A preliminary density estimate for Andean bear using camera-trapping methods

Boris Ríos-Uzeda[1,3], Humberto Gómez[1,4], and Robert B. Wallace[1,2,5]

[1]*Wildlife Conservation Society — Greater Madidi Landscape Conservation Program, Casilla 3-35181, San Miguel, La Paz, Bolivia*
[2]*Wildlife Conservation Society, 185th Street and Southern Boulevard, Bronx, NY 10460, USA*

Abstract: Andean (spectacled) bears (*Tremarctos ornatus*) are threatened across most of their range in the Andes. To date no field-based density estimations are available for this species. We present a preliminary estimate of the density of this species in the Greater Madidi Landscape using standard camera-trapping methods and capture–recapture analysis. We photographed 3 individually recognizable Andean bears in a 17.6 km^2 study area spanning 4 adjacent high elevation humid Andean valleys during August–September 2004. Capture–recapture statistics estimated an abundance of 3 bears; plausible geographic buffers yielded density estimates of 4.4 or 6 bears/100 km^2. We recommend that future camera-trapping studies on this species sample larger areas over longer periods and use 3 camera trap units at each station.

Key words: abundance, Andean bear, Bolivia, camera-trapping, capture–recapture, density, spectacled bear, *Tremarctos ornatus*

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The Andean (spectacled) bear (*Tremarctos ornatus*) is an endemic species of the tropical Andes, and the only bear species in South America. It ranges across 260,000 km^2 in Venezuela, Colombia, Ecuador, Peru, and Bolivia, with the latter 2 countries representing over 60% of the range (Peyton 1999). In Bolivia, Andean bears inhabit a broad altitudinal swathe (450–4,000 m) on the eastern slopes of the Andes, mainly in montane humid grasslands, montane forests, and Andean foothill forests (Rumiz and Salazar 1999). Despite their charismatic qualities and their status as a threatened endemic of the ecoregion, surprisingly little is known about Andean bears. For example, no density estimation is available across the entire range (Peyton 1999). Kattan et al. (2004) used 3 different density estimates to analyze the fragmentation of the Andean bear habitat in northern Andes. However, their estimates (4, 11, and 25 bears/100 km^2) were proposed by Yerena (1994) and Peyton et al. (1998) based on intuition and extrapolations from American black bear (*Ursus americanus*) data (Kattan et al. 2004).

We present the first attempt to estimate Andean bear density in northwestern Bolivia using capture–recapture methodologies and camera trap technology. Based on the results, we also recommend future efforts using this technique.

Study area

The study was conducted in 2 adjacent Bolivian protected areas, Madidi National Park and Natural Area of Integrated Management and Apolobamba Natural Area of Integrated Management. These protected areas are in the northern portion of the Department of La Paz in Bolivia (69°02′–69°50′W and 14°12′–15°10′S). Elevations in the study area (17.6 km^2) are 2400 to 3900 m (Fig. 1).

The study area is part of the biogeographical province of the Bolivian Yungas (Mueller et al. 2002; Navarro and Maldonado 2002). Vegetation types in the study area include humid Andean open grasslands (páramo yungueño; 60% of the study area) at high elevations changing into elfin forest (35%) at the tree line, and upper montane humid forest (5%) (F. Zenteno, Herbario Nacional de Bolivia, La Paz, Bolivia, unpublished data). The study area consists of 4 adjacent valleys 5 km from the nearest human settlement. Extensive livestock management occurred in the study area with human visits occurring around once a month to provide salt for cattle. Previous studies by Paisley (2001) and Rios et al. (2006) confirmed the year round presence of Andean bears at this site.

Methods

We adapted the method developed and implemented by Karanth and Nichols (1998, 2000, 2002) and

[3]borisborito2000@yahoo.com.mx [4]hgomez@fan-bo.org [5]rwallace@wcs.org

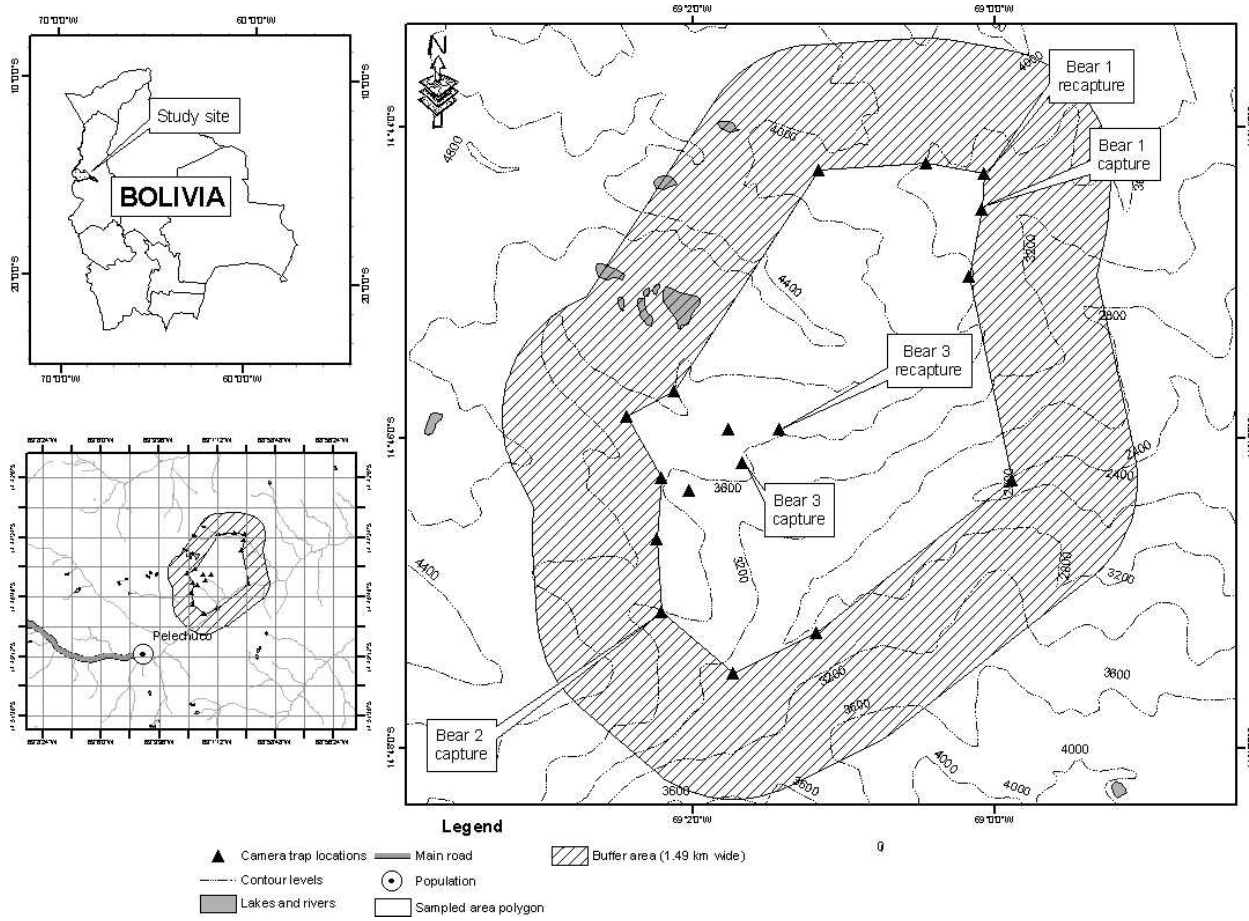

Fig. 1. Study area for Andean bear camera-trapping efforts, Aug–Sep 2004, in the Apolobamba protected area in the northwest Bolivian Andes.

Silver et al. (2004) to monitor tiger (*Panthera tigris*) and jaguar (*Panthera onca*) populations, respectively. The technique takes advantage of distinctive individual markings through photographs taken with remote camera stations and applies the theoretical framework of capture–recapture models to estimate population abundance (Otis et al. 1978, Nichols 1992).

During an initial visit to the study area we identified potential sites for the placement of camera trap stations based upon the presence of Andean bear sign (Peyton 1980, Goldstein 1986, Cuesta et al. 2001), especially established bear trails. These potential camera trap stations were then mapped in a GIS (geographic information system) of the study site, and a subset of 17 stations were selected to adequately cover the study area while meeting capture–recapture assumptions. Only sites with recent evidence of bear presence were selected, and areas of unusable habitat such as cliffs and streams were ignored. Camera trapping was conducted in August and September of 2004, at the height of the dry season. Camera trap stations were placed in relatively flat locations across the study site. Nine stations were placed in paramo and 8 in forest.

We employed Camtrakker® (Camtrakker, Watkinsville, Georgia, USA) and DeerCam® (DeerCam, Park Falls, Wisconsin, USA) camera traps. To photograph bears from 2 angles, we used 2 camera traps at each station. Cameras were positioned opposite each other, 30–60 cm from the ground, and at least 1 m from the area we expected the bear to pass. Cameras used 400 ASA print film and functioned continuously for a period of 29 days; we visited each of the 17 stations approximately every 7 days to change film and batteries. We defined a trap night as a 24-hour monitoring period at a single camera station with at least 1 functioning camera. Cameras recorded the day and time for each photograph. Stations were not baited.

Individual Andean bears were identified by their facial and pelage patterns. Each Andean bear is recognizable by white and cream facial, neck, and chest markings (Roth 1964, Peyton 1999). Each sample day (n = 29) was considered a detection period. Capture history data were analyzed using CAPTURE (Otis et al. 1978, White et al. 1982, Rexstad and Burnham 1991). We let CAPTURE choose between estimation models following the recommendations of White et al. (1982).

To estimate density we divided the abundance calculated above by the effective sample area (Karanth and Nichols 2002). The effective sample area included a circular buffer around each camera trap site, with a radius half the mean maximum distance (HMMD) among multiple captures of individual bears during the census period (Wilson and Anderson 1985). We also used available radio telemetry data on this species to calculate 2 alternative HMMD buffers; one was based on a 1-year telemetry study on 2 bears at our study site (Paisley 2001), the other was based on preliminary results of a study of 6 Andean bears in the Andes of Ecuador (Castellanos 2004).

Results

We expended 493 camera trap nights of effort (17 stations, each operating for 29 nights). Although individual cameras occasionally failed, we replaced malfunctioning cameras with spares thereby ensuring that each camera-trapping station always had one fully functional camera trap. Andean bears were photographed on 7 occasions, yielding 3 individual animals (Fig. 2). Although we are certain of individual identification at each event, we were unable to determine the animals' gender. Estimated capture probability was low (P = 0.08), and because of the small sample size, CAPTURE selected the use of the jackknife estimator and model M_o (χ^2 = 1.250, 28 df, P = 1.000). The population was considered closed (Z = −1.585; P = 0.05646). CAPTURE estimated 3 individuals in the area sampled. Two of the 3 were photographed on 3 distinct occasions, and all 3 were identified at 2 or more stations. However, the low number of recaptures provided a very small buffer area that did not seem reasonable given published reports on Andean bear ranging behavior (Paisley 2001, Castellanos 2004). Density estimates were 4.4–13.6 bears/100 km^2, depending on the buffer (Table 1).

Fig. 2. The 3 recognizable Andean bears in the Apolobamba protected area in the northwestern Bolivian Andes, Aug–Sep 2004.

Table 1. Andean bear density (individuals/100 km^2) estimates using different buffers, calculated from 13.28 captures/1,000 trap-nights, for a capture probability of 0.0805 and an abundance of 3, as estimated from CAPTURE.

Buffer (km)	Area sampled (km^2)	Density	95% Confidence limits per 100 km^2
0.25[a]	22.06	13.6	7.96–19.24
1.49[b]	49.95	6	3.55–8.46
2.14[c]	68.4	4.4	2.60–6.17

[a]Using half the mean maximum distance between recaptures.
[b]Using a mean home range of 7 km^2 from Paisley (2001).
[c]Using a mean home range of 14.37 km^2 from Castellanos (2004).

Discussion

Density estimates we report fall within the range of density estimates recently reported in the literature (Kattan et al. 2004). Our highest estimate (13.6 bears/100 km^2) may be unrealistic because it is based on a buffer value of only 250 m. Such a small buffer assumes home ranges of less than 0.2 km^2. Thus, we suggest that the lower density estimates, based on limited movement data from this site and more comprehensive movement data from a site in Ecuador (6 and 4.4 bears/100 km^2, respectively), are more reasonable. During recent Andean bear habitat preference surveys across 33 sites in the northwest Bolivian Andes, elfin forest and upper montane forest were shown to be preferred habitat and the study site itself was considered intermediate-to-high in terms of Andean bear relative abundance, as measured by frequency of encountered sign (Rios-Uzeda et al. 2006).

Given the low number of captures in this preliminary study, information on individual bear movements, habitat use, and activity patterns are limited, particularly considering the radio tracking research already conducted at this site (Paisley 2001). However, 1 of the bears photographed in this study is almost certainly a male bear that was captured and radiotracked (Paisley 2001) in the same valley for over a year in early 1998 (S. Paisley, Durrell Institute of Conservation and Ecology, Canterbury, UK, personal communication, November 2004). This is intriguing because it may indicate site fidelity on the part of that animal. Although we have no data on this bear from mid-1999 until late 2004, we know that it used the same valley in 2004 as 1998.

To improve future camera-trapping density estimates for this species, we recommend sampling over a larger area. This would increase the chances of capturing bears and would also generate more accurate HMMD values for density estimation. However, in a montane landscape this implies a major investment. Our survey required approximately 24 person/weeks of field effort. Operational cost of this study was approximately $3,000 including personnel time. The camera traps used in this survey are valued at approximately $12,000, although they have been used in multiple surveys for other species. Expanding the sampling area would require more camera traps as well as personnel and logistical costs.

We recommend against deploying camera traps for Andean bears in open high Andean grasslands. Five of our camera traps were repeatedly triggered by unknown environmental factors, which was not a problem at the cloud forest camera trap stations.

Efforts should also be made to increase the number of recaptures, thus improving the accuracy of HMMD values for a better estimate of density, particularly in areas where no telemetry data are available. Increasing the number of trap nights would increase recapture rates, although at the risk of violating the demographic closure assumption. Another option would be to increase the density of camera-trapping stations within the sample area. We also recommend using 3 cameras at each station. Given the nature of individual markings for Andean bears, recognition is likely to become more difficult as the number of bears increases.

Andean bears appeared inquisitive and investigated camera traps. In 6 of 7 instances we obtained multiple photographs for a given event. Use of 3 cameras would therefore allow 3 angles and increase the probability that captured bears would be recognizable. Verifying photographic identification using hair traps to obtain DNA would be useful and would provide gender information.

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Literature cited

Castellanos, A. 2004. Andean bear research project in the Intag Region, Ecuador. Andean Bear Conservation Project, Quito, Ecuador. International Bear News 13:25–26.

Cuesta, F., M. Peralvo, and D. Sanchez. 2001. Métodos para investigar la disponibilidad del hábitat del oso andino: El caso de la cuenca del río Oyachi, Ecuador. Ecociencia, Quito, Ecuador. (In Spanish.)

Goldstein, I. 1986. Distribution, habitat use and diet of spectacled bear (*Tremarctos ornatus*) in Venezuela. Proceedings of the First International Symposium on the Spectacled Bear. Institute of Museum Services, Lincoln Park Zoological Society, Chicago Park District, Chicago, Illinois, USA.

Karanth, K., and J. Nichols. 1998. Estimation of tiger densities in India using photographic captures and recaptures. Ecology 79:2852–2862.

———, and ———. 2000. Ecological status and conservation of tigers in India. Final technical report to the Division of International Conservation. Centre for Wildlife Studies, Washington DC, USA.

Karanth, U.K., and J.D. Nichols, editors. 2002. Monitoring tigers and their prey. A manual for researchers, managers and conservationists in Tropical Asia. Centre for Wildlife Studies, Karnataka, India.

Kattan, G., O.L. Hernández, I. Goldstein, V. Rojas, O. Murillo, C. Gómez, H. Restrepo, and F. Cuesta. 2004. Range fragmentation on the spectacled bear *Tremarctos ornatus* in the northern Andes. Oryx 38:155–163.

Mueller, R., S.G. Beck, and R. Lara. 2002. Vegetación potencial de los bosques de Yungas en Bolivia, basado en datos climáticos. Ecología en Bolivia 37:5–14. (In Spanish.)

Navarro, G., and M. Maldonado. 2002. Geografía ecológica de Bolivia. Fundación Patiño, Cochabamba, Bolivia. (In Spanish.)

Nichols, J. 1992. Capture–recapture models. BioScience 42:94–102.

Otis, D., K. Burnham, G. White, and D. Anderson. 1978. Statistical inference from capture data on closed animal populations. Wildlife Monographs 62.

Paisley, S.L. 2001. Andean bears and people in Apolobamba, Bolivia: Culture, conflict and conservation. Dissertation, Durrell Institute of Conservation and Ecology, University of Kent, Canterbury, UK.

Peyton, B. 1980. Ecology, distribution, and food habits of spectacled bears, *Tremarctos ornatus*, in Peru. Journal of Mammalogy 61:639–652.

———, E. Yerena, and D.I. Rumiz. 1998. Status of wild Andean bears and policies for their management. Ursus 10:87–100.

———. 1999. Spectacled bear conservation action plan. Pages 157–198 *in* K. Pelletier, K. Moll, C. Servheen, S. Herrero, and J. Moll, editors. Status and Conservation Action Plan, BEARS. IUCN/SSC Bear and Polar Bear Specialist Groups, IUCN, Gland, Switzerland), and Cambridge, UK.

Rexstad, E., and K.P. Burnham. 1991. User's guide for interactive program CAPTURE. Abundance estimation of closed populations. Colorado State University, Fort Collins, Colorado, USA.

Ríos-Uzeda, B., H. Gómez, and R.B. Wallace. 2006. Habitat preferences of the Andean bear (*Tremarctos ornatus*) in the Bolivian Andes. Journal of Zoology 268:271–278.

Roth, H. 1964. Ein Beitrag zur Kenntis von *Tremarctos ornatus* (Cuvier) Der. Zoologische Garten 29:107–129. (In German.)

Rumiz, D.I., and J. Salazar. 1999. Status and management of the spectacled bear in Bolivia. Pages 164–168 *in* C. Servheen, S. Herrero, and B. Peyton, compilers, editors. Bears: Status survey and conservation action plan. IUCN/SSC Bear and Polar Bear Specialist Groups, IUCN, Gland, Switzerland, and Cambridge, UK.

Silver, S.C., L.E.T. Ostro, L.K. Marsh, L. Maffei, A.J. Noss, M.J. Kelly, R.B. Wallace, H. Gómez, and G. Ayala. 2004. The use of camera traps for estimating jaguar *Panthera onca* abundance and density using capture/recapture analysis. Oryx 38:148–154.

White, G.C., D.R. Anderson, K.P. Burnham, and D.L. Otis. 1982. Capture–recapture and removal methods for sampling closed populations. Los Alamos National Laboratory, Los Alamos, New Mexico, USA.

Wilson, K.R., and D.R. Anderson. 1985. Evaluation of two density estimators of small mammal population size. Journal of Mammalogy 66:13–21.

Yerena, E. 1994. Corredores ecológicos en los Andes de Venezuela. Parques Nacionales y Conservación Ambiental, Caracas, Venezuela. (In Spanish.)

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