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Behavioural responses are associated with mortality and mobility after reintroduction in the endangered Yellow Cardinal

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Reintroductions are an important management tool for the conservation of threatened species. Personality or temperament of individuals is likely to influence survival in the reintroduction success of released individuals. We studied behavioural traits related to personality in the globally endangered Yellow Cardinal *Gubernatrix cristata* and analysed whether these traits were associated with the outcome of a reintroduction programme in Argentina. We found that exploratory behaviour and anti-predator responses were correlated in Yellow Cardinals. Individuals with higher activity levels in the presence of a predator had a lower risk of mortality following release. Also, less neophobic individuals with increased exploratory behaviour moved farther away from the release site. High activity levels in terms of a predatory response could outweigh the cost of higher exposure to predators and may be beneficial in decreasing predation probability. We recommend the enhancement of predatory responses before release, especially in individuals with inherent low mobility. Long-term monitoring of future releases will help understand how individual variation in behaviour influences reintroduction success in this species.

Keywords: conservation, exploratory behaviour, *Gubernatrix cristata*, release, risk-taking behaviour, wildlife trafficking.

Reintroductions of endangered species (i.e. the intentional movement of an organism into a part of its native range from which it has disappeared or become extirpated in historical times; Armstrong & Seddon 2008) have become a conservation strategy used with increasing frequency in recovery programmes (Seddon *et al.* 2007, Seddon 2010). These often constitute an immense cost in terms of effort and resources and it is worthwhile determining the factors affecting their success. Such factors involve characteristics of the release site (habitat suitability, threats, the presence of an existing population), the translocation protocols (handling, transport, release method), as well as individual characteristics (such as health condition, age and time spent in captivity; Letty *et al.* 2007). Behaviour should also be considered in reintroductions (Sutherland 1998, Ewen & Armstrong 2007, Greggor *et al.* 2016, Merrick & Koprowski 2017), as behavioural traits such as risk-taking (response to a potentially dangerous situation) and exploratory behaviour (response to a new situation) could play a key role in survival of reintroduced animals and adaptation to their new environment (Smith & Blumstein 2008, Page *et al.* 2019, Moiron *et al.* 2020, Wilson *et al.* 2022). For example, bolder captive-bred Swift Foxes *Vulpes velox* showed a lower post-release survival (Bremner-Harrison *et al.* 2004), whereas Desert Tortoises *Gopherus agassizii* with higher exploratory behaviour were more likely to find and use refugia, which led to higher survival following

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release (Germano *et al.* 2017). The novelty of the new environment can generate an acute stress on released individuals (Letty *et al.* 2007), and the way each individual copes with that stress and reacts to the new environment may influence reintroduction success (Cockrem 2013). These behavioural traits are usually studied in the framework of animal personality research. The term personality refers to behavioural differences between individuals that are consistent in time and are correlated in different contexts and situations (Réale *et al.* 2007). Behavioural traits usually measured as personality components are aggressiveness, sociability, activity, risk-taking (boldness) and exploratory behaviour (Réale *et al.* 2007, Merrick & Koprowski 2017). These personality traits can correlate with each other at the individual level, forming so-called behavioural syndromes (Sih *et al.* 2004, Garamszegi *et al.* 2013). Also known as 'coping styles' (Koolhaas *et al.* 1999, Carere *et al.* 2010), behavioural syndromes describe how individuals cope with stressful situations and position them along a proactive–reactive axis, where proactive individuals are characterized by actively exploring new environments and being both aggressive and risk-taking, as opposed to reactive individuals, which are less aggressive, less bold and have lower activity levels while exploring new environments. Personality traits can have a direct influence on the individual's fitness, as they are related to mortality and fecundity (Smith & Blumstein 2008).

The Yellow Cardinal *Gubernatrix cristata* is a South American passerine categorized as Endangered in the IUCN Red List (BirdLife International 2022). Currently, its largest populations occur in the Espinal ecoregion in Argentina (Reales *et al.* 2019, Domínguez *et al.* 2020). Threats include habitat loss and the capture of individuals to stock the illegal cagebird market (BirdLife International 2022), although brood parasitism by the Shiny Cowbird *Molothrus bonariensis* also affects population viability (Domínguez *et al.* 2015, Atencio *et al.* 2020). For the past 4 years, a management plan for rescued individuals from the illegal pet trade has been carried out in Argentina following IUCN guidelines for the management of confiscated live organisms (IUCN 2013). After being seized by governmental wildlife authorities, rescued Yellow Cardinals go through a sanitary rehabilitation at the wildlife recovery centre 'Fundación Temaikèn'. After completion of this rehabilitation process, they are released back into areas with suitable habitat within their region of origin, determined by the use of molecular markers (Domínguez *et al.* 2019).

In this study we examine exploratory and risk-taking behaviours in Yellow Cardinals recovered from illegal wildlife trafficking to determine whether a behavioural syndrome exists in this species and to discover whether exploratory and risk-taking behaviours are associated with the survival of released individuals.

METHODS

Behavioural tests

We carried out three behavioural tests to characterize personality in Yellow Cardinals at the Temaikèn Species Recovery Centre (CRET, after its acronym in Spanish) during 2018, 2019 and 2021. We measured exploratory behaviour by subjecting birds to a novel environment test and a neophobia test. Although neophobia can be characterized as risk-taking or boldness (Frost *et al.* 2013, Brust & Guenther 2017, Collins *et al.* 2019), we follow Réale *et al.* (2007) in considering neophobia primarily an exploration measure, as it constitutes a response to a novel stimulus (Germano *et al.* 2017, Tan & Tan 2019, Vernouillet & Kelly 2020, also reviewed in Takola *et al.* 2021). The third test was an anti-predator response test used as a measure of risk-taking behaviour (Réale *et al.* 2007, Krenhardt *et al.* 2021, Sbragaglia & Breithaupt 2022).

All behavioural tests were recorded using a Sony HDR-CX110 handycam. The neophobia and novel environment tests were carried out in the mornings (08:00–10:00 h) and the anti-predator test was carried out in the afternoons (15:00 and 16:00 h). Behavioural tests were performed on different days. Due to logistical constraints within the recovery centre, not all individuals could be tested for all three behavioural responses (novel environment test $n_{2018} = 8$, $n_{2019} = 20$, $n_{2021} = 21$; neophobia test $n_{2018} = 0$, $n_{2019} = 19$, $n_{2021} = 20$; anti-predator response test $n_{2018} = 5$, $n_{2019} = 18$, $n_{2021} = 14$). Behavioural responses should ideally be tested repeatedly to diagnose a personality pattern (Dingemanse & Wright 2020), although personality tests in threatened species should be carried out with the least manipulation of the animals involved (Richardson *et al.* 2019). To minimize stress and handling, we were reluctant to obtain repeated measures for each behavioural test and so the behavioural measures obtained in this study should be considered as proxies for personality rather than personality traits *per se*.

Upon arrival at the recovery centre, birds were housed in 8-m^2 enclosures 2.4 m in height. Each bird went through a comprehensive recovery process, which includes strict quarantine, medical check-ups and health rehabilitation. Only when they were discharged by the team of veterinarians and biologists, judging them fit for release according to international animal welfare protocols (World Association of Zoos and Aquariums 2003), were behavioural tests carried out.

Exploratory behaviour

Exploratory behaviour was measured as the response of an individual in the presence of novel stimuli using two different tests: a novel environment test (response to a novel environment) and a neophobia test (response to a novel object).

Novel environment test. We carried out a novel environment test on 49 Yellow Cardinals. Each bird was tested once in an octagonal 2.8-m-high experimental cage of 19.30 m^2 containing four artificial perches, each of them in a different quadrant (Fig. 1). Yellow Cardinals were captured from their original enclosure and transported to the experimental arena in a wooden transport cage with a sliding door. The transport cage was then placed inside the experimental arena (Fig. 1). Due to the high levels of stress that the capture process is likely to elicit, we set a long acclimation period (45 min) before the sliding door was opened for the bird to enter the arena. The closed, wooden transport cage precluded the bird becoming familiar with the experimental arena during the acclimation period. The sliding door was opened from behind, so that the bird did not see the person who opened it. We recorded the total number of hops and flights, number of quadrants visited (1–4) and number of quadrant changes during the first 5 min after the bird entered the experimental arena. The total number of hops and flights constitutes a variable that describes the Cardinal's overall mobility in the new environment, and the number of quadrants visited and number of quadrant changes describes the individual's movement around the experimental cage.

Neophobia test. We conducted a neophobia test on 39 Yellow Cardinals to obtain another measure of exploratory behaviour. In 11 cases, the neophobia test was carried out in the same experimental arena as the novel environment test; the remaining 28 birds were tested in their original housing enclosures. The difference in testing enclosure was accounted for in the analysis. To study the Cardinal's response to a novel object, we presented the bird's regular diet on a familiar feeding plate on top of a green cloth early in the morning. The green cloth was used as the novel object in the experiment. Neophobia was measured as the latency to approach the novel object to a distance of less than 1 m. All individuals were food-deprived from the night before, so all birds had a strong and similar motivation to eat.

Risk-taking behaviour

Anti-predator response test. Anti-predator response was tested in 37 Yellow Cardinals, either in the experimental arena (n = 23) or in original housing enclosures (n = 14). The test consisted of presenting a live potential aerial predator to each Yellow Cardinal and recording the bird's mobility (number of hops and flights) during the first 20 s of exposure to the predator. Two trained raptors were used for this test, a Harris's Hawk *Parabuteo unicinctus* and a Peregrine Falcon *Falco peregrinus*, both of which occur within the natural distribution of Yellow Cardinals (BirdLife International 2022). We chose to work only with aerial predators since these were the only live potential predators of Yellow Cardinals available for the trials at the recovery centre. Initially the test consisted in having the raptor make a direct flight of 10 m towards the experimental arena where it ate from a decoy in front of the cage, and nine Yellow Cardinals were tested in this way. However, the raptors eventually became unresponsive to training and for the remaining 28 trials we instead had a human walking around the Yellow Cardinal's cage at <1 m distance carrying the predator on a falconry glove. The differences in testing location, approach and predator species were accounted for in the analysis. Anti-predator response was measured from the moment the Yellow Cardinal saw the predatory bird (i.e. the predator was within the Yellow Cardinal's visual field). We considered bolder or less risk-averse individuals as those that presented a higher mobility in the anti-predator test. This assumption was made because being highly active in the presence of a predator is considered to

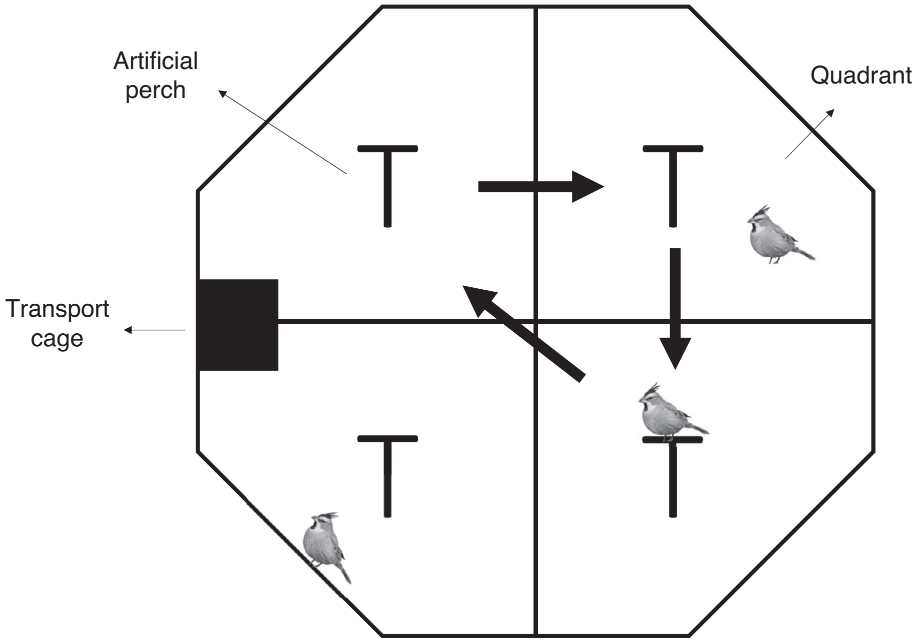

Figure 1. Layout of the experimental arena in which we tested the Yellow Cardinal's exploratory behaviour. The arena was divided into four different quadrants, each with an artificial perch. The birds could be found perched on the cage's mesh, on the floor or on the artificial perch. Arrows indicate a possible movement pattern during the experiment, which would correspond to three quadrant changes and a total of three different quadrants visited.

increase their exposure to them, hence putting them in a riskier situation (Sih *et al.* 2003, Ward *et al.* 2004, Bell 2005); conversely, reducing activity in the presence of a threat might minimize the probability of a prey being detected by a predator (Chelini *et al.* 2009).

The protocols used in this study have been subjected to an ethical review process by the Research Ethics Committee of Fundación Temaikèn (Research Protocol #2018–01). Fundación Temaikèn is a member of the World Association of Zoos and Aquariums (WAZA) and thus complies with their standards on animal welfare (World Association of Zoos and Aquariums 2003).

Release and monitoring

The recovered Yellow Cardinals were released in suitable habitat within their area of origin in Argentina at the beginning of the reproductive season (late September to early October) between 2018 and 2021. Nineteen Yellow Cardinals were monitored after being released in a private field in La Pampa province, Argentina (36°48′S, 4°37′W) in 2019. Therefore, the survival data used for subsequent analysis only included individuals liberated in 2019. Of the released animals, 17 had been tested for all behavioural responses in 2019. Prior to release, the birds were banded with a unique colour-ring combination and 17 were equipped with radio-transmitters weighing 1.0 g (model A1055; Advanced Telemetry Systems, Isanti, MN, USA), which corresponds to <3% of Yellow Cardinal mass. Radio-tags had an 88-day lifespan and a detection range of approximately 800 m considering the characteristics of our study area. We carried out radiotracking sessions on foot during mornings (07:00–12:00 h) and afternoons (16:00–19:00 h) with the exception of rainy days. We tracked each radiotagged bird daily using a Yagi antenna and a hand-held receiver (model Sika; Biotrack, Wareham, UK). The Yellow Cardinals were tracked until visual contact was made. Birds were identified and their location was recorded using a global positioning system device (eTrex Legend HCx; Garmin, Olathe, KS, USA). Monitoring took place during most of the breeding season starting immediately after release (5 October–22 December). We studied whether the behavioural traits measured were associated with

Yellow Cardinal survival and the maximum distance travelled from release site.

Statistical analysis

All statistical analyses were performed in R, version 4.0.5 (R Core Team 2020). To describe each individual's exploratory behaviour for the novel environment test, we computed a principal components analysis (PCA) using the 'vegan' package (Oksanen *et al.* 2013), where the total number of hops and flights (mobility), number of quadrants visited and number of quadrant changes were summarized on a single axis (exploration principal component, exploratory PC) that covered most of the variability (see Results). We performed a Pearson correlation test between the individual's body condition (estimated as the residuals of the body mass on tarsus length regression, n = 37) and the exploratory PC to examine whether the Yellow Cardinals' capacity to move was associated with their physical condition. Tarsus length was measured from X-ray images using ImageJ software (Abràmoff *et al.* 2004).

We conducted an ANOVA test between the different enclosures used for the neophobia test to determine whether enclosure generated differences in the mean response of the Yellow Cardinals. To assess differences between enclosure and approach in the anti-predator response tests, we conducted two one-way ANOVA tests. Because the first approach (direct flight of the predator towards the bird's cage) was only carried out in the experimental arena and the second approach (predator held in falconry glove) was carried out in both enclosures (experimental arena and original enclosure), we explored differences in enclosures only for the second approach. We then tested differences in approach only for the experimental arena. We conducted Pearson correlations between the measures from the different behavioural tests to identify groups of correlated behaviours.

A Cox Proportional Hazards Model was implemented with the package 'Survival' (Therneau 2021) in R to test the different behavioural measures as predictors of survival of the monitored Yellow Cardinals. We used monitoring data from the individuals released in 2019 that had been previously tested for all three behavioural tests and for which we had monitoring data (n = 10). Tagged birds that were lost immediately after liberation (n = 7) were excluded from the analysis. The proportional hazards model is the most widely used regression model for studying the survival time using predictor variables (Fox 2002). As this model allows the use of censored data, we were able to include two individuals that were lost during the course of monitoring. These two individuals were followed for 10 and 13 days, respectively. The proportional hazard assumption required for this model was checked using the Schoenfeld test.

We also analysed whether exploratory behaviour (measures from the novel environment and neophobia tests) was related to the maximum distance travelled from the release site. To explore this association, we performed Pearson's correlations between the released Cardinals' maximum distance travelled from the release site for the first 10 days after liberation and the measures obtained from both exploratory behaviour tests. We used the maximum distance travelled within the first 10 days after release in order to include the two individuals that were lost during the course of the monitoring (monitored for 10 and 13 days). For this analysis we only included individuals for which we had three or more GPS points, or at least two GPS points if they survived for <3 days.

When necessary, normality and homoscedasticity were tested analytically using the Shapiro–Wilk and the Levene tests, respectively. In cases where the normality assumption was not met, the data were log-transformed.

RESULTS

The variables measured for exploratory behaviour in a novel environment were standardized and summarized in a single axis (exploratory PC) that explained 67.42% of the variation. The loading of all three variables measured for exploratory behaviour was high on this axis (correlations between original variables and exploratory PC > 0.59; Table 1), implying that this principal component is a good overall indicator of exploratory behaviour in a new environment. An individual with a high exploratory PC score shows high mobility *per se* (total number of hops and flights) as well as a high mobility throughout the novel environment (total number of quadrants visited and quadrant changes) during the first 5 min of experimentation. Exploratory PC values were not associated with individuals' body condition (Pearson's $R = 0.11$, $P = 0.53$).

Table 1. Correlations between the novel environment test variables and the exploratory principal component.

Selected axis	Exploratory PC (69.5%)
Mobility	$R = 0.91$ $P < 0.001$
Quadrants visited	$R = 0.59$ $P < 0.001$
Quadrant changes	$R = 0.92$ $P < 0.001$

The values shown are Pearson's correlation coefficients (*R*) and their associated significance values.

The ANOVA for different enclosures used for the neophobia test did not show evidence of differences in the mean response ($F = 0.017$, $P = 0.897$). Also, the anti-predator response trials did not show any difference in the mean response between the different enclosures or approaches (ANOVA, $F_{enclosure} = 0.76$, $P = 0.4$, $F_{approach} = 0.49$, $P = 0.5$).

There was a significant correlation between exploratory PC values and the anti-predator test measures (Pearson's $R = 0.51$, $P = 0.02$; Fig. 2). No significant associations were found between exploratory PC values and neophobia measures (Pearson's $R = 0.16$, $P = 0.35$) or between neophobia measures and anti-predatory behaviour (Pearson's $R = 0.26$, $P = 0.14$).

Survival analysis and post-release displacement

We were able to obtain monitoring data for 10 of the previously tested Yellow Cardinals, of which three survived until the end of the monitoring period, two were lost 10 and 13 days post-liberation, and the remaining five died after 2 ($n = 2$), 15, 18 and 41 days.

The Cox regression model indicated a significant effect of anti-predator behaviour on survival

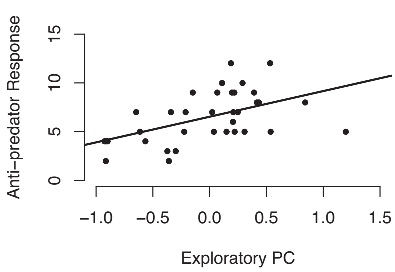

Figure 2. The association between exploratory PC values and anti-predator response measures ($n = 35$).

(Cox regression $\beta = -1.16$, se = 0.5, $z = -2.31$, $P = 0.021$). The negative association indicates that the risk of mortality is lower for individuals with higher anti-predator response. No significant effects of exploratory behaviour in a novel environment (Cox regression $\beta = -0.15$, se = 2.25, $z = -0.065$, $P = 0.95$) or neophobia (Cox regression $\beta = 0.002$, se = 0.002, $z = 0.881$, $P = 0.38$) on survival were found. The proportional hazards assumption for this model was met (Schoenfeld's global $P = 0.23$).

We found significant associations between maximum distance travelled from the release site during the first 10 days post-liberation and exploratory behaviours (Exploratory PC Pearson's $R = 0.77$, $P = 0.03$; Neophobia Pearson's $R = -0.75$, $P = 0.03$; Fig. 3).

DISCUSSION

Yellow Cardinals varied in their exploratory and risk-taking behaviours and there was a positive correlation between exploratory behaviour in a new environment and the response to a predator. Individuals that showed higher mobility in the presence of a predator also performed increased exploratory behaviours in a novel environment. This pattern has been already observed for other species (Van Oers *et al.* 2004, Jones & Godin 2010) and is in accordance with the coping styles behavioural syndrome (Koolhaas *et al.* 1999, Carere *et al.* 2010). For this temperament indicator, individuals are placed along a reactive–proactive axis, where proactive individuals initiate a flight/fight response towards stress, and are characterized as being less risk-averse, more aggressive and explore new environments actively. In contrast, reactive individuals are shyer, less aggressive and less active. Although behavioural responses of Yellow Cardinals might reveal a behavioural syndrome, we cannot rule out the possibility that the association found between anti-predator behaviour and exploratory behaviour in a novel environment is a consequence of a carryover of a general activity level of the individuals (Réale *et al.* 2007, Carter *et al.* 2013). To be certain about the personality component, activity trials within a non-novel environment could be carried out to correct for measures of activity in the novel environment (Herborn *et al.* 2010).

Interestingly, the two different measures for exploratory behaviour, novel environment and

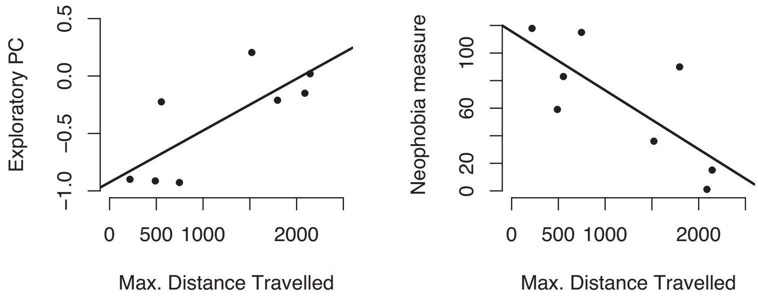

Figure 3. Maximum distances travelled (m) from the release site in the first 10 days post-release in relation to measures obtained in the novel environment and the neophobia tests (n = 8).

neophobia, were not correlated. This absence of significant contextual repeatability for exploratory tests has been observed in other species (Jones & Godin 2010, Arvidsson *et al.* 2017, Germano *et al.* 2017, Vernouillet & Kelly 2020), suggesting that exploration is a context-dependent behaviour and does not necessarily reflect temperament. Neophobia was also not correlated with anti-predator response.

As our study species is globally threatened, we tried to minimize manipulation and stress throughout the study, precluding the collection of repeated measures of behaviour. Thus, we cannot be certain whether the behavioural responses measured reflect personality patterns. Predation is one of the key factors responsible for the failure of many conservation reintroductions (Moseby *et al.* 2011, Cortez *et al.* 2015, Lopes *et al.* 2017, Destro *et al.* 2018). In fact, the main cause of mortality for released Yellow Cardinals during past liberations has been predation (Domínguez *et al.* 2019). The results of the survival analysis indicated that Yellow Cardinals showing higher activity levels when exposed to a potential predator in captivity had a lower mortality risk after reintroduction compared with individuals that were less active in the trials. Despite the low sample size of our study, we did detect a significant association of behavioural traits with survival and post-release dispersal, suggesting that the association between these variables is indeed very strong. Boldness or risk aversion is a personality trait that has been generally associated with lower survival rates (Smith & Blumstein 2008, Carter *et al.* 2010, May *et al.* 2016) as bolder individuals present lower risk aversion, which increases their exposure to predators and makes them more likely to be predated. Our findings contrast with most studies, as less risk-averse Yellow Cardinals presented increased survival. Studies on fish have shown that boldness is not always a maladaptative trait when it comes to predation (Smith & Blumstein 2010), as bolder individuals take more risks inspecting predators, which could dissuade them from attack (Godin & Davis 1995, Brown & Dreier 2002) and could also provide them with a better risk assessment (Licht 1989). Moreover, the higher activity recorded in the predator trial could reflect a benefit of the escape response that outweighs the cost of higher exposure to predators. It is possible that a freezing or low mobility response to predators could decrease survival from a predator attack. In our study we did not witness predatory events the moment they occurred, and hence we do not know whether higher survival of less risk-averse Yellow Cardinals occurred as a consequence of fewer predatory attacks (as a result of a higher risk assessment) or an enhanced ability to escape an attack once initiated. In either case, in a conservation programme that involves returning rescued individuals back into the wild, it could be advantageous to enhance potentially lost or decayed predatory recognition in pre-release training sessions (Griffin *et al.* 2000, Cortez *et al.* 2015) to compensate for the inherent low mobility of reactive individuals. Classical conditioning procedures in which animals learn that model predators are predictors of an aversive event can enhance predator recognition (Griffin *et al.* 2000).

Post-release dispersal and movement patterns can be influenced by an individual's personality traits (McDougall *et al.* 2006, Watters & Meehan 2007, Cote *et al.* 2010, Sih *et al.* 2012, Merrick & Koprowski 2017, West *et al.* 2019). In our study, Yellow Cardinals with a higher exploratory score in the behavioural tests (high exploratory PC in the novel environment test and lower latency to approach a novel object) moved farther away from their release sites during the first 10 days post-liberation. Similar results have been found in the past for other birds (Botero-Delgadillo *et al.* 2020, Smetzer *et al.* 2021). Study of the post-release exploratory movements is of great importance when it comes to making management decisions for reintroduction projects (Berger-Tal & Saltz 2014). These exploratory movements may help individuals to familiarize themselves with the new habitat by allowing them to gain information about the novel environment, leading to efficient resource utilization, predator avoidance and mate location (Berger-Tal & Saltz 2014). Our results show the potential for using behavioural traits in captivity to anticipate the movement patterns of released Yellow Cardinals.

Environment can change spatially and temporally, and so personality traits that are favourable in one context may be suboptimal in a different one (Dingemanse *et al.* 2004). The largest populations of Yellow Cardinals are currently found in the northeastern, central and southern areas of its distribution range in Argentina (Reales *et al.* 2019, Domínguez *et al.* 2020). Due to the intensification of agricultural activities and livestock ranching, these areas continue to undergo loss and transformation of natural habitats (Arturi 2005, Matteucci 2012). Thus, it is important to keep in mind that less risk-averse individuals were more successful for this particular release site and in this particular study period. Further, in variable or unpredictable conditions, birds with reactive personalities (less risk-averse, less aggressive, lower exploratory behaviour) may be more likely to be successful, whereas in non-changing or predictable conditions, proactive personalities (bolder, more aggressive, high exploratory behaviour) may have greater fitness (Cockrem 2013, Smit & van Oers 2019). Because of this context-dependency, we recommend management efforts to maintain behavioural variability for released populations of rescued Yellow Cardinals (Watters & Meehan 2007, Merrick & Koprowski 2017).

Which behavioural traits may succeed in the long term cannot be predicted by our findings. Long-term monitoring could deliver a better understanding of the role personality plays in reintroduction success for this species. Our results reflected associations of behavioural traits with short-term survival, which is linked to the individual's challenges of facing and adapting to a new environment (Letty *et al.* 2007, Stamps 2007). However, how personality affects survival of Yellow Cardinals beyond this early stage of post-reintroduction is something still to be determined. For example, personality can significantly impact reproductive success (Both *et al.* 2005, Cole & Quinn 2014, Roth *et al.* 2021), which is another key fitness component that should be considered in reintroduction programme evaluations (IUCN 2013).

Our study contributes new evidence for the relevance of individual behavioural variation as a key factor influencing the reintroduction success of a globally endangered species. The publication of results of reintroduction outcomes are crucial for optimizing conservation strategies for endangered species (Caro & Sherman 2011) and should be encouraged among researchers and conservation practitioners.

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AUTHOR CONTRIBUTIONS

Melina Atencio: Conceptualization; data curation; formal analysis; funding acquisition; methodology; project administration; visualization; writing – original draft. **María Alicia de la Colina:** Conceptualization; funding acquisition; resources; writing – review and editing. **Bettina Mahler:** Conceptualization; funding acquisition; project administration; supervision; visualization; writing – original draft; writing – review and editing.

CONFLICT OF INTEREST

The authors have no conflict of interest.

ETHICAL NOTE

None.

FUNDING

None.

Data Availability Statement

The data used for this study are available for access at Elsevier's Mendeley Data repository (doi: 10.17632/bzbfzyb873.2).

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