A COMPARISON OF THREE METHODS TO ESTIMATE VARIATIONS IN THE RELATIVE ABUNDANCE OF MOUTAIN VIZCACHAS (*Lagidium viscacia*) IN THE HIGH ANDES ECOSYSTEMS

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ABSTRACT: Mountain vizcachas are large rodents that constitute the main prey of the High Andes meso-carnivores. We compared the line transect pellet count, observation rate and photographic rate methods to estimate the relative abundance of Mountain vizcachas in the High Andes ecosystems. Although a more formal validation based on the comparison with true abundances is desirable, our results suggested that these simple and affordable indices are promising methods, especially if protocols and sampling efforts are carefully standardized. We recommend the use of photographic rates, which are likely to provide the most reliable estimates, especially where Mountain vizcachas are active at night.

RESUMEN: Una comparación de tres métodos para la estimación de las variaciones en la abundancia relativa del chinchillón (*Lagidium viscacia*) en ecosistemas alto-andinos. Los chinchillones son roedores de gran tamaño que representan la presa principal de los meso-carnívoros alto-andinos. Para estimar la abundancia relativa de chinchillones en los ecosistemas alto-andinos, se compararon conteos de fecas en transectas lineales, frecuencia de observación y de capturas fotográficas. A pesar de que una validación más formal basada en la comparación con abundancias reales es deseable, nuestros resultados sugieren que estos índices simples y de bajo costo son métodos prometedores, en particular si los protocolos y el esfuerzo de muestreo son cuidadosamente estandarizados. Recomendamos el uso de la frecuencia de capturas fotográficas, que probablemente brinda las estimaciones más confiables, especialmente en los sitios donde los chinchillones son activos durante la noche.

Key words. Andean cat. Camera trapping. Direct counts. Fecal pellet counts. Rodents.

Palabras clave. Conteos de fecas. Conteos directos. Gato andino. Roedores. Trampeo fotográfico.

Estimating and monitoring the abundance of animals is essential for understanding their population ecology and devising management and conservation strategies (Caughley and Sinclair, 1994; Wilson and Delahay, 2001). However, in many cases, precise estimates of absolute abundance may be difficult to obtain (Gibbs, 2000), and tested methodologies for accurately estimating population trends across a variety of habitats are adequate to formulate and achieve wildlife conservation and management objectives (Walker et al., 2000a; Tomas et al., 2006).

Mountain vizcachas (*Lagidium viscacia*) are large rodents occurring in the dry areas of the Andes and the Patagonian steppe, where they are strictly associated to rocky habitats (Redford and Eisenberg, 1992; Walker et al.,

2000b; 2003). Mountain vizcachas are the main prey item in the diet of the Andean cat (Walker et al., 2007; Napolitano et al., 2008), an endangered small felid endemic to the High Andes (Villalba et al., 2004), and it has been hypothesized that Mountain vizcacha availability affects this cat's abundance and distribution (Nowell and Jackson, 1996; Walker et al., 2007). Since direct population counts require to maximize detection probability, and the patterns of activity of this rodent may vary according to the site and the time of the year (Walker et al., 2008; Lucherini et al., unpubl. data), this technique may demand large amounts of time (Walker et al., 2000c; 2008). Thus, affordable and simple methods are useful to estimate the abundance of Mountain vizcacha populations and provide reliable indices of variation between areas. Indices are often used for monitoring and comparative analyses of populations (e. g., Smallwood and Schonewald, 1998; Slade and Blair, 2000). To be valid as a measure of relative abundance, an index should be related to true abundance by a constant proportion (Lancia et al., 1994; Gibbs, 2000). Walker et al. (2000c) showed that counts of fresh fecal pellet groups along the top of cliffs was a valid index of abundance under the condition of their study area in the Patagonian steppe, where small groups of Mountain vizcachas inhabit low, vertical cliffs.

In this paper, we modified Walker et al. (2000c) pellet count method to account for more variable environmental conditions and compared it with two alternative methods, observation rate and photographic rate, to estimate the relative abundance of Mountain vizcachas in the high Andes ecosystems.

From 2001 to 2006, we carried out Mountain vizcacha abundance estimates in seven sampling areas of Northwestern Argentina, latitudinally distributed from central Catamarca province (latitude: 26°30'S) to the north of Jujuy province (21°50'S), and with altitudes ranging from 3700 m to 5000 m (**Table 1**). Since Walker et al. (2000c) did not find differences in vizcacha abundance between spring and fall, fieldwork was carried out in both

seasons. However, in order to avoid variations due to temporal factors, in a given area, each method was conducted simultaneously. We estimated Mountain vizcacha relative abundance through three methods:

1. Observation rate. Mountain vizcachas were counted while moving through the study area in search for carnivore signs and an observation rate index was computed as the number of vizcachas sighted divided by sampling effort. Sampling effort, estimated as the number of researchers multiplied by the number of search hours, proved to be highly correlated to distance walked in three areas where both data on sampling effort were recorded.

2. Line-transect-based estimation of fecal pellet abundance. As line transects were walked in search for carnivore signs, the abundance of Mountain vizcacha fecal pellets abundance (henceforward scat abundance) was estimated by eye and assigned to one of four classes, ranging from 0 (absent) to 3 (very common), at sampling points separated by 15-25 m of distance and averaged among points. All researchers trained together to ensure consistency in the use of these classes. The length of each transect was measured using a 50-m-long measuring tape. Since the use of these classes is potentially subject to personal interpretation, we also used presence/absence and computed the proportion of sampling points occupied by Mountain vizcachas as a second index of abundance. Since these two indices of abundance resulted correlated (Pearson $r = 0.586$, n = 10 areas, p = 0.038, 1-tailed), for the following analyses, we discarded the presence/absence index, which has the disadvantages of retaining a lower amount of information and is subject to becoming saturated at high population densities, resulting in a asymptotic relationship between index values and actual abundance (Gibbs, 2000).

3. Photographic rate. Comparisons of camera trapping capture rates to independent estimates of animal density have suggested that this index may provide a robust estimate of animal abundance for a wide range of species (Carbone et al., 2001; McCarthy, 2007), and has been applied for several species (Griffiths

Table 1

Elevation range and mean values of the three indices of relative abundance for the seven study areas in the High Andes of Argentina where Mountain vizcacha populations were studied.

Study area	Elevation range (m)	Observation rate	Scat abundance	Photographic rate
Los Alisos	3700-4850	0.96	1.43	8.97
Coranzuli	3800-4050	0.84	1.24	5.45
Laguna Blanca	3800-4350	1.13	1.29	6.81
Santa Catalina	3950-4300	0.8	0.71	5.88
Loma Blanca	4100-4850	0.56	0.99	5.41
Cuevas	4500-4900	0.69	0.91	6.71
Vilama	4640-5000	0.24	0.77	2.98

and van Schaik, 1993; Cutler and Swann, 1999; Silveira et al., 2006). Camera traps (n = 15) were placed in close proximity to sites where Mountain vizcachas or their feces were observed. Stations were checked every three days. All camera traps used passive infra-red detection systems that were programmed to operate continuously without a camera delay. Camera traps were set at a height of approximately 30 cm and were programmed to record the date and hour on each photograph. In order to avoid double counts of individuals, photographic rate was calculated as the number of «photo events» during the survey/100 camera trap days (Carbone et al., 2001; Jackson et al., 2005). We define a photo event as being any photo (or set of photos at a given photo-trap site) of a Mountain vizcacha taken during a distinct time period (daylight and nighttime).

In an effort to ensure independence of estimates, Mountain vizcacha counts were carried out over a much larger area than that covered by line transects, and camera traps were not positioned along line transects. Although the total sizes of sampling areas were not calculated precisely, they ranged from 10 to 25 km^2, approximately, and included many rocky outcrops with Mountain vizcacha colonies.

The use of indices to estimate variations in abundance is based on the assumption that the detection probability in different areas is comparable (e.g., Conn et al., 2004; Karanth et al., 2004; Greenwood and Robinson, 2006). In spite of the fact that sampling effort varied between areas, in an effort to reduce varia-

tions in detectability we adopted standardized protocols for all methods. Although standardization of methods has been widely recognized as a valuable tool to reduce the variations likely to affect index ratios (Greenwood and Robinson, 2006), it is possible that variations in index values are due to differences in detectability and before adopting them as estimates of relative abundance they should be compared to true population numbers. None of the methods we used here provides an estimate of population size, which can be compared to our indices to test them. So, to test if the variations in density provided by these indices reflect the true variations in population numbers, we assessed correlation among them (Bonesi and Macdonald, 2004). Our assumption is that if two independent estimates do not reflect true population abundances, their variations would not be correlated to one another.

Simple correlation analyses were used to compare values from each method to one another, with alpha levels set at 0.10. Due to small sample sizes, and high levels of potential error, we felt that an alpha of 0.10 represented a significant difference from null hypothesis.

First, we constructed pairwise scatterplots of our indices and a regression line was drawn through the points to visually inspect the existence of a linear association between them (Kinnear and Gray, 2006). A Pearson correlation (r) matrix was then built between all three methods.

We observed 942 Mountain vizcacha (range: 59-246 vizcachas) during 1303.67 researcher hours (range: 80.4-250.5 researcher hours); 83 line transects (range: 9-22 transects per area) were completed, for a total length of 28 985 m (range: 2850-6535 m); camera trapping effort totaled 1385 trap days (range: 51-570 trap days), and enabled us to record 396 Mountain vizcacha photos. To avoid double counts, these photos were grouped in 70 Mountain vizcacha events (range: 3-19 events).

Means (± SD) were 0.74±0.29 vizcachas/research hour for observation rate, 1.05±0.28 for scat abundance, and 6.03±1.82 events/100 trap days for photographic rate (**Table 1**).

Pairwise scatterplots suggested the presence of a linear positive relationship, the lack of important outliers, and that the use of the Pearson correlation statistic was meaningful (**Fig. 1**). All values of pairwise correlations were significant and relatively strong (**Fig. 1**).

In spite of relatively large variations in sampling effort, and the great variety of habitats covered by expeditions, our results showed the existence of positive and strong relationships among the Mountain vizcacha abundance values provided by all methods. Although the possibility that differences among index values are the results of differences in detectability can not be excluded (Conn et al., 2004; Greenwood and Robinson, 2006), and a more formal validation based on the comparison with true abundance estimates is still desirable, we conclude that it is rather unlikely to find such an agreement among index values if they are not produced by real variations in abundance. Considering the remoteness and extreme field conditions of the High Andes, we suggest that these simple and affordable indices are promising methods for the estimation of Mountain vizcacha relative abundance in the High Andes ecosystems, especially if protocols and sampling efforts are carefully standardized.

Some landscapes are so remote, steep or densely vegetated that only a few survey methods could be practicable (Silveira et al., 2003). Indirect methods are potentially more practical for large-scale surveys as they are usually less expensive. In addition animal signs are
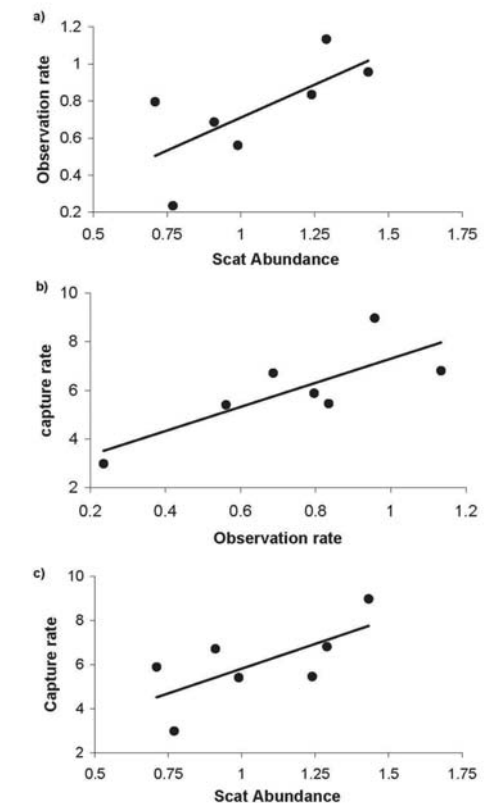

Fig. 1. Pairwise scatterplots between three indices for the estimation of Mountain vizcacha relative abundance. Pearson r values and their respective significativity were as follows: a) $r = 0.70$, $p = 0.08$; b) $r = 0.792$, $p = 0.034$; c) $r = 0.681$, $p = 0.092$.

often detectable across a range of animal densities and in a wide variety of habitats, including those where direct visibility is poor, and may result in estimates with lower confidence limits (Jachmann, 1991). Nevertheless, in our study, the proportion of variability of data explained by the relationships between index values was particularly large in the case of the two methods based on direct evidences (observation rate and photographic rate), indicating that they are probably more reliable as indices for relative abundance for Mountain vizcachas. This is not surprising, since indices based on fecal pellet abundance are affected by additional sources of variability, such as feces decay and defecation rates, as well as

environmental factors (e.g., exposure to winds, slope steepness), which can influence pellet detectability and abundance (Walker et al., 2000c; Greenwood and Robinson, 2006).

Sometimes the choice of a method is limited not by technique efficiency, but by field costs, especially when studied populations occur in remote areas (Silveira et al., 2003). Camera trapping is clearly the most expensive of the three methods compared here, since it requires the use of relatively expensive equipment, comparatively long sampling periods, and frequent checking (especially in the case of film cameras). Nevertheless, costs can be greatly reduced if this technique is simultaneously used to study other ecological subjects, like animal activity patterns, and/or collect data on other species. Additionally, a recent study concluded that a single count of mountain vizcachas at a site does not provide a reliable index of relative abundance (Walker et al., 2008). Finally, in comparison to direct observations, camera trapping has the additional advantage that is not limited to daylight hours, which may be of importance where nocturnal activity is frequent, and is not affected by reduced visibility, as may be the case where terrain is very broken (Walker et al., 2008). Although Mountain vizcachas have been described as mainly diurnal (Nowell and Jackson, 1996), 72% of the photos we obtained were taken at night. This suggests that, in the High Andes, indices of abundance based on direct diurnal observation may be affected by this additional source of bias. Thus we suggest that photo rate is likely to provide the most reliable estimate of relative abundance among the ones we tested.

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