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Estimating the size of the Andean Condor population in the Apolobamba Mountains of Bolivia

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ABSTRACT. Population estimates of Andean Condors (*Vultur gryphus*) are urgently needed across their range to more accurately assess their conservation status and design appropriate conservation measures. From July to September 2005, six feeding stations in the Apolobamba mountain range of Bolivia were monitored for 3 days each and all visiting condors were digitally photographed and video-taped. Using distinctive marks, the size and shape of crests, and plumage patterns, we were able to individually recognize 23 adult male Andean Condors, or 30% of all observed condors. By extrapolation, we estimated a minimum population size for Apolobamba during the sampling period of 78 condors. Considering that the current estimate of the total population of Andean Condors in Colombia is 180 individuals, our results illustrate the importance of Apolobamba for Andean Condors and the potential importance of the Bolivian Andes for the conservation of this species. The methods we used to attract, observe, photograph, videotape, and recognize adult males may be useful for other populations of Andean Condors, as well as for other species of threatened vultures.

SINOPSIS. **Estimando el tamaño de la población de Condor de los Andes (*Vultur gryphus*) en las montañas Apolobamba, Bolivia**

Los números poblaciones del Condor de los Andes (*Vultur gryphus*) son necesarias conocerlas a todo lo largo de su distribución para determinar su estatus y diseñar medidas apropiadas de conservación. Desde julio a septiembre de 2005, se monitorearon (por 3 días), seis estaciones de alimentación en las montañas Apolobamba, Bolivia. Todos los condor que visitaron dichos lugares fueron grabados en video y fotografiados digitalmente. Utilizando características como, el tamaño y forma de la cresta y patrones en el plumaje, pudimos identificar a 23 machos adultos o el 30% de todas las aves observadas. Mediante extrapolación, estimamos una población mínima de 78 individuos en Apolobamba. Tomando en consideración que el estimado de la población de estas aves en Colombia es de 180 individuos, la población de Apolobamba es de gran importancia y de potencial importancia para la conservación de la especie. El método que utilizamos, para atraer, observar, grabar, fotografiar y reconocer individuos machos adultos, puede ser de utilidad para estudiar otras poblaciones de esta ave, al igual que a otras especies de buitres en peligro de extinción.

Key words: abundance, age-class proportion, minimum population estimate, sex ratio, *Vultur gryphus*

Andean Condors (*Vultur gryphus*) are found throughout the Andes Mountains from western Venezuela to southern Argentina and Chile (Fjeldsa and Krabbe 1990, Díaz et al. 2000). Unfortunately, condor populations have declined across most of their range and the current total population is an estimated 6200 individuals, with over two-thirds of these birds thought to occur in Argentina and Chile (Díaz et al. 2000). Andean Condors are now listed in CITES Appendix 1 and are considered Near Threatened by the IUCN (IUCN 2004). Factors contributing to the decline in condor populations include habitat loss, competition from introduced species such as domestic dogs (*Canis familiaris*), accidental poisoning, reduced prey availability, power line collisions, and direct conflict with local people and subsequent persecution including deliberate poisoning (Díaz et al. 2000, L. Jacome pers. comm. to D. Hilliard 2000).

Condors have almost been extirpated in Venezuela and Colombia, and reintroduction efforts have begun in an attempt to increase populations (Diaz at al. 2000). No information is currently available regarding populations in Ecuador, Peru, and Bolivia (Díaz et al. 2000), but condors are increasingly scarce in Ecuador

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(R. Williams pers. comm. to R. Wallace 2001). In Bolivia, condors are found on the western and eastern cordilleras from 300–4500 m asl (Del Hoyo et al. 1994, Díaz et al. 2000, Hennessey et al. 2003), but little is known about their population status.

Several investigators have used natural markings to identify individual birds (Bretagnolle et al. 1994, Oien et al. 1996, Arroyo and Betragnolle 1999). Male Andean Condors are easily identified because they have a crest and black eyes and females have no crest and red eyes (Del Hoyo 1994). In addition, adult condors have white secondary feathers and subadults do not. Finally, juveniles are brown, with no white secondary feathers or neck feathers (Wallace and Temple 1987a, Wallace and Temple 1988, Sarno et al. 2000, Donazar and Feijoo 2002). This has facilitated estimation of Andean Condor sex ratios, reproductive rates, and population status (Wallace and Temple 1988, Sarno et al. 2000). However, to date, individual recognition has not been systematically attempted as a possible means of generating data on abundance and movement patterns for Andean Condors. As a first step toward determining the conservation status of Andean Condors in Bolivia, we used digital photography and individual recognition to improve the abundance estimates for this species and examine population structure in the Apolobamba mountain range of northwestern Bolivia.

METHODS

Field work was conducted in two national parks in the Apolobamba Mountains of northwestern Bolivia: Madidi National Park and Natural Area for Integrated Management and Apolobamba Natural Area for Integrated Management. The area surveyed was between 14°36′ S and 15°12′ S, and 68°48′ and 69°18′ W. Three vegetation types dominated the study area, including 'páramo yungueño,' a humid grassland vegetation on the eastern side of the Andes, 'humid puna' another grassland with shrubs, and high Andean 'puna' vegetation around the Andean peaks and the western side of the Andes (Ibisch and Merida 2003). Extensive cattle and sheep farming was the main human activity over the entire study area.

Within our survey area, we identified six locations for observing condors using a GIS map of the region, information about observation points used previously by members of our field team, and informal interviews with park guards and local people. We also considered the logistical implications of each potential location in terms of distances and security. Observation points were 10 km apart, with distances measured using GPS positions and a GIS map of the study area. All locations were Andean valleys lying on the eastern flank of the Andes (Table 1). Fieldwork was conducted from July to September 2005.

At each location, we identified an open spot at least 1 km from our base camp and constructed a strategically-placed blind using rocks, moss, and grass. We then placed a locally purchased donkey or horse carcass 80–100 m from the blind. At each location, we observed the carcass for 3 consecutive days from 08:00 to 17:00. However, total observation time varied across days because of weather conditions, particularly mist and rain. After the third day, we dismantled the blind and left the area as it was when we arrived.

We continually photographed and filmed each approaching and feeding condor using a camera (Coolpix 4500; Nikon, Tokyo, Japan) and camcorder (DCR-DVD203; Sony, Tokyo, Japan). To improve the range of this equipment (up to 60 times), we mounted both on a spotting scope (Televid 77; Leica, Solms, Germany) using an adaptor (ScopeTronix, Cape Coral, Florida).

Table 1. Locations where Andean Condors were observed in the Apolobamba Mountains of Bolivia.

Location (nearest human settlement)	Coordinates	Altitude (m) asl	Survey dates
Kenuani	14 33 18.1 S; 69 07 34.6 W	4155	20–22 July 2005
Pasto Grande	14 45 20.7 S; 69 03 53.9 W	4380	29–31 July 2005
Munamachay	14 41 53.0 S; 69 00 16.5 W	3635	13–16 August 2005
Cuchillo	14 56 58.8 S; 68 58 27.6 W	5000	21–24 August 2005
Ilusani	15 13 20.8 S; 68 56 06.2 W	4080	15–17 September 2005
Solizpampa	15 05 33.8 S; 68 58 28.9 W	3772	21–23 September 2005

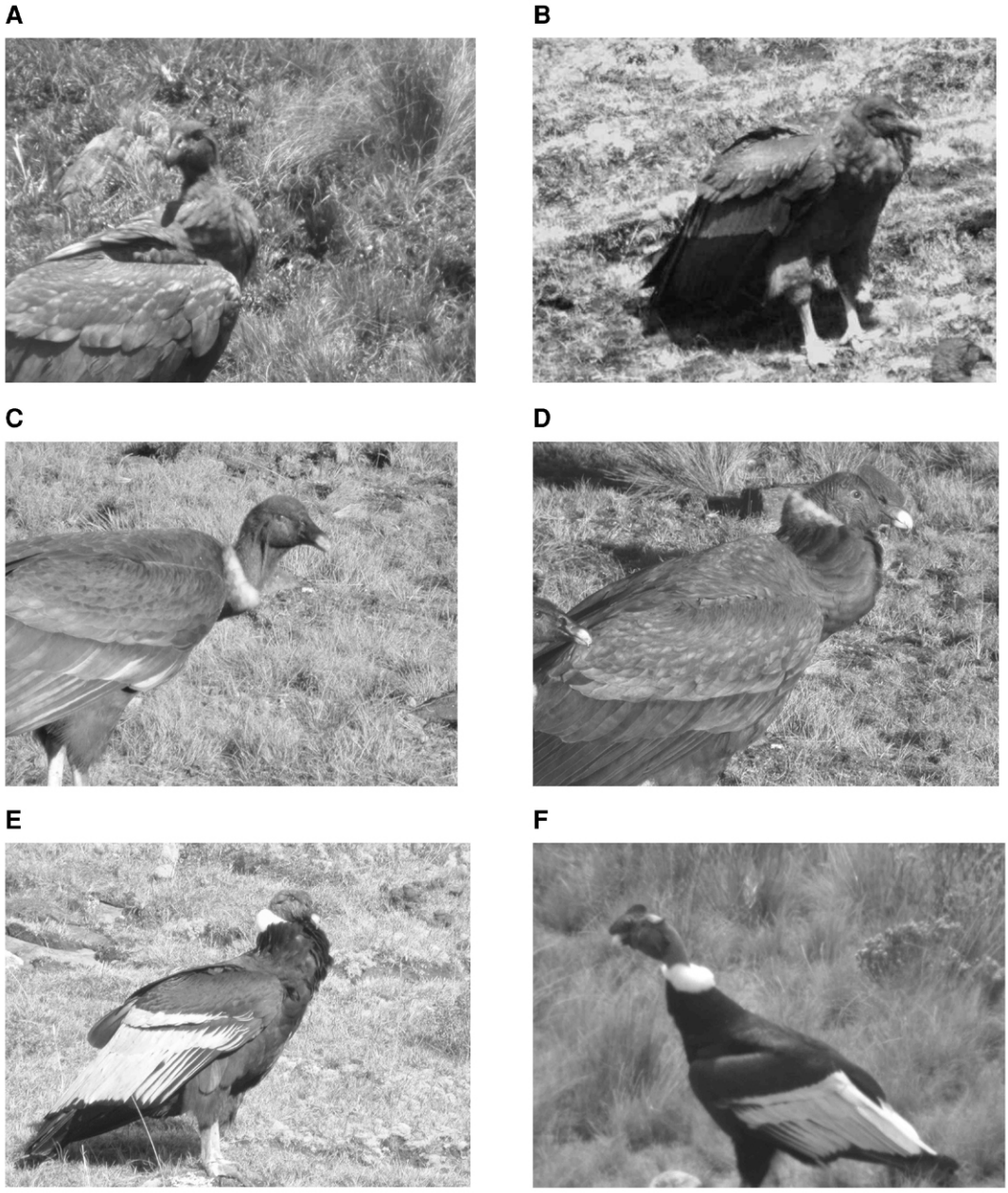

Fig. 1. The six recognized age-sex classes of Andean Condors: (A) juvenile female, B) juvenile male, (C) subadult female, (D) subadult male, (E) adult female, and (F) adult male. Note differences in the neck and the wings between adults and immatures and the male crests.

Photographed and filmed individuals were categorized by age and sex and then, if possible, individually identified using distinctive marks, the size and shape of crests, and plumage patterns. Six categories of condors were identified (Fig. 1): juvenile females, juvenile males, subadult females, subadult males, adult females, and adult males (cf. Wallace and Temple

1987a,1988, Sarno et al. 2000, Donazar and Feijoo 2002). We could only reliably identify individual adult males and, therefore, concentrated our abundance estimates on them. We first calculated the minimum number of males in the population by determining the number of individually recognizable males observed at our six observation locations. Using the estimated proportion of adult males, calculated by averaging values across observation events, we then estimated the minimum number of condors in the Apolobamba range.

RESULTS

Condors visited all six survey locations and we photographed and video-taped all visiting condors at each location. During our study, condors visited carcasses 30 times and we observed 108 individuals, including 32 adult males. Individual recognition allowed us to determine that the 32 male observations represented 23 adult males (Fig. 2). Males represented 30% of the observed population, with the remaining population including adult females (10%), subadult females (10%), subadult males (19%), juvenile females (22%), and juvenile males (9%; Fig. 2). Based on the observed proportion of adult males in the population and the number of recognized adult males, we extrapolated a minimum condor population of 78 condors during our sampling period. Overall, the ratio of males to females was 1:0.7, the ratio of adult males to adult females was 1:0.3, the ratio of immature (subadults and juveniles) males to immature females was 0.9:1, and the ratio of adults to immatures was 1:1.5.

Five adult male condors were photographed at more than one feeding station. Male 7 was observed at Kenuani, Munamachay, and Ilusani (62 km maximum distance). Male 8 was observed at Pasto Grande (39 km south at Ilusani). Male 11 was observed at Pasto Grande (23 km south of Cuchillo). Male 12 was observed at Pasto Grande, Cuchillo and Ilusani (39 km maximum distance). Finally, male 13 was observed at Munamachay, Ilusani, and Solizpampa (59 km maximum distance).

DISCUSSION

Using photographs and videos, we were able to categorize Andean Condors by sex and age class (Wallace and Temple 1987a, b, 1988, Sarno et al. 2000, Donazar and Feijoo 2002). Although the observed population structure of Andean Condors in Apolobamba was similar to that at Condorito National Park in Argentina (Donazar and Feijoo 2002), the adult sex ratio was more even in Argentina (ca.1:0.85). The low proportion of adult females observed during our study could have been due to differences in habitat use by males and females (Sarno et al. 2000), or because females spend more time at nests with young. Andean Condor chicks in Apolabamba apparently hatch from April to June (N. Rios, WCS-Bolivia, unpubl. data) so females may have been less active during our study. Another possible explanation for the male-biased sex ratios

Fig. 2. Total numbers of male and female Andean Condors ($N = 108$) of each age class observed in the Apolobamba Mountains of northwestern Bolivia.

is differences in survival rates, with adult males possibly having the highest survival rates and juvenile females the lowest. This hypothesis is supported by observations at Andean Condor roosts where adult males used more protected and warmer roost sites and juvenile females used the least protected and colder sites (Donazar and Feijoo 2002). Finally, competition at feeding places, where males dominate females, may also explain female-skewed mortality in Andean Condors (Donazar et al. 1999).

The ratio of adult to immature condors in our study differed from that reported in Chile (1:0.23; Sarno et al. 2000) and Perú (1:0.52; Wallace and Temple 1988). Wallace and Temple (1988) suggested that this ratio could be used as an indicator of the reproductive rate in populations of Andean Condors and populations with ratios approaching 1:1 were healthy in terms of reproduction. The observed adult to immature ratio in our study was 1:1.5, suggesting a healthy rate of reproduction.

We identified at least 23 adult male Andean Condors at Apolobamba during our study and, by extrapolation, a total of 78 condors. Considering that the current estimate of the total population for Colombia is 180 individuals (Forero 2005), our study illustrates the importance of Apolobamba for Andean Condors, the potential importance of the Bolivian Andes for the conservation of this species, and provides the first empirical estimate of population size for the region. Previous population estimations were based on the maximum number of condors observed feeding at a singles carcass in the region (22 individuals; Dona Conchita ANMIN Apolobamba, pers. comm. to R. Wallace) or an extrapolation (ca. 40 individuals) based on known nests currently considered to be in use (N. Rios, WCS-Bolivia, unpubl. data).

The methods we used to attract, observe, photograph, video-tape, and recognize adult male condors may be useful for other populations of Andean Condors and for other species of threatened vultures. Additional study may also reveal that individuals in other sex and age classes of Andean Condors, for example, adult females, can be recognized. Increasing the number of sampling occasions at each survey site would also permit the use of mark-recapture statistics to estimate total abundance (Otis et al. 1978).

Clearly there are also limitations to our approach. Andean Condor movements are poorly understood and the size of sample areas needed to estimate population size is unknown. Information from reintroduced subadult male Andean Condors in Argentina suggests substantial movements (up to 60 000 km^2; Dudley and Hilliard 2005). In addition, Wallace and Temple (1987b) reported ranges of up to 1300 km^2 over a 170-day period for reintroduced birds in Peru and straight-line movement distances of up to 210 km (Wallace and Temple 1987b). Additional data concerning the movements of wild Andean Condors is urgently needed because large-scale movements would have major implications in terms of the design and effectiveness of local conservation efforts.

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