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Flight behavior in guanacos and vicuñas in areas with and without poaching in western Argentina

Emiliano Donadio*, Steven W. Buskirk

Department of Zoology and Physiology, University of Wyoming, 1000 E. University Avenue, Laramie, WY 82071, USA

ARTICLE INFO

Article history:

Received 17 November 2004

Available online 12 September 2005

Keywords:

Guanacos

Vicuñas

Poaching

Flight behavior

Neotropics

ABSTRACT

Poaching of wild South American camelids remains widespread in Argentina, even inside reserves. Such poaching could have important effects on populations and behavior, neither of which has been studied. To increase our understanding of possible behavioral responses to poaching, we studied the flight behavior of guanacos and vicuñas in two reserves where poaching is common, and in one where it is negligible. We conducted a total of 43 surveys from a vehicle, and recorded behavioral responses to our presence from 299 groups of camelids. Frequency of flight behavior, flight distance, and time to first flight were recorded for each group, along with species, group size, and presence or absence of juveniles. Following the detection of the vehicle, 70% of the camelid groups reacted by running out of the sight of the observers in the reserve with poaching; conversely, only 30% of groups took flight in the reserve without poaching. Median flight distances were larger for vicuñas, and median time to first flight shorter for both species in the areas with poaching than without. Neither group size nor group composition influenced frequency of flight, flight distance, or time to first flight. In the reserves where poaching occurred, camelids become noticeably wary; the presence of humans forced them to leave their grazing activities. Since poaching is facilitated by roads inside the reserves, we recommend closing some roads as a means of reducing effects on grazing behaviors. Frequency of flight behavior may be a useful index of poaching pressure.

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1. Introduction

Once widespread in the arid and semi-arid landscapes of South America, guanacos *Lama guanicoe* and vicuñas *Vicugna vicugna* have become scarce throughout their ranges, with current populations representing <10% of those first observed by Europeans (Koford, 1957; Raedeke, 1979; Torres, 1992). Distributions of both species have declined correspondingly. In Argentina, the present geographic ranges of guanacos and vicuñas are about 40–56% and 75% of the original ranges, respectively (Cajal, 1991; Franklin et al., 1997). Of these areas, only 3% of the range of guanacos and 34% of that of vicuñas

fall within protected areas (Cajal, 1991). Human activities such as sheep ranching and intensive hunting, either legal or illegal, have been regarded as the main causes for the dramatic decreases in distributions and abundances of both camelid species during the last century (Franklin, 1982; Roig, 1991; Baldi et al., 2001). Although ecological relationships between guanacos and domestic sheep have been explored (Baldi et al., 2001), the effect of poaching on populations of guanacos and vicuñas remains poorly understood.

In Argentina, the world's largest sympatric populations of guanacos and vicuñas are effectively protected at San Guillermo National Park (SGNP; Cajal, 1991), but are poached

* Corresponding author. Tel.: +1 3077665299.

E-mail address: emiliano@uwyo.edu (E. Donadio).

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doi:10.1016/j.biocon.2005.08.004

intensively in much of the surrounding landscape, including within the Laguna Brava Provincial Reserve (LB) to the north and San Guillermo Biosphere Reserve (SGBR) to the south of SGNP. Although the hunting of camelids is prohibited in all three reserves, interviews with local residents suggest that poachers frequently visit LB and the southern portion of the SGBR. There, they use vehicles and a network of dirt roadways from which they shoot the animals. If camelids are too far from a road, poachers drive off road and chase them (A. Carrizo and A. Montañez park rangers SGNP, pers. comm.).

A direct assessment of camelid mortality due to poaching has been difficult because poachers usually remove carcasses of hunted animals and scavengers consume offal. However, an indirect assessment may be possible; the harassment caused by chasing and shooting may modify camelid behaviors, with individuals becoming more wary in those areas where they are poached. This pattern has been reported for several ungulate species, including white-tailed deer *Odocoileus virginianus* (Kilgo et al., 1998), roe deer *Capreolus capreolus* (de Boer et al., 2004), elk *Cervus elaphus* (Bender et al., 1999), reindeer *Rangifer tarandus* (Baskin and Hjältén, 2001), and moose *Alces alces* (Altmann, 1958). Overall, it has been found that ungulates under strong hunting pressure tend to flee more often from humans and have longer flight distances (i.e. minimum distance to which a wild animal can be approached without causing it to flee).

In this paper, we examine the possible effects of poaching on the behavior of guanacos and vicuñas by comparing different flight responses to an approaching vehicle in areas with (LB and SGBR) and without (SGNP) poaching. Specifically, we predicted that frequency of flight behavior would be higher, flight distance would be greater, and time to first flight would be shorter in areas with poaching activity. Further, we assess the effect of species, group size, and group composition on the behavioral responses of these camelids to the approach of a vehicle. Finally, we recommend conservation measures to decrease poaching in LB and SGBR, and discuss the usefulness of flight behavior as an index of poaching pressure.

2. Methods

2.1. Study area

LB, SGBR, and SGNP, three contiguous reserves in western-central Argentina, encompass a 1.4 million-ha area that ranges from 28° 27'–29° 55'S to 68° 45'–70° 02'W. They lie within one of the most ecologically intact areas of South America (Sanderson et al., 2002).

LB, located in La Rioja province, was established in 1980. This reserve has two main entrances, one of which lacks any management oversight. Tourist access is unrestricted and two-wheel-drive vehicles are able to reach the high plains where camelids occur. SGBR, in San Juan province, was established in 1981 and is a UNESCO reserve. Despite its protected status, this reserve undergoes intensive mining in its northern and southwestern sections. A network of dirt roadways, related to mining activity and accessible for all vehicles, crosses most of this reserve, which lacks wildlife law enforcement. SGNP, located in San Juan province, was established in 1998. This area has one main entrance, which is controlled by

park rangers. Tourist access is restricted and guides are required to escort tourists visiting this area. Only 4 × 4 vehicles can access the area due to poor road conditions.

Law enforcement varies across the three areas. In LB and SGBR the level of law enforcement is low or nil, with poaching of guanacos and vicuñas being common and occurring throughout the 2 reserves (A. Carrizo and A. Montañez park rangers SGNP, and H. de la Fuente manager LB, pers. comm.). Conversely, in SGNP the level of enforcement is high and poaching negligible. Besides poaching, human activity, mostly tourism is very limited. SGNP receives an average of 50 visitors per year, LB receives 1000 visitors per year, and no data are available for SGBR, but tourism activity there seems similar to or lower than in SGNP.

The region is cold and dry, with average annual temperatures of –5 to 5 °C, and winter minimum temperatures reaching –24 °C. Precipitation ranges from 400 mm/yr in the western section to 20 mm/yr in the eastern section. Low-elevation valleys and high-elevation deserts and open plains or “llanos” (2000–6800 m elevation), delimited by steep mountains, characterize the landscape. A shrubby steppe characterizes the vegetation in the valleys (2000–3100 m), where dominant species are *Larrea* spp., *Bulnesia retama*, and *Atriplex lampa*. In the high llanos (3200–4300 m) the vegetation is sparse with <10% of the ground covered by plants. Dominant plant species here are short grasses of the genus *Stipa*, and shrubs such as *Adesmia* spp., *Senecio* spp., and *Atriplex* sp. (Cajal et al., 1981; Carrizo et al., 1997).

2.2. Field sampling

Data were gathered during winter (June–August) 2004. Nine line transects of variable length (4.9–26.5 km), three in each reserve, were defined based on the distribution of dirt roads and tracks, and the likelihood of observing guanacos and vicuñas from these roads. All observations were made in the habitat type (llanos) in which camelids graze in the three reserves. To avoid the potential confounding influence of tourism on the behavior of camelids, transects in LB were placed in sites rarely visited by tourists. Transects were traveled by vehicle (speed 20–35 km h⁻¹) with two observers standing in the back. Each transect was traveled at least three times, and a total of 85.3, 307.6, and 149.7 km were covered in LB, SGBR, and SGNP, respectively. Surveys were conducted between 9 a.m. and 4 p.m. The extensive open llanos where camelids graze, the short grass vegetation, and the availability of lightly traveled dirt roads and tracks made the three reserves excellent sites to visually monitor the reactions of camelids to human presence.

Three flight responses were recorded: frequency of flight behavior, flight distance, and time to first flight. Frequency of flight behavior was evaluated by defining three response categories: (1) staying – animals became more alert but did not flee; (2) walking away – animals slowly moved away from the vehicle but did not leave the llanos; and (3) fleeing – animals galloped out of the sight of the observer and left the llanos. For statistical analyses, the first two categories were aggregated because groups displaying these two responses were relatively little disturbed when compared to those that galloped away. Animals were considered members

of the same group if they exhibited cohesive behavior. Within a group, the behavior of the first reacting animal was considered the behavior of the group.

Flight distance was defined as the minimum distance to the vehicle approaching in the road at which animals started an evasive response. Time to first flight was defined as the time between when the animals detected our presence and initiated an evasive response. Flight distances were measured to the center of the group using a range finder (Bushnell Yardage Pro 1000). Flight response times were measured to the nearest second using a stopwatch.

All flight responses were recorded, with the aid of binoculars when necessary, for groups no farther than ca. 1500 m from the road. For each observation, ancillary information such as species, group size (three categories: <5, 5–10, and >10 individuals), and presence of juveniles of the year (two categories: with and without juveniles) was noted. Sample sizes for each category are presented in Table 1.

Because predation risk may influence flight responses, we indirectly investigated this factor by estimating the relative abundance of pumas, the primary predator of guanacos and vicuñas, in each reserve. Relative puma density (R) was calculated as $R = Sc h^{-1}$, where Sc and h are the number of scats found and the total time (in hours) walked by one surveyor during one transect, respectively. Transects followed defined landscape features, mainly the base of accessible rocky cliffs, which were moderately common in all reserves. Scats found within a radius of 10 m were considered as one observation. A total of 80 transects, requiring 271 h, were walked in the three reserves [SGNP = 40 (138 h), SGBR = 20 (60 h), LB = 20 (73 h)]. Due to logistical constraints, primarily limited accessibility of rocky cliffs, random placement of transects was precluded; therefore, our data represent a crude estimate of puma abundance.

2.3. Data analysis

Frequency of flight behavior data was analyzed using 2×2 contingency tables, with the response variable arranged in the columns and defined as walking/staying and fleeing, and the G-test of independence (Zar, 1999). Data on flight distance and time to first flight did not conform to a normal distribution

after transformation; therefore, they were analyzed using the Mann–Whitney U (two-sample comparisons) and the Kruskal–Wallis one-way analysis of variance (k -sample comparisons). For all flight responses, comparisons between areas (with and without poaching) were conducted separately for each species, whereas comparisons between species were conducted within areas. Following significant results for between-species comparisons, the effect of group size and composition on flight responses in each area was evaluated separately for each species; otherwise, these analyses were conducted by pooling data of both species. Median puma relative density among reserves was compared using a Kruskal–Wallis test. Differences were considered significant for all tests when $P < 0.05$. All statistical analyses, except G-tests, were performed using the program SPSS release 10.0 (SPSS Inc., 1999).

3. Results

We collected information on flight behavior from a total of 234 groups of vicuñas and 65 groups of guanacos. Only guanaco groups were observed in SGBR, whereas only vicuña groups were observed in LB. The effect of an approaching vehicle differed significantly between areas, with guanacos and vicuñas fleeing more and staying/walking less than expected in the areas with poaching (guanacos: $G = 5.13$, $df = 1$, $P = 0.02$; vicuñas: $G = 12.81$, $df = 1$, $P < 0.001$; Fig. 1). Within areas, neither frequencies of fleeing nor staying/walking differed between species (with poaching: $G = 0.05$, $df = 1$, $P = 0.81$; without poaching: $G = 0.23$, $df = 1$, $P = 0.62$). Likewise, frequencies of fleeing and staying/walking were independent of group size (with poaching: $G = 0.44$, $df = 2$, $P = 0.80$; without poaching: $G = 1.70$, $df = 2$, $P = 0.42$) and group composition (with poaching: $G = 2.87$, $df = 1$, $P = 0.09$; without poaching: $G = 0.57$, $df = 1$, $P = 0.45$).

Median flight distance was significantly greater in the areas with poaching than in the area without poaching for vicuñas (Mann–Whitney $U = 1441$; $z = -5.60$; $P < 0.0001$), but not for guanacos (M–W $U = 302.5$; $z = -0.39$; $P = 0.97$; Table 2). In the area without poaching, the median flight distance did not differ between species (M–W $U = 1053$; $z = -1.63$; $P = 0.10$), but in the area with poaching was greater for vicuñas than for guanacos (M–W $U = 431$; $z = -2.70$; $P = 0.007$; Table 2). Flight

Table 1 – Number of observations per group size and group composition categories for guanacos and vicuñas in areas with and without poaching of western Argentina, winter 2004

	Group size (number of individuals)			Group composition	
	1–4	5–10	>10	With juveniles	Without juveniles
<i>With poaching</i>					
Guanacos	8 (7)	9 (6)	4 (3)	10 (7)	11 (9)
Vicuñas	44 (27)	22 (11)	1 (1) ^a	31 (18)	36 (21)
<i>Without poaching</i>					
Guanacos	13 (15)	7 (9)	9 (9)	10 (11)	19 (22)
Vicuñas	35 (44)	44 (50)	12 (12)	52 (59)	39 (47)

The number of groups analyzed for the flight distance variable is shown first followed by the number of groups analyzed for the time to first flight variable (between brackets).

^a Due to the small sample size ($n = 1$), this category was not used to assess the effects of group size on flight distances for vicuñas in the area with poaching.

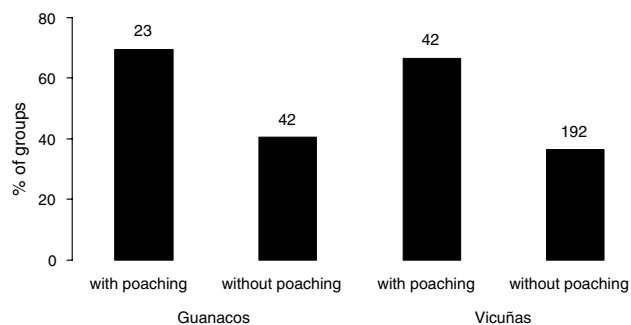


Fig. 1 – Percentage of groups of wild South American camelids, that fled after observing a vehicle in areas with and without poaching of western Argentina, winter 2004. Total number of groups observed is displayed above bars.

distance was affected by neither group size (median = 334 m; Kruskal–Wallis $X^2 = 0.97$; $df = 2$; $P = 0.61$) nor group composition (median = 334 m; M–W $U = 1557$; $z = -1.23$; $P = 0.21$) in the area without poaching. Similarly, flight distance was affected by neither group size (guanacos: median = 433 m; K–W $X^2 = 2.13$; $df = 2$; $P = 0.34$; vicuñas: median = 1000 m; M–W $U = 415$; $z = -1.02$; $P = 0.31$) nor group composition (guanacos: median = 433 m; M–W $U = 48$; $z = -0.49$; $P = 0.65$; vicuñas: median = 1000 m; M–W $U = 486$; $z = -0.98$; $P = 0.33$) in the areas with poaching.

Median time to first flight was significantly shorter in areas with poaching, although the difference was less evident for guanacos (M–W $U = 182$; $z = -1.89$; $P = 0.06$) than for vicuñas (M–W $U = 1494.5$; $z = -2.47$; $P = 0.01$; Table 2). Within areas, median time to first flight did not differ between species (with poaching: M–W $U = 266$; $z = -0.831$; $P = 0.41$; without poaching: M–W $U = 1729$; $z = -0.10$; $P = 0.92$; Table 2). Similarly, time to first flight was not affected by neither group size (with poaching: median = 1 s; K–W $X^2 = 4.56$; $df = 2$; $P = 0.10$; without poaching: median = 20 s; K–W $X^2 = 4.46$; $df = 2$; $P = 0.11$) nor group composition (with poaching: median = 1 s; M–W $U = 312.5$; $z = -1.21$; $P = 0.23$; without poaching: median = 20 s; M–W $U = 2100$; $z = -1.37$; $P = 0.17$).

Median relative density of pumas differed among reserves (K–W $X^2 = 7.04$; $df = 2$; $P = 0.03$), and was higher in the area

without poaching [SGNP: median (min–max) = 0.27 (0–2.41) $Sc\ h^{-1}$] than in the areas with poaching [SGBR: median (min–max) = 0 (0–0.75) $Sc\ h^{-1}$; LB: median (min–max) = 0 (0–1.33) $Sc\ h^{-1}$].

4. Discussion

Several behavioral traits of South American camelids were correlated with and presumably affected by the relative prevalence of poaching. As predicted, guanacos and vicuñas took flight more frequently and sooner after observing a vehicle in areas with poaching than in areas without poaching. Similarly, the distance at which vicuñas fled an approaching vehicle was greater in areas with than without poaching, whereas guanacos did not behave as expected for this response variable. Camelid flight responses appeared to not be related to the abundance of their main predator in the Andes region; relative density of pumas was higher in the area without poaching than where poaching occurred.

Besides the direct removal of individuals, poaching and related harassment might have less overt but important effects on ungulate populations. Harassment contributes to poor physical condition in ungulates by affecting the balance between energy intake and energy expenditure, since fleeing animals spend energy and reduce food intake. Such an effect may be enhanced if harassment induces changes in habitat preferences, with animals selecting less productive but more secure areas (Douglas, 1970; Jeppesen, 1987). Nearly 70% of the guanaco and vicuña groups took flight and left their grazing areas at our approach in the reserves with poaching. In such an extreme environment with low productivity and food availability (Hofmann et al., 1983; Cajal, 1991), poaching-related harassment could negatively affect the energetic reserves of individuals to a point where survival may be reduced. In SGBR and SGNP, 60% of the camelids found dead during an unusually harsh winter had bone marrows partially or totally depleted (Cajal and Ojeda, 1994); this finding highlights the important role that energetic exhaustion may play at the population level in these species.

In areas with poaching, both species reacted as soon as they detected our vehicle; however, guanacos had unexpected shorter flight distances than vicuñas. Guanaco groups under

Table 2 – Flight distance (in meters) and time to first flight (in seconds) for groups of wild South American camelids in areas with and without poaching of western Argentina, winter 2004

	With poaching			Without poaching		
	n	Median	Min–max	n	Median	Min–max
<i>Flight distance</i>						
Guanacos	21	433 ^{a,1}	150–1000	29	390 ^{b,2}	50–1850
Vicuñas	66	1000 ^{c,1}	152–1000	91	318 ^{c,3}	35–1700
<i>Time to first flight</i>						
Guanacos	16	1 ^{a,1}	0–240	33	15 ^{b,3}	0–340
Vicuñas	38	1 ^{c,2}	0–107	106	27 ^{c,4}	0–480

Lettered superscripts represent same-species comparisons between areas with and without poaching.

Numbered superscripts represent comparisons between species in the same area.

Medians sharing a superscript were significantly different at $\alpha = 0.05$.

Medians with different superscripts were not significantly different (see Section 3).

poaching pressure were observed only in SGBR. Although we sampled the same habitat (llanos) in all three reserves, the topography and vegetation in SGBR were slightly different. In this reserve, some portions of the llanos were characterized by gently sloping hills; further, grasses of the genus *Stipa*, the preferred food of guanacos (Cajal, 1989; Cortés et al., 2003), appeared to be less abundant than in LB and SGNP. Whether topography influenced the distance at which our vehicle was detectable or the shortage of grasses forced guanacos to remain in the llanos, foraging in profitable food (i.e. *Stipa* spp.) until the threat was close, is unclear. Whatever the case, differences in flight distances between poached guanacos and vicuñas seemed to be a result of habitat characteristics rather than species-specific differences in flight behavior. Future studies should explore the effects of foraging behavior, food availability, and habitat structure on the flight responses of poached guanacos and vicuñas.

Available data on the relationships among group size and composition and flight responses in ungulates are contradictory. Flight responses have been reported to be either positively (e.g. bison *Bison bison*, mule deer *Odocoileus hemionus* and pronghorn *Antilocapra americana*, Taylor and Knight, 2003), or negatively related to group size (e.g. chamois *Rubicapra rubicapra*, Cederna and Lovari, 1985; fallow deer *Dama dama*, Recarte et al., 1998). In South American camelids, flight responses were independent of group size. Similarly, Borkowski (2001) reported a lack of relationship between group size and flight responses in sika deer *Cervus nippon*. Flight responses of ungulate groups can be either influenced (e.g. bison, Fortin and Andruskiw, 2003) or not (e.g. reindeer, Baskin and Hjältén, 2001) by the presence of juveniles. We observed some, though a statistically weak, trend for camelid groups with juveniles to flee more frequently than adult-only groups in areas with poaching. This apparent increased sensitivity to harassment for groups with juveniles is of concern because it forces groups with juveniles into steep and rugged terrain, which in turn may favor stalking and ambushing by pumas *Puma concolor* (Bank et al., 2002). Pumas frequently prey on camelids in SGBR and SGNP (Cajal and Lopez, 1987). Sarno et al. (1999) found that cougar predation accounted for 80% of the total winter mortality of juvenile guanacos in southern Chile. We commonly saw puma tracks in the three reserves and found several juvenile carcasses of both camelid species with signs of puma predation. How the combination of poaching and increased vulnerability to predation due to harassment might affect camelid populations is unknown.

In the area without poaching, guanacos and vicuñas were tolerant of our presence, a behavior predicted by Geist (1971) for wild ungulates when they are not harassed. In our area, 60–64% of guanaco and vicuña groups either stayed or slowly walked away without leaving their grazing areas in the llanos. In a highly visited area such as Torres del Paine National Park (Chile), guanacos can be observed from distances <10 m without disturbing their behavior (Bank et al., 2003). Borkowski (2001) reported a population of sika deer as being tolerant of human disturbance because only 50% of the groups he observed fled in the presence of humans. This potential for habituation could be used to monitor the behavior of tourists towards camelids in the case that tourism activity increases in this area (see Section 5).

Frequency of flight behavior was the most sensitive variable to an approaching vehicle, followed by time to first flight. Conversely, flight distance yielded less clear results. Similar findings were reported for a sika deer population, for which frequency of flight behavior was a better measure of sensitivity to disturbance than flight distance (Borkowski, 2001). We found that both quantitative responses might be hard to evaluate under field conditions since they require at least two observers, who must split their time between taking measures and observing the animals. This is problematic when only one person is monitoring several camelid groups at the same time. Simple straightforward techniques that require neither special equipment (i.e. range finders) nor many observers are more likely to be used in developing countries. Therefore, although all possible variables should be measured in the field, we recommend the use of frequency of flight behavior if one has to be chosen.

5. Conservation implications

The behavior of free ranging ungulates towards humans mirrors the behavior of humans towards ungulates. If humans harass or harm ungulates, they will respond by fleeing at the sight of them (Geist, 1971). We found that guanacos and vicuñas were more prone to take flight in those areas where poaching occurred. Local residents, park rangers, and park managers concurred that poachers use vehicles and the network of dirt roads to access reserves and poach animals. The fact that camelids in the areas with poaching fled immediately after, and on occasions even seconds before, visually detecting our vehicle confirmed that they perceived vehicles as a threat. On two of six visits we observed trucks with poachers in SGBR, which suggests the commonness of poaching. Both reserves with poaching have in common the lack of patrolling and the existence of a network of dirt roads in fairly good condition. Conversely, the reserve without poaching is located in an isolated place, with access restricted to 4 × 4 vehicles. This fact, coupled with high levels of control, discourages poachers from visiting it. Increasing the level of control at the main entrances to the reserves with poaching should have an impact on decreasing the levels of this activity. Further, closing some of the roads within the reserves, particularly those that traverse the llanos where camelids graze, will provide the animals with undisturbed and secure refuges.

Current trends in land use in SGBR include a sharp increase in mining operations with a concomitant increase in the density of mining-related roadways, which in turn facilitates the access by poachers and increases poaching activity. Further, the construction of a road to facilitate the access of tourists to the area without poaching (SGNP) is imminent. If this road is built, an increase in the number of tourists visiting the area should be expected. An abrupt increase in the number of tourists has the potential to negatively affect guanacos and vicuñas, if visitors harass animals by, for example, attempting close approaches either on foot or vehicle.

Our data on flight behavior of guanacos and vicuñas suggest that two of the reserves we surveyed are not effectively protecting populations of South American camelids. Since only a small fraction of the actual range of guanacos and vicuñas fall within protected areas (Cajal, 1991), actions to ensure

the protection of these species within reserves are urgently needed. In addition, and regardless of the measures that could be taken to decrease poaching or soften the impact of the increasing tourism activity, tools need to be developed to evaluate the effectiveness of these measures. We believe that flight responses, particularly frequency of flight behavior, can be used to monitor the success of conservation measures. Monitoring the frequency of flight behavior is an inexpensive method, easy to apply, and applicable with little training. The data reported here can be used as a baseline for the three reserves against which new data can be compared in the future to evaluate whether conservation actions, such as closing roads or increasing control, have succeed in decreasing harassment.

Acknowledgements

R. Battistella, M.J. Bolgeri, R. Palacios, M. Vitali, and A. Wursten deserve much credit for their invaluable assistance with data collection. A.J. Novaro and M.C. Funes provided helpful suggestions that improved the study design. A. Montañez and A. Carrizo, park rangers SGNP, and H. de la Fuente, manager LB, provided logistical support and important information on poaching activity. We thank the Lincoln Park Zoo, Rufford Small Grants, Graduate School of the University of Wyoming, Denver Zoological Foundation, and Idea Wild for funding this project. Permission to conduct this research was granted by the governments of La Rioja Province (LB), and San Juan Province (SGBR), and by the Dirección Nacional de Parques Nacionales Delegación Centro (SGNP). E.D. was supported by a Fulbright fellowship awarded by the Department of State, USA.

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