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Challenges of monitoring reintroduction outcomes: Insights from the conservation breeding program of an endangered turtle in Italy

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ABSTRACT

Captive breeding and reintroduction programs remain a powerful but divisive tool for management of threatened species, with a proven potential to avoid extinction, but low long-term success rates and high resource requirements. Monitoring the results of reintroductions is critical to be able to assess short- and long-term success, adjusting management decisions as new information becomes available. In this study, we assessed the first 15 years of the captive breeding and restocking program for the European pond turtle *Emys orbicularis* in Liguria, northern Italy. We estimated survival of released turtles by modelling mark-recapture monitoring data. We then used those estimates to update our prior expectations about long-term outcomes, and to adjust management decisions about the age of individuals to release. Modelling results suggest released turtles had sufficiently high survival, matching prior expectations, such that local extinction has been averted in the short-term. Survival was similar among candidate age classes for releases, suggesting the release of younger individuals can provide positive outcomes while reducing management costs. On the other hand, survival varied among sites, indicating the need for ongoing in-situ habitat management to ensure long-term persistence. Moreover, the late onset of sexual maturity in the species means reproduction of released animals cannot yet be determined with certainty. Captive breeding and reintroduction programs normally require long-term efforts; therefore, focused monitoring that is clearly linked to decision-making is necessary to continually refine and adjust management strategies.

1. Introduction

The conservation of endangered species requires diverse and often complex conservation strategies of variable intensity (Byers et al., 2013). Captive breeding programs for reintroduction and reinforcement of populations (hereafter "conservation breeding") are at the most management-intensive end of this spectrum. Since the first modern conservation breeding programs started in the late 1980s (see review in Seddon et al., 2007), reviews have highlighted low overall success rates (Dodd and Seigel, 1991; Fischer and Lindenmayer, 2000; Griffith et al., 1989; Wolf et al., 1996), compounded by a general difficulty in assessing long-term success (at least partly due to often inadequate monitoring; Ewen and Armstrong, 2007). To date, the few reviews of conservation breeding programs for reptiles have highlighted patterns similar to those of other taxa, where the potential for avoiding extinction in the short term is often challenged by unclear or negative outcomes in the long term (Dodd and Seigel, 1991; Ettling and Schmidt, 2015; Ewen et al., 2014; Germano and Bishop, 2009).

At the population level, the aim of reintroductions is to ensure population establishment and persistence, which in turn are ultimately determined by the vital rates (survival and fecundity) of released and wild individuals (Armstrong and Seddon, 2008). Those vital rates may be influenced by management decisions such as the sites and methods of release (such as "soft" or "hard" releases: Batson et al., 2015) and individual traits at release, such as age or body condition (e.g. Bremner-Harrison et al., 2004; Hardman and Moro, 2006). However, managers often have little information about whether and how their decisions affect vital rates and ultimately success. Monitoring of reintroduction outcomes generally aims to provide such information, in the expectation this will reduce uncertainty, facilitate decisions and improve management outcomes (e.g. Armstrong and Ewen, 2002; Bertolero et al., 2007; Steury and Murray, 2004). However, by itself the collection of collecting information does not automatically translate into better

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management decisions. Learning can be a slow process, for example in species with long generation times; imperfect detection, small sample sizes or confounding factors may limit the inference that can be made from monitoring data (Nichols and Armstrong, 2012). Even when sufficient information is collected, adequately responding to it by adjusting management actions can be challenging (McCarthy et al., 2012).

In this contribution, we illustrate how the information obtained by monitoring reintroduction outcomes can be used to update knowledge and adjust management decisions. We use as a case study the conservation breeding program for the European pond turtle *Emys orbicularis* in Liguria, northern Italy. We analyze the empirical data collected during the first seven years of turtle releases to estimate the vital rates of individuals, the management decisions that affect them and their influence on short- and long-term outcomes (respectively, avoiding extinction and ensuring population persistence). We then use these results to update prior expectations about management outcomes, assessing how monitoring has reduced uncertainty and modified management decisions.

2. Methods

2.1. Case study

The European pond turtle *E. orbicularis* is widely distributed throughout the European continent, north Africa and east Asia, and is therefore listed as Lower Risk/Near Threatened in the IUCN Red List (Tortoise and Freshwater Turtle Specialist Group, 1996). However, the listing requires updating since the species has become locally rare in several countries (Fritz and Chiari, 2013), following habitat destruction and fragmentation (Ficetola et al., 2004) and introduction of allochthonous species such as American sliders (*Trachemys* spp.) that have been linked to competition (Cadi and Joly, 2004) and to the spread of alien pathogens and parasites (Iglesias et al., 2015). Conservation programs for *E. orbicularis* are underway in several European countries, often involving conservation breeding and translocation actions (Fritz and Chiari, 2013). In the north-western Italian region of Liguria, the species was thought to be extinct following habitat destruction (Doria and Salvidio, 1994), until the rediscovery in the early 1990s of a few individuals of what was later identified as a separate subspecies endemic to Liguria (*E. orbicularis ingauna*; Jesu et al., 2004). The small number and old age of the captured individuals, and the lack of evidence of breeding in the wild, suggested an impending risk of extinction.

A program for in situ and ex situ conservation and restocking program for *E. orbicularis* was initiated in 1999, and an outdoor breeding facility ("Centro Emys") was built in 2000 on public land at Leca di Albenga, <2 km from the nearest known site of occurrence of the species. As of 2015, the breeding center hosts a total of 22 adult turtles (15 females and 7 males). From June until the end of July, a small opening connects the nesting site to the adult tank allowing females to lay egg clutches in clay-sandy soil. Eggs are left in the nest and hatchlings are collected after their emergence from the soil. Turtles are active from mid-March until October and overwintering takes place in mud on the bottom of the tanks. Newborns usually hatch in September, but sometimes eggs overwinter and hatch the following spring. Newborns are always transferred to the Aquarium of Genova and reared in a dedicated indoor facility for about two years before being returned to the outdoor facility for a period of acclimatization before release into the wild. Since 2008, turtles are released yearly in June or July at five different sites across the Centa river plain, after a screening for blood and gastrointestinal pathogens in accordance with veterinary protocols. Before release, each animal is individually marked following the methods of Cagle (1939) and by the subcutaneous implantation of a pit tag. To estimate survival patterns, released turtles at all sites are monitored annually, using baited funnel traps during three sessions (between May and August), each consisting of three consecutive trapping days.

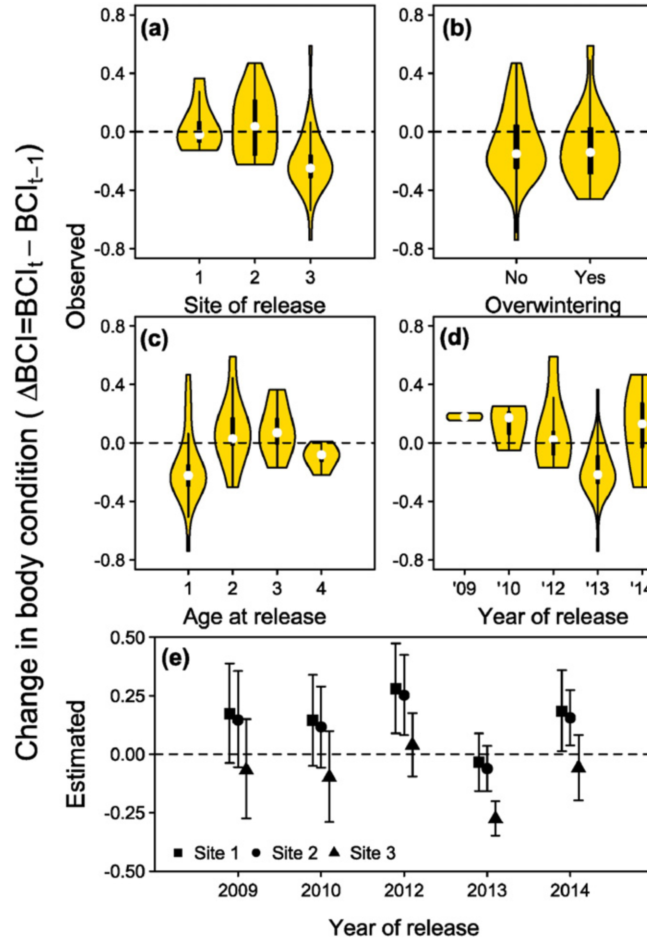

Fig. 1. Post-release body condition of turtles. The y-axis indicates the observed change in body condition index (BCI), calculated as the residual of a regression between body weight and carapace length, between the time of release and recapture in the first year. Plots (a) to (d) summarise the observed data, grouped by time of release, wintering type, age at release and year of release. Plot (e) indicates the estimated change in body condition for each year of the program, at each release site, as predicted by the model with the highest DIC support. The dashed line indicates no change, negative and positive values indicate condition loss and gain respectively.

The release program seeks to maximize the probability of persistence of *E. orbicularis* in the region; however, budget constraints influence management decisions, particularly in regard to the age of individuals to release. Among candidate age classes for release (3-, 4- and 5-year-olds), releasing older individuals may allow bypassing high-mortality juvenile stages and increase the chances of successful establishment, but the longer captive period would increase management costs. The relative benefits of releasing older turtles may also be offset by age-specific post-release mortality, for example if older turtles were more likely to disperse away from the site. In a previous study, Canessa et al. (2015b) used a stage-structured population model to predict the viability of a reintroduced population, focusing on management decisions about the age of individuals to release. Most of the information used to parameterize the model presented in Canessa et al. (2015b) was sourced from studies about other subspecies of *E. orbicularis*, across a wide range of geographic and environmental conditions (from the Iberian peninsula to Poland), potentially different from *E. o. ingauna*. This additional uncertainty was incorporated in model predictions by formalizing uncertainty in expert judgment as probability distributions for four uncertain parameters (survival of hatchlings, survival of turtles 3 to 5 years old, fecundity of subadult and adult turtles).