminants in wildlife: interpreting tissue concentrations. Society of Environmental Toxicology and Chemistry, Clemson University, Clemson, South Carolina.

Fuller, M. R., and J. A. Mosher. 1987. Raptor survey techniques. Pages 37-66 in B. A. Giron Pendleton. B. A. Millsap, K. W. Cline, and D. M. Bird, Editors. Raptor Management Techniques Manual. National Wildlife Federation, Washington, D.C.

Grier, J. W., and R. W. Fyfe. 1987. Preventing research and management disturbance. Pages 173-182 *in* B. A. Giron Pendleton. B. A. Millsap, K. W. Cline, and D. M. Bird, Editors. Raptor Management Techniques Manual. National Wildlife Federation, Washington, D.C.

Harmata, A. R., and M. Restani. 1995. Environmental contaminants and cholinesterase in blood of vernal migrant bald and golden eagles in Montana. Intermountain Journal of Sciences 1:1-15.

Heinz, G. H. 1996. Selenium in birds. 1996. Page 447-458 *in* Beyer, W. N., G. H. Heinz, and A. W. Redmon-Norwood (Eds.), Environmental contaminants in wildlife: interpreting tissue concentrations. Society of Environmental Toxicology and Chemistry, Clemson University, Clemson, South Carolina.

Miller, M. J. R., M. Restani, A. R. Harmata, G. R. Bortolotti, and M. E. Wayland. 1998. A comparison of blood lead levels in bald eagles from two regions of the North American Great Plains. Journal of Wildlife Diseases 34:704-714.

Appendix
(Tables 1-6)

Table 1. Summary of banding data of Chihuahuan ravens in New Mexico, 2007.

Band number	Location	Sampling date	Zone	UTM E	UTM N
1045-79001	Nest 47	31-May-07	13 S	628377	3630333
1045-79002	Nest 47	31-May-07	13 S	628377	3630333
1045-79003	Nest 47	31-May-07	13 S	628377	3630333
1045-79004	Nest 47	31-May-07	13 S	628377	3630333
1045-79005	Nest 47	31-May-07	13 S	628377	3630333
1045-79006	Nest 47	31-May-07	13 S	628377	3630333
1045-79007	Nest 8	26-Jun-07	13 S	607642	3599390
1045-79008	Nest 8	26-Jun-07	13 S	607642	3599390
1045-79009	Nest 8	26-Jun-07	13 S	607642	3599390
1045-79010	Nest 8	26-Jun-07	13 S	607642	3599390
1045-79011	Nest 8	26-Jun-07	13 S	607642	3599390
1045-79012	Nest 13	26-Jun-07	13 S	634101	3601172
1045-79013	Nest 13	26-Jun-07	13 S	634101	3601172
1045-79014	Nest 13	26-Jun-07	13 S	634101	3601172
1045-79015	Nest 13	26-Jun-07	13 S	634101	3601172
1045-79016	Nest 13	26-Jun-07	13 S	634101	3601172
1045-79017	Nest 5	26-Jun-07	13 S	633962	3601455
1045-79018	Nest 5	26-Jun-07	13 S	633962	3601455
1045-79019	Nest 5	26-Jun-07	13 S	633962	3601455
1045-79020	Nest 47	26-Jun-07	13 S	633962	3601455
1045-79021	Nest 16	27-Jun-07	13 S	633817	3600100
1045-79022	Nest 16	27-Jun-07	13 S	633817	3600100
1045-79023	Nest 16	27-Jun-07	13 S	633817	3600100
1045-79024	Nest 16	27-Jun-07	13 S	633817	3600100
1045-79025	Nest 10	27-Jun-07	13 S	628880	3597491
1045-79026	Nest 10	27-Jun-07	13 S	628880	3597491
1045-79027	Nest 10	27-Jun-07	13 S	628880	3597491
1045-79028	Nest 9	27-Jun-07	13 S	630378	3601918
1045-79029	Nest 9	27-Jun-07	13 S	630378	3601918
1045-79030	Nest 9	27-Jun-07	13 S	630378	3601918
1045-79031	Nest 30	29-Jun-07	13 S	615668	3641509
1045-79032	Nest 30	29-Jun-07	13 S	615668	3641509
1045-79033	Nest 32	29-Jun-07	13 S	614514	3641957
1045-79034	Nest 32	29-Jun-07	13 S	614514	3641957
1045-79035	Nest 32	29-Jun-07	13 S	614514	3641957
1045-79036	Nest 32	29-Jun-07	13 S	614514	3641957
1045-79037	Nest 34	29-Jun-07	13 S	614135	3641817
1045-79038	Nest 34	29-Jun-07	13 S	614135	3641817
1045-79039	Nest 55	30-Jun-07	13 S	612827	3648400
1045-79040	Nest 55	30-Jun-07	13 S	612827	3648400
1045-79041	Nest 55	30-Jun-07	13 S	612827	3648400
1045-79042	Nest 35	30-Jun-07	13 S	617253	3642221
1045-79043	Nest 35	30-Jun-07	13 S	617253	3642221
1045-79044	Nest 35	30-Jun-07	13 S	617253	3642221

1045-79045	Nest 35	30-Jun-07	13 S	617253	3642221
1045-79046	Nest 35	30-Jun-07	13 S	617253	3642221
1045-79047	Nest 44	01-Jul-07	13 S	618868	3640611
1045-79048	Nest 44	01-Jul-07	13 S	618868	3640611
1045-79049	Nest 58	01-Jul-07	13 S	617931	3640637
1045-79050	Nest 16	27-Jun-07	13 S	633817	3600100
1045-79051	Nest 32	29-Jun-07	13 S	614514	3641957
1045-79052	Nest 55	30-Jun-07	13 S	612827	3648400
1045-79053	Nest 44	01-Jul-07	13 S	618868	3640611
1045-79054	Nest 58	01-Jul-07	13 S	617931	3640637
1045-79055	Nest 37	01-Jul-07	13 S	617931	3640637
1045-79056	Nest 36	01-Jul-07	13 S	617737	3641166
1045-79057	Nest 20	02-Jul-07	13 S	629933	3601037
1045-79058	Nest 22	02-Jul-07	13 S	629011	3601367
1045-79059	Nest 23	02-Jul-07	13 S	627066	3600657
1045-79060	Nest 61	04-Jul-07	13 S	648988	3617613
1045-79061	Nest 64	04-Jul-07	13 S	664622	3614918
1045-79062	Nest 67	06-Jul-07	13 S	657028	3593932
1045-79063	Eunice, NM landfill	09-Nov-07	13 S	681024	3589533
1045-79064	Eunice, NM landfill	09-Nov-07	13 S	681024	3589533
1045-79065	Eunice, NM landfill	10-Nov-07	13 S	681024	3589533
1045-79066	Eunice, NM landfill	10-Nov-07	13 S	681024	3589533
1045-79067	Eunice, NM landfill	10-Nov-07	13 S	681024	3589533
1045-79068	Eunice, NM landfill	10-Nov-07	13 S	681024	3589533
1045-79069	Eunice, NM landfill	10-Nov-07	13 S	681024	3589533
1045-79070	Eunice, NM landfill	10-Nov-07	13 S	681024	3589533
1045-79071	Nest 37	01-Jul-07	13 S	617931	3640637
1045-79072	Nest 37	01-Jul-07	13 S	617931	3640637
1045-79073	Nest 36	01-Jul-07	13 S	617737	3641166
1045-79074	Nest 36	01-Jul-07	13 S	617737	3641166
1045-79075	Nest 36	01-Jul-07	13 S	617737	3641166
1045-79076	Nest 20	02-Jul-07	13 S	629933	3601037
1045-79077	Nest 20	02-Jul-07	13 S	629933	3601037
1045-79078	Nest 22	02-Jul-07	13 S	629011	3601367
1045-79079	Nest 22	02-Jul-07	13 S	629011	3601367
1045-79080	Nest 23	02-Jul-07	13 S	627066	3600657
1045-79081	Nest 23	02-Jul-07	13 S	627066	3600657
1045-79082	Nest 61	04-Jul-07	13 S	648988	3617613
1045-79083	Nest 61	04-Jul-07	13 S	648988	3617613
1045-79084	Nest 64	04-Jul-07	13 S	664622	3614918
1045-79085	Nest 64	04-Jul-07	13 S	664622	3614918
1045-79086	Nest 67	06-Jul-07	13 S	657028	3593932
1045-79087	Nest 67	06-Jul-07	13 S	657028	3593932
1045-79088	Nest 68	06-Jul-07	13 S	653838	3593864
1045-79089	Eunice, NM landfill	27-Dec-07	13 S	681024	3589533
1045-79090	Eunice, NM landfill	27-Dec-07	13 S	681024	3589533
1045-79091	Eunice, NM landfill	27-Dec-07	13 S	681024	3589533
1045-79092	Eunice, NM landfill	27-Dec-07	13 S	681024	3589533

1045-79093	Eunice, NM landfill	27-Dec-07	13 S	681024	3589533
1045-79094	Eunice, NM landfill	27-Dec-07	13 S	681024	3589533
1045-79095	Eunice, NM landfill	27-Dec-07	13 S	681024	3589533
1045-79096	Eunice, NM landfill	27-Dec-07	13 S	681024	3589533
1045-79097	Eunice, NM landfill	27-Dec-07	13 S	681024	3589533
1045-79098	Eunice, NM landfill	27-Dec-07	13 S	681024	3589533
1045-79099	Eunice, NM landfill	27-Dec-07	13 S	681024	3589533
1045-79100	Eunice, NM landfill	27-Dec-07	13 S	681024	3589533
1045-79101	Eunice, NM landfill	27-Dec-07	13 S	681024	3589533
1045-79102	Eunice, NM landfill	28-Dec-07	13 S	681024	3589533
1045-79103	Eunice, NM landfill	28-Dec-07	13 S	681024	3589533
1045-79104	Eunice, NM landfill	28-Dec-07	13 S	681024	3589533
1045-79110	Eunice, NM landfill	27-Dec-07	13 S	681024	3589533
wpt.80 #3	Nest 35	30-Jun-07	13 S	617253	3642221

Table 2. Prevalence (ppm) of heavy metals in Chihuahuan ravens in New Mexico, 2007.

Band Number	Sampling Location	Age	Lead	Mercury	Selenium
1045-79050	Nest 16	Nestling	ND[1]	ND	0.39
1045-79051	Nest 32	Nestling	ND	ND	0.26
1045-79052	Nest 55	Nestling	ND	ND	0.27
1045-79053	Nest 44	Nestling	ND	ND	0.27
1045-79054	Nest 58	Nestling	ND	ND	0.23
1045-79055	Nest 37	Nestling	ND	ND	0.19
1045-79056	Nest 36	Nestling	ND	ND	0.30
1045-79057	Nest 20	Nestling	ND	ND	0.27
1045-79058	Nest 22	Nestling	ND	ND	0.36
1045-79059	Nest 23	Nestling	ND	ND	0.35
1045-79060	Nest 61	Nestling	ND	ND	0.52
1045-79061	Nest 64	Nestling	ND	ND	0.23
1045-79062	Nest 67	Nestling	ND	ND	0.36
1045-79063	Eunice, NM Landfill	Adult	0.23	ND	0.86
1045-79064	Eunice, NM Landfill	Adult	0.07	ND	0.64
1045-79065	Eunice, NM Landfill	Adult	ND	ND	0.61
1045-79066	Eunice, NM Landfill	Adult	0.09	ND	1.00
1045-79067	Eunice, NM Landfill	Adult	0.10	ND	0.54
1045-79068	Eunice, NM Landfill	Adult	0.06	ND	0.58
1045-79069	Eunice, NM Landfill	Adult	0.12	ND	0.67
1045-79070	Eunice, NM Landfill	Adult	0.17	ND	0.68
1045-79098	Eunice, NM Landfill	Adult	0.20	0.038	0.80
1045-79100	Eunice, NM Landfill	Adult	0.09	0.055	0.51
1045-79101	Eunice, NM Landfill	Adult	0.21	0.024	0.57
1045-79102	Eunice, NM Landfill	Adult	0.06	0.026	0.78
1045-79103	Eunice, NM Landfill	Adult	ND	ND	0.59
1045-79104	Eunice, NM Landfill	Adult	ND	ND	0.63
1045-79110	Eunice, NM Landfill	Adult	ND	ND	0.55

[1] ND = none detected. Reporting limits: lead (0.06 ppm), mercury (0.005-0.05 ppm), selenium (0.005-0.05).

Table 3. Prevalence of PCBs in Arcolor mixtures in Chihuahuan ravens in New Mexico, 2007.

		Arcolor tested						
Band Number	Sampling Location	1221	1232	1242	1248	1254	1260	1262
1045-79063	Eunice, NM landfill	ND[1]	ND	ND	ND	ND	ND	ND
1045-79064	Eunice, NM landfill	ND	ND	ND	ND	ND	ND	ND
1045-79065	Eunice, NM landfill	ND	ND	ND	ND	ND	ND	ND
1045-79068	Eunice, NM landfill	ND	ND	ND	ND	ND	ND	ND
1045-79069	Eunice, NM landfill	ND	ND	ND	ND	ND	ND	ND
1045-79089	Eunice, NM landfill	ND	ND	ND	ND	ND	ND	ND
1045-79090	Eunice, NM landfill	ND	ND	ND	ND	ND	ND	ND
1045-79091	Eunice, NM landfill	ND	ND	ND	ND	ND	ND	ND
1045-79093	Eunice, NM landfill	ND	ND	ND	ND	ND	ND	ND
1045-79094	Eunice, NM landfill	ND	ND	ND	ND	ND	ND	ND
1045-79096	Eunice, NM landfill	ND	ND	ND	ND	ND	ND	ND

[1] ND = none detected. Reporting limits (0.1-0.2 ppm).

Table 4. Cholinesterase levels in Chihuahuan ravens in New Mexico, 2007.

Band Number	Sampling Location	Age	Cholinesterase (uM/ml/min[1])
1045-79089	Eunice, NM Landfill	Adult	1.3
1045-79090	Eunice, NM Landfill	Adult	1.7
1045-79091	Eunice, NM Landfill	Adult	1.7
1045-79093	Eunice, NM Landfill	Adult	1.2
1045-79094	Eunice, NM Landfill	Adult	1.2
1045-79096	Eunice, NM Landfill	Adult	1.0
1045-79101	Eunice, NM Landfill	Adult	1.3
1045-79102	Eunice, NM Landfill	Adult	0.8
1045-79104	Eunice, NM Landfill	Adult	1.4

[1] Reporting limit 0.1 uM/ml/min.

Table 5. Prevalence of Avian Influenza (H5 and H7 subtypes) in Chihuahuan ravens in New Mexico, 2007.

Band Numbers	Sampling location	H5	H7
1045-79001	Nest 47	ND[1]	ND
1045-79002	Nest 47	ND	ND
1045-79003	Nest 47	ND	ND
1045-79004	Nest 47	ND	ND
1045-79005	Nest 47	ND	ND
		ND	ND
1045-79006	Nest 47	ND	ND
1045-79007	Nest 8	ND	ND
1045-79008	Nest 8	ND	ND
1045-79009	Nest 8	ND	ND
1045-79010	Nest 8	ND	ND
		ND	ND
1045-79011	Nest 8	ND	ND
1045-79012	Nest 13	ND	ND
1045-79013	Nest 13	ND	ND
1045-79014	Nest 13	ND	ND
1045-79015	Nest 13	ND	ND
		ND	ND
1045-79016	Nest 13	ND	ND
1045-79017	Nest 5	ND	ND
1045-79018	Nest 5	ND	ND
1045-79019	Nest 5	ND	ND
1045-79020	Nest 5	ND	ND
		ND	ND
1045-79021	Nest 16	ND	ND
1045-79022	Nest 16	ND	ND
1045-79023	Nest 16	ND	ND
1045-79024	Nest 16	ND	ND
1045-79025	Nest 10	ND	ND
		ND	ND
1045-79026	Nest 10	ND	ND
1045-79027	Nest 10	ND	ND
1045-79028	Nest 9	ND	ND
1045-79029	Nest 9	ND	ND
1045-79030	Nest 9	ND	ND
		ND	ND
1045-79031	Nest 30	ND	ND
1045-79032	Nest 30	ND	ND
1045-79033	Nest 32	ND	ND
1045-79034	Nest 32	ND	ND
1045-79035	Nest 32	ND	ND
		ND	ND
1045-79036	Nest 32	ND	ND
1045-79037	Nest 34	ND	ND
1045-79038	Nest 34	ND	ND
1045-79039	Nest 55	ND	ND
1045-79040	Nest 55	ND	ND
1045-79041	Nest 55	ND	ND
1045-79042	Nest 35	ND	ND
1045-79043	Nest 35	ND	ND
1045-79044	Nest 35	ND	ND
1045-79045	Nest 35	ND	ND
		ND	ND
1045-79046	Nest 35	ND	ND
1045-79047	Nest 44	ND	ND
1045-79048	Nest 44	ND	ND
1045-79049	Nest 58	ND	ND
1045-79050	Nest 16	ND	ND
		ND	ND
1045-79057	Nest 20	ND	ND
1045-79058	Nest 22	ND	ND
1045-79059	Nest 23	ND	ND
1045-79060	Nest 61	ND	ND
1045-79061	Nest 64	ND	ND
		ND	ND
1045-79062	Nest 67	ND	ND
1045-79071	Nest 37	ND	ND
1045-79072	Nest 37	ND	ND
1045-79073	Nest 36	ND	ND
1045-79074	Nest 36	ND	ND
		ND	ND
1045-79075	Nest 36	ND	ND
1045-79076	Nest 20	ND	ND
1045-79077	Nest 20	ND	ND
1045-79078	Nest 22	ND	ND
1045-79079	Nest 22	ND	ND
		ND	ND
1045-79080	Nest 23	ND	ND
1045-79081	Nest 23	ND	ND
1045-79082	Nest 61	ND	ND
1045-79083	Nest 61	ND	ND
1045-79084	Nest 64	ND	ND
		ND	ND
1045-79085	Nest 64	ND	ND
1045-79086	Nest 67	ND	ND
1045-79087	Nest 67	ND	ND
1045-79088	Nest 68	ND	ND
Wpt.80-3	Nest35	ND	ND

[1] ND = none detected.

Table 6. Prevalence of West Nile Virus in Chihuahuan ravens in New Mexico, 2007.

Band number	Location	Age	WNV
1045-79001	Nest 47	Nestling	ND[1]
1045-79002	Nest 47	Nestling	ND
1045-79003	Nest 47	Nestling	ND
1045-79004	Nest 47	Nestling	ND
1045-79005	Nest 47	Nestling	ND
1045-79006	Nest 47	Nestling	ND
1045-79007	Nest 8	Nestling	ND
1045-79008	Nest 8	Nestling	ND
1045-79009	Nest 8	Nestling	ND
1045-79010	Nest 8	Nestling	ND
1045-79011	Nest 8	Nestling	ND
1045-79012	Nest 13	Nestling	ND
1045-79013	Nest 13	Nestling	ND
1045-79014	Nest 13	Nestling	ND
1045-79015	Nest 13	Nestling	ND
1045-79016	Nest 13	Nestling	ND
1045-79017	Nest 5	Nestling	ND
1045-79018	Nest 5	Nestling	ND
1045-79019	Nest 5	Nestling	ND
1045-79020	Nest 5	Nestling	ND
1045-79021	Nest 16	Nestling	ND
1045-79022	Nest 16	Nestling	ND
1045-79023	Nest 16	Nestling	ND
1045-79024	Nest 16	Nestling	ND
1045-79025	Nest 10	Nestling	ND
1045-79026	Nest 10	Nestling	ND
1045-79027	Nest 10	Nestling	ND
1045-79028	Nest 9	Nestling	ND
1045-79029	Nest 9	Nestling	ND
1045-79030	Nest 9	Nestling	ND
1045-79031	Nest 30	Nestling	ND
1045-79032	Nest 30	Nestling	ND
1045-79033	Nest 32	Nestling	ND
1045-79034	Nest 32	Nestling	ND
1045-79035	Nest 32	Nestling	ND
1045-79036	Nest 32	Nestling	ND
1045-79037	Nest 34	Nestling	ND
1045-79038	Nest 34	Nestling	ND
1045-79039	Nest 55	Nestling	ND
1045-79040	Nest 55	Nestling	ND
1045-79041	Nest 55	Nestling	ND
1045-79042	Nest 35	Nestling	ND
1045-79043	Nest 35	Nestling	ND
1045-79044	Nest 35	Nestling	ND
1045-79045	Nest 35	Nestling	ND
1045-79046	Nest 35	Nestling	ND
1045-79047	Nest 44	Nestling	ND
1045-79048	Nest 44	Nestling	ND
1045-79049	Nest 58	Nestling	ND
1045-79063	Eunice, NM landfill	Adult	ND
1045-79064	Eunice, NM landfill	Adult	ND
1045-79065	Eunice, NM landfill	Adult	ND
1045-79066	Eunice, NM landfill	Adult	ND
1045-79067	Eunice, NM landfill	Adult	ND
1045-79068	Eunice, NM landfill	Adult	ND
1045-79069	Eunice, NM landfill	Adult	ND
1045-79070	Eunice, NM landfill	Adult	ND
1045-79071	Nest 37	Nestling	ND
1045-79072	Nest 37	Nestling	ND
1045-79073	Nest 36	Nestling	ND
1045-79074	Nest 36	Nestling	ND
1045-79075	Nest 36	Nestling	ND
1045-79076	Nest 20	Nestling	ND
1045-79077	Nest 20	Nestling	ND
1045-79078	Nest 22	Nestling	ND
1045-79079	Nest 22	Nestling	ND
1045-79080	Nest 23	Nestling	ND
1045-79081	Nest 23	Nestling	ND
1045-79082	Nest 61	Nestling	ND
1045-79083	Nest 61	Nestling	ND
1045-79084	Nest 64	Nestling	ND
1045-79085	Nest 64	Nestling	ND
1045-79086	Nest 67	Nestling	ND
1045-79087	Nest 67	Nestling	ND
1045-79088	Nest 68	Nestling	ND
1045-79098	Eunice, NM landfill	Adult	ND
1045-79099	Eunice, NM landfill	Adult	ND
1045-79100	Eunice, NM landfill	Adult	ND
1045-79101	Eunice, NM landfill	Adult	ND
1045-79102	Eunice, NM landfill	Adult	ND
1045-79103	Eunice, NM landfill	Adult	ND
1045-79104	Eunice, NM landfill	Adult	ND
1045-79110	Eunice, NM landfill	Adult	ND
wpt. 80 #3	Nest 35	Nestling	ND

[1] ND = none detected.