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Short communication

Translocations and human-carnivore conflicts: problem solving or problem creating?

Francisco E. Fontúrbel & Javier A. Simonetti

Translocation is a non-lethal practice used to manage carnivore-livestock conflicts. Nevertheless, its use has been questioned due to its low success rate and high cost. We performed a literature review to assess the effectiveness of translocation, human-related mortality and cost. We estimated the overall effectiveness to be 42% ± 6, felids were involved in 70% of the translocations and 80% of the case studies were conducted in North America and Africa. Human-related mortality accounted for the 83% of deaths after translocations. Translocation cost per individual was estimated at US$ 3,756 ± 357 (N = 16), a sum equivalent to compensate for up to 30 livestock heads. For conservation purposes, translocation is costly and less effective than other alternatives such as compensation with best herding practices.

Key words: compensation, felids, human-related mortality, lethal control, predation, survival

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Translocation is the deliberate and mediated movement of wild individuals from one part of their range to another. Translocations are commonly carried out by wildlife managers aiming at reintroduction, supplementation and resolution of human-wildlife conflicts (Fischer & Lindenmayer 2000, Treves & Karanth 2003). Carnivores are frequently engaged in predation upon livestock. The occurrence of conflicts is expected to increase in the near future because of the loss of natural habitat to anthropic activities (Bales et al. 2005). Among carnivores, 75% of felid species in the wild are involved in human-wildlife conflicts, of which 43% are species of conservation concern (Inskip & Zimmermann 2009). Consequently, the use of non-lethal methods ought to be encouraged when dealing with carnivore-human conflicts (Bradley et al. 2005).

Despite its widespread use, there is no consensus regarding the effectiveness of carnivore translocation (Bradley et al. 2005, Fischer & Lindenmayer 2000, Goodrich & Miquelle 2005). Additionally, neither is there an analysis of whether translocation of conflicting carnivores is in fact a cost-effective method, nor is there a consensus position about this kind of translocation, as has been put forward by the IUCN for introduction, reintroduction and restocking translocations (Soorae 2008:266-277). Survival might be compromised when individuals are translocated to new territories (Stamps & Swaisgood 2007), affecting the effectiveness of this approach as a non-lethal conflict-solving tool. The challenges of establishing territories in a new environment, coupled with homing behaviour in carnivores, might render translocated animals death-prone. This might be particularly relevant when hard releases are practised (i.e. when animals are translocated directly into new grounds without any adaptation period; Eastridge & Clark 2001). Furthermore, translocations are considered expensive (Linnell et al. 1997, Woodroffe & Ginsberg

1997), but to our knowledge, no cost-benefit analysis has been carried out to compare whether translocation ought to be preferred to alternative approaches such as compensating livestock losses caused by carnivore predation (Treves et al. 2009a,b). We performed a literature review aiming at: 1) determining the effectiveness of translocation practices as a human-carnivore conflict-solving approach, 2) determining whether translocation failures can be ascribed to human-related mortality and 3) comparing the costs of translocation with the costs of compensation of livestock losses.

Material and methods

Data gathering

We conducted a literature survey searching the ISI Web of Science and Google Scholar. We searched for scientific articles that contained the terms 'translocat* + carnivore*' or 'relocat* + carnivore*'. We completed our search in September 2009 and included all relevant papers available, regardless of their publication dates.

Data analysis

We examined published information for well-documented human-carnivore conflicts. The variables that we considered in the analysis were:

- overall success, defined as the proportion of translocated individuals that survived during the post-release monitoring period and/or at least for one year. We furthermore analysed if success was associated with the use of soft or hard-release approaches as well as human-related mortality (e.g. car accidents, poaching or shooting);
- the geographic region (i.e. continent) and habitat type where the translocations were carried out;
- the group of carnivore involved (i.e. felids, canids, ursines or mustelids);
- conflict resolution defined as the proportion of translocated individuals that did not return to the conflict area and/or produced new conflicts in the release areas;
- translocation cost defined as the total amount of money spent on moving one individual;
- compensation cost, comparing the expenses incurred for translocating a given carnivore to the economic cost of replacing livestock lost to predators. Reference costs for compensation and the average number of livestock killed annually by a given carnivore were obtained from published information. We referred compensation costs to well-implemented compensation schemes, in which false claiming and verification costs were considered. In order to render compensation payments comparable, we standardised such figures by the *per capita* annual income of an average citizen for each country in which compensation has been carried out (*per capita* income values obtained from the CIA World Factbook online (available at: https://www.cia.gov/library/publications/the-world-factbook/, updated in 2009)).

As none of the papers reported translocation costs, we conducted an Internet-based survey. We consulted scientific experts about the translocation costs connected with the translocation of one individual. Our survey consisted of three simple questions: 1) the name of the institution that conducted the translocation, 2) the translocated species and 3) the overall translocation cost per individual, considering personnel salaries, transportation, veterinary drugs and other expenses. We sent our questionnaire to seven scientific-purpose mailing lists, three IUCN/SSC specialist groups (on canids, cats and reintroductions) and 42 experts in 14 countries. When costs were reported in currency other than U.S. dollars (US$), we converted the amount. To make costs comparable across countries with different economic development, we standardised these costs by the annual *per capita* income as above. These survey data corresponded only to conflict-solving translocations, conducted with hard release procedures.

Results

A total of 50 scientific articles published between 1993 and 2009 fulfilled our search criteria. Among these, 39 were original articles and 11 were reviews. Of the studies conducted, 41% were in deciduous forests, 23% in savannahs, 10% in scrublands, 8% in freshwater, 8% in grasslands, 3% in temperate forests, 3% in boreal forests, 2% in taiga and 2% on islands. Examining data by region, 54% of the studies were conducted in North America, 23% in Africa, 12% in Europe, 8% in Asia and 3% in Oceania. We found no published reports from Central and South America. Felids were the study

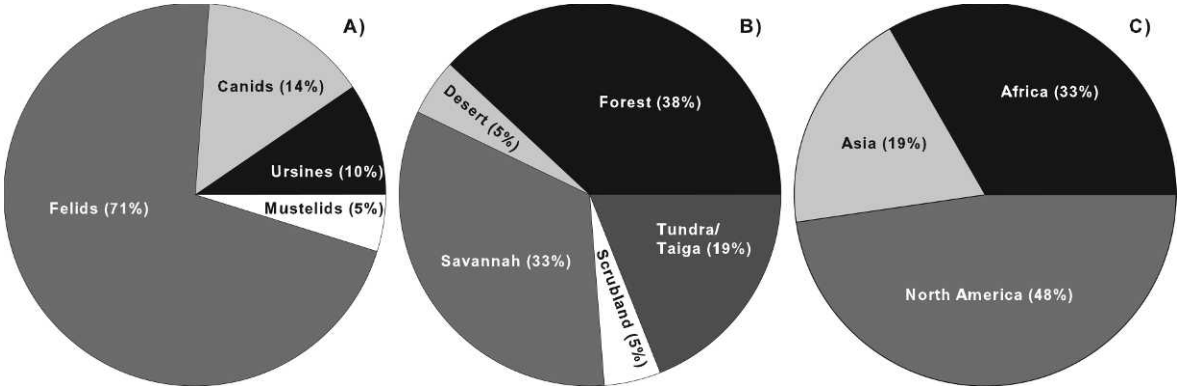

Figure 1. Translocation data related to human-carnivore conflict solving, grouped by carnivore group (A), habitat type (B) and geographical region (C). In each case N = 21.

subjects in 44% of the cases, ursines 22%, canids 20% and mustelids 14%.

Of the articles, 13 documented the effectiveness of translocation aimed to solve human-carnivore conflicts, particularly related to livestock killing. These articles provided 24 case studies (i.e. a given article might provide > 1 case study), of which 12 case studies reported both translocation success and conflict resolution data; nine case studies reported only translocation success and three reported only conflict resolution data. Of the translocations, 90% were conducted with hard release procedures (N = 19). Therefore, we based our effectiveness analyses on only the 21 case studies with translocation success data. In the same way, we based conflict resolution analyses on only the 15 case studies reporting it.

Only 19% (N = 4) of the translocated individuals were released into protected areas. About 70% of the translocations to solve human-carnivore conflicts dealt with felids (Fig. 1A). These translocations were conducted mainly in forest and savannah habitats (see Fig. 1B) of North America and Africa (see Fig. 1C). Post-release success rate (i.e. the proportion of individuals that survived at least for one year after release) was 42% ± 6 (mean ± 1SE; N = 21), being quite variable among species (Table 1).

Regarding solving conflicts, 64% ± 11 (N = 15) of the translocated individuals did not return to the area from which they were removed and did not engage in new conflicts. Of the translocated animals, 47% died within 110 days ± 34 after release. Human-related mortality (i.e. illegal hunting, poaching and vehicle collisions) accounted for 83% the losses among carnivores translocated in attempt to mitigate human-wildlife conflicts (N = 12). The cause of mortality was not disclosed in seven case studies.

Regarding translocation costs, 16 wildlife managers from nine countries answered our questionnaire. Another 27 respondents acknowledged that they had no information, despite the fact that some of them had been involved in translocation operations. On average, translocation cost per individual was US$ 3,756 ± 357 (N = 16). When we had standardised the translocation costs, the cost was approximately 0.35 ± 0.10 times the annual *per capita* income of an average citizen.

Disaggregating cost data by carnivore group, ursines and felids were the most expensive to translocate (US$ 3,981 ± 1,412, N = 6 and US$ 3,941 ± 1,242, N = 7, respectively). Canid translo-

Table 1. Translocation success rates, defined as the proportion of translocated individuals that survived at least for one year (mean ± 1SE) of four carnivore groups, with the number of case studies for each species shown in parentheses.

Carnivore group	Species involved		Species success	Group success
Mustelids (1)	*Enhydra lutris*	(1)	11 %	11 %
Felids (13)	*Puma concolor*	(5)	46 ± 7 %	
	Panthera tigris	(3)	17 ± 17 %	
	Panthera leo	(2)	39 ± 14 %	
	Panthera onca	(1)	50 %	
	Lynx canadensis	(1)	61 %	
	Acinonyx jubatus	(1)	36 %	39 ± 6 %
Canids (2)	*Canis lupus*	(1)	31 %	
	Lycaon pictus	(1)	100 %	66 ± 35 %
Ursines (2)	*Ursus americanus*	(1)	90 %	83 ± 8 %
	Ursus arctos	(1)	75 %	

cation was the least expensive (US$ 2,875 ± 350, N = 3). Translocation costs varied also according to the transportation means used. Air transportation was more expensive than terrestrial operations (US$ 7,837 ± 2,678, N = 3 vs US$ 2,805 ± 389, N = 13). When looking at the standardised costs, felid translocation was the most expensive (0.45 ± 0.13 times the annual income of an average citizen), followed by ursines (0.30 ± 0.24) and canids (0.19 ± 0.06).

Compensation costs were available for livestock lost to carnivores in nine countries. We gathered five instances of compensation costs in North America (Mech 1998, Ontario Ministry of Agriculture 2001, Nyhus et al. 2005, Haney et al. 2007, Treves et al. 2002), eight in Africa (Butler 2000 with two sets of compensation data, Patterson et al. 2004, Frank et al. 2005, Woodroffe et al. 2005, Gusset et al. 2009, Hemson et al. 2009, Maclennan et al. 2009), two in Europe (Swenson & Andrén 2005 with two sets of compensation data) and five in Asia (Mishra 1997, Karanth & Gopal 2005, Miquelle et al. 2005, Chhangani et al. 2008 with two sets of compensation data). The mean compensation per head of livestock was US$ 148 ± 24 (i.e. 0.05 ± 0.02 times the annual income of an average citizen when

Table 2. Number of livestock heads that could be compensated for by using the same amount of money as spent on translocating one wild carnivore, calculated from standardised compensation and translocations costs (see text for details). Conservation status (IUCN version 2010.2) for each species is shown in parentheses; NT indicates not threatened, LC indicates low concern, VU indicates vulnerable and EN indicates endangered.

Carnivore group	Species involved		Livestock heads to be compensated	Individual heads of livestock killed by a carnivore in one year (range (mean) [source])
Felids (6)	*Panthera onca*	(NT)	15	0.75 - 1.25 (1) [a]
				1 - 6 (2.6) [b]
	P. pardus	(NT)	8	1 - 3 (1.05) [c]
				1 - 3 (1.7) [d]
				1 - 9 (2.7) [e]
				1 - 5 (1.9) [f]
	Puma concolor	(LC)	4	1 - 2 (1.24) [a]
				1 - 6 (2.6) [b]
				1 - 2 (1.8) [g]*
	P. yagouaroundi	(LC)	4	No data
	Leopardus pardalis	(LC)	4	No data
				1 (1) [h]
				0.1 - 8.2 (3.2) [I]
	Acinonyx jubatus	(VU)	8	1 - 4 (1.3) [f]
Canids (2)	*Lycaon pictus*	(EN)	6	1 - 6 (3.6) [j]
				1 - 2 (1.8) [k]
				1 - 2 (1.5) [l]
				1 - 2 (0.7) [f]
				1 - 2 (1.5) [m]
				1 - 3 (1.39) [n]
	Canis lupus	(LC)	2	1 - 3 (1.7) [o]
Ursines (3)	*Tremarctos ornatus*	(VU)	30	~ 9 [p]**
				3 - 6 (4.5) [q]**
	Ursus arctos	(LC)	2	1 - 4 (2.5) [r]**
	U. americanus	(LC)	1	1 - 2 (1.5) [s]
	Mean compensation		7	

Sources: [a] de Azevedo & Murray (2007), [b] Conforti & de Azevedo (2003), [c] Kolowski & Holekamp (2006), [d] Kissui (2008), [e] Butler (2000), [f] Woodroffe et al. (2007), [g] Polisar et al. (2003), [h] Patterson et al. (2004), [I] Marker et al. (2003), [j] Gusset et al. (2009), [k] Rasmussen (1999), [l] Woodroffe et al. (2005), [m] Harper et al. (2008), [n] Muhly & Musiani (2009), [o] Treves et al. (2002), [p] Goldstein (2002), [q] Knarrum et al. (2006), [r] Zimmermann et al. (2003), [s] Baruch-Mordo et al. (2008).
* Calculated from paper data.
** May correspond to more than one problem carnivore.

standardised). The cost of translocating one individual thus could be used to compensate up to 30 killed animals. Except for the black bear *Ursus americanus* and the brown bear *U. arctos*, the number of lost livestock that could be compensated with the money spent on one translocation, was greater than the number of individuals that a given carnivore could have killed in one year (Table 2).

Discussion

Solving human-carnivore conflicts through non-lethal approaches is a desirable goal, particularly when threatened species are involved. Translocations are often conducted to fulfill this goal. It is common worldwide, and it is sometimes referred to as a cost-effective humane technique (Linnell et al. 1997). The conflict resolution success rate of ~ 64% (being 100% successful in 33% of the cases), suggests that translocation might be effective. However, our review depicts a more critical scenario as the high conflict resolution rate might emerge from the high mortality incidence among translocated animals.

While a translocation success rate of 36-48% might appears to be high, caution should be applied when interpreting this figure. There is a high probability that these values are overestimated, due to a publication bias towards reporting only successful translocations (Fischer & Lindenmayer 2000). Regardless of the precise figure, high mortality rates in groups like large felids cast doubts regarding the use of translocation as a conservation-sensitive tool. This is critical as almost 50% of the translocated species are of conservation concern (Inskip & Zimmermann 2009).

Despite many possible mortality causes in translocated animals (Hayward et al. 2007), human-related mortality accounted for 83% of the death causes. Out of our 21 cases, 17 (80%) reported that translocated animals were released into non-protected areas, potentially exposing them to nearby human settlements. While human-related deaths might occur even within protected areas (Woodroffe & Ginsberg 1998), the high mortality among translocated carnivores questions the effectiveness of translocation as a non-lethal method.

Furthermore, homing behaviour appears to be common in all carnivore groups (Linnell et al. 1997), and soft-release procedures may help to reduce it (Hunter et al. 2007). However, soft-release procedures were not used in the case studies we reviewed. Critical release distances to avoid homing on large carnivores usually range between 100 and 300 km, but could be > 500 km for pumas *Puma concolor*, reducing the chances of translocation success. This fact might render long distance releases impractical or extremely expensive to conduct effective translocations in real-life situations (Linnell et al. 1997).

The abundance of native prey at the release site is also a determinant of success. Homing behaviour and attacks on livestock are unlikely to occur in areas with adequate prey supply (Gusset et al. 2009, Hayward et al. 2006, Stamps & Swaisgood 2007). Regrettably, no consideration of the prey base at the release site is presented among the case studies we reviewed.

According to Treves & Karanth (2003), there was no clear evidence of attack in 41% of the cases where a carnivore was killed to avoid livestock predation. In fact, > 75% of the attack reports may be false (e.g. Hunter et al. 2007, Perrin 2002). Livestock losses due to carnivore attacks are expected to have significant effects at a regional economy scale (see Baker et al. 2008). Nevertheless, natural livestock mortality is rarely considered, although it could be up to 10 times larger than carnivore-related mortality (Kissui 2008, Mazzolli et al. 2002).

Best-herding practices may help to reduce carnivore-livestock encounters. Free-ranging animals are more prone to be predated upon than when corralled (Mazzolli et al. 2002). In most situations, the resulting economic losses are usually lower than the translocation costs. Data shown in Table 2 give break points for nine species. Below these thresholds, compensation would be cheaper and more humane than translocating. For example, on average one jaguar *Panthera onca* may prey on 2.6 livestock heads/year, but the cost of translocating it would be equivalent to compensate for 15 heads. Therefore, funding allocated to translocating one jaguar, could compensate the losses provoked by up to six individuals (see Table 2). Conversely, in most situations, translocation would be a cost-effective option for a grizzly or a brown bear.

Compensatory payments might not be easily implemented and might not suffice for changing the ranchers' attitude towards carnivores, or discourage them from killing carnivores (Nyhus et al. 2005). Thus, if compensation is associated with best herding practices (Gusset et al. 2009, Inskip & Zimmermann 2009), it might improve peoples' tolerance for carnivores and facilitate product certifi-

cations. Certified 'Carnivore-friendly meat' (or any other commodity) offers an add-on value in the final consumer market, as currently happens with other products such as dolphin-friendly tuna fish *Thunnus* spp. This benefit could encourage ranchers to have a more tolerant attitudes towards wild carnivores (Le Gall et al. 2009, Velho et al. 2009).

From a conservation perspective, translocation appears equivalent to lethal removal (Miller et al. 1999, Treves & Karanth 2003) for six out of 10 translocated individuals. The evidence we present shows that in the vast majority of cases, a well-implemented compensation scheme, associated with best herding practices, would be a more cost-effective alternative rather than translocating endangered carnivores.

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