MORPHOMETRICS OF NESTLING CINEREOUS VULTURES *(Aegypius monachus)* IN MONGOLIA

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abstract. We present morphological data of nestling cinereous vultures from Mongolia. Body measurements taken from near-fledgling age cinereous vultures were examined for differences between sexes. Although the data show females tend to be slightly larger than males in several measurements, the differences were not statistically significant. The discriminant analysis provided no useful information for separating morphological differences, thus we recommend using molecular techniques for sex determination of nestlings in this species.

Keywords: Cinereous Vulture, sexing, sexual dimorphism, morphometrics

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Introduction

Raptor population monitoring and management often involves collecting information related to the gender of birds (Bildstein and Bird, 2007; ; Newton, 1979 ; Steenhof and Newton, 2007). Identification of gender in birds can be performed through direct gonadal examination, plumage, genetic and karyotype methods, analysis of urine and blood samples, voices, surgical procedures, or morphological measures (Fry, 1983; Platt et al. 2007; Wink 2007). Use of a noninvasive method such as measurement can be an important consideration when dealing with rare and threatened species. Therefore, we explored use of morphometrics with the apparently monomorphic cinerous vulture (*Aegypius monachus*) .

Sexing raptors based on morphological measurements is a widely used study technique (Bortolotti, 1984; Helander et al., 2007; Shephard et al., 2004; Xirouchakis and Poulakakisi, 2008). But, not all birds of prey are suitable for sex determination using morphological measurements as a convenient method. For example, it is most inconclusive in Old World vultures due to their ecological and behavioral adaptations, which resulted in little external sexual dimorphism (Hertel, 1994; Houston, 1983; Kruger, 2005; Newton, 1979).

The cinereous vulture is the largest raptor in the Old World and is a monomorphic in appearance with very similar dark brown plumage, making it impossible to distinguish the sexes of birds observed in the field (Clark, 1999; Forsman, 1999) without study of behavior of adults. Field sex identification is essential part of research because such information is important for understanding basic biology and for conservation and management decisions (Arshad et al., 2009; Reading et al., 2005; Villegas et al., 2004). The study of population biology and monitoring for the cinereous vultures is costly and time consuming due to their lengthy breeding season and life span. Thus researchers have been seeking to develop methods to accurately determine the age (Batbayar et al., 2006; Puente and Gamonal, 2006; Reading et al., 2005) and the sex (Elorriaga et al., 2006) of cinereous vultures to keep disturbance level and nest monitoring costs low.

Although plumage similarity of the cinereous vultures has been described as unreliable for determining the sex, the use of morphological measurements from this species rarely has been tested, and we are unaware of measurements of nestlings for sex determination. In our experience, capture and handling of nestlings is less time consuming and stressful to the birds than with adults. Therefore, sexing with morphometrics from nestlings would be useful. We examined near-fledgling age cinereous vultures for potential morphological differences because while monitoring for nesting success in central Mongolia, we saw noticeable variability in size and shape of beak, tarsus, wing, tail, and weigh among same age nestlings. However we were not able to relate them to the sex of birds until genetic data become available. Therefore, we wanted to test if the observed variability can be used to determe of sex of advanced age cinereous vulture nestlings.

Methods

Cinereous vulture nestlings at near-fledgling age (>85 days old) were measured at their nests during the field study in 2002 and 2003 at two study sites, Erdenesant and Khustain Nuruu National Park, which are about 100 km from each other, in central Mongolia. Bill height and length, wing chord, tail, and tarsus lengths, and body weight were taken by same researchers from 53 cinereous vulture nestlings just before they leave nests. Tarsus and bill were measured with dial calipers (±0.2) and tail and wing chords were measured with a ruler and cloth tape. Body mass of each nestling was obtained using 20 kg Pesola spring scale. Crop size was noted as empty, half full, or full. In addition to the five liner measurements, we created four additional variables by ratios of some variables such as bill length and height (BHL), tail and tarsus length (TailTar), tarsus and bill length (TarBL), and tarsus and bill height (TarBH). We did not use the body mass for further analysis because the crop contents varied greatly in among nestlings. We used results from a molecular sexing analysis to determine sex of vulture nestlings. A small amount of blood from a leg vein or a growing feather was collected from nestlings for genetic analysis. Samples were stored in small tubes with ethanol and were shipped to the Department of Genetics and Molecular Biotechnology of Hellenic Centre for Marine Research in Heraklion, Greece. Detailed DNA analytical methods and comparative population level genetic research results are fully described in Poulakakis et al. 2008.

Before running statistical tests, the data were checked for normality using Shapiro-Wilk test, sample mean and outliers were checked using box and whisker plots. Analysis of variance (ANOVA) was used to test for differences between sexes for all measurements. We reported mean, standard deviation (SD), and range of each measurement, and ANOVA test results. Sexual size dimorphism was calculated as differences between mean value of male and female nestlings divided by mean value in males. We used one-way discriminant analysis (DA) with one of the sexes being a response and ten morphological measures as independent variables (Tabachnick and Fidell, 2007). Discriminant analysis is sensitive to missing values, thus the records with missing values had to be omitted. Unequal sample sizes are acceptable in DA, but the minimum sample size must be greater than predictor variables. The sample size of the two sexes was not high, but not below the required sample size. Also DA is highly sensitive to outliers; accordingly the outliers were removed. Thus, the actual dataset for DA consisted of 46 nestlings with no missing data. We tested the data for linearity to see magnitude of linear relationships between variables; because a weak linear relationship could lead to reduced power and a Type I error. Testing the discriminant function predictive model accuracy was by cross validation and jackknife classification methods (Tabachnick and Fidell, 2007). All statistical analysis was done using R program (R Development Core Team, 2012).

Results

Detailed base statistics of morphological measurements are provided in Table 1 and Figure 1. In general, means of all measurements from females were slightly bigger than males except bill length, BLH, and TarBH, but no statistically significant differences were found between sexes. Wing and tail were highly correlated (R^2=0.89, p value = 0.001). Sexual size dimorphism was not observed between sexes (N=46).

Table 1. Descriptive statistic, sexual dimorphism, and univariate comparisons of male and female near-fledgling age cinereous vultures in central Mongolia

Variable	Male (N=20)			Female (N=26)			% dimor phism	Wilks' lambda	F-val-ue	P
	mean±sd	min	max	mean±sd	min	max				
Wing, *mm*	656.8±46.2	559	731	664.19±64.5	536	768	-1.13	0.977	0.19	0.67
Tail, *mm*	263.25±48.2	182	345	270.5±53.5	151	356	-2.75	0.976	0.23	0.64
Bill length, *mm*	83.64±3.6	73.8	88.9	83.62±3.7	74.9	90.8	0.02	0.975	0	0.99
Bill height, *mm*	46.09±2.5	40.3	50.2	46.73±2.6	41.9	53.3	-1.39	0.948	0.70	0.41
Tarsus, *mm*	145.5±5.6	134.8	153.3	145.51±8.6	130.4	163	-0.01	0.978	0	0.99
Weight, *g*	8582.5±654.0	7400	10000	9010±953.8	7700	11000	-4.98	0.934	2.91	0.09
BLH	1.82±0.1	1.64	2.09	1.79±0.1	1.41	1.95	1.65	0.946	0.53	0.47
TailTar	1.81±0.3	1.28	2.38	1.86±0.4	1.15	2.42	-2.76	0.969	0.23	0.63
TarBL	1.74±0.1	1.58	1.92	1.74±0.1	1.54	2.18	0.00	0.924	0	0.99
TarBH	3.17±0.2	2.86	3.8	3.12±0.2	2.74	3.57	1.58	0.966	0.54	0.47

Discriminant analysis correctly classified 62% of females and 10% for males. Overall, model accuracy was 39%, which is not useful. Log transformation of data slightly improved the correct classification of males, but it was not useful as well. It correctly classified 58% of females and 35% of males, with overall accuracy of 49%. In general, the use of DA was not helpful for sexing cinereous vultures with morphological data.

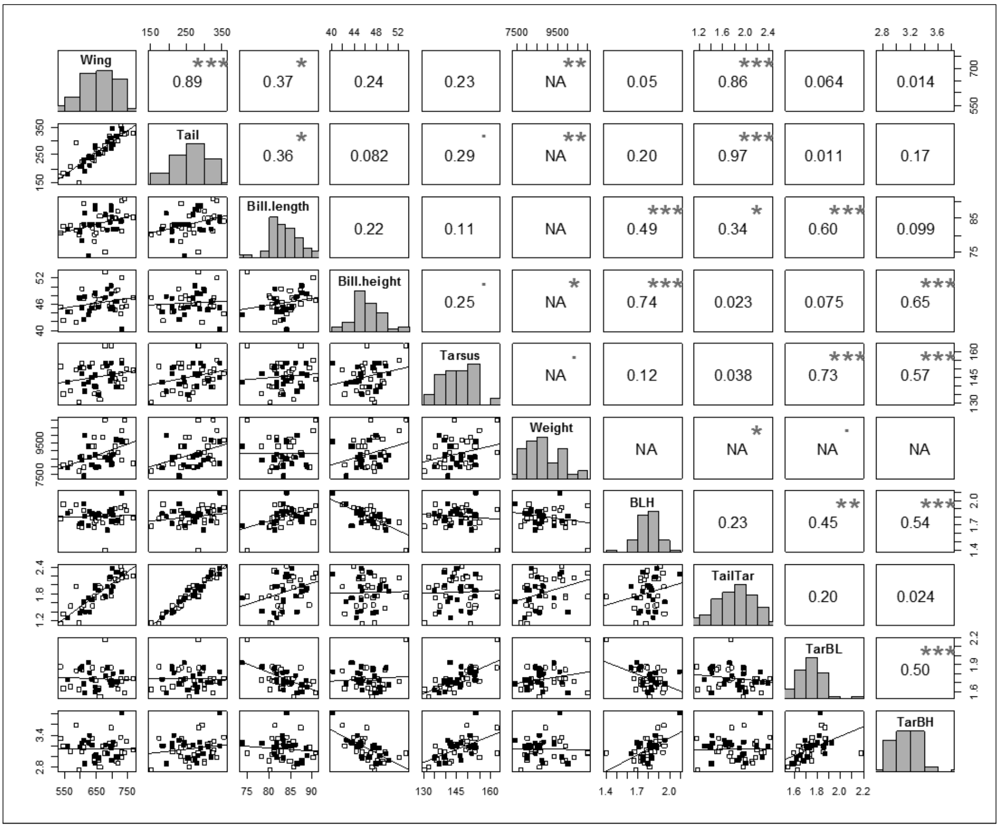

Figure 1. Correlation plot showing all ten variables. White squares denote females and black squares are for males.

Discussion

We compared ten biometric variables from male and female cinereous vulture nestlings in Mongolia. The study subjects in our case were near-fledgling age individuals. The growth rate of cinereous vulture nestlings reach a peak towards the end of nesting period, but declines to adult levels just before the fledge (Dorjderem, 2006; Reading et al., 2005); therefore, the measures from near-fledgling age individuals should be similar to that of adults. We found no statistically significant differences between sexes in all variables and it was not possible to differentiate the sexes with morphological measurements. We did not try to further investigate the biological significance of these findings. Reporting these morphometric data of cinereous vultures provides a basis for comparison to results from other studies, and the results of our analyses reveal that when determining sex is required. .

There is only one previous attempt of sex determination in the cinereous vultures using morphometric measurement which was made in Greece (Elorriaga et al., 2006). They used 16 biometric measures taken from 32 adult (age >5 CY) and immature (age <5 CY) vultures. The variables used in this study were the primaries from 7th to 9th, wing chord, central rectrices, middle toe, middle-toe nail, tarsus height, tarsus width, tarsus length, bill width, bill height, bill length, bill-cere length, head length, and head width. They found significant size differences in bill width, bill height, head width, and head length between adult and immature vultures, and were able to find higher reversed dimorphism in immatures than adult vultures. Tarsus width, bill length, and bill-cere length were highly correlated. Stepwise Discriminant Analysis found only tarsus height to predict gender in both age groups. Also, they found that the head length, bill height, and bill width were possible gender predictors for immature Cinereous Vultures. Their findings differ from our results from nestlings in Mongolia. The results from our measurements and those of Dorjderem, 2006; Reading et al., 2005, Elorriaga et al., 2006 indicate that the growth and morphology of cinerous vultures differes as birds develop from nestlings to fledglings, through age <5CY, and as birds >5CY. It is possible that these differences are associated with methodology or geography, but for now, they complicate the determination of sex.

Xirouchakis and Poulakakisi (2008) used 16 morphological measures to determine the sex of Griffon Vultures *Gyps fulvus,* which is another species of Old World vulture for which the sexes appear similar in the field.. Variables they used were wing chord, wingspan, tarsus, tail, middle toe, middle talon, head length, head width, bill length, bill-cere length, bill width, bill depth, weight, wing area, wing loading, and aspect ratio. In this study, four variables which are the head length, the head width, the bill length, and the bill-cere length differed between sexes.

Although reversed sexual dimorphism is absent or very weak among Old World vultures, there is still need further investigation of this subject. Morphometric data from cinereous vultures and Griffon Vultures in Europe have shown that biometrics related to bill and head indicated different sexes. In our case, we had data only for bill length and bill height. Perhaps additional biometric data would be useful for sex determination in nestling Cinereous Vultures. Until, then we recommend using genetic methods for sexing cinereous vultures as most reliable method. Alternatively, behavioral observations during breeding could be used to identify sexes in adult vultures as it was used for griffon vultures Gyps fulvus in Spain (Blanco and Martinez, 1996).

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