Use of wild–caught individuals as a key factor for success in vertebrate translocations

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Abstract

Use of wild–caught individuals as a key factor for success in vertebrate translocations.— Success of vertebrate translocations is crucial to improve efficacy and efficiency of conservation actions but it is often difficult to assess because negative results (failed translocations) are seldom published. We developed surveys and sent them to heads of conservation services in three major Spanish Mediterranean regions. The purpose of our surveys was to determine which methodological factor that could easily be implemented in practice was more influential for translocation success. These factors included the origin of translocated individuals (captive or wild) and translocation effort (propagule size and program duration). After analyzing 83 programs, corresponding to 34 vertebrate species, by means of generalized linear mixed modelling, we found that 'origin' was more relevant for translocation success than 'effort', although we could not rule out some role of translocation effort. Variance in success of translocation programs involving individuals from wild sources was smaller and consequently results more predictable. Origin interacted with taxa so that success was higher when using wild birds and especially wild fish and mammals, but not when releasing reptiles. Hence, we suggest that, for any given effort, translocation results will be better for most vertebrate taxa if individuals from wild sources are used. When this is not feasible, managers should release captive–reared individuals for a long number of years rather than a short number of years.

Key words: Translocation success, Vertebrates, Origin of individuals, Reintroduction effort, Captive–breeding, Cost of release

Resumen

La utilización de individuos capturados en el medio natural como factor fundamental del éxito en las translocaciones de vertebrados.— Resulta fundamental que las translocaciones de vertebrados den buenos resultados para mejorar la eficacia y la eficiencia de las medidas de conservación, si bien a menudo es difícil de evaluar debido a que los resultados negativos (translocaciones fallidas) raramente se publican. Elaboramos encuestas y las remitimos a los jefes de los servicios de conservación de tres importantes regiones mediterráneas de España. La finalidad de nuestras encuestas era determinar el factor metodológico, que pudiera ponerse en práctica con facilidad, más influyente en el éxito de las translocaciones. Entre estos factores figuraban la procedencia de los individuos translocados (cautividad o medio natural) y el esfuerzo de translocación (tamaño del propágulo y duración del programa). Tras analizar 83 programas, correspondientes a 34 especies de vertebrados, por medio de modelos mixtos lineales generalizados, observamos que la procedencia era más importante para el éxito de la translocación que el esfuerzo, si bien no pudimos descartar que este último tuviera alguna influencia. La varianza en el éxito de los programas de translocación que utilizan individuos procedentes del medio natural fue inferior y, en consecuencia, los resultados, más predecibles. La procedencia interaccionó con los taxones de forma que el éxito fue mayor cuando se utilizaron aves silvestres y, en especial, peces y mamíferos silvestres, pero no sucedió lo mismo cuando se liberaron reptiles. Por consiguiente, sugerimos que, para un esfuerzo dado, los resultados de la translocación serán mejores para la mayoría de taxones de vertebrados si se utilizan individuos procedentes del medio natural. Cuando esto no sea posible, los gestores deberían liberar durante muchos años individuos criados en cautividad.

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Introduction

Wildlife managers have at their disposal in *situ* and *ex situ* measures to prevent decline or extinction of threatened species or populations or to revert them to their original state. *Ex situ* conservation, defined as conservation of components of biological diversity outside their natural habitats (Secretariat of the Convention on Biological Diversity, 2005) involves removal of the threatened species from its wild habitat to promote breeding in captivity. However, *ex situ* conservation programs should include release of individuals into the wild to comply with the ultimate goal of species conservation, defined as recovery of self–sustainable populations in their natural environments. Translocation programs are hence a specific type of *ex situ* conservation actions.

IUCN (1987) defined translocation as 'the movement of living organisms from one area, with subsequent free release in a second area, involving organisms coming either from wild or captive sources'. Here we follow the original definitions established by the IUCN, distinguishing between three major types of translocations: 'introduction', as movement of living organisms by humankind outside their indigenous distribution, 'reintroduction', as intentional movement of organisms by humankind into a part of the native range from which the species has disappeared or become extirpated, and 'reinforcement', as movement of individuals by humankind within their original habitat with the intention of building up number of individuals of an existing population (IUCN/SSC, 2013).

Direct persecution and increasing habitat loss due to human impact has resulted in translocation programs becoming a widespread tool to protect and enhance wildlife (Griffith et al., 1989; IUCN, 1998; Seddon et al., 2007). For example, while at the beginning of the 1990s the number of animal species involved in reintroduction programs worldwide was 126, by the year 2005 it had risen to 489 (Seddon et al., 2007). The prospect of fast results and the high–publicity character, supported by numerous success stories, explain the general popularity and acceptance of translocation programs (Wolf et al., 1996; Seddon et al., 2007) despite success rates being relatively low. These rates, assessed in several studies, vary between 11% (Beck et al., 1994) and 67% (Wolf et al., 1996), and are likely overestimated because successful programs are more likely to be published than failed programs or programs with an uncertain outcome (Reading et al., 1997; Fischer & Lindenmayer, 2000; Miller et al., 2014).

The Reintroduction Specialist Group of the IUCN's Species Survival Commission published a first set of guidelines for reintroductions (IUCN, 1998) with the aim of increasing the success rate of translocations. These guidelines have been updated recently (IUCN/SSC, 2013), and ideally every practitioner should use them before planning and implementing a translocation program. This document points out that reintroduction is only reasonable when the previous causes of extinction, such as over–harvest, habitat loss or predation, have been removed or sufficiently reduced to guarantee long–term survival of the reintroduced species. Detailed feasibility studies and risk assessments must be conducted to check whether the release site is suitable for the reintroduced population. In addition, every translocation program should include monitoring and continued management so that the outcome of the program can be assessed and reported, independently of whether translocation has been successful.

Despite these IUCN suggestions, there is a lack of well–documented post–release monitoring assessments that can provide information on consequences of particular conservation actions, and improve future decision–making regarding design and implementation of translocation programs (Sutherland et al., 2004; Armstrong & Seddon, 2008; Pérez et al., 2012). The success of translocation programs has been evaluated in detail in only a few cases, to some extent due to the difficulty in providing a generally applicable definition of 'success' (Seddon, 1999; Fischer & Lindenmayer 2000; Robert et al., 2015). Consequently, some factors which might determine the outcome of conservation–oriented translocations have yet to be identified by studies analyzing the methodological, environmental, species–specific and social or economic factors involved (Griffith et al., 1989; Wolf et al., 1996; Fischer & Lindenmayer, 2000).

For this study, we focused only on the methodological factors that are important in the success of vertebrate translocations, to provide conservation practitioners with applied guidance for improving success of their translocations programs in relation to variables that they can implement in practice (see table 1 for a review of factors identified in past literature that may determine outcome of conservation–oriented translocations). Specifically, we focused on two major methodological factors whose influence on success of translocation programs has been well documented in the literature: (1) the origin (wild or captive) of released individuals and (2) reintroduction effort, measured as number of released individuals and as duration of the program (*i.e.*, defined as the period when releases occurred). We were interested in evaluating whether the origin of released individuals and the effort involved in translocation were equally relevant. Our a priori expectation was that the origin of released individuals would be a more relevant factor than effort in our modelling of translocation success, because a cost in terms of high mortality following release from captivity (*i.e.*, incapacity to find food or escape from predators) is emerging as a usual property of translocation programs involving captive–bred individuals (see Tavecchia et al., 2009).

Material and methods

Data collection

Data on the success of translocation programs (*i.e.*, re–introductions/introductions and reinforcements) with conservation goals were obtained by surveying managers of wildlife conservation services in the autonomous regions of Catalonia, the Balearic Islands, and Valencia (fig. 1). These three regions cover a

Table 1. Review of factors identified in past literature that may determine outcome of conservation–oriented translocations.

Tabla 1. Examen de los factores que, según los datos publicados, pueden determinar el resultado de las translocaciones orientadas a la conservación.

Factor	Citations
Environmental	
Habitat quality	Griffith et al. (1989), Wolf et al. (1996, 1998), Burgman et al. (1998), Sheean et al. (2012), White et al. (2012), Cochran–Biederman et al. (2015)
Habitat improvement/ removal of initial cause of decline	Griffith et al. (1989), Wolf et al. (1996, 1998), Fischer & Lindenmayer (2000), White et al. (2012), Cochran–Biederman et al. (2015)
Habitat range	Griffith et al. (1989), Wolf et al. (1996, 1998), White et al. (2012)
Predation	Short et al. (1992), Fischer & Lindenmayer (2000), Matson (2004), Shier (2006), Bertolero et al. (2007), Aaltonen et al. (2009), Grey–Ross et al. (2009), Moseby et al. (2011), Sheean et al. (2012), White et al. (2012)
Competition	Griffith et al. (1989), Burgman et al. (1998), Bertolero et al. (2007), Sheean et al. (2012)
Species–specific	
Reproductive potential	Griffith et al. (1989), Wolf et al. (1996)
Migratory tendency	Wolf et al. (1996, 1998), Cochran–Biederman et al. (2015)
Diet	Griffith et al. (1989), Wolf et al. (1996, 1998)
Methodological	
Origin of released individuals	Griffith et al. (1989), Bright & Morris (1994), Wolf et al. (1996, 1998), Fischer & Lindenmayer (2000), Stoinski et al. (2003), Nicoll et al. (2004), Brown et al. (2006), Jule et al. (2008), Aaltonen et al. (2009), Roe et al. (2010), Champagnon et al. (2012)
Number of released individuals	Griffith et al. (1989), Short et al. (1992), Wolf et al. (1996, 1998), Green (1997), Fischer & Lindenmayer (2000), Matson (2004), Moulton et al. (2012), White et al. (2012), Cochran–Biederman et al. (2015)
Program duration	Griffith et al. (1989), Wolf et al. (1998), Cochran–Biederman et al. (2015)
Release method (hard *vs.* soft)	Griffith et al. (1989), Bright & Morris (1994), Wolf et al. (1996, 1998) Richardson et al. (2013)
Age at release	Sarrazin & Legendre (2000), Shier (2006), Aaltonen et al. (2009), Martínez–Abraín et al. (2011), White et al. (2012)
Others	
Public relations / attitude	Reading & Kellert (1993), Reading et al. (1997)
Management and organization	Clark & Westrum (1989), Reading et al. (1997), Sheean et al. (2012)
Long –term commitment to the project	Short et al. (1992)
Funding	Reading et al. (1997), Cochran–Biederman et al. (2015)

Fig. 1. Spanish Mediterranean regions whose vertebrate translocation programs were analyzed in this study, shown within the context of the western Mediterranean.

Fig. 1. Regiones mediterráneas de España cuyos programas de translocación de vertebrados se analizaron en este estudio, mostrados en el contexto del Mediterráneo occidental.

major part of the western Mediterranean, and are linked by close cooperation in implementing translocation programs. Data collection was a long process of exchanging information between managers and researchers to guarantee comparability of information available from the three regions. Program managers listed, independently, all the translocation programs that involved vertebrate species since the existence of regional governments in Spain (*i.e.*, approximately since the early 1980's). The final dataset contained information on 83 translocation programs, involving 34 vertebrate species (table 2, appendix 1). The duration of programs that were still in progress at the time of data collection was calculated as the number of years of implementation up until 2013. Managers were asked to provide information on the following variables: species translocated, number of animals released, origin of animals (*i.e.*, captive–bred or from the wild), year of initiation and ending of the program, type of translocation (*i.e.*, re–introduction/introduction or reinforcement), and program success. Researchers asked managers to evaluate, according to their personal experience, the success of their translocation programs. They were asked to evaluate success on a subjective scale from 0 to 10, where 0 was a complete failure and 10 a complete success (*i.e.*, establishment and reproduction in the wild of the species translocated). Intermediate scores meant that establishment and/or reproduction had not been permanent. The process assumes that managers have similar knowledge and backgrounds to judge program success, which we feel is a reasonable assumption given the geographical proximity of their regions, and the knowledge of managers from any of the regions about programs from the other regions. A more objective criterion of success based on demographic parameters (*e.g.*, a positive population growth rate or a low probability of quasi–extinction) would be preferred, but it requires detailed monitoring of the study species, which is not always done.

Our dataset

In some cases, the number of fish or reptiles/amphibians released was one or two orders of magnitude higher than the maximum number of mammals and birds released (*i.e.*, which was 2,350). Thus we used the $\log_{10}$ of 'number' for statistical analyses, preventing convergence problems. Also, AIC had to be corrected for small sample size by means of AICc (Burnham & Anderson, 2008).

Secondly, variance in the variable 'success' exceeded its mean, suggesting overdispersion, and hence making a Poisson distribution of errors probably inappropriate. In fact, the $\hat{c}$ value (*i.e.*, residual deviance/residual degrees of freedom) of the saturated model was 6.15. We dealt with overdispersion by using a negative binomial distribution (with the package glmmADMB), but reduced it minimally. Furthermore, the use of QAICc rather than AIC, for model selection did not improve our modelling. Thus, we reduced the variance of the variable 'success' by merging success scores into four categories with arbitrary cut–off points, and analyzing it as an ordinal variable (1 = from 0 to 3, 2 = from 4 to 6, 3 = from 7 to 8, and 4 = from 9 to 10). This new scale follows the same idea of

Table 2. Summary of the main features of translocation programs examined in this study by taxa: * For statistical analyses the log_{10}–transformed variable 'number' was used; B. Birds; M. Mammals; F. Fish; H. Herpetofauna.

*Tabla 2. Resumen de las principales características de los programas de translocación examinados en este estudio por taxón: * Para los análisis estadísticos, se usó la transformación logarítmica de la variable "número": B. Aves; M. Mamíferos; F. Peces; H. Herpetofauna.*

	B	M	F	H
Number of programs				
Total	28	10	31	14
Reintroductions/ introductions	24	10	29	7
Reinforcements	4	–	2	7
Number of programs per region				
Balearic Islands	11	–	–	6
Catalonia	12	10	28	8
C. Valenciana	5	–	3	–
Number of species	16	5	6	7
Origin				
From the wild	12	9	1	5
Captive–bred	16	1	30	9
Number of individuals released per program (*)				
Median	58.5	48.5	1,058	1,124.5
Minimum	2	10	12	20
Maximum	2,350	63	260,000	5,300
Duration (years)				
Median	4	4.5	1	10
Minimum	1	2	1	2
Maximum	24	17	21	34

the original survey procedures, but it reduces the complexity of the analysis.

Statistical analysis

Translocation success was analyzed using Probit Logistic Regression models. 'Success' was the response variable and 'origin', 'number' and 'taxa' were introduced as fixed effects. We intended to control for 'species' and 'region' as random effects to account for the fact that programs dealing with related species or programs coming from the same region can be more similar in their success than programs dealing with unrelated species or those coming from different regions. However, this was not possible due to the use of Probit Logistic Regression Models.

Our fixed effects are the most relevant effects among methodological factors, and importantly the most suitable variables to be modified by conservation practitioners: translocation effort, measured as number of released individuals and as duration of the program in years, plus origin, considering whether individuals were captive–breeding or from the wild.

We set up 12 models corresponding to an equal number of biologically–sound hypotheses, with either one single fixed effect or the addition or interaction of two fixed effects. We contrasted multiple hypotheses (*i.e.*, model comparison and selection) using theoretical information criteria (AIC). Models with a $\Delta_i < 2$ were considered statistically equivalent, whereas Δ_i values between three and seven were considered to indicate a considerably lesser relative–fit of the model (Burnham & Anderson, 2008). All analyses were performed using R (Version 3.1.0) software including the packages MASS and AICcmodavg (http://www.r–project.org/).

The relationship between success and duration and success and number, in relation to the use of wild or captive individuals, was analyzed using ANCOVA.

Results

When analyzing the success of translocation programs using multiple hypotheses testing, the models with the least AICc value (*i.e.*, the most parsimonious models among our set of candidate models) were models 1, 2 and 3. All three models included the variable 'origin', either as the only fixed effect, as an additive effect of origin and duration, or as an interaction of origin with taxa (table 3). Taken altogether, the first three models accounted for ca. 70% of w_i, suggesting that the origin of released individuals was the most important determinant of success in relation to translocation programs. Model 2 included duration of translocation programs, as an additive effect to origin but, when duration was taken individually, as a fixed effect, the model had very little support, suggesting that origin was more influential than duration (table 3). The same happened with the variable number. In summary, translocation success seemed to be considerably more affected by 'origin' than by 'number' or 'duration', the two variables measuring translocation effort.

The fact that one of the best models included taxa as an interaction with origin suggests that the effect of success on origin differed depending on the taxa considered (*i.e.*, fish, reptiles, birds and mammals). According to figure 2, success was greater for most taxa when using wild animals, especially for fish and mammals and, to a lower extent, for birds. However, success was lower when using wild herpetofauna.

For translocation programs using individuals from wild sources, the median success score was 8, with the upper limit of the boxplot (the 3rd quartile) reaching 10, meaning that one quarter of all programs using indivi-

Table 3. Model comparison testing effect of explanatory variables (origin of individuals, duration of translocation programs and number of individuals released) on success scores taken as an ordinal variable. See Material and methods for further modelling details: K. Number of identifiable parameters; NL. Natural logarithm of the likelihood function. (Best models shown in bold.)

Tabla 3. Comparación entre modelos para probar el efecto de las variables explicativas (procedencia de los individuos, duración de los programas de translocación y número de individuos liberados) en las puntuaciones de éxito tomadas como variable ordinal. Véase el apartado Material and methods *para encontrar información detallada de los modelos: K. Número de parámetros identificables; NL. Logaritmo neperiano de la función de probabilidad. (Los mejores modelos se señalan en negrita.)*

ID	Model	K	NL	AICc	Δi	wi
1	**success ~ origin**	**4**	**–107.65**	**223.43**	**0**	**0.26**
2	**success ~ origin + duration**	**5**	**–106.64**	**223.47**	**0.04**	**0.25**
3	**success ~ taxa * origin**	**6**	**–105.82**	**223.90**	**0.47**	**0.20**
4	success ~ origin * duration	6	–106.55	225.36	1.93	0.10
5	success ~ origin * number	5	–107.64	225.46	2.03	0.09
6	success ~ origin + number	5	–107.64	225.46	2.03	0.09
7	success ~ duration + number	5	–111.14	232.46	9.03	0
8	success ~ number	4	–112.70	233.52	10.10	0
9	success ~ taxa	4	–112.79	233.71	10.28	0
10	success ~ taxa * number	6	–110.77	233.80	10.37	0
11	success ~ duration * number	6	–111.11	234.48	11.06	0
12	success ~ duration	4	–113.60	235.32	11.89	0

duals from the wild were evaluated with the greatest success score (fig. 3). However, the median success score for translocations using individuals from captive sources was only 5.5, and one out of four programs was evaluated with a success score of 0. Both types of programs were able to achieve high success scores, but use of individuals from wild sources seldom led to low success scores, whereas programs using individuals from captive sources frequently failed. Variance of the median success was hence greater for programs dealing with captive–bred individuals, and as a consequence, the predictability of results was greater for programs dealing with individuals from a wild origin (fig. 3).

Figure 4 shows the influence of the variables 'duration' and 'number' on translocation success depending on the use of wild or captive individuals. Success increased with program duration (with a greater effect when dealing with wild individuals) and the variance in success decreased with increasing program duration: programs lasting five years or less were evaluated with almost every possible success score from 0 to 10, whereas success scores of long–lasting programs had mostly high values (fig. 4A). Surprisingly, (because one would expect that long–lasting programs were associated with the release of greater numbers of individuals) success decreased with the number of released individuals (fig. 4B). This puzzling result is explained by exploring origin of individuals, because programs using greater numbers were those releasing more captive–reared individuals for which the relationship success/number was lower than for individuals from wild sources (fig. 4B). Furthermore, the correlation between 'duration' and 'number' (log_{10}–transformed) was positive and statistically significant but weak (r = 0.28; 95% CI of Rho 0.07–0.47).

Discussion

Our results indicate that success of vertebrate translocations increases when using wild individuals. This effect was clear for all major taxa considered, except for herpetofauna that seemed to benefit from captivity. This exception could be related to a higher physiological and/or behavioral plasticity of terrestrial ectotherms than terrestrial homeotherms and aquatic ectotherms. Anyhow, success translocating captive–reared reptiles and amphibians should be more common than when releasing other vertebrate groups.

Although 'origin' was the main determinant of success, we cannot exclude an effect of program duration, given that one of the best models included 'duration' as an additive fixed effect. The optimal situation would then be a program releasing wild individuals for a long period of time.

Programs using individuals from wild sources achieved greater median success scores than pro-

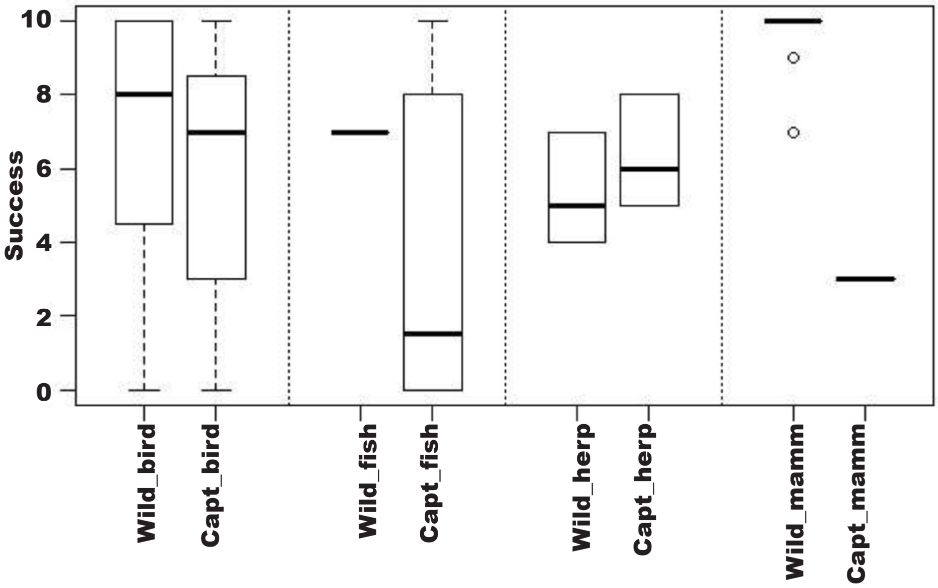

Fig. 2. Boxplot showing the interaction of translocation success and taxa (birds, fish, herpetofauna, and mammals) when using wild individuals (wild) or individuals from captivity (capt).

Fig. 2. Diagrama de caja en el que se muestra la interacción del éxito de la translocación y los taxones (aves, peces, herpetofauna y mamíferos) cuando se utilizan individuos silvestres (wild) o individuos en cautividad (capt).

grams using individuals from captive sources. Similar results were obtained by past studies which have shown that animal translocations are more likely to succeed when individuals from wild sources are released (Griffith et al., 1989; Wolf et al., 1996; Fischer & Lindenmayer, 2000). For example, Brown et al. (2006) conducted a reintroduction program with wild–born and hacked Aplomado falcons, *Falco femoralis,* and found that captive–born falcons survived at lower rates than wild–born falcons, possibly because they did not

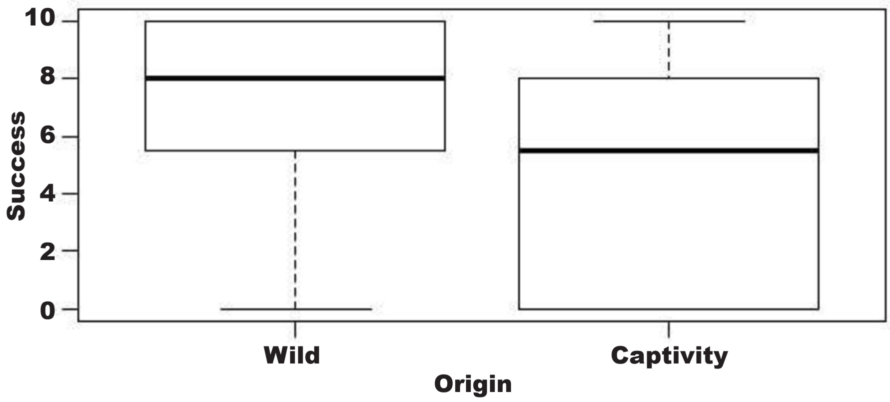

Fig. 3. Boxplot comparing median success scores assigned by wildlife managers to translocation programs dealing with captive–bred individuals or individuals from wild sources.

Fig. 3. Diagrama de caja en el que se comparan las medianas de las puntuaciones de éxito asignadas por los gestores de fauna silvestre con los programas de translocación en que se utilizan individuos criados en cautividad o individuos procedentes del medio natural.

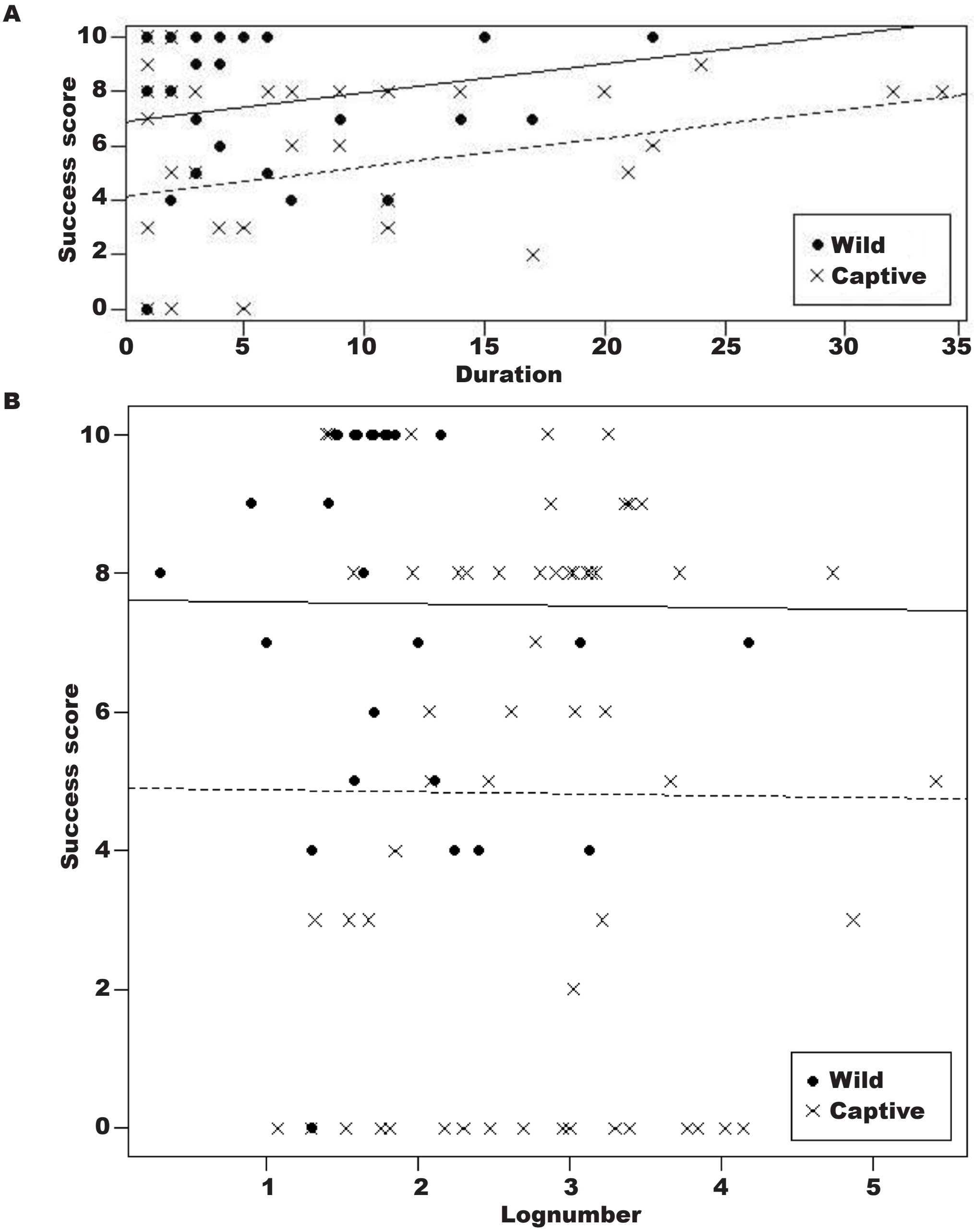

Fig. 4. A. Linear relationship between translocation success scores and duration of translocation programs for wild and captive individuals from an ANCOVA model. B. Linear relationship between success scores and number of individuals released in translocation programs for wild and captive individuals from an ANCOVA model.

Fig. 4. A. Relación lineal entre las puntuaciones de éxito de la translocación y la duración de los programas de translocación para individuos silvestres y en cautividad, obtenida mediante un modelo ANCOVA. B. Relación lineal entre las puntuaciones de éxito y el número de individuos liberados en programas de translocación para individuos silvestres y en cautividad, obtenida mediante un modelo ANCOVA.

develop foraging skills or learn to recognize and avoid predators during their time spent in captivity (Brown et al., 2006; Jule et al., 2008; Schetini de Azevedo et al., 2012; Gil et al., 2014). Many captive–born individuals die immediately after release due to their inability to adapt to their new environments regarding predators or to find food. In fact, this immediate 'cost of release' (a high mortality rate among captive–reared individuals during the first weeks after release) seems to be an emergent property of animal translocations, especially when individuals from captive sources are involved. In this context, Tavecchia et al. (2009) found that approximately one third of the post–release mortality of reintroduced crested coots, *Fulica cristata,* which were raised in captivity, occurred within the first month post–release. As the survival rate increased with time spent in the wild, the authors concluded that it is probably the lack of experience of captive–born individuals that caused a high post–release mortality until released individuals became familiar with their new wild environment. Cabezas et al. (2013) provided a physiological explanation (*i.e*., differences in acute stress response) for greater establishment success of individuals from wild origins.

Some authors failed to find differences between programs based on wild or captive–reared individuals. However, these results can be due to artifacts occurring for other reasons. For example, the negative results by White et al. (2012) in a long–lived parrot species could be related to both the definition of reintroduction success (first year survival > 0.5) and to low statistical power.

In addition, programs dealing with individuals from wild sources had smaller variances in success, meaning that prediction of results is greater when using wild–caught individuals, a property that is desirable in any translocation program.

The importance of the origin of released individuals for translocation success is supported indirectly by recent findings in invasion biology, where the determinants of establishment success of introduced birds were examined. Conclusions drawn from animal introductions may be used to interpret the results of analyses with animal translocations as it has been shown that introduced and reintroduced species show comparable properties (Blackburn & Cassey, 2004). Specifically, Carrete & Tella (2008) found that the key factor for success in establishing exotic pet bird species that escaped into the wild was their origin and the number of escaped birds. Surprisingly, the most successful invaders were those birds that were caught in the wild and then traded at the pet market, and not the most common pet bird species, which provide the most cases of escaped birds, that is, the greatest introduction effort. One of the reasons behind that success seems to be that wild–caught individuals have higher antipredatory responses and escape abilities than captive–bred individuals (Carrete & Tella, 2005) and also that international trade acts as a selection agent of the most resistant individuals (Carrete et al., 2012).

Although there has been a substantial increase in number of animal translocations for conservation during the last 20 years, only a few include detailed evidence–based evaluations of program outcomes, making it difficult for practitioners to learn from previous failures, and to improve their methods to maximize probability of success. Therefore, conclusions drawn from our results (along the same line identified previously by other authors) can be useful guidelines to conservation practitioners when designing a translocation program involving vertebrate species. We recommend, for any given translocation effort, to use individuals from wild sources whenever possible, to increase the probability of achieving a successful establishment of the translocated species and a greater predictability of the outcome. This point is especially relevant in times of economic hardship because scarce available resources should be used optimally when considering costs and benefits. When it is not feasible to obtain individuals from wild sources, either because they are extinct in the wild or the species is threatened with extinction, the best alternative is to implement the program for a long number of years (10–30 years), rather than releasing many captive–reared individuals for a short period of time. Perseverance also pays in translocation.

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Appendix. List of species considered in our study (in alphabetic order) including the number of translocation programs (#Prg) for each species and the percentage of programs (%Prg) with the maximum success score.

Apéndice. Lista de especies examinadas en nuestro estudio (por orden alfabético), que comprende el número de programas de translocación (#Prg) para cada especie y el porcentaje de programas (%Prg) con la máxima puntuación de éxito.

Species	#Prg	%Prg
Birds		
Aegypius monachus	2	50
Bubulcus ibis	1	100
Ciconia ciconia	4	25
Circus pygargus	1	0
Egretta garzetta	1	100
Falco naumanni	2	50
Fulica cristata	3	0
Hieraetus fasciatus	1	100
Larus audouinii	2	0
Marmaronetta angustirostris	1	0
Netta rufina	1	100
Nycticorax nycticorax	1	100
Oxyura leucocephala	1	0
Pandion haliaetus	1	0
Porphyrio porphyrio	4	25
Tetrao urogallus	2	0
Fish		
Aphanius iberus	7	43
Barbus meridionalis	1	0
Gasterosteus aculeatus	2	100
Gasterosteus gymnurus	1	0
Salaria fluviatilis	3	0
Valencia hispanica	17	0
Herpetofauna		
Alytes muletensis	1	0
Bufo viridis	1	0
Calotriton arnoldi	2	0
Emys orbicularis	3	0
Mauremys leprosa	1	0
Testudo graeca	1	0
Testudo hermanni	5	0
Mammals		
Capra hispanica	1	100
Capreolus capreolus	6	100
Felis sylvestris	1	0
Lutra lutra	1	100
Ursus arctus	1	0