The recovery of a population of the Vulnerable taruka *Hippocamelus antisensis* near La Paz, Bolivia: opportunities for conservation and education

Josef Rechberger, Luis F. Pacheco, A. Nuñez, A. I. Roldán O. Martínez and Geovanna Mendieta

Abstract The taruka *Hippocamelus antisensis*, a species of deer categorized as Vulnerable on the IUCN Red List, was thought to be locally extinct in the environs of La Paz, Bolivia. However, local people from Mecapaca municipality reported seeing tarukas at their former community establishment, which had been abandoned several years previously. After confirming the presence of taruka we conducted intensive surveys from which we estimated minimum abundance, and then calibrated relative abundance indices (faecal and track counts) to the abundance estimate. Using these calibrated indices we carried out a preliminary estimate of the total abundance of the species in the municipality of Mecapaca. We also carried out conservation education activities with teachers and students at local schools, which we discuss here in terms of the long-term conservation of this threatened species.

Keywords Andean deer, Bolivia, conservation education, *Hippocamelus antisensis*, species recovery, taruka, threatened species

Introduction

The taruka *Hippocamelus antisensis* is found in high-altitude (2,300–5,000 m) habitats of Peru, Bolivia, Chile and Argentina (Redford & Eisenberg, 1992; Anderson, 1997) and is categorized as Vulnerable on the IUCN Red List of Threatened Species (Barrio & Ferreyra, 2008). Based on national assessments the species is Endangered in Argentina (Díaz & Ojeda, 2000) and Vulnerable in Chile (Gonzáles et al., 2000) and Peru (Decreto Supremo No 034-2004-AG). It is considered to be extinct in Ecuador, although it may never have occurred there (Tirira, 2001). Archaeological studies have shown that the taruka was once present in Colombia (Díaz, 1995) but the species probably never occurred further north than Peru (Barrio, 2010).

In Bolivia the main threats to taruka are illegal hunting (all hunting of this species is illegal), habitat destruction and expansion of agricultural frontiers (Nuñez, 2009). Tarukas were once common in the dry valleys surrounding the city of La Paz, where they were hunted by local people for sport (LFP, pers. obs.). By the late 1980s the species was considered locally extinct (Mercado & Miralles, 1991), probably as a result of sport hunting activities given that relatively large patches of slightly degraded habitat areas were still available close to La Paz (Forno & Baudoin, 1991).

Following conversations with local people from the Mecapaca municipality in 2009, a systematic search for taruka signs was carried out and we confirmed the return of this species to areas where it was reported to be extinct c. 30 years ago. Here we present our findings on the distribution and abundance of tarukas in an area close to La Paz and discuss opportunities for improving conservation efforts for the taruka through educational activities.

Study area

The municipality of Mecapaca is adjacent to the city of La Paz and is located to the south, south-east and south-west of the city (Fig. 1). It covers c. 405 km², at altitudes of 2,450–3,700 m. Urban development is restricted to the centre of the municipality and next to the southern extension of La Paz. Mecapaca is accessible from La Paz by a two-way, partially paved road, with the exception of a small number of communities that are accessible only by foot.

Vegetation in the study area is dominated by shrubs (*Acacia macracantha, Tecoma arequipensis, Adesmia spinosa, Baccharis boliviensis, Stevia bangii, Baccharis tola* var. *incarum, Baccharis obtusifolia, Aristida asplundii, Nassella meyeniana* and *Bidens andicola*) and cacti (*Oreocereus pseudofossulatus, Trichocereus lageniformis* and *Corryocactus melanotrichus*) (R.P. López, pers. comm., 2010) . There are some open woodlands, with species such as *Schinus molle, Prosopis flexuosa* and *Carica quercifolia*. Grass and herbaceous species include *Stipa ichu, Nassella*

Josef Rechberger, Luis F. Pacheco* (Corresponding author), A. Nuñez, A. I. Roldán and Geovanna Mendieta Centro de Estudios en Biología Teórica y Aplicada, Av. Las Retamas No. 15, entre calles 34 y 35, Cota Cota, La Paz, Bolivia. E-mail luispacheco11@yahoo.com

O. Martínez Museo Nacional de Historia Natural, Colección Boliviana de Fauna, Universidad Mayor de San Andrés, La Paz, Bolivia

*Also at: Instituto de Ecología, Colección Boliviana de Fauna, Universidad Mayor de San Andrés, Casilla 10077, Correo Central, La Paz, Bolivia

Received 22 June 2012. Revision requested 13 August 2012. Accepted 13 November 2012. First published online 12 May 2014.

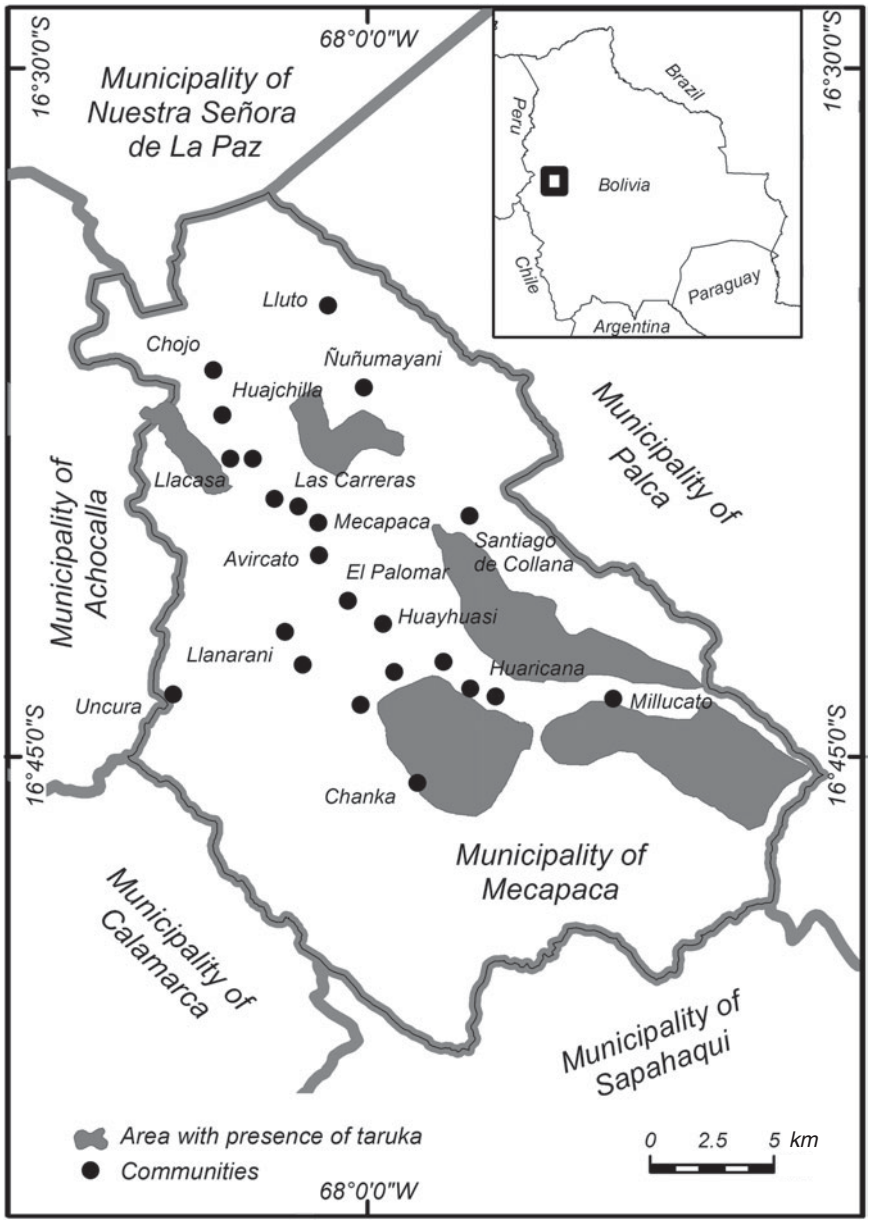

FIG. 1 Location of the study area, near La Paz, Bolivia, showing the distribution of taruka *Hippocamelus antisensis* in the municipality of Mecapaca.

meyeniana, Dichondra microcalyx, Aristida asplundii and *Festuca dolichophylla.*

Methods

We carried out field work in three phases. The first two consisted of 15-day periods in November 2009 and January 2010, focused on the community of Llacasa, one of the closest to La Paz. This community was chosen based on local people reporting the presence of tarukas in areas where dwellings had been abandoned because residents wanted to move closer to the road to La Paz and the La Paz River. The field surveys were carried out in an area of 2,000 ha, at an altitude of 3,300–3,600 m. Although the study area is used extensively for sheep ranching and as seasonal grazing land for a small number of horses and cows during the rainy season (December–March) it is not visited frequently during the rest of the year and is free of livestock during April–November.

During the third phase of field work (15 days in May and June 2010) we visited 17 other communities across the municipality. We assessed the occurrence and relative abundance of taruka sign (tracks and faeces) at each community and conducted some informal interviews with local residents.

We also carried out conservation education workshops and activities at five local schools, focused on the Cycle of Inquiry (Feinsinger et al., 1997, 2010). A total of 708 children aged 5–13 and their teachers participated in 27 activities, including 1-day research projects, a science fair and role play. Role-playing activities involved 80 older

https://doi.org/10.1017/S0030605312001561 Published online by Cambridge University Press

children (> 12 years) at three schools, and students had to defend their positions as hunters, ecotourism entrepreneurs or conservationists.

Sampling at Llacasa community

During the first 7 days of our first visit to Llacasa two experienced researchers (JR and OM) searched the area for signs of taruka (sightings, tracks and faeces). We used these data to estimate the relative abundance of signs, to be used as a calibrated index for the other sites. We then established eight 500-m transects in the area actively used by tarukas. Transects were spaced at least 100 m apart. Immediately after establishment each transect was searched thoroughly and deer signs were erased after data had been collected. Each transect was then surveyed twice per day (early in the morning and before sunset) over 6 consecutive days. Tracks and faecal samples were recorded, as well as any sightings of taruka. There were no sheep in the study area during our survey, nor were there other deer or camelid species, virtually eliminating the possibility of mistaking tracks or faeces of other wildlife or livestock for those of taruka. Two transects (separated by at least 300 m) were surveyed simultaneously by one or two observers to increase the probability of direct sightings and reduce the possibility of double counting. As a further measure against double counting we considered the timing of observations and the distance between simultaneous observations. Direct observations made at the same time on different transects allowed us to estimate the minimum abundance of individuals in the area (modified from Povilitis, 2002; Barrio, 2007; Wittmer et al., 2010), which we used to calculate the minimum density for calibration of our indirect abundance indices. We used tracks to confirm that no other tarukas were using the area at the same time on other transects and we are confident that our abundance estimate is only for a minimum number of individuals.

Preliminary estimate of abundance for Mecapaca municipality

Given the similarity of all the sampled sites in terms of vegetation, altitude and past perturbations and that the same human migration patterns occur at all sites, we assumed that sampling using the same methods and protocols as used at Llacasa would give comparable results at other localities. To estimate the relative abundance of tarukas at other sites we used a calibrated index based on mean values of the number of faecal samples collected and tracks recorded per day during the 3-day search at Llacasa; i.e. the index of faecal samples per day and tracks per day (sequence of tracks, not individual marks) obtained during 1-day surveys at the other communities where tarukas were confirmed to be present were used to estimate the density of individuals as a proportion of the density at the Llacasa site, where we considered that we had a good estimate of minimum abundance. Using this estimated density and the size of the sampled area (calculated using *ArcView v. 9.3*; ESRI, Redlands, USA) we estimated the abundance at each of the other areas (groups of communities) visited. Based on the assumption that our relative density indices are linearly related to absolute density, this provided a preliminary estimate of the total population in the municipality.

Results

We confirmed the presence of taruka at nine of the 18 sites surveyed, covering an estimated 20.1% of the total area of the Mecapaca municipality. Sites where the presence of tarukas was confirmed were grouped according to their sharing of contiguous taruka habitat.

At Llacasa community, which is relatively isolated from the other sites (Fig. 1), we estimated that a minimum of eight adult tarukas (2–3 males and 5–6 females) inhabited an area of c. 4.63 km^2. Data from the 3-day search at Llacasa yielded abundance indices of 7.6 ± SD 0.58 tracks per day and 15.3 ± SD 8.50 faecal groups per day. Using this index as a calibrated relative abundance index at the other five sites we estimated densities of 13–63% of that at Llacasa, abundance of 5–23 deer per site, and a total of 58 tarukas in the entire municipality of Mecapaca (Table 1).

Direct observations of deer were not common and yielded the most variable data (having a relatively large coefficient of variation). The smallest coefficient of variation was obtained when all data gathered during transect surveys were considered recordable (Table 2). There was a concern that tarukas might move away from an area used intensively by humans, resulting in data from consecutive days being flawed. However, the highest (negative) correlation between sampling day and index of abundance was found for the track counts and was not statistically significant ($r_s = -0.42$, $P = 0.39$, $n = 6$), suggesting that the presence of researchers in the area was not affecting our sampling, at least within this time frame.

Using *Monitor v. 10.0* (Gibbs & Ene, 2010) we simulated a 10-year monitoring programme under the same conditions (number of transects, number of surveys and coefficient of variation) as this study. The sampling procedure was sufficient to obtain an 80% power to detect trends as small as a 6% annual decrease in the population of Llacasa, even when only direct observations were used. Therefore, we are confident that we can detect biologically relevant population trends, using faecal counts, track counts or all the data, including signs and direct observations. Our method of choice is to consider data for tracks and faeces separately.

https://doi.org/10.1017/S0030605312001561 Published online by Cambridge University Press

TABLE 1 Relative abundance of the taruka *Hippocamelus antisensis* in Mecapaca municipality, Bolivia (Fig. 1), based on tracks and faecal group counts calibrated to an absolute abundance estimate (at the Llacasa site). Figures for communities other than Llacasa are estimates based on the relationship of a 1-day survey to the calibrated index for Llacasa (see text for further details). The total is an estimate of the minimum number of adults in Mecapaca.

Site	Area (km^2)	Mean ± SD no. of tracks per day	Mean ± SD no. of faecal samples per day	% relative density (tracks or faecal samples per day for Llacasa)	Estimated density (as proportion of density at Llacasa)	Estimated no. of individuals
Chanka	21.14	0	6	39	0.67	14
Milocato-Tahuapalca	25.94	4	0	53	0.89	23
Collana	22.64	0	2	13	0.22	5
Ñuñumañani	7.41	5	0	66	1.12	8
Llacasa	4.63	7.6 ± 0.58	15.3 ± 8.50	0	1.7	8
Total						58

Discussion

We acknowledge that the use of an index calibrated at one site to estimate abundance at other sites is not recommended, given that the index (faecal counts and track counts in this case) may be affected by factors dependent on the locality surveyed (these effects will have been minimal in our case, given the similarity and closeness of the sites) and by other factors (such as weather and individual variations in sign production) associated with the specific date of the survey (Walker et al., 2000). Our result can therefore only be considered a first approximation of the abundance of the taruka in Mecapaca and not as a basis for management decisions. Furthermore, our density estimate for each of the localities surveyed using the index calibrated at Llacasa is based only on a 1-day effort estimation. We did not try to calculate confidence intervals for any of those estimates because of our small sample size. However, we believe that an estimate of 58 tarukas in Mecapaca municipality may be a reasonable minimum estimate. Further work is required to test the hypothesis that the probability of detection of signs is similar between sites, and to examine the relationships of both faecal and track counts with actual density in more locations in the study area.

The recovery of the taruka population from presumed extinction in an area to a population of c. 58 individuals is a rare but not totally unexpected event. The site at Llacasa, where our most intensive fieldwork was done, was abandoned by residents about 3 years before our study and local people had started to leave the area about 10 years before our first visit. Grau & Aide (2008) described positive effects of rural–urban migration on ecosystem recovery in several parts of Central and South America. In this regard the recovery of the taruka in Mecapaca may be the result of a common process among human societies in the Andes and other regions in America.

Our density estimate for the taruka in Llacasa (1.7 km^{-2}) is similar to the highest recorded density of the taruka in Peru (1.76 km^{-2}; Barrio, 2007), which is the highest reported for the species so far. Our density estimate was larger than that reported by García et al. (2008) for huemul *Hippocamelus bisulcus* in central Chile (< 1 km^{-2}) and comparable to that reported for huemul in Chilean Patagonia (mean 1.79 ± SD 0.33 for 3 years; Corti et al., 2010). Given the history of hunting and the fact that the taruka population at Mecapaca may still be recovering from local extinction, we believe that the population at Mecapaca may not be at carrying capacity and hence we may expect further increases in abundance in the coming years if habitat is preserved and hunting does not occur.

Although *Hippocamelus* species may feed on some of the same food as livestock (Barrio, 2007; Vila et al., 2009), Bolivian ranchers do not generally complain about possible

https://doi.org/10.1017/S0030605312001561 Published online by Cambridge University Press

TABLE 2 Data from transect surveys at Llacasa, with percentage of transects (n = 8 for each survey) for which tracks, faeces and sightings were recorded.

Survey	Tracks[1]	Faeces[2]	Sightings	All data (% of transects for which at least one type of sign was recorded)
1	75.00	25.00	0.00	75.00
2	25.00	25.00	25.00	50.00
3	37.50	25.00	25.00	50.00
4	50.00	25.00	12.50	62.50
5	62.50	37.50	12.50	75.00
6	12.50	12.50	12.50	37.50
Mean ± SD	43.75 ± 23.39	25.00 ± 7.91	14.58 ± 9.41	58.33 ± 15.14
Coefficient of variation	0.53	0.32	0.65	0.26

[1]Sets of imprints, not individual tracks
[2]Groups of faecal samples

competitive interactions between tarukas and their domestic animals (Nuñez, 2008). Hunting of tarukas is therefore a consequence of other human interests, such as sport. Tarukas were hunted by the Incas from as early as the 1500s, and possibly used for ceremonies (Díaz, 1995). However, the collapse of the taruka population in the 20th century is thought to have been caused by extensive hunting in the environs of La Paz during the 1960s and 1970s. Hunting of tarukas in Mecapaca is not common although it still occurs (LFP, pers. obs.). Based on our initial contact with local people and children through this study and our conservation education activities, we believe that they would be willing to cease hunting taruka for meat. Sport hunting may be the main threat to be addressed for the long-term conservation of taruka in the vicinity of La Paz. Hunting must be controlled to facilitate the continued recovery of taruka populations, as demonstrated for other threatened species (Ale et al., 2007; Recharte Uscamaita & Bodmer, 2009; Herrero et al., 2010).

The elimination of hunting both for meat and for sport may not be possible if local people are not actively engaged in the conservation effort, which requires them to know and care for the species. Prior to our educational workshops only 5% of local children knew about the existence of the taruka on their lands, and all of them lived in the communities where the presence of the taruka was verified during field work. In all three role-play sessions students decided not to hunt deer but to use the species as an ecotourism attraction or to conserve it for its intrinsic value (our participation in those discussions was mostly as referees or moderators).

Our education activities also suggested that local people may be willing to engage in conservation efforts, especially if there are economic benefits, for example through ecotourism. The taruka is large, charismatic and easily visible, with the potential to become a flagship species. It can be found within an hour's drive from La Paz, which is the most visited city in the country, and one of the most populated. We propose that an ecotourism initiative may be the best way to ensure the conservation of this and other species in the region while providing economic benefits for local people.

Ecotourism alone is not a sufficient tool for the conservation of a species and presents its own problems, requirements and limitations (Krüger, 2005) but it is worth exploring. Tarukas can serve as an entry point for conservation education and awareness-raising, and the participation of local people in conservation programmes will increase the likelihood of their success. Since completing this study we have not conducted further work in the field because the new community authorities at Llacasa were not receptive to the idea of working to protect a threatened species. However, we maintain contact with members of the community at Llacasa and of other communities within Mecapaca municipality and we are confident that we will gain support for the idea of maintaining part of the communal lands as a wildlife refuge.

Acknowledgements

Funding was provided by the Chicago Board of Trade Endangered Species Fund of the Chicago Zoological Society. Mario Mamani, the highest local authority at Llacasa community during the period of field work, helped with permits to work in the area. The Bolivian authority Dirección General de Biodiversidad provided permits to carry out the research. Jaime Jiménez, Alejandra Muñoz, Walfrido M. Tomas, Heiko Wittmer, Stephen Taranto and an anonymous reviewer all helped improve this article. Celestino Quispe and Gilbert Tusco helped during field work.

References

ALE, S.B., YONZON, P. & THAPA, K. (2007) Recovery of snow leopard *Uncia uncia* in Sagarmatha (Mount Everest) National Park, Nepal. *Oryx*, 41, 89–92.

Anderson, S. (1997) Mammals of Bolivia: taxonomy and distribution. *Bulletin of the American Museum of Natural History*, 231, 1–652.

Barrio, J. (2007) Population viability analysis of the taruka *Hippocamelus antisensis* (D'Orbigny, 1834) (Cervidae) in southern Peru. *Revista Peruana de Biología*, 14, 193–200.

Barrio, J. (2010) Taruka *Hippocamelus antisensis* (d'Orbigny, 1834). In *Neotropical Cervidology: Biology and Medicine of Neotropical Deer* (eds J.M.B. Duarte & S. Gonzalez), pp. 77–88. FUNEP, Jaboticabal, Brazil, and IUCN, Gland, Switzerland.

Barrio, J. & Ferreyra, N. (2008) *Hippocamelus antisensis*. In *IUCN Red List of Threatened Species v. 2011.2*. Http://www.iucnredlist.org [accessed January 2011].

Corti, P., Wittmer, H.U. & Festa-Bianchet, M. (2010) Dynamics of a small population of endangered huemul deer (*Hippocamelus bisulcus*) in Chilean Patagonia. *Journal of Mammalogy*, 9, 690–697.

Díaz, N.I. (1995) Antecedentes sobre la historia natural de la taruca (*Hippocamelus antisensis* D'Orbigny 1834) y su rol en la economía andina. *Chungara*, 27, 45–55.

Díaz, G.B. & Ojeda, R.A. (eds) (2000) *Libro Rojo de Mamíferos de la Argentina*. Sociedad Argentina para el Estudio de los Mamíferos, Buenos Aires, Argentina.

Feinsinger, P., Álvarez, S., Carreño, G., Rivera, E., Cuéllar, R.L., Noss, A. et al. (2010) Local people, scientific inquiry, and the ecology and conservation of place in Latin America. In *The Ecology of Place* (eds I. Billick & M.V. Price), pp. 403–428. The University of Chicago Press, Chicago, USA.

Feinsinger, P., Magutti, L. & Oviedo, R.D. (1997) School yards and nature trails: ecology education outside the university. *Trends in Ecology and Evolution*, 12, 115–120.

Forno, E. & Baudoin, M. (1991) *Historia Natural de un Valle en los Andes, La Paz*. Instituto de Ecología. Carrera de Biología. Facultad de Ciencias Puras y Naturales. Universidad Mayor de San Andrés, La Paz, Bolivia.

García, K., Jara, A., Ortiz, J.C. & Victoriano, P. (2008) Evaluación de un escenario de extinción para la última población de *Hippocamelus bisulcus* (Molina 1782) de Chile Central. *Interciencia*, 33, 152–159.

Gibbs, J.P. & Ene, E. (2010) *Monitor v.11.0.0*. Estimating the statistical power of ecological monitoring programs. Http://www.esf.edu/efb/gibbs/monitor/ [accessed 14 April 2014].

Gonzáles, G., Torres-Mura, J.C. & Muñoz Pedreros, A. (2000) Orden Artiodactyla. In *Mamíferos de Chile* (eds A. Muñoz Pedreros & J. Yañez-Valenzuela), pp. 189–205. CEA, Valdivia, Chile.

Grau, H.R. & Aide, M. (2008) Globalization and land-use transitions in Latin America. *Ecology and Society*, 13, 16.

Herrero, J., Garin, I., Prada, C. & García-Serrano, A. (2010) Inter-agency coordination fosters the recovery of the Pyrenean chamois *Rupicapra pyrenaica pyrenaica* at its western limit. *Oryx*, 44, 529–532.

Krüger, O. (2005) The role of ecotourism in conservation: panacea or Pandora's box? *Biodiversity and Conservation*, 14, 579–600.

Mercado, I. & Miralles, J. (1991) Mamíferos. In *Historia Natural de un Valle en los Andes, La Paz* (eds E. Forno & M. Baudoin), pp. 293–344. Instituto de Ecología, Universidad Mayor de San Andrés, La Paz, Bolivia.

Nuñez, A. (2008) *Estado de conservación de la taruka (Hippocamelus antisensis) en Bolivia*. MSc thesis. Universidad Nacional Experimental de los Llanos Occidentales Ezequiel Zamora, Barinas, Venezuela.

Nuñez, A. (2009) Mamíferos. In *Libro Rojo de la Fauna Silvestre de Vertebrados de Bolivia*, pp. 479–481. Ministerio de Medio Ambiente y Agua, La Paz, Bolivia.

Povilitis, A. (2002) El estado actual del huemul (*Hippocamelus bisulcus*) en Chile Central. *Gayana*, 66, 59–68.

Recharte Uscamaita, M. & Bodmer, R. (2009) Recovery of the endangered giant otter *Pteronura brasiliensis* on the Yavarí-Mirín and Yavarí rivers: a success story for CITES. *Oryx*, 44, 83–88.

Redford, K.H. & Eisenberg, J.F. (1992) *Mammals of the Neotropics, Volume 2: The Southern Cone*. The University of Chicago Press, Chicago, USA.

Tirira, D. (2001) *Libro Rojo de los Mamíferos del Ecuador*. Sociedad para la Investigación y Monitoreo de la Biodiversidad Ecuatoriana (SIMBIOE)/Ecociencias, Ministerio del Ambiente/UICN. Publicación Especial sobre los Mamíferos del Ecuador, Quito, Ecuador.

Vila, A.R., Borrelli, L. & Martínez, L. (2009) Dietary overlap between huemul and livestock in Los Alerces National Park, Argentina. *Journal of Wildlife Management*, 73, 368–373.

Walker, R.S., Novaro, A.J. & Nichols, J.D. (2000) Consideraciones para la estimación de abundancia de poblaciones de mamíferos. *Mastozoología Neotropical*, 7, 73–80.

Wittmer, H.U., Corti, P., Saucedo, C. & Galaz, J.L. (2010) Learning to count: adapting population monitoring for endangered huemul deer *Hippocamelus bisulcus* to meet conservation objectives. *Oryx*, 44, 516–522.

Biographical sketches

Josef Rechberger's work focuses on surveying mammal populations for environmental impact assessments and developing management plans for protected areas. Luis Pacheco's research interests include wildlife ecology and management, and the conflicts between conservation and development. Ángela Nuñez specializes in deer biology, with a particular focus on Andean deer in Bolivia. Alejandra Roldán is an ecologist with a focus on conservation education. Omar Martínez's research is focused on birds. He also works on the management of wildlife and protected areas. Geovanna Mendieta works mainly in environmental education.

https://doi.org/10.1017/S0030605312001561 Published online by Cambridge University Press