



Global Re-introduction Perspectives: 2013

Further case-studies from around the globe
Edited by Pritpal S. Soorae



IUCN/SSC Re-introduction Specialist Group (RSG)





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An investigation into the effect of individual personality on re-introduction success, examples from three North American fox species: swift fox, California Channel Island fox and San Joaquin kit fox

Samantha Bremner-Harrison^{1,2}, Brian L. Cypher² & Stephen W.R. Harrison^{1,2}

¹ - School of Animal, Rural and Environmental Sciences, Nottingham Trent University, Brackenhurst Lane, Southwell, England, UK

Samantha.bremnerharrison@ntu.ac.uk, Stephen.harrison@ntu.ac.uk

² - California State University – Stanislaus, Endangered Species Recovery Program, PO Box 9622, Bakersfield, California 93389, USA, bcypher@esrp.org

Introduction

Swift fox (*Vulpes velox*) and San Joaquin kit fox (*Vulpes macrotis mutica*) are small, den-dwelling foxes found in North American arid grassland habitats. The Catalina Channel Island fox (*Urocyon littoralis catalinae*) is endemic to Catalina island. Swift fox (SWF) are listed by the IUCN as Least Concern, but listed in Canada as Threatened (COSEWIC, 2009) and as a Category One species under the US Endangered Species Act (USFWS, 2001). The kit fox is listed as Least Concern, however the sub-species San Joaquin kit fox (SJKF) is listed as Endangered under the US Endangered Species Act (USFWS, 1998). The Catalina Channel Island fox (CCIF) is listed as Critically Endangered (IUCN, 2008). Decline of the species' were associated to anthropogenic factors. Extreme habitat loss caused a loss of >90% the historic range of both SWF and SJKF, with decline also attributed to non-target predator control, whilst CCIF numbers

crashed due to an outbreak of distemper. As a result, there have been on-going recovery efforts for each species, incorporating captive breeding and re-introduction (SWF and CCIF), habitat restoration (SWF, SJKF and CCIF) and re-introduction feasibility planning (SJKF).



San Joaquin kit fox

Goals

- Goal 1: Development of methods to determine individual personality type via an assessment of boldness.
- Goal 2: Demonstrate repeatability of tests to show individual stability of personality type.
- Goal 3: Monitor assessed individuals either post-release or for 1+ years post-behavioral assessment.
- Goal 4: Evaluate the effect of personality on survival post-release and the effect of habitat differences on population-level personality and fitness variables.
- Goal 5: Identification of optimal levels of boldness relative to habitat conditions.

Success Indicators

- Indicator 1: Calculation of a boldness score for each assessed individual.
- Indicator 2: Evaluation of within population personality variation.
- Indicator 3: Evaluation of between population personality variation.
- Indicator 4: Obtaining post-release/post-assessment survival and fitness data on a sample size that allows statistical determination of a relationship between personality and survival, movement and reproductive output.

Project Summary

Feasibility: One factor affecting the success of re-introduction is intraspecific behavioral variation. The existence of different personality types, e.g. boldness, indicates adaptive strategies within a species that are acted on by natural selection (Wilson & Richards, 2000). Inappropriate boldness levels may have deleterious effects on fitness. With levels of boldness subject to natural selection, it is possible that release candidates with optimal levels of boldness for a source-habitat similar to the release site may be more likely to survive than individuals from a source population with differing selection pressures than the release site. However, it is also likely that behavioral variation is key within a release population to ensure the ability of the founders to adapt to environmental pressures. Developing an assessment of the likely behavioral response of an individual to re-introduction was the overall goal across the three projects. The aim was to find a means of predicting the likely response of an individual to the novelty of release via a simple behavioral personality test, and implement this knowledge to improve survival and re-introduction success. The first project assessed personality of individual captive-bred SWF and survival after release at a site with predation (Bremner-Harrison *et al.*, 2004). The second project assessed the effect of personality on survival and reproductive output of CCIF released in an environment with no predators (Bremner-Harrison *et al.*, 2005). The final project evaluated the effect of personality in two free-living populations of SJKF in the San Joaquin valley of California, USA, with differing habitats (urban and rural). These two populations are possible source populations for a planned re-introduction.



Fox trapping in Lokern

Implementation: A boldness score was calculated for 34 captive-bred SWF using two repeats of a four x novel-object test prior to release. A boldness score was calculated for 11 captive CCIF using a reduced test of a two x novel-object test. Three measures of boldness were calculated for free-living SJKF: a handling boldness score assessed during trapping and handling (T/H); an extended novel object test (ENOT: two x novel object

(1 novel food and 1 novel threat) + two x baseline assessing pups) and a rapid novel object test (RNOT: 1 x novel-object test assessing juveniles and adults).

Post-release monitoring: Thirty-one SWF were released onto the Blackfeet Indian Tribal Reservation in Montana, USA; 16 were radio-collared. Foxes were monitored intensively for 6 weeks, weekly/fox for the following 4.5 months, and again intensively for a 2-week period 6 months post-release to determine survival. Nine radio-collared CCIF were released in the final year of a four-year re-introduction program on Catalina Island. Post-release monitoring was conducted twice-weekly/fox. For SJKF the T/H test assessed 87 urban:67 rural. The ENOT assessed 24 urban:9 rural, with 21:1 radio-collared. The RNOT assessed 27 urban:27 rural, all radio-collared. Post release monitoring for ≥ 1 year post-boldness testing aimed to locate each SJKF a minimum of once per week, recording survival, dispersal data, and reproductive data. The relationship between the variables listed and boldness was assessed for each fox species.

In a habitat with predators it was determined that SWF that died ($n = 5$) were those with higher levels of boldness ($t_{14} = 2.942$, $P < 0.01$). Boldness scores were positively correlated with the total distance moved from release site ($r_{14} = 0.588$, $p < 0.02$) and the mean distance moved per telemetry fix ($r_{14} = 5.574$, $p < 0.02$), the mean distance moved between fixes was significantly greater for foxes that died ($U = 6$, $p < 0.02$).

In a predator-free habitat released CCIF had no mortalities. However, CCIF showed a trend towards foxes with higher boldness having increased reproductive output. For SJKF, the urban habitat had no predation but vehicle-caused mortality and food resources were consistent, but there were limited dispersal opportunities. The rural habitat had predation risks, food resources fluctuated and dispersal opportunities were unlimited. Overall, urban foxes were bolder than rural foxes (T/H: $t_{149} = 2.52$, $P < 0.01$; ENOT: $t_{29} = 3.05$, $P < 0.005$; RNOT:

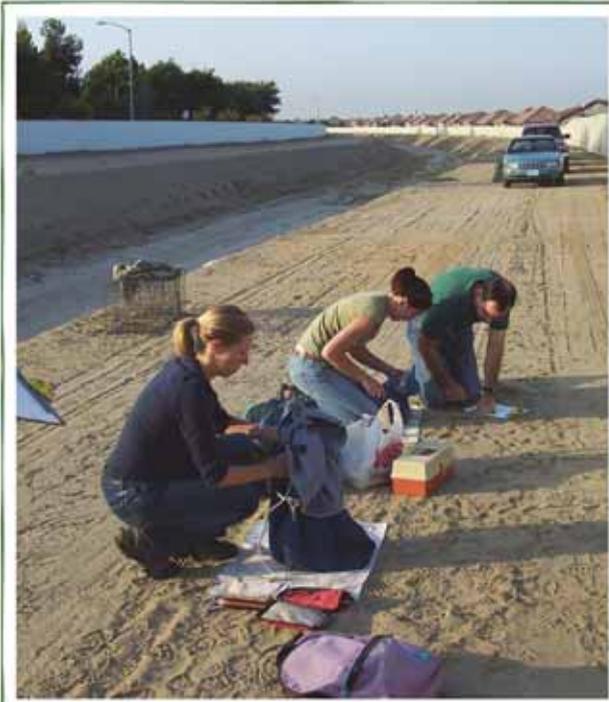
$t_{43}=2.85$, $P<0.01$), and there were a wider range of boldness scores across urban foxes, indicating a greater variability in the expression of behavioural type. Urban adults and juveniles were bolder than rural (T/H: $t_{63}=2.15$, $P<0.05$; RNOT: $t_{17}=2.30$, $P<0.05$), but there was no difference between urban vs. rural pups (T/H and ENOT test for baseline and novel threat). Within populations there was no difference between boldness across ages classes of urban foxes but rural adults were less bold than rural juveniles and pups ($t_6=-2.12$, $P=0.07$). The differences in boldness between and within habitats across age classes indicate young bolder foxes are more likely to be selected against than their shyer conspecifics. Rural foxes that died had higher boldness than surviving foxes ($t_{33}=-2.01$, $P=0.05$), with a similar trend in urban foxes. However, bolder rural foxes that survived to reproductive age reproduced in their first year ($t_{17}=2.058$, $P=0.05$) and had increased litter sizes ($F_{18}=4.729$, $P<0.05$).

Major difficulties faced

- Limited data: In the SWF project 31 foxes were released, 16 of which were radio-collared. Survival and movement was not obtained for the remaining 15 foxes as the stakeholders in the project did not wish trapping to be conducted at the site during the period of the study.
- Appropriate tests for free-living animals: The behavioral tests were originally designed for use on captive animals. Conducting the tests on free-living individuals highlighted the need for modification of the tests to produce robust data on wild animals.
- More intensive monitoring required: While the three studies produced informative insights into how personality can potentially influence re-introduction success, more intensive monitoring of individuals would produce greater information about dispersal movements and resource use. Limited numbers of personnel in the SJKF project meant that there was a limit to the amount of time that could be spent monitoring each fox. In addition, there were a large number of behavioral tests to be conducted in the short period of time before pups dispersed from the natal den, however in the interest of consistent evaluation of behavioral type only one observer conducted the test which limited the number of dens that could be observed.
- Limited animals for testing: As the behavioral analysis was conducted as part of ongoing conservation efforts, the number of animals available for testing were dependent on either the numbers captive-bred or the numbers available to be tested, i.e. number of individuals born or trapped. While the numbers available produced informative data regarding the effects of personality on re-introduction, in some instances (especially CCIF) data collected was not of the magnitude to conduct statistical analysis. While this does not restrict disseminating information to conservation organizations via project reports, it limits the capacity to disseminate to a wider audience through scientific journals.

Major lessons learned

- Boldness levels of individuals may be inappropriate or put the individual at a disadvantage for habitat conditions: Foxes that had very high levels of boldness showed higher levels of mortality due to both predation and vehicle-



**Processing foxes trapped along water canal
in Bakersfield**

associated mortality than those with lower boldness. Predicting the likelihood of individuals to survive relative to the mortality risk at a release site may allow for determining either the placement of individuals within the site or levels of pre-release training required. While it is recommended that a range of behavioral types be released, it may be advisable in particularly high risk situations to delay releases of particular individuals until the predator density is reduced if deemed appropriate.

- Levels of boldness may influence the movement of an individual within a release site: Very bold foxes showed a greater propensity for either increased total movement (SJKF) or for

moving around more between daily radio-telemetry fixes (SWF). This resulted in bolder foxes either leaving the release/study site or having increased mortality associated to increased movement. This was likely due to foxes that moved around more having a greater risk of encountering a predator, or alternatively being in unfamiliar terrain with limited knowledge of escape dens. Therefore it was concluded that foxes with overly high levels of boldness may be at a disadvantage when released at a site with high predation risk. The movement data suggests it is likely that individuals of particular personality types will explore their new release site in different ways. For example, bolder individuals may explore the release site more thoroughly and be more likely to disperse out of the site, but may also be more likely to find food resources and potential mates. Shyer individuals may remain closer to their release site, expose themselves less to mortality risks but may be less likely to locate adequate resources and potential mates. Intensive monitoring would have provided information regarding these theories; however current and future studies are focused on exploring these areas to determine whether it is possible to produce a release placement strategy in regards to resource availability and predator risk based on personality type.

- Bolder animals that survived were those that reproduced in their first year and had bigger litters: This suggests there is a trade-off between high boldness having a greater risk of mortality but the potential for greater reproductive output. Therefore, while bolder animals may be more likely to be predated on

or put themselves at risk relative to anthropogenic threats these individuals are also more likely to facilitate recruitment in the founding release population faster than shy individuals.

- Captive-bred SWF litters and SJKF litters in both the urban and rural habitat showed variation in boldness levels: This supports the view that boldness is an adaptive trait with variation in the litter allowing a greater potential for there being individual personality types in the litter who will be suited to current environmental conditions. The reduction in boldness levels in the higher age classes indicates bolder SJKF were selected against at a young age. However, the continuing presence of variation in litters suggests it is an adaptive strategy to continue to produce variation in pups. Therefore, it is recommended that a founder population contains representatives of all behavioral types to ensure the potential for the population to adapt under variable environmental conditions, or if there is variation within the release site. It may be advantageous in some instances to consider releasing founders with behavioral types in certain proportions depending on habitat pressures, and then varying the mix in subsequent releases to ensure variability. For examples, in release sites where predators are present the initial releases could comprise of a majority of shy individuals, but gradually switch to a higher proportion of bolder individuals as density increases and the need for dispersers to create linkage with neighboring populations arises.

Success of project

Highly Successful	Successful	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- Co-operative partnerships and financial support: A broad range of organizations supported these projects. The SWF project was facilitated by the Cochrane Ecological Institute, Defenders of Wildlife, the Blackfeet Fish, Game and Wildlife Department in Montana and Queen’s University of Belfast. Financial support was provided by The Department of Education for Northern Ireland. The CCIF project was a co-operative effort between the California State University - Stanislaus Endangered Species Recovery Program and the Catalina Island Conservancy. The former provided financial support and personnel while the latter provided access to animals and logistical support such as accommodation and transport. The SJKF project was conducted by personnel from the California State University - Stanislaus Endangered Species Recovery Program with funding provided by the Central Valley Program Conservation Project (CVPCP), a funding source administered by the US Bureau of Reclamation.
- Local community support: Both the SWF and the CCIF project experienced high levels of support from the community. Community feeling regarding SJKF was considered varied within the urban habitat; however, the majority of people encountered were supportive. The SWF project in particular demonstrated community support through the cooperation of the Blackfeet

Indian tribal community. Swift fox are considered a culturally significant animal to the Blackfeet, therefore they were highly supportive in terms of allowing access to land, passing on information regarding fox sightings, den locations and assisting with monitoring.

- Development of behavioral ethograms and boldness tests: Initial work was conducted on captive individuals. While working on captive foxes was a function of the re-introduction process for SWF, it allowed for effective development and modification of the behavioral tests. Close range observation of foxes habituated to the observer allowed for development of an extensive ethogram that was then modified for the CCIF and SJKF projects.
- Adaptation of tests for use in the wild: The original behavioral test was developed for captive foxes and relied upon the individuals remaining in a fixed location for the 1-hour testing periods. This method was generally applied successfully to SJKF pups who remained within the immediate vicinity of the natal den during the testing period. However, difficulties were encountered with locating natal dens between tests as adults move pups between den sites as a means of predator avoidance and as fleas build up in dens. Intensive monitoring of parents allowed all pups to be located and behaviorally tested. The original test was not particularly suited for juvenile and adult SJKF as shortly after emerging from the den individuals would leave to hunt. The CVPCP provided an extension of contract and funding to allow for effective testing of adults and juveniles using a modified behavioral testing method.

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