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EFFECTIVENESS OF AFRICAN WILD DOG (LYCAON PICTUS) REINTRODUCTIONS IN SOUTH AFRICA

Systematic Review

GUSSET, M., STEWART, G.B., BOWLER, D.E. & PULLIN, A.S.

Wildlife Conservation Research Unit - Department of Zoology - University of Oxford – Tubney - Abingdon - OX13 5QL - United Kingdom

Correspondence: mgusset@bluewin.ch
Telephone: +41-31-5364962

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Systematic Review Summary

Background

Our ability to evaluate the effectiveness of conservation interventions is primarily reliant on and often limited by the available evidence. As claimed conservation success (or failure) might merely be an artefact of the quantitative approach used for evaluation, both in terms of locating and analysing data, cross-validation of results may be important. We thus re-evaluated the effectiveness of African wild dog (*Lycaon pictus*) re-introductions in South Africa using a systematic review approach, which included comprehensive data searching and meta-analysis not employed in the original assessment.

Objective

The objective of this study was to cross-validate the management recommendations of a previous evaluation of an endangered species recovery programme using a systematic review approach.

Search strategy

Data on the survival of re-introduced wild dogs and their offspring as well as on covariates potentially impacting survival were available from all wild dog re-introductions and translocations known to have been attempted in South Africa since 1995. To assess whether any additional survival data existed, relevant people and organisations involved in wild dog re-introductions and translocations were contacted, and literature databases and internet search engines were searched using keywords.

Selection criteria

References captured by the above search were deemed relevant if all of the following were present: subject (African wild dog or *Lycaon pictus*), intervention (re-introduction or translocation) and outcome of interest (qualitative or quantitative reporting of re-introduction success). As in the original assessment, 40 covariates that vary among re-introduction sites and release events were identified as potential factors that may explain heterogeneity in the survival of re-introduced wild dogs.

Data collection and analysis

Raw data on survival and covariates potentially impacting survival were extracted from the original assessment. Meta-analysis of outcome measures (i.e. survival rates) was used to generate effect sizes via analysis of risk ratios based on a modified Cohen's *g* metric. Univariate random effects meta-regression for all categorical and continuous covariates was used to examine heterogeneity in the survival of re-introduced wild dogs.

Main results

The original dataset was confirmed to be complete by an exhaustive search to locate additional data. Both evaluations suggested that wild dog re-introductions are successful in the short-term, with high survival rates of the released animals and their offspring. The meta-analysis of all the available evidence corroborated the importance of pre-release socialisation in promoting post-release survival at the pack level. In contrast, the original assessment found additional covariates affect the survival of re-introduced wild dogs at the individual level.

Conclusions

The available evidence suggests that wild dog re-introductions in South Africa are an effective conservation tool, the success of which is largely determined by pre-release socialisation. This study emphasises the importance of cross-validating management recommendations in endangered species recovery programmes with different quantitative methods to assess and communicate the reliability of results.

1. Background

The African wild dog (*Lycaon pictus*) is an intensely social species in danger of extinction if nothing is done to halt its decline (Woodroffe et al., 2004). In South Africa, in an effort to restore wild dog numbers in increasingly fragmented landscapes and to complement the single viable population occurring in Kruger National Park, a plan was launched to manage separate sub-populations of wild dogs in several small, geographically isolated conservation areas as a meta-population (Mills et al., 1998). This intensive management approach involves the re-introduction of wild dogs into suitable conservation areas, and periodic translocations among them to mimic natural dispersal and maintain gene flow.

Conservation managers in their every day work generally do not rely on the best scientific information (Pullin et al., 2004; Pullin and Knight, 2005). Consequently, conservation decisions are often based upon expert opinion rather than a critical appraisal of the available evidence (Pullin and Knight, 2001, 2003; Sutherland et al., 2004). The repercussions of not using all the available evidence may include poor decisions on the allocation of limited conservation funding. It is problematic that such systematic evaluations are still rare and their paucity raises the question of whether and how an evaluation's outcome will be affected by the quantitative approach used, both in terms of locating and analysing data. However, this potentially important limitation of evaluating conservation efforts rarely has been addressed to date.

The conservation strategy considered here is largely based upon expert opinion (Wild Dog Advisory Group of South Africa – WAG–SA) and there has been no predictive framework available to quantify which re-introduction techniques are the most efficient, despite the initial failures and high costs associated with wild dog re-introductions and translocations. Consequently, Gusset et al. (2008a) sought to elucidate those factors that have affected the survival of re-introduced wild dogs and their offspring, with survival of and breeding by the release generation being a pragmatic criterion for short-term re-introduction success (Seddon, 1999). Using an information-theoretic approach, known-fate modelling in program MARK was employed to estimate the survival of re-introduced wild dogs and their offspring, and to model covariates that may affect survival. Survival estimates for the released animals and their offspring were high (overall 6-month survival estimate $S = 0.89$), with offspring produced at all release sites. Survival analysis revealed that the determinants of re-introduction success can be reduced to two factors relevant for management, suggesting that wild dog re-introductions should be attempted with socially integrated animals that are released into securely fenced areas.

What remains unclear, however, is the influence of the chosen quantitative approach, including potential sampling bias in the selection of relevant data, on the outcome of this evaluation. Several factors hypothesised by experts to impact survival were not found to have an effect, including controversial interventions such as vaccination and predator control, whereas expensive measures such as fencing and pre-release socialisation had a positive impact on survival. Here, using a systematic review approach (Pullin and Stewart, 2006), we re-evaluate the determinants of re-introduction success in this actively managed meta-population of wild dogs in South Africa, which represents one of the most extensive endangered species re-introduction efforts to date. Systematic reviews follow a rigorous and structured methodology to comprehensively search for, critically appraise and synthesise all the available evidence (e.g. Stewart et al., 2005). This approach thus provides conservation practitioners with transparent, repeatable and reliable scientific information upon which to base their management decisions.

2. Objectives

2.1 Primary question

Are wild dog re-introductions in South Africa an effective conservation tool?

2.2 Secondary question

What are the determinants of wild dog re-introduction success in South Africa?

3. Methods

3.1 Search strategy

Data on the survival of re-introduced wild dogs and their offspring as well as on covariates potentially impacting survival were available from all wild dog re-introductions and translocations known to have been attempted in South Africa since 1995 (Gusset et al., 2008a; see appendix, Table A.1). Survival data were collected by post-release monitoring from 12 re-introduction sites and 18 release events, resulting in a total of 256 individual records (127 released wild dogs that produced 129 pups). Gusset et al. (2008a) quantified the survival of re-introduced wild dogs 6, 12, 18 and 24 months after release and that of pups produced to 6 and 12 months of age (see appendix, Fig. A.1). In addition, 40 covariates hypothesised to impact survival, collated from extensive individual experiences, were quantified (Gusset et al., 2008a; see appendix, Table A.2).

To assess whether any additional survival data existed, relevant people and organisations (most notably WAG–SA) involved in wild dog re-introductions and translocations were contacted. The literature databases CAB Direct, Ecology Abstracts, Index to Theses Online, JSTOR, Science Direct and Web of Science were searched, using the search string ('African wild dog*' OR '*Lycaon pictus*') AND (re-introduction* OR reintroduction* OR translocation*). Hits were judged on relevance upon inspection of title and abstract. Using the above six search term combinations, the internet search engines All the Web, Dogpile, Google, Google Scholar and Scirus were searched to capture possible grey literature. The first 50 Word or PDF hits were examined for relevance. These hits may or may not represent primary studies. Hits were considered possible leads if they included some indication of a past or planned attempt to re-introduce or translocate wild dogs or a reference not captured in the literature database search. In case of the former, this may represent re-introductions or translocations carried out recently (i.e. post-2005). In case of the latter, reference inclusion was based upon inspection of title only (no indication as to whether study population was wild or re-introduced), and the reference was thus retained for further investigation.

3.2 Study inclusion criteria

References captured by the above search were deemed relevant if all of the following were present: subject (African wild dog or *Lycaon pictus*), intervention (re-introduction or translocation) and outcome of interest (qualitative or quantitative reporting of re-introduction success). To maximise sample sizes for re-introduced wild dogs and their offspring, outcome measures were survival rates (i.e. proportion alive in each re-introduced pack, to account for within-pack dependency of individual fates) to 12 months after release or birth. Any study providing survival data for re-introduced wild dogs and their offspring was considered. Gusset et al. (2008a) summarised the available data on all known wild dog re-introduction and translocation attempts in South Africa up to 2005. As in the original study (Gusset et al., 2008a), 40 covariates that vary among re-introduction sites and release events were identified as potential factors that may explain heterogeneity in the survival of re-introduced wild dogs.

3.3 Study quality assessment, data extraction strategy and data synthesis

All re-introduced wild dogs were sufficiently monitored after release and the methodological quality of data collection from different re-introductions sites and release events was likely to be equal. Raw data on survival and covariates potentially impacting survival were extracted from Gusset et al. (2008a). Meta-analysis of outcome measures (i.e. survival rates) was used to generate effect sizes via analysis of risk ratios based on a modified Cohen's *g* metric (Box 1). Univariate random effects meta-regression for all categorical and continuous covariates was used to examine heterogeneity in the survival of re-introduced wild dogs. Where significant relationships were found, binary covariates were analysed as sub-groups to assess if they were significantly different from the overall pooled risk ratio. Meta-regressions were performed in Stata/SE 8, with the significance level set at $p = 0.05$.

Box 1 – Meta-analysis of proportions

The heart of meta-analysis is combining different research findings on a common metric scale (i.e. generation of an effect size), so that the resulting values can be pooled and compared between different studies. Effect sizes are combined, with each value weighted by a term that reflects its precision. Sample size sometimes performs this function, but optimal weights are derived from the standard error of the effect size (Hedges and Olkin, 1985), resulting in weighting by inverse variance. This is straightforward for many effect size metrics, particularly those based on comparisons of treatments and controls (e.g. standardised mean difference), because statistical theory provides robust estimates of standard error. However, meta-analysts may need to synthesise single variables, such as proportions, where standard weighting procedures are problematic because of dependency between effect size and standard error. There are a number of options to meta-analyse proportions:

Direct analysis of proportions: This method provides robust estimates of overall effect size but underestimates confidence intervals and overestimates heterogeneity across effect sizes, especially when the observed proportions are very high or very low

(Lipsey and Wilson, 2001). This distortion is due to compression of the standard error when the proportions approach one or zero (these extremes are given high weight in the analysis). The direct analysis is therefore only recommended in the rare circumstance when mean proportions are expected to be between 0.2 and 0.8 and only the mean is of interest.

Logit analysis of proportions: Unlike the proportion, which is constrained to values between zero and one, the logit can take any numerical value and is approximately normal with a mean of zero. It therefore has appealing statistical properties. However, it now arbitrarily gives high weight to studies with mid-range proportions (Lipsey and Wilson, 2001).

One potential solution to this problem is to arbitrarily assume a 50% event rate in a hypothetical control group (Cohen's *g* metric) (Cohen, 1977). Here, we have modified this approach by standardising the proportion of the control group event rate (i.e. death) so that the overall pooled risk ratio is one. Risk of death is therefore higher than a weighted average where the risk ratio is >1 and lower where the risk ratio is <1. Our approach might prove generally useful for future meta-analyses of proportions where explanation of heterogeneity is the primary objective.

4. Results

4.1 Compilation of dataset

All contacted people and organisations involved in wild dog re-introductions and translocations indicated that no additional survival data for re-introduced wild dogs and their offspring beyond that listed in Gusset et al. (2008a) currently exist. The literature database search resulted in 74 hits (after removal of duplicates), 14 of which were judged relevant (EndNote file is available upon request). The agreement score on relevance decisions between evaluators was high ($\kappa = 0.86$). None provided additional survival data. The internet engine search yielded 378 hits (after removal of duplicates), of which 22 were deemed relevant and 32 were considered possible leads (39 URLs were not available) (Excel file is available upon request). None provided additional survival data. We thus proceeded with the meta-analysis using this apparently complete dataset (Excel file is available upon request).

4.2 Meta-analysis of available data

Assuming a 50% event rate in the hypothetical control group (Box 1), the risk ratio of the survival data was 0.67 (95% confidence interval: 0.50–0.90). This risk ratio differed significantly from the overall pooled risk ratio ($z = 2.67$, $p = 0.008$), indicating high short-term survival rates. The overall pooled risk ratio was adjusted to one by setting the event rate (i.e. death) in the hypothetical control group to 26%. One of the 18 re-introduced packs had a significantly higher (risk ratio = 2.40, 95% confidence interval: 1.04–5.56) and one pack a significantly lower (risk ratio = 0.13, 95% confidence interval: 0.02–0.94) risk ratio than the average (Figure 1), as evidenced by confidence intervals not overlapping one.

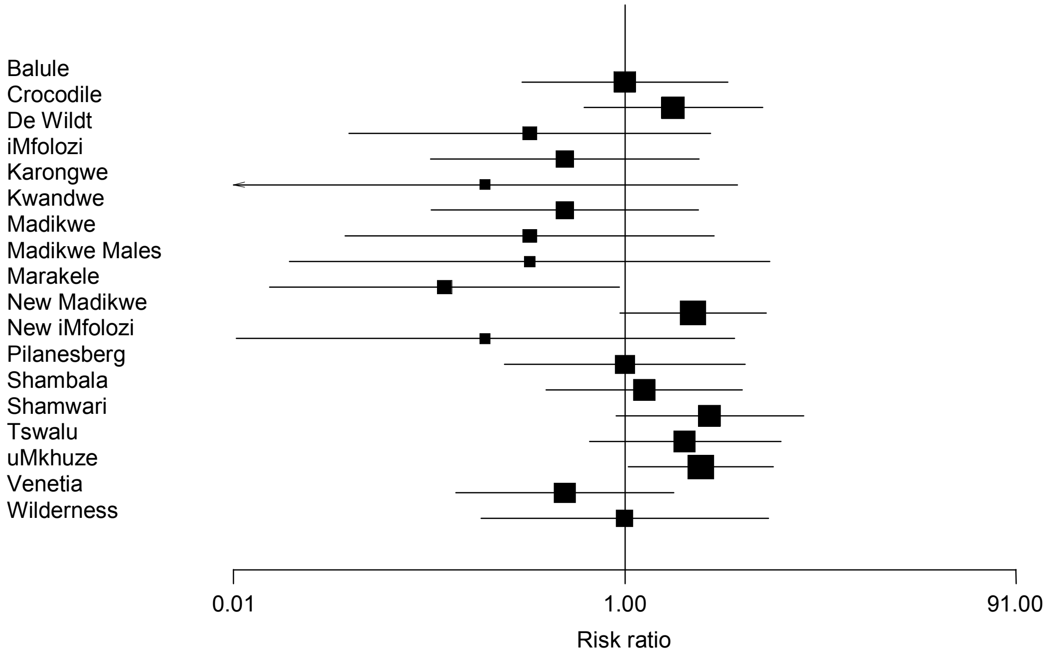

Figure 1 – Forrest plot illustrating effect sizes of re-introduced packs of wild dogs in South Africa. Box size is related to sample size and error bars represent 95% confidence intervals. One re-introduced pack (uMkhuze) had a significantly higher and one pack (Marakele) a significantly lower risk ratio than the average, as evidenced by confidence intervals not overlapping one.

There was thus evidence of heterogeneity in the survival among different re-introduced packs, prompting us to use random effects meta-regression, although overall between-pack heterogeneity was not significant (χ^2 = 24.96, df = 17, p = 0.096). Only two covariates were significantly different from the overall pooled risk ratio and both positively influenced survival rates: occurrence of birth while in the pre-release enclosure (boma) facilities and group split after release (Table 1).

Table 1 – Determinants of wild dog re-introduction success in South Africa. Only two covariates were significantly different from the overall pooled risk ratio and both positively influenced the survival rates of re-introduced wild dogs

Covariate	Risk ratio	95% confidence interval		Deviance from risk ratio = 1	
		Lower	Upper	*z* score	*p* value
Birth	0.34	0.13	0.88	2.23	0.026
Group split	0.36	0.16	0.84	2.36	0.018

5. Discussion

The methodology used to investigate the effectiveness of conservation interventions might affect whether or not an intervention is deemed successful. We thus re-evaluated the effectiveness of wild dog re-introductions in South Africa, using a systematic review approach (Pullin and Stewart, 2006) to compare the results with a previous assessment (Gusset et al., 2008a).

The dataset used by Gusset et al. (2008a) appears to be complete, but the exhaustive search carried out as part of our systematic review to locate additional data was just as much part of the cross-validation process as the meta-analysis. Both evaluations found wild dog re-introductions to be successful in the short-term, with high survival rates of the released animals and their offspring (long-term persistence of re-introduced wild dogs is assessed by means of population viability modelling elsewhere [Gusset, 2006]). Analyses of independent datasets confirmed the conclusions reached by Gusset et al. (2008a) regarding the importance of pre-release socialisation (Gusset et al., 2006; see below) and the human-induced negative consequences of wild dogs leaving conservation areas that lack secure fencing (Gusset et al., 2008b). The only re-introduced pack with a significantly higher risk ratio than the average (Fig. 1) was released into the sole area that was not entirely fenced.

Our meta-analysis of all the available evidence (i) corroborates that the determinants of re-introduction success can indeed be reduced to very few factors and (ii) stresses that the occurrence of birth while in the boma and group split after release promote re-introduction success (Table 1), as previously noted by Gusset et al. (2008a). However, Gusset et al. (2008a) found five additional covariates affect the survival of re-introduced wild dogs (female sex, unknown sex of pups born after release, wild-caught origin, length of perimeter fence around release area and time kept in boma together). Continued monitoring of re-introduced wild dogs will be necessary to elucidate the relative importance of these, and other, indicators of re-introduction success. Survival analysis (Gusset et al., 2008a) is probably more powerful than the present meta-analysis, as all individual data points were used and suites of covariates were combined and tested together. However, survival analysis might not fully account for the correlation of data points between individuals from the same pack, as the covariates might not operate similarly on individual fates in different packs (Gusset et al., 2008a), which we explicitly accounted for by meta-analysing data at the level of the pack. Other forms of meta-analysis, such as Bayesian hierarchical modelling, could be used to explore all sets of covariates and account for non-independence, but the large number of covariates relative to sample size remains a major source of uncertainty whatever approach is adopted. The current approach emphasises the necessity of cross-validating endangered species recovery programmes with different quantitative methods, each with its specific underlying assumptions, to reduce the uncertainty surrounding the relative importance of potentially influencing factors.

The positive influence of group split after release on the survival of re-introduced wild dogs seemingly conflicts with the emphasis that interventions put on social integration. Some packs reportedly split into single-sex groups in past wild dog re-introduction attempts that have failed (Gusset et al., 2006). A probable reason why group splits improved survival in both evaluations is that most of the splits observed in the meta-population (75%) were pack fissions (i.e. splits into two mixed-sexed packs). Most packs that underwent fission after release (67%) gave birth in the boma, which can be viewed as the result of successful bonding (Gusset et al., 2006). The only re-introduced pack with a significantly lower risk ratio than the average (Fig. 1) experienced both birth while in the boma and pack fission after release. These findings suggest a link between successful bonding, occurrence of birth in boma and pack fission after release, resulting in the benefits derived from an increased number of packs in a sub-population (Somers et al., 2008). This re-emphasises the importance of pre-release socialisation for wild dog re-introductions to be successful, including management manipulation of social relationships based on behavioural observations (Graf et al., 2006; Gusset et al., 2006). Building boma facilities and maintaining wild dogs in a boma is costly (Lindsey et al., 2005), but both evaluations suggest that these expenses can be scientifically justified.

Similar cross-validations of management recommendations, including a critical appraisal of the available information within an evidence-based framework, are encouraged in other endangered species recovery programmes. Such cross-validations might have unveiled the use of flawed science in tiger (*Panthera tigris*; Karanth et al., 2003) and Florida panther (*Puma concolor coryi*; Beier et al., 2006; Conroy et al., 2006) conservation practice before the situation escalated. In both cases, relying on expert opinion prompted unsound management decisions, causing much resentment after the undesired conservation outcomes became public (e.g. Gross, 2005). Failure to objectively evaluate programmes could lead to the acceptance of practices that may be suboptimal and unevaluated practices may be adopted simply because they have been used in the past. Moreover, as pointed out by Gusset et al. (2008a), making the most of the available evidence provides a foundation not only for informed decision-making but also for communicating policy to a wider public.

6. Reviewers' Conclusions

The available evidence suggests that wild dog re-introductions in South Africa are an effective conservation tool, the success of which is largely determined by pre-release socialisation. We provide conservation practitioners with the opportunity to rely not only on their expert knowledge but also on a strong scientific fundament upon which to base management decisions regarding wild dog re-introductions and translocations. The present study thus expands on the use of the systematic review process for assessing conservation effectiveness (Pullin and Knight, 2001, 2003; Sutherland et al., 2004) by demonstrating its power to cross-validate previous evaluations of endangered species recovery programmes. We echo Meffe et al. (1998) in calling for independent scientific review in natural resource management and present a transparent scientific tool for how this goal can be achieved.

7. Acknowledgements

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8. Potential Conflicts of Interest and Sources of Support

No potential conflicts of interest declared. Financial support for this study was provided by the Natural Environment Research Council.

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10. Appendices

Table A.1 – Wild dog re-introductions and translocations in South Africa (up to 2005) (Gusset et al., 2008a)

Release site	Province	Geographic position	Release date(s)
Balule Nature Reserve	Limpopo	24°13' S / 30°59' E	2005
Hluhluwe-iMfolozi Park	KwaZulu-Natal	28°05' S / 31°56' E	1980/1981 (4x)[a], 1986[a], 1997, 2001, 2003
Karongwe Game Reserve	Limpopo	24°15' S / 30°35' E	2001[b], 2002
Kgalagadi Transfrontier Park	Northern Cape	25°45' S / 20°15' E	1975[a]
Klaserie Game Reserve	Limpopo	24°15' S / 31°15' E	1991[a]
Kwandwe Private Game Reserve	Eastern Cape	33°09' S / 26°62' E	2004
Madikwe Game Reserve	North West	25°00' S / 26°12' E	1995, 1998 (2x), 2000
Marakele National Park	Limpopo	24°25' S / 27°40' E	2003
Pilanesberg National Park	North West	25°15' S / 26°85' E	1999, 2001
Shambala Private Game Reserve	Limpopo	24°19' S / 27°58' E	2002
Shamwari Game Reserve	Eastern Cape	33°27' S / 26°03' E	2003
Tswalu Kalahari Reserve	Northern Cape	27°12' S / 22°31' E	2004
uMkhuze Game Reserve	KwaZulu-Natal	27°40' S / 32°15' E	2005
Venetia Limpopo Nature Reserve	Limpopo	22°20' S / 29°20' E	1992[a], 2004

a Not included in meta-analysis because of a lack of data.
b Excluded from meta-analysis because all animals were recaptured 4 months after release.

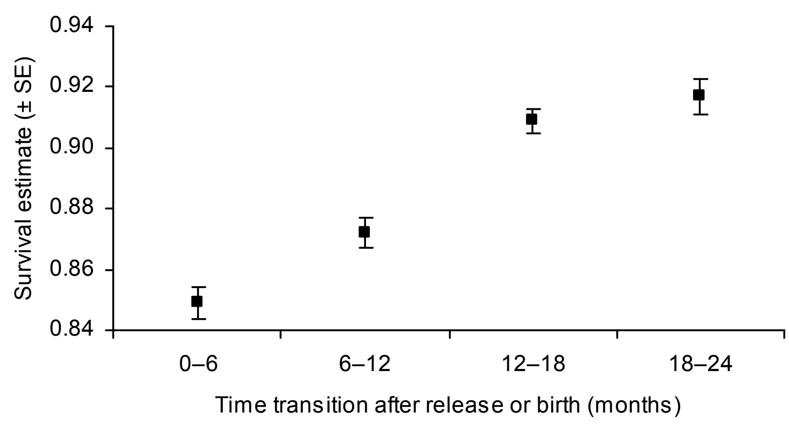

Figure A.1 – Survival estimates for re-introduced wild dogs and their offspring over four time transitions after release or birth (Gusset et al., 2008a).

Table A.2 – Factors hypothesised to influence the survival of re-introduced wild dogs (Gusset et al., 2008a)

Parameter	Parameter value (percentages or mean ± SE)
Age of released wild dogs	Pup 24% (30/127), yearling 9% (12/127), adult 67% (85/127)
Sex of released wild dogs	Male 54% (68/127), female 46% (59/127)
Origin of released wild dogs	Wild-caught 61% (79/127), wild-caught but captive-raised 13% (16/127), captive-bred 13% (16/127), mixed (pups only) 13% (16/127)
Human population density (km^{-2}) in surroundings of release area	72 ± 16 (range 9–197, n = 12)
Main land use practiced in surroundings of release area	Livestock farming 50% (6/12), communal land 25% (3/12), game ranching 25% (3/12)
Public high-speed road traversing release area	17% (2/12) of release areas
Release area entirely fenced or contiguous to large protected area	92% (11/12) of release areas
Length of perimeter fence (km) around release area	115 ± 9 (range 64–160, n = 12)
Protection status of release area	Private 67% (8/12), government 33% (4/12)
Release area located at international border	8% (1/12) of release areas
Size of release area (km^2)	380 ± 75 (range 84–900, n = 12)
Number of release events per release area	1.9 ± 0.6 (range 1–8, n = 12)
Number of wild dogs released per release area	12.8 ± 3.0 (range 3–42, n = 12)
Domestic dogs occurring outside release area	75% (9/12) of release areas
Rabies vaccination programme for domestic dogs	75% (9/12) of release areas
Infectious diseases in other carnivores in release area	83% (10/12) of release areas
Rabies vaccination programme for released wild dogs	72% (13/18) of release events
Prey (>10% in wild dog diet) density (km^{-2}) in release area	15 ± 3 (range 1–38, n = 18)
Competitor (lion and spotted hyaena) density (km^{-2}) in release area	0.13 ± 0.03 (range 0.01–0.40, n = 18)
Management reduction of competitor density in release area	75% (9/12) of release areas
Number of wild dogs released per release event	7.1 ± 0.9 (range 2–16, n = 18)
Wild dogs resident in release area	33% (6/18) of release events
Season of release	Mating 22 % (4/18), denning 45% (8/18), other 33% (6/18)
Supplementary feeding upon release	44% (8/18) of release events
Group splits upon release	22% (4/18) of release events
Wild dogs breaking out of release area	56% (10/18) of release events
Conservation education programme	33% (6/18) of release events
Birth of offspring upon release	94% (17/18) of release events
Time wild dogs kept in boma (days)	Individually 212 ± 17 (range 15–634, n = 127), together 181 ± 18 (range 15–634, n = 127), apart 6 ± 2 (range 0–86, n = 127)
Sequence of bonding wild dogs in boma	In same boma from beginning 83% (15/18), initially separated by fence 17% (3/18)
Aggression in boma	50% (9/18) of release events
Death in boma	17% (3/18) of release events
Pregnancy in boma	44% (8/18) of release events
Birth of offspring in boma	17% (3/18) of release events
Emergence of dominant pair in boma	89% (16/18) of release events
Removal of wild dogs that interfered with social integration in boma	22% (4/18) of release events
Structure of release group	Existing packs 11% (2/18), packs result of bonding groups in boma 83% (15/18), single-sex groups 6% (1/18)
Composition of release group	Naturally composed groups (existing packs/groups or packs result of bonding single-sex groups in boma) 61% (11/18), artificially composed groups (packs result of bonding non-single-sex groups in boma) 39% (7/18)
Age ratio of released wild dogs (proportion adults)	0.75 ± 0.07 (range 0.33–1.00, n = 18)
Sex ratio of released wild dogs (proportion males)	0.56 ± 0.04 (range 0.17–1.00, n = 18)