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Abstract: This review focuses on the success and survivorship of captive-born versus wild-caught carnivores used in reintroductions. Previous reviews have suggested that reintroduction projects using captive-born animals are less likely to be successful than projects translocating wild-caught animals. The purpose of this paper is to examine this statistically and investigate how captivity may affect the survival of reintroduced carnivores. We examined results published in previous reviews, and found evidence to support that reintroduction projects using wild-caught animals are significantly more likely to succeed than projects using captive-born animals. We further compiled our own review of 45 case studies in carnivore reintroduction projects (in 17 species across 5 families) to investigate survival rates rather than overall project 'success'. We found that (1) wild-caught carnivores are significantly more likely to survive than captive-born carnivores in reintroductions; (2) that humans were the direct cause of death in over 50% of all fatalities and (3) that reintroduced captive-born carnivores are particularly susceptible to starvation, unsuccessful predator/competitor avoidance and disease.

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Review

The effects of captive experience on reintroduction survival in carnivores: A review and analysis

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ABSTRACT

This review focuses on the success and survivorship of captive-born versus wild-caught carnivores used in reintroductions. Previous reviews have suggested that reintroduction projects using captive-born animals are less likely to be successful than projects translocating wild-caught animals. The purpose of this paper is to examine this statistically and investigate how captivity may affect the survival of reintroduced carnivores. We examined results published in previous reviews, and found evidence to support that reintroduction projects using wild-caught animals are significantly more likely to succeed than projects using captive-born animals. We further compiled our own review of 45 case studies in carnivore reintroduction projects (in 17 species across 5 families) to investigate survival rates rather than overall project 'success'. We found that (1) wild-caught carnivores are significantly more likely to survive than captive-born carnivores in reintroductions; (2) that humans were the direct cause of death in over 50% of all fatalities and (3) that reintroduced captive-born carnivores are particularly susceptible to starvation, unsuccessful predator/competitor avoidance and disease.

Contents

1. Brief introduction and background 356
2. Previous reintroductions for conservation 356
3. Previous reviews and their findings on the effect of source population 357
4. Why focus on carnivores? 357
5. Main objectives 357
6. Methods 357
   6.1. Literature search 357
   6.2. Creation of the data base 359
   6.3. Statistical analyses 359
7. Results 359
   7.1. An analysis of success of reintroduction projects using wild-caught versus captive-born 359

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7.2. Survival of wild-caught versus captive-born animals and family differences . . . 359
7.3. Investigating cause of death . . . 360
8. Discussion . . . 360
8.1. Success of projects based on results of previous publications . . . 360
8.2. Success at the individual level in carnivore reintroductions . . . 361
8.3. Problems with the data set and suggestions for future studies . . . 361
9. Conclusion . . . 361
Acknowledgements . . . 361
References . . . 361

1. Brief introduction and background

Humans have a long history of translocating animals, whether by intention or not. In the past, intentional translocations of animals have predominantly been for the purpose of supplementing game species. However, more recently, translocation for the purpose of re-establishing endangered animals into their native habitat has become an increasingly popular conservation technique (MacKinnon and MacKinnon, 1991; Stuart, 1991). The IUCN (International Union for the Conservation of Nature and Natural Resources, also known as the World Conservation Union) (1998) defines a translocation as "a deliberate and mediated movement of wild individuals or populations from one part of their range to another" (p. 6) and a "reintroduction (a)s an attempt to establish a species in an area which was once a part of its previous historical range" (p. 6). It is important to note that the IUCN definition of a reintroduction makes no mention of the origin (i.e. wild-caught or captive-born) of the source population. Reintroduction has been seen as a valuable tool for conservation with the potential to save many species from extinction (Kleiman, 1989; MacKinnon and MacKinnon, 1991; Sarrazin and Barbault, 1996; Seal, 1991; Stuart, 1991; Tear et al., 1993).

However, reviews have found that translocations and reintroductions of endangered species for conservation purposes have average success rates ranging from 11% to 53% (Beck et al., 1994; Fischer and Lindenmayer, 2000; Wolf et al., 1996), which suggests that the use of translocations and reintroductions as a conservation tool needs to be further investigated and improved upon in order to ensure that they are viable options.

2. Previous reintroductions for conservation

There have been a number of well publicized reintroductions carried out for conservation purposes, e.g. golden lion tamarin (Kleiman and Mallinson, 1998), red wolf (Oakleaf et al., 2004), California condor (Toone and Wallace, 1994), black-footed ferret (Russell et al., 1994), and Arabian oryx (Stanley Price, 1989). Most of the animals used in these projects were either captive-born or brought into captivity due to their near extinct status. To evaluate the outcome of these projects, many have attempted to define reintroduction success (Fischer and Lindenmayer, 2000; Kleiman et al., 1991; Kleiman et al., 2000; Seddon, 1999; Stanley Price, 1991) and a combination of the following four criteria are now generally agreed upon as indicating project success: (1) breeding by the first wild-born population, (2) a three year breeding population with recruitment exceeding adult death rate, (3) an unsupported wild population of at least 500, and (4) the establishment of a self-sustaining wild population.

However, there are difficulties in setting minimum success criteria (Kleiman et al., 1994), as they can lead to assumptions that there is an end-point to which supplemental releases or continued monitoring of projects may no longer be required (Seddon, 1999). Therefore, the success of a reintroduction can only be examined at a specific point in time; which, in the majority of projects, is often shortly after release-since long-term monitoring is infrequent due to time and budget constraints. Also, current reintroduction success criteria do not include success at the level of the individual animal.

Previous reviews have highlighted several factors that appear to contribute to the success or failure of a reintroduction project. A comprehensive evaluation of the factors affecting success in reintroduction projects is beyond the scope of this paper, and many have already been published (e.g. see Seddon et al., 2007; Beck, 1995; Beck et al., 1994; Breitenmoser et al., 2001; Fischer and Lindenmayer, 2000; Griffith et al., 1989; Reading and Clark, 1997; Stanley Price, 1991; Wolf et al., 1996). However, the main biological and ecological factors contributing to project outcome can be summarised as follows: habitat suitability, long-term food availability, the season of release, type of release (soft or hard) and the source (wild-caught or captive-born) of released animals. We are interested in how the source of animals (i.e. whether they were obtained wild-caught from a sustaining wild population or from captive breeding stocks) might affect the success of a reintroduction project. In most cases of translocating game species, the stock comes from a stable wild population. However, reintroduction projects for the purpose of conservation are carried out because wild populations are declining; thus, founder stock are increasingly being sourced from captive populations (Wilson and Stanley Price, 1994).

There are many risks involved when reintroducing captive animals; however, the main concern is that animals in captivity often show a loss of natural behaviours associated with wild fitness. Deficiencies can be seen in foraging/hunting, social interactions, breeding and nesting, and locomotory skills. (Rabin, 2003; Snyder et al., 1996; Stoinski et al., 2003; van Heezik and Ostrowski, 2001; Vickery and Mason, 2003; Wallace, 2000). Other considerations include captive-born animals' lack of immunities to viruses/diseases prevalent in their wild counterparts (Bush, 1994; Cunningham, 1996; Woodford and Rossiter, 1994). Studies have suggested that projects using captive-born animals are less likely to be successful than projects using wild-caught animals (Mathews et al., 2005). A review by Beck et al. (1994) estimated that only 16 out of 145 reintroduction projects using captive-born animals were successful.

3. Previous reviews and their findings on the effect of source population

Out of the several previously published reviews, three in particular, Griffith et al. (1989), Wolf et al. (1996) and Fischer and Lindenmayer (2000), have reported differences between the success rates of reintroduction projects and the source of animals used, and in all cases projects using captive-born animals averaged a lower success rate than those using wild-caught. Further to their 1989 paper, Griffith et al. (1990) statistically reported that this difference was significant; however, they did not investigate differences in survival rates between sources across species, and therefore do not account for species biases.

4. Why focus on carnivores?

Carnivores are well represented in reintroduction projects; this can be explained by the taxonomic bias observed in species selected for conservation. Conservation societies often use flagship species, for example the giant panda (*Ailuropoda malanoleuca*), to promote conservation efforts and these are often chosen for their visual appeal, e.g. flagship species are typically large mammals. This preference for animals with 'visual appeal' can also be seen in species selected for reintroduction projects. Bias can be seen towards mammals, and to some extent, birds; and despite their proportionally greater endangered status fish, amphibians, reptiles, invertebrates and plants comprise a much smaller ratio of reintroduction projects. Within mammals, two Orders are particularly overrepresented in reintroductions, artiodactylids (e.g. ungulates) and carnivores (Seddon et al., 2005).

There are many causes of decline in carnivore numbers, such as decreasing prey densities, loss of habitat, and competition with humans. Direct human-carnivore conflicts are generally related to livestock, and as a result carnivores have been heavily persecuted (Johnson et al., 1996; Woodroffe, 2003). Indirect human-carnivore conflicts, such as the effects of hunting and rising human densities, also heavily affect the decline of carnivore populations (Woodroffe and Ginsberg, 2000). Carnivore population densities are particularly sensitive to eco-system changes and are often quite variable (Wildt et al., 2001). Carnivores are long-lived, have extensive social learning (Gittleman, 1996), and have a relatively long generation time, which means that populations do not quickly recover from extensive decline. These aspects of their natural history have implications for both ex situ and in situ conservation.

There have been several reviews that specifically examine carnivore conservation (Breitenmoser et al., 2001; Clark et al., 1996a,b; Reading and Clark, 1997; Soorae and Stanley Price, 1997; Weber and Rabinowitz, 1996), and it is generally proposed that long-term in situ efforts, such as habitat protection and ensuring prey densities, are more effective conservation measures than ex situ releases. A major difficulty facing carnivore reintroductions is that often the cause behind the initial extirpation (i.e. conflict with humans) is not resolved at the time of proposed reintroduction (Miller et al., 1999; Wilson, 2004).

Furthermore, there are not many sustainable carnivore populations left in the wild to provide release stock. This necessitates the use of captive populations, either to establish a new population or to supplement existing populations. However, there are particular difficulties unique to captive-born carnivores, which include loss of socially learned skills (e.g. hunting), conditioning to humans, experience feeding on livestock, inappropriate social behaviours (e.g. mating and dominance) and other factors associated with adaptation to captivity (Soorae and Stanley Price, 1997). Wide-ranging carnivores appear to respond poorly (e.g. low breeding success and high levels of stereotypies) to captivity (Clubb and Mason, 2003) and it has been further shown that these stereotypies (or abnormal behaviours) are strong behavioural deficiencies that may have an effect on reintroduction survivorship (Vickery and Mason, 2003, 2005).

5. Main objectives

There are two main objectives for this paper. One was to statistically verify differences between the success rates of reintroduction projects (obtained from previously published reviews) based on their source of founder stock. The prediction is that projects using wild-caught animals will be more successful than those using captive-born animals (Mathews et al., 2005). The second objective was to provide an updated review and analysis on the survival rates of reintroduced and translocated endangered carnivores. Reading et al. (1997) and Breitenmoser et al. (2001) carried out reviews of carnivore reintroductions; however these reviews are now out of date and did not specifically investigate the effect of source animals. Therefore, we have compiled statistics from the results of reintroductions and translocations of carnivores published since 1990 in order to investigate the survival rates of reintroduced animals in relation to the source of founder stock, wild or captive. We looked at survival percentages of released animals instead of "success" criteria, which can define a project as successful despite the high mortality of released animals. Survival can be used as an assay of animal welfare as well as a tool to assess factors contributing to individual successes or failures; though it is worth mentioning that a successful reintroduction may well be considered to have a worthy outcome in the face of possible extinction, despite mortality costs.

6. Methods

6.1. *Literature search*

The literature search was carried out on carnivore reintroduction and translocation projects that have been published post 1990. Literature was collected over a 5 month period in early 2005, and included over 25 journals, two of which were particularly applicable – *Biological Conservation* and *Conservation Biology*, and over 30 relevant books and symposium proceedings. Journals were searched via online databases and electronic

Table 1 – Carnivore reintroduction and translocation programs (post-1990)

Class: Mammalia order: Carnivora	Species	No. of Animals released captive/wild		Percentage of founder population surviving captive/wild		Cause of death (In order of prevalence)
Felidae	Lynx					
	Lynx canadensis[1]	0	96	NA	.59	Starvation, various
	European lynx					
	Lynx lynx[2]	19	0	.68	NA	Disease, various
	Lynx lynx[3]	7	0	.42	NA	Human
	Lynx lynx[4]	25	0	.30	NA	Recapture, human, unknown
	Lynx lynx[5]	21	0	.30	NA	Human, recapture, starvation
	Iberian lynx					
	Lynx pardinus[6]	0	2	NA	.50	Unknown
	Bobcat					
	Felis rufus[7]	0	32	NA	.90	Drowning
	Mountain lion					
	Felis concolor azteca[8]	0	14	NA	.35	Injuries, disease, human
	Felis concolor[9]	0	7	NA	.57	Unknown, human
	Felis concolor stanleyana[10]	0	7	NA	.57	Human, unknown
	Felis concolor stanleyana[11]	0	8	NA	.63	Human, unknown
	Wildcat					
	Felis silvestris[12]	6	0	.33	NA	Unknown
	Cheetah					
	Acinonyx jubatus[13]	0	21	NA	.66	Human
	Acinonyx jubatus[14]	0	3	NA	.33	Human, unknown?
	Amur tiger					
	Panthera tigris altaica[15]	0	2	NA	1.0	N/A
Canidae	Swift fox					
	Vulpus velox[16]	16	0	.68	NA	Starvation, humans, unknown
	Vulpus velox[17]	108	19	.06	.32	Coyotes, various
	Vulpus velox[18]	365	204	.11	.47	Coyotes
	Wild dog					
	Lyacon pictus[17]	8	0	0	NA	Humans
	Lyacon pictus[19]	13	0	0	NA	Lions, rabies, humans
	Lyacon pictus[19]	11	0	0	NA	Humans
	Lyacon pictus[19]	9	0	0	NA	Unknown
	Lyacon pictus[19]	0	4	NA	.25	Lions
	Lyacon pictus[19]	0	6	NA	0	Unknown
	Grey wolf					
	Canis lupus[20]	0	31	NA	.71	Human, unknown
	Red wolf					
	Canis lupus baileyi[21]	79	51	.18	.35	Human, recapture
	Canis lupus baileyi[19]	0	100	NA	.63	Human, unknown
	Canis lupus baileyi[19]	0	45	NA	.62	Human
	Canis lupus baileyi[19]	0	11	NA	.27	Human
Ursidae	Black bear					
	Ursus americanus[22]	0	43	NA	.25	Unknown
	Ursus americanus[22]	0	21	NA	.43	Unknown
	Ursus americanus[23]	0	79	NA	.70	Human, unknown
	Ursus americanus[24]	0	14	NA	.54	Unknown
	Ursus americanus[25]	23	0	.25	NA	Various
	Brown bear					
	Ursus arctos[22]	0	3	NA	.66	Unknown
	Ursus arctos[22]	0	3	NA	.66	Human
	Ursus arctos[22]	0	4	NA	.25	Unknown
Mustelidae	European otter					
	Lutra Intra[27]	25	11	.42	.79	Various
	River otter					
	Lontra Canadensis[28]	0	303	NA	.88	Various
	Lontra Canadensis[29]	0	25	NA	.72	Human/Various
	Black-footed ferret					
	Mustela nigripes[30]	49	0	.20	NA	Various, Unknown
	Mustela nigripes[31]	94	0	.59	NA	Unknown
	Mustela nigripes[31]	77	0	.32	NA	Unknown
	Mustela nigripes[31]	26	0	.69	NA	Unknown

Table 1 – continued

Class: Mammalia order: Carnivora	Species	No. of Animals released captive/wild		Percentage of founder population surviving captive/wild		Cause of death (In order of prevalence)
Ailuridae	Red panda *Ailurus fulgens*[26]	2	0	.5	NA	Predated

[1]Shenk (2001), [2]Anders (personal communication, 2004), [3]Boer et al. (1995), [4]Blomqvist et al. (2000), [5]Vandel et al. (2006), [6]Rodriguez (1995), [7]Warren et al. (1990), [8]Ruth (1994), [9]Ross and Jalkotzy (1995), [10]Belden and Hagedorn (1993), [11]Jansen and Logan (2002), [12]Olmo and Mino (1992), [13]Purchase (1998), [14]Phiri (1996), [15]Miquelle et al. (2001), [16]Bremner-Harrison et al. (2004), [17]Woodroffe and Ginsberg (1997), [18]Carbyn et al. (1994), [19]Moehrenschlager and Somers (2004), [20]Phillips and Smith (1997), [21]Oakleaf et al. (2004), [22]Clark et al. (2002), [23]Wear et al. (2005), [24]Eastridge and Clark (2001), [25]Stiver et al. (1997), [26]Pradhan (personal communication, 2004), [27]Sjoasen (1996), [28]Johnson et al. (1999), [29]Johnson and Berkley (1999), [30]Russell et al. (1994), [31]Vargas et al. (1999).

journals, such as Web of Science, EBSCO, JSTOR, IngentaConnect, and Elsevier ScienceDirect. We also carried out extensive web searches with keywords such as "reintroduction", "translocation", and "carnivore", as well as specific carnivore species. In these web based searches, we were able to find unpublished reports, government run projects, and projects published in lesser known journals, newsletters, and updates. Additionally, articles were collected opportunistically, and in some cases by referral (see Table 1 for a list of all projects included in review).

6.2. *Creation of the data base*

Because of our interest in looking at survival rates of the founder stocks, we restricted our search to include only projects that (1) reported actual numbers of animals released, and (2) also carried out some form of post-release monitoring and thus were able to report on the number of mortalities or survivors. Post-release monitoring varied across projects, but ranged in time from 6 to 18 months. Given these criteria, we were able to include only 45 projects, some projects using only captive or only wild subjects; some using a combination of both. Combination projects were only included if independent data were available on source of animal, and were therefore analysed as separate projects, which for the purpose of analysis brought the N up to 49 (see Table 1). The 49 ($N_{wild} = 29$, $N_{captive} = 20$) case studies included 17 carnivore species across 5 families (Felidae, Canidae, Ursidae, and Mustelidae and Ailuridae) using a total of 2152 animals ($N_{wild} = 1169$, $N_{captive} = 983$).

6.3. *Statistical analyses*

Fischer and Lindenmayer (2000) reported that wild reintroduction projects were more successful than captive projects but they did not test this difference statistically. We calculated an independent G test to see if this difference was significant. It is important to note that the original authors did not control for species biases and/or over-representation; therefore, it is not clear whether there were any external factors influencing the results, such as different representation of species between the two sources (wild/captive). The purpose of this test was merely to look at previous trends in reintroduction projects using different source populations.

We carried out a nested mixed model ANOVA (using SPSS v. 14) for the independent variables 'species' within 'families'; the dependent variable was 'percent survive' and the grouping variable was 'source' (wild or captive). Projects ($N = 49$) were weighted by 'sample size' (number of animals in each project) as a regression weight, which applies an estimated modification to the variance or weights in an effort to control for the differences in representation across species in the projects used for this analysis. Analyses carried out before weighting for sample size suggested an effect of species, thus weighting for the sample size helped to control for effects of projects with either very high or very low numbers of individuals. An ANOVA was used instead of a G-statistic because initial G calculations showed that the samples (species and families) were not statistically independent.

Individual G-tests of independence were carried out on each species where both sources were represented; this was done in order to investigate how consistent the survival trends were within each species (in one case (wild dog), a Fisher's exact test was used because two cells contained numbers less than 5). To investigate whether this was a trend across species, we then carried out a Wilcoxon related samples test on all species where both sources were represented.

7. Results

7.1. *An analysis of success of reintroduction projects using wild-caught versus captive-born*

The calculated G statistic on the results from Fischer and Lindenmayer's (2000) review, shows that reintroduction projects appear to be significantly more likely to succeed when a wild source population is used (31% of 45 projects) than when animals from a captive source are used (13% of 52 projects); $G = 4.466$, df = 1, $p = 0.035$.

7.2. *Survival of wild-caught versus captive-born animals and family differences*

The results of the ANOVA show that wild-caught carnivores survived significantly more (53%) than captive-born carnivores (32%), $F_{(1,4.66)} = 17.697$, $p = 0.01$; Fig. 1.

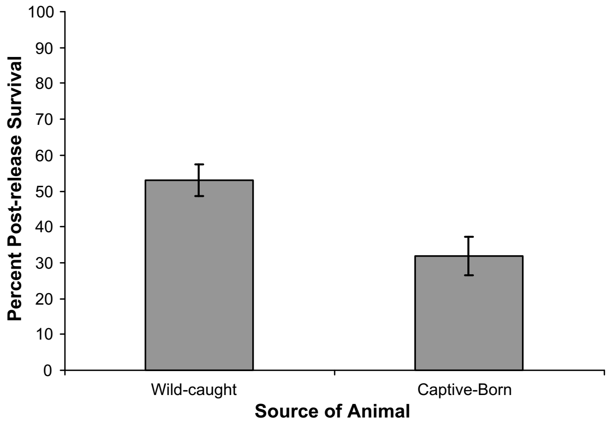

Fig. 1 – Percentage survival rates in reintroductions based on source of animals. Error bars represent the standard errors from the average percentage of survival for each source.

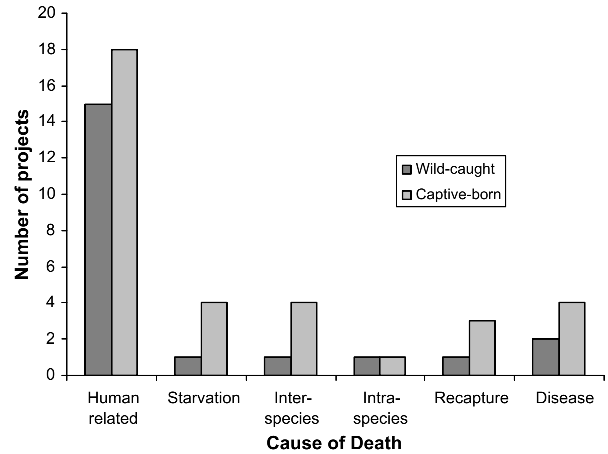

Fig. 3 – Percent cases where main cause of death is known.

When controlling for sample size, there were no significant differences in post-release survival across families ($F_{(3,0.29)} = 13.140$, $p > 0.05$) or species within families ($F_{(12,10.76)} = 0.667$, $p > 0.05$). Nor were there any significant interactions between source survival and families ($F_{(2,14.93)} = 0.121$, $p > 0.05$) (Fig. 2) or species within families ($F_{(2,27)} = 0.805$, $p > 0.05$). We did not include the Ailuridae family in this analysis due to low sample size.

We repeated the analysis, this time removing species that were represented by fewer than 3 animals, the red panda (also removed from previous analysis), the Iberian lynx, and the Amur tiger. This was done in an attempt to eliminate a biased effect from a small sample size. The new project N was 46, and animal N was 2146. The F value for the main effect of source remained unchanged, $F_{(1,4.81)} = 17.378$, $p = 0.01$ and all other effects remained non-significant.

Analyses were carried out on species where both captive and wild sources were represented, $N = 5$; swift fox (*Vulpus velox*), red wolf (*Canis lupus baileyi*), black bear (*Ursus americanus*), European otter (*Lutra lutra*) and wild dog (*Lyacon pictus*). There was a significant effect of source on four of the species tested such that animals from wild sources survived better than animals from captive sources; swift fox ($G = 96.619$, df = 1, $p < 0.001$), red wolf ($G = 33.055$, df = 1, $p < 0.001$), black bears ($G = 5.442$, df = 1, $p = 0.01$), European otters ($G = 5.714$, df = 1, $p = 0.01$) all results reported are two-tailed. A Fisher's exact test was used (due to low cell values) to calculate effect of survival on wild dogs, and was not significant at $p = 0.20$, in this case survival for both wild and captive animals was very low. The Wilcoxon related samples test showed a significant difference between source survival across the 5 species ($z = 2.023$, N-Ties = 0, $p = 0.043$) such that survival was better from wild sources (48.5%) than from captive sources (19%).

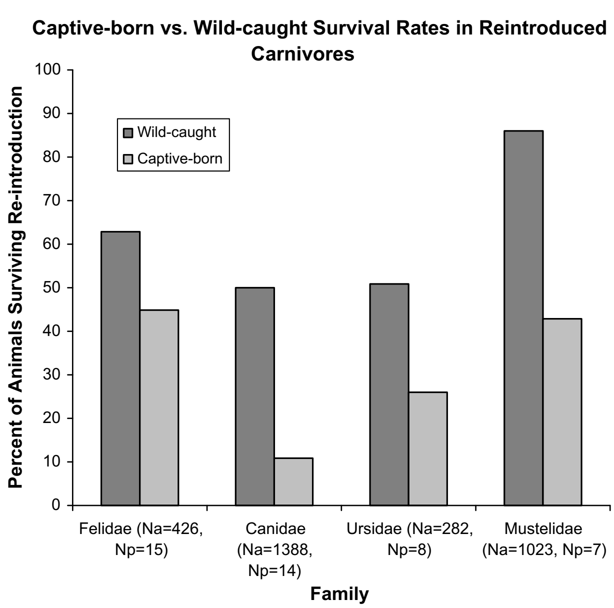

Fig. 2 – Reintroduction survival rates across carnivore families (N_a = number of animals, N_p = number of projects). No error bars present as percentages were calculated from grand totals for each family.

7.3. *Investigating cause of death*

Regardless of the success or failure of a reintroduction project, the most common cause of death for both wild and captive animals, was by human means (this included shooting, poisoning, automobile driving accidents, and other related incidences) (refer to Fig. 3). Starvation, inter-species aggression (e.g. reintroduced wild dogs killed by lions) and disease (such as rabies and distemper) were also prevalent causes of death for captive animals. Recapture was measured as death, since individuals were only removed in cases where they would not otherwise survive.

8. Discussion

8.1. *Success of projects based on results of previous publications*

Our results support that the use of different source populations has an effect on the success of the project and corroborates Fischer and Lindenmayer's (2000), Griffith et al.'s (1989) and Wolf et al.'s (1996) reviews. This evidence suggests that captivity negatively influences animals' capabilities to survive, and can result in a lack of appropriate 'wild' type behaviours (Rabin, 2003). Other potential factors influencing captive animals' lack of success can range from lack of immunities to diseases present in wild populations and/or to an unnatural confidence towards humans (Woodford and Rossiter, 1994; Woodroffe, 2003). There needs to be further investigation into the factors affecting success rates between wild and captive source populations in order to determine where these differences may lie.

8.2. *Success at the individual level in carnivore reintroductions*

We investigated differences in survival as well as causes of death across families. Ideally, it would be advantageous to statistically evaluate differences between or across species; in our case our non-significant findings across families and species may be due to our relatively small data set containing unequal source and species representation. Despite the data in this review not being robust enough to investigate any species differences, we were still able to look at trends across four of the five families presented. It appears from Fig. 2 as though captive experience has a particularly negative effect on survival for canids and slightly less so for ursids and mustelids. It would be worthwhile to see if this trend could be supported statistically in a larger data set.

In examining survival rather than success rates, we were able to preliminarily investigate which factors influenced cause of death in captive-born or wild-caught animals. Our results indicate that behaviours associated with tameness towards humans, lack of social influence from con-specifics, and lack of foraging/hunting skills are factors that should be investigated more thoroughly in order to improve upon the survival of captive-born released carnivores. For future studies, we recommend not just evaluating survival, but breeding success, longevity, and causes of fatality and mortality; however, with the information available from published reintroductions, this is ambitious. Additionally, unsuccessful reintroduction projects are less likely to be published than successful projects (Fischer and Lindenmayer, 2000; Reading et al., 1997) which suggests that our estimates of survival are likely to be conservative.

8.3. *Problems with the data set and suggestions for future studies*

Because of the publication bias, the selection process of species involved in reintroduction projects (i.e. flagship species), and the limited amount of the literature and resources available, a more robust and complete data set would be difficult to compile. There are also inherent difficulties in analysing reviews of published literature, such as repeatability likelihood and issues facing the methodological rigour of carrying out literature searches (Fazey et al., 2005; Roberts et al., 2006 and Stewart et al., 2005).

An ideal data set should be able to control for effects of species by having: relatively equal sample sizes across families and species as well as between source, comprehensive post-monitoring, and information on individual animals. A more exhaustive review of this type of data set including a wider range of species, as well as those outside the order Carnivora, would greatly improve our knowledge on the effects of captivity.

A data set such as this could identify what factors or species characteristics may influence captive survival rates (i.e. home range size or social structure) as well as elucidate factors which could increase the success of reintroduction projects using captive-born animals. This would allow researchers to identify areas where captive animals might benefit from specific training programs (e.g. Shier and Owings, 1997). Results could also lead to development of more specific reintroduction guidelines for particular species. Investigating the effects of husbandry, and pre-release experience on survival of released animals is equally important. Determining which species were more successful in reintroductions after captive experiences would allow for recommendations on the improvement of both in situ and ex situ conservation efforts. More reviews should be conducted on reintroduction projects using primarily captive animals (but also projects using a combination), in order to investigate overall trends and to flag important effects or variables influencing the success of individual animals (i.e. effects of hand-rearing versus dam rearing).

9. Conclusion

Our findings support previous reports that reintroduction projects using wild-caught animals are more successful than those using captive-born animals. We also found that wild-caught carnivores are more likely to survive than captive-born carnivores in reintroductions and that this trend appears to remain consistent across species and families. Further reviews should be conducted on carnivores, as well as other species, in order to improve our understanding on how captivity affects survival in reintroductions.

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