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Supplementary Online Material for

BEAK DEFORMITIES IN NORTHWESTERN CROWS: EVIDENCE OF A MULTISPECIES EPIZOOTIC

Caroline Van Hemert[1,2,3] and Colleen M. Handel[1]

[1]*U.S. Geological Survey, Alaska Science Center, 4210 University Drive, Anchorage, Alaska 99508, USA; and*
[2]*Department of Biology and Wildlife, Institute of Arctic Biology, University of Alaska Fairbanks, P.O. Box 757000, Fairbanks, Alaska 99775, USA*

Supplementary Methods

Field methods.—Between March 2007 and April 2008, we captured a total of 186 Northwestern Crows at six sites in coastal Alaska using modified drop-net traps (Willson and Comet 1993, Caffrey 2002, C. Van Hemert unpubl. data) and bungee-loaded whoosh nets (Sutherland et al. 2004). For each bird captured, we recorded the following standard measurements: mass, unflattened wing chord, tail length, and diagonal tarsus. We identified birds as juveniles (<1 year of age) or adults (≥1 year) on the basis of molt limit, rectrix shape, and mouth color (Pyle 1997). We used molecular techniques to determine sex from blood samples drawn from the brachial vein (Handel et al. 2006, 2010). All birds were marked with a U.S. Geological Survey (USGS) stainless steel leg band and a unique combination of three plastic colored leg bands for visual identification. Work was completed under guidance of the University of Alaska Fairbanks and the USGS Alaska Science Center Institutional Animal Use and Care committees (assurance no. 07-049).

For beak morphometrics, we followed protocols outlined by Handel et al. (2010) and used digital calipers to measure (to 0.1 mm) the chord length of the upper beak from nares to tip; gonys of the lower beak; any overbite or underbite; and the direction and extent of any lateral crossing of upper and lower beaks. We then assigned a field classification of each beak as normal, deformed, or unknown. Field classifications were based on the expected range of variation assessed from museum specimens measured at the American Museum of Natural History (C. Van Hemert unpubl. data) and historical live-capture data (Johnston 1961, R. Ha unpubl. data). We considered a beak to be deformed if it met any of the following conditions: overbite >7.5 mm, nares to tip >45.0 mm, underbite >3.5 mm, or gonys >35.0 mm. These criteria generally identified abnormalities that were grossly visible and often detectable from a distance of several meters or more. Individuals that exhibited more subtle beak overgrowth (overbite >5.0 mm, nares to tip >40.0 mm, underbite >0.5 mm, or gonys >31.0 mm) or possible incipient deformities were field-classified as unknown. All other beaks were classified as normal. We photographed each bird's beak and documented any unusual growth patterns, ridges, or other irregularities. In addition, we examined all keratin structures, including beaks, claws, and skin, for possible abnormalities. Terminology and measurements of the beak follow Lucas and Stettenheim (1972) and Pyle (1997).

Data analysis.—To determine the deformity status of beaks that were field-classified as unknown, we used an objective, iterative approach to establish prediction intervals for the range of expected background variation in adult beak morphometrics. This method was based on the rationale that, given the lack of historical background data on beak morphometrics, we could use measurements from the relatively large sample of apparently normal birds in our study ($n = 115$) to identify prediction intervals beyond which a beak would be considered deformed. These upper and lower bounds could then be used to determine whether a given measurement exceeded the range of normal values for our sample population. We observed no evidence of beak deformities in juveniles, so we restricted all analyses to adult birds.

First, we combined overbite and underbite measurements into a single, continuous variable termed "relative overgrowth," which was a measure of the amount by which the tip of the upper beak exceeded (positive value) or was shorter than (negative value) the tip of the lower beak (calculated as overbite – underbite). We conducted a multiple regression analysis for each of the three beak variables (nares to tip, gonys, and relative overgrowth) as a function of sex and several morphometric indicators of body size (wing length, tail length, tarsus length, and body mass) for adult birds with beaks field-classified as normal. We calculated the standardized residuals ($e_i/\sqrt{MSE}$) and examined normal probability plots to confirm that data met the assumption of Gaussian distribution.

In the first step of the iterative classification process, we used the three resulting equations to estimate 99.5% prediction intervals for sex- and size-adjusted residuals of nares to tip, gonys, and relative

[3]E-mail: cvanhemert@usgs.gov
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Table S1. Coefficients from multiple-regression models of three beak morphometrics (nares to tip, gonys, and relative overgrowth) as functions of sex and measurements of body size (wing, tarsus, tail, and mass) among Northwestern Crows with normal beaks captured during winter in 2007 and 2008 in Alaska. We used an iterative process (see Supplementary Methods) to determine 99.5% iterative prediction intervals (PI) of residuals for normal beak measurements. Beaks whose sex- and size-adjusted residuals were outside the PI were classified as deformed.

	Regression coefficients						99.5% PI of residuals	
Morphometric[a]	Intercept	Sex[b]	Wing (mm)	Tarsus (mm)	Tail (mm)	Mass (g)	Lower	Upper
Nares to tip	−2.074	−0.017	0.028	0.286	0.058	0.014	−5.45	5.88
Gonys	8.989	−0.453	0.038	0.243	−0.065	0.013	−5.20	5.69
Relative overgrowth	0.544	0.213	−0.025	−0.038	0.054	0.005	−2.02	2.12

[a] Nares to tip measured from anterior end of the right nare to the tip of the upper beak; gonys measured from the central notch on the lower beak to the tip; relative overgrowth calculated as the amount the tip of the upper beak exceeds (+) or is less than (−) the tip of the lower beak (overbite − underbite; see Supplementary Methods).
[b] For variable "sex" used in model, males = 0, females = 1.

overgrowth for the field-classified normal birds. We then used these equations to estimate the residuals for nares to tip, gonys, and relative overgrowth for each individual with a beak field-classified as unknown. Any beaks that fell within the "normal" prediction intervals for a particular measurement were reclassified as normal for that measurement. In the next step, we then included these reclassified individuals in calculations to estimate a new prediction interval. We repeated this process for each of the three beak variables until no new individuals were included. We then used these final prediction intervals for residuals of nares to tip, gonys, and relative overgrowth to classify a beak as normal or deformed (Table S1). Beaks that fell outside of the prediction intervals for one or more of the three beak morphometrics were classified as deformed. We then used logistic regression (Zelterman 2006) to model the presence or absence of beak deformities within individual adult birds in relation to site and sex. We calculated the overall prevalence of deformities across our study areas as the mean of the six site-specific rates. All statistical analyses were conducted in SPSS, version 14.0 (SPSS, Chicago, Illinois).

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