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Short communication

Trailing hounds vs foot snares: comparing injuries to pumas *Puma concolor* captured in Chilean Patagonia

L. Mark Elbroch, Brian D. Jansen, Melissa M. Grigione, Ronald J. Sarno & Heiko U. Wittmer

We compared injuries resulting from two different capture methods, i.e. trailing hounds and foot snares, for pumas *Puma concolor* in a mixed landscape with open grasslands and limited 'retreat' habitat in southern Chilean Patagonia. Injury scores were not significantly different for the two methods, although the small sample size for captures made with snares likely influenced our findings. Based on a potential range of 0-400, the mean injury score for pumas caught using hounds was 56.3 ± 132.9 (SD). The mean puma injury score for five animals caught in snares was 3.8 ± 1.1. Pumas were injured and/or killed in 86% of captures using trailing hounds. The number of hounds used in a capture attempt did not predict the likelihood of successfully catching a puma ($P = 0.35$), whereas there was a strong relationship between the number of dogs and the likelihood of a fight with the puma ($P < 0.0001$). The odds ratio calculation predicted a 14.7% increase in the likelihood of a fight between puma and hounds with the addition of each dog to the chase. Our results highlight the potential risks associated with trailing hounds in open landscapes. We suggest guidelines for the use of hounds in predominantly open landscapes, and that alternative capture methods such as foot snares should be considered as a potentially safer alternative. Lastly, we make recommendations for the development of injury assessment systems more relevant to catch-and-release research.

Key words: capture, foot snare, hounds, injury, mortality, Patagonia, puma, Puma concolor

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Wildlife research is not without risk to the animals involved, and thus guidelines (for mammals: e.g. Onderka et al. 1990, Powell & Proulx 2003, Sikes et al. 2011, Proulx et al. 2012) and governing organizations (e.g. the Animal care and use committee of the American Society of Mammalogists; Sikes et al. 2011, The Institutional Animal Care and Use Committee; available at http://www.iacuc.org/) have been created to ensure that modern research is both ethical and justifiable in its pursuit of new knowledge. Capture-related injuries and mortalities, however, still occur, but data are not always shared due to increasing public sensitivity to animal welfare (Jacques et al. 2009). Thus, it is paramount that researchers continue to strive for the most effective and humane capture methods available for a given

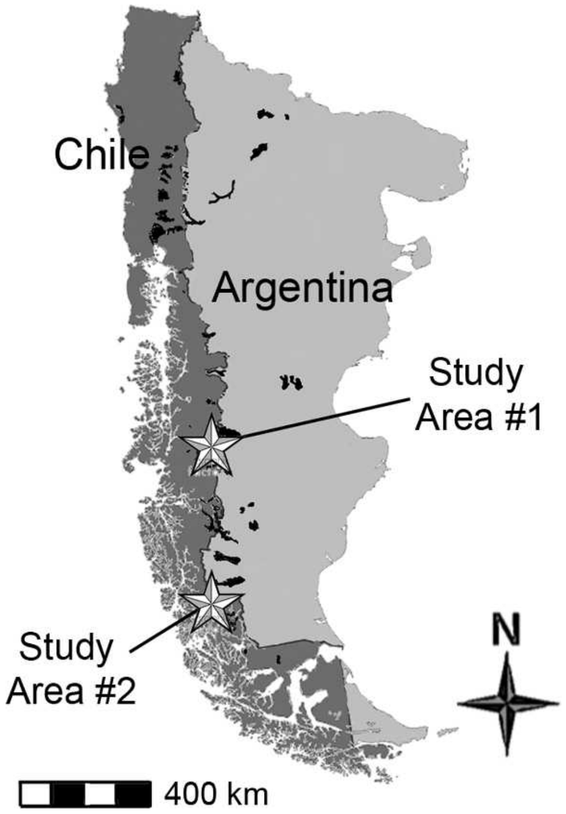

Figure 1. Location of the two study sites in Chilean Patagonia.

species, as well as communicate their successes and failures to the larger scientific community (Powell & Proulx 2003). For specific species there have been periodic reviews that encourage better capture methods (e.g. white-tailed deer *Odocoileus virginianus;* in Jacques et al. 2009), but for many species, best-capture practice protocols do not exist (Arnemo et al. 2006).

The puma *Puma concolor* is a large, solitary felid that has commanded considerable research attention in forested ecosystems of North America, but minimal attention in the open steppe habitats of South America (Hornocker & Negri 2010). Information on capture-related injuries and mortalities of pumas caused by research efforts is scant and largely anecdotal in published literature, except for a single quantitative assessment for pumas studied in the Chihuahua Desert in North America (Logan et al. 1999). More information on the suitability of capture methods in different habitats is urgently needed to reduce risks for researchers and pumas, and to improve conservation practices for this charismatic carnivore.

Trained scent-trailing hounds are currently the predominant method used to capture pumas throughout their range (Logan et al. 1999, Cougar Management Guidelines Working Group 2005), while far fewer researchers employ foot-snares and box-traps as alternative, and potentially safer, methods (Proulx et al. 2012). The question remains, however, whether certain environments are more suitable for a particular method (Logan et al. 1999), and whether the use of hounds in open country meets the safe criterion outlined in Proulx & Barrett (1994) for live trapping with regards to injury scores: "Criterion II for live traps: State-of-the-art live traps should, with 95% confidence, trap $\geq$ 70% of animals with $<$ 50 points scored for physical injury". In this article, we assess injury scores for two capture methods from two study areas in southern Chilean Patagonia (Fig. 1), a mixed landscape with open grasslands and limited 'retreat' habitat for pumas pursued by hounds. These results were part of larger projects aimed at quantifying puma predation on endangered huemul deer *Hippocamelus bisulcus* and domestic sheep *Ovis aries* (Elbroch & Wittmer 2013, Wittmer et al. 2013, M.M. Grigione, P. Burman, K. Barrera, O. Roth, N. Soto, R. Thomas, A. Wells & R.J. Sarno, unpubl. data).

Material and methods

Study areas

Study site 1 was located in the southern portion of Chile's Aysén District, north of Lago Cochrane in central Chilean Patagonia (W 47.8000, S 72.0000; see Fig. 1). Site 1 covered approximately 1,200 km^2 and included the 69-km^2 Lago Cochrane National Reserve, the 690-km^2 private Estancia Valle Chacabuco and approximately 440 km^2 of the 1,611-km^2 Jeinimeni National Reserve. Site 2 encompassed the eastern portions of Torres del Paine National Park (W 51.0553, S 72.9950) in southernmost Chile. Landscapes in both study areas were predominantly open grasslands, but at higher elevations, deciduous forests dominated by lenga *Nothofagus pumilio* provided islands of suitable retreats for pumas. Lower elevation shrub communities dominated by ñirre *N. antarctica* and calafate *Berberis microphylla* occurred intermixed with grasslands but provided limited protection to pumas from pursuing hounds.

Capture methods and assessment of injuries

We used hounds to capture pumas in study site 1 during the Austral fall and winter (March-August

2008 and May-September 2009). When snow carpeted the ground, we traveled on horseback until we encountered fresh tracks in the snow. We released 2-7 hounds per capture attempt to force pumas to retreat to a tree or rocky outcrop where we could safely approach the animals. We employed foot snares to capture pumas in study site 2 during the same time periods. Foot-snares (described in Logan et al. 1999) were placed along suspected puma travel routes or set in conjunction with an electronic call device to lure them to the trap. We used 4.5 mm diameter steel cable to reduce the risk of cutting skin, a large steel spring for shock absorption and an in-line swivel placed between the cable and anchor to minimize torsion of the foot and potential bone fracture. Snares were secured to a sturdy tree, devoid of limbs, with a steel chain, or in areas devoid of suitable trees, with wedge anchors bolted to immovable boulders and bedrock. All snares were equipped with telemetry devices and monitored a minimum of twice per day (one hour after sunrise and again prior to midnight). Snares were checked at no longer than 12-hour intervals. In both methods, pumas were anaesthetized using ketamine (2.5-3.0 mg/kg) and medetomidine (0.075 mg/kg) before they were processed, sampled and fitted with collars. While animals were under anaesthesia, we monitored heart rate, respiration and temperature at 5-minute intervals, conducted external checks for injuries and documented the length and depth of any lacerations. Shallow wounds were treated with Wound-Kote (48% isopropyl alcohol, 0.04% Acriflavin), and deeper lacerations were cleaned with isopropyl alcohol but left open to avoid closing in infections. Pumas suffering large lacerations were also administered an antibiotic (20,000 units/kg of Penicillin G). In foot-snare captures, the puma's leg and wrist caught in the snare were additionally checked for injury by rotating the joints slowly and carefully to determine whether any internal grating or crackling betrayed tearing or breakages not apparent on the surface. Some degree of swelling is common in trapped feet, and we recorded the degree of swelling from 1 to 10 points (scoring is discussed further below). The effects of the medetomidine were reversed using atipamezole (0.375 mg/kg), and pumas were released at capture sites.

Analysis

We used Onderka et al.'s (1990) scoring system to quantify external injuries that we detected while processing pumas at capture events: 5 points for a cutaneous laceration < 2 cm long, 10 points for a cutaneous laceration > 2 cm long, 30 points for a subcutaneous muscle laceration or maceration and 30 points for a tendon or ligament maceration with partial severance. We diverged from the Onderka et al. (1990) protocols in three ways: 1) whereas they assigned 400 points for limb amputation, we assigned 400 points to mortalities, 2) we assigned 10 points to hyperventilation, which we concluded was an external indicator of high stress and 3) whereas Onderka et al. (1990) used a 1-5 scale for swelling, we assigned scores of 1-10 (1 = lowest and 10 = highest) to denote the highly variable level of swelling in the foot caught by a snare.

Due to the small sample for captures with snares and the large difference in variance between the two methods, we employed a simple non-parametric Mann-Whitney U test, or Wilcoxon rank sum test, to assess the influence of capture methods on injury scores (Mann & Whitney 1947). We did this two times; the first time inclusive of all capture events but excluding attempts in which the puma escaped, and the second time without the mortality events to increase the sensitivity of the test. We then determined whether 1) the mean injury score for pumas captured with hounds and foot snares met Criterion II guidelines: "with 95% confidence, trap $\geq 70\%$ of animals with < 50 points scored for physical injury" (Proulx & Barrett 1994).

We used logistic regression to test whether the number of hounds in a chase explained the likelihood of a successful capture, and a second logistic regression to test whether the number of hounds in a chase explained the likelihood of a fight between dogs and pumas during capture. We employed odds ratios to quantify how much the probability of a puma conflict would increase or decrease contingent upon the addition of hounds during a particular capture event, while maintaining all other variables constant. We did not include capture attempts in which pumas escaped capture in these analyses.

Results

In study site 1, we successfully caught and processed 13 new adult pumas in 20 attempts, and we unintentionally caught two kittens while attempting to capture adult females (Numbers 22 and 23 in Appendix I). We did not include these kittens in our counts of 'successful captures' in Table 1 or Appendix I) because kittens were not targeted as part

Table 1. Summary statistics of captures and recaptures using hounds in central Chilean Patagonia, and new captures using foot snares in southern Chilean Patagonia. Puma injuries are inclusive of pumas that exhibited hyperventilation.

Capture method	New or recapture	Capture attempts	Effort (in days)	Successful puma captures	Puma injuries	Puma mortalities	Puma escapes	Capture rate (pumas/day)
Hound hunts	New	20	50	13*	10	3	4	26
	Recaptures	8	8	7	6	0	2	75
Foot snares	New		26	5	0	0	0	19

* Does not include two kittens captured unintentionally while attempting to capture adult females, because they were not targeted as part of our research questions.

of our research, but we did include them in analyses of injuries. We recaptured pumas on seven occasions in eight attempts, when a VHF beacon facilitated capture (see Table 1). One puma was recaptured twice. Pumas were injured in 10 (50%) and died in three (15%) new capture attempts (N = 20): an adult male, a subadult male and a kitten killed while attempting to capture an adult female. Pumas were injured in six (75%) recapture attempts (N = 8; see Table 1 and Appendix I). Hounds were seriously injured (defined as requiring stitches and time off for healing) on three occasions (see Appendix I).

In study site 2, we employed a variable number of traps during two trap sessions. The first session was 10 days in length (46 trap nights), and the second was 16 days in length (180 trap nights). We successfully captured pumas on 19% of 26 capture nights (see Table 1). No pumas died, and all injuries were superficial.

Injury scores proved not significantly different between hound captures and snare captures in analyses including mortality events ($U_{29} = 88.0$, $P = 0.11$) and excluding mortality events ($U_{26} = 73.0$, $P = 0.18$). The mean puma injury score for all hound captures was 56.3 ± 132.9 (SD). In capture attempts including puma escapes, the mean hound injury score was 20.9 ± 46.3 (SD). The mean puma injury score for five snare captures was 3.8 ± 1.1 (SD; Table 2). We also caught two non-target animals (a guanaco *Lama guanicoe* and a young domestic cattle) and neither were injured nor required drugs to be released from snares. Based on our adaptation to Onderka et al.'s (1990) system, mean puma injuries during hound captures were slightly higher than recommended by Proulx & Barrett's (1994) Criterion II for Live Captures, whereas the mean injury score for hounds fell within the acceptable range. Nevertheless, 22 of 25 puma captures (88%) with hounds in which the puma did not escape scored < 50 injury points, well above the 70% of captures recommended by Proulx & Barrett (1994).

We used 3.4 ± 1.2 (SD) hounds per puma capture attempt (see Appendix I). The number of hounds did not predict the likelihood of capturing the puma ($F_{1,27} = 0.868$, $P = 0.35$), but there was a strong positive relationship between the number of dogs and the likelihood of a fight with a puma ($F_{1,27} = 5.60$, $P < 0.0001$). The odds ratio analysis indicated that the addition of each hound to the chase increased the likelihood of a fight with the puma by 14.7% (range: 1.9-113.3).

Discussion

While the presence of snow in winter made for greater success rates in capturing new pumas using scent-trailing hounds than foot snares, inflicting injuries or causing mortality in a combined 19 of 22 total capture attempts (86%) in study site 1 raised questions about our ethical obligations as conservation scientists. Thus, these data suggest that hound captures in Patagonia and other open landscapes need to be conducted with the utmost care and

Table 2. Details from snare captures including estimated hours in the snare (HIS), injury scores for pumas (IS) and descriptions of injuries (DI).

Capture attempt	HIS	IS	DI
1	< 8	3	Minor swelling of the foot
2	< 16	3	Minor swelling of the foot
3	< 8	5	Irritated nail cuticle with very minor bleeding. Minor swelling of the foot
4	< 16	5	Median swelling of the foot
5	< 16	3	Minor swelling of the foot

support Logan et al.'s (1999) assertion that in open terrain, foot snares may be the more ethical capture method. Although our analysis of puma injuries during capture events lacked the clinical approach of some previous studies (e.g. Onderka et al. 1990, Proulx et al. 1993), we hope our analyses encourage the necessary dialogue that could improve how we approach puma captures in open country. Our analyses also suffered biases because of small sample sizes limiting our ability to statistically compare injury scores related to capture method. As researchers, we must be vigilant in collecting enough data at captures so that we can compare a robust sample of injury scores from snares and hounds in the future. Furthermore, we likely overlooked internal injuries, difficult to detect with live animals in the field, although no pumas died post release.

In contrast to more clinical approaches, however, our methods benefited from the fact that we did not kill animals to assess their injuries. The Onderka et al. (1990) scoring system is ideal for dead animals assessed with full necropsies, but we see the need for a new system for assessing live animals during routine captures. External injuries can follow Onderka et al. (1990), but in assessing live animals, we need additional methods to assess internal stress. For instance, we scored hyperventilation as a sign of high stress. Perhaps initial temperature at capture may also prove to be a useful measure of internal stress. We, as researchers, need to design a method of assessing injuries and an animal's physiological condition that can be broadly applied during routine captures with planned releases.

Hounds provide an effective capture method in snow and in terrain that provide pumas ample safety retreats (e.g. trees), where they can both escape confrontation with dogs and where they can be safely approached by researchers. Injuries during hound captures can be minimized by using drugs which allow pumas to grip trees (e.g. administering ketamine to a puma in the tree and then medetomidine or xylazine when they are on the ground), and by either physically securing and lowering a captured puma to the ground or providing a cushion upon which it can fall (McCown et al. 1990).

Hound hunting is especially dangerous when pursuing females with kittens (Cougar Management Guidelines Working Group 2005) as dogs may focus upon one or more kittens rather than the adult. In a number of chases, we witnessed pumas passing up large trees where they could have escaped from hounds and, instead, taking their stand in dense thickets, into which the hounds followed and engaged them. Thickets were especially dangerous to both hounds and pumas because they were often so dense as to block researchers access to disengage them. The fact that pumas often retreated into dense thickets to defend themselves rather than retreating into trees may be a behaviour particular to Patagonia, where they lack large terrestrial competitors like gray wolves *Canis lupus* and may never have learned to defend themselves against large canids (Elbroch & Wittmer 2012).

For researchers who decide to use hounds to capture pumas in open terrain, we make the following nine suggestions: 1) Hunt in winter or in terrain where you feel confident you can see puma tracks before you release dogs. In this way you can confirm whether kittens might be present; 2) do not 'free cast' hounds that cannot be controlled with voice commands, but rather keep them leashed until you decide to release them as this enables researchers to decide how many dogs to commit to a chase; 3) use well-trained dogs to minimize the need for large packs; 4) use hounds with non-aggressive temperaments, especially when chasing females with kittens; 5) restrict dog packs to three hounds, especially where retreat habitat is minimal; 6) restrict dog packs to one or two non-aggressive dogs when pursuing adult females with kittens $<$ 6 months of age (Logan et al. 2008) and run your least aggressive hound alone when starting the hunt of a family group and only add in additional hounds when the adult female has clearly separated from her kittens; 7) use telemetry collars on hounds to minimize the time it takes to find them when they have successfully cornered a puma; 8) be ready to intervene in puma-dog conflicts to minimize the chance of injury to either puma or hound and; 9) consider using foot-snares for recaptures, especially where new GPS collars facilitate the detection of kills that can be used as bait.

Foot-snares and large box-traps can be set safely and offer puma researchers an alternative to chasing pumas with hounds in Patagonia and other open landscapes (Logan et al. 1999, Powell & Proulx 2003). Injuries during box and snare captures can be minimized by using trap transmitters and frequent trap checks and through the selection/preparation of a safe capture site to ensure that pumas have limited opportunity to injure themselves after capture. In Patagonia, where there are relatively few roads, large box-traps are often too cumbersome to transport into suitable areas. Box-traps, however, may be appropriate in depredation scenarios where pumas return to an accessible area to hunt livestock. Foot-snares, by comparison, can be transported over long distances and using creative adaptations (i.e. earth anchors and wedge bolts), can be set in more varied terrain. Auditory calls can also be used to lure pumas to snares in open terrain in which they do not use narrow paths to travel.

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Appendix 1

Capture/ Recapture attempt	Retreat habitat	Number of dogs	Successful capture?	Puma-hound conflict	Puma injury score	Hound injury score	Description of injuries
N1	Meadow	3	Yes	Yes	0	10	Dogs: two cutaneous lacerations < 2 cm long
N2	Tree	2	Yes	No	0	0	
N3	Escape*	5	No	No	?	0	
N4	Escape*	5	No	No	?	0	
N5	Tree	2	Yes	No	5	0	Puma: one cutaneous laceration < 2 cm long on foot
N6	Cliff	3	No	Yes (Mortality)	400	10	Puma: fell off >100 ft cliff while pursued. Trauma to neck
N7	Cave	4	Yes	Yes	5	25	Puma: one cutaneous laceration < 2 cm long Dogs: one cutaneous laceration < 2 cm long
N8	Tree	3	Yes	No	5	0	Puma: one cutaneous laceration < 2 cm long
R9	Tree	2	Yes	No	0	0	
R10	Cliff	2	Yes	No	5	10	Puma: one cutaneous laceration < 2 cm long Dogs: two cutaneous lacerations < 2 cm long
N11	Tree	3	Yes	No	10	5	Puma: two cutaneous lacerations < 2 cm long on feet Dogs: one cutaneous lacerations < 2 cm long on foot
R12	Tree	3	Yes	No	5	5	Puma: one cutaneous laceration < 2 cm long on foot Dogs: one cutaneous lacerations < 2 cm long on foot
N13	Bushes	4	Yes	Yes	10	5	Puma: two cutaneous lacerations < 2 cm long Dogs: one cutaneous lacerations < 2 cm long
R14	Bushes	4	Yes	Yes	25	160	Puma: one subcutaneous muscle laceration
R15	Bushes	3	Yes	Yes	10	10	Puma: two cutaneous lacerations < 2 cm long Dogs: two cutaneous lacerations < 2 cm long
N16	Bushes	7	Yes	Yes	?	50	Dogs: one subcutaneous muscle laceration
N17	Cliff	2	Yes	No	10	15	Puma: two cutaneous lacerations < 2 cm long on feet Dogs: three cutaneous lacerations < 2 cm long on feet
R18	Escape*	2	No	No	?	10	Dogs: two cutaneous lacerations < 2 cm long on feet
R19	Bushes	5	Yes	Yes	10	10	Puma: two cutaneous lacerations < 2 cm long Dogs: two cutaneous lacerations < 2 cm long
N20	Cliff	3	Yes	No	5	10	Puma: one cutaneous laceration < 2 cm long on foot Dogs: two cutaneous lacerations < 2 cm long on feet
N21	Tree	3	Yes	No	0	5	Dogs: one cutaneous laceration < 2 cm long on feet
N22	Bushes	4	No	Yes	20	10	Puma: hyperventilation
N23	Bushes	4	No	Yes	10	5	Puma: hyperventilation Dogs: one cutaneous laceration < 2 cm long
N24	Bushes	4	Yes	Yes	0	0	
N25	Ground	4	No	Yes (Mortality)	400	10	Puma: hyperventilation. Multiple subcutaneous punctures to muscles and tissues from biting hounds
N26	Ground	4	No	Yes (Mortality)	400	200	Puma: hyperventilation. Multiple subcutaneous punctures to muscles and tissues from biting hounds
N27	Bush	2	Yes	Yes	10	10	Puma: hyperventilation Dogs: two cutaneous lacerations < 2 cm long on feet
R28	Cave	2	Yes	No	5	10	Puma: one cutaneous laceration < 2 cm long on foot Dogs: two cutaneous lacerations < 2 cm long on feet

* Puma never retreated to safety habitat and instead outran the hounds